THE NEXUS TIMES

THE MAGIC CONSORTIUM

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MAGIC

NEXUS

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INTRODUCTION

What is the Nexus? Definitions of the Nexus abound – one research study identified 114 different ones. At its core, however, the Nexus is a concept for the connections and interrelations between various "things". These "things" could be parts of the material world, issues to be tackled by authorities and other social actors, or policy sectors – or a combination of those. Often, the "things" would be Water, Energy and Food – the so-called Water-Energy-Food Nexus or WEF Nexus. Sometimes, the issue of climate change is included to make it the CWEF Nexus; sometimes, environmental protection, making it the WEFE Nexus. One important reason for the interest in the Nexus is the presence of tensions, trade-offs and contradictions: A policy to limit the use of freshwater, for instance, may have a negative impact on agricultural production, and vice versa. To understand the Nexus one has to be prepared for complexity: not only a lot of things and a lot of data but highly connected causal networks with myriads of negative and positive feedback patterns and sometimes with high levels of uncertainty and unpredictability. To govern in the Nexus, one has to be prepared not only for scientific uncertainty and complex science but also a myriad of different understandings, values and interests among the many stakeholders, actors and concerned parties, giving rise to an equally diverse range of problem definitions, priorities and issue framings, typically leading to different practical approaches and strategies. Moreover, the many different practical and political perspectives imply different needs for knowledge. The knowledge needs may be met by different research disciplines that may build upon theoretical and methodological assumptions that are not only different but sometimes also in tension or outright contradiction. In this way, scientific facts and political and social values are also entangled into each other. The Nexus is – if not a mess – terribly complex. This is why we – the MAGIC Consortium, the authors and editors of this book – say that you cannot govern the Nexus, as if you could control it. You can only govern in the Nexus, because it is so big and complex, and because you are part of it yourself.

This book is an attempt at providing glimpses of Nexus issues in an accessible form for a general audience. It consists of short and sometimes very short articles that originally were published on the website of a research project. The book documents four years of intensive discussions within this research project, "Moving Towards Adaptive Governance in Complexity: Informing Nexus Security" (MAGIC). MAGIC was coordinated by ICREA Professor Mario Giampietro at the Autonomous University of Barcelona, and was at the time arguably the largest project endeavour to merge a complexity-based approach to integrated environmental assessment (namely the method called "MuSIASEM", to be explained later) with social research (policy analysis, science and technology studies and others) under a theoretical umbrella provided by the philosophical concept of post-normal science. To this purpose, Giampietro had gathered researchers from six countries, spanning 4,000 km from the Canary Islands to Norway, and 2,000 km from Aberdeen in the West to Naples in the East, to submit a proposal to the European Union's eighth framework programme for research and innovation, the so-called Horizon 2020. In 2016, the consortium got the good news that the project was funded by EU's Horizon 2020, under the H2020-WATER-2015-two-stage programme and its topic "Integrated approaches to food security, low-carbon energy, sustainable water management and climate change mitigation".

MAGIC began in June 2016 and ended in September 2020. It was an immensely productive and prolific research project that resulted in a lang series of reports, scientific articles, books, book chapters and videos as well as an outreach platform called "the Uncomfortable Knowledge Hub" that can be found on the internet. An important factor for this success, we believe, was the modus operandi of the project that Giampietro took from complexity studies: Open-ended endeavours such as research projects should keep degrees of freedom and not be killed by too much planning. Creativity is boosted by working for, and allowing for, the emergence of an attractor pattern that strengthens mutual collaboration and individual initiative. Furthermore, as is well-known from the literature on interdisciplinarity, time and space is required for mutual learning processes in order to go from the coexistence of different research approaches and disciplines in a project, to true, interdisciplinary collaboration. It has to be noted that it was a challenge to make this creative approach possible while also respecting the many rules, regulations and obligations of EU-funded research, obligations that emphasize a type of accountability that is measured in terms of plans and compliance with plans.

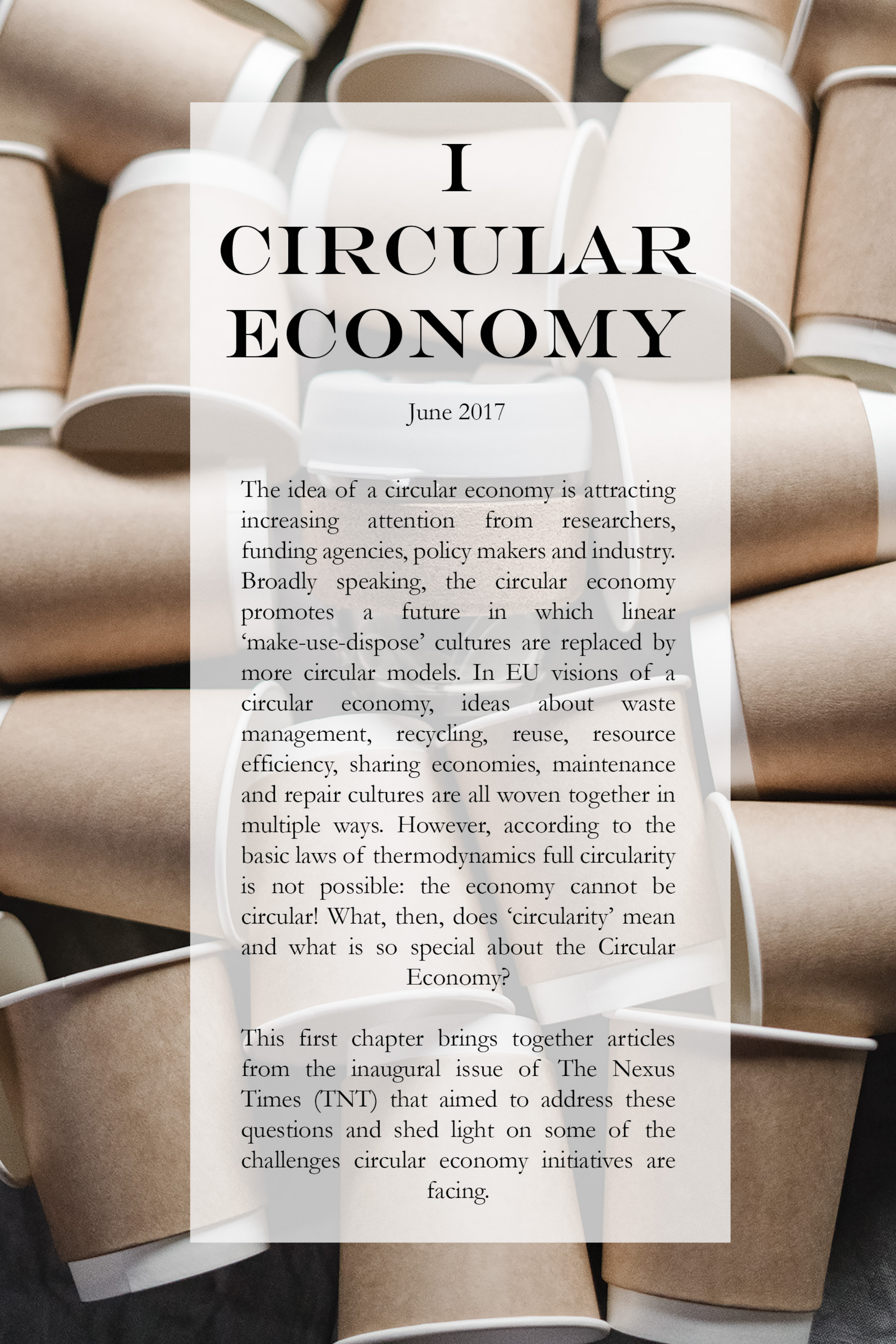
In this book, we have collected articles from the online newsletter The Nexus Times, created and published by MAGIC. The content of The Nexus Times played a significant part in the interdisciplinary development of MAGIC. The Nexus Times, or TNT as we often called it, served as such a double purpose. First and foremost, it was a newsletter – a communication channel from the project to disseminate results, communicate broader ideas and engage with publics by publishing thought-provoking articles on a regular basis. At the same time, it also served as one of the platforms for mutual learning and discussion within the project itself. A group of early-career researchers (Zora Kovacic, Tessa Dunlop, Louisa Jane De Felice, in the early phase also Luis Zamarioli) were responsible for organising and editing TNT and created its lively, dynamic character. However, virtually everybody who worked in MAGIC, contributed to TNT with one or more articles, and several of us were guest editors (including Sandra Bukkens and Thomas Völker in addition to the authors of this introduction). Accordingly, we have chosen to publish this book – this collection of the online TNT issues – under the collective name of "The MAGIC Consortium".

A range of topics related to sustainability, energy production, water management, climate and economy are explored and discussed in the chapters to follow. The contributors call attention to the current topics at the time. Each chapter represents an issue of the newsletter and takes on a different theme by presenting a handful of opinion pieces written by different members of the MAGIC consortium. We would like to emphasize that the texts are opinion pieces and not in any way pretends to present a comprehensive overview of issues nor go into much scientific detail. Those who need the latter, should consult the scientific literature, to which the volume contains selected references. Furthermore, the pieces are written in order to stimulate thought and debate, taking quite strong and radical positions when called for. The worst-case scenario for a TNT piece was not that it was not 100% accurate in all its detail but that it was boring. That being said, the pieces were always subjected to intra-project peer review in addition to editorial quality assurance.

The first issue of The Nexus Times was published in June 2017, and the last in September 2020. In what follows, we have included every article from the Nexus Times newsletter as they were published, with only minor edits. This has been a deliberate choice. Some of the issues quite strongly reflect the historical circumstances at the time, in particular with respect to policy agendas, and as such they are also a witness of those circumstances. Other than correcting simple mistakes, we have accordingly refrained from editing and revisions that would alter the authenticity of the contents. Irmelin Wilhelmsen Nilsen has been in charge of the production process of the book, in collaboration with the rest of the MAGIC team at the University of Bergen and in close interaction with the TNT editorial team and the always helpful and efficient MAGIC project manager, Sandra Bukkens at the Autonomous University of Barcelona. The book project was also made possible by the long-standing collaboration between the two mentioned universities and the European Centre for Governance in Complexity and its publishing house, Megaloceros Press. Finally, without the financial support of the European Union, through the MAGIC H2020 Grant Agreement No. 689669, none of this would have been possible.

We began to conceive of a printed collection of The Nexus Times during the COVID-19 lockdown in Spring 2020. As conferences started to be cancelled, we saw that we had to change our communication strategy and return to the possibly old-fashioned medium of the printed book. Since many of us are indeed old-fashioned and still hold romantic feelings for printed books, we decided to pay attention to its aesthetics and print it in full colour, with the original online illustrations. At first we talked of "the TNT booklet"; however, as we began to assemble the materials, their magnitude dawned upon us and it was clear that the production process had to aim at a 200-page book volume filled with short pieces. We imagine the volume to be an interesting read for anyone with an interest in sustainability issues, perhaps as a coffee table book or a companion in the lunch room. It is not at all necessary to read it chronologically, from page 1 and chapter by chapter. Rather, we invite readers to read here and there, picking issues according to their liking and curiosity. Furthermore, we encourage readers to consult other legacies from the MAGIC project, including the Uncomfortable Knowledge Hub which will be easy to find with internet search engines. The MAGIC project has ended but it is our hope that it was just the end of a beginning of a new style of complexity-based approaches to sustainability issues also grounded in social science; perhaps The Nexus Times can inspire other to take on that lead.

September 2020
Roger Strand & Irmelin Wilhelmsen Nilsen



I
CIRCULAR ECONOMY

June 2017

The idea of a circular economy is attracting increasing attention from researchers, funding agencies, policy makers and industry. Broadly speaking, the circular economy promotes a future in which linear 'make-use-dispose' cultures are replaced by more circular models. In EU visions of a circular economy, ideas about waste management, recycling, reuse, resource efficiency, sharing economies, maintenance and repair cultures are all woven together in multiple ways. However, according to the basic laws of thermodynamics full circularity is not possible: the economy cannot be circular! What, then, does 'circularity' mean and what is so special about the Circular Economy?

This first chapter brings together articles from the inaugural issue of The Nexus Times (TNT) that aimed to address these questions and shed light on some of the challenges circular economy initiatives are facing.

What does the concept of the Circular Economy mean?

Tessa Dunlop

The Circular Economy first appeared in waste management policy, referring to the increased recycling of products. The reduction of waste is beneficial to the environment in terms of pollution, emissions reduction and of decreased resource use. An uptick in recycling necessitates the development of new business models, the emergence of different industries that can process waste and recycle products, as well as new markets for these products – this is where the economy part comes in. The Circular Economy has become a vision for resource efficiency, environmental concerns and economic growth.

The Circular Economy vision has grown beyond the issue of waste management. Given the potential benefits of a circular model for the economy and the environment, what could be achieved by expanding the Circular Economy to include agriculture, energy and other related industries?

There are also important caveats to take into consideration when looking at the policies and framing of circular economy goals. Firstly, it is important to consider how circular the economy actually is, and how circularity can be measured. Some believe that the percentage of materials that are either reused or recycled is as low as 6% at the global level (Haas et al. 2015). This is because a great proportion of the products we use cannot be recycled, including energy resources and construction materials. For food and biomass to be effectively recycled by humans, our economy would need to depend on slow-moving ecological systems to produce materials we need – including wood, food and the regulation and replenishment of water, soil and gas resources. Furthermore, what are the risks and uncertainties linked to an increase in recycling? Research has shown that the treatment process to recycle many materials often involves the application of substances that are dangerous to human health and the environment.

Taking these issues into account, are circular economy objectives feasible, viable and desirable?

Can the Circular Economy boost job creation?

Zora Kovacic

The meaning of the term 'Circular Economy' can be interpreted in two different ways: (1) as an alternative economic strategy that includes the integration of agriculture, energy, and water policy and (2) as a specific policy goal that aims to improve the EU approach to waste management.

1. The first definition of 'Circular Economy' looks at the potential to change the way that resources are used within the economy. It involves shifting away from the current linear model in which resources enter and exit the economic process, towards a circular model in which resources are reused repeatedly in the economic process.

As a broader concept, the Circular Economy requires a re-organization of the economic process as a whole. Such an important change could have a significant impact on job creation. However, if the entire economic process is to be reorganized and restructured, how can we measure the potential impact that a Circular Economy would have on job creation? We need a more concrete idea of what a 'significant' potential impact could be – significant, because changes would incorporate the whole economy, and potential because we cannot be sure about how the economy will change, adapt, and what challenges may emerge.

2. The second definition of 'Circular Economy' applies specifically to the EU's Circular Economy directive, which amends Directive 2008/98/EC on waste.

One of the main goals of the Circular Economy directive is employment growth. The directive reads: "Taking waste policy further can bring significant benefits: sustainable growth and job creation, reduced greenhouse gas emissions, direct savings linked with better waste management practices, and a better environment".

Job creation has been on top of the agenda in the wake of the 2008 financial crisis. Can the Circular Economy live up to its promises? Jobs in the waste management sector comprised 1% of employment in the EU28 in 2015 (Eurostat, 2017). According to the Eurostat Database, this 1% includes waste collection, treatment and disposal activities as well as in remediation and other waste management services.

The Circular Economy directive goal to boost jobs creation states that "More than 170,000 direct jobs could be created by 2035, most of them impossible to delocalize outside the EU". 170,000 jobs equates to a 15% increase in employment in the waste management sector in the next 20 years, which corresponds to a mere 0.1% increase in total employment.

Given these low numbers, it is clear that in order to ensure that the Circular Economy really does boost job creation, the strategy must go beyond the waste management sector.

Acknowledging risk migration in recycling

Maddalena Ripa

The main idea behind the Circular Economy is that materials are reused for long periods of time; much more than is already the case. In the current system, recycling undergoes a process of downcycling. This means that materials and products are designed to have one single life, so that when they are recycled, they lose valuable properties such as quality and functionality every time they are reused. The problem is that chemicals need to be added to recycled products to improve their quality each time they are reused. This process is polluting, and recycled materials often contain more additives than the original product. It is no surprise then that recycling reduces the quality of the materials, as it is difficult to manufacture the same product again and again.

With plans to recycle more as part of new Circular Economy initiatives, closing the loop on a global scale presents new uncertainties. An increase in recycled products including plastic, paper and cardboard, lubricants and other products can cause unpredictable health and safety problems. This is important when considering that the recycling of products contains toxic chemicals. If waste re-enters the economy as either new products made with recycled materials or as secondary raw materials to be traded, it may create a double exposure to toxic substances.

Take Brominated Flame Retardants (BFRs) as an example. These chemicals are commonly found in furniture and building materials, and are increasingly seen in electronics as metal components become replaced by plastic. BFRs are almost entirely banned in countries across the European Union, as they can lead to health problems such as lower mental, psychomotor and physical development. Nevertheless, they are still persistent on the market. BFRs appear in products imported from countries such as China, where e-waste is on the rise and recycling regulations and policies are less stringent. Plastics recovered from electronics contain PBDEs (Polybrominated diphenyl ethers), one of the most commonly used BFRs. PBDEs generally end up in recycled plastics because these toxic, bio-accumulative and persistent substances cannot be easily separated from plastic waste streams. In addition to direct migration of BFRs from waste materials, there is evidence that higher brominated flame retardants can undergo degradation and de-bromination during waste treatment. In some instances, this may lead to the formation of more toxic and bioavailable compounds. In effect, PBDE would be released into the environment and wildlife, endangering human health, two times during a product lifecycle.

Similar risk migration concerns have been raised for paper recycling. Several studies have demonstrated that paper, cardboard and waste paper potentially contain a significant number of chemicals, some of which have been classified as 'critical'. This is because they are likely to remain in the solid matrix during paper recycling and end up in new products where their concentration may be even higher when compared to virgin fibre-based products (for example in case of phthalates and phenols). One of the most controversial examples refers to the detection of small quantities of BPS (bisphenol-S) in paper products. These are often made with recycled content such as napkins, flyers, and magazines. Bisphenol A and S are chemical compounds used as strengtheners in polycarbonate plastics, epoxy resins in water pipes, coating on the inside of food and beverage cans and in making thermal paper (used in sales receipts, for example). These compounds are toxic to human health, due to their hormone disrupting properties, and potentially to the environment. The amount of BPA released during recycling can vary widely, depending on the processes used, but recent studies suggest that BPS, like BPA, is transferred from thermal paper that has been recycled and accumulates in the recycled products.

The uncertainties created by the Circular Economy have to be acknowledged both by policy and by science. With regard to policy, the European Commission is issuing new regulations regarding the use and recycling of these toxic compounds. This approach can be seen as a precautionary approach to policy making.

But what is the response and responsibility of the scientific community? One possible answer to this challenge is uncertainty assessment, which Jeroen van der Sluijs is developing together with the Health and Environment Surveillance Committee of the Netherlands Health Council. The purpose of this work is to conduct a quality check in terms of uncertainty on potential side-effects of policy measures in order to alert the authorities to important links between recycling, the environment and human health. The role of science in this case is not only that of producing facts, but also that of communicating uncertainty.

What type of complexities are involved in circularity?

Luis Zamarioli

Circularity means different things in physics, biology and economics. But what do different narratives imply for European policy? 'Closing the loop' is the European Commission's slogan for promoting the Circular Economy agenda. The choice encapsulates the idea that in order to improve certain economic and environmental standards, Europe must transition from an open-ended and linear economy to a closed one. From physics and biology, we learn that closed systems are never perfectly isolated, or really closed. This is because they lose energy to surrounding systems in thermodynamic processes and also mutually communicate and influence each other in biological autopoietic systems. The economy also can never be entirely closed. Matter will always change and lose functionality internally, energy will be lost at varying degrees and a 'Circular Economy' will always communicate, shape and be shaped by other economies through trade. Based on these considerations, this article looks at why a circular economy could not realistically aim to be considered as a static state, but rather as an aspirational process to be monitored, managed and improved.

Our current economy is still largely based on a linear get-change-consume-discard approach. If this linearity continues unchanged, we risk exhausting Earth's limited resources with too much 'getting', and we compromise the availability of other resources through our current rate of discarding. A circular economy attempts to close that system, bringing the two loose ends together – of 'get' and 'discard'. But does the Circular Economy mean that just any circularity would suffice? The answer is no. Simply transforming the economy into a circular one would not immediately improve efficiency and reduce resource use and waste. For example, if the energy necessary for transforming a material that has been disposed of is higher than obtaining a raw material, we must question whether this is a desirable solution. Also, does that process produce more pollution, such as in the form of liquid residues or CO2 into the atmosphere, contributing to climate change? This questioning brings us to the conclusion that even within circularity, some less energy intensive and less polluting processes are preferred over others.

A useful concept borrowed from waste management to address this issue is the 'waste hierarchy'. The hierarchy states that processes that require less energy and less new material in order to maintain the cycle should be prioritized over others which involve high energy and material loss. That is to say that if we reduce the amount of waste we produce, through better design and packaging, the system will be more efficient than if we choose to reuse discarded materials. When comparing reuse with recycling however, reusing a material requires less energy than putting it through a recycling process that makes it a relatively new product again. Another step further down the hierarchy, recycling is more efficient than recovering materials by transforming them into something else, such as energy production through incineration. At the bottom end of the hierarchy, disposal is the least efficient, since it removes the possibility of closing the system.

Looking more broadly outside internal circularity processes, a circular economy also behaves as a biological autopoietic system due to constant communication and exchanges, continuously shaping and being shaped by other systems. In economic terms, this means that even if it were functioning according to the highest internal standards and efficiency, a singular economy will never be entirely isolated from other systems. The exchanges it makes with others will impact the system itself and will also affect other systems, mutually and continuously. Economically, this could mean that by reducing Europe's raw materials usage, the costs of such inputs would potentially drop globally, creating an incentive for other markets to raise their consumption and resource-intensity. As a significant importer, such increases would mean that imported products would come with higher aggregated resource-intensity, raising the relative levels of materials and energy that Europeans absorb on the consumption side. This could happen even if Europe's own production moves away from such unsustainable business types.

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II
EFFICIENCY PARADOX

September 2017

Efficiency has become a popular measure in many of the policy areas of the European Union, including energy policy, the circular economy and climate policy. However, the term efficiency is surrounded by considerable confusion, which in some cases this might lead to severe paradoxes as improvements in efficiency may lead to increased consumption.

This edition of The Nexus Times provided critical analyses of the term efficiency and its related paradoxes. The pieces discuss the efficiency paradox from

different points of view, highlighting some of the challenges that efficiency targets may pose for the governance of the water-energy-food nexus. In addition, the essays assembled here give an introduction to the historical origins and development of the concept and how this

The paradox of efficiency: Can uncertainty be governed?

Zora Kovacic, Louisa Jane Di Felice and Tessa Dunlop

In a world of limited resources and increasing human impact on the environment, using resources more efficiently seems sensible. Many policies see efficiency as an important instrument to achieve their goals. In the case of energy policy, the EU has published in 2012 a directive on energy efficiency and in June EU energy ministers agreed to support a 30% energy efficiency target for 2030 as part of proposed legislation to improve the EU's electricity market. In water management, efficiency is seen as a means to deal with water scarcity in arid regions. In waste management, resource efficiency is pursued as a means to reduce waste production. But does efficiency guarantee that less resources will be used? Does it guarantee that resources will be used better? The Jevons paradox suggests that the answer is not so straightforward and that efficiency policies may not achieve the desired results.

In 1865, William Stanley Jevons observed that increased efficiency in coal engines led to an increase in consumption of coal in a wide range of industries. The improvements in coal engines made it possible to use engines not only in coal mines, but also on rail and sea transport. Jevons concluded that, contrary to common intuition, increases in efficiency do not necessarily reduce resource consumption because they also open up for new applications and uses and ultimately new demands. This is called “the Jevons paradox”. This paradox is one of the many ways that complexity displays itself. In a complex system, if a part is changed or taken out and substituted with a different part, interactions within the system may change and lead to surprising and paradoxical changes throughout the entire system. The Jevons paradox suggests that efficiency policies may not lead to the desired outcomes, because the economic system will adapt to increased efficiency and technological improvements.

A similar concept has emerged also in economics, called the rebound effect. The rebound effect is the reduction in expected gains from increases in efficiency, because of systemic responses to the increase in efficiency. While the rebound effect recognises that systemic responses may offset the benefits of technological improvements, it does not presuppose changes in the essential workings of the system. The rebound effect can be calculated through mathematical formulas, which assume that the interactions between the parts of the system remain stable. There are sometimes varying definitions, but scholars generally differentiate between 1) direct, 2) indirect 3) economy-wide and 4) transformational rebound effects, with the latter most comparable to the Jevons paradox. From the point of view of complexity, however, the rebound effect is different from the Jevons paradox in as far as changes in complex systems cannot be precisely calculated.

What this means is that the rebound effect essentially leads us to do more of the same thing, while Jevons paradox leads us to do something different. To make this distinction clearer, we can draw a parallel with diets. If I am trying to cut my calories to lose weight and decide to buy fat free yogurts, I may end up eating two fat free yogurts instead of a regular one – leading overall to a higher caloric consumption. This would be the rebound effect. On the other hand, I could also eat a fat free yogurt and then, feeling that I have saved on calories, I could take the bus instead of walking, or go out and eat a slice of pizza. This would be the Jevons paradox. This doesn't necessarily mean that one should stop buying fat free yogurts, or stop improving our efficiency, but it does have implications for governance.

The existence of direct rebound effects is uncontroversial, with quantitative evidence in a large number of studies. The possible effects of the Jevons paradox and how to measure it, however, are in dispute. But rather than focusing on technicalities, the Jevons paradox reveals an important philosophical dilemma regarding complex systems. Because it focuses on unforeseen changes in the interactions between the parts and the identity of the whole, the paradox cannot be modelled nor predicted with precision. Therefore, the Jevons paradox and the rebound effect have different implications for policy, and cannot be treated as equivalent. The rebound effect suggests that gains in efficiency can be estimated and that efficiency policies are a means to govern complex systems (although these are not as effective as one may hope). The Jevons paradox instead suggests that complex systems cannot be controlled, and that increases in efficiency may not produce the expected results. Given this uncertainty, which theory should policy rely on for advice? If one takes the Jevons paradox seriously, governance is as much a matter of relying on evidence as it is about taking into account uncertainty.

Paradox or Paradigm?
A deeper discussion about societal goals

Jan Sindt

The Jevons Paradox and rebound effect can be seen as one of the same thing as both observe higher consumption levels due to increased efficiency. But the real public policy question we should be asking is: do we want to live in a consumption-driven society?

Some 150 years ago, when the industrial revolution took up steam in England, the British economist William Jevons described how efficiency gains could paradoxically increase resource consumption. Today, energy conservation policies in Europe are observing efficiency gains again in order to try to mitigate the greenhouse effects caused by the revolution's spread

across the globe. This time seemingly to solve the problem of which efficiency gains created or at least contributed to an increase in
energy consumption in the first place. But could we reasonably expect different results from increased efficiency compared to 150 years ago, given that the generalised economic goals are similar in both circumstances?

The short answer is that Jevons Paradox has a number of particular preconditions, which include economic objectives of unregulated growth and increased consumption of resources. Some of the preconditions could be created by and trigger at least a rebound effect. A rebound effect is an increase in demand following a price reduction of a certain product or service due to its reduced resource intensity, i.e. efficiency gains. Hence, it depends on the relation between product price and consumer demand. Jevons Paradox is basically a special case of a rebound effect with elastic demand for energy. Jevons observed an increased demand for coal in excess of the actual efficiency improvement of the steam engine, caused by the efficiency gains of the steam engine (c.f. Alcott (2008) for a detailed assessment). The range of economically viable applications expanded, including of coal mining through providing cheaper water pumps, which in turn allowed the exploitation of previously inaccessible coal veins. Thus, the rebound effect was greater than the efficiency gains, which was possible because it affected the production of the very resource that was being used more efficiently.

An example of rebound effect of around 20% has also been more recently observed with respect to efficiency gains in vehicle fuel consumption. If vehicles are more efficient and hence cheaper to use, people feel more inclined to use them. A meta-study estimates such particular effect at around 3% of increased transport demand per 10% of increased efficiency (Dimitropoulos, Oueslati and Sintek, 2016).

So what? On the one hand, increased efficiency does not necessarily translate into reduced resource consumption. In terms of transport, fuel efficiency gains in the US before 2001 have been compensated by the size and weight of cars (c.f. York 2006). This ought not be confused with Jevons Paradox, as there is no direct causal link between efficiency gains and bigger cars. Furthermore, improved efficiency has not created demand but removed restraints, and has ultimately not increased fuel consumption but only proven insufficient to reduce fuel consumption on its own.

On the other hand, increased efficiency does not necessarily cause a rebound effect, let alone a Jevons Paradox. As the rebound effect and Jevons special case thereof are entirely driven by cheaper supply due to efficiency gains, all it takes to curb the effect is to increase the price through market interventions like taxes on energy in order to at least compensate the efficiency gains. Economists may argue that such an intervention would strangle economic growth, but that is exactly the point to take away from an economist predating the industrial revolution: efficiency gains can technically reduce resource consumption with equal output, however widespread normative convictions demand instead that output must be increased. The freed resources provide an opportunity for economic expansion, instead of closing the mine. Cheap resources have fuelled economic growth from the very beginning, literally. Growth is a paradigm of capitalist societies, rather than a paradox of efficiency. The question is not so much if we can avoid such growth but if we actually still want that growth after 150 years, also keeping in mind who benefits and who pays for it. With an answer to that normative question, Jevons could finally rest in peace.

Is renewable energy efficient?

Louisa Jane Di Felice

Renewable energy and efficiency are both essential to meet the EU's sustainability goals, but synergies and trade-offs between the two measures are under-studied.

The EU 2050 Energy Strategy, released in 2011, identified four pillars needed to reach a sustainable energy system: energy efficiency, renewable energy, nuclear energy and carbon capture and storage. Across other EU strategies and communications, energy efficiency and renewable energy are predominant: on one hand, similar targets are set for both – see, for example, the 2020 Energy Strategy, calling for a 20% increase in both renewable energy and efficiency; on the other, they are both seen as measures needed to reach similar goals: namely, the reduction of greenhouse gases, with a 2020 target of 20%, and 30% by 2030. However, the reduction of greenhouse gases isn't the only motive behind renewables and efficiency, with renewable energy also increasing local production and security, and efficiency lowering energy bills.

With both measures dominating EU energy strategies, as well as national and regional energy plans, a question arises: do they contradict each other? While many studies focus on the importance of either one of the two, it is becoming apparent that, if the EU is to meet its ambitious targets, cross-checks among policies (both in the same realm, such as energy, and across different areas) are essential. The question, however, isn't simple. An initial search on the synergies and trade-offs between renewables and efficiency yields diametrically different opinions. Renewable energy supporters claim that renewable energy systems are vastly more efficient (Burn-Murdoch, 2012) than their fossil-fuelled counterpart. They are not wrong: losses in the transformation from renewable energy sources to electricity are almost negligible, while thermal combustion plants have an inevitable heat loss, dictated by Carnot's principle, limiting their conversion efficiency to a theoretical maximum, dependent on the maximum temperature at which the conversion process can operate. This is called thermal power generation efficiency. Coal plants, for example, have an average thermal efficiency ranging between 32% and 42% (Bright Hub Engineering, 2010). Those who are more sceptical of renewable energy systems, however, argue that they are clearly less efficient (Poulter, 2014) than conventional power plants. Again, they are not wrong: wind turbines and solar panels operate at their full potential no more than 40% of the time, at best. Moreover, for the same electricity output, renewable energy generally requires more land, labour and investment.

So, who is right? To help untangle this mess, the first step is being able to compare renewable and non-renewable plants, and this in itself is not an easy task. Energy systems are composed of various phases, from extraction and transport of primary energy sources, to their conversion into fuels or electricity, to the transport of the former and the transmission and distribution of the latter leading, finally, to consumption. Each of these steps can be characterized by its own efficiency, and they are not easily comparable: an efficient coal plant is not the same as an efficient toaster. By harnessing primary energy sources when they are readily available, renewable energy systems avoid the steps of extraction and transportation of primary energy sources. Moreover, by relying on the conversion of renewable elements such as the sun and the wind, no resource is wasted in the process. However, by comparing energy systems based on their structure, and not on their differences in output, only part of the picture is visible.

One of the main issues with renewable energy is intermittency. This means that while a wind turbine and a natural gas turbine may both produce a certain output of electricity, these two outputs are not the same: one can be controlled and used when needed during peak demand, while the other is produced randomly, regardless of demand curves. So to compare renewable and non-renewable systems, one has to start by assuming that they are producing the same output, and this means factoring storage into the equation. Only by considering the combined system of "renewable energy plant plus storage" can it then be compared to a conventional power plant, as both produce the same kind of electricity (the useful kind).

Quantifying the efficiency of energy storage, however, isn't trivial. Similar to energy conversion, the efficiency of storage can be considered from different angles: one could, for example, check how much energy is lost in the storage cycle. Pumped hydro storage (PHS), where water is pumped to a high basin when electricity demand is low and then released during high demand, loses on average 25% of electricity over one cycle (also known as round-trip energy efficiency). But this isn't really a loss, or we'd be mad to go through the cycle in the first place – the electricity pumped up-hill, and the portion that is lost in the process, is cheap electricity, generated at low demand times, while the one produced at a later stage is expensive, covering a much needed peak. They may both be electricity, but one is more valuable than the other. Lithium-ion batteries, another popular storage technology, have a higher round-trip energy efficiency of up to 90% (EnergyMag). However, round-trip energy efficiency isn't the only way to describe the efficiency of storage technologies. In 2014, researchers at Stanford University introduced the concept of "energy stored on investment" (ESOI), quantifying the storage potential of a technology against the storage capacity over its lifetime. In this case, PHS fares much better than chemical storage, with an ESOI of 210, over twenty times higher than that of lithium-ion batteries.

Quantifying the efficiency of renewable energy systems is no simple task. When it comes to discussing renewable and non-renewable energy systems, it is essential that they are compared against the same output. This means that storage cannot be left out of the equation. However, the question of what efficiency means in terms of storage is still under-explored, and better tools to assess storage technologies are needed, as renewable energy plays a greater role both in energy systems and in energy policies. It's unclear whether renewable energy is more or less efficient, but accepting that there may not be exact answers to these kinds of questions, and that different framings and definitions of efficiency lead to different results, may be a necessary step forward in shaping comprehensive policies in times of uncertainty.

From religious concept to industrial tool

Tessa Dunlop

Far from having a straightforward definition, the term 'efficiency' has taken on many different meanings throughout history, showing that its meaning is highly contextual. In its most general sense, the term 'efficiency' has become a central ideal in the world's advanced industrial cultures. Efficiency often signifies something good, as in a job well and economically done, and is associated with ideals of individual discipline, superior management, and increased profits.

But if you pull apart the meaning of efficiency, and observe how the term has evolved over time, its underlying definition is far from simple. In her book, The Mantra of Efficiency, Jennifer Karns Alexander traces the complex history of the meaning of efficiency, from its beginnings as a religious philosophical concept to describe divine agents and causes of change, its use in the 19th Century as an industrial tool to measure the performance of machines, right through to its varied and sometimes contradictory usage today. Throughout the 19th and 20th centuries efficiency has been applied to various fields including biology, economic thought, personal development, worker management, and social history.

Interestingly, Alexander teases apart two dominant, yet distinct, interpretations of efficiency over this time. One is an efficiency of balance, a static efficiency, that accounts for the conservation of measured elements. The other is a creative and dynamic efficiency, which brings about growth through careful management.

Static efficiency was a priority during the Progressive era in the United States when factory owners prioritized stability, reliability and control of their production lines amid social turbulence. To help them maintain stability, production managers enlisted the help of efficiency consultant and mechanical engineer Henry Gantt. When analyzing worker practices, Gantt noted a problem with the incentives that workers were given. Workers that were paid a piece rate depending on the amount or 'pieces' they produced were at first motivated to greater productivity, but eventually lost motivation once they saw that managers eventually cut the rate per piece the more they produced. This meant that the workers had to work even harder just to break even. To solve this problem, Gantt proposed a differential piece rate, in which workers who met a daily quota received a higher rate for each piece. He wanted not just to stimulate production, but more importantly, to make it predictable.

Dynamic efficiency is allied to visions of change and progress, including the evolution of mechanical engineering during the 19th century. This encompassed the development of laws of thermodynamics such as the conservation of energy. Dynamic efficiency was famously used by Charles Darwin to describe the dynamic effectiveness natural selection and change through evolution. While the two ideas of static and dynamic efficiency often interwoven together, sometimes they created conflict, notably in the different ways to measure efficiency. In the 19th century, engineers and physicists argued about different measures of dynamic efficiency in waterwheels and thermal combustion engines. Although the efficiency of a waterwheel may seem like a simple idea (which waterwheel design is most effective in producing the most energy), engineers and scientists struggled to decide how to conceptually relate the source of a water wheel's motion to the work it produced. Some believed that one should measure the water wheel efficiency statically – that is, measuring the energy throughput of the wheel before and after it turned – i.e., in two static states. But an English engineer, John Smeaton, raised a philosophical dilemma for his time: How does one measure matter in motion? I.e., dynamic efficiency. The vast majority of engineers during, and for the century following Smeaton's experiments, chose to conveniently sidestep this issue of motion, due to its inherent complexity of measurement. But Smeaton's measures of dynamic efficiency led to significant disputes not only on how to measure efficiency but over who had the right to define the terms and measurement.

The multiple and sometimes contradictory definitions of efficiency imply that the term is highly contextual. It can be measured in different ways, depending on who is making the calculations. According to Alexander, this means that efficiency is an instrumental value, without inherent meaning of its own. Given the rich history of the term efficiency and its varied applications today, one must carefully scrutinize what efficiency means in each specific context – does it refer to conservation and stability, or dynamism and growth?

The circular economy: A new efficiency paradox?

Tessa Dunlop

Proponents of the circular economy call for actions to be 'eco-effective': but is this another efficiency paradox? The goal to create a Circular Economy has gained traction in recent years with calls from both government and civil society to 'close the loop'. The European Union has pledged over EUR 6 billion as part of its Circular Economy Package and various NGOs around the world have championed the cause. Broadly speaking, the circular economy aims to increase environmental sustainability and spur economic growth through greater resource efficiency in the recycling and reuse of products. The idea is to decrease environmentally intensive primary production in favor of lower-impact secondary production whilst creating less waste, or 'output'. Some are distancing the objective of circular economy away from the concept of efficiency in the traditional sense (the ratio of useful output to total input, for example the amount of coal used to power a steam engine), and replacing it with the idea of eco-effectiveness. According to the Ellen MacArthur Foundation, the idea behind eco-effectiveness is to transform products and their associated material flows such that they "form a supportive relationship with ecological systems and future economic growth" in a cyclical way such that materials can "accumulate intelligence over time (upcycling)" as opposed to simply trying to minimize the linear flow of materials that characterizes our current consume and throw-away culture. But is this perspective really that different to the objectives that underpin efficiency? Whether considering efficiency in relation to energy generation, or eco-effectiveness as applied to product manufacturing and consumption, both terms imply a reduction of resource inputs into the economic system, because natural resources are finite. And what if, like the paradox of efficiency, a circular economy could perversely lead to an increase in product demand, and thus more primary production and resource extraction?

Zink and Geyer (2017) have introduced the term 'circular economy rebound effect' to describe a phenomenon whereby increases in production or consumption efficiency are offset by increased levels of production and consumption. They have criticized the fact that circular economy proponents focus too much on the engineering aspects of the circular economy and not enough on its complex economic effects. In other words, they question whether a circular economy would reduce or displace primary production, or even if it might increase it.

While there is a solid body of research that measures the environmental impacts of recycling and repair activities, there is little known about the impact that these practices have on primary material and product production. This is in large part due to the complexity and difficulties in measuring the economic interactions between the primary and secondary goods markets, which are expected to become more competitive in a circular economy. Zink and Geyer (2017) argue that there is evidence pointing to the existence of circular economy rebound effects that could erase any gains in product recycling or reuse by increasing market demand for products. Take, for example, the income effect when lower-price recycled goods enter the market. Wholesalers often sell lower-grade quality recycled or reused products such as recycled paper or plastic at a discount to higher quality first-use goods. When purchasers perceive themselves as wealthier because they are able to buy more for less, they can purchase more material and use it to make more products than before. The excess wealth may be spent elsewhere, with unpredictable results.

One can also conceive of unexpected consequences of circular economy actions on a larger scale, explain Zink and Geyer (2017). An increase in recycling could, for instance, prompt consumers to purchase more disposable products under the belief that they are reducing their environmental impact. Wealthy consumers may sell their second-hand phones to subsidize their purchase of more expensive first-hand phones, thereby increasing demand and primary production. This effect may be fueled by an increase of secondary phone buyers, for example in poorer countries, who did not previously have an option to buy a phone. And how might a shift towards reuse and repair occupations effect the macroeconomy, including employment levels, affluence, immigration and consumption patterns?, query Zink and Geyer (2017). What if cheaper recycled products become less cool? (And thus less valued than their harder-to-come-by primary production alternatives?)

This is not to say that the circular economy will necessarily lead to increased primary production. Many initiatives can reduce negative environmental effects if products truly substitute primary production alternatives and they do not create perverse market incentives to consume more new products. The point is that there is currently not enough research to say definitively whether circular economy initiatives will displace and/or reduce primary production. Thus one must critically examine the credentials of circular economy initiatives in their claims to increase 'eco-effectiveness'.

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III
AGRICULTURE AND THE NEXUS

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The articles making up this chapter get down to basics: why is the MAGIC project focusing on the water-energy-food nexus? The obvious yet slightly circular answer would be: because the nexus matters crucially for many EU policies! To add some substance to this assertion, the pieces in this TNT edition explored the relations between agriculture, food security and biodiversity. On the one hand, agriculture depends on biodiversity, for services such as pollination, soil generation, and so on. On the other hand, agricultural expansion competes with biodiversity and land set aside for conservation.

What are the (potential) contributions of the Common Agricultural Policy (CAP) to nexus policy-making? How are farmers as a workforce represented in discussions about "planetary boundaries" and what might be constraints regarding how we organize ourselves as a society? What does nexus governance mean when it comes to the contentious relation between food security and biodiversity?

The WEFE Nexus and the Common Agricultural Policy

Keith Matthews

The MAGIC Nexus project team has identified policy narratives that illustrate complexities and tradeoffs regarding the European Union's Common Agricultural Policy (CAP) in the context of the water, energy, food and environment (WEFE) nexus.

The importance of the Nexus for the Common Agricultural Policy

The Common Agricultural Policy is increasingly having to reconcile sectoral interests with those of the wider population in the context of the water, energy, food and environment (WEFE) nexus. The explicit inclusion of energy within this policy-making context allows for a better-informed analysis of progress towards EU sustainability goals. But this doesn't mean that achieving these goals is easier. Nexus analysis highlights the dependence on substituting non-renewable stocks in the lithosphere and the degradation of quantity or quality of renewable resources in the biosphere. Indeed, nexus studies tend to raise fundamental questions about the nature of society that can be supported long term within knowable biophysical limits. Such studies also ask policy makers to look again at whether innovation-led, GDP growth is really the panacea for public policy (a narrative since the mid-18th century). Given the EU's commitments to the UN Sustainable Development Goals, nexus studies that look across geographical scales can also highlight the nature of externalities and dependencies, assessing the consequences for the EU and other trading parties.

Importance of Common Agricultural Policy for the Nexus

In financial terms the CAP still dominates EU policy and provokes fierce debates between stakeholders both as part of the agreement of the multi-annual financial framework and coming to an agreement on how funds are used. Co-decision-making with the European Parliament and trilogue processes with Commission, Parliament and Council of Ministers have only added to the intensity of scrutiny and arguably to the complexity of the CAP. The inclusion since 2003 of rural development within CAP (Pillar 2) means that the CAP is a key source of funding to underpin delivery of EU directives and strategies on water, biodiversity, climate change and wider rural economic development. The CAP thus has the potential to be a force for change, but the shares of resources devoted to such activities, while increasing, remain small. The finances provided by the CAP combined with the tariffs imposed on non-EU states by the Single Market combine to stabilise the EU agri-food systems.

Institutional and narrative evolution of the Common Agricultural Policy

The CAP as an institution with a long history (conceptually from 1957 in the treaty of Rome) has generated many narratives - some seeking to preserve the status quo and others seeking reform or abolition. Indeed, almost from the inception of CAP, reforms have been proposed (e.g. Mansholt in 1962). It is possible to argue, however, that at a fundamental level the CAP continues to transfer money from general taxation into businesses many of which enjoy incomes or capital wealth significantly beyond that enjoyed by citizens. What has evolved are the number and diversity of narratives used to justify the continued operation of the CAP. Justifications include the promotion of innovation, efficiency, green-growth, a bio-economy, food security, food quality, food costs, poverty alleviation, social cohesion, environmental quality, ecosystem services, animal welfare, and climate change mitigation. With so many justifications there is a danger that the effectiveness of the CAP cannot be rationally evaluated.

Disentangling the CAP Narrative Nexus

Within the H2020 MAGIC project the intention is, with Commission staff and other stakeholders, to critically re-examine some of the key underpinning assumptions or definitions in the nexus of CAP narratives. The analysis seeks to assess CAP narratives in terms of their feasibility (within biophysical limits), viability (within the limits of socio-economic institutions) and desirability (their normative or distributive consequences) and to assess the degree of openness required (that is the resources beyond the control of Member States). The latter is particularly significant since if the CAP combined with other EU institutions generate negative rather than positive externalities then it undermines the EU's commitments the UN SDGs potentially perpetuating poverty, environmental degradation, political instability, extremism, conflict and mass migration.

Planetary boundaries and the global food system: what about the farmers?

Louisa Jane Di Felice, Mario Giampietro and Tarik Serrano-Tovar

Planetary boundaries have become a popular concept in sustainability, as a way to show the amount of stress that human activities and lifestyles are putting on the earth's ecosystem. In 2009, a study conducted by a team of researchers at the Stockholm Resilience Center identified nine planetary boundaries of the earth system, ranging from ocean acidification and climate change to fresh-water use and land system change. The goal of the study was to define a "safe operating space for humanity". Scientists worldwide agree that the EU's current way of living does not fall within such a "safe operating space": recently, over 15,000 researchers signed an article warning humanity against "the current trajectory of potentially catastrophic climate change due to rising GHGs from burning fossil fuels, and agricultural production—particularly from farming ruminants for meat consumption".

Agriculture, as a big emitter of greenhouse gases and user of land, is central to boundary debates. It is also a complex topic for researchers and policymakers alike: looking at food systems from different perspectives shows how their complexity cannot be easily modelled or reduced to a single indicator of sustainability. Food systems are shaped both by production and consumption patterns, and these are in turn shaped by a variety of factors, which are constantly co-evolving, therefore making their evolution incredibly hard to predict. For example, food requirements are determined, among other drivers, by population structure and size, dietary preferences and culture. Untangling the mess of possible relations determining how the EU produces and consumes food is almost impossible, but in terms of sustainability some sort of simplification is needed in order to determine what possible boundaries will affect future food systems.

These simplifications, leading to assessments revolving around natural and ecosystem boundaries linked to agriculture, are valuable and necessary. This holds true not only from an academic perspective: the simplification of ecosystem constraints to planetary boundaries is also very powerful for communication purposes. However, while they might not convey strong images of glaciers melting and species going extinct, it is also important to consider the boundaries that arise when analyzing how society is structured, and how this structure shapes the way food is produced. In this sense, boundaries can be viewed not only as external to societies, depending on environmental constraints, but also as internal to the way we live, particularly in relation to how people use their time. In the EU, for example, if one looks at the total amount of hours available to the population, labour statistics show that 70% of working hours are used in the service sector. A very small percentage is allocated to food production, meaning that productivity must remain high. The internal societal and external environmental boundaries are, of course, related: there is a link between the small amount of work Europeans put into agriculture, and the consequences it has on the environment. Running an agricultural system with very few farmers means that manual labour is substituted with machines running on fossil fuels, and that most food is imported. The EU, in fact, imports almost four times the amount of food as China does, even though it has double the amount of arable land per capita. So the issue isn't that the EU doesn't have enough land to produce its own food, but that it doesn't have enough people willing to do it.

The situation worsens when considering future trends: the EU has an aging population structure, which will lead to a reduced labour force and more people to be supported in the coming years. The diet is also changing towards a higher consumption of meat products. And yet, most people work in services. This is the famous service economy, but looking at the other side of the coin, by also considering imports, quickly shows how the service economy is little more than an import economy – the EU does not run our society on services, but it outsources its basic food and energy requirements to other countries. So not only is the EU importing food, but it is importing food based on cheap and time intensive labour. This means that if the whole world were to produce and consume food the way the EU does, not only would it require more land, water and energy, but also (and crucially) more people willing to work as farmers. This was the norm in the past, but new norms are quick to re-emerge, and the notion of farming is so distant from the majority of the EU population that it has become imbued with an old-timey nostalgia - one that has little grounding in the reality of the business. From labour statistics, the amount of hours of agricultural work embodied in the food imported by EU is of around 80 hours per capita per year. This quantity doubles the hours of agricultural work used in domestic production within the EU, of around 40 hours per capita per year. In simple terms, this means that the food imported by the EU needs a lot more work than what Europeans put into their own agricultural sector.

Discussions of the classic planetary boundaries of land use, water use, and other ecosystem constraints related to agriculture should run alongside conversations about the way society is organized and functions. If not, by viewing agriculture only from an environmental perspective, one runs the risk of forgetting about who is producing the food. In fact, farmers are often left out of the equation when it comes conversations about sustainability and agriculture - policymakers and academics talk about climate smart agriculture, sustainable food systems, green farming and so on, but little mention is given to how these innovative systems will affect the labour force, specifically farmers and rural communities. This is a big issue for Europe: a recent report by the EU showed how less than 6% of farmers are below the age of 35, and a worryingly high 30% are 65 and over. No matter how green, circular or climate-smart agriculture becomes, such advances will be useless if there is no one to take care of the land and little regard for the preservation of rural communities. And moving towards a service economy by outsourcing food production to the rest of the world may work at the EU level, but looking at the problem from a global scale leaves little room for manoeuvre, and reveals societal planetary boundaries that may be just as pressing as the ecosystem ones.

The land sharing vs. land sparing debate: Options to ensure food security while preserving biodiversity

Raimon Ripoll Bosch, Akke Kok and Evelien de Olde

The human population is expected to increase to 9.7 billion people by 2050. The increase in the number of people, combined with their increased wealth, is expected to increase the overall demand for food, and especially for animal feed (Godfray et al., 2010).

To meet the increasing demand for food, agricultural land has been expanded (at the expense of other land uses, such as grasslands and forests) and/or intensified (to increase the productivity of crops and livestock per unit of land). It is expected that the trends of expansion and intensification of agricultural land will continue. Agricultural expansion and intensification, however, create controversy and raise concerns about the impact on the environment, biodiversity and ecosystem services other than food supply (such as pollination, carbon sequestration or maintenance of cultural landscapes, among others).

In recent years, there has been an increasing debate about how to ensure food supply while reducing the impact of agricultural production on biodiversity. Agricultural land already occupies nearly 40% of earth's terrestrial surface. Further expansion of the agricultural land seems undesired, as it increases environmental impacts and conflicts with nature preservation. Increasing land use efficiency by means of intensification has boosted agricultural production, but has also been associated with detrimental effects to the environment and biodiversity decline.

The concepts of land sharing or land sparing have been posed as solutions to increase food production and maintain biodiversity. Land sharing means that food production (usually at lower intensity and yields) is combined with biodiversity conservation on the same land. An example of land sharing strategy are the European Union's agri-environmental schemes, meant to compensate potential loss of income by farmers that mitigate detrimental effects of intensification on biodiversity (Michael et al., 2016). Land sparing implies a segregation of agricultural land (usually at high intensity production, with high yielding varieties) and protected areas for biodiversity or nature conservation. An example of land sparing strategy are protected areas, which are geographically delimitated and legally protected, to preserve biodiversity and nature, and the associated ecosystem services (Michael et al., 2016).

A key question remains whether land sharing, or land sparing can host higher biodiversity while ensuring food supply. Some studies argue that increasing productivity of both crops and animals would reduce the total land needed for agriculture and spare land for nature conservation purposes (Phalan et al., 2016). In contrast, other studies claim that nature inclusive agriculture can satisfy the increased demand for food while promoting biodiversity. For instance, traditional farming practices in Europe (currently declining) are inherently linked to provision of many public goods and conservation of biodiversity (Tscharntke et al., 2012).

The interdependence of agriculture and biodiversity is complex and not always well understood (Tscharntke et al., 2012). There may not be a simple answer in the dichotomy land sharing vs. land sparing. Indeed, agriculture can be a driver for biodiversity decline through pollution or habitat destruction, but can also contribute to biodiversity enhancement through creation or preservation of habitats, and through the maintenance of local breeds and varieties. Ultimately, agricultural production depends on biodiversity and the continued provision of ecosystems services. Biodiversity, moreover, can enhance the resilience of systems, including agricultural systems. The loss of biodiversity, therefore, has far reaching effects, as can influence the supply of ecosystem services and ultimately affect human well-being. The way forward may be to understand where and when land sharing or land sparing is the better alternative to ensure food security while preserving biodiversity.

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IV
OUTSOURCING

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Industrial and agricultural production are often outsourced to countries with lower production and labour costs, and the impacts of these activities are externalised along with production. Outsourcing may be the direct result of policy decisions, such as when a country exports its toxic waste, or may be a secondary effect of decisions taken at firm level, such as relocation driven by labour costs and tax reliefs. Outsourcing is also referred to as displacement or and externalisation (referring to the concept of externalities in economics), understood as the consequence of an industrial or commercial activity which affects other parties without this being reflected in market prices.

In this edition of The Nexus Times, the role of outsourcing in European industry was explored. The contributions asked for the role of outsourcing for the effectiveness of EU policies to reduce greenhouse gases emissions, promote renewable energies, increase recycling and reduce environmental impact of agriculture.

What if Europe had to process its own waste?

Tessa Dunlop and Zora Kovacic

A great deal of Europe's waste is exported to the Global South, including electronic, chemical and incinerator waste. Despite recent policy action to reduce plastic waste, the EU still plans to export a significant amount of plastic to other countries. But what if Europe did not export any waste at all?

In the case of plastics, the EU generates a whopping 25.8 million tonnes of plastic waste per year, with packaging making up 40%. Most of this packaging waste (70%) is either incinerated or sent to landfill, with less than 30% collected for recycling. But almost half of the plastic packaging material collected for 'recycling' is sent to third-party countries - the exported plastics are included in the official recycling rate. While plastics packaging cannot be seen as a representative study of other types of exported waste, it is a worthwhile sector to analyse given recent policy announcements by the EU. The EC is updating its plastic strategy following the announcement by China in late 2017 that it would ban imports of single-use plastics, including from the EU.

So why is collected waste sent far overseas?

Because it is still cheaper to do so than to process it in Europe. Labour costs are higher in Europe, and the high fragmentation of collection and sorting means that high-quality recycling is difficult to perform cheaply at scale. Not to mention a great deal of collected material is of 'poor' quality, meaning that it has been contaminated by food or other substances. Contaminated waste materials are difficult to recycle and require intensive treatment to produce high quality recyclates. Furthermore, the manufacturing processes (injection, extrusion, blow moulding, thermoforming, etc.) can differ significantly depending on the product-specific requirements that define the resistance, weight and aesthetic aspects of the product.

The performance of sorting and recycling varies greatly from country to country, as do the commitment pledges to improve waste recycling and sorting practices. Recycling targets have generated some controversy in the European Parliament, as many of the Eastern European countries are reluctant to face the high costs of recycling given their limited relative contribution to waste generation. Returning to the case of plastic waste, in 2014 five countries generated approximately 70% of Europe's plastic packaging waste – namely Germany, Italy, the UK, France and Spain. Only Germany in 2014 was close to reaching a 55% recycling target. France, on the other hand, has the lowest performance – even though it is responsible for approximately 13% of the total EU generated waste.

So how is the EU responding to China's ban on plastic waste?

- The Circular Economy Package aims to increase packaging recycling to 70% by 2025. But this ambitious target may be watered down, especially under pressure from the plastics industry. Plastics Recyclers Europe has commissioned a study showing that a 55% recycling target can be achieved by 2025, or by 65% if extra exports are included.
- In 2017 the EC also proposed a new plastics package to ensure that all plastic packaging is reusable or recyclable by 2030.
- Recycling does not mean that waste is processed. Slovenia for example has one of the highest recycling rates in Europe and also one of the highest waste export rates. The EU imposed legislation to reduce landfilling to less than 10% of waste output by 2030 – which has been a successful strategy in Germany to increase the recycling performance – but risks increasing incineration rates if measures aren't imposed on this practice too. Waste processing methods are not mutually exclusive and may generate trade-offs.
- Calls have also been raised to place a tax on single-use plastics, although it is expected to be politically unpopular. Also, this would only tackle one waste stream, ignoring the considerable amount of non-plastic waste generated including construction and energy waste.

While China's import ban is expected to lead to a significant reduction of the extra-EU exports, it is assumed that exports of plastic packaging waste will remain at half their 2014 level (50%) to countries including Malaysia, Indonesia and Vietnam, according to the Plastics Recyclers Europe study. There is little information about what happens to this waste after it is exported, as it is costly to monitor.

MAGIC diagnosis: waste outsourcing is a question without a straight answer

Waste in general (not just plastic packaging) is difficult to monitor, measure, keep track of and dispose of. Measurements are more easily available for specific waste streams (such as plastics, electronic equipment, construction waste, food waste) than for total waste. Policies break waste down by each waste stream, and sometimes classify waste by economic activity. As a result, it is difficult to get an overall picture of how much waste is produced and discarded. How relevant is it to focus on plastics? According to a recent report published by the European Commission (2018a), plastics represent less than 3% of material flows.

Secondly, how should waste be measured? By weight, construction materials contribute to about 35% of total waste in the EU-28 (European

Commission, 2018a), but other factors are also important: e.g. the proper disposal of hazardous substances is needed to avoid health and environmental hazards, and the recovery of rare earth metals may be an important measure against scarcity and price fluctuations. When the quality of materials contained in waste is taken into consideration, measurements may change from relative quantities to chemical properties.

Third, there may be blind spots in waste management. While many initiatives - not least in the Circular Economy Package - deal with recycling, reuse & repair, eco-design, waste prevention and sharing economies, the issue of waste outsourcing is not mentioned. The issue of outsourcing points at the fact that waste management is not just a matter of individual behaviour or recycling methods, but is linked to the way economic activities are organised. The question "What if Europe didn't export any waste?" requires a complexity-based approach that takes into account the ramifications of economic activities, including the interdependencies with foreign trade.

What if energy imports mattered?

Maddalena Ripa and Louisa Jane Di Felice

During the past few hundred years, growing numbers of people have obtained their energy from further and further afar, and supply has become inextricably linked to distant locations and events, expanding the spatial and temporal chain linking energy supply to demand. This is particularly true of oil, but also of all the other energy sources that can be moved across borders: coal, electricity, natural gas, and nuclear fuel (Overland, 2016). In 2012, the EU imported 53% of all the energy it consumed, at a cost of more than €1 billion per day. Looking at energy imports reveals how the decline in energy use per unit of GDP (i.e., Economic Energy Intensity) in EU advanced economies is not necessarily because they have become much more efficient in terms of energy and resources use, but because they increasingly rely on other countries to fulfil their supply of primary energy sources. Energy makes up more than 20% of total EU imports - a fifth of the EU's total import bill (European Commission, 2018b). Implicit in the import of energy products is the indirect import of labour and resources, such as water and primary energy sources, embodied in the production process and transport of these products.

Specifically, the EU imports:

- 88% of its crude oil
- 66% of its natural gas

- 42% of its solid fuels
- less than 4% of its renewables (mostly concentrated on biomass)

If we consider embodied fossil energy imports (also known as 'virtual imports'), as for example the oil embedded in the import of diesel, the gap between fossil energy consumption and production (one traditional measure of energy security) in the EU is even larger than commonly assumed. This has prompted the MAGIC project to investigate the narrative of energy security as a nationally bounded imperative.

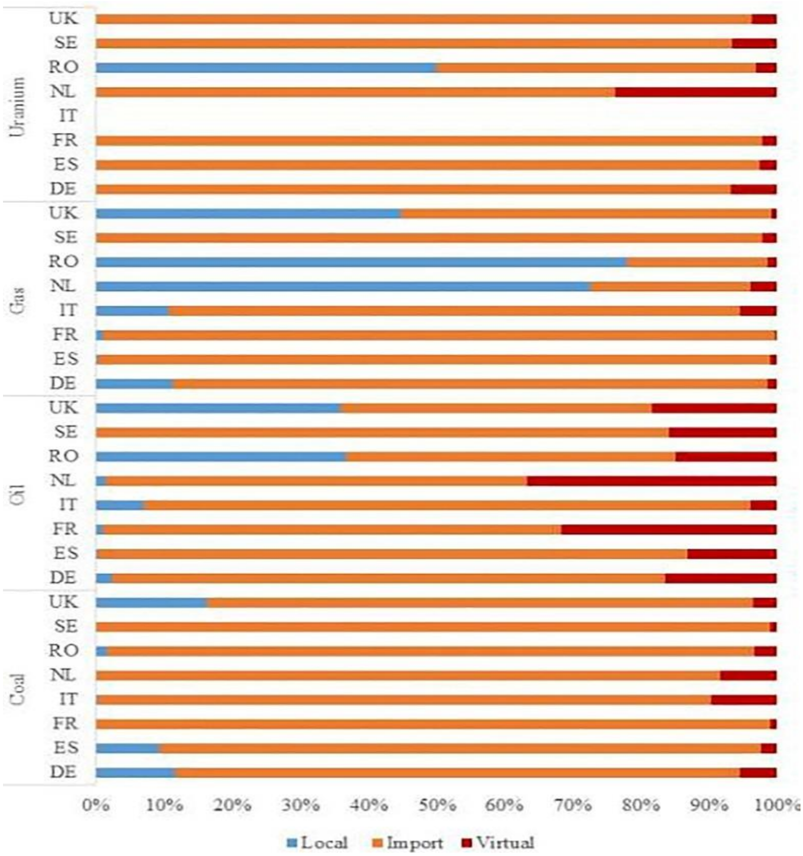

Figure 1: *Percentage of fossil primary energy sources outsourced abroad – direct import in orange and virtual import in dark red (DE – Germany, ES – Spain, FR – France, IT – Italy, NL – Netherlands, RO – Romania, SE – Sweden, UK – United Kingdom). More details available in MAGIC Deliverable 4.2.*

MAGIC research has shown that the percentage of fossil primary energy sources directly and indirectly outsourced is higher than 80% in all most EU countries: Figure 1 shows the percentages of outsourced fossil primary energy sources, including coal, oil, gas produced outside the country, directly and indirectly required (virtual) to produce the total energy metabolized by UK, Sweden, Romania, Netherlands, Italy, France, Spain and Germany.

Misrepresenting the share of inputs sourced from foreign suppliers can introduce a significant bias in the analysis. Indeed, the level of outsourcing of economic sectors heavily affects their performance. A country outsourcing the production of inputs that are particularly "costly" in terms of resources or labour requirement may appear more efficient than a country producing its own input.

In the EU, similar to other global economies, pressure for greater energy self-sufficiency is rooted in the narrative of preventing major supply disruptions (European Energy Security Strategy, 2014). This means that broader discourses on the socio-economic implications of the energy globalized trade are systematically ignored.

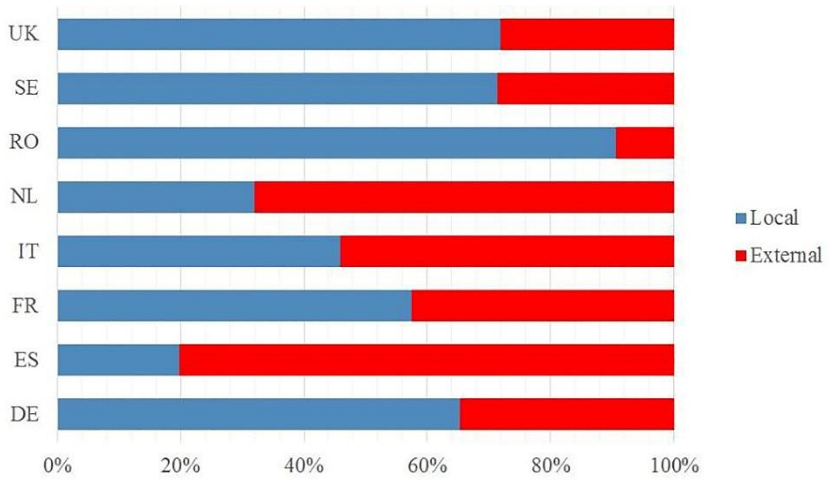

Figure 2: *Percentages of working hours employed to produce the energy metabolized (directly and indirectly) by eight EU countries. The blue part of the bar shows the percentage of working hours employed locally, whilst the red part of the bar expresses the outsourced percentage.*

Figure 2 shows the percentage of labour (one key nexus element in MAGIC analysis) that is directly and indirectly required and outsourced (red bar) to produce the energy needed to sustain the country. This percentage is comparatively high and for some EU countries (e.g., Spain and Netherlands) it is higher that the local labour investment. In addition, the missing nexus link is that the EU workers whose job is moved offshore do not stop using energy, even if they become permanently unemployed or retire as a result of the change. And the beneficiary of the job transfer offshore will use more energy, as the accompanying increase in income translates into a standard of living that affords more consumer goods, and possibly a move to lower density housing.

	RER	RU	RAF	RNA	RLA	RME + RAS
DE	26%	37%	22%	0%	2%	12%
ES	0%	14%	35%	0%	26%	25%
FR	11%	14%	37%	0%	3%	35%
IT	1%	14%	36%	0%	0%	49%
NL	21%	30%	20%	0%	2%	27%
RO	0%	30%	0%	0%	0%	70%
SE	46%	42%	6%	0%	5%	0%
UK	53%	12%	30%	1%	2%	2%

Table 1: *Origin of oil imports (in %) for selected EU countries (Regions of origin: RER -Europe , RU – Russia, RAF – Africa, RNA – North America, RLA – Latin America, RMS – Middle East, RAS – Asia and the Pacific)*

Labour is an essential but often neglected nexus element that is of paramount importance to study the broader socio-economic implications of EU economies and provide trans-disciplinary insights. For example, Table 1 shows the origins of EU oil imports. The largest share of oil is derived from developing countries, where low income and illegal, low security jobs pose ethical issues that are not adequately tackled by the current EU legislation.

Globalization has demonstrated an unexpected ability 'to manage the non-resolution of its problems, accommodate its dysfunctions, even drawing renewed strength from this state of affairs' (Barca, 2017). These side-effects are serious and, if left unchecked, will impose limits on the ultimate extent of globalization's spread. Addressing this will require novel approaches and may result in some counter-intuitive solutions. Through the MAGIC project, our aim is to provide better quantitative framings of the issue at hand, in order to aid decision makers who are confronted with the complex challenges associated with an increasingly globalized world.

What if healthy diets had a hidden cost?

Violeta Cabello and Tarik Serrano

Europe consumes around 200 million tonnes of fruits and vegetables (F&V) annually, which is about 12% of the total biomass consumed in our continent. This volume has steadily increased over the last decades, a consumption pattern that is a sign of the healthier and richer dietary habits and lifestyles of Europeans. However, these habits need to be met with increased production, which is not feasible everywhere. Contrary to other crops such as cereals or tubers, most F&V require high irrigation levels and warm weather conditions for growing. This is the reason why most of F&V production in Europe is located in Southern European countries which also tend to have conditions of lower water availability. Therefore, the increase of F&V production is usually associated with impacts in water resources availability and aquatic environments, challenging the water management in these regions.

The fact that northern European F&V consumption is to a large extent sustained by southern countries' production is nothing new. We have recently witnessed the empty sections of vegetables in UK supermarkets due to weather vagaries limiting the supply capacity of Spain. However, how much water are they saving thanks to the externalized production? Let's look at the two major importers, UK and Germany. Whereas Germany imports only 36% of the F&V it consumes, it saves an amount of water equal to 23% of the total water used for irrigation in agriculture in the country. The UK is even more impressive: 60% of F&V consumed within the country are imported, accounting for 34% of the total water used in agriculture in the country (meaning that 12 times more water is imported virtually than used for F&V production within the country!). If these countries were to produce what they consume, they would have to either significantly increase their water availability, or take it from other uses. Both alternatives have trade-offs.

How does the picture look like in their mirror countries, the net exporters? Well, 36% of F&V production in Italy is exported and in Spain it reaches up to 52%. This trade is translated into 4,125 million cubic meters of water exported virtually from those countries, a share of 14% of the total water used for irrigation. Whereas the share might not look dramatic at the national scale, there is a sharp contrast when looking at regional differences with most production concentrated in water scarce areas. For instance, the arid province of Almeria in Spain exports virtually around 85% of the water it uses, causing a heavy impact on the already strained local aquifers.

The conundrum is that neither Northern countries can produce what they consume because of climatic constraints, nor can Southern countries maintain their production patterns if they want to manage their water resources sustainably. It is not surprising then that European policymakers face a huge challenge in harmonizing water and agricultural policies to solve this nexus problem.

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V
THE GOVERNANCE CHALLENGE

June 2018

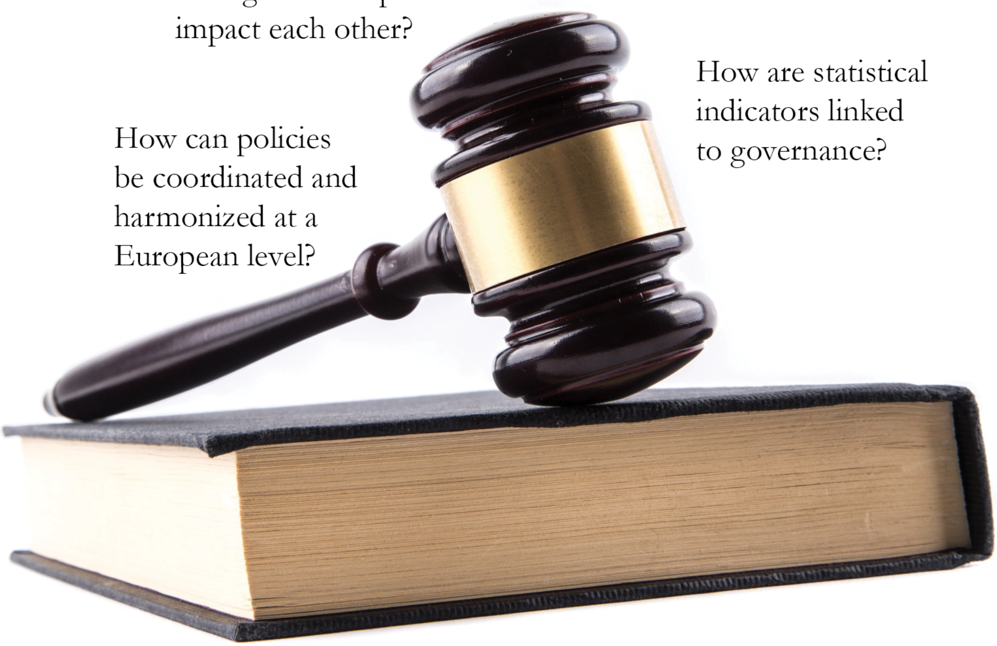
The nexus between water, energy and food is usually defined as a matter of biophysical interconnections, trade-offs and linkages. But perhaps one of the most important ways it should be thought of is as a governance issue. The institutions, coordination and rules involved in tackling contemporary sustainability challenges across the nexus are crucial to its effective governance. The essays in this chapter share insights gained from our engagements with policy actors and explore some of the questions that arise from the understanding of the nexus as a policy challenge:

Which types of evidence can be used to govern the nexus?

How do water, energy and agricultural policies impact each other?

How are statistical indicators linked to governance?

How can policies be coordinated and harmonized at a European level?



WHERE do we govern the Nexus?

Kirsty Blackstock, Kerry Waylen, Alba Juarez-Bourke and Keith Matthews

In Europe and beyond there is a growing interest in how we might manage and govern the water-energy-food nexus. The nexus is complex, contested, and difficult to resolve with existing solutions. Therefore, understanding and intervening in the nexus not only requires new diagnostic methods and combinations of technical innovations, but also needs decisions to take account of its many interconnections. This is a challenge, as most policies deal separately with different aspects of the nexus.

To address this challenge, within the Horizon 2020 MAGIC-Nexus Project, we are assessing how policy-making at the level of the European Union may create opportunities to allow people to 'govern the nexus'. Policies made by the European Union are a central influence on how we first perceive and then govern the nexus. In MAGIC we focus on five policies which have a direct link to the nexus: the Circular Economy, the Common Agricultural Policy, Energy Efficiency Directive, Natura 2000 – the Habitats and Birds Directives, and Water Framework Directive. These provide the greatest opportunity to ensure that 'nexus-thinking' shapes how land and waters are managed across Europe in the context of climate change and delivering sustainability.

Based on initial analysis of policy documents and interviews with those in the European Commission, it is clear that there is interest in the nexus approach. Yet, the nexus is a concept that no single entity has a direct mandate to deliver. Therefore, coordination will be needed. There are several structures set up to encourage cross-fertilisation of ideas between Directorate General (DGs), to ensure that policies are coherent (in other words, there are no direct conflicts or unintended consequences that prevent policy objectives being met). These include the 'Inter-Service Steering Groups' (ISSGs), which ensure internal consultation across the Directorate-Generals within the Commission and these ISSG consultations inform the impact assessment of any policy proposal. Furthermore, the role of Vice Presidents has also been created to encourage working across DGs at the highest level. There are also other potential venues for promoting a nexus approach, such as the Commission's in-house think tank – the European Policy Strategy Centre, whose mission is to "innovate and disrupt".

The policy formation and revision process involves organisations outside of the Commission. Could these organisations help introduce the nexus concept into policy? Unfortunately, again, the nexus is relevant to many, yet central to none of them. Policies proposed by the European Commission are scrutinised by the European Parliament and Council of the European Union as co-legislators; and the Committee of the Regions, and European Economic and Social Committee as consultees. Within each of these structures, there are multiple committees, councils or sections, which tend to mirror the division of policy between agricultural, environment and development, so issues related to the nexus might be split across several committees. Likewise, these bodies are informed by Civil Dialogue Groups (CDGs) and at least three of these (CAP, Rural Development, Environment and Climate Change) are relevant to the nexus but there is no specific CDG with a focus on the nexus. Finally, the European Environment Agency (EEA) has an important role in informing policy making across the nexus through its European Environment - State and Outlook reporting. However, the EEA does not initiate policy and can only advise and support.

Overall, our initial analysis reveals that the space for governing the nexus is 'everywhere and nowhere'. The formal procedures for development, evaluation and revision of policies at the EU level do ensure some coordination and a cross-fertilisation of views. However, at present no existing formal procedures drive a nexus-first approach to policy making. There is resilience in having multiple spaces from which interconnections can be considered, but there is also the danger of fragmentation and marginalisation especially if there is no influential body or formal process to which the nexus is central.

As previous editions have noted (see Agriculture and the Nexus , Section III) the policy process offers opportunities for both change and maintaining the status quo. Further research with those working within the European Commission will be required to understand under what circumstances we can shift to taking a nexus perspective. Would it be useful to create a new process that starts from a nexus perspective, with direct link to existing policy processes that shape our environment? Or would this become confusing given the already complex and crowded landscape of policy processes? As the project moves forward, and we start to discuss the results of the Quantitative Story-Telling approach with those responsible for the five main policies of interest, we will also explore strategies for using existing spaces, or developing new spaces, to help 'govern the nexus'.

The idea of governing the nexus is still quite new, so it is exciting to be at the forefront of trying to overcoming these challenges.

Governing by numbers?

Thomas Völker and Zora Kovacic

The use of quantification in governance processes is widespread and rarely questioned. Several authors have attributed the attractiveness of numbers to their ability to travel. In this way, quantification can be seen as a positive tool or technology that enables policy actors to govern and understand phenomena from a distance (Scott, 1998). Although it may seem trivial at first glance, this issue reaches the very core of how European society works and is governed – because how one calculates and knows something is just as important as the what that one calculates. To make governance through numbers possible considerable investment in capacity is needed to establish infrastructures of 'knowing' – the processes of knowledge gathering and sharing. This includes technical infrastructures and institutional environments, but it also refers to the development of methods and training a skilled workforce.

On the other hand, once quantification infrastructures, or "machineries" (Edwards, 2010) are put in place, they become reactive. In other words, the processes and choices inherent in quantification become performative and can influence society and the way that it is ordered. For example, the way national surveys are conducted affects the way nations are seen (Porter, 1995). Environmental metrics such as ecological indicators, carbon stocks and CO2 emissions create particular natures that may emphasize some environmental aspects over others and, in turn, become the basis upon which decisions are made (Turnhout, Hisschemöller, and Eijsackers, 2007).

What's more, this performativity of measurement leads to further complications down the line. This is due to the difficulties in introducing novelties and making changes to long-established accounting procedures. The critical question here is: Is it the policy goals that define which indicators are needed or do the available indicators define which goals can be attained? The assumption would be that the goals that determine the choice of indicators, but in practice, often the direction of causality between policy goals and indicator development is more complex. One can think for example about difficulties of measuring waste and the role of waste in Circular Economy indicators.

Armed with an understanding of how particular ideas of quantification become stabilized and reinforced through institutional frameworks, the next question then becomes, what elements of quantification do policy-makers take for granted that they should not? Processes of measurement and categorization have been associated with outcomes of both emancipation and persecution throughout history. Today, the enlightenment ideals of rationality, human agency, planning, control and progress are deeply inscribed into modern institutions of governance. They are central to evaluative practices, to processes of categorization, legitimation, standardisation and the production of hierarchies or 'grammars' or 'orders' of worth (Boltanski and Thévenot, 2006; Welch, Keller, and Mandich, 2017). For example, studies have shown that school administrators adapt their curriculums to the rating and ranking systems of schools in order to achieve high scores (Espeland and Sauder, 2007). In this case, quantification practices are transformed in ordering practices.

When it comes to policymaking, research has found that the use of evidence for decision making is a process that is far less linear then commonly assumed. In fact, in many cases the link between evidence and policymaking may be disconnected (Waylen and Young, 2014). Evidence does not necessarily inform policy making. Instead, evidence may be used after policy priorities have already been established, through target setting negotiations and in monitoring progress towards targets. Quantified evidence plays an important procedural role in policymaking. Numbers as quantified evidence give a sense of authority and legitimacy. In a situation in which the authority of politicians is questioned, trust is transferred to the ideal of "mechanized objectivity" (Porter, 1995). In other words, quantification can render issues apolitical and therefore non-debatable.

A principal challenge that surrounds nexus policymaking is described as methodological and disciplinary "silos" through which policy relevant evidence is produced (Stirling, 2015). Silos in this respect denote a lack of communication and coordination among institutions, much like a sealed-off concrete silo where grains are kept untouched for long periods of time. Although there are active channels and interconnections among different sectors - for example, water and energy departments work together in the cases of desalination and hydropower - there are great challenges in understanding the nature of these connections on a systemic level. The challenge of modelling the nexus as a whole is not just one of changing the models used. This then requires changing the procedures and technologies of producing quantitative evidence. In this respect, we query how might institutional and organizational orderings change with a nexus approach?

Using these observations as a starting point, the MAGIC project explores – through focusing on narratives and their quantitative basis - how alternative modes of environmental governance might open up paths for a more productive and effective use of quantification in governance.

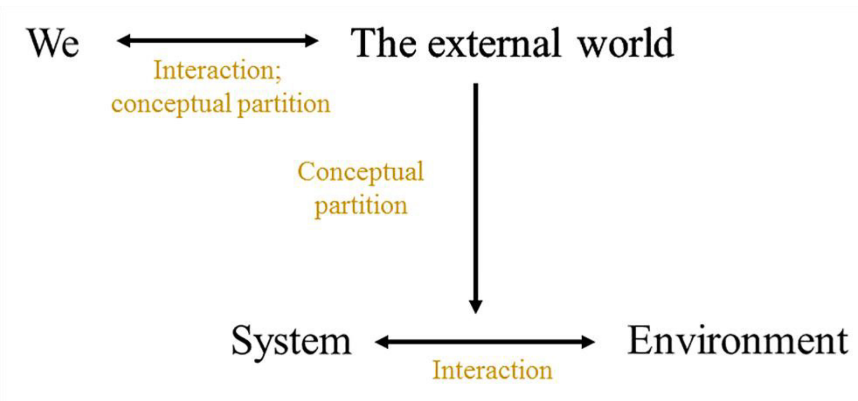
Complexity in Nexus Governance

Roger Strand

Whatever the water-energy-food-environment Nexus is, everybody tends to agree that it is complex. Unfortunately, nobody agrees what it means to be complex. In this piece, I claim that more time ought to be spent on serious discussion about what complexity is and what it entails for our possibilities to achieve some kind of governance of the Nexus. By serious discussion I mean not only that current knowledge on complexity theory and other relevant sciences are taken into account but also to be willing to admit when things are difficult and not going well, for instance when policy goals are far from reach or seem mutually contradictory.

Definitions of complexity abound. A useful approach to complexity is to define simplicity, which is easier (Strand, 2002). A simple system consists of identifiable parts that interact with law-like regularity. The parts are stable and have a limited number of measurable properties, and their interactions are linear. There is no controversy on what counts as the borders of the system, the number and identity of their parts, and the number and identity of their relevant properties. This allows scientists and citizens to believe that the knowledge is objective. You may get to different concepts of complexity by negating different parts of the concept of simplicity, focussing on features such as nonlinearity, stochastics, fuzziness, radical openness or contextuality (Chu et al, 2003). In post-normal science, one has often focussed on "emergent complex systems", defined as systems that include intentional, sense-making agents (such as humans). Funtowicz and Ravetz (1994) showed how such systems in general are cannot be predicted and may have multiple legitimate descriptions that are in contradiction with each other.

When one tries to know something, one approach is to perform two conceptual partitions – literally, two mental operations. The first is to distinguish between "I" or "we" on one hand and everything else, "the external world" on the other. The second is to divide the external world into a "system" of interest and everything else, "the environment" on the other (Rosen, 1994):



If the world were simple, this approach would have allowed us to obtain perfect, precise and objective knowledge of the external world. Indeed, this approach is known as "Modern Science" or the "Scientific Method", celebrated in Europe and beyond for centuries. The only mystery that remains for it, is ourselves. Ever new sciences try to mentally externalize and objectify aspects of the "I" – body parts, genes, neural circuits, mental processes – to smoke the genie of out of the bottle and eliminate the mystery. Such a perfectly known world can also be perfectly governed. Francis Bacon (1620) famously pointed this out: "Human knowledge and human power come to the same thing, for where the cause is not known, the effect cannot be produced." A philosophical problem is the question of where that "I", that human subject, resides, and if it can be trusted. When finally fully objectified, no human subject is left to rule the world and governance must be left to God or to a self-evolving Artificial Intelligence. Francis Bacon's contemporary, René Descartes (1641), tinkered on the Christian (and Platonic) solution to this intellectual problem and located the immutable human soul (res cogitans) outside the physical universe and therefore beyond the scope of the Laws of Nature.

The Nexus, whatever it may be, is not simple. Some people think of the Nexus as something physical: The Nexus is the socio-ecological natural system of waterways, soils, aquifers, mountains, villages, acres, roads, food stores, kitchens, sewages, animals, plants and humans all interconnected in nonlinear ways, exchanging energy and matter but also information and meaning, as when episodes of water scarcity leads to political measures that again lead to anger, protests, conflict or perhaps even war, all with its own feedbacks into air, water and soil. The Nexus in this sense is nonlinear, stochastic, fuzzy and radically open and accordingly its future trajectory cannot be precisely predicted or governed by a command-and-control type of logic. It is also clearly an emergent complex system. However sophisticated the science, the Nexus will have multiple legitimate descriptions that depend on the framing of the system and its relevant and valuable properties. Accordingly, one should not expect consensus about the knowledge base. Indeed, as nicely demonstrated by the piece by Blackstock et al. in the Nexus Times, there is no "point of nowhere", no neutral stance or position from which to observe and govern the Nexus. Both knowledge and action depends on the place (country, region, institution, location in the ecosystem) of the knowing and acting subject.

This leads us to a central insight: We are inside of the so-called external world and we are part of it. It is an illusion to believe in governance of complexity, or governance of the Nexus. What we actually can achieve, is governance in complexity (Rip, 2006). It is to be expected that things don't go well and that policy targets are not met. Human knowledge and human power come to the same thing, Bacon insisted, and in complexity, inside the Nexus, there can be no perfect knowledge and hence no perfect power.

The lack of perfect power of a command-and-control type is not the same as powerlessness. We all know that, in our own lives as private individuals and family members. In the political institutions in modern states, however, the acknowledgement of imperfection is sometimes accompanied with a sense of disbelief, disempowerment and a peculiar type of dishonest, desperate optimism: If we only do some more research and some more expert groups, we are going to know what to do (Strand, 2002). One pretends that scientific knowledge allows us to predict the consequences of public decisions and that things are "under control". When things then go wrong, this is explained away with reference to external disturbances (which are ubiquitous, because the Nexus is radically open), or calling for more research, or more action. This is why I called above for a serious discussion on complexity. Over the years, I have talked to so many serious and reflective individuals inside of governmental institutions who are well aware of complexity but still find little room to articulate its implications within the institutional setting in which they work. Instead, they feel compelled to take part in policy discourses and practices that implicitly assume that the world is a simple system.

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VI INNOVATION

September 2018

Innovation plays an important role in policy-making, this is no different when it comes to the water-energy-food nexus. Sometimes, however, idealized and simplified innovation-narratives and the expectations attached to particular (mostly technological) innovations-as-products cannot meet the needs of all sectors at the same time. For example, while desalination technologies produce extra water for residential and industrial use, it also requires extra energy inputs. How can policy-makers reconcile diverging policy goals with the promises of technological solutions? And how can decision-makers analyse and account for the possible adverse effects of certain policies in other areas?

In the MAGIC project, the role of such innovations in the policy-making process was analysed together with the emergence of "nexus policies". This chapter invites the readers to take a look at a selection of the project's case studies and the core theoretical issues surrounding the role of innovations.

Can Europe utilize bioenergy without compromising sustainability?

Abigail Muscat

Humans use biomass for multiple uses, mainly as sources of food, feed for livestock, energy generation and, recently, biomaterials. With a growing global population, a shift in diets towards one based on animal-source food, and higher expected demand for bioenergy and biomaterials, the pressure on biomass and the resources needed for its production will continue to increase. These growing demands can be met by increasing biomass production, but the intensification of production is often associated with higher input agriculture, which has effects on soil and biodiversity. In the EU, the potential for increased productivity is limited as yield gaps are small. Expanding the areas for biomass production could potentially avoid the damaging effects of higher input agriculture, however this could come at the expense of natural areas of high biodiversity value. For these reasons, the expansion of areas for biomass production to meet EU demands has occurred mostly outside of the EU. In fact, the imported share of the biomass footprint in the EU has grown by 33% from 1995 to 2009. If Europe decides to achieve all the Sustainable Development Goals while minimising its need for imports, trade-offs among goals of food security, climate change mitigation and sustainability may appear.

This raises the question of how the multiple claims on biomass can be handled sustainably. Bioenergy still remains one of the major renewable energy sources, with 64% of all renewable energy in the EU-28 coming from biomass in 2016. Many potential solutions are available to avoid the competition for biomass and minimise its impacts. Solutions include using marginal lands that do not compete with food production, the use of biorefineries that produce many high-value products from few resources or making use of biomass residues that currently go to waste. Therefore the question becomes, what is the scale of the current problem and which solutions may present likely futures?

Such integrated problems and solutions will require a new kind of policy-making, as the trade-offs linked to expanding bioenergy touch upon a number of policy domains in the EU, especially the Circular Economy and Bioeconomy policies. Synergies between policies will have to be better exploited and policy-design will likely have to address consumers as much as producers. Given that the EU increasingly relies on biomass imports and on natural resources worldwide, this also has implications for the EU's ability to meet the Sustainable Development Goals. To what degree does the EU need to take responsibility for the impacts of its material consumption?

To answer some of these questions we will assess the current situation. We will look at biorefineries processing biomass and producing a host of outputs such as fuels, feed, chemicals, materials and heat. Does Europe have enough land and water to meet its bioenergy use? Are capital and labour being displaced from elsewhere? To what degree does Europe depend on biomass from outside the EU, and is this socially desirable? Furthermore, we will ask what solutions represent likely futures and what their possible effects would be. Many biorefinery configurations are possible, generating different products and sourcing different feedstocks from different types of land. Such innovations will need a careful assessment from a range of perspectives as the innovations themselves are constantly developing.

The problem of using biomass in a resource efficient way to meet the EU's goals has been chosen for MAGIC because it is at the crossroads of sustainability governance and the water-energy-food nexus. It provides an excellent opportunity to discuss such a key innovation right when key EU policies, such as the Bioeconomy strategy and the Renewable Energy Directive are being re-assessed and the bioeconomy is gaining ground. Many solutions exist to address the competition for biomass but often these solutions come with their own trade-offs; for example, increasing biomass availability will be difficult in Europe and the dependency on biomass imports could worsen. Other examples include using marginal lands that don't compete with food production, but this may interfere with other possible uses, such as nature conservation or livestock production. MAGIC will help in acting as a quality check for such solutions, to best avoid the pitfalls of being locked into incoherent policies.

Is Shale Gas Dead?

Cristina Madrid-Lopez

It's been a rough ride for the shale gas sector. The market boomed in 2008 shortly after natural gas prices reached USD $6 per million BTU ($/MMBTU). Then, lower gas-prices during 2014-2016 marked what many considered the beginning of the end of the shale gas extraction era – producers could hardly afford the high costs of horizontal drilling and hydraulic fracturing at a time when prices were close to USD $2/MMBTU. But then, as prices inched up in mid-2018 to USD $3/MMBTU, there was a mixed reaction. While shale gas enthusiasts regained optimism about the sector's future and its potential contributions to energy policy objectives, critics were and still are sceptical of its potential due to the impacts and financial costs of extraction. With such uncertainty then, is there cause for optimism for shale gas, or is the market facing a bleak future?

Finding consensus on the answer to this question is going to be difficult because shale gas extraction is a component of what Stephenson has called "the fracking phenomenon". In other words, "fracking" is a complex issue and as Roger Strand has put it, it is more useful to accept that some questions might not have one straight answer, but many valid ones. And that is fine.

Considering different answers as valid is not the same as falling into vague or "unscientific" methods. Analysts that follow the principles of Post-Normal Science (PNS) often use the same tools as other scientists and take into account factors other than facts, such as people's perceptions and knowledge. Consequently, they do not look at quantitative results as an absolute truth but understand them as the final step of an analytical process influenced by a (mostly social) context.

The Bioeconomics view

Bioeconomics is a useful lens with which to understand the energy and material flows associated with a productive activity such as shale gas extraction. Figure 1 maps the productivity of all wells in Pennsylvania, US, at different ages where three main stages can be observed. During the early stage of drilling and fracturing, productivity increases. At the same time, the adverse impacts on water, air and land and the local population also increase. During the production phase, the well is capable of providing enough gas to recover production costs and the environmental impacts are usually minimal. Finally at the decay stage, gas production is too low to provide benefits and adverse impacts are usually the result of a lack of proper maintenance.

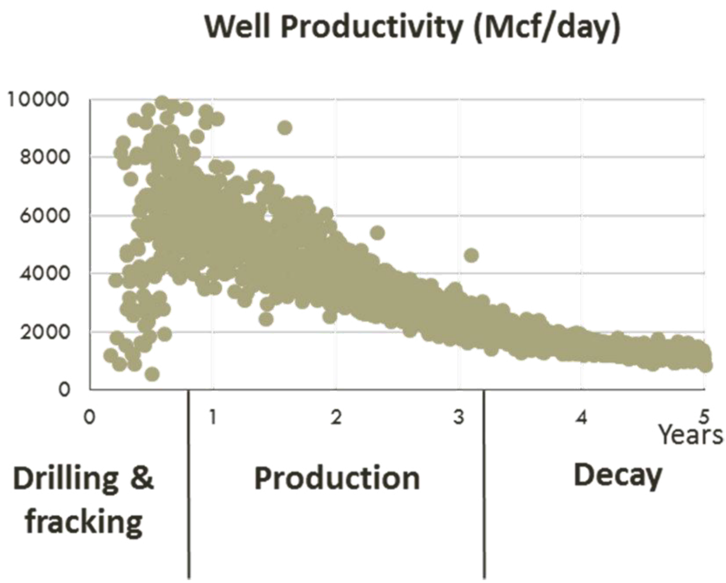

Figure 1: *Average productivity and life stages of a shale gas well.*

The point at which a well leaves the production stage and enters the decay stage is determined by the price of the gas. Clearly, once a well enters the decay stage, the gas company might prefer to plug it up and open another one, creating a more significant impact on land and water ecosystems. In a situation of lower gas prices, the production stage is minimized. The shale gas sector can only maintain a regular level of daily production if the number of wells (and their impacts) are increasing.

The Geopolitical view

When shale gas is saved for the times when gas prices are higher, however, the production of natural gas decreases, endangering the energy security of the producer. Wood Mackenzie reports that China's shale gas extraction has doubled since 2016 and that, despite the relatively higher costs of shale gas development in China, the government's commitment to the sector is grounded in energy security and geostrategic reasons. Since mid-2016 the sector's productivity in the US has increased again, even when prices are close to USD $4/MMBTU which is about the average cost of production in the US. The Trump administration has heavily supported shale gas producers in Pennsylvania and other states, partly in order to fulfill local-development campaign promises that made Pennsylvania swing from a Democrat to a Republican majority state and partly to maintain a strong influence over the world energy market.

With Dutch natural gas reserves close to exhaustion and the international relations between Europe's main gas provider, Russia, and the European Union in a critical moment, being a trade partner of Europe sounds like an appealing option for exporting countries. Consequently, despite low gas prices and high environmental and social impacts, governments might choose to promote shale gas development for strategic reasons.

Power relations and public participation

Power relations play an important role in defining political agendas and, consequently, what actions are taken. Trade-offs between global, national and local strategic policies are very important to determine the future of shale gas development. It can be argued that the high income states of New England in the US suffers from a global scale 'NIMBY' effect, meaning that they benefit from a regular and low-cost gas supply, while extraction has been banned in most of the state.

In order to ensure that the analysis that we are carrying out will provide answers to questions that are relevant for stakeholders, the obvious step is to involve them in the analysis. Traditionally, public participation is included in research either to gather information about a case study prior to the analysis or to gather feedback afterwards. In MAGIC, public participation is also included before the design of the analytical method. Thus, in the WP6 case study on shale gas we include a consultation to key actors in the European Commission.

Innovation to policy
Shale gas fracking can be viewed from different perspectives, as discussed here with framings from Bioeconomics or Geopolitics. What does this mean in terms of policy measures, and more broadly for the governance of innovations? The contribution of technological innovations to policy objectives is uncertain but can nevertheless be studied. Some have argued that having shale gas at hand will delay the energy transition to renewables. However, natural gas, due to its market-readiness and its potential for use in decentralized systems, has been proposed as an energy source that can contribute to achieving a Low Carbon Economy.

Shale gas development might not have the potential to make a major contribution to climate or energy policy. However, it has a high geopolitical value. It would be wise for Europeans to keep an eye on its mid-term development in the current scenario of fracturing diplomatic relations among the major external gas providers, which happen to coincide with the depletion and closure of one of Europe's most productive gas fields, the Groningen field in the Netherlands.

Green bonds: how could they affect Nexus governance?

Luis Zamarioli

The implementation of the Paris Climate Agreement and the Sustainable Development Goals follow an underlying narrative that public investments are insufficient to fund countries' financial needs. As a solution, innovative financial mechanisms and structures have been created in order to attract private capital and bridge this gap. The expression "shifting the trillions" is now a common phrase alluding to the perceived size and importance that the private sector represents in terms of public value creation. In this context, green bonds have emerged as one such increasingly important policy innovation, being used by governments to boost environment-related public budgets. It has also been promoted as a policy nudge to the financial sector away from unsustainable activities. Below, we aim to present green bonds and raise a few questions relating to the roles played by governments in this new market and in the greening of the financial sector.

What are green bonds?
Green bonds function similarly to normal bonds. A title is issued and bought, providing ready money for the issuer while giving the buyer the chance to trade it freely in secondary markets.


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The "green" component differentiates them from normal bonds, as the issuer pledges to use the money only in recognised green activities. In return, the issuer pays a price to the title's owner for a number of years until the bond matures and must be repaid in full. By adding green instruments to debt markets, it's expected that environment-related projects can tap into the "big money" of large-volume funds, such as institutional investors. From a policy perspective, governments can participate in the green bond market in two ways - as an issuer or regulator - each raising questions regarding the government's role, and responsibility in terms of limitations and possible interventions.

Governments as issuers of green bonds

First, as issuers of green bonds, local and national governments have sought to increase the present available funding for green activities by selling their debt. The European public sector has been at the forefront of green bond issuances, The European Investment Bank issued its first Climate Awareness Bonds in 2007, followed by cities such as Paris and Stockholm, the region of Île-de-France, and the Polish and French national governments. Understanding the relationship between issuance, the use of proceeds and the public interest matter enormously to safeguard the interest of present and future generations in Europe.

An immediate question regarding public issuance of green bonds is (i) to what degree tax-based revenues might be disadvantaged politically in favour of innovative financial instruments such as green bonds, since debt instruments must be repaid and incur an increase in public debt – unlike tax-based revenues. What's more, while promoting the narrative of budget additionality for green sectors, it remains to be seen (ii) whether state capitalisation through financial markets indeed delivers capital additionality for "green" priorities. For example, does the capital raised from issuing green bonds actually represent an increase in the overall budget for green policies in the following years? If the budget for sustainable activities remains flat or increases less than that earned from bond proceeds, we can infer that the tax-based budget previously used for sustainability is now freed-up for other budgetary uses. This hardly indicates an interest in green additionality. How can we ensure that freed-up money is not used to subsidise polluting activities or to incentivise unsustainable growth? If that is the case, in light of the need for public accountability, a call should be made to reform the political narratives that seek to justify the issuance of green bonds. Also, (iii) while offering the possibility to channel larger amounts of capital into areas needed for achieving internationally agreed climate targets and sustainable goals, financial markets have the potential to shape sustainability governance based on financial criteria. Project bankability, sector capacity to generate profits, conditions of debt markets and the credit ratings of issuing governments add an additional and strengthened component to the decision for any given policy. This so-called financialisation can create a bias towards certain sectors to the detriment of others, affecting the governance of the Nexus.

Government as regulator

Secondly, the public sector can act as a regulator, as above all else it has (iv) the power to legitimise the characteristic of "green" attributed to financial titles, as opposed to definitions derived from self-regulation within the financial market. This creates procedural smoothness to issuances, which can be translated into lower transaction costs and reduced reputational risks from greenwashing claims against issuers. Going forward, another challenge lies in (v) defining green, which is not a straightforward task. A wide array of environmental complexities must be simplified into static or semi-static numerical indicators, so they can be operationalised by financial players in the form of benchmarks and used to compare and value different titles. How then, as it is the specific case of the Nexus, (vi) can we represent the constantly adapting relationships and context-dependent flows and funds across different sectors? After all, it's not a static picture of the environment that provides us with the best assessment of how much stress we're putting on planetary boundaries, but often the sum of those stresses and the interdependency between different environmental functions. Under the regulatory perspective, the European Commission has been moving swiftly to discuss and develop a taxonomy of which investments might be considered "sustainable" and what might the definition of a "green" bond entail. Innovating in such unchartered waters is no easy task, but a necessary one if we're to expect financial markets to hold their share of responsibility in shifting our economy away from environmentally unfit and unsustainable levels. Under the MAGIC project we have been closely following these policy developments, aiming to create a dialogue with the Commission for clarifying the narratives and task dimensions. We will feed this process with timely assessments from a complexity perspective and Nexus considerations and exploring the broader discussion and analysing a number of case studies in selected areas.

What is the role of scientific innovations in EU policy?

Jan Sindt

The European Union sees scientific innovation as vital for economic growth and competition in global markets. This perspective is so deeply rooted in the self-perception of European political and scientific elites that it is hard to argue with. In times of economic crisis, the European Union has kept this focus, even increasing its financial support to scientific research. In addition, efforts are made to mobilize private capital for research and development.

Scientific communities submitted 400,000 proposals during the first three years of Horizon 2020, The European Union's flagship research programme. Some 700,000 Europeans are pursuing a PhD or equivalent and European scientists roll out well over 430,000 peer-reviewed scientific publications each year*. Albeit only providing a coarse measure, these figures hint at substantive progress toward making Europe a world-class science performer. The volume of scientific output might support the assumption that a lot of innovative capacity is available to support the European Commission's policy-making as well. And indeed, policy-making is increasingly making use of - and relying on - cross-disciplinary scientific expertise to tackle the increasing complexity of the problems faced across Europe. Making the water-energy-food nexus sustainable can serve as an example: no single person would claim expertise in all the relevant aspects of that challenge.

No single scientist does either, and at a certain level of complexity, deliberation and the force of the better argument ultimately surrender to the limitations of human brains. When that happens, we have to trust in the expertise and best intentions of the other. Pushing innovation in any area further will sooner or later result in complexity beyond the intellectual capacity of individuals, and they have to build trust within mostly interdisciplinary teams. This would appear obvious, but it is important. It means that innovators cannot claim the benign innocence of rational thinking since a social component, including their motivations, is woven into their scientific outputs. Public debates around innovations respond to that, for example by questioning the motives behind introducing genetically modified organisms into the food chain, rather than discussing the impact on health and biodiversity or uncertain long-term effects. Substituting scientific argument with trust in experts opens the door for all kinds of competing knowledge claims by actors whose motives by far outweigh their expertise in the field of study. This in turn ultimately undermines public trust in science per se.

Innovations in information technologies contribute to the problem by lowering access barriers to broadcast competing knowledge claims, hence removing the traditional noise filters employed by scientific communities (like scientific methods, peer-review and editorial decisions). While the free exchange of ideas greatly benefits from open access web based platforms, the individual has to determine the quality of available information. Combined with the aforementioned substitution of scientific argument by trust in experts, this introduces a new social component to knowledge generation and innovation. In extreme cases, the self-selection of trust-worthy sources of knowledge traps individuals in echo chambers, reinforcing trust in specific knowledge claims, filtering out access to competing knowledge claims, and creating frictions in the socio-political sphere. The public debate over health risks posed by glyphosate could serve as an example, even though it is not a recent innovation**. With a broader non-scientific stakeholder base being able to engage in discussions about innovations and how they are being used, building trust is becoming even more important to avoid misinformed debates potentially leading to poor policy decisions.

How does the European Commission address the social component of innovative science? In addition to helpful measures like improving stakeholder participation and making the many involved interest and lobby groups transparent, the Commission is also increasing the share of private capital and profit-oriented actors in research and innovation. While having companies that benefit from innovative research foot a part of the bill may appear to be in taxpayers best interest, a collusion of private capital incentives and scientific curiosity may not help to build trust with a broader political stakeholder base. If people increasingly ask who proposed an innovation instead of what argument supports its implementation, business interests and their motivations will need to be clearly identifiable. This is important, because scientific solutions to political problems ultimately have to convince the broader public rather than comparably well-informed policy-makers in order to inform democratic decision-making.

* The figure only counts those publications registered by the Science Citation Index of Thomson Reuter's Web of Science. So-called grey literature, which is scientific assessments not published in dedicated peer-reviewed journals, would drastically inflate this figure.

** Glyphosate was found to potentially cause cancer for humans as well as to be toxic for bees, which triggered a debate about banning the pesticide in Europe. During the public debates, one author of the cancer study was discredited for being paid by US lawyers bringing a related civil case against a main producer of Glyphosate. The European Chemical Agency's Risk Assessment Body was later also criticized for a conflict of interest of several of its members due to their involvement in chemical business operations. Furthermore the same Body was criticized for using unpublished evidence provided by the industry. On the other side, some farmer interest groups claimed that large parts of Great Britain would be overgrown by weeds and there is no other way to control those, should Glyphosate be banned in the European Union. It turned very difficult to find unbiased scientific assessments in the middle of the debate.

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VII
THE WATER-ENERGY NEXUS

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There is an increasing demand for energy to alleviate water scarcity pressures, and, vice-versa, a growing water footprint required to produce many energy forms – including new energy technologies. The governance of water and energy then is crucial if we are to safely manage these finite resources into the future.

The essays in this chapter talk about the origin of the concept itself and reflect on the potentials and pitfalls of introducing novel concepts into policy-making, discuss the challenges of quantifying nexus-relations in water use and provide insights from a case study on the attempt of providing a technological solution to problems posed by water and energy governance.

The origins of the "nexus": a water governance concern

Zora Kovacic

The "nexus" has become a buzzword (Cairns and Krzywoszynska, 2016), used in many different contexts for many different purposes. It indicates the interlinked nature of resource management, and is used as an inclusive tool to address environmental, climatic and land use issues. The most popular formulation of the nexus refers to "water, energy and food", but the term is used with reference to a broad range of topics. In this article, we trace back the emergence of the term "nexus" and ask: what did the concept mean to achieve? The term "nexus" hails from the water community, and although it may be seen as a means to articulate concerns and policy priorities of actors involved in water governance, we also show that the term was used in many different ways from the onset.

The term "nexus" was put forward by the '2030 Water Resources Group', which was founded in 2008 and brought together companies from the food and beverage industry, including the likes of the Barilla Group, Coca-Cola Company, Nestlé, SABMiller, PepsiCo, New Holland Agriculture, Standard Chartered Bank and Syngenta AG (Leese and Meisch, 2015). The idea of a "water-energy nexus" was mainstreamed through the Bonn2011 conference organized by the World Economic Forum Water Initiative. In its early formulations, the nexus was tied to business concerns of a variety of corporations, whose interests ranged from securing access to water resources, to using water resources "efficiently". Shaped in this way, the nexus has been presented as a means to ensure economic growth that is compatible with resource availability, which Leese and Meisch link to the green growth agenda.

The nexus has also received considerable attention from modellers. Shannak and colleagues (2018) provide an overview of the models that analyse the nexus, and find that most modelling efforts are centred on water. Such models include: the Water Evaluation and Planning Model (WEAP); the Global Policy Dialogue Model developed by the International Water Management Institute; the "water energy and food security nexus" developed by Hoff (2011), which is centred on water availability; the Climate, Land, Energy and Water Strategies (CLEWS) that estimates the suitability of different crops and biofuels under rain-fed and irrigated conditions for current and future climates; the "Diagnostic tool for investment in water for agriculture and energy" developed by the UN Food and Agriculture Organisation. Water is often an "invisible" input needed to produce other goods, such as food, or used in production processes that require cooling, washing, etc. The "virtual water" approach also highlights the importance of taking into account water uses embedded in other products. For this reason, modelling the nexus can be seen as a useful tool to give visibility to water use.

Also with regard to public policy at the European level, the term "nexus" can be found in the realm of water governance. For instance, the MAGIC project responds to the call "WATER-2b-2015 - Integrated approaches to food security, low-carbon energy, sustainable water management and climate change mitigation" which asks proposals to "develop a better scientific understanding of the land-water-energy-climate nexus" (European Commission, 2015).

The term "nexus" has emerged in policy and academic parlance as recently as the early 2010s, and it has been a buzzword almost from the onset. The term does not necessarily lack definitional clarity. Rather, it is associated with many definitions and used in many contexts. Some see the nexus as yet another rehearsal of older debates about interdisciplinary research, questioning the novelty of the idea. We suggest that the popularity of the term may in some ways help meet the aim of rendering water use more visible, and mainstreaming resource management in business practices. At the same time, the term "nexus" may acquire a life of its own, becoming a new problem in need of governing, requiring new metrics and models, and new institutional arrangements that make it possible to work "across silos". As the nexus becomes an issue in its own right, it may or may not be a good ally to water governance.

Water for energy: quantifying the massive amounts of water that go unaccounted for

Maddalena Ripa and Violeta Cabello

Water and energy systems are inextricably linked. According to the Energy Efficiency Directive (European Parliament, 2012), the water sector consumes up to 3.5% of EU's electricity for purposes such as water treatment, pumping or desalination. Similarly, water is essential for cooling power plants, for the generation of electricity and the production of bio-fuels, and for the the extraction, mining, processing, refining and disposal of fossil-fuel residues. The International Energy Agency projected an 85% rise in global demand growth in water use for energy production between 2012 and 2032 alone (IEA, 2017).

These changes are driven by a combination of factors. First among these is human population growth, which is estimated to rise from 7.4 billion people today to between 9.6 and 12.3 billion by 2100. Another important factor is the improvements in access to energy for the 1.4 billion people who currently have no access to electricity and the billion people who currently only have access to unreliable electricity networks. Last but not least, the progressive electrification of transport and heating as part of efforts to reduce dependence on fossil fuels and reduce greenhouse gas emissions is expected to be a key driver in the surge of water consumption (The Conversation, 2016). While it is important to consider these factors in policy making, it is equally important to establish an adequate accounting framework to assess the viability of increments in the use of water by the energy sector. In this article we discuss some conceptual and methodological challenges we encountered when searching for European energy and water statistics.

Water for energy: accounting gaps in Eurostat

The challenge of data availability at relevant spatio-temporal scales for analysing the water-energy nexus is well documented (Larsen and Drews, 2019). While in general energy systems can be considered to be well-monitored, the availability of integrated data sets covering water and energy domains is often severely limited at the relevant levels of aggregation in relation to nexus calculations, that is, beyond the site-specific level. Water and energy accounting are poorly harmonized in European statistics. Eurostat accounts for only one water-energy relation, the use of water for electricity generation (Eurostat, 2012). This broad category encompasses water use for cooling and the rest of water use for electricity production, without specifying the types of electricity production systems. While water for cooling accounts for a relevant share of water uses in some European countries, other relevant uses of water along the energy supply chain are neglected by Eurostat. For instance, fossil fuel extraction and processing are assimilated within the broader 'mining and quarrying' category, hindering nexus analysis. Water for biofuel crops and processing are included in the agriculture and manufacturing sectors, respectively.

Water for energy: consumptive vs non-consumptive uses

In order to better inform decision-makers, care should be taken to understand the differences between water use, water withdrawal (or water abstraction*), water consumption, and what the categories represent (Kohli et al., 2010). In this regard, two additional conceptual considerations are noteworthy. First, while Eurostat distinguishes between water abstraction/withdrawal** and water uses (European Environment Agency, 2018), the separation between consumptive and non-consumptive*** water uses is not included in the statistics. In fact, most water used for cooling purposes is non consumptive. This means that water is either recycled or returned to water bodies after use. A small share of withdrawn water is evaporated (consumed) along the cooling chain, falling into the consumptive use category. Second, hydroelectricity is excluded from the accounting because it is an in-situ use (Eurostat 2014, p. 43). However, hydroelectricity does also evaporate water (consumptive uses) and uses tremendous volumes in a non-consumptive manner.

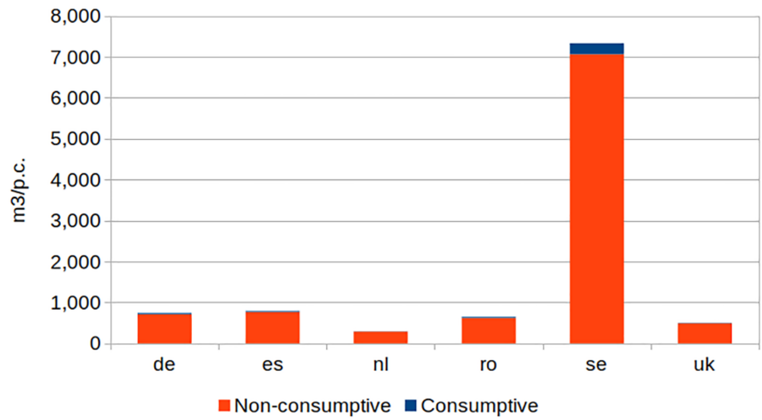

Figure 1: *Water use for energy production in European countries 2012 (m3/p.c).*

The quantitative multi-scale approach used in MAGIC allows maintaining the distinction between green water, consumptive blue-water and non-consumptive blue-water. In particular, in a recent report of the MAGIC project (Ripoll-Bosch and Giampietro, 2018), we calculated water use for the energy sector in different European countries (Germany, France, Italy, Romania, Spain, Sweden and United Kingdom). The water consumed for refineries, evaporated during electricity production and biofuel crop irrigation, as well as the water used in the mining and extraction of Primary Energy Sources (which can be contaminated due to acid mine drainage), was considered to be consumptive.

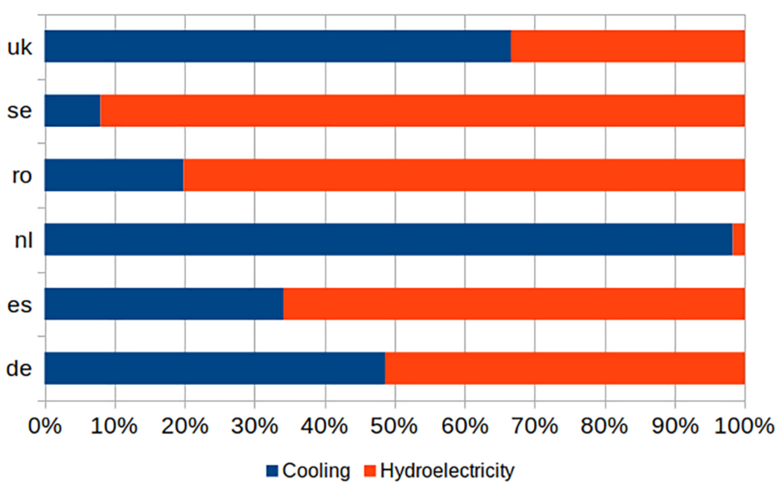

Figure 2: *Contribution of different processes to the non-consumptive water share (%)*

The water for cooling and for hydropower (excluding the water evaporated during the process) was accounted for as non-consumptive.

If this distinction between consumptive and non-consumptive water uses for energy supply is introduced, and hydroelectricity is included in the accounting, the resulting picture for European countries is quite interesting: Most water uses for energy supply fall within the non-consumptive category (figure 1). Within this category, the pattern significantly varies among countries depending on how much hydroelectricity they have developed (figure 2). When looking at the consumptive share (figure 3), electricity generation is still the largest water consumer in all analysed countries. Whereas this share looks negligible in comparison to non-consumptive uses, it gains relevance when contrasted with other consumptive uses such as water for agriculture or households.

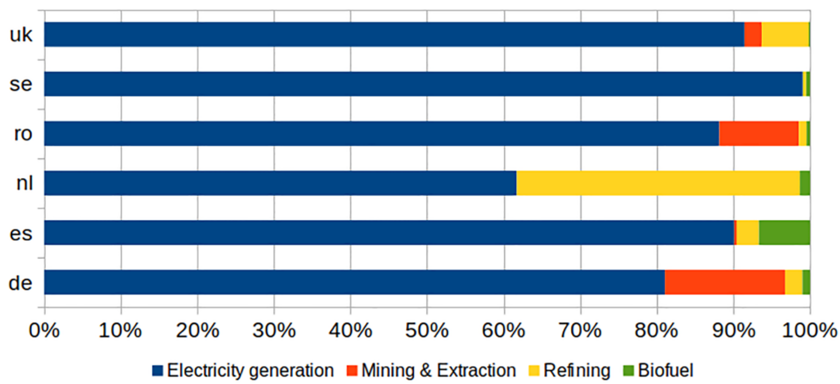

Figure 3: *Contribution of different processes to the consumptive water share (%).*

The announced expansion of electrification will generate competition for water not only between sectors, but also between different consumptive and non-consumptive uses of water in energy generation. Moreover, the impacts of increments in electricity demand on surface water bodies need to be evaluated against the disaggregated contribution of different energy supply processes. Therefore, it is imperative to advance to a more comprehensive water-energy nexus accounting framework that can quantify and characterize all water uses together across sectors.

*Eurostat (2014, p. 43) defines water abstraction as 'Water removed from any source, either permanently or temporarily. Mine water and drainage water are included. Water abstractions from groundwater resources in any given time period are defined as the difference between the total amount of water withdrawn from aquifers and the total amount charged artificially or injected into aquifers. Water abstractions from precipitation (e.g. rain water collected for use) should be included under abstractions from surface water. The amounts of water artificially charged or injected are attributed to abstractions from that water resource from which they were originally withdrawn. Water used for hydroelectricity generation is an in-situ use and should be excluded.'

**Groundwater abstraction is the process of taking water from a ground source, either temporarily or permanently (European Environment Agency, 2018).

***A use of water is consumptive if that water is not immediately available for another use. Losses to sub-surface seepage and evapotranspiration are considered consumptive, as the water that is polluted or degraded to insufficient quality for reuse. Water that can be immediately treated or directly returned to water bodies in a continuous loop is considered non-consumptive. Therefore, a non-consumptive use is when water use does not diminish the source or impair the future water use.

Desalination is a viable nexus technology: but local conditions are key

Juan A. de La Fuente and Baltasar Peñate

The world population is expected to increase from the current 8.5 billion to 11.2 billion by 2100 (World Population Prospects, United Nations, 2017). By 2050, global demand for energy will nearly double, while water demand is set to increase by over 50%. To overcome the increasing constraints the world faces, we need to rethink how we produce and consume energy in relation to the water sector.

The authorities responsible for water and energy are generally separated. Each has its own priorities and there seems to be little incentive to collaborate in the planning and development of new policies. At the same time, the water and energy sectors have always operated independently and there may be some resistance to a better integration of both sectors. Often, studies on the interconnection between water and energy have been initiated and driven by specific local circumstances, such as water and energy crises.

Seawater desalination is an important option for addressing the world's water supply challenges, but current desalination plants use huge quantities of energy causing several environmental issues. The energy intensity of desalination processes has dramatically decreased over the past 30 years, from slightly more than 15 kWh/m3 in the 1970s to approximately 2.5 kWh/m3 today thanks in large part to reverse osmosis (RO) technology improvements. Still, several physical constraints limit the ability to reduce the energy intensity of RO much further. This means that energy efficiency in RO has almost reached its biophysical limits.

Brine discharge into the sea can have a negative environmental effect on the marine ecosystems due to its high salt concentration and other chemicals. Devices like Venturi diffusers for brine discharge can be used to improve the dilution process and reduce their environmental impact. It has been shown that the capacity to improve the dilution of Venturi system is greater than 2.3 times the dilution obtained with conventional diffusers. Another option could be the valorisation of brine, by using it for the culture of the microalgaes for the production of molecules such as β-carotene and polyunsaturated acids. The biomass obtained can be used in animal nutrition and Nutraceutics.

It is very likely that the water issue will be considered, like fossil energy resources, to be one of the determining factors of world stability. Desalination processes involve a recurrent energy expense which few of the water-scarce areas of the world can afford. Even if oil were much more widely available, could we afford to burn it in such a manner so as to provide everyone with fresh water? Given the current understanding of the greenhouse effect and the importance of carbon dioxide levels in the atmosphere, environmental pollution caused by burning fossil fuels for desalination is a major concern.

Renewable energy (RES) technologies, mostly solar and wind energy systems, can provide access to a cost-effective, secure and environmentally sustainable supply of energy that can be used for water desalination. As RES technologies continue to improve, and as freshwater becomes scarce and fossil fuel energy prices rise, utilising RES for desalination becomes more viable economically. RES may provide water desalination cost reductions due to lower greenhouse gas emissions. For example, a seawater RO desalination system operating on traditional fossil fuel-based energy sources produces 1.78 kg and 4.05 g of CO2 and NOx per 1 m3 of desalted water, which can be reduced to 0.6 kg/m3 – 0.1 kg/m3 and 1.8 kg/m3 – 0.4 kg/m3, respectively, with electricity generated from wind or solar energy (Raluy et al., 2005).

On the other hand, the role that desalination could play in the integration of electricity produced by renewable sources in the electricity grid is also an interesting topic.

The major constraint on increasing penetration of RES is their availability and intermittency, which can be addressed through using energy storage or smart control, when available, to balance renewable energy generation with energy demand.

The Canary Islands archipelago in Spain is a perfect example of how a region with water shortage and presence of RES resources has alleviated its water scarcity problem using desalination technologies, exploiting in turn the sun and wind resources available in the area.

The water – energy nexus has been one of the key R&D lines of the Canary Islands Institute of Technology (ITC). The ITC has developed and tested prototypes of different renewable energy driven desalination systems, operating in off-grid mode, since 1996. The ITC facilities in Pozo Izquierdo (Gran Canaria Island) are an ideal platform for testing RES desalination systems thanks to the excellent local conditions: direct access to seawater, annual average wind speed of 8 m/s, average daily solar radiation of 6 kWh/m2. Up to 18 different combined systems of renewable energy generation and desalination processes have been tested at the ITC.

Depending on the local environmental conditions, regulation and policy, desalination is a viable technology where RES resources are readily available. With planning and an adequate policy, desalination should be an alternative water resource. However, the energy dependence and the relatively high water cost must be analysed on a case by case basis before proposing specific arrangements.

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VIII
TRANSPORT TRADE-OFFS

March 2019

Transportation, although not an explicit element in the water-energy-food nexus, is nonetheless a crucial issue for the its study. It is both the target of innovation-oriented solutions to energy and climate related challenges, and the source of challenges and trade-offs in sustainability governance.

The essays in this TNT issue engaged with biofuels and electric vehicles as examples for innovative technological fixes that promise an alternative to fossil fuel-based transport or a more sustainable energy sourcing respectively. They ask for potential problems of these solutions, highlight some of the issues with emission measurement and, finally, suggest that we might have been solving the wrong problems all along.

Why it is so difficult to measure biofuel emissions

Bunyod Holmatov

People's use of energy around the world is increasing (WB, 2017). This is caused by a combination of factors such as a growing population, a higher concentration of people in urban areas and higher rates of industrialization (Johansson et al., 2012). Since the industrial revolution, most of the energy in the world has been obtained from fossil fuels that are, notably, linked to the release of greenhouse gas (GHG) emissions.

By now, there is widespread consensus among scientists that anthropogenic GHG emissions contribute to changing the climate by disrupting the planet's inherent energy balance. Among all the sources of anthropogenic GHG emissions, energy production and use contributes the most – around two thirds (IEA, 2015), making the energy sector central to climate change discussions. Therefore, a transition is underway towards renewable energy obtained from "cleaner" sources such as the sun, wind, biomass, tides and so on.

Among different types of renewables, biofuels are of particular interest because they can emit less GHGs and make countries less dependent on oil imports and their volatile prices (Karatzos et al., 2014). In a little over two decades, between 1990 and 2014, emissions from the transport sector increased by 71% (IEA, 2016), and these emissions will continue to increase in the near future. The International Energy Agency (IEA, 2017) projects that under the current policies, emissions in the transport sector will increase by 17% between 2015 and 2040. Switching to biofuels can thus bring multiple long term benefits.

However, despite the general agreement that biofuels emit less than oil-derived fuels, the actual GHG emissions (for the same type of biofuels, i.e. bioethanol, biogasoline, etc.) may vary. The variation between studies emerges because of complexity of calculations that involve different inputs during the numerous production steps. Moreover, there is a distinction between the biofuels based on the type of feedstock. The so called "conventional" biofuels are produced using agricultural crops (i.e. sugarcane, sugar beet, etc.) while "advanced" refers to non-crop based biofuels (i.e. derived from biomass, algae, etc.; EC, 2016) that have not reached large commercial-scale production.

Calculating total GHG emissions of biofuels involves data from multiple stages of production, such as the crop cultivation (conventional biofuels) or extraction (advanced biofuels), processing, transport, and distribution. Each step can also have many sub-steps, i.e. producing "conventional" biofuels involves cultivating the crops that cover four main categories of inputs: (1) agro-chemical application; (2) field nitrous oxide emissions; (3) fossil fuel use; and (4) seeding material (Ecofys, 2010; EC, 2016). Thus, reported GHG emissions for the same type of biofuel can be different depending on where and how it was produced.

When discussing biofuels, it is important then to understand what type of biofuel is being discussed, what feedstock type, how it was produced (process route) and where. Sometimes, such as in the EU energy directive, the reported ranges also specify whether emissions of biofuels refer to "typical" GHG or "default" GHG. The former is an estimate that is typical in the EU while the latter is derived from the typical value using pre-determined factors (EC, 2016). In other words, factors such as the crop yield in Europe can be different from the specified 'default' crop yield.

The following examples demonstrate how biofuel type, feedstock type, and process route affect the GHG emissions of biofuels. "Conventional" bioethanol can be produced using a range of crops. Using sugar based crops such as sugar beet or sugarcane requires less processing steps because sugars are readily fermentable. This means that sugar based crops emit less GHGs than starch based crops such as maize, that require relatively more processing steps to convert them to fermentable sugars. Therefore, a typical emission of a "conventional" bioethanol produced from sugarcane is 28 g CO2eq/MJ and for sugar beet is around 31 g CO2eq/MJ. In contrast, a typical emission of maize based "conventional" bioethanol is around 49 g CO2eq/MJ (EC, 2016).

While both bioethanol and biodiesel are biofuels, biodiesel emissions are higher than bioethanol emissions. Typical GHG emissions of a sunflower based "conventional" biodiesel is around 40 g CO2eq/MJ. Using palm oil as the feedstock can increase typical emissions to 58 g CO2eq/MJ. It is important to note that the "default" GHG emissions can be even higher. For instance, palm oil based "conventional" biodiesel has a default emission of 70 g CO2eq/MJ (EC, 2016). At the same time, despite having higher emissions, biodiesel can be readily used in diesel cars whereas bioethanol has to be blended with a certain ratio of gasoline to prevent corrosion of car parts.

"Advanced" biofuels are usually promoted for their dependence on non-crop feedstocks, while in reality, they also lead to less GHG emissions compared to "conventional" biofuels. For example, producing bioethanol from corn stover can lower emissions to 31 g CO2eq/MJ (IEA, 2013), whereas using wheat straw would typically emit 13.7 g CO2eq/MJ (EC, 2016). Similarly, using waste cooking oil to produce "advanced" biodiesel would typically emit 16 g CO2eq/MJ (EC, 2016).

In terms of process routes, they are more applicable to "advanced" biofuels than to "conventional" biofuels. The latter are produced using more established methods. In contrast, feedstock processing routes of "advanced" biofuels are still in development and their effect on GHG emissions are less clear cut. For example, converting wood residue to gasoline through the "pyrolysis" processing route can emit around 49 g CO2eq/MJ while choosing the "sugar catalysis" process only emits around 5 g CO2eq/MJ (IEA, 2013).

For practical reasons, biofuel's GHG emissions are also compared to fossil fuel emissions to indicate the degree of emissions that can be 'saved' by switching to a given biofuel. To give some examples, approximately 87 grams of CO2eq emissions are emitted per MJ of oil based gasoline. In contrast, converting wood residue to gasoline can lower emissions to a range between 2 and 49 grams per MJ (depending on the process route) that translates to the GHG emission savings in the range of 98% and 43%, respectively (IEA, 2013).

In conclusion, many factors contribute to the GHG emissions of biofuels. General biofuel emissions always embody certain underlying assumptions related to the feedstock, process route, location specific conditions, etc. Addressing each and every assumption of biofuel production that can yield a certain cumulative GHG emission is challenging. Thus, from the policy making perspective, the old proverb "measure twice and cut once" is ever pertinent.

Meeting EU biofuel targets: the devil is in the detail

The Autonomous University of Barcelona team

Transport is one of the most unsustainable sectors in the EU: it lags behind all other sectors in terms of emission reduction, and alternatives have been tricky to find, monitor and implement. In 2016, just 3.8% of the energy consumed in the transport sector came from renewable energy sources (EUROSTAT, 2019). Electric vehicles are gaining momentum as a possible solution to sustainable transport, but so far they can only substitute road passenger vehicle, leaving a big gap for other forms of transport, such as shipping and aviation. Similar to electric vehicles, biofuels are seen as a solution to simultaneously lower emissions and lower dependence on imported oil. Following concerns over indirect land use change (ILUC), the recast renewable directive set strict criteria on the sustainability of biofuels, however they are still considered to be a central element to the sustainable transport transition. Differently from renewable electricity which is generated with local resources on the spot, and from fossil fuels that are extracted with associated environmental damage, biofuels represent a peculiar case of renewable energy, since, similar to fossil fuels, they rely on a multi-step process: first the cultivation of crops, and then their conversion to fuels, with intermediate steps depending on the type of fuel. This makes their accounting more complicated. With the EU setting rigorous sustainability targets for biofuel implementation, how can this sustainability be monitored when more than half of the feedstock used to produce biofuels in the EU is imported? (Buffet, 2017)

The fact that biofuels require multiple steps, and that steps can occur within different sectors and economic domain (first in agriculture and then in the energy sector) adds more layers to the openness of the system, and with each layer come difficulties in monitoring and accounting. Take the case of the Netherlands: between 2010 and 2015, the country quadrupled its consumption of residues of Used Cooking Oil (UCO) as a raw material to produce biodiesel. As it does not have an adequate local supply, it imported 81% of UCO, of which roughly 51% came from countries outside the EU (CE Delft, 2017). Following high impact media campaigns, it has become generally well known that palm oil production leads to biodiversity loss in Indonesia and Malaysia, a fact which led the EU to implement a strategy to reduce palm oil imports from Asian countries. However, the imports of UCO derived from palm oil are not limited, and if left unchecked a rise in UCO demand may lead to a rise in palm oil production. Another issue linked to the openness of the biofuel production chain is related to the double accounting mechanism, a political guideline included in the first EU renewable energy directive.

Following this guideline, the energy participation of certain residues of animal and vegetable origin are counted twice with respect to reaching the proposed objectives. What is problematic here is that not all countries have applied the guideline, and the difference in applicability has increased dynamics in waste trade. For example, Germany, which does not apply the double accounting mechanism, exports its animal fat waste to The Netherlands (where, in contrast, the double accounting principle is applied) (CE Delft, 2015). In addition, double accounting can lead to a "virtual" share of biofuels in the transport sector, which implies that this virtual percentage will be covered in the real world by another type of fuel, perhaps fossil fuels.

Biofuels are being pushed in the EU as a solution for increased sustainability and security of supply. They also generate a massive business: in economic terms, Charles et al. (2013) estimated that for 2011 the EU allocated between 9.3-10.7 billion euros to subsidize the use of conventional biofuels - a significant figure considering that the size of the biofuel market in the EU for that year was around 13-16 billion euros. Each EU country has varied agricultural production capabilities, and setting uniform targets across all member states may push governments to import feedstock to locally produce biofuels, or to see this as a business opportunity to import and export biofuels, like The Netherlands is doing. If the EU is serious about the sustainability of it transport fuels, it should account for all steps of the biofuel production process, and regulate the trade of primary and secondary products to avoid turning biofuels into a business opportunity with little positive impact on the environment.

Biofuels at a crossroads: the concerns are stacking up

Maddalena Ripa, Mario Giampietro and Juan José Cadillo Benalcazar

The International Energy Agency reports that 'modern bioenergy is the overlooked giant within renewable energy.' In the United States, as in many OECD countries, emissions from electricity generation are no longer the top contributor to climate change: the first position in terms of carbon emissions now belongs to cars and trucks. The Intergovernmental Panel on Climate Change (IPCC, 2018) recently reported that electricity's involvement in the transport mix should increase to 1.2% in 2020, 5% in 2030 and 33% in 2050, meaning that by 2030 biofuel-powered vehicles would still be as important as e-cars.

Biofuels are therefore at a crossroads. In the EU28, biofuel consumption in the transport service has grown more than six fold over the last decade, however biofuels still account for just three to four percent of all transport fuel energy. What are the concerns related to the plausibility of a fast and effective expansion of this option?

1. Around half of the EU's production of crop biodiesels is based on imports of feedstock, not crops grown by EU farmers (Transport & Environment, 2017)

Over the years 2000-2016, the production of biofuels in EU28, especially biodiesels, has increased exponentially in EU28. However, imports and exports associated with biofuels increased as well, especially in countries like The Netherlands. This scale-up adds another level of complexity, making it difficult to get a clear picture of the situation: to what extent is the production of biofuels in the EU aimed at lowering emissions, and to what extent is it a mechanism aimed at profiting on subsidies? Looking at the feedstock mix, only 47% of the feedstocks were grown in the EU for EU production in 2015, meaning that over half the feedstock mix was imported (EC, DG AGRI, 2016). Evidence for this can be found in the different oils used in the EU: in 2016, according to OilWorld, 33% of EU vegetable-oil biodiesel came from imported palm oil. Rapeseed still remains the most used raw material (around 60%). This is also true for Used Cooking Oil (UCO): according to the European Commission DG AGRI Medium-Term Agricultural Outlook, 56% of raw materials used for the production of biodiesel in Europe originated from within the Union in 2015. However, this figure assumes that waste oil is all domestic, which is incorrect. Imported used oils mean it is likely that less than half of the biodiesel supply is from EU production.

2. There is debate about whether biofuels represent a net energy supply (i.e., whether biofuels require more energy inputs in their production phase than what they provide).

The process of growing crops, manufacturing fertilizers and pesticides, and processing plants into fuel consumes a lot of energy. At the moment, most of the energy used in the various phases of production comes from oil, coal and natural gas (fossil energy). This implies that the assessment of the net energy supply of biofuels is still quite controversial. Endless discussions and a large amount of scientific publications have been dedicated to this issue. For example, various studies have estimated the EROI (Energy Return on Investment) of corn ethanol at between 0.8:1 and 1.7:1, meaning that we get between 0.8 and 1.7 joules of energy from ethanol for every joule of energy invested in producing that ethanol. The EROI of gasoline, by comparison, is between 5:1 and 20:1, depending in part on the source of the petroleum (Hall et al., 2011). However, the general agreement is that, when compared with the production of fossil fuels, the energetic convenience of producing biofuels is much lower, even less in case of advanced biofuel (Forbes, 2018).

3. Total life-cycle greenhouse gas emissions from biofuels are virtually impossible to measure
While 'direct emissions' can be lower for biofuels (if one agrees on how to calculate the net supply), the assessment of 'indirect emissions' are elusive. Greenhouse gases (GHG) are emitted throughout various stages in the production and use of biofuels: in producing the fertilizers, pesticides, and fuels used in farming, during chemical processing, transport and distribution, up to final use. This process involves a significant amount of fossil energy uses along the entire supply chain that can make biofuels less environmentally friendly than petroleum-based fuels. In relation of indirect emissions, the elephant in the room is represented by the potential increase of overall GHG emissions due to indirect land-use change (ILUC) – e.g. the controversy over palm oil. Indeed, when considering in the assessment the effects of land-use changes, the claim that biofuels do imply a reduction of emissions becomes very difficult to defend.

4. What about aviation?
Between 2005 and 2017, carbon dioxide emissions increased by 16% and nitrogen oxide emissions went up by 25%, according to the second European Aviation Environmental Report (EAER). Specific to aviation, total GHG emissions were projected to increase by 400%–600% between 2010 and 2050, based on projected growth in travel (ICAO, 2013). In relation to the growing concern for this specific typology of liquid fuels, the potential use of biojet kerosene is very limited because of the higher cost compared with petroleum jet fuel. There are several initiatives to promote aviation biofuel, such as higher subsidies, but…as the International Air Transport Association forecasts the 3.8 billion air travelers in 2016 to double to 7.2 by 2035, the question arising is: is there enough land available to produce biojet fuel?

5. There isn't adequate technological infrastructure to produce advanced biofuels in the EU
In the effort to decarbonise the transport sector, EU Member States recently decided to revise the Renewable Energy Directive (RED II) setting an obligation for Member States to ensure the achievement of 14% Renewable Energy Sources (RES) in transport by gradually phasing out crop-based biofuels (from 7% in 2020 to 3.8% in 2030) and boost 2nd and 3rd generation biofuels. However, the production of advanced biofuels from non-food crop feedstocks is still limited. Biodiesel and HVO (Hydrotreated Vegetable Oil) from waste oil and animal fat feedstocks is around 6-8% of all biofuel output and is anticipated to remain modest in the short term, as progress is needed to improve technology readiness (IEA, 2019).

6. There is an acute lack of transparency about the biofuels used in the EU
Data about biofuels can generate confusion in relation to three main points:

- What 'biofuels' are we talking about? - the label may refer to liquid fuels, biogas or wood pellets. These three different forms have very different functions – wood pellets, for example, cannot be used to power a car. Summing up these three different energy forms into an overall estimate should be avoided because the overall number generated by summing 'apples' and 'oranges' does not have any policy relevance and muddles the discussion;
- What 'primary source' are we talking about? - production can be based on two different processes. The first is the actual production of biomass. This type of primary source entails constraints on supply related to the availability of land, water and the ecological sink capacity for technical inputs. A second process is the valorisation of wastes. Here, we are dealing with 'secondary sources' leading to constraints on the supply determined by the availability and the cost of collection of the waste. Addressing this difference is essential to estimate how much the given supply of biofuels can be scaled-up when looking for a substitution of the actual consumption of oil;
- Accounting of imports - imports of biofuels 'energy carriers' vs imports of feedstocks 'primary sources'. The emissions associated with the processes taking place in the countries generating the imported inputs are often neglected in local assessments. Moreover, double counting was included in the RED I (art. 3f) and was applied to the advanced or second-generation biofuels. Double counting means, for instance, that if molasses consumption is 2%, it will be counted as 4% of the total energy used in transport.

With growing fuel demand in the transport sector, all these controversies surrounding biofuels should deserve attention at the science-policy interface.

Electric cars: an answer to the wrong question?

Louisa Di Felice

When they were first commercialised in the 1880s, electric cars had a brief moment of glory – or at least brief in technological terms, as they were the car of choice in the US and in Europe for almost three decades. 1Their popularity against steam-powered and gasoline cars was due to faster start up times and a lack of vibrations that led to an overall smoother driving experience. The underdeveloped intra-urban road infrastructure also had a part to play in their success, as it meant that cars were mostly needed in cities, with longer journeys being covered by trains. However, things quickly turned sour for electric car manufacturers in the 1920s, when the availability of cheap oil and the expansion of road infrastructure boosted the popularity of cars with internal combustion engines (ICEs), which could be used for longer journeys at a cheap price.

Fast forward almost a century later and ICEs are still dominating the road transport market, locked into a vicious cycle of expanded infrastructure and consumption of liquid fossil fuels. Recent trends, however, point to a potential renaissance of electric cars. While the number of regular cars on the road still greatly outnumbers those running on alternative fuels, concerns over pollution, climate change and security have contributed to a revival in the interest for the ICE's long forgotten technological opponent. Take the European Union, for example: in 2018, electric car sales increased by 42%, leading to a flood of articles proclaiming that the era of ICE vehicles is over. With an average of lower lifetime GHG emissions (although strongly dependent on the electricity mix), reduced air pollution and a potential to reduce imported oil, it is easy to see why electric vehicles have become popular in sustainability discourses both in the media and in policy circles.

On the other side of what seems to be a win-win solution, social and environmental implications linked to their material requirements taint electric cars' green reputation. The amount of lithium needed for batteries is high, and is expected to grow exponentially as the demand for electric vehicles rises – even more so given the underwhelming recycling rates of batteries and their short lifetimes. To give an idea of the scale of the problem, the Tesla Model S contains 12 kilos of pure lithium, while an iPhone battery uses less than a gram. Not only does the high concentration of lithium in a few countries pose security of supply concerns, with the risk of shifting from an oil dependency to a lithium dependency, but the extraction itself has led to a number of ongoing conflicts due to water use and pollution as well as poor working conditions, among other reasons.

Earlier this month, twenty indigenous communities of Northern Argentina, whose land falls under what is known as the lithium triangle spanning across Argentina, Bolivia and Chile, protested in mass against lithium mining, on environmental as well as cultural grounds. One of the arguments put forth by the communities, which is underrepresented in Western framings of benefits and trade-offs, is that the extractive activities clash with their social philosophy of Buen Vivir. Lithium isn't the only resource to be concerned about: electric car batteries also require cobalt, which is notoriously linked to child labour in the Democratic Republic of Congo.

These issues are deeply entangled within dynamics of extraction and consumption that permeate the use of resources in the global economy. Electric cars are not generating new patterns, but if implemented on a large scale they have the power to exacerbate existing ones. Their capacity to contribute to an unequal distribution of environmental burdens, and of local and global effects, lies in the green narrative that makes them so popular. By framing electric cars as a necessary solution to fight climate change, other effects of their large-scale implementation risk being cast aside as secondary ones, somewhat inevitable in the fight for the greater good. Critical transport scholars, however, stress that electric vehicles are simply one part of a portfolio of solutions needed to transform the transport sector into a sustainable one. This resonates with discourses of deep sustainability, which call for changes in both technologies and practices. Being part of the complex social-ecological system, these types of changes are not separate: the introduction of a new technology may have unpredictable effects on human practices depending on a number of factors, including culture and mind-set. The current western car culture upholds the ideal of individual freedom through an unregulated use of personal vehicles. Introducing electric cars into this environment may carry the risk of fostering a transport culture that is dominated by personal cars, outshining alternative practices such as car sharing and the improvement of public transport networks.

These alternatives are central to a sustainable transport revolution that aims at changing not only how cars are run, but also how people get around. The generation of scientific knowledge has a part to play in giving weight to a diverse portfolio of alternatives. The majority of academic discourses on the topic of electric cars has so far focused on the comparison between the sustainability of different types of engines (electric vs. ICE). Taking a different view of the issue, in MAGIC we are zooming out of the picture and comparing the effects of a fully electric car fleet in Europe with other types of changes, such as car sharing and an increased use of public transport. Focusing on the nexus, we will check through different scenarios how behavioural and technological changes compare in terms of GHG emissions, labour, energy and water use. It is likely that a sustainable future will require a combination of all of these solutions, but by reducing the scientific debate to a comparison of technologies we risk forgetting about behavioural alternatives.

The Sharing Economy: More than a new business model?

Roberta Siciliano

Have you ever used a service offered via a collaborative platform? Nearly a quarter of Europeans have, according to a 2018 survey of 26,544 citizens from different social and demographic groups (Flash Euro barometer, 467). One in two has done so in accommodation by renting an apartment (57%) as well as in transport by car sharing (51%) (multiple answers possible). Eight in ten would recommend it in almost all countries, with the Netherlands being the only exception. Collaborative platforms are considered a convenient access to services; thanks to the availability of rating and reviews by users. When it comes to transport, platforms facilitating car sharing and car-pooling rank among the most popular in Europe.

What is driving the shift towards a sharing economy, and can it fix the problems of Europe's unsustainable transport system? Perceived sustainability is an important factor in the formation of positive attitudes towards a sharing economy, but economic benefits are a stronger motivator. Thus, environmental benefits tend to be a secondary effect rather than a primary mover of the sharing economy.

From a policy perspective, regulations and technological possibilities differ greatly per country. The European Commission has fixed "A European Agenda for Collaborative Economy" to coordinate important aspects such as requisites of access to the market, responsibility criteria if the platform has only intermediation functions or also guarantees payment, user protection, job regularization of subcontracted workers, the fiscal duties. Nonetheless, there is still a lack of rules and agreements, so the desirability and equity of a sharing economy remain questionable, as the harsh confrontation between Uber and taxi drivers in many occasions has highlighted, with echoes of the recent taxi strike in Barcelona that spread in many other major Spanish cities still in the air.

From the economic standpoint, it seems this business model has many benefits for individuals, companies and society. This is why it is one of the fastest growing business trends in history with investors dumping more than 23 billion in venture capital funding since 2010 into start-up operating with a share-based model. Most business is private so that is impossible to know the actual size of the sharing economy. However, there are several clues to indicate its massive impact on our society. Uber along with Airbnb have a combined $103 billion market cap, which would rank the as the 38th wealthiest country in the word. McKinsey estimates that in the U.S. and

Europe alone 20-30% of the workforce are provides on sharing platforms. And there is still opportunity for growth: PwC study on 2017 has evaluated a market value of 28 billions of euro in Europe on 2015 with an expected value increasing up to 570 billions on 2025.

Uber is not the only transport platform used by Europeans. The Share Economy Automotive and Transportation sector includes services such as car-, ride- and bike-sharing. In addition to Uber, companies such as MyTaxi, Car2Go and DriveNow are transforming urban mobility. Car-sharing fleet operators offer flexible mobility solutions and Car2Go and DriveNow had customer bases of 2.2m and 0.75m people respectively by the end of 2016. Additionally, there are peer-to-peer car- and ride-sharing solutions such as Zipcar or Blablacar. The e-hailing sector is also growing rapidly in Europe and both Mytaxi and Taxi.eu have more than 100,000 drivers. Therefore, the urban mobility environment is changing rapidly – even in smaller cities, in which big players such as Deutsche Bahn, LIDL and particularly regional energy providers develop bike- sharing networks. Based on PwC study, the European market in 2017 reached €9.5billions with an expected increase of 90% already in one year.

Uber's ascension in the transportation industry is one of the best examples to illustrate the effect of the sharing economy in a traditional sector. Uber and other ride-sharing services offer an affordable, safe, and convenient alternative to traditional transportation options such as public transit or taxicabs. By utilizing an efficient mobile application and network of vetted drivers, Uber satisfies consumers' transportation demands while providing an arguably better user experience than traditional means. But, as mentioned above, this new moon also has a dark side. In New York City alone, there are roughly 4.5 times more Uber drivers than yellow cabs. This has caused the price of owning a taxicab in New York City to drop from $1 million in 2015 to less than $200,000 today. Top Sharing Economy Brands in the Transportation Space: Uber ($72 Billion), Didi ($50 Billion), Lyft ($11 Billion).

In the car sharing segment of the fast growing sharing economy, the environmental benefits are actually limited and mainly a corollary of the economic ones. Cars could be considered responsible for around 12% of total EU emissions of carbon dioxide (CO2), the main greenhouse gas (European Commission, Climate Action, 206). Even if a 20% saving could be reached through more eco-friendly vehicles combined with better driving practices, given that the share of these vehicles only amounts to 5% of all, passenger cars circulating in the EU, they would reduce total emissions by an underwhelming 0.12%.

Nonetheless, local effects beyond climate change should not be ignored. A substantial change in mobility patterns is central in easing congestion and pollution in cities: according to a study conducted on 2015 in the

Netherlands, the reduced car use of car sharers yields an annual CO2 reduction of 90 kilograms on average, an encouraging figure calculated following a Well-To-Wheel approach (WTW), including the emissions involved in fuel production (both for petrol and electricity).

In conclusion, car sharing is not the dreamed "silver bullet" that can fix the excessive burdens imposed by private transportation on cities, unless combined with changes capable of much more substantial impacts on mobility. It is worth quoting European majors struggling with traffic issues who recognize that policy actions to promote greener mobility must include both soft and hard measures and that car sharing is still a significant piece of the puzzle.

As in all nexus-related issues, governance is called in and contrasting narratives that animate the political debate and sustain the proposed solutions should be collectively mobilized toward a socially constructed wise way for mobility.

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IX
LAND USE

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Research in the MAGIC project understands land as a crucial fund in resource accounting, which reflects not only the Earth's surface, but also land uses and the various land management systems that are the interactions of human activities with environmental resources.

The articles in this issue of The Nexus Times talked about the relation between land-use research and social metabolism analysis and highlighted how land could play a "pivotal" role in shaping a way to better understand and respond to the challenges of achieving sustainability within the water, energy, food and environment nexus. Doing so, they touch on the relation of land use and biodiversity, provide historical perspectives on land-use patterns and reflect on the role of land within the water-energy-food nexus.

This thing called Land Use: Reflecting on a life in land use research

Keith Matthews

The sign on the open plan door that I walk through on my way to my office says Land Use. It has said Land Use since 1992 when I moved into our new building, opened to house the then five-year-old Macaulay Land Use Research Institute. The sign has never changed, despite reorganisations, rebranding, reviews and mergers. While there are no longer thematic departmental structures in the now James Hutton Institute, the sign still defines in two words an idea that profoundly shapes the professional and personal lives of a significant majority of the people who pass the sign each day. It represents a community of practice with deep roots, but one which is, perhaps only now 27 year later, able to fully articulate the ambitions of the people who put the sign on the door.

To elaborate a little what this thing called land use research is I searched my book shelves for a vaguely remembered report I had been passed by a senior colleague from the Land Use Division on his retirement. It has sat there largely undisturbed, surviving decluttering, as a piece of institutional history. The report is a Review of Land Use Research in the UK (Birnie et al., 1995) and the contents are a fascinating time capsule which highlight what the original vision for land use research was and which allows readers today to reflect on how far their own state-of-the-art has advanced and how many of the problems faced in 1994 are still ahead of us now.

- There is an increasing need to develop more coordinated research programmes in the future focused on major issues like sustainability. The wider rural socio-economy is generally a poorly researched topic …
- The vision of agriculture as "the backbone of the rural economy " is still prevalent […] this Review suggests that the rural economy a much more complex policy objective than is, for example, the wellbeing of agriculture. It raises issues […]that have seldom been considered together before.
- Few scientific groups […] are capable of delivering across the range of disciplines involved. […] need to find ways of creating and nurturing such interdisciplinary groups if a coherent body of relevant knowledge, theory and expertise is to be developed.
- […] for research to be classified as "land use science" […] it must seek explanation through an integrative, multi-disciplinary approach and preferably be focused on whole land systems[…] above the individual […] above the field".

- Little evidence of underpinning theoretical or methodological research that seeks either to develop a framework for integrated research of this type or develop a fundamental understanding of process.
- There is the need to involve the user community in the research process where the output is specifically designed to support the policy process. […] little evidence of this […] little understanding of how this might be done […] far from clear how research findings are communicated […] to what extent research actually informs policy.

For the Hutton researchers in the MAGIC team our view would be that all the challenges identified above remain "live" issues but that projects like MAGIC are demonstrating progress and signposting ways forward. The societal metabolism analyses pioneered by Mario Giampietro and others at UAB bring a theoretical coherence and analytical precision to the analysis of land use and provide a tractable way to make sense to the potentially overwhelming complexity. Land Use research brings to societal metabolism analysis the insights of spatial analysis. Yet even their combined scientific rigour still needs to be translated into outcomes and impacts. Here the deliberative inclusive processes, crossing the science-policy interface using Quantitative Story Telling (QST) are key. QST recognises that transdisciplinary research should strive to shape policy (colloquially speaking truth to power) but also that is must engage with and be shaped by stakeholders (post normal science).

The study of land use has never been more relevant with the recognition that the challenges faced by humanity are increasingly clearly not just socio-economic but also biophysical. How populations cope with resource limits are old challenges, thought to have been consigned long ago to the text books of economic and social history (my first undergraduate lecture in 1985). Yet whether Malthus proves to be wrong or not, may just depend on the temporal scale over which one considers the topic of land use.

The climate change policy challenge: Balancing the multiple roles of land use

Mike Rivington

Responding appropriately to climate change presents many complex challenges for policy makers and other stakeholders, especially when considering the use of land for mitigation and adaptation purposes. This is because they represent additional burdens imposed on the biosphere on top of all the others. The capability and capacity of land to provide goods and services will also be affected by climate change impacts (e.g. changes in rainfall amounts and extremes (IPCC, 2018a). These impacts will coincide with population growth and increasing demand for resources per capita. Further, the quality of available land has been and continues to be degraded. The recent Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Global Assessment Report painted a stark picture of degradation of the worlds ecosystems and loss of biodiversity (IPBES, 2019).

For climate change mitigation, afforestation and bio-energy crops are argued as having the potential to capture carbon and reduce the use of fossil fuels. This makes them an essential component of policies to achieve net zero emissions as they can offset emissions from sectors where it will be neither technically feasible nor economically viable to eliminate GHG emissions (van Vuuren et al., 2011). Yet any plantation for woodland expansion within the EU would need to be set against the substantial losses of old growth forests in the tropics. This creates an additional demand on land, adding to the developing conflicting requirements made on it at a time of the need for increasing food security.

Cutting through this complexity is the need for policy makers to understand "what are the required changes in balance between land uses needed in order to keep temperature rise below 1.5°C?". This question has been explored in the Shared Socio-economic Pathways (SSPs) (Raihi et al., 2017), and subsequent analysis of mitigation pathways (IPCC, 2018b) to inform policy makers on opportunities for carbon dioxide removal. The IPCC report (2018b), figure 2.11 illustrates four alternative scenarios for the global land requirements for bioenergy with carbon capture and storage (BECCS) and afforestation and the consequent reduction in the area of other land uses. The figure portrays land use changes in 2050 and 2100 (in relation to 2010) in four socio-economic pathways that are consistent in potentially limiting temperature rise to 1.5°C (IPCC, 2018b).

All these 1.5°C scenarios have a reduction in area for food production, most noticeably in pasture, though much less so for the Low Energy Demand scenario (LED) (Grubler et al., 2018). The reduction in crop and pasture areas are to enable increases in energy crops and forests. Such substantial changes in land use have very large consequences on existing land-based economies (e.g. the livestock industry) and societies and thus present complex trade-off issues. Add to this that there are difficulties of carbon accounting for such land used (e.g. see Nexus Times "Why it is so difficult to measure biofuel emissions") and for competing land uses means the need to adequately frame and conduct analysis in a way that does not seek to "simplify out" or ignore the complexity.

To identify potential solutions to this complex set of problems (development pathways that lead to sustainability) within a Social Metabolism

Analytical framework, it is helpful to use three key benchmarks:

- Is the solution Feasible? Can the development pathway be achieved within the limits of available resources? Does it respect ecological limitations such as water availability restrictions and the need to maintain soil health? Therefore, is it physically feasible?
- Is the solution Viable? We in the EU currently solve feasibility problems by externalising them, e.g. by using imports, but what are the consequences of this? Will externalisation remain feasible during the period of transition to a new and sustainable state?
- Is it Desirable? Does the pathway resolve some issues but not others, or compound other problems and therefore risk not achieving sustainability? What does it do for aims such as the Sustainable Development Goals?

These questions identify dependencies (e.g. risk of externalisation) that whilst trying to resolve one problem cause another. For example, in 2009 the EU set targets in the transport sector for renewables and the de-carbonization of fuels that lead to substantial investment in biofuels (Valin et al. 2015), the production of which were outside of the EU. Hence the development of the biofuels industry has driven the expansion of cultivated land (e.g. causing deforestation). This has posed substantial issues in carbon and environmental impact accounting (see Nexus Times "Meeting EU biofuel targets: the devil is in the detail").

The details above have created a picture of a land use and climate change complex 'wicked' problem. It is yet unclear what a feasible, viable and desirable pathway solution looks like. What is clear, though, is that conventional economics-based approaches to cost benefit analysis, with limited risk assessment, single scale accounting and trade-off analysis whilst considering ecological and entropy limits, are inadequate to deal with such complex problems. Within the context of a deteriorating environmental state, growing resource demand and climate change pressures, land is a key medium through which to consider the food-energy-water nexus using a MAGIC Social Metabolism Analysis approach.

Balancing food production and biodiversity conservation

Akke Kok and Abigail Muscat

Agriculture causes some of the largest impacts of land use and is a key influence on biodiversity conservation. Agriculture has both negative and positive impacts on biodiversity. The conversion of natural land and changes in agricultural land use directly result in habitat loss and fragmentation. Also, agriculture contributes to environmental impacts such as climate change, that indirectly cause biodiversity decline. In contrast, agriculture is a major contributor to Europe's biodiversity, through diverse farming traditions that have resulted in a wide range of agricultural landscapes. In aggregate, however, farmland biodiversity shows a rapid decline, due to changes in management such as intensification and industrialisation of agriculture. For example, populations of farmland birds have more than halved in the last three decades.

To effectively conserve biodiversity, we need to define what is biodiversity, and what targets to set. This is not a straightforward task. Defining biodiversity and setting targets relies, to a large extent, on stakeholder input and societal values. One stakeholder may wish to conserve a specific group of vulnerable or iconic species – such as meadow birds, whereas another focuses on generic conservation measures to reduce extinction risk across species within agriculture. Others may argue that it is better to produce food as intensively as possible in a limited area, so as to spare other land from agriculture to conserve natural habitats, such as forest. Either way, creating or maintaining a suitable landscape for some species will potentially be less suitable for other species. Because it is not possible to boost all species everywhere while still delivering the provisioning services of food, fibre and increasingly energy, then one has to choose which landscapes and inhabiting species to conserve and to what extent.

The EU released the EU Biodiversity Strategy in 2011 to halt the loss of biodiversity by 2020 (European Commission, 2011). To ensure conservation of biodiversity in agriculture, the target is to maximise areas under agriculture covered by biodiversity related measures under the Common Agricultural Policy. However, biodiversity assessments at EU level have so far shown that biodiversity loss has continued, and that more stringent protection is required to stop biodiversity decline.

To develop more effective scenarios for biodiversity conservation on agricultural land, we interviewed experts and stakeholders in biodiversity conservation and assessed proposals for conservation in the Netherlands and France. More heterogeneous landscapes and more extensive (i.e. lower intensity) production were key in their priorities to boost biodiversity. Our scenario calculations suggested that measures to conserve a specific species or habitat, could be realized with a limited overall impact on the existing patterns of land use and food production, because measures only applied to a limited share of the land. Going to more extensive practices to mainstream biodiversity conservation throughout agriculture, however, would have a much larger impact on food production, because it would affect all agricultural production. Especially in case of a large reduction in food production, this could result in intensification of production or land use change elsewhere. Alternatively, a reduction in food production could be achieved by less food waste, less over consumption, and dietary changes.

In conclusion, there is an unavoidable trade-off between biodiversity conservation and food production. Therefore, conservation scenarios may have unwanted effects in regions other than the conservation area due to land use change elsewhere. More effective biodiversity conservation will depend on societal values and stakeholder input around land use. Targets are needed, but policy-makers should be aware of the process, values, frames, and narratives behind these targets.

Land use change connected with the evolution of farming systems: modernisation in practice

Richard Aspinall and Michele Staiano

How land use changes through time says a great deal on the story of a country; a review of the path it followed in biophysical and economic terms could significantly help in highlighting the trajectory and capturing the relationships it discloses about the nexus. The recorded history of land use change encapsulates and summarises the ways that policy and institutional changes, including governance, and national and international pressures, play out in practice, rather than in the economic theory that attempts to inform decision-making.

In a recently published study we have explored the sequence of changes in agricultural land use and the dynamics of change in provisioning services from agriculture in Scotland between 1940 and 2016. The goal, to develop understanding of whole-system and landscape-scale approaches to ecosystem services, food production, and land use, calls for including a metabolic analysis alongside an economic reading of the long time series. Specifically, our analysis identifies ways in which funds of capitals and flows of inputs and output ecosystem goods are linked to land management practices and policies at a national scale.

Figure 1 shows for Scotland as a whole, for the periods 1950-4 and 2005-9,the average economic inputs and outputs, the energy inputs, outputs and end-uses of agricultural products, and the land used for agriculture, The figure thus provides a summary of the funds of land and the related flows within the agricultural land system.

Although Scotland's has remained a mixed arable-livestock farming system, with livestock the more significant component, these figures highlight large changes within the system. Even though the total area of arable land has remained almost the same throughout the time there have been increases in area for wheat, barley, oilseed, cash crops, fallow, and permanent grass, and declines in area for oats, potatoes, turnips, and rotation grassland (Figure 2).

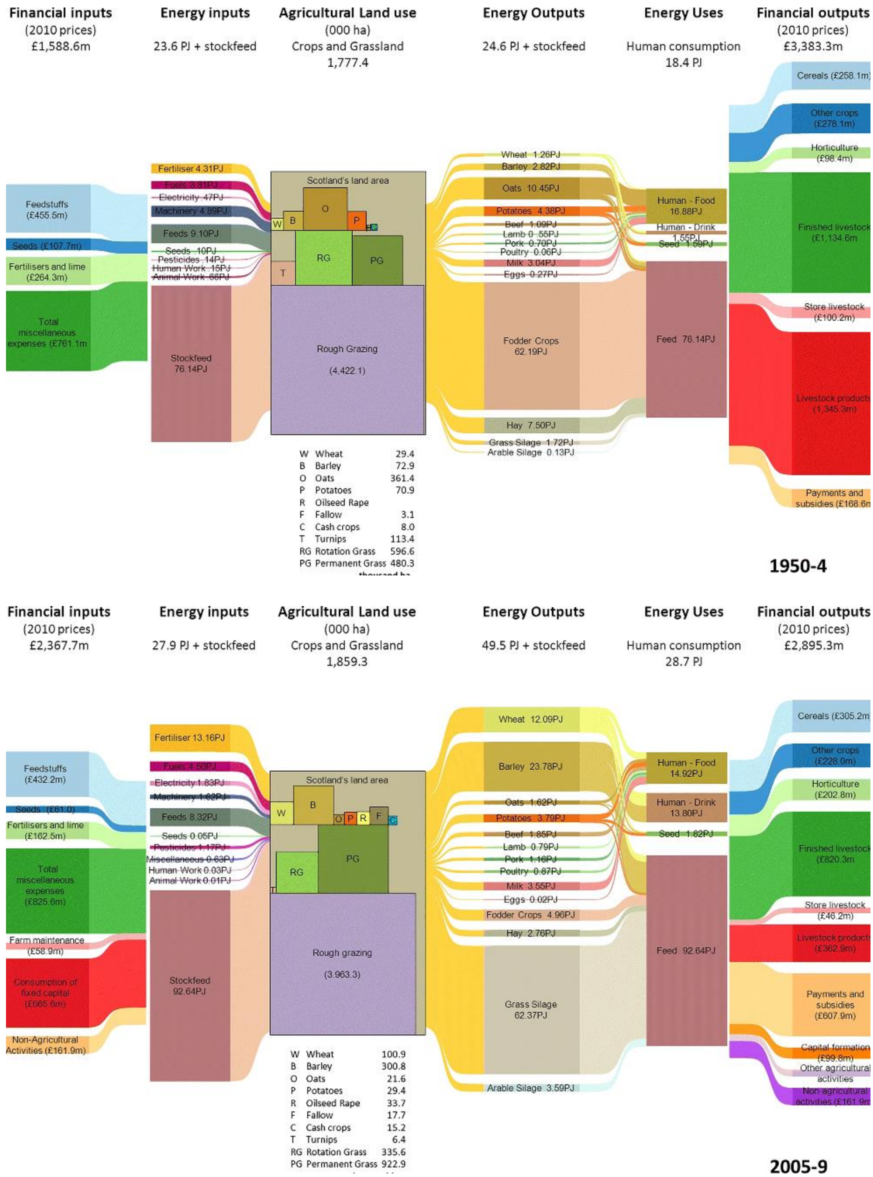

Figure 1. *Sankey diagrams for financial and energy inputs and outputs through agricultural land in Scotland, 1950-4 and 2005-9. All financial values are in 2010 prices. Source: Aspinall and Staiano, 2019.*

Comparison of inputs and outputs for finance shows a greater return on investment in 1950-4 compared with 2005-9, total output being more than double the input as opposed to about 1.2 times for 2005-9. Return on direct operating costs, ignoring capital investment in farming, in 2005-9, though, remains at about 1.95 times. The financial data in Figure 2 also show the increased real terms value of cereals, horticulture, and payments and subsidies in 2005-9 compared with 1950-4. Similarly, finished and store livestock, and livestock products are relatively of lower value. Fertilisers and seeds cost less in real terms in 2005-9 than in 1950-4.

Figure 1 also summarises inputs and outputs measured as energy. Although the total energy inputs in 1950-4 and 2005-9 are similar, the total energy outputs are much higher in 2005-9 than in 1950-4. There are large increases for wheat and barley, and large relative increases for pork, and poultry between the two periods. Oats and fodder crops show declines, while grass silage has increased. Inputs of fertiliser measured in the energy account shows that about three times as much fertiliser is used in 2005-9 compared with 1950-4.

Further, Figure 1 shows the end uses of the outputs from agriculture, measured in energy units. Although the total energy content of agricultural products used for human food is similar in the two periods, the amount used for making drink, through distilling and malting, has increased by 9 times over the last 50 years. The proportion of cereals used for stockfeed remains at just over 50% of production.

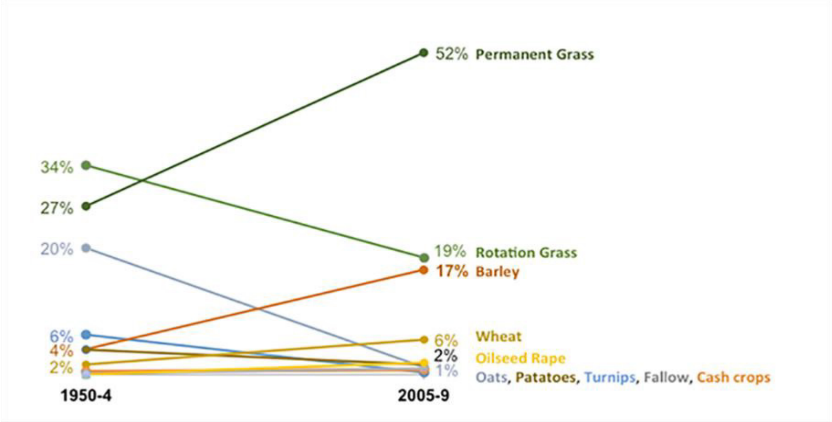

Figure 2: *Change in area of key crop types between 1950-4 and 2005-9 in Scotland*

Using an integrated accounting approach for understanding the use of agricultural land to supply provisioning services, and, particularly, examining a long time-series of accounts, enables understanding of land changes and underlying drivers, as well as the contribution of cultural and other aspects of human systems coupled with environment systems. Accounting for ecosystem services using costs as well as benefits, measured by metrics beyond financial benefit, can effectively support debate and evaluation of trade-offs between services, impacts of land management activities, and has direct relevance for decision- and policy-making.

It is not surprising to see that, in general, Scotland's agriculture has modernised since 1940, and particularly since 1973 when the UK joined the Common Market. Interestingly, it has become more efficient in conversion of resources, with a consequent increase in delivery of provisioning goods and services, albeit with associated increase in pressures on natural capital.

The tradeoff between land use and natural capital

Richard Aspinall and Michele Staiano

Our recent study of land use change in Scotland explored the sequence of changes in agricultural land use and the dynamics of change in provisioning services from agriculture in Scotland between 1940 and 2016. Among the changes associated with modernisation of land use in Scotland, our analysis identified some ways in which funds of capitals and flows of inputs and output ecosystem goods are linked to land management practices and policies.

Our analysis is summarised for each year from 1940 to 2016 in Figure 3, using a series of benchmarks computed from flows and funds. Figure 3-a records the total financial inputs and outputs and total income from farming (at 2010 prices) and Figure 3-b the total energy inputs and outputs as well as the yearly balance (output-input). Results for inputs and outputs for both finance and energy follow the same general pattern of change over time, although the energy and economic efficiencies, measured as the ratio of outputs to inputs or simply as the excess of outputs over inputs, show two different patterns (Figure 3-a and b). The economic efficiency of Scotland's farming system, taken as a whole, was greater, in real terms, before 1973, than since. This period of greater efficiency coincides with the period of deficiency payments from 1947 until 1973, guaranteeing prices. The energy efficiency, however, shows a different pattern, with increased efficiency following modernisation of agriculture and greater intensification after Britain joined the Common Market.

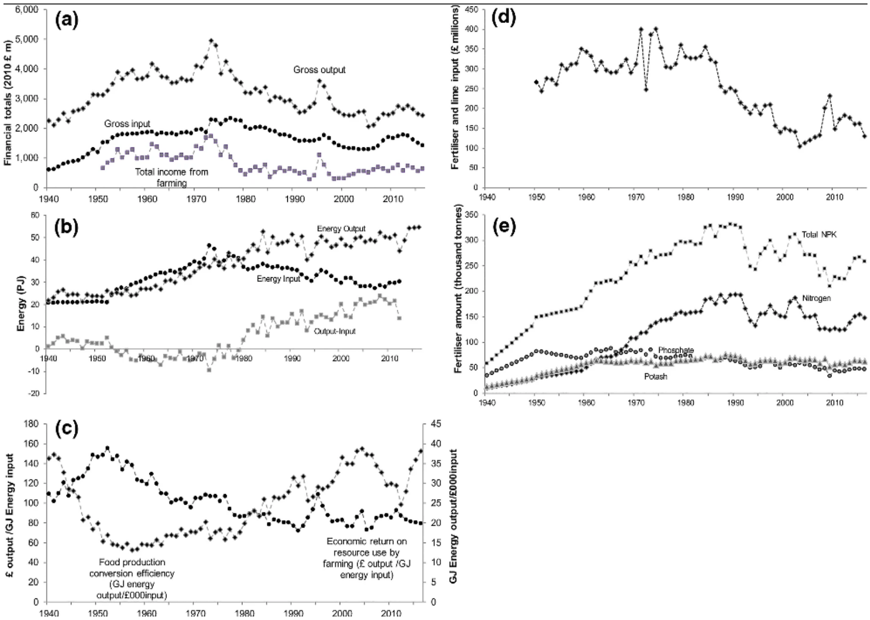

Figure 3: *(a, b, c, d, e). Our analysis is summarised for each year from 1940 to 2016, using a series of benchmarks computed from flows and funds. Source: Aspinall and Staiano, 2019.*

Figure 3-c shows two flow-flow ratios: food production efficiency of agriculture, as conversion of finance to energy (GJ energy output/£000 input) and the economic return on resource use by farming (£000 output value/TJ energy input). These two graphs combine the energy and economic output-input ratios, showing the complex change in efficiencies that have occurred between 1940 and 2016. The graphs emphasise the changes summaries in the Nexus Times article (this issue) 'Land use change connected with the evolution of farming systems – modernisation in practice', placing these periods within a sequence of changes that have:

- increased flows of provisioning goods through increased production,
- increased the energy and resource use efficiency of farming, and
- seen a decline in the economic efficiency and value (in real terms) of provisioning goods.

Figure 3-d shows the expenditure on fertiliser and lime inputs to Scotland's farming from 1950 to 2016, highlighting a decrease in cost over time. Figure 3-e however, shows the quantity of fertiliser used in Scotland each year, and

particularly, the increase in nitrogen fertiliser used, albeit with a tendency to decrease since the early 1990s.

This history of land use change, shows that although the energy efficiency and flow of goods per unit hectare and per unit labour have increased as farming has modernised, the inputs necessary to maintain those flows of ecosystem goods are also increasing, as their relative economic costs decrease. Increases in use of fertiliser suggest that the natural capital fund is not being maintained without a large, and increasing, input. Our analysis of the complexity of the coupled agricultural land system also shows that land management rather than biodiversity is a necessary subject for evaluation of provisioning services from agriculture, and that loss of natural capital under current management practices is unsustainable, given the large inputs of fertilisers that are required annually

The Nexus and Land: the spinning record and the pivot

Michele Staiano and Richard Aspinall

The way we strive to capture the Nexus in the MAGIC project is with the aim of describing the key metabolic processes that make it possible for our societies to reproduce themselves. We are aware that these processes operate concurrently in different spheres and at various temporal as well as spatial scales; the MuSIASEM approach is precisely about addressing the relationships they show and highlighting them in story-telling to inform social debate and policy making.

Land should represent an unforgettable fund in resource accounting. As a fund, land reflects not only the Earth's surface, but also land uses and the various land management systems that are the interactions of human activities with environmental resources. Those complex interactions make any attempt to model the processes even more challenging; nonetheless, it is useful to envision a conceptual model that describes land systems as a coupled human-environment system (Figure 4).

Land and land systems link to resource accounting and to the operation of multi-scale integrated assessment for nexus issues in a variety of ways. Land represents a geographical area, defined by relevant boundaries; a production factor, in the sense that Ricardo, in the early 19th century, described land, labour and capital to identify a set of resources and their uses; and a set of geographically distributed human and environmental funds, qualities and processes. As a geographic area, land gives a place-based foundation for analysis of how nexus issues affecting specific combinations of people and environments. As a production factor and set of human and environmental funds, land embodies ideas of natural capital as the fund that yields a flow of ecosystem goods and services. We argue that the roles and importance of natural capital are to be included in MuSIASEM, as a tool for investigating sustainability, through land systems and land use.

Understanding land use in sustainability and the nexus face a number of issues: Figure 4 could offer a glimpse of how many sub-systems, roles and processes express their interactions in the frame of land system.

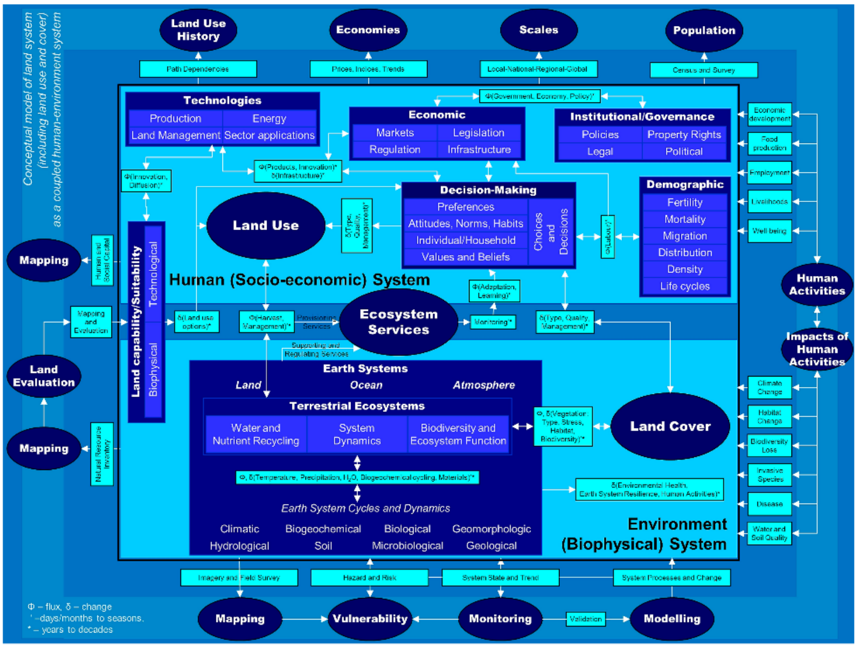

Figure 4: A conceptual model of land system. Source: Aspinall and Staiano, 2017.

So, where to start? In the Figure 5 we present the latitudinal distribution of land cover of the Earth, along with graphs of population density and elevation; this visualization clearly shows that also at global scale there are many ways to explore and examine data for human and environment systems and the way they interact, as we attempt to establish a sustainable future.

The upper frame of the Figure 5 includes a smooth graph of total population by latitude (based on 0.5-arc-minute resolution data) along with the plot of maximum and mean elevation. It gives a picture of the distribution of population on colonized land by latitude (see the labels of main continental areas under the graphs). In the lower frame the distribution of land cover by latitude is depicted. Even at a coarse scale it is easy to see how limited the potential area for expansion for cropland is and the link between the location of pasture land and higher population densities. From the combined reading of the two frames it appears clear that orography and climate leave limited opportunities for big adjustments at the global scale.

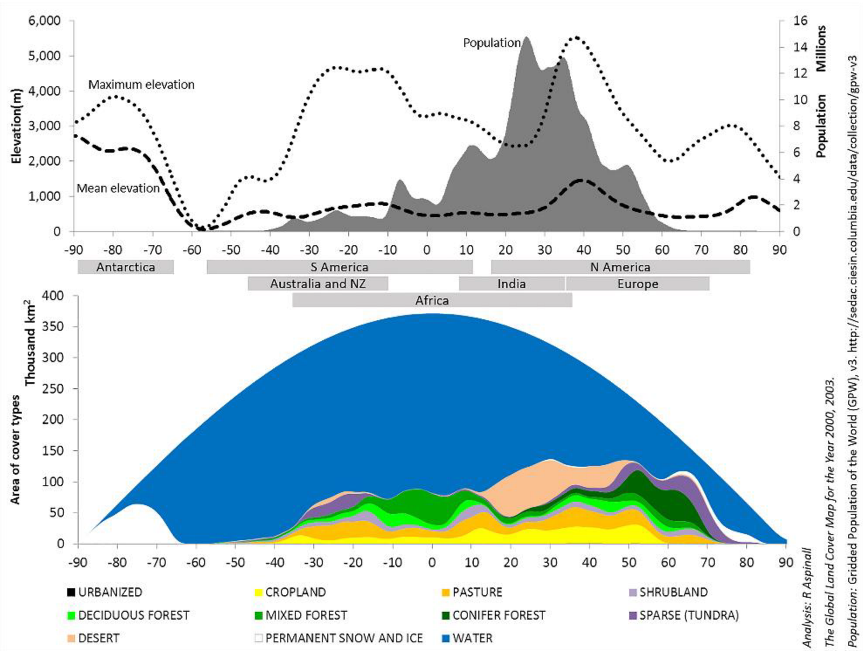

Figure 5. *A visualization of Earth elevation (maximum and mean), population (upper frame) and area of land cover types by latitude (lower frame).*

Land (through soil, land cover and land use) delivers a vast set of vital functions, primary productivity, water purification and regulation, carbon cycling and storage, recycling of other nutrients and wastes, habitats for biodiversity and cultural services (like landscape aesthetics and sense of place), that all sustain and enrich our lives.

Metaphorically speaking, a working, balanced nexus that offers the possibility of sustainability, can be thought of as orchestral music played on a well-mixed record. All the parts are harmonized so that we can really enjoy the music, being at the same time able to listen to a single instrument and appreciate the richness of the ensemble. For people used to playing vinyl LPs, it is easy to be enchanted by the lucid disk calmly spinning and disregard the pivot at the centre of the turntable…

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X
WATER-AGRICULTURE NEXUS

September 2019

The articles comprised in this chapter address nexus-governance with a focus on water use in agriculture. The overarching theme is that of complexity as it is simply impossible to talk about comprehensive and robust agricultural policy without addressing the complexities involved. This includes multiple factors at different scales, and the uncertainties involved in administering any given solution to water scarcity challenges.

Questions raised in the pieces that made up this edition of The Nexus Times included how current monitor systems understand the links between agriculture and water resource use on a European level, if desalination can become a solution to water scarcity in the Canary Islands and how our understanding of "efficiency in agricultural water use" shape the solutions we are able to imagine.

Coupled monitoring of water and agricultural policies: The challenge of indicators

Violeta Cabello and Ansel Renner

The integration of European water and agricultural policies is the subject of a long-lasting debate. Within that debate, the importance of agriculture as the main driver of impacts on water bodies has been formally considered since the approval of the Water Framework Directive in the year 2000. Only recently, however, has the European Commission (EC) promoted alignment of water and agricultural policies in its Rural Development Programmes. One important step in that promotion was the creation of a joint working group between the Directorate-General for Agriculture and Rural Development and the Directorate-General for the Environment—a working group tasked with steering integration of the two policy domains (EC, 2017). Currently promoted strategies focus primarily on the optimization of contemporary water and agrochemical use practices at the farm level (Rouillard and Berglund, 2017). In the light of on-going experiments, how to better harmonize water and agricultural policies, what concepts and instruments to use in that harmonization and at what governance levels are questions that will be addressed in the years to come.

One policy instrument that merits more attention in the ongoing policy discussion is the coupling of monitoring systems. Monitoring is the process by which the implementation of policies is followed up and evaluated, usually through a set of quantitative criteria and indicators. Indeed, indicators are the main tool used by the European Commission in their assessments, partially because they enable the bottom-up aggregation of information from the scale of implementation up through to the continental level. Both water and agricultural policies have innovated in their monitoring systems by developing varied sets of indicators and measurement procedures. Yet, these systems are not integrated. The recent Common Agricultural Policy monitoring and evaluation framework includes indicators on water quality and availability, but those indicators refer to the national scale and lack any connection with the monitoring efforts associated with the Water Framework Directive. Therefore, by looking at the set of numbers provided, it is impossible to know why and how agriculture impacts water resources in Europe. In a previous article of *The Nexus Times*, Völker and Kovacic caution against the performative role of numbers in evaluating progress towards policy targets. That is, the way indicators are conceived has an effect in the way policy goals themselves are perceived. Once measurement procedures are established, Völker and Kovacic argue, they become more rigid and difficult to change. Therefore, it is pertinent to ask now what indicators and accounting procedures are relevant and needed in the process of harmonization of water and agricultural policies.

As part of the MAGIC project, we prototype a coupled water-food accounting system that connects farming system typologies to the water bodies they depend on. The following data dashboard shows an integrated set of environmental and socio-economic indicators using data from the province of Almería in southeastern Spain. In this prototype, we focused on quantitative impacts on aquifers and diagnosed social-ecological patterns in the year 2015. That is, we explored and relayed crucial information over what farming systems are driving the various levels of aquifer overexploitation.

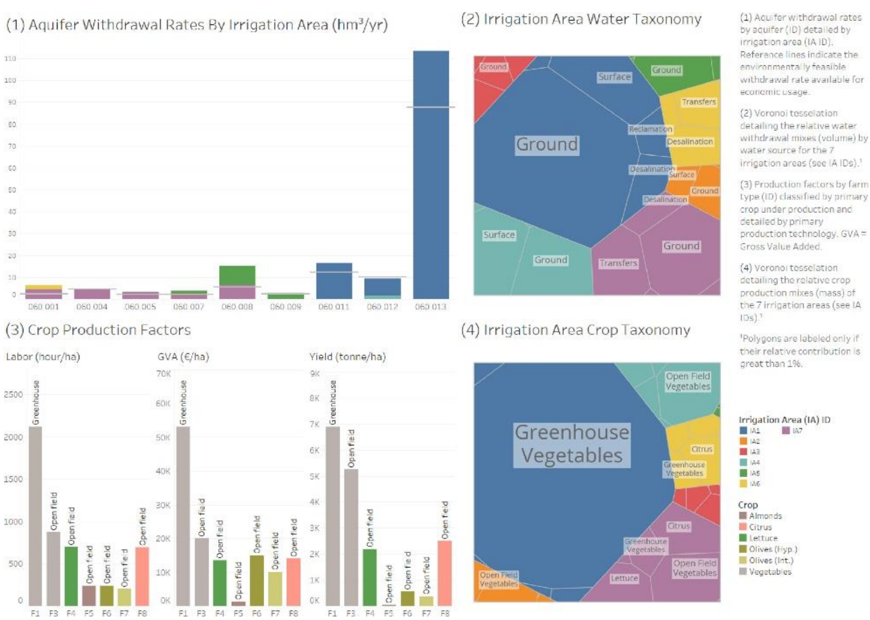

Figure 1: *An example of an integrated monitoring system of water and agricultural policies for the region of Almería in Southern Spain. Source: Cabello et al., 2019.*

During our research, we learned that it is key to both monitor impacts in relative and absolute terms and to place environmental pressures such as water withdrawal and fertilizer leakage in the context of their wider eco-hydrological system. For instance, in the analyses of indicators in Figure 1, we observed that high overdraft rates were observed in both high-volume and low-volume aquifers. While low aquifer recharge rates were a major driving factor, we also learned that similar levels of aquifer impact can be driven by various mixes of agricultural system types each with different production and market strategies. Attending to social-ecological diversity, such as that provided by mixes of agricultural system types, appears as a key challenge for future policy reviews and integration efforts. Current efforts are bogged down by sparse agricultural data defined at relatively aggregate scales, an aspect which creates difficulty as far as integration with water data is concerned. Difficulties aside, the integration of water and agricultural policies is an urgent task highly relevant for the future health of the European environment. Moving forward, the advancement of a coupled monitoring system between water and agricultural policies will require public administrations to make a serious effort to produce extensive biophysical databases.

Paying due attention to complexity in water governance for agriculture

The Magic Nexus team

In a recent publication from the MAGIC project, Serrano-Tovar and colleagues take a closer look at desalination, powered from renewable energy sources, used in water-scarce areas to support agriculture. The case study of reference is a project in the Canary Island of Gran Canaria, an island that depends on fossil fuel and food imports to supply its energy needs and food consumption. The case study reunites all the elements of the nexus: agricultural food production, its related water requirement met through desalination, and the energy required for water desalination. At first glance, the project seems to close the "nexus loop" by solving both the challenge of water supply in an arid region and of powering the desalination plant without fossil fuels. Upon closer inspection, it is far these specific solutions go and the answers that these technologies offer, due to the complexity of the environmental and socio-political problems encountered.

The study focuses on the company Soslaires Canarias S.L., which contributes to the irrigation of up to 230 ha of agricultural land pertaining to farmers of a local agricultural cooperative, which grow mainly fresh vegetables and fruits. The water derived from the desalination plant is stored in a reservoir, which acts as a strategic buffer element that allows for the use of wind energy (an intermittent energy source) by storing desalted water in periods when irrigation is not needed. Farmers have the option of combining the desalted water with other water sources. The water accounting is thus open: water from the desalination plant contributes to water supply to farmers, but does not cover 100% of the water requirement.

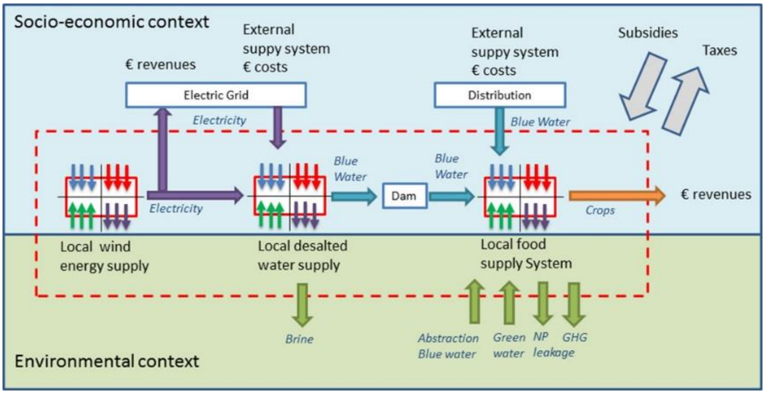

Figure 2: *Contextualizing the representation of functional elements in relation to the socio-economic context (top) and environmental context (bottom). Source: Serrano-Tovar et al., 2019.*

The desalination system is connected to a wind farm, which contributes to the electricity demand of the desalination plant. The extent of this contribution is quite complex: wind power output depends on the strength and intermittency of the wind, which is variable. The wind farm does not provide power at maximum capacity year-round. Moreover, the desalination plant cannot use all the electricity produced by the wind farm at maximum power capacity. Hence, part of the electricity output of the wind farm is sold to the electricity grid and part of the electricity requirement of the desalination plant is obtained from the grid. Energy accounting is also open: the wind farm contributes but does not ensure the viability of the system.

Needless to say, the farmers only provide part of the fruits and vegetables used by the population of Gran Canaria. Therefore, the food flow is also open. In this case, the authors note that food production should be understood not only as contributing to food supply, but also as an economic activity that warrants access to the subsidies of the Common Agricultural Policy of the European Union, especially when food crops are exported to other EU countries. The food flow acquires interest in economic terms, more than with regard to its contribution to food security.

Overall, although the integrated wind farm-desalination-farming system seems to tie in the various components of the water-energy-food nexus, the analysis shows that many loose ends appear through this nexus system. The challenge is not just a matter of missing data or insufficient models. As the authors argue, "the analysis of the resource nexus is extremely complex and requires the consideration of many factors and functional elements operating at different scales. This makes it impossible to adopt simple standard models (of the type 'one size fits all') that identify 'optimal' solutions and eliminate uncertainty from the results." In other words, the nexus presents some irreducible uncertainties. Uncertainties suggest that there are limits to the governability of "nexus solutions".

The Hydra and Hydro-Governance in Tenerife: who defines the problems and who proposes the solutions?

David Romero Manrique

In Greek mythology, the Hydra was a giant aquatic monster with numerous heads. If one of the Hydra's heads was cut off, two more would grow back in its place. So essentially trying to fix one problem made that problem worse. The lesson to be learnt in this case is to properly understand the problem in order to find the most effective solution. Water governance is similar in that the framing and identification of the issues is a crucial step for effective policy-making, i.e. policies that change (unsustainable) business-as-usual practices. Defining the solutions before properly defining the problems will not only fail to solve the root issues of concern (Type II error), but will also lead to additional problems.

Alternative water sources, namely reclaimed and desalinated water, have emerged as technologically reliable sources of water to face drought and scarcity(ies) in many regions worldwide (De López et al., 2011; March et al., 2014; Bichai et al., 2018). Drought is mostly related to physical and meteorological variables (Van Loon and Laaha, 2015) while scarcity is basically related to situations where water consumption exceeds water availability (Postel, 2014).

In order to face scarcity, the EU has recently launched a Communication on minimum requirements for water reuse with "the objective of alleviating water scarcity across the EU (…)".

According to this COM, the problem is essentially framed as the over-abstraction of natural water resources – scarcity – and the proposed solution is to increase water availability – reuse. In the European broad policy context, the proposal might seem logically coherent, but at smaller scales we could inadvertently gain many Hydra heads.

- In Tenerife (one of the Canary Islands), the MAGIC Project team explored narratives surrounding the implementation of water reuse technologies with a wide range of social actors. Here, the main natural sources of water have been both surface and groundwater. Part of the rain water is collected in dams, ponds and other deposits, while the groundwater comes from aquifers historically extracted through privately owned artificial galleries and wells. In Tenerife, 87% of the total water consumption comes from aquifers. Hence, private water owners provide almost 90% of the total water consumption of an island with almost 1 million inhabitants and 2.5 million tourists per year. Water scarcity due to aquifer depletion is the official institutional discourse behind the development of industrial waters. But is water scarcity a narrative that supports vested interests? Is this a social construct? Are scientific models supporting this perspective? After undertaking our interviews we revealed different perspectives:

- In the Tenerife Hydrological Plan, no area of the island of Tenerife has been declared by the Tenerife Water Council (water governance body) as over-exploited, which seems contradictory to the clear hymn to the scarcity discourse which is: a) there is water scarcity in the island: aquifers and other resources are overexploited by human pressure; and b) the lack of water is due to climatic factors: droughts, climate change, etc.
- Other actors uphold that the status of aquifer overexploitation is surrounded by uncertainty sustaining that existing models are useless.
- Finally, other actors suggest that the lack of water is caused by inefficient management of the existing resources (water leaks and losses, poor water quality, etc.).

The unclear problem definition gets more complicated with the identification of other tensions: high energy costs of water consumption and production; health risks; eutrophication; soils degradation and pollution.

The interviews indicate that the main beneficiaries of water reuse for irrigation will be farmers. But the abandonment of agricultural lands in the island seems related to socio-economic factors rather than water scarcity: subsidies, external competence, or the lack of intergenerational succession and knowledge. So, what are alternative water sources resolving really? Specifically, are agricultural issues faced by farmers diminishing, and should we be placing our focus elsewhere to benefit other actors or the environment?

Too many “un-definitions” require a debate to collectively evaluate the plausibility of contrasting narratives, because in environmental governance, framing is the condition sine qua no, to avoid multiplication of Hydra heads.

Multiple perspectives on the water-use efficiency of food production

Joep Schyns and Arjen Hoekstra

Due to increasing pressure on Europe's freshwater resources, driven by changing climatic conditions, population growth, and shifting dietary and energy patterns, the interest in water-use efficiency is enormous. Especially water-use efficiency in agriculture is a hot topic, since agriculture uses around 40% of the all water abstracted from Europe's groundwater and surface water resources on an annual basis (EEA, 2018).

There are three perspectives on water-use efficiency (Hoekstra, 2020). From the production perspective, we can address the question of how to produce a given crop with less water. From the geographic perspective on water-use efficiency, we can ask the question of where we can best produce what from a water point of view. Lastly, from the consumption perspective we can pose the question of how to best fulfil certain consumer needs with less water. The consumer perspective thus addresses the issue of demand and questions what actually is produced.

Nearly all attention and advancements around water-use efficiency in agriculture have focused on the production perspective. Food cannot be grown without water, because transpiration by plants is an essential element of plant growth. Strategies to increase crop water productivity therefore should aim at reducing the non-beneficial part of evapotranspiration from a crop field, which includes water evaporated during the application of irrigation water to the field and the water that evaporates from the bare soil and the leaves without contributing to biomass growth. This can be achieved by specific forms of tillage and mulching of the soil, or by installing more efficient irrigation systems (Chukalla et al., 2015). The replacement of sprinkler by drip irrigation systems in arid regions such as the Segura basin in Spain is a good example of the latter (Aldaya et al., 2019). In addition, since water productivity is a function of water use and crop yield, increasing yields by adopting good agricultural practices and optimal crop cultivars is an effective way to enhance water-use efficiency in agriculture. Such yield improvements have largely contributed to improved crop water productivity in Europe, especially in the past century.

The risk of solely focusing on the production perspective of water-use efficiency is that we end up producing the wrong crops in Europe most efficiently. Think of efficient large-scale production of water-demanding almonds, olives, tomatoes and fruits in Southern Europe for export. When we take the geographic perspective, we will look where we can best produce certain crops from a water point of view. Several local and global studies have shown that significant water savings can be achieved, maintaining current production levels, if crops would be produced in different places than they are at the moment (Davis et al., 2017a;b).

When we consider the water-use efficiency of food from a consumption perspective, we look at how we can fulfil the food needs of European consumers with less water. This can be done by changing our dietary patterns, particularly by replacing meat and dairy by suitable plant alternatives, maintaining the same nutritional value but reducing the water footprint per kilocalorie or per gram of protein. Food consumption patterns and associated water footprints largely vary across the North, South, East and West of Europe, but in all regions substantial water savings can be achieved by adopting diets according to regional health standards, and even more when meat and dairy products are replaced by nutritionally equivalent plant-based alternatives (Vanham et al., 2013).

Talking about changing production and especially consumption patterns is way more difficult than implementing best practices in the current agro-food system. Yet solutions from all perspectives on water-use efficiency will be required to tackle the nexus challenge of sufficient and nutritious food for all Europeans while sustainably managing Europe's freshwater resources. To achieve sustainable water use, we need to reduce overall water consumption in all those catchments where overdraft currently affects local ecosystems and biodiversity, which particularly occurs in Southern Europe, and reduce the water pollution as a result of excessive use of fertilizers and pesticides, which happens throughout Europe. Better agricultural practices, smarter choices on what to produce where, and adjustments in diets are all essential elements of the solution. Finally, given that forty percent of Europe's water footprint lies outside Europe (Hoekstra, 2011), we need to consider and reduce the external environmental impacts of Europe's food consumption as well.

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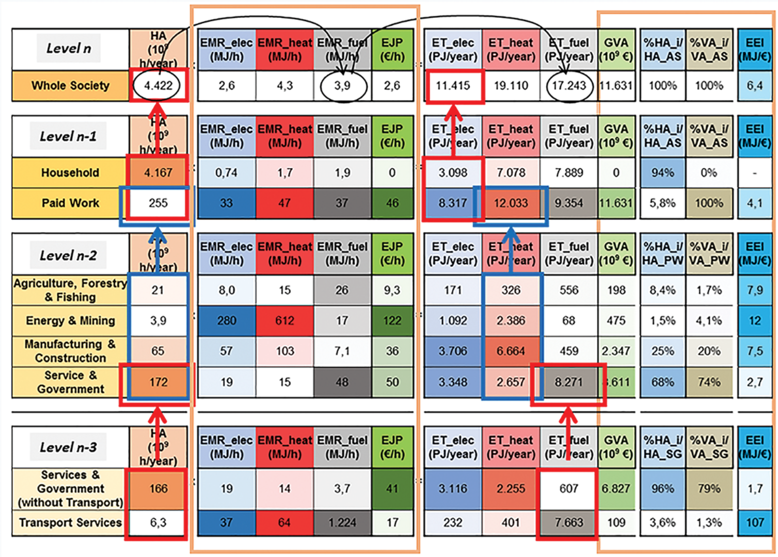
XI
NEXUS STRUCTURING SPACE

December 2019



Level n	HA (10^9 h/year)	EMR_elec (MJ/h)	EMR_heat (MJ/h)	EMR_fuel (MJ/h)	EJP (€/h)	ET_elec (PJ/year)	ET_heat (PJ/year)	ET_fuel (PJ/year)	GVA (10^9 €)	%HA_i/ HA_AS	%VA_i/ VA_AS	EEI (MJ/€)
Whole Society	4.422	2,6	4,3	3,9	2,6	11.415	19.110	17.243	11.631	100%	100%	6,4

Level n-1	HA (10^9 h/year)	EMR_elec (MJ/h)	EMR_heat (MJ/h)	EMR_fuel (MJ/h)	EJP (€/h)	ET_elec (PJ/year)	ET_heat (PJ/year)	ET_fuel (PJ/year)	GVA (10^9 €)	%HA_i/ HA_AS	%VA_i/ VA_AS	EEI (MJ/€)
Household	4.167	0,74	1,7	1,9	0	3.098	7.078	7.889	0	94%	0%	-
Paid Work	255	33	47	37	46	8.317	12.033	9.354	11.631	5,8%	100%	4,1

Level n-2	HA (10^9 h/year)	EMR_elec (MJ/h)	EMR_heat (MJ/h)	EMR_fuel (MJ/h)	EJP (€/h)	ET_elec (PJ/year)	ET_heat (PJ/year)	ET_fuel (PJ/year)	GVA (10^9 €)	%HA_i/ HA_PW	%VA_i/ VA_PW	EEI (MJ/€)
Agriculture, Forestry & Fishing	21	8,0	15	26	9,3	171	326	556	198	8,4%	1,7%	7,9
Energy & Mining	3,9	280	612	17	122	1.092	2.386	68	475	1,5%	4,1%	12
Manufacturing & Construction	65	57	103	7,1	36	3.706	6.664	459	2.347	25%	20%	7,5
Service & Government	172	19	15	48	50	3.348	2.657	8.271	[illegible].611	68%	74%	2,7

Level n-3	HA (10^9 h/year)	EMR_elec (MJ/h)	EMR_heat (MJ/h)	EMR_fuel (MJ/h)	EJP (€/h)	ET_elec (PJ/year)	ET_heat (PJ/year)	ET_fuel (PJ/year)	GVA (10^9 €)	%HA_i/ HA_SG	%VA_i/ VA_SG	EEI (MJ/€)
Services & Government (without Transport)	166	19	14	3,7	41	3.116	2.255	607	6.827	96%	79%	1,7
Transport Services	6,3	37	64	1.224	17	232	401	7.663	109	3,6%	1,3%	107

During the past three years, MAGIC has critically examined prevailing narratives and proposed innovations in EU policy spheres involving one or more elements of the resource nexus: water, energy, food and the environment. To this end, MAGIC researchers have employed quantitative story-telling, a novel approach that involves a predominantly quantitative exploration of multiple narratives in a given policy domain. Rather than trying to compile evidence in support of a given narrative, or determine the 'best course of action', researchers explored whether or not the examined narratives were congruent with quantitative analytical checks. Previous issues of the Nexus Times have focused on the outcomes and policy relevance of this research. In this issue, we take a look behind the screen and show how these quantitative analytical checks are obtained in what we call the MAGIC 'Nexus Structuring Space'.

A Marauder's Map to depict the resource nexus

Mario Giampietro

In the saga of Harry Potter, the Marauder's Map allows the magician to reveal the whereabouts of any person in space, covering all the levels (floors) of the castle, its secret passages, as well as the surrounding grounds. The term marauder (i.e., a plunderer*) neatly reflects the roving nature of the scientist involved in multi-scale transdisciplinary assessment. The resource nexus requires the scientist to identify relevant descriptive domains and reconcile top-down and bottom-up assessments, thereby providing meaning and coherence to the various sets of non-equivalent data required for informing policy across scales and dimensions. In this sense, the Nexus Structuring Space, developed in MAGIC, can be considered a sort of Marauder's Map guiding the use of the MuSIASEM** tool-kit for the analysis of the nexus. It allows the analyst to move quantitative assessments across levels and dimensions to check the feasibility, viability, desirability and openness of the metabolic pattern of a social-ecological system.

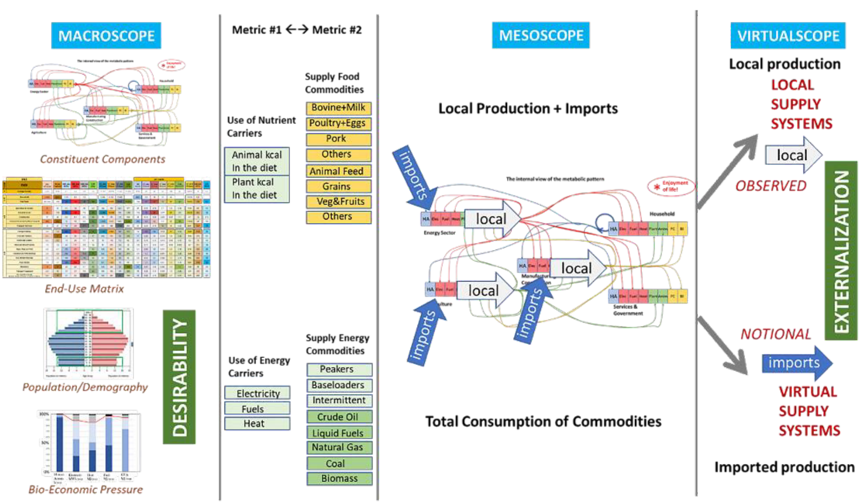


Figure 1: *The nexus structuring space: What can be seen through the macroscope, mesoscope and virtualscope.*

Figure 1 shows an overview of the functioning of the Nexus Structuring Space and its ability to identify, as in the Marauder's Map, the sources of information that are relevant for different research questions. Starting from the left, we see the information available when looking through the macroscope. On the top left, we see the entanglement over the activity of the constituent components of the system (agriculture, energy and mining, manufacturing and construction, service and government, and the household sector). They are producing and consuming the inputs for/from each other. In MAGIC, we define a socio-economic system as "a metabolic network in which constituent components stabilize each other in an impredicative (self-referential) set of relations in presence of favorable boundary conditions" (Giampietro and Renner, 2020; Renner, Giampietro and Louie, 2020). A quantitative representation of the forced metabolic relations across the elements of the constituent components is obtained by characterizing these forced relations in an end-use matrix. Using the macroscope, the end-use matrix allows us to see: (i) who is using either energy, food, water; (ii) why; (iii) how much; and (iv) how. The end-use matrix thus allows the establishment of a bridge with demographic variables (i.e. the demographic structure) and characterizes the profile of distribution of the secondary inputs among the different constituent compartments. The resulting concept of Bio-Economic Pressure (Figure 1) indicates that economic development requires a significant fraction of internal resources to be allocated to final consumption and to the service sector.

Looking through the mesoscope, we can identify other sources of information that permit an analysis of the level of openness of the system determined by trade (see Figure 1). Here, we have to change the categories of accounting and use another metric (metric #2) to assess the flow of commodities. Through the lens of the mesoscope we study how much of the production of internal inputs in the various constituent components of the system is due to local processes or to imports. After having clarified this point, we look at the system through the virtualscope to characterize what exactly is required in terms of end-uses and environmental pressures to produce the local secondary inputs inside the system and what is required in terms of end-uses and environmental pressures to produce the imported commodities (right hand side of Figure 1).

To identify the sources of useful information for this assessment we have to move to yet another set of descriptive domains, which are illustrated in Figure 2. Starting from the left of Figure 2, and using as inputs the overall required supply of commodities observed through the mesoscope and measured in metric #2, we can associate the set of commodities locally consumed to a set of production processes required for their production.

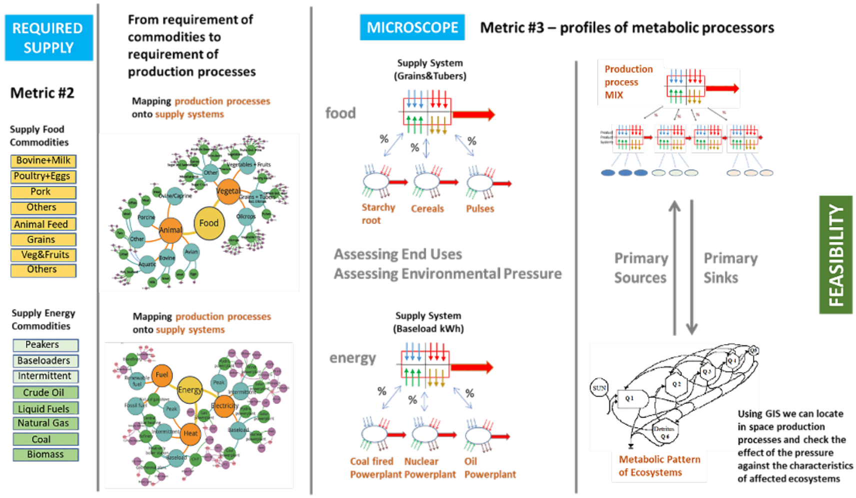


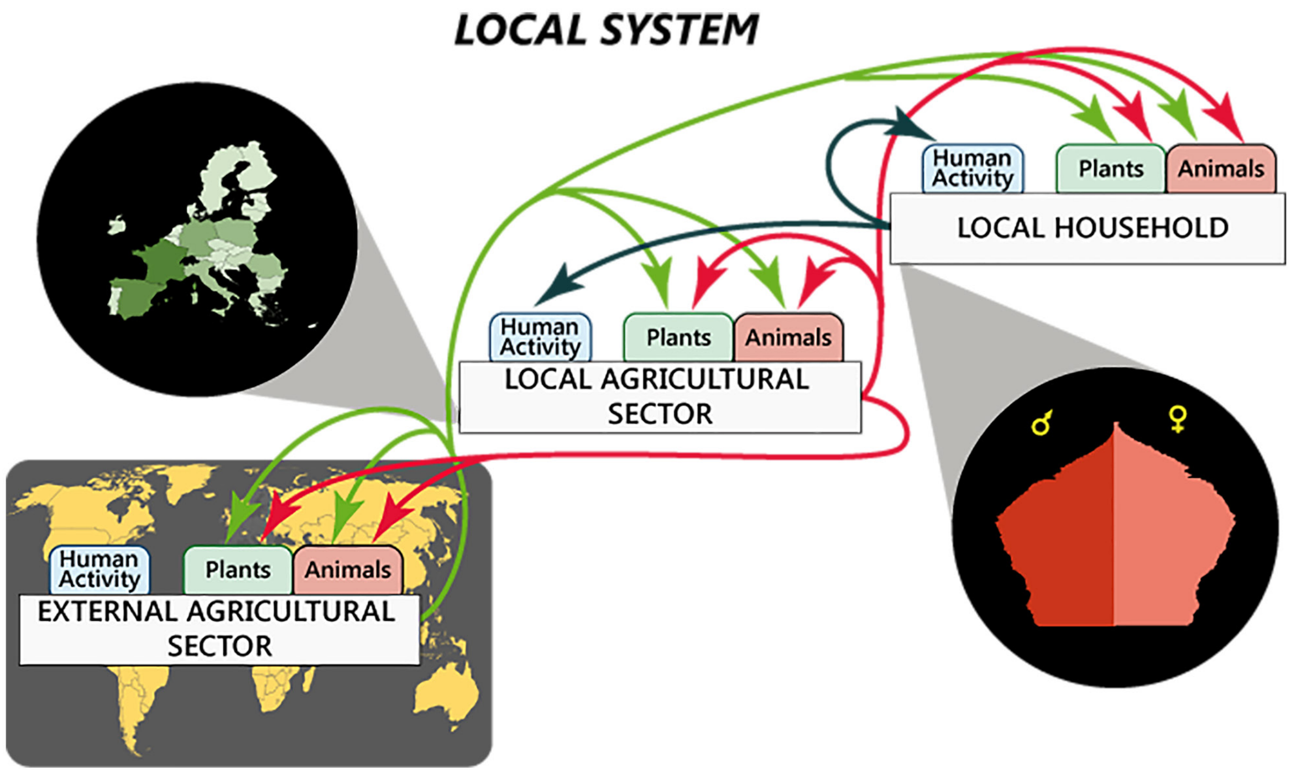
Figure 2: *The Nexus Structuring Space: What can be seen through the microscope*

At this point, we need to look through the microscope to visualize, at the local scale, the profile of inputs and outputs associated with each of the local processes. These inputs and outputs can go: (i) inside and outside the technosphere (secondary flows that are relevant for the socio-economic process); and (ii) inside and outside of the biosphere (primary flows that are relevant for the compatibility with ecological processes). When observing local processes with the microscope we can geo-localize these processes and check whether the environmental pressures associated with the primary flows exchanged with the biosphere – both on the supply and sink side – are compatible with local ecological funds and therefore assess the resulting environmental impacts.

In conclusion, when dealing with the analysis of the nexus, depending on the research question, we can use a logical map —the Nexus Structuring Space — to guide our search for and use of data from among the available sources of information. The Nexus Structuring Space shows the role of the various available grammars in MuSIASEM (specified sets of expected relations over metabolic processes) and helps the analyst to identify the type of data that is relevant to generate the desired types of result.

More information on the toolkit and its applications is available in MAGIC Deliverable 4.4.

*One who roams from place to place making attacks and raids in search of plunder (https://www.merriam-webster.com/dictionary/marauder)
**MuSIASEM: Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism



LOCAL SYSTEM
Human Activity
Plants
Animals
LOCAL HOUSEHOLD
Human Activity
Plants
Animals
LOCAL AGRICULTURAL SECTOR
Human Activity
Plants
Animals
EXTERNAL AGRICULTURAL SECTOR
♂
♀

Applying the Nexus Structuring Space to Characterize the EU Food System

Juan José Cadillo Benalcazar and Ansel Renner

In the MAGIC project, an evaluative framework called quantitative story-telling (QST) was developed as a capable way of generating robust inputs on the science-policy interface. This article demonstrates the potential of that approach to characterize a flexible information space capable of supplying the structured quantitative data demanded by QST exercises. In this article, we focus on examples taken from an analysis of European Union (EU) agriculture.

In diagnostic mode, our analysis evaluated the current metabolic profile of the agriculture sectors of 29 European countries (the EU-27 plus the United Kingdom and Norway). In anticipation mode, our analysis then evaluated the possibility of a dramatic agricultural internalization for each of those 29 countries—what would be needed for near-complete self-sufficiency in foodstuffs, a crude look at downscaling planetary boundaries to the national level under the assumption that current imports become undependable. Across both analytical modes, a semantic interface referred to as the nexus structuring space was developed in which four lenses across four different descriptive domains were used. Fig. 3 summarizes the four lenses used.

When adopting a macroscope lens (symbol A in Fig. 3), multi-metric data concerning the absolute and relative sizes of the various societal sectors (the household sector, the manufacturing sector, the agriculture sector, etc.), as well as their respective metabolic characteristics, was generated. In our analysis, the macroscope gathered information on the end-uses of various foodstuffs and related those end-uses to more general societal consumption patterns. The mesoscope lens describes the dependence of the country under study on other social-economic systems. This dependence is evaluated in terms of how much of each agricultural commodity consumed is of local origin and how much is imported.

In Fig. 3, two descriptive domains are identified for the mesoscope—symbol B describes the external dependency in terms of primary/secondary products while symbol C describes the external dependence in terms of live animals required to maintain animal production systems. The mesoscope thereby provides rich information relevant for discussions of food security and vulnerabilities to external factors. The microscope lens (symbol D in Fig. 3) describes the pressure exerted by local agricultural activities on the local ecosystem, differentiating between elements under human control (for example, fertilizers, human activity/labor, blue water) from those that are not (for example, green water, aquifers, soil).

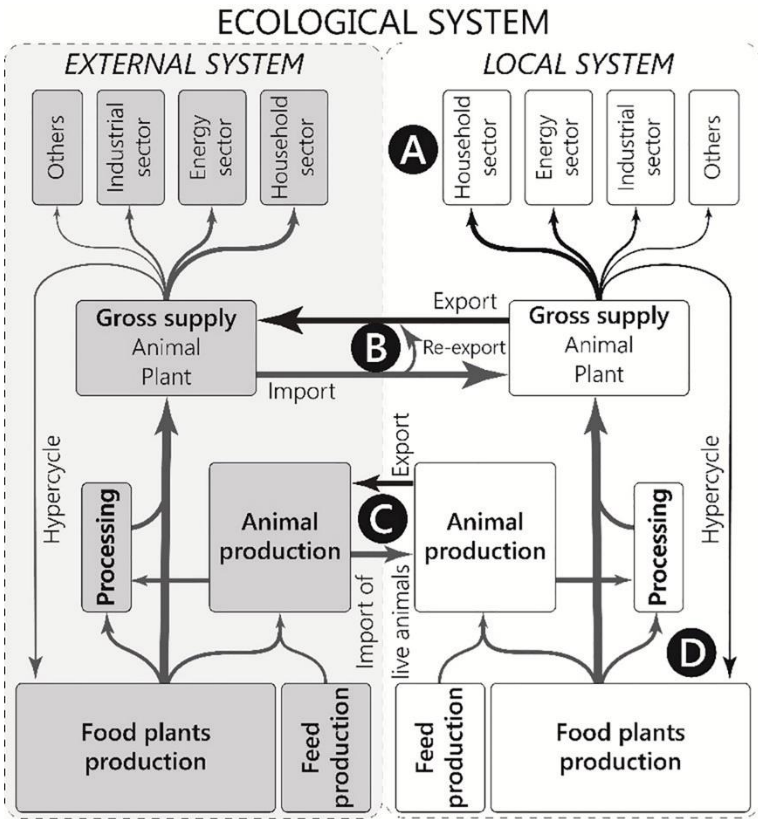


Figure 3: *Analytical representation of a modern agriculture sector, highlighting the macroscope (A), mesoscope (B and C) and microscope (D) lenses proposed by the nexus structuring space*

Finally, the virtualscope lens describes the characteristics of the "virtual" production processes that are required for the production of imported goods. The virtualscope is not visualized in Fig. 3 since, in practice, its characterization depends on the set of assumptions made. For example, the virtualscope can be understood from the anticipatory perspective of saving local biophysical resources (what would be needed for local self-sufficiency) or from the diagnostic perspective of pressure exerted on external social-ecological systems (outsourcing).

In diagnostic mode, the macroscope revealed substantial heterogeneity in the dietary profile of the EU countries, due mainly to a mix of cultural and environmental factors. In Portugal, for example, 21% of food consumed derives from animal products (in energy terms, fat products and marine/aquatic products not included). That same figure is 31% for Sweden. Similarly, 27% of the food consumed in Austria derives from grains, roots and tubers (in energy terms, again). On the other hand, grains, roots and tubers represent a full 46% of food consumed in Romania. The mesoscope suggests that when products are considered in terms of primary product equivalent, most of the countries assessed (20 out of 29) exceeded a 50% self-sufficiency level concerning plant products. That number of countries reduces by approximately half when analyzing animal products. When assessing animal feed (again, primary product equivalent), nearly all countries stand at less than 30% self-sufficiency. In anticipation mode, evaluating the possibility of a near-complete (90%) internalization of foodstuff imports by 2050—considering also population, diet and yield projections—the microscope and virtualscope lenses revealed that countries such as the Netherlands and Belgium would need to increase their agricultural area by 14x and 8x, respectively. In terms of NPK fertilizer usage, those same two countries would expect to increase application rates by approximately 90%. It should be stressed that these figures include in their consideration import for re-export, but also that the obverse (e.g. the elimination of high throughput agribusiness) would imply dramatic economic transformation in some countries.

The results obtained in our application of the nexus structuring space to agriculture in the EU illustrate—across a wide set of biophysical indicators—that the import of low added value agricultural products is an essential lifeline for the EU's contemporary agribusiness model. Our examples prove highly relevant when considering aspects such as the expected dramatic increase in global food demand by 2050 (putting strain on imports), the major agricultural demands being placed on EU agriculture by the European Green Deal, ongoing revision efforts related to the Common Agricultural Policy (CAP) and the uncomfortable fact that the CAP's nine primary objectives currently imply several mutually antagonistic actions. The objective of "increasing competitiveness", for example, may likely lead to increased biophysical stress, which is antagonistic to the objective of "preserving landscapes and biodiversity". Our approach facilitates the integration of diverse perspectives by researchers and the development of policy-relevant indicators capable of informing the discussion between what is wanted and what can be done.

Modelling energy systems as multi-scale systems

Louisa Jane Di Felice

One of the main goals of the MAGIC project has been that of modelling the interactions between energy, food and water, taking a perspective that is grounded in complexity. Most systems in the world can be broken down into components: cities are made of neighbourhoods; molecules are made of atoms; societies are made of people. Nexus interactions span through systems across different scales, with each scale affecting one another. For example, a coal power plant may affect its local embedding environment by polluting a nearby water source, while also generating global greenhouse gas emissions which, in turn, alter its local environment.

Our approach to modelling nexus interactions has been to focus on this multi-scale perspective, by using different information to describe nexus patterns at different scales of analysis. These types of information cannot be reduced to a single metric, and each description may be more or less useful depending on the goal of the analysis. This is why in MAGIC we do not rely on single indicators, such as efficiency or energy intensity, to measure the performance of the energy system.

The way we have broken down the energy system across different scales has not been in purely material forms – e.g., breaking down power plants into their components. Instead, we have focused on the distinction between function and structure of the energy system, taking inspiration from biology. For the case of energy, this means considering the different functions played by energy technologies – e.g., providing heating, or fuels, or baseload electricity

Figure 4 shows an example of this, mapping Spain's energy sector as a multi-scale network. The main node, "Energy sector", is split into a fuels and an electricity component (since Spain does not have a heating sector). Electricity and fuels are then split hierarchically into further sub-sectors. Additional functional layers could be added depending on the goal of the analysis. Electricity, for example, could be split into baseload, peak and intermittent electricity. Each node in the network represents a processor, i.e., each node is associated with a set of nexus inputs and outputs (water, GHG emissions, labour, land, etc.). Further information on how elements of the energy systems can be described as processors can be found in Di Felice et al. (2019) (see the link to the open-access article at the bottom of this page). While intermediate levels in the network are functional, at the lowest level these functional layers are mapped onto their structures, i.e. the technologies fulfilling different purposes.

Here, the network in Figure 4 shows a distinction between blue and red nodes. Blue nodes are local ones. They are the processes taking place within the geographic boundaries of Spain. This includes most power plants and most refineries. Red nodes, instead, are those connected to Spain's energy system, but which take place elsewhere (what we refer to as externalised processes). These include the extraction processes tied to Spain's direct and indirect imports, for example.

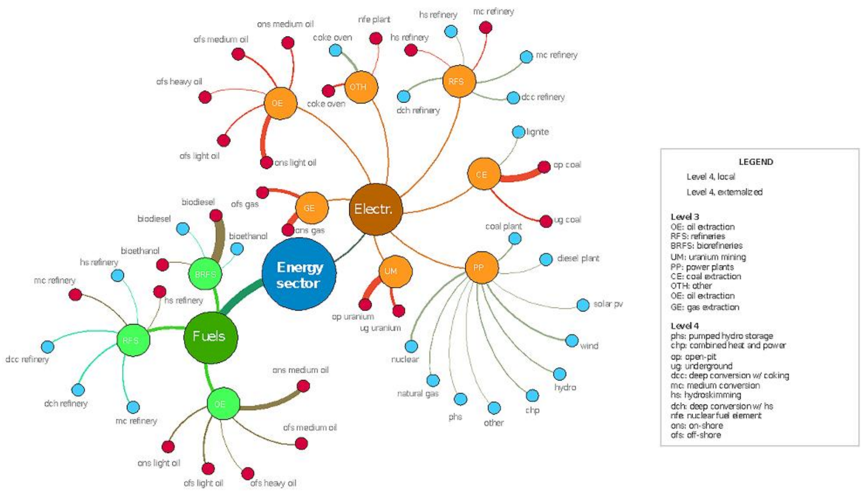


Figure 4: *A multi-scale description of Spain's energy sector (for the year 2018)*

These include the extraction processes tied to Spain's direct and indirect imports, for example. Mapping the energy sector across these different functional layers, associating each node with a set of nexus inputs and outputs, and making the distinction between local and externalised processes allows us to tap into questions that are relevant to the multi-level governance of sustainability, including:

- Which functions of the energy sector emit most greenhouse gases? How can these functions be reduced or substituted?
- What would happen to nexus elements across different scales, if the energy sector were to be gradually electrified?
- How would the pattern of local and global environmental effects shift, if Spain decided to produce all of its energy locally?

The Role of Human Activity in the Nexus Structuring Space

Laura Pérez-Sánchez, Raúl Velasco-Fernández, Michele Manfroni, Sandra Bukkens and Mario Giampietro

Current discussions on sustainability tend to focus principally on the shortage of natural resources and environmental degradation: water and material footprints, peak oil, greenhouse gas emissions, destruction of habitats, etc. Society is mostly pictured as a black box and its environment as a factor limiting its expansion. Constraints operating inside the society are often overlooked. Human activity or time use is one such constraint. A shortage of human time in one or more critical elements of society constrains the trajectory of economic growth, in a way like other biophysical production factors do, such as water, energy, and land. Whereas the limits to primary resource supply and sink capacity are difficult to assess, the human time yearly available both at the national and at the global level has a well-defined limit: population size × hours in a year. MuSIASEM is unique in that it analyzes sustainability from a metabolic perspective including internal societal constraints. Indeed, MuSIASEM expresses resource flows not only per unit of land but also per unit of time use (e.g. electricity per hour of human activity in the transport sector). The adopted metabolic perspective thus allows us to address the entanglement over the diverse factors (demographic, cultural, socio-economic, technical and biophysical) that affect the option space of desirable (compatibility with culture and values), viable (compatible with technology, infrastructure, and institutions) and feasible (compatible with nature's capacity to contribute to people) profiles of human time allocation.

Any human society simultaneously generates and requires human time for its reproduction. The demographic structure of society and the prevailing social practices define a forced dynamic equilibrium between supply and demand of time. Natural population growth does not necessarily solve a problem of shortage of time, as it does not only lead to a larger supply of human activity but also an increased requirement of working time (e.g. for child care, education, health care etc.). Post-industrial countries can (temporarily) overcome economic stagnation caused by shortage of working time through the use of technology and energy—boosting labor productivity, through immigration of adult workers—notably seasonal and temporary workers— and through the externalization of the requirement of working time in the form of imported goods and services. Indeed, the contemporary mode of socio-economic development has entailed a massive movement of workers away from the agricultural and industrial sectors to the service and government sector. This was made possible during the industrial revolution, which saw the mechanization of the primary and secondary sectors thus freeing up labor time for the service sector and, importantly, leisure time for the consumption of goods and services (Zipf, 1941; Cipolla, 1962; Giampietro, Mayumi and Sorman, 2012; Smil, 2013). The post-industrialization process (globalization) has consolidated this trend through the use of embodied working time in the form of imported goods and services (notably in agriculture, mining, manufacturing, and waste treatment) and (seasonal/temporary) foreign migrant workers (notably for low-skilled occupations in the sectors of agriculture, mining, construction, transport and the private sector—house cleaning). Note that imported working time in the form of imported goods and services often concerns labor with lower salaries and less social protection.

Many of the applications of the Nexus Structuring Space in MAGIC have addressed the externalization of human labor. But probably the most striking ones are the comparison of the metabolic pattern of China with that of the EU and the USA (Velasco-Fernández, Pérez-Sánchez and Giampietro, 2020) and the assessment of the virtual hours of labor embodied in imports in the EU (Pérez-Sánchez, Velasco-Fernández, and Giampietro, 2020). These applications concern the use of the macroscope (internal end-use matrix), mesoscope (trade) and the virtual scope (embodied labor in imported goods and services). For instance, the overall amount of work required to produce the goods and services consumed by an average US, EU and Chinese citizen is respectively: 1430, 1230 and 985 hours per capita per year (Pérez-Sánchez, Velasco-Fernández, and Giampietro, 2020). As for the actual hours of paid work allocated to the economy of these countries, we found that the USA and EU allocate, respectively, 790 and 730 hours per capita per year, whereas China allocates 1300 hours per capita per year (see Figure 5). China is the only country of these three presenting a positive work balance: a part of the available work hours of its internal work force goes into exports. The USA and the EU, on the other hand, almost double the internally available hours of labor to produce the goods and services they consume, thanks to embodied labor in imported goods and services. For instance, in 2011 the EU used 500 hours of embodied work per capita per year in its imports that are equivalent to more than 120 million annual work units (virtual workers; assuming a work load per unit/virtual worker of 1700 hours/year). Similar results were found for the USA. The large import of hours of embodied work in the EU is possible only because of the small size of its population compared to the world population. Given the fixed time budget at the global level, the reproduction of EU (and US) consumption levels that emerging economies such as China and India are striving for is simply implausible, given the limited size of the 'fund' of human activity. This raises important ethical issues and questions the EU's commitment to the Sustainable Development Goals.

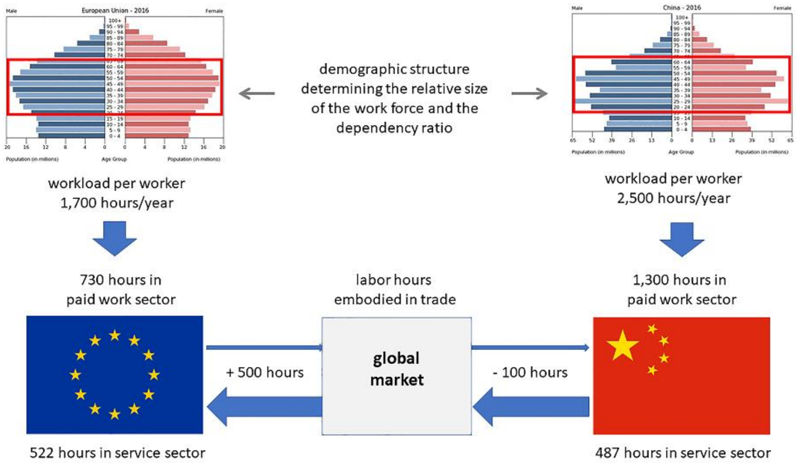


Figure 5: *Time allocation in the EU and China in hours per capita per year.*

The characterization of human activity patterns currently observed through the macroscope refers only to the allocation of human activity inside the paid work sector. In the future we plan to extend this analysis by characterizing the metabolic pattern associated with social practices outside the formal economy (e.g. residential/household sector). Social practices outside of the paid work sector represent the equivalent of the microscopic view of the technological process of production inside the paid work sector.
These applications show the relevance of the MuSIASEM framework in informing sustainability discussions with regard to the viability and desirability concerns. A detailed theoretical exposition on the profile of time allocation as an emergent property of the metabolic pattern of society is forthcoming (Manfroni, Velasco-Fernández, and Giampietro, 2020).

The biofuel promise: examining sustainability and policy expectations around liquid biofuels

Maddalena Ripa

Biofuels represent a 'wicked problem' (i.e. a problem characterized by a diversity of conflicting values at stake and associated with high uncertainties) and have triggered sharply contested views in the policy arena. The heterogeneous methods used to measure compliance of biofuels with sustainability criteria, as well as the changing regulatory frameworks and moving targets have created a substantial confusion.

In MAGIC, biofuels have been framed both as a technological innovation—referring to the sustainable use of biomass to produce energy (mostly fuels)—and as a promise, providing a way out of the nexus policy impasse.

First, biofuels are framed as innovations potentially offering win-win solutions to the double problem of reducing the consumption of fossil fuels (to improve energy security and/or mitigate climate change) and supporting economic growth (and all the activities dependent on liquid fuels that cannot run on electricity). Over the last twenty years, several assessment methods have been employed to investigate biofuels from a sustainability viewpoint, such as energy analyses, life cycle assessment, carbon and water footprints (Azadi et al., 2017). These approaches, however, are usually based on just one or a limited set of indicators (e.g. GHG emissions and energy efficiency) that can be reduced to a single index (UNEP, 2017). Even when a larger set of indicators are provided, the protocol of analysis dislocates these indicators from any specific context (Bridge, 2001; Levidow, 2013). For example, questions of uneven spatial distribution in terms of where biomass has come from, which regions have borne the negative impacts, which ones benefited, and alternative techniques of production are not typically included in 'sustainability assessment'. As a result of the lack of a more holistic picture and despite a large amount of studies, controversy has historically surrounded the assessment of the sustainability of biofuels and uncertainty has been growing in relation to their possible benefits and risks.

In MAGIC, we developed an analytical framework to characterize and contextualize in quantitative terms the performance of biofuel systems (see Ripa et al. 2020). This framework derives from the integration of three scientific fields – energetics (Ostwald, 1907), relational analysis (Rosen, 2005), and the flow-fund model of Georgescu-Roegen (Georgescu-Roege, 1975) – and helps to tame the confusion about the performance of biofuels. Figure 6 presents the four relevant perspectives on biofuels of the proposed framework:

1. The social factors determining their requirement on the demand side – why do we want to produce biofuels?
2. The internal technical and economic constraints affecting their mode of production on the supply side – how can we produce biofuels?
3. The external biophysical constraints limiting their production – what are the material limits imposed by the availability of natural resources?
4. The level of openness of the biofuel system referring to imports

being specifically used to overcome local limits (thus externalizing the requirement of natural resources and technical production factors).

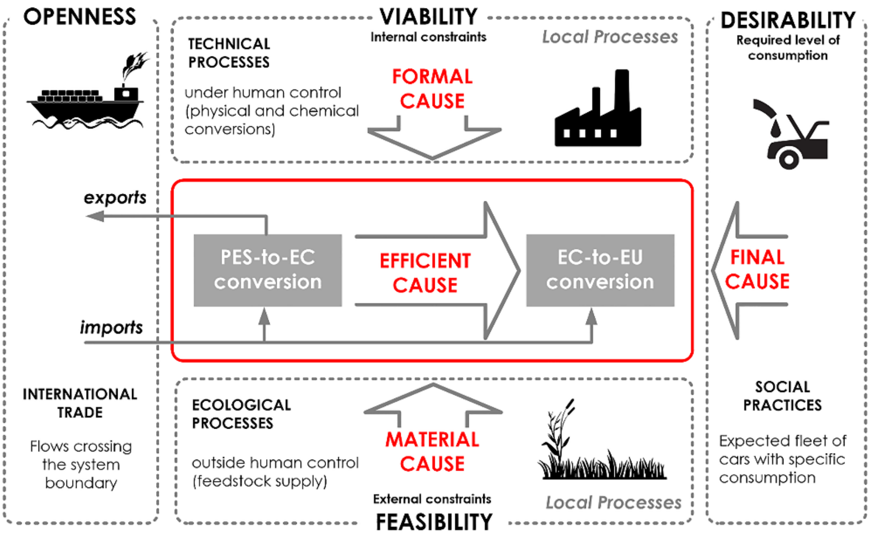


Figure 6: *The relations over the factors relevant for studying the feasibility, viability, desirability and level of openness (externalization) of biofuel systems. Source: Ripa et al., 2020.*

The framework aims to check the quality of energy strategies in terms of desirability, viability and feasibility by comparing the technical characteristics of the energy supply system against the specific characteristics of the social-ecological systems expected to use them (Figure 7). Therefore, this analytical framework enhances the diversity of the quantitative information used in the process of decision-making. Rather than looking for the 'best course of action' or 'optimal solution' in relation to technical processes described "in general" and out of context, our approach allows a special tailoring of the definition of both the purpose of the analysis and the resulting characterization of performance.

The second framing used in MAGIC is that of biofuels as a promise. In this case, what matters is the idea of biofuels as an environmentally-friendly and renewable way of producing fuels. The EU has consistently supported biofuels, despite controversies, criticisms and even discontinuities in political support. Hence, in this analysis we examined why some 'solutions' persist, even when they have persistently failed once materialized.

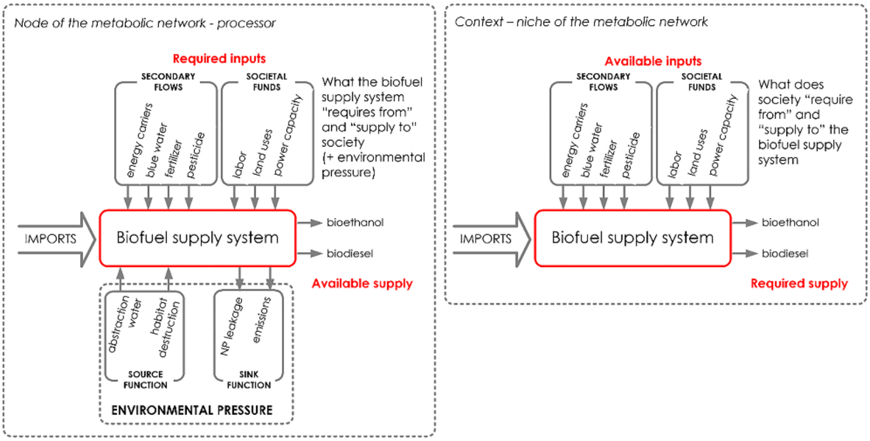


Figure 7: *The characteristics of the metabolic node – the supply reflecting the characteristics of the material-formal-efficient cause) vs the characteristics of the metabolic niche – the demand reflecting the characteristics of the efficient-final cause.*

Our results show that, in spite of scientific criticisms regarding the viability of biofuels, the European Commission has maintained its support for their development through a continuous adjustment of expectations (i.e. why producing biofuels) - energy security, reduction of GHG emissions, employment in agriculture, improvement of fuel quality, contribution to the circular economy and avoidance of sunk costs to investors - and targets in the various policies regarding biofuels (Cadillo-Benalcazar et al. 2020). Our analysis challenges the plausibility of biofuels' policies and concludes that, depending on their specific legitimate perspectives, social actors may first identify a convenient target to set (or preserve) and then select a fitting justification (from among the many possible ones) to support that target. Therefore, achieving biofuel targets has become a justification in itself (Cadillo-Benalcazar et al. 2020).

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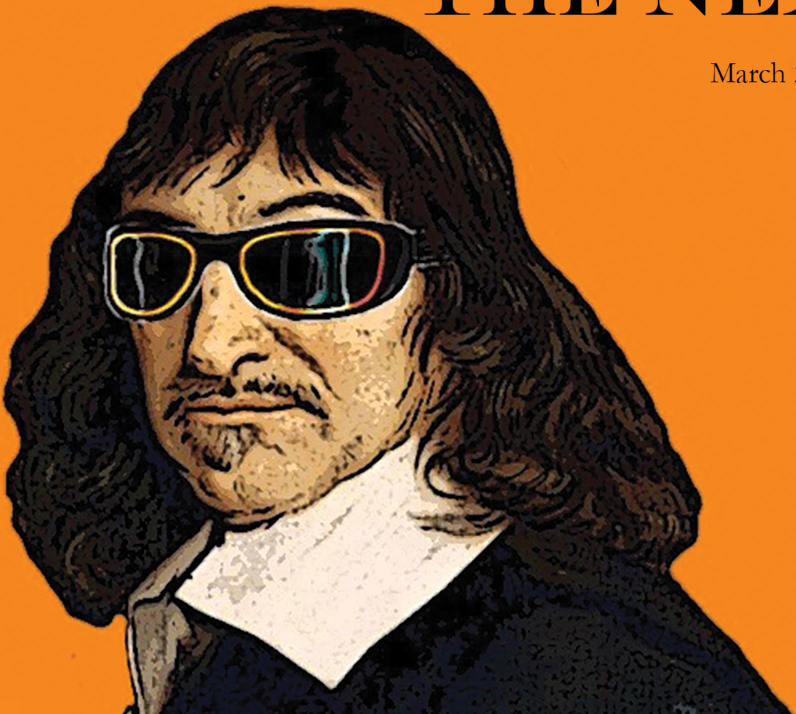
XII
GOVERNING IN THE NEXUS

March 2020



Over the last 4 years, the MAGIC team has engaged with policy-makers in the European Commission, European Parliament, and national as well as local governments with the aim to establish ongoing dialogues about the challenges poses to governance by the nexus. Some recurrent questions are: How can we make sure that improvements in one area (say, support for agricultural production) do not negatively affect other areas (for example, water supply and water quality)? How can policy-makers identify the synergies and handle the trade-offs created by the nexus?

We have come to learn that the governance of the nexus is not just a matter of identifying trade-offs, but in addition requires a balancing act between different equally legitimate policy goals (i.e. 'managing' trade-offs). The following series of essays suggest that the nexus creates a new situation in which governance has to let go of the paradigm of prediction and control. This can be achieved by moving from promoting the governance of complexity to one of developing approaches for governance in complexity.

Story-telling gorillas and sustainability discourses of the European primary sector

Ansel Renner and Louisa Jane Di Felice

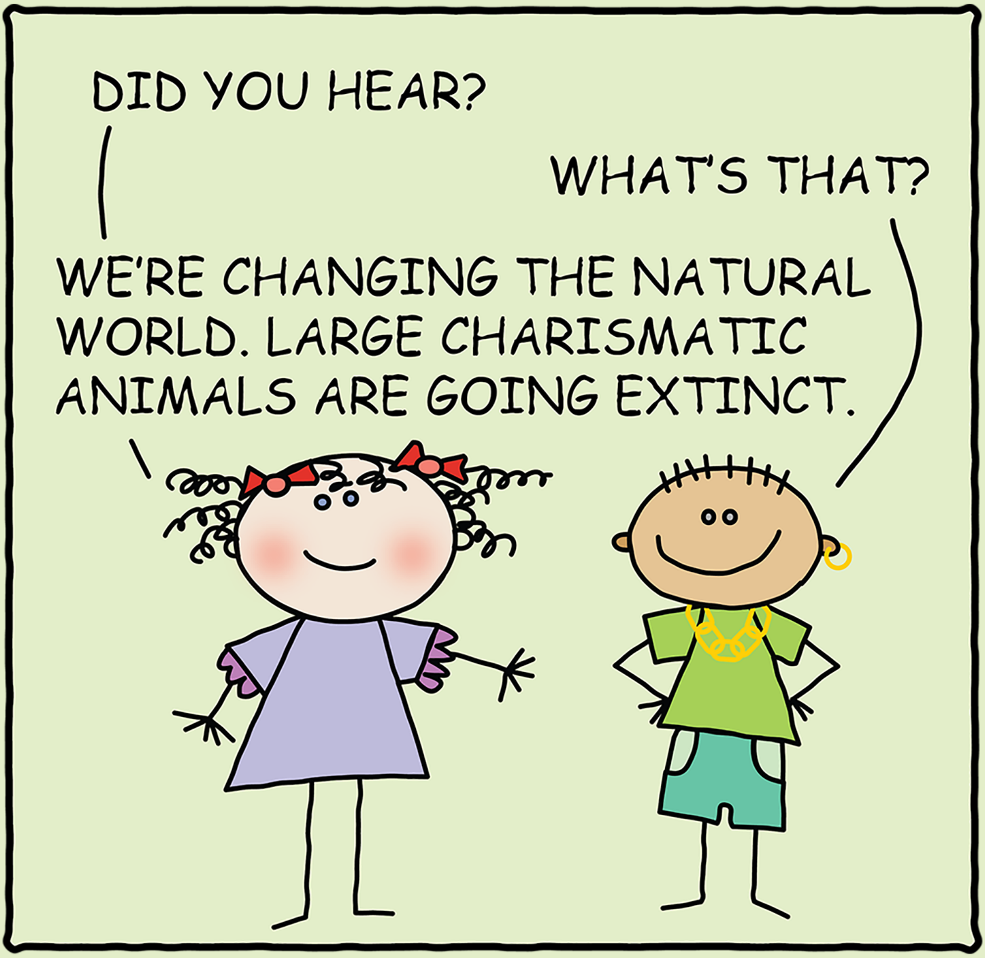
In January of this year, the European Commission released the European Green Deal. Thereby, the Commission laid down a 10-year roadmap for the "complete decoupling of economic growth from resource use". Somewhere behind the crowds of neoclassical economists applauding the idea of absolute decoupling stand biophysical economists—many of whom are likely rolling their eyes at the idea of increasing economic growth in the face of declining resource (ab)use. How is it that the two factions coexist? How is it that neither faction is shown to be more logically consistent than the other?

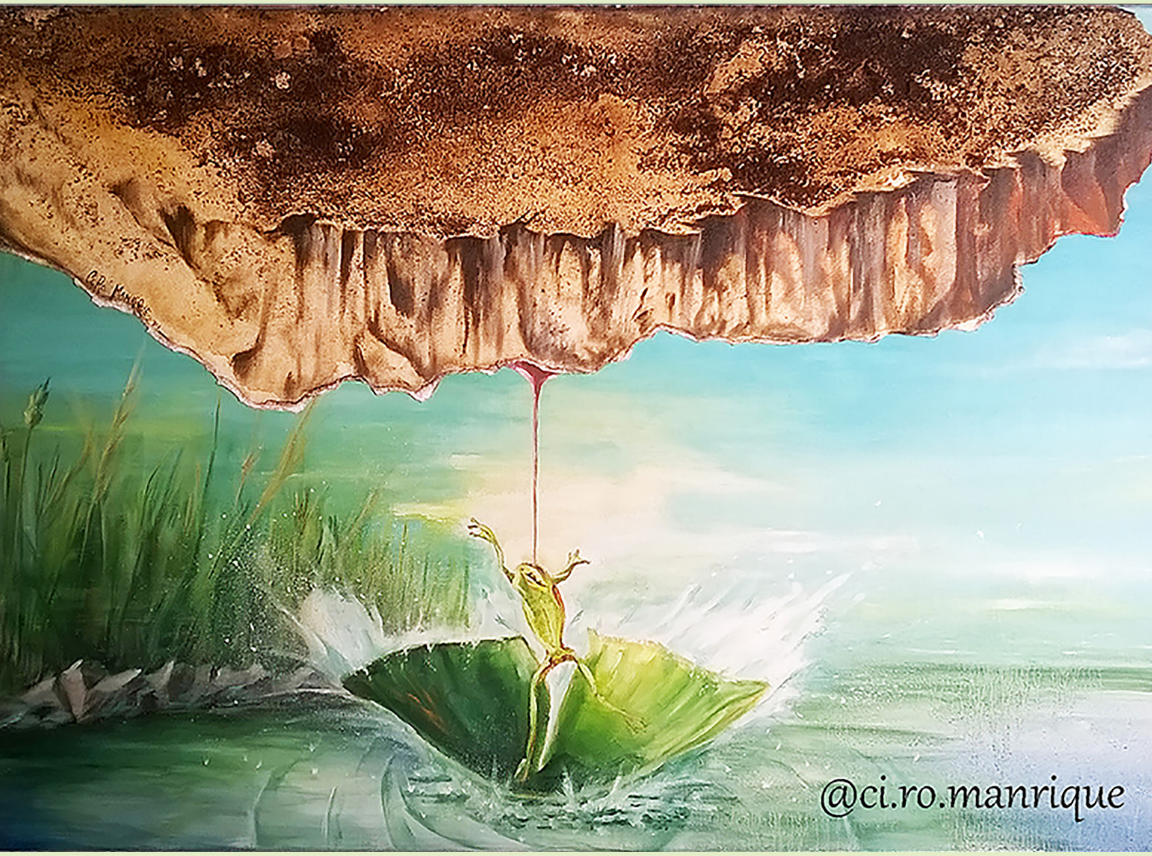
To answer such questions, let us take a brief foray from European policy and reflect on the teachings of Daniel Quinn's bestselling novel *Ishmael*. In Quinn's novel, a Socratic conversation between a man and a wise gorilla is used as a pedagogical device to show readers just how peculiar and idiosyncratic human society is. Students of sustainability and the environment will likely recall the novel's two koans—anecdotes presented with the purpose of demonstrating the inadequacy of logical reasoning (Quinn, 1995, p. 160):

"WITH MAN GONE, WILL THERE BE HOPE FOR GORILLA?"
and later
"WITH GORILLA GONE, WILL THERE BE HOPE FOR MAN?"

Does the extinction of man give hope to gorilla or does it condemn gorilla? Does the extinction of gorilla give hope to man or does it condemn man? Koans are pregnant with meaning for sustainability, and all interpretations are equally valid. Just as with those individuals who converse with wise gorillas, scientists rely on cultural narratives to deter ambiguity. Such narratives provide epistemic boundaries—boundaries that allow one to distinguish between justified belief and opinion. Epistemic boundaries are constrictive. Epistemic boundaries are also necessary for the creation of purpose and meaning, however, and their adoption is unavoidable. All too often, the assumption of epistemic boundaries is left implicit and unquestioned. In the context of a global sustainability crisis, this blasé attitude is not necessarily constructive.

In two forthcoming scientific articles, we took a look at how energy and agriculture policy in the European Union are shaped by justificatory, normative, and explanatory narratives. Those three narrative types, respectively answering questions of why?, what?, and how?, can be understood to form epistemic boundaries of decision-makers.


DID YOU HEAR?
WHAT'S THAT?
WE'RE CHANGING THE NATURAL WORLD. LARGE CHARISMATIC ANIMALS ARE GOING EXTINCT.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From a scientific research standpoint, their purposeful identification can reveal inherent cultural biases. Their identification can also help reveal how primal, societal concerns are transmuted into problems formally represented in policies as well as solution propositions for those problems.

In that work, in conclusion, we identified a number of ways in which European knowledge society as it relates to energy and agriculture policy could benefit from the adoption of a complexity paradigm over a paradigm of reductionism. Among other things, the complexity paradigm prescribes the acceptance of irreducible value pluralism. Such an acceptance is difficult to entertain in reductionism—a prevailing approach to science infatuated with objectivity and optimization. While the current version of the European Green Deal can be understood as reductionist in spirit, naysayers should be comforted by recalling that Europe occupies a unique position among Western political entities. More so than in, for example, the United States, the European policy-scape prescribes a precautionary handling of conflicting epistemic boundaries (precaution being quite different than risk). Regarding scientific decision-support under a complexity paradigm, a promising line of research arises thanks to that precautionary stance—a line of research suitable for shedding light on indeterminate dialectics related to decoupling and green deals such as:

WHEN DECREASING ENVIRONMENTAL IMPACTS, CAN WE HOPE FOR ECONOMIC GROWTH?
and also
WITH ECONOMIC GROWTH, CAN WE HOPE TO DECREASE ENVIRONMENTAL IMPACTS?

Alternative water resources and the illusion of control

David Romero Manrique, Violeta Cabello and Angela Guimarães Pereira

The theory of the illusion of control was developed within the psychological sciences during the 70s by Ellen Langer. The illusion of control is defined as an expectancy of a personal success probability that exceeds the objective probability of the outcome (Langer, 1975). In other words, it is the tendency of humans to believe they have full control over situations that actually exceed their capacity of control.

The overestimation of the efficacy of technological solutions to address complex situations in water governance is one example. Under this 'illusion', Alternative Water Resources (AWR), namely desalinated and reclaimed waters, have emerged in the last decades as the new panacea for agricultural production in regions facing water scarcity. The construction of AWR as a technological fix to water scarcity needs examination.

In the Canary Islands, we explored narratives about the feasibility and desirability of these technologies with a wide range of actors. Through an integrated methodology combining quantitative, qualitative and participatory analysis, the following questions were investigated: what role do AWR play in the recovery or reduction of pressures on natural sources? Is it plausible and desirable to implement these technologies within future e scenarios of climate change, energy crisis or hardening of export conditions? What role do 'alternative waters' play in agricultural development if we consider current limitations such as its price, quality, emerging pollutants and impacts on the soil, and the environment?

Similarly to many other Southern European areas, several dynamics have historically contributed to increasing the pressure on fresh water resources in this region: population growth (local and stationary), strong competition among economic sectors (industrial, tourism and agriculture) and the gradual decrease of the average annual rainfall, anticipating the effects of climate change. This is a complex situation which faces different types of uncertainty and clearly exceeds the governance capacity of regional and local water-related actors.

In our study, we observed how the invited actors justify the need for AWR by referring to water scarcity, which is attributed to the depletion of freshwater resources and the effects of climate change. Other drivers for water scarcity (population pressure, sectoral competition) are mentioned only in alternative narratives held by a few actors with low stakes and lower capacity to articulate them. Moreover, we found narratives that questioned the causal connection between the use of AWR and the recovery of freshwater resources in the absence of other more comprehensive measures.

Under such complex social-ecological situation, expecting that AWR by themselves will solve all water problems is most likely an overestimation of efficacy, even more if the risks associated with the exploitation of these technologies are ignored. The framing of AWR as a panacea to govern the waters in the Canary Islands allows to maintain the status quo and avoiding the question of what is wrong in the relationship between water and the agro-economic model of the Canary Islands, while keeping the illusion of control.

Nexus governance – not so unique after all?

Chelsea Jones and Jan Sindt

In theory, governing the water-energy-food nexus is not so different from governing any other issue area characterized by complexity, conflicting interests over scarce resources and questions around their fair distribution. For instance, nexus-type governance is at the heart of any budget decision about the distribution of public funding to line ministries. Those decisions are facilitated by simplification, measuring the importance of an entire segment of society in terms of a budget share. The main difference, then, is that the water-energy-food nexus is mostly concerned with aspects that either don't have a price, or have a price which may reflect a narrow view, as it cannot take into account the diverse set of values they may hold for different actors. This includes: "externalities", "commons" like rainwater, biodiversity, intact ecosystems, a safe climate, but also undervalued resources like groundwater, food, and land. One commonly used solution is to attach a price to these common goods, to "internalize" them into the economy.

One example of using price-based valuation is the use of a carbon tax as a means of signalling a preference for low-carbon solutions in the economy, while leaving the selection of optimal solutions to the private sector. A carbon tax does not technically turn a safe climate into a commodity for the market to work with, as the resulting carbon price is fixed and does not react to scarcity the way the other fixed carbon price scheme - permits in an emissions trading scheme - would. Pricing through either instrument introduces economic incentives to reduce emissions up to the point where it is cheaper to pay or trade than to avoid paying and leaves it to the market to determine that point. Capping through permits further defines that point as the amount of permits issued for trading, offering no incentive for further emission reductions beyond that point and sending a wrong signal that emissions up to that point are not problematic. In both cases, governance requires a defined benchmark for either the national price of carbon emissions or size of the national carbon budget.

Determining the value of a carbon price or the size of a budget is in itself a subjective decision taken through a process of political deliberation, considering a number of economic trade-offs involved like the impact on profitability of existing business operations and repercussions on the job market and social inequalities, in addition to scientific deliberation about the safe limits for global emissions and political-philosophical deliberation about the just distribution of a hypothetical global carbon budget among nation states. Many political decisions involve a similar level of complexity (e.g. trade policy, humanitarian interventions). However, the pricing of impacts related to climate change is unique among such political decisions as it heavily relies on benchmarks and targets that are defined outside the political system and, to a large extent, through the development and application of highly complex scientific models. Scientists cannot be held accountable in the same way policy makers can be, insofar as they are not elected to govern the community and their work is also rarely scrutinized by a wider public. Policy makers end up being responsible for the impacts of decisions they base on scientific advice regarding the costs of emissions or the global carbon budget. Adding to that, the impacts of decisions around climate change, and more broadly sustainable management, often only materialize in the long term, and hence those constituencies who would hold politicians accountable for their decisions can only do so in the more distant future. With respect to nexus-governance, there is not so much of a complexity problem as there is an accountability problem.

Part of the benefit in using a methodology such as Quantitative Storytelling lies in its ability to examine the underlying narratives of decision-making and policy recommendations. The use of carbon prices and the prioritization of decisions based on economic parameters is just one example of these policy narratives: the narrative that natural resources and environmental goods can be valued economically and that the trade-offs among them can be managed via monetary means. By using the QST framework of evaluating not only the feasibility of options, but also their viability and social desirability, narratives can be evaluated against a policy-relevant range of indicators which better captures the more intangible components of their value. By examining the underlying narratives surrounding a policy, more information is also made available regarding its inherent assumptions on what should be valued how much, thereby helping to hold policy-makers accountable for what they choose to value in their decisions and why.

The role of metrics in EU governance of the water-energy-food nexus

Thomas Völker and colleagues

In a recent publication by the MAGIC project, Völker and colleagues investigate the changes that are emerging in governance with regard to the water-energy-food nexus. Recognizing the interconnections between water, energy and food means also acknowledging how water policies, energy policies and food policies interact with each other – sometimes by reinforcing each other, and sometimes by supporting contradictory goals. In order to make these synergies and trade-offs visible, policy makers in the European Union increasingly rely on indicators. To what extent, are indicators – and quantification practices more broadly - a suitable means of rendering intelligible the complexity of governing for sustainability and for challenging existing governance structures?

Contrary to the popular view of quantified evidence as objective representation of the world out there in a single number indicating political action, quantification requires considerable work and relies on technical and administrative infrastructures that allow for data collection and processing. Once such "accounting machineries" are put in place, however, they become not only quite stable and "sticky". Thus, the creation of new metrics on the nexus theoretically have the potential of creating new paths of accountability. For example, nexus indicators can expand accountability of agricultural policies outside of the agricultural realm and including water governance, energy governance and other sustainability goals, such as climate and biodiversity. But indicator production may also suffer from the stickiness of the current "managerial" system of governance.

For this article 28 interviews with 32 actors from different European Commission DGs, members of European Parliament and its Science and Technology Options Assessment (STOA) as well as from the European Environment Agency (EEA) were conducted. The conversations with these actors focused on their views on and experiences with governing the nexus. Our data indicate that there are institutional logics and mechanisms that might hinder an implementation of nexus governance. Interviewees stressed that there is little room to think about what people are doing when one is busy and focused on immediate priorities. Metrics on the nexus are welcome as what interviewees refer to as "eye-opening evidence" to direct attention to the water-energy-food nexus. While this desire is perfectly rational within the EC policy realm, we argue that things are more complex and 'messy'. Here is why: while the problem of nexus governance is often presented as information/indicator deficit the actual challenge lies in the political and cultural practices of the organizations themselves. This is visible already in how the debate about indicators is framed: numbers are understood in terms of a linear rational model of knowledge where metrics are self-evident, value-neutral, objective and comprehensive. The way in which our interviewees talk about indicators and their work, however, points to 'messy' governance struggles within a political and normative setting. The quest for finding the most useful indicators is shaped by certain ways of working. One of the central activities in this regard has been described as "boundary work" in relation to the activities of scientists. Boundaries, usually labelled 'silos' by our interviewees, are constantly worked on in policy-making processes. Epistemic challenges of working on trade-offs and interlinkages thus become organizational challenges of aligning different policy objectives and groups within an organization. These boundaries are described e.g. in terms of "portfolios" that people in the EC tend to be very protective about. In that sense, the demand for novel forms of quantified knowledge is not only embedded in but potentially also reinforcing a mode of governance that relies on a "managerial" approach to metrics, which can lead to a process of de-politicizing difficult political decisions about the trade-offs of sustainability through the notion of the nexus as measurable interconnections.

Developing new indicators to represent the water-energy-food nexus differently, while still necessary, will thus not suffice. It will be crucial for the success of nexus approaches to simultaneously develop alternative approaches to policy-making.

Opinion: The Awakening from the Cartesian Dream?

Mario Giampietro

The current coronavirus crisis has succeeded where climate change has failed: it has made us aware of the shortcomings of the Cartesian Dream of prediction and control. The idea that our society is able to control events by using science and technology has suddenly lost its credibility. In the Church of the Carmine in Naples the Crucifix of Miracles, used in 1600 to protect the city against the black plague, has reappeared on the main altar. For some, the crucifix has become a more effective means to combat the stress associated with the COVID-19 pandemic than the scientific advice given by experts. As the virus directly threatens our own life, the implausibility of the claim that 'everything is under control' has become evident. The coronavirus has shown us just how fragile our society is. We have now come to realise that everything that is dear to us, like visiting family or having a coffee with a friend, can suddenly change or disappear.

However, an important lesson we can take away from the COVID-19 pandemic is that, if need arises, it is possible to make changes to our lifestyle and, more importantly so, in a very short period of time. At present, society is enduring the restrictions imposed by governments in the hope of controlling the virus and returning to normality. But what if there will be no return to normality? What if this crisis will bring about lasting societal changes (another "black swan"—Taleb, 2007); changes that will not be determined by the grand narratives and plans about how to fix the world (e.g., the European Green Deal) but by a forced need to adapt to new circumstances? This looming possibility adds to the current feelings of unease and fear.

The Cartesian Dream of prediction and control is exactly what has prevented us from making changes to our social practices in response to the threat of climate change. In fact, it is currently unthinkable for us to adopt new solutions without assuring ourselves that we will be able to control them. But what happens if society is faced with the realisation that 'total control' is simply impossible? Are we condemned to do 'more of the same'—technological fix after technological fix—until our system collapses and we will be forced to accept alternative solutions?

The fragility of our identity

Our contemporary identity—I like to call it the 'cyborg identity'—is imposed on us by our capitalist economy, as well as by media and influencers (hyper-cycles of self-referential messages). It no longer reflects the culture and traditions passed down through generations. As a consequence, our identity has become increasingly shallow and vulnerable to perturbations such as the COVID-19 pandemic. We are becoming less and less capable of handling 'the tragedy of change.' In order to fight, resist and adapt to change, we must have a clear and shared understanding of who we are and where we want to go. A fragile identity hinders decisions about what we are willing to lose in order to preserve what we would like to retain. We are increasingly unable to see, let alone thread the difficult path through change.

Technology is no match for nature

In the 1953 movie The War of the Worlds, Earth is attacked by spaceships from Mars. The US army employs its best weapons but cannot compete against Martian technology. After several defeats, the US army decides to drop the best they have—an atomic bomb—but, unfortunately, also this last resort fails. When humans are resigned to their fate a miracle occurs. The Martian ships start crashing to the ground, their occupants having succumbed to a viral infection. The narrator concludes the movie by saying: "[…] the Martians were destroyed and humanity was saved by the littlest things, which God, in His wisdom, had put upon this Earth…"; a virus! The morale is that technology is no match for nature. Descartes' vision of humankind as 'masters and possessors of nature' must be modified by Bacon's maxim: 'nature, to be commanded, must be obeyed'[1]. Friend or foe, viruses are part of nature and we need to accept to live with them.

Can we avoid the collapse of complex societies?

The inability of our health care systems to handle the COVID-19 crisis in a 'prediction and control' mode confirms Joseph Tainter's (1988) concern regarding the risk of over-complicating the functional structure of society. It is impossible for societies to guarantee absolute prediction and control over all potential future perturbations. As a consequence, allocating resources under such assumption may not be a wise choice. It may be more useful to govern society using strategies based on: (i) monitoring and anticipating by considering non-equivalent perceptions of our interaction with nature based on feelings and concerns held by the extended peer community (not only based on data generated by scientific experts); (ii) preserving the diversity of social practices in society to boost adaptability.

The role of science in governance

Apart from satisfying our curiosity, science is expected to provide society with useful information to guide decision-making processes and in this way to reduce stress for its citizens. However, the COVID-19 pandemic has clearly shown that science not always lives up to this expectation. It can provide us with essential information on the mechanisms of the epidemic outbreak, but it does not provide us, for example, with a solution on how to deal with the shortage of ventilators needed for treating COVID-19 patients. Science cannot help us decide whose concerns, fears, and needs to prioritise. In the Cartesian Dream, science is purported to reduce stress by controlling the world and calculating risk. It does not acknowledge that danger (e.g., death) is an unavoidable part of life (Saltelli and Boulanger, 2020). To date, science has been predominantly used to selectively improve the quality of life of some social groups, providing them with an edge on the competition, and replacing religion as the source of legitimization of their power. With the COVID-19 pandemic, the expectations about science are losing their credibility, even for the selected few. As a result, the more reflexive citizens have begun to re-think the validity of the Cartesian Dream, while others have stocked up on toilet paper.

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[1] Quote from Jerome Ravetz, personal communication.

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XIII THE NEXUS AND THE SDGS

June 2020

Announcing the European Green Deal in December 2019, European Commission President Ursula von der Leyen outlined the aim “to reconcile the economy with our planet, to reconcile the way we produce and the way we consume with our planet and to make it work for our people.” Research undertaken through the MAGIC project has used an accounting framework understand exactly such patterns of production and consumption of resources within global systems and identified the implications of trade-offs necessary for achieving the Sustainable Development Goals (SDGs)

This issue of The Nexus Times looked at some of the challenges of the SDGs and shows how research approaches developed through the MAGIC project can help researchers and policymakers understand and interrogate complexities within social-ecological systems. One of the central insights is that prioritisation of targets is necessarily a political rather than scientific process and that it will be necessary to counteract tendencies of ‘depoliticising’ the 2030 Agenda. Progressing the Sustainable Development Goals thus requires understanding complexity on various levels: MAGIC research shows a way to achieve that.

Freshwater: a pivotal resource in achieving the interlinked SDGs

Joep Schyns

Freshwater is a renewable, yet finite resource. The amount of precipitation that falls on EU territory each year is limited. Although water that is used in one place will eventually come down as precipitation in another place, we cannot use more water than is available within a certain period of time. We can put the available water to use in several ways: to produce drinking water, food, or energy, or let it flow through the landscape to support ecosystems that depend on freshwater flows as well (Schyns et al., 2019; Mekonnen and Hoekstra, 2016). The increasing competition between alternative uses of limited freshwater resources leads to water scarcity. In Europe, water scarcity affects 10% of the population and 17% of the territory (European Commission, 2007). Water scarcity particularly manifests itself in semi-arid areas like Southern Europe, although it also affects the generally wetter parts of the EU in dry months of the year.

The UN Sustainable Development Agenda contains a Sustainable Development Goal (SDG) focused on water (SDG6), which includes targets to reduce the level of water stress and to increase water-use efficiency. Yet, freshwater resources are linked to many other SDGs, including food security (SDG2), energy security (SDG7), life below water (SDG14), and life on land (SDG15) (Figure 1; Vanham et al., 2019b). Assessing the (water-related) interlinkages across the SDG agenda is key to achieving the targets, without impairing progress towards others.

The objective of the EU project "Moving Towards Adaptive Governance in Complexity: Informing Nexus Security" (MAGIC) is to assess the interlinkages in the water-food-energy-ecosystem nexus to better inform policy-making. Several MAGIC contributions have shed light on the role of freshwater in this nexus domain and the interlinked SDGs:

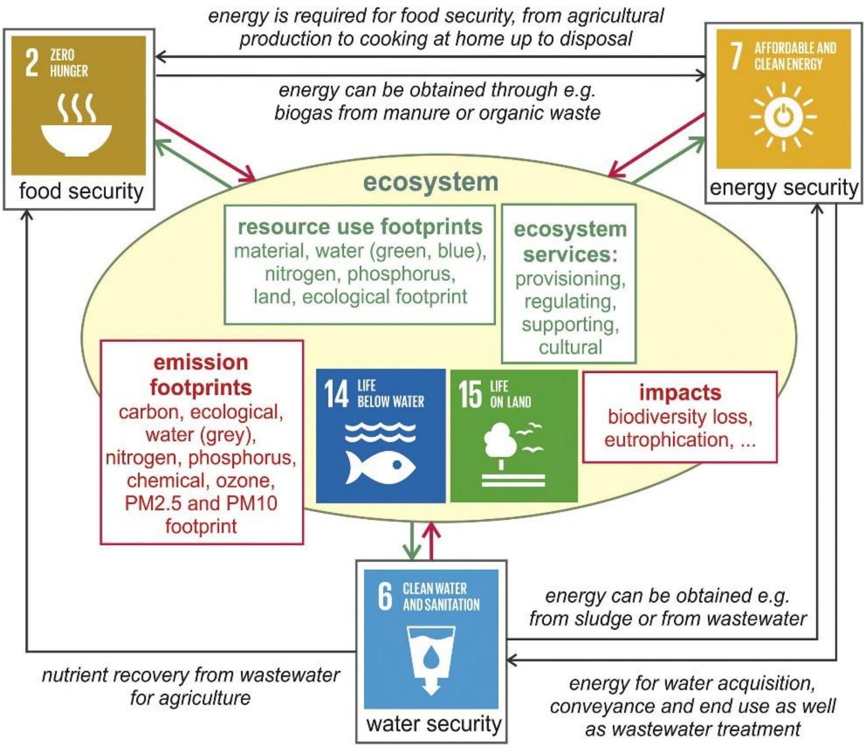

Figure 1: *Graphical representation of the Water-Energy-Food-Ecosystem (WEFE) nexus, with representation of different environmental footprints of the footprint family. The green arrows represent resources and ecosystem services (ES) (where certain provisioning ES also relate to resources) required to provide the securities. The red arrows represent pollution and impacts on the ecosystem due to the provision of the securities. Source: Vanham et al., 2019b.*

Water, food and the environment

- In another recent MAGIC report, water savings in irrigation have been explored through five different narratives on the role of crop production in the EU (Vargas-Farías et al., 2020). The study illustrates a lack of coherence between current EU agriculture and water management policies. The analysis increases the understanding of viable narratives and preferred water-saving innovations with the aim to contribute to more effective EU policies that safeguard both food supply and water resources.
- MAGIC researchers (Krol, 2019) evaluated the Water Framework Directive (WFD), looking at the links between water, agriculture and

> the environment. The study concludes that over the first planning period of the WFD, changes in agricultural production practices showed desired tendencies towards lower intensity of water use (case study: Spain) and water pollution (case study: the Netherlands). However, shifts in production between commodities, or volatility in production volume, prevented these tendencies to translate into stable reductions of pressures on water resources.

All these examples illustrate that to achieve SDGs on food, energy and water security within safe environmental boundaries, a coherent inter-sectoral policy framework informed by quantitative assessments is a must.

Unclear route map for EU SDG journey

Kirsty Blackstock, Alba Juarez-Bourke, Kerry Waylen and Keith Matthews

In a previous issue of the Nexus Times, we asked where was the nexus governed? (Issue V) drawing attention to the distribution of the actors involved in trying to govern the water-energy-food nexus across European Union (EU) institutions. Our conclusion was the space(s) for governing the nexus are 'everywhere and nowhere'. This seems also to be the case with the Sustainable Development Goals (SDGs).

Let us elaborate. The signatories to the UN2030 agenda are over 170 nation-states, and the EU is also a signatory. This means the SDGs are objects of shared competence between the EU and its Member States. Member States can, and do, track their own progress on delivery and submit voluntary national reviews to support the UN's assessment of progress e.g. Greece in 2018, United Kingdom in 2019.

The EU is not a monolith but consists of several institutions including the tripartite governance structure of the Council of the European Union, the European Parliament and the European Commission. Their shared commitment to the SDGs was formalised in "Our World, Our Dignity, Our Future" (2017) although each institution has its own role in governing the SDGs. The Council has a working party on Agenda 2030 to oversee delivery shared between the EU and Member States. Various European Parliament committees and associated commissions (e.g. Committee of Regions) have debated delivery of the SDGS. The Commission set up a Multi-Stakeholder Platform on SDGs to support and advise them and all stakeholders involved on the implementation of the SDGs at the EU level. Within the Commission, the cabinet for the Vice President has responsibility for sustainable development, and the Secretariat General helps to coordinate delivery. An interservice group was convened to develop a Reflection Paper "Towards a sustainable Europe by 2030." The supporting agency, Eurostat, has repurposed its sustainable development indicators to help track delivery of the SDGs; whilst all policy development processes must consider the SDGs as part of their impact assessment processes.

Our analysis of the narratives regarding the EU's role in delivering the SDGs is as follows. In the reflection paper, the EU is presented as a front runner in sustainable development, and hence "exceptionally well-positioned to lead" (European Commission, 2019). Whilst the adoption of the SDGs has highlighted the need for everyone everywhere to contribute to the goals, the focus is still primarily on the 'external dimension' such as development aid and trade (European Parliament, 2019). Finally, the way to deliver the SDGs is presented as ensuring policy coherence between existing EU policies and actions, rather than taking new approaches to address complex and intertwined problems (e.g. economic and social exclusion, state fragility and environmental degradation, all of which are also exacerbated by climate change). This suggests that the SDGs can best be addressed by incremental refocusing of an existing approach to sustainable development.

However, the Commission has been criticised for failure to have a clear and coherent strategy about how the SDGs will be delivered (European Parliament, 2019); and a suggestion that the EU will not achieve the goals by 2030 (SDSN and IEEP, 2019). This is unsurprising given that the previous sustainability goals in the EU Sustainable Development Strategy also remained elusive (CEU, 2009). At the time of writing, there is no visible SDG implementation strategy beyond a list of existing EU policies and actions brigaded under each SDG. We await the imminent adoption of the Green Deal and hope that here it will include a meaningful implementation plan with associated clear lines of accountability to ensure that the SDGs are governed in specific EU spaces by specific EU actors. This may help to ensure that delivery can start to match the EU's laudable ambition. If not, delivery will remain fragmented and perpetuate the capability-expectations gap that has dogged the EU since its inception.

The treacherous use of indicators for SDGs

Mario Giampietro

The experience of the UNFCCC Conference of the Parties (COP) has shown the difficulty of trying to achieve international consensus on required action to tackle global challenges such as the problem of climate change. The 2030 Agenda for Sustainable Development on the other hand, rather than looking for an international consensus on specific actions for achieving "peace and prosperity for people and the planet, now and into the future", directly opted for a detailed formulation of targets and indicators. In 2015 the UN General Assembly provided no less than 17 Sustainable Development Goals (SDGs), 169 targets for the 17 goals, each of which has between 1 and 3 indicators to measure progress toward the targets. In total, 232 approved indicators to measure progress. However, as with the case of climate change, when looking at the results both on people (provided by UNHCR) and on the planet (in the latest IPBES report) there is no sign of an imminent wave of peace and prosperity.

The question we need to address here is the following: Is there is a systemic problem with the strategies selected by international bodies and national governments to deal with so-called "wicked" problems such as sustainable development and climate change? Is the translation of a mission explained in semantic terms as "peace and prosperity for people and the planet, now and into the future" into a set of 232 pre-approved indicators a wise move? To address this question, I use the approach developed in MAGIC to look at three types of narratives that need to be integrated when discussing complex policy issues.

Justification narratives—To guide specific actions useful for society, it is essential first of all, to identify societal concerns i.e. the perception of a stress to be avoided or the existence of unsatisfied wants. Next step is to prioritise these concerns because valid justification narratives can be in contrast. For example, "aspiration for economic growth" (SDG 1 & 2) and "need to preserve the environment" (SDG 14 & 15). This entails that the priority given to justification narratives always depends on the context. Dealing with contrasting justification narratives is a political problem, not a scientific one.

Normative narratives—In the context of governance and politics, normative narratives identify actions needed to address specific concerns. However, the choice of a specific action depends not only on a previous prioritisation over existing concerns but also on the analysis of the consequences of the action in terms of winners and losers. When dealing with the goal of "zero hunger" (SDG 2) we can make several suggestions: (i) give funding to the ministers of agriculture of countries with malnutrition; (ii) making fertilizers available to poor farmers; (iii) distribute emergency food in refugee camps. Trade-offs between these solutions will generate different types of winners and losers. Implementing more effective agricultural policies may improve the situation in the future, but does nothing to help poor farmers now; starving people want food not fertilizers. The perception of the usefulness of the chosen normative narratives always depends on the feelings and values of stakeholders. When "considering the nexus between energy, food, water, land use, ecological services, across different scales and dimensions, the legitimate aspirations of individual countries, the whole planet, present and future generations" (Giampietro and Funtowicz, 2020) it becomes obvious that the choice of a specific action(s) to be taken is a political problem, not a scientific one.

Explanation narratives—In modern society, when implementing policies, "scientific evidence" is commonly cast in quantitative form, and thus indicators become a privileged form of evidence. Indicators allow the analysis of relevant attributes to characterise the performance of proposed solutions with numbers. Fractal geometry (Mandelbrot, 1967) flags the problem faced with this solution when dealing with issues requiring a multi-scale analysis. Let's imagine that we want to use indicators to select a passenger tour around the coast of UK that minimises the consumption of fuels and the number of overnight stops. Detailed maps and reliable information about fuel consumption and the speed of the means of transport will not enable the identification of a solution that can be used by different operators using both boats and buses. By boat (keeping a safe distance from the shore), the UK coastline is approx. 2800 km. By bus, using coastal roads, the distance is 3400 km. Fractal geometry [2] explains that the length of the UK coastline "changes" not because of lack of accuracy in its representation, but because of a different understanding of what can or should be measured. When different perceptions of the external world co-exist because of different concerns and different purposes, the need to adopt different scales and dimensions of analysis makes the use of quantitative indicators and targets treacherous. Indicators for poverty (SDG 1), justice (SDG 10) and biodiversity (SDG 15 & 16) will always be contested.

Conclusion

The identification of policies linked to the SDGs should be based on: (i) definition of priorities over concerns (for which justification narratives should be used on a case by case basis); and (ii) decision of how to deliberate on the existence of "incommensurable trade-offs" across scales and dimensions. Normative narratives should be selected, again, on a case by case basis. When dealing with the implementation of the SDGs, the issue of how to prioritise concerns and who should be involved (and how) in decision-making is a paramount political issue. This explains why, as illustrated by the experience of the climate COP, getting results through globalised political processes is not easy. However, the current solution through the 2030 Agenda for Sustainable Development is even worse. Given the unavoidable existence of trade-offs and uncertainty, SDG targets and indicators should only be considered after a political discussion of the proposed normative narratives in a specific context. In specific situations none of the 232 approved SDGs indicators can be used as evidence of an "improvement" outside of a process of unpleasant political discussions about priorities and losers.

Depoliticizing and repoliticizing SDGs

Raúl Velasco-Fernández

Sustainable Development Goals (SDGs) have become an important political reference for all kinds of institutions, whether public administration, multinationals or NGOs. However, there are still important debates about the appropriateness, consistency and the underlying interests which led to their definition. Advocates of SDGs indicate that they represent a unique global covenant for development, emphasizing they are the result of a deliberative and public decision-making process building on expert knowledge and considering a plurality of moral arguments about human dignity. In this view, the SDGs have a discursive consensus with strong universalist legitimacy that, even being a non-binding soft-norm, give them a strong symbolical power (Sanahuja, 2016). SDGs are also seen as a step forward from Millennium Development Goals providing a more extensive, comprehensive and integrated global development strategy. Those sceptical about SDG point out that without identifying the interaction among goals (the unavoidable side effects they have on each other) and a prioritization among them (when considering trade-offs) it is impossible to have an effective implementation (Weitz, Carlsen, Nilsson, & Skånberg, 2018). Moreover, this translates into an excessive discretionality given to the current power structures when choosing among the various policies justified by SDGs. This is a situation that can depoliticize[1] the international agenda.

There are different ways to deflect attention from critical aspects of the current power structure, e.g. declaring global wars against poverty or climate change while disregarding the fact that they are generated by the current status quo. Narratives that become "hero stories" such as the need of growth and technical innovation to "leave no one behind" and achieving "peace and prosperity for people and the planet, now and into the future" become unquestionable (Weber, 2017). Since the SDGs (the justification of the policy) are clearly identified and the targets are set (the expected results of the policy are already measured by indicators) such a strong framing of these "hero stories" does not leave space for discussing sustainable development using alternative narratives – i.e. noticing that in sustainability, optimal or win-win solutions do not exist.

Depoliticization is still a political action. It is a tactic for eliminating certain issues from public debate, or reducing discussion about them (Schulz and Siriwardane, 2015). This is precisely what Weber (2017, p. 399) points out when indicating that the SDG agenda "is designed to promote and consolidate a highly contested neoliberal variant of capitalist development", which "may be aimed in part at undermining political struggles that aspire for more socially just and ecologically sustainable approaches to development" by privileging "commercial interests over commitments to provide universal entitlements to address fundamental life-sustaining needs". Other authors as Ashukem (2020) flag the use of the SDG agenda inside the "green economy" policies promoted by the EU. Ashukem indicates that SDG can be used to promote the practice of land-grabbing in sub-Saharan Africa by foreign governments, companies and multinational financial institutions to produce biofuels crops. These practices will create more pressure on local impoverished populations, while richer countries will sell themselves as greener and more sustainable.

This concern about the risk of greenwashing conventional neoliberal policies is confirmed by the clear power asymmetry in the ability to endorse 'purpose specific' narratives. We can easily find many narratives about how to implement SDGs that are proposed by multinationals. It is more difficult to find narratives proposed by social movements fighting hegemonic globalization (e.g. World Social Forum). As Weber (2017) points out, this alternative view over the implementation of SDGs exposes the risk of reinforcing the dynamics that generate poverty and inequality. Even if SDGs are not binding, they provide important symbolic power to the actors that can mobilize and endorse action using them. This point is especially important given that public funds are available for SDGs, but their use by public and private actors is conditioned to the endorsement of the "official" SDG strategies.

To address some of these critical points it is important to repolitcize the discussion over SDGs, going beyond prescriptive interpretations of normativity that unnecessarily polarize the debate, but also avoiding depoliticization through the use of sociotechnical imaginaries often promoted by self-referential institutions (Jasanoff and Kim, 2015). In that sense, MAGIC uses Quantitative Storytelling to challenge the uncritical acceptance of rosy scenarios and simplified political framings.

Summarizing, there are a few issues that should be considered when dealing with the governance of SDGs: (i) the implications of the nexus (side effects and trade-offs) should always be acknowledged when discussing the implementation of SDGs to avoid the silo-governance syndrome, and openly addressing the political dimension of the prioritization among goals (Weitz et al., 2018); (ii) the weaknesses and opportunities given by the process of implementing the SDGs should not be ignored but considered useful inputs for the discussion (Sanahuja, 2016); (iii) power relations (and power asymmetries) exist in any status quo and therefore it is important to explore how they can affect policy choices related to SDGs (Weber, 2017); (iv) the hegemonic conceptions of development and justice based on the narratives selected by existing international institutions should be critically reappraised (Menton et al., 2020); and (v) inconsistencies and problems generated by current applications of the SDG framing should be identified and discussed in the form of case studies (Ashukem, 2020). None of these issues taken in isolation will solve the problem of how to properly implement the 2030 Agenda. However, continuing to ignore the conflictive nature of the process required to achieve a more sustainable development on this planet will not help the cause and will contribute to the growing mistrust in institutions.

[1] Depoliticization is used here as the "deliberate tactics that are deployed by political actors to maintain the status quo of existing power relations and to deflect attention from specific aspects of risks and vulnerability that stand in conflict with their desires, values and interests" (Schulz and Siriwardane, 2015).

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XIV
POST-NORMAL MAGIC

September 2020

September 2020 marks the end of the MAGIC project. This last issue of The Nexus Times is devoted to the overarching question: "What is the contribution of MAGIC to Post-Normal Science?" In this issue, project members reflect on the project's research and engagement activities, its strengths and challenges, as well as its contributions and accomplishments, particularly related to post-normal science (PNS). Policy narratives, "wu wei", mixed science-policy teams, transdisciplinarity, and uncomfortable knowledge are among the topics that are elaborated and reflected on in this issue and in the epilogue.

Managing a Post-Normal Science Project within Horizon 2020: Dream, Nightmare or Both?

Sandra Bukkens

In this article, I briefly elaborate on what made MAGIC management a 'unique' experience.

Probably one of the main characteristics of a post-normal science project is that there is not, and cannot be, a pre-determined plan. In post-normal science, the course of action is flexible and shaped by the stakeholder engagement. Policies and innovations of interest, relevant stakeholders, and engagement opportunities are unpredictable and fluid. While the philosophy of post-normal science research closely adheres to the recommendation of the Commission for Responsible Research and Innovation, notably its emphasis on public engagement, it is incompatible with the Commission's vision of a Grant Agreement, which resembles more of a five-year Soviet plan. This has been particularly problematic in MAGIC, where the public engagement was set to take place in the pre-analytic phase. How to co-create the research plan without having to continuously resort to amendments? Fortunately, there (still) is a human face behind the EC participant portal, which helped to resolve some of these problems!

The impacts strived for by the project—awareness, changes in mindset, attitude, and connectivity of policymakers—do not easily let themselves capture by numerical indicators, patents or other tangible outcomes. Especially not if this change is to take place within the Commission itself. Impacts strived for by MAGIC are largely imperceptible on the surface, but nonetheless of great significance. A quote from a retired EC policy officer, writing to the project coordinator (MG) after reading the MAGIC publication on policy legends (Giampietro and Funtowicz, 2020), may illustrate this: "Now I understand a lot better how already then there must have been this "ancien régime syndrome" by which uncomfortable facts are silently and almost unconsciously filtered out to "avoid the unavoidable" (called "unknown knowns" by MG)". Note that there is only one key performance indicator (KPI) in Horizon 2020 for Responsible Research & Innovation, i.e. "institutional change", but this KPI is normally assumed to measure changes everywhere else than within the EC directorates themselves. The inclusion of filters/criteria such as "policy related results" and "raise awareness and possibly influence policy" in the recently created Horizon2020 Results Platform is a promising step forward. Reflexive evaluation by stakeholders could be another solution.

Transdisciplinarity has been quite another test. MAGIC has shown that transdisciplinary research is easier said than done and the ambition of the consortium to jointly develop a novel transdisciplinary approach was a bold one. Indeed, it quickly became evident in the early stages of the project that many of the consortium partners did not quite fully realize what they had signed up for. Transdisciplinary research requires collaboration (which translates in time, patience and trust), an open mindset, and willingness to question business as usual and embark on something new and possibly risky. This involves making compromises and willingness to face uncertainty. In this sense, the project/consortium itself has served as a small-scale experiment for what it pretended to achieve at EC level. MAGIC has shown that genuine change takes time, but that eventually it can be done!

A post-normal science project does not offer optimal solutions nor best courses of action for policymaking. MAGIC's quantitative story-telling works by exposing untenable assumptions in prevailing ('politically correct') narratives, thereby paving the way for the recognition of the relevance of alternative narratives for other social actors. Therefore, results produced by MAGIC, almost by definition, create uncomfortable knowledge for the establishment. This not only is at odds with the expectation from a H2020 project, but also creates a considerable challenge for project communication. MAGIC has seen significant discussion within the consortium regarding the handling of social media and project dissemination at times akin to censorship (''we cannot say that!''). With several beneficiaries in the MAGIC consortium also being involved in other research projects, which evidently demanded more politically correct messages, MAGIC's communication with the outside has been under continuous scrutiny, not only from the outside, but also from within, notably in the early phases of the project when consortium members had yet to learn to trust each other and assimilate the spirit of post-normal science.

Looking back, now that the project is drawing to an end, I might be inclined to say that MAGIC has been a rewarding adventure, but I rather wait till we have concluded the final reporting …

Post-Normal Science and the European Commission's Joint Research Centre

Ângela Guimarães Pereira and Thomas Völker

Engagements with different actors on various levels of governance and policymaking were a central element of Quantitative Story Telling (QST) approach developed and applied in MAGIC. This approach builds on ideas developed by Jerry Ravetz and Silvio Funtowicz as a part of their writing on post-normal science (PNS). In particular, our work made use of their concept of an 'extended peer communities' (Funtowicz and Ravetz, 1993), i.e. "consisting not merely of persons with some form or other of institutional accreditation, but rather of all those with a desire to participate in the resolution of the issue." (Ravetz, 1999: 651)

While these engagements were for the most part carefully designed and orchestrated, sometimes chances for interacting with the world of policy emerge as a coincidence. We want to use an event of the latter sort to reflect on the relation between PNS and the European Commission (EC).

Midway through the project, the Joint Research Centre (JRC) started contributing to a so-called Flagship-project on the Water-Energy-Food-Ecosystem (WEFE) nexus, which brought together different units at the JRC. Since it was common knowledge at that time that both of us were part of the MAGIC project and thus also working on nexus governance, we were approached to "do something together". Our JRC colleagues thus were able to report collaboration with different nexus initiatives while we could tick the box of science-policy-engagements.

The workshop we came up with aimed at bringing together JRC researchers, policy officers from policy DGs and scholars working on the WEF concept with a selection of MAGIC consortium partners to discuss nexus narratives together with challenges to nexus governance and approaches for addressing these challenges. The main aim of the workshop was discussing key narratives that were distilled from a document analysis of policy papers and interviews with EC policymakers. The idea was that these could inspire future model requirements.

Reading this description, you might have stumbled across the notion "narrative", which we casually dropped a couple of times already. What do we mean by that and how does it fit with this workshop?

Conceptually speaking, narrative means a (mostly retrospective) sequential ordering of events from a narrator's perspective, thus constituting particular temporal and spatial structures and establishing a set of actors/subject positions with particular rationales, often together with a causal relationship between a problem and a solution. Narratives are a fundamental part of how we as individuals and organised social collectives engage with the world. When we walk through a wood, we might see a habitat for certain species, the "lungs" of our world, a recreational space in a world characterised by increasing urbanisation, or – more recently – an area increasingly threatened by climate change and wildfires. It is practically impossible to cognitively and interactionally make sense of 'the wood' without embedding it in a story. It is in that sense that Jerome Bruner talks about human beings as "storied animals" (Bruner, 1991). Consequently, stories or narratives not only refer to a cognitive capacity of single isolated actors, but additionally they can be regarded as a "sociocultural artefact" (Herman, 2003). Narratives do something, they way in which we narratively grasp the world in which we live in does have consequence for how we live in it. They express broader imaginations about the world, who and what has agency in it and what is valued. They are closely related to institutional, cultural, moral and material formations of society (Bremer et al., 2017). In policy-making, narratives tacitly define possible horizons for action and distinguish actors from non-actors and issues from non-issues (Hajer, 2006). They naturalise the "normal", the "taken for granted". Thus, when working with narratives it is eminently important to talk about not only what is actually there but to also stay attentive to that which is absent. This was done in MAGIC by asking for the relation of dominant to counter narratives or to explore the functions of certain types of narratives (see Mario Giampietro and Silvio Funtowicz in this issue).

Working with narratives in MAGIC has been a way to collaborate more closely with policy DGs to explore how policy narratives relate to scientific representations, while also aiming to extend the peer community of policymakers. Additionally, talking and reflecting about policy narratives is a way to tackle the more informal side of institutions and practices of governance (Hajer, 2006). They become a method to "challenge unthinking consensus" as our colleague Keith Matthews likes to put it.

In this contribution to the Nexus Time we don't want to reflect on the outcomes of this particular workshop in terms of the main take-aways, nor do we want to engage in the practice of selling success stories that are among the most valuable commodities within the JRC/EC institutional ecology. What we want to do is to use this workshop to reflect on peer-group extension as a practice with the Joint Research Centre to see what "doing post-normal science" entails and means in this particular context. The term "extended peer community" is usually used descriptively, e.g. "the case of AIDS" (Funtowicz and Ravetz, 1993: 753) or normatively to call for the involvement of heterogeneous actors in policy- and decision-making processes.

If PNS is indeed characterised by extended peer communities and extended facts (Funtowicz and Ravetz, 1993) this in turn makes it necessary to reflect on the problem of extension (Collins and Evans, 2002; Dickel and Franzen, 2016) and on questions about the legitimacy of certain ways of knowing and claims to expertise. We argue that is important to consider extension as a practice involving competing claims about the legitimacy of certain sets of expertise, methods and even disciplines in a given organisational-cultural process for any given problem. Extension then becomes a messy practice involving actors with different stakes and aims.

So, why was this workshop made possible? What happened during and after the event, and (maybe more importantly) what did not happen?

In the more recent past, the JRC was led by a management that made a lot of effort to break down existing "silos", attempting to walk the talk of interdisciplinary research and paying attention to questions of complexity; there was a new attention e.g. to social sciences and humanities and some organisational push towards collaborative work through transversal and flagship projects. Furthermore, there was a de facto restructuring of services.

In practice, however, this hasn't always translated into epistemic dialogue but rather resulted in amalgamations of different standpoints, with the consequence that the historically stabilised - usually inoffensive - standpoints are channelled to policy. In the case of this workshop, a senior manager was open to the opportunity to conduct this encounter. Not surprisingly, he has anticipated the kinds of resistance that we faced later on but was nonetheless quite enthusiastic about it.

After the workshop, a report was produced, which mapped and described the different nexus-challenges (and controversies about them) for each of the narratives that we discussed with participants. The challenges were subsequently translated into questions that could potentially be addressed by the existing or adapted models. However, it is on what follows that we can further our reflection on what "extension" means in practice.

First, we think that there was institutional momentum to conduct this activity. Not only did the JRC strategy at that time require cross-unit "collaborative work", but also the management actors involved saw an opportunity to safely explore the interdisciplinary pursuit: safely here means that there were no real (political) commitments of follow-up and no "witch-hunting" on the horizon. To put it bluntly, the outcomes could be outright ignored, and the reputations would not be touched.

Secondly, on the same vein, to start with many of the researchers involved had genuine interest in the conceptual discussions that the narratives helped to prompt. The discussions were often uncomfortable, as there was open criticism of taken for granted concepts (e.g. water scarcity) or regarding the reductionism of adopted concepts in nexus related policy (e.g. ecosystems services). However, there was no real mandate for the researchers to follow-up on those discussions and to change anything in existing practices or to be committed to this "extension" for longer period of time; this has found in very pragmatic justifications (e.g. lack of personnel, no policy request, urgency to deliver narratives) no practical implementation of the discussions, as far as modelling was concerned.

Thirdly, we want to direct attention of an ongoing politics of expertise that was part of this experiment in extension: To start with, the authors of this paper are not formally trained on the models that were discussed in the workshop. Hence, to some extent our legitimacy was granted whilst we prepared and run the workshop, after which the workshop outcomes were deemed "philosophical", which may mean that they were considered unpractical. Furthermore, it must be noted that the dissenting and competing expertise present at the workshop was from outside the JRC, which gave the JRC actors some leeway in how and if to make use of these inputs; in the end of the day, the material form of the workshop became therefore a shelved report for which there is no clear accountability.

So, what can MAGIC learn from this experiment of extension as means to channel uncomfortable knowledge into a science-for-policy-milieu like the JRC? And what are potential broader implications for engagements with the policy-realm?

When we look at extension as a practice of social, epistemic, organisational and moral re-ordering, we see that in order for this workshop to take place, there needed to be momentum in the sense of coinciding interests of various actors on different institutional levels, agreement on the necessary people to involve and on the acceptable degree of disruptiveness. Also, and this is probably the most important element, the workshop depended on powerful actors that functioned as gatekeepers or "champions" of extension. What we described as an event emerging by "coincidence" in the beginning of this essay, is the outcome of what can be described as a complex politics of extension. This also became visible in the ongoing struggle for legitimacy of different ways of knowing and kinds of expertise (uncomfortable knowledge as "philosophical").

Next to such politics of extension, one needs to stay attentive to the temporalities involved. As we laid out, there was no mandate, accountability, or long-term commitment, so it was safe to conduct this workshop.

Overall, one may ask whether there was any extension. We have two possible answers for this question: either the extension did not exist, to the extent that the workshop was merely performative, useful to tick some boxes, or the question is outright inappropriate, as the workshop did not actually invite an "extended" but an "inconvenient" peer community that brought in uncomfortable knowledge. Hence, it is important to note that the honest discussion has not led to change, and in the spirit of PNS, one is left to wonder if science-policy institutions would ever be able to work with extended peer communities. We could argue that the extension in this case was the work on and with narratives, which - shelved or not - was a warning that the "taken for granted" narratives might not always be what they seem.

In conclusion, it is important to remember that it took the Commission almost 20 years to pass from a seminal White Paper on participatory governance (2001) to advance the extension talk into a political priority and commitment. The process of making it visible took perseverance, subversive work, and some degree of serendipity. The uncomfortable knowledge generated by MAGIC seems to be still overwhelming in an institutional sense. The process of making it visible might take either a catastrophe or hopefully courageous politics to avoid the former, precisely by institutionalising practices of extension.

Post-Normal Policy Interactions: Paradoxes for Science-Policy teams

Kirsty Blackstock, Kerry Waylen and Keith Matthews

The premise of Post-Normal Science (PNS) is to focus on how knowledge is (co)-produced and used by different actors in different contexts. One activity within MAGIC has explored use of the Quantitative Story Telling (QST) methodology within European policy domains, working with actors from EU policy institutions in 'mixed science-policy teams'. During the QST cycle exploring the progress of the EU towards Sustainable Development Goal 2 (Zero Hunger), we engaged with actors in 13 European policy organisations. Most of these individuals worked within the Directorate Generals (DGs) of the European Commission. Although we were warned that transdisciplinary working in such settings would be difficult, we persisted and made some useful contacts who helped deepen our understanding of how the SDGs and sustainable agriculture are understood and operationalised within different DGs. However, reflecting on our experiences of trying to complete the full QST cycle (outlined in Figure 1 below) has led us to identify several paradoxes regarding working in mixed teams. We present a selection of these paradoxes below.

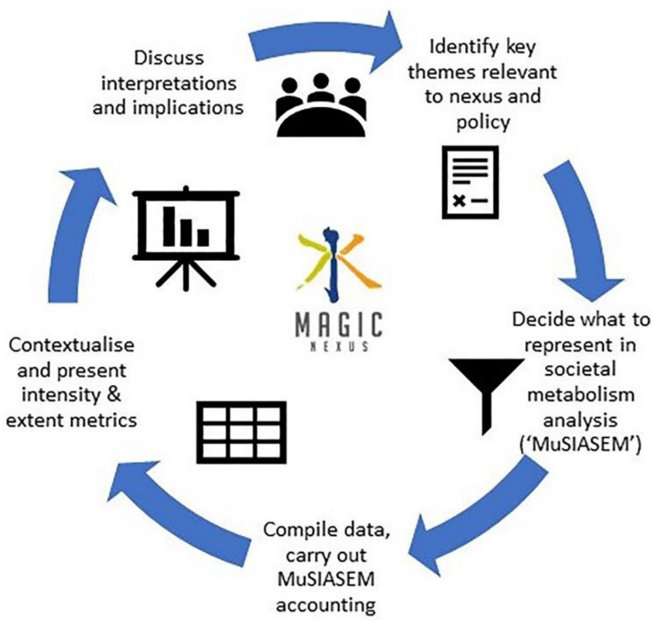

Figure 1: *Steps in Quantitative Story Telling Cycle*

Engage many versus engage few
We received advice to engage with more actors or other groups beyond the EU institutions, to raise their awareness amongst the many other stakeholders of the agri-food system. This advice emphasised the distributed nature of the responsibility to achieve change for sustainability. Yet at the same time, we were encouraged to engage with targeted stakeholders in a more in-depth way to build interpersonal trust and confidence. Whilst both responses are understandable, it was impossible to engage with every possible relevant group and also build in-depth relationships with strategic individuals.

Focus on specific problems or highlight systemic issues
Some stakeholders expressed desires for more specific and targeted advice that would help inform current policy questions and processes. These stakeholders suggest that awareness of current policy context is important. We had contextualised the quantified metrics in light of current policy objectives, but some expected more specific policy recommendations. In parallel, other stakeholders commented that the value of new approaches such as MAGIC is to highlight aspects of the system that are not currently well-considered by policy-making. PNS also encourages us to avoid reducing systemic problems to single aspects. However, a detailed evaluation of specific policy instruments is more constructive and salient to individual bureaucrats than a systemic diagnosis of (un)sustainability.

Provoke reactions versus build relationships
Most advice on science-policy interactions advises building interpersonal relationships. This was mirrored by the instinctive approach of some MAGIC team members when attempting to make contacts or when reacting to questions from participants, i.e. giving emollient responses to questions and making enquiries about participants' own work. However, the QST cycle is premised on questioning the robustness of current framings that shape policy responses to sustainability challenges, with the normative goal of questioning the status quo. Such a critical stance can make building relationships more difficult.

These tensions suggest QST is not easily implemented to satisfy all expectations and interpretations. Our work's contribution to PNS is to illustrate the tensions and challenges inherent when working with actors working on processes and in institutions that do not (yet) reflect the post-normal ethos. One potential solution is to find a policy entrepreneur to champion a post-normal approach within the existing institutional arrangements. Such interactions require significant scientist investments of time and energy to locate and engage such champions, and the use of science to support transformation from the inside, potentially at short notice. Putting PNS into practice may first depend on adapting to prevailing norms and expectations – as well as responding to policy cycles and opportunities – before science-policy relationships are sufficient to allow its more provocative and challenging ways of working.

The MAGIC-Post-Normal Science Nexus

Mario Giampietro and Silvio Funtowicz

1 Insights of PNS in MAGIC

Innovative conceptual aspects of MAGIC have complemented an understanding of Post-Normal Science (PNS) grounded on complexity (Funtowicz and Ravetz, 1993; 1994; 1997) that proved useful to achieve practical results during the 4 years of the MAGIC research journey.

1.1 The impossibility of decoupling passion from reason in sustainability analysis

MAGIC has developed a set of narratives found in policy discussions offering a new interpretation of the PNS insights: (1) justification narratives (about concerns to be addressed, resulting from the political management of feelings and emotions); (2) normative narratives (about actions to be taken, based on power relations and knowledge claims); and (3) explanation narratives (about scientific evidence for the selection of the first two narratives) (Giampietro, 2018). The three types of narratives, as will be illustrated below, are not independent, interacting in an impredicative loop.

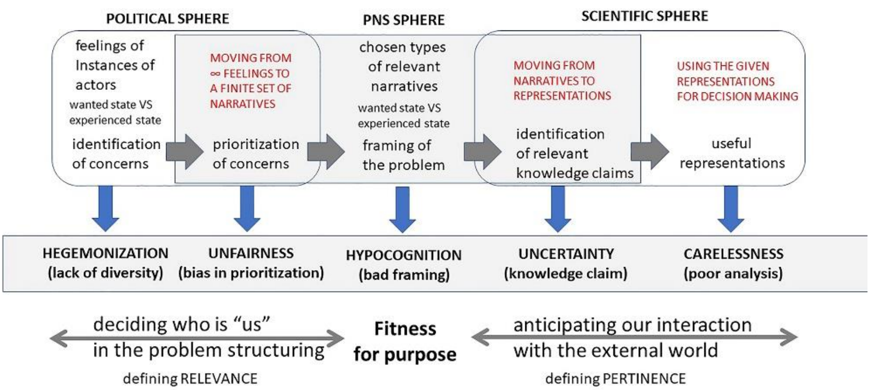

Figure 2: *The sources of concern for the quality of knowledge inputs for governance*

1.2 Quality control, in sustainability science, requires an extended peer community

Fig. 2 shows why rigor is not a robust quality criterion in governance-related research for the scientific analysis generating the evidence. Before arriving to a specific framing of the problem at hand (in the center of Fig. 2), priorities about relevant concerns must be addressed to select narratives to be used as justification narratives.

At the same time, information from existing knowledge claims is used to provide relevant insights about "the best" framing of the relevant problem. Therefore, the interaction of these two different inputs, and their impredicative relation, implies that in sustainability science, "optimal solutions" based only on a scientific evidence are a mirage.

Thus, Fig. 2 is a conceptual interpretation of the PNS insight about the need to integrate the scientific and value inputs in the problem-solving practice, which was confirmed by research in MAGIC when assessing the quality of EU policies in different policy domains and innovations. The consistency among justification, normative and explanation narratives, in the MAGIC case studies clearly indicated the need for extended peer communities (Renner and Giampietro, 2020; Cadillo-Benalcazar et al, 2020). An additional result has been the identification of five sources of concern about quality in the steps needed to use and produce scientific evidence for policy. These five are represented in the horizontal strip in the middle of Fig. 2.

1.3 Sustainability is about learning how to deal with the tragedy of change (update the identity of the society while remaining functional) something requiring managing passion and feelings

The definition of the identity of a society can be related to two sets of constraints: (1) the expression of social practices must match what is expected by the rules, institutions and validated knowledge claims endorsed by society (to be verified at the level of the society), and (2) the affective interactions, when expressing societal practices, must be compatible with the fears, hopes, feelings and emotions of individual. This implies that, as suggested by Luhmann (1995), we could assume the existence of a psychic structure of the society in which, the aggregated effect of personal emotions, when scaled-up to the level of the whole society, affect and are affected by the expression of social practices. This process of definition of the identity of social systems, is at the core of issues addressed by PNS.

2. Main messages of MAGIC

2.1 In relation to the quality of the narratives used for deliberating sustainability

- MAGIC has illustrated that the main institutional narratives used to address the sustainability crises are based on legends, a strategy that is unlike to provide sound policies to face the challenges (Giampietro, and Funtowicz, 2020).

The claims that with the green deal, moving to a circular bio-economy, in the next 30 years, the EU will be able to substitute fossil fuel with biofuels, decarbonize the electricity sector, make its agriculture competitive, environmentally friendly, and capable of guaranteeing food security no longer depending on imports, show a remarkable lack of scientific and political understanding of these issues. Implausible narratives are impossible to implement, risking of delegitimating the institutions proposing them. It is becoming ostensibly clear that the current pattern of economic growth is incapable to solve growing concerns about inequity, environmental protection, dangerous dependence on disappearing resources and on the exploitation of less powerful social-ecological systems. To avoid the risk of a collapse in the credibility of the EU system, it is the right time to move from the present class of "yes we can" narratives to the class of narratives "Houston we have a problem". A growing proportion of EU citizens can feel the seriousness of the sustainability crises, opting, however, not to acknowledge its deep implications, including the loss of their urban privileged lifestyles. But for how long can this situation last? For how long can we keep abusing natural processes and disrupting social-ecological systems?

- MAGIC has illustrated that it is possible (and urgent) to abandon the illusion of simplistic economic narratives to explain the sustainability predicament (Giampietro, 2019).

The existing reliance on received economic narratives led to a simple problem structuring – i.e. decisions can be taken using only scientific evidence. However, it is obvious that the assumptions that we will always have prices – i.e. that we will never experience absolute scarcity - entails the impossibility of unsustainability. Obviously, narratives that cannot see the possibility of experiencing absolute scarcity cannot be useful to study the sustainability predicament. It is time to move to alternative methods of analysis and alternative methods of decision making based on the acknowledgment of complexity and the need of reflexivity. Sustainability research must avoid the silo-governance attractor by integrating in a coherent way different inputs of relevant information referring to different levels and dimensions of analysis. This is essential in order to be able to reflect the existence of a variety of legitimate but non-equivalent concerns found in society. This cannot be done by relying on "Frankenstein models" (e.g. Integrated Assessment Models) in which a basic framework of analysis developed within economic narratives is fed with simplistic "ad hoc" models studying "water", "energy", "food", "emissions" linked to a variety of non-equivalent descriptive domains impossible to integrate. In the era of big data, we still use quantitative analysis based on differential equations: an inferential system that requires the adoption of a scale and a dimension at the time.

- The COVID-19 has clearly shown the possibility that large-scale perturbations can impose sudden radical changes in society, and the futility of searching for a Laplacian demon that will restore prediction and control. We do not have (or we do not recognize) the quality evidence required for a fair and robust deliberation about radical re-adjustments of social practices.

History tells us that the legitimacy (and stability) of the institutions of a society depends on their ability of reducing the stress (associated with the fears and hopes experienced daily) of its population. We are now living in a "full" and over-connected world in which it is becoming more and more likely to experience large scale perturbations coming either from nature, political turmoil, or financial collapses. A discussion over the possibility of quick adjustments of society to forced change should start from a share understanding of actual societal practices and their relation to feelings. The COVID-19 has shown that we can change our social practices overnight, something that cannot be done by technological silver-bullets. So rather than working on more and more complicated technological fixes (that would require decades to become operational) we should explore the remarkable capability of adaptation of human societies.

Why are we using resources? To do what? How are resources used? Which resources are more essential? How are they affecting the quality of social practices? These are some of the questions needed to explore and deliberate over a transition to alternative lifestyles institutions, and ways of developing and deploying technology.

This is the information that MAGIC has generated, and that is systematically ignored by convention. Unfortunately, rather than understanding the deep challenges in order to be prepared for changes, we bet that technocratic promises, based on shallow innovations and new business models, will be capable of preserving the existing institutions and life styles forever.

2.2 In relation to epistemological reflections

- MAGIC has illustrated the complexity of the Nexus. We have to accept that error and failure are inevitable parts of the policy-making ecosystem; it is urgent to develop a culture of experimentation and resilience in a context in which the mainstream narrative has always been one of efficiency and control.

- MAGIC has shown that there is untapped useful knowledge beyond accredited expertise and institutional boundaries. Some of these types of knowledge are not utilized because of bureaucratic and disciplinary constraints, and other types of relevant knowledge becomes invisible because it can perturb a perceive fragile status-quo. It is urgent to develop democratic processes for the seamless deployment of uncomfortable knowledge.

- MAGIC has shown that many institutional goals reflect a nostalgic view of the past, including the privileged role of expert evidence as an input to policy-making. What constitutes quality evidence is not sculpted in stone but modulated by power, tradition, culture and other contextual and contingent considerations. It is urgent to democratize evidence, developing or enhancing robustness by inclusion, diversity, and plurality.

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EPILOGUE

MAGIC: a Journey with Uncomfortable Knowledge and Values

Roger Strand

30 September 2020 is our last day as researchers in the Horizon 2020-funded Research and Innovation action "MAGIC: Moving towards Adaptive Governance in Complexity: Informing Nexus Security". For me personally, MAGIC has been an enormously enriching experience. As the project in its formal sense is coming to an end, I will try to put into words some lessons from it.

In this last issue of the Nexus Times, we ask: "What is the contribution of MAGIC to Post-Normal Science?" Part of the answer follows from the sheer size and institutional positioning of the project. With a budget of 7 million euros and with formal connections with European Commission departments and agencies, MAGIC was able to go massively into ongoing policy issues and analyse them from the post-normal science perspective. In our studies, we have combined number crunching integrated environmental assessments, theoretically grounded social science and real-life engagement with policy-makers at what I believe is a hitherto unprecedented depth and scope in the post-normal community. I have also argued elsewhere that MAGIC developed into a truly inter- and in some respects transdisciplinary journey in which researchers coming from different fields and different epistemological postures learned, developed and changed on the way (Strand 2019).

Working inside of and living with this huge project has given opportunities to further develop the philosophy of post-normal science. What follows, are some early reflections.

Post-Normal Science

What is post-normal science (PNS)? In order to answer the question, it is useful to distinguish between the diagnosis and the proposed therapy, to borrow from medical jargon (Strand 2018). In the very first statement of the diagnosis, five years before the term "post-normal science" was invented, Funtowicz and Ravetz (1985) explained how there is a class of decision problems where stakes and/or systems uncertainties are very high. Indeed, uncertainties are not only high but irreducible because technical and scientific attempts to reduce them end up being contested, and instead of consensus on knowledge and action there is only more controversy. Reducing uncertainty in a decision problem by means of scientific and technical expertise implies reducing the scope. One has to define a problem that is tractable for science or engineering, meaning that the borders of the system have to be defined, the model of causal networks considered has to be closed (Wynne 1992), the time frame has to be limited, and ultimately cut-offs have to be made with respect to what are the legitimate stakes and who are the affected parties by the decision. Scientific choices accordingly have consequences for what is seen as legitimate stakes. Conversely, choices on who are the legitimate stakeholders and what are their stakes, have bearings on the definition of the scientific and technical problems to be pursued.

While PNS literature tends to say "high stakes or high uncertainties", this may lead readers to believe that stakes and uncertainties are two separate and independent criteria. They are not, and this was made crystal clear already in the original treatment of the subject (Funtowicz & Ravetz 1985). Stakes and uncertainties are deeply entangled, and more generally, so are knowledge and values. The latter entanglement is perhaps the only significant insight that grew out of the many theoretical debates in philosophy of science in the 20th century and that led to the culmination and decline of logical positivism and logical empiricism.

When are stakes and uncertainties high? They are high when the controversy does not go away. In principle, anyone with the required skill and effort can find uncertainty and complexity. Already the ancient rabbis knew that he who destroys a single soul destroys a whole world, and in addition, there are innumerous connections between that single soul and its surroundings. The "therapy" proposed by Funtowicz and Ravetz in 1985 to governmental actors in charge of public decision-making processes was to accept the state of affairs in cases of seemingly never-ending controversies instead of trying to enforce consensus by imposing scientific and technical reduction of uncertainty. The post-normal answer to the decision problem was to admit that it was a hybrid political and technical one, in which both facts and values have to be deliberated upon – a "total-environmental assessment" in their words:

"This evolution, towards rationality and dialogue, may indeed take years to accomplish: in its early stages a "total-environmental assessment" may really seem to be a clash between incommensurable world-view. But such debates tend to stimulate the production of knowledge, of relevant facts and of value commitments, which eventually enable such problems to be resolved by political debate rather than by civil war." (Funtowicz & Ravetz 1985, p. 844)

We might add: rather than by civil war or by unilateral violence or other forms of hegemonic power to silence others.

Since the 1990s, a PNS community of scholars and practitioners emerged and the focus on practical implementation and progress increased. Techniques developed for characterising and managing uncertainty, as well as participatory approaches to producing and appraising knowledge claims ("extending the peer community"). Along the way, the original argumentative link between the diagnostic and therapeutic part of PNS has in my opinion been somewhat lost or deflated. Funtowicz and Ravetz did not sell or offer techniques in order to make decision-making easier or more efficient; PNS was not proposed as a "quick fix". It was a matter of accepting that the usual strategies in the modern state and in modern bureaucracies (of relegating knowledge questions to science) sometimes do not work; of accepting that sometimes there can be no quick fix. In particular, controversies tend not to go away by using the quick fix of imposing narrow notions of rationality which exclude every type of reason that does not pretend to be value-neutral. "Le cœur a ses raisons, que la raison ne connaît point," Pascal (1670) said. Besides of that, there is no deduction from the diagnosis to the one "right" therapy. Indeed, Funtowicz and Ravetz always welcomed new approaches to PNS and never policed against them as long as they shared the fundamental value commitment to deliberation and conviviality rather than violence (Ravetz & Funtowicz 1999).

Uncomfortable knowledge

Since 1985, never-ending public controversies about almost any kind of decision in our sociotechnical systems have become ubiquitous. The concept of post-normal science is widely cited and used, and so are more or less similar concepts such as "wicked problems", "Mode 2", "socially robust" and many others. The creation of the internet and the information society made it easier for billions of people to retrieve, produce and disseminate facts, values and worldviews. In this sense, the world has become post-normal and possibly also post-modern in the sense that the monopoly on Grand Narratives is weaker.

Nexus issues, which arise at the interface between different sectors and areas of governance, each with their specific scientific, technical and legal expertise, are almost by definition post-normal in the sense of high stakes and system uncertainties. All the issues that MAGIC analysed and engaged with, were definitely post-normal, and the MAGIC research approach was tailored to deal with that by studying the relationship between value commitments (in the form of preanalytical policy narratives) and facts (in the form knowledge claims about decision options and consequences).

At the same time, the knowledge production inside MAGIC, in particular that related to MuSIASEM, the multiscale, multi-level type of integrated environmental assessment developed by the project coordinator Mario Giampietro and his colleagues, comes with its own value commitment. It is committed to respect the value of sustainability of the biosphere. Accordingly, perhaps the singularly most important concept in MAGIC was that of biophysical feasibility: of whether a given course of action allows or undermines the regeneration of the biophysical funds upon which it depends. For instance, agriculture is not feasible in the long run if performed in such a way that the soil is eroded or destroyed. Again and again, MAGIC case studies indicated the biophysical unfeasibility of policies that are very real and very much alive and endorsed by the EU and its member states. Current energy policies, agricultural policies and policies for the circular economy were found to be unfeasible.

MAGIC was of course not the first research effort to make this discovery. Colleagues within and outside of the MAGIC consortium have been making similar claims for years if not decades, in particular within the field of ecological economics. The special circumstance of MAGIC was, however, that we had an institutional anchoring to engage with policy-makers in the European Commission and its agencies to discuss the results with them. Recalling the 1985 Funtowicz and Ravetz classic, we were placed – or rather placed ourselves – within a total-environmental assessment in which we sometimes even played two roles simultaneously, as dissidents that created and upheld a controversy around the policies, and as creators and custodians of that deliberative space in which the controversy played out.

Unsurprisingly, our contributions were not always so welcome. This observation is reflected upon elsewhere in the Nexus Times and in our project deliverables (from WP5 and WP6) and it was even endorsed as an empirical finding by our project reviewers. In order to make sense of that finding, we found Steve Rayner's (2012) concepts of "uncomfortable knowledge" and "socially constructed ignorance" to be particularly useful. Any actor (be it an institution or an individual) has to simplify complexity in order to be able to act at all. One cannot wait for complete understanding of everything from every point of view. This is even more so for bureaucracies, which have a value commitment to legal certainty and predictability and work by applying an institutional logic (in terms of rules, regulations and practices). That institutional logic, in Rayner's analysis, is in need of legitimization, which it gets from a (largely implicit) model of the world with which it interacts. This model has to be a simplified view of reality that justifies action in the absence of full information about the parts of reality that lie outside of the scope of the model. Otherwise the institution cannot act. In this sense, the institutional logic is justified by socially constructed ignorance outside of its subject domain. A simple word for this is "silo". Now, the problem occurs when the institution is presented with knowledge that undermines the credibility of that simplified view of reality and accordingly, the legitimacy of the institutional logic and its practices. Such knowledge is what Rayner called uncomfortable.

In the course of its four years, MAGIC produced nothing but uncomfortable knowledge from the perspective of European policies. Almost all our findings could be taken to undermine the credibility of the more or less implicit assumptions of the nexus policies we investigated. In part, this discrepancy (or whatever we should call it) probably reflects back on us as scientists/scholars and our own academic identities, value commitments and idiosyncrasies. More fundamentally, however, we believe the discrepancy to be part of a collective, civilisational discrepancy that produces dangerous forms of socially constructed ignorance in our institutions, and a dangerous form of cognitive dissonance in individuals. Kjetil Rommetveit described this as a tension between two meta-narratives of our time (Rommetveit et al. 2013). The first narrative is "GEOS", the narrative that builds on the systems sciences (ecology, climate science, ecological economics and others) to say that things are not going well, there are limits to growth and that sustainability calls for radical changes in society and the economy. The second narrative is "BIOS", the narrative building on neo-classical economics and the optimism surrounding biotechnology and ICT that says that things are going very well, and that we should continue with business-as-usual, innovation and growth within some form of capitalism.

In Kovacic et al. (2019) we discussed how both BIOS and GEOS concerns are present in the policies and the bureaucracies (though quite unevenly distributed across directorates and agencies). However, BIOS is the more powerful narrative, deeply embedded in the European institutions, which means that GEOS concerns (sustainability, biodiversity, climate change etc) often are dealt with in policy-making by devising a BIOS solution attempt (emission trading, circular economy, technological innovation etc). Most MAGIC results, however, indicated that these translations from GEOS concerns to BIOS solutions fail to be biophysically viable.

For many policy-makers, MAGIC findings were accordingly not useful because they could not be translated into action within the existing institutional logic. Worse, the findings delegitimized existing policy and action.

Uncomfortable values

Rayner's vision for how to escape the lock-in of uncomfortable knowledge and socially constructed ignorance is simply institutional change. If there is valid knowledge around that discredits the model of reality upon which an institution is built, the model should be revised, and the institutional logic and practice should change. Rayner warned about sources of inertia that impede necessary change.

In the case of the tension between BIOS and GEOS, the roots of the inertia seem to run deep and far beyond the organisational culture of the governmental organisations. The European Green Deal appears to acutely express this depth. While it describes the unsustainability of our societies and the severity of the various environmental crises more clearly than perhaps any such high-level policy did before, it proceeds directly into promises of continued growth and increased wealth for everybody, "ensuring that no one is left behind" (EC 2019). Europe is to become a society "where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" (EC 2019).

Now, one does not need a big research project to know that these statements, indeed the fundamental assumption on which the entire narrative of the European Green Deal is built, simply are contrary to existing knowledge. Decoupling has not taken place and there are decades of research that strongly indicate that it cannot take place to any significant degree (Parrique et al. 2019). When a one-trillion euro policy is built around a knowledge claim that would not survive introductory exams in sustainability science, this cannot be accounted for by rigid institutional structure. Rather, it stands out as an expression of affect, of combined hope, fear and despair. It emanates the emotional necessity of material wealth and prosperity. Economic decline is too painful to endure. If reality tells the Europeans that their level of prosperity and affluence has to decrease in order that society become sustainable, then reality must cede.

A similar analysis was made with respect to the Sustainable Development Goals, seeing them as expressions of fantasy in the psychoanalytic sense (Fletcher & Rammelt 2017).

The MAGIC project has also been a venue to discuss such ideas. Mario Giampietro has moved his multi-level, multi-scale style of thought also into the relationship between societies, communities and individual human psyche. In his perspective, the conspicuous lack of feasibility of dominant narratives on food, energy and the environment can be interpreted as a form of collective delirium of affluent urban elites (Giampietro 2018), as a wilful loss of cognitive function in order to escape the cognitive dissonance between BIOS and GEOS, and the unbearable pain of fear for becoming poor.

To recall Pascal, also the policy-makers' hearts have reasons that reason does not know. Parallel to Rayner's analysis, one could postulate that reality offers too much complexity also in the affective dimension, and that actors both at the collective and individual level have to shield themselves from being overwhelmed and paralysed by conflicting values and desires. In this case, the dissonance arises from the fact/value-complex that the citizens of the urban elite (1) want and need to consume at unsustainable levels now and for the rest of their lives but they also (2) want that future generations enjoy the same affluence, and (3) you cannot have both in reality. Of these three elements one can only choose two; or perhaps one and two halves, sacrificing a bit of cognitive function and a bit of the concern for future generations. In this sense it appears to be a hybrid of socially constructed ignorance and socially constructed intemperance. This could also explain the occasional outbursts of affect when MAGIC researchers have engaged with policy-makers. It may not have been just a case of uncomfortable knowledge; it may also have been a matter of uncomfortable values that discredited the intemperance as we stated the concern of (real) sustainability with such clarity. At least my personal experience fits with this explanation: The angrier the response, the more knowledgeable was the responder. And the anger was perhaps mixed with self-anger.

The Ego, wuwei and the TAO

What some might think is a dry topic – nexus issues in European policy-making – was accordingly also a journey into the deep existential issues of citizens of the 21st century, of hopes and desires, of fear and denial, of conviviality and co-existence with the biosphere on which we depend for long-term survival.

The final and unfinished part of that journey, which at least to me was helpful for my understanding of post-normal science, is the one that asked about our own role in society, as post-normal thinkers in a big research project of this type. What we already largely knew at the onset of the project, was that we as researchers do not speak Truth to Power but that we too have a view from somewhere, from our own epistemic and value commitments. This is an insight that calls for reflexivity and modesty (Strand & Cañellas-Boltà 2006). As researchers-citizens-activists we care for some issues, which means that there are other issues that we do not care equally much for; care is not morally innocent (Puig de la Bellacasa 2011).

In our efforts to engage with nexus policy-making, we tried to combine the care for sustainability (understood in terms of biophysical feasibility and societal viability) with a posture of care for the individuals and institutions with which we engaged. While it is far too early to know what we may have achieved, I would not be too surprised if it turns out that little traceable impact in the direction of institutional change can be attributed to our efforts.

The question is, however, if one should aim for impact, or if this is another of these metaphors that reduce complexity in unfortunate ways. "Impact" connotes a mechanical relationship between interlocutors, in this case us researchers and them, the policy-makers, as if we run into them at high speed and the collision sets them in motion.

Towards the end of the project, some of us – as witnessed on Zora Kovacic' blog and in the final chapter of Kovacic et al. (2019) – consulted the history of philosophy to reflect around these issues, and found gems in ancient Taoist writings, notably Laozi's Tao Te Ching and Zhuangzi's writings. In Zhuangzi's stories "In the World of Men", there is indeed a profound discussion about how to give advice to the ruler who is not impressed by the advisor. As always in Taoism, the answer lies in wuwei – "non-action", which does not mean passivity but to abstain from trying to enforce change, from pushing and trying to control. This motif is already present in Laozi,' Tao Te Ching:

Trying to control the world?
I see you won't succeed.
The world is a spiritual vessel
And cannot be controlled.
Those who control, fail.
Those who grasp, lose.

-and has been utilized in the writings of Mario Giampietro and Kozo Mayumi as a way to explain how to govern in complexity (see e.g. Giampietro et al. 2012). If we think of the biosphere as the TAO, we realize that we, through our very partial understanding of it, will fail if we try to control it. Rather, wuwei means to act in accordance with the workings of the biosphere, and do as little as we can to oppose it. If we try to force it, we risk destroying subtle workings that we do not understand.

Zhuangzi took the analysis further by also recognising that humans and human individuals, including the ruler, are also TAO. We do not fully understand their minds and we should not try to push them; wuwei would mean to act in accordance with their workings.

Interpretations of this relatively vague insight abound. It can be seen as a pedagogical point – that nudging is better than screaming, perhaps, still within a logic of "impact" and manipulation, quite alien to the ethos of post-normal science of deliberation and conviviality. Or it can be seen as an ethical point, akin to yogic thought where one would say that one should try to meet one's fellow human being at a higher chakra. To confront the urban elite for being ignorant, selfish and deluded would perhaps be to meet them at the lowest of chakras, kicking them in the belly or below. If so, it would not be surprising that the response is defensive or hostile. A posture of care would at least have to rise to the heart chakra to empathise.

Zhuangzi, however, makes a much taller order, all the way up to what the yogis would call the highest chakra, and asks for a posture of "fasting the mind", that is, emptying and bracketing one's ego and one's own sense of urgency and desire to push and achieve. Our own actions should not be caused by the prospect of "impact". Rather, they should be grounded in our own TAO, in who we are, who we choose to be and what we choose to care for.

In modern language, the line of argument from post-normal science via reflexivity seems to flow towards virtue ethics (to which the ethics of care belongs). A similar argument was developed by Funtowicz and Strand (2011), going towards the philosophy of Hannah Arendt rather than Zhuangzi. I see this rediscovery as a MAGIC contribution to post-normal science that emphasizes even more strongly that PNS is not and should not be a set of techniques and promises of quick fix, and that the currently ubiquitous sense of urgency is part of our troubles. I call it a rediscovery because in its spirit, these trains of thought seem to return to the very first articulation of total-environmental assessment (Funtowicz & Ravetz 1985): that in some instances, there is no simple solution and the attempt to enforce it will simply make things worse. The challenge we are confronted with is to accept that the world is what it is and maintain a spirit of respectful engagement and conviviality, while staying true to our desire to change the things for the better and strive for sustainability. In less prosaic terms, what is called for is a reconciliation of our minds, hearts and bodies. While certainly not offering any quick fix, MAGIC developed knowledge, tools and approaches to pursue that path, the first steps to try to integrate the wuwei of governing within the complexity within the biosphere and within society and its complex institutions and individuals, without losing ourselves on the way.

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