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Investigating science for governance through the lenses of complexity

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ABSTRACT

This paper assesses the contributions of complexity theory to post-normal science. The oversupply of facts in science for governance is explained as a matter of complexity, defined as irreducible pluralism in the knowledge base. The paper shows how complexity provides an interface to engage with the multiple facts of science through three different examples. First, water narratives are used to show how different scales of analysis produce contradictory scientific representations of the same system. Second, smart electricity grids are assessed to demonstrate how different levels of uncertainty are associated with different representations. Third, the case of slum upgrading is used to discuss the need to take into account stakes in science for governance.

1. Introduction

"Post-truth" has been named word of the year, due to its wide usage in reference to Brexit and Trump as the products of political decisions no longer based on facts (Flood, 2016). According to a New York Times article, "The problem is the oversupply of facts in the 21st century: There are too many sources, too many methods, with varying levels of credibility, depending on who funded a given study and how the eye-catching number was selected" (Davies, 2016). The oversupply of facts reveals one of the fundamental challenges of the use of science for policy, which is the focus of this paper. The challenge is dealing with complexity, both in the definition of issues and in the scientific and political processes governing them.

Complexity is defined as the existence of non-equivalent representations of the same object of study. Non-equivalent refers to the fact that different representations cannot be reduced to one another. An example of non-equivalent representations is the debate about water scarcity in Israel. While the level of the Sea of Galilee, the country's largest fresh water source, is constantly monitored and used to provide evidence on the water crisis, the agricultural sector is taken as exemplary in overcoming water scarcity through efficiency and innovation, thanks to the adoption of drip irrigation, grey water recycling in agriculture and the development of sea-water resistant crops (Ministry of Environmental Protection, 2009; Ministry of Foreign Affairs, 2013; Rejwan & Yaacoby, 2015). Both narratives, the water crisis and the water efficiency narrative, are backed-up by scientific evidence. However, one cannot compare, or establish a trade-off, between the ecological status of a lake and water efficiency in agriculture.

The proposition "post-factual politics" assumes that facts play, or should play, a role in policy. Complexity raises a number of questions with regard to this assumption: which facts should be used for policy? If oversupply of facts is a problem, which facts should be left out? Should certain facts (e.g. ecological concerns, threats to sustainability) be given priority over others

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(e.g. the economic viability of farmers)? The answer to these questions requires value judgements and raises further questions: Who should decide which facts are to be considered? Post-normal science highlights the relevance of these questions for the science-policy interface. Funtowicz and Ravetz (1993) speak of soft facts as a criticism of the positivist view of facts as hard evidence that can guide policy towards the right course of action. Facts are not always hard, the right course of action cannot always be identified, and decisions cannot be taken in the abstract, with reference to supposedly undisputed values.

This paper analyses the science-policy interface from the point of view of complexity theory. The objective of this study is to assess how the complexity approach contributes to the understanding of some of the challenges of science for governance flagged by post-normal science.

2. Mobilising complexity theory in science for governance

One of the core questions of post-normal science is: What type of science should be done when facts are soft? Different answers and practical applications of post-normal science have emerged, including uncertainty assessment (revisiting the role of science as that of communicating uncertainty instead of facts), quality assurance (revisiting the practices of science to include reflexivity and accountability), participatory approaches and citizen science (broadening the scientific endeavour to include extended peers and extended facts), and complexity theory. My work focuses on the latter. In what follows I will highlight how complexity theory can help shed light over the different roles played by science and scientific evidence in different contexts.

Complexity theory turns on a redefinition of science away from the ideal of prediction and control, from the assumption that systems can be adequately described and understood by observing the mechanisms that govern a system's behaviour, that is, by observing the system. This approach criticizes the concept of observation as an act that requires no interpretation on behalf of the analyst. Instead, complexity embraces notions of emergence, non-linearity, impredicativity, autopoiesis and adaptive systems to point at the existence of different scales of analysis to describe the behaviour of a system (Funtowicz & Ravetz, 1994). The decision of what to observe and how determines the representation of the system. Observation is a crucial analytical step, rather than a self-evident, and interpretation-free pre-analytical step.

Ambiguity and uncertainty are not necessarily a problem of insufficient evidence and are not always a temporary deficit that can be overcome with more research, but rather reflect the limits of a single representation of the system and invite a plurality of perspectives to the scientific knowledge base. Complexity allows to build pluralism in scientific representations and to account for different levels of uncertainty. Complexity applications of post-normal science can be seen as an operationalization of the concept of extended facts (see for example Quantitative Story Telling, Saltelli & Giampietro, 2017).

The concept of system is central to this approach, and it refers to a complex whole, that is, a whole that can be analysed as an indivisible entity or as being made up of parts. It is a concept that invites multiple epistemologies. Complexity does not refer to the properties of the system under observation, it is not an ontological claim with respect to the nature of the object of study. From this perspective, more powerful computers or more complicated inferential systems cannot deal with the challenge posed by complexity. Complexity refers to the fact that the more one complexifies the definition of problems, the greater will be the selection of narratives used to describe and represent problems. The analytical tools of complexity theory include, among others, the use of multiple scales of analysis and multiple levels of uncertainty, as a means to produce non-equivalent representations of a given system.

Multiple scales of analysis are used to distinguish between the analysis of the whole (higher scale) and the analysis of the parts (lower scale) as two analytically distinct activities, requiring different descriptive choices (the level of analysis) and an explicit acknowledgment of the role of the observer that produces the observation (the level of observation). The existence of multiple non-equivalent descriptions of a system deconstructs the idea that the description of the system is independent of the observer, as different observations are produced by different observers.

The apparent contradictions between the different representations of water in Israel can be explained as referring to different scales of analysis. At the level of the ecosystem, water is seen as a scarce resource because water extraction far exceeds aquifer recharge. At the level of the agricultural sector, different levels of observation can be used to describe agriculture. According to the internal view (how the agricultural sector works), technological innovations have managed to reduce water consumption per ton of crop produced; according to the external view (how the agricultural sector relates to the whole), the growth in overall agricultural production has led to an increase of water demand in absolute terms.

Each scale of analysis is represented with different quantitative indicators. Fig. 1 assigns different indicators to different scales of analysis. The implication of this assessment is that contradictory evidence is not necessarily the result of sloppy science, but the consequence of irreducible pluralism.

A second analytical tool is the assessment of uncertainty through the lenses of complexity. Multiple levels of uncertainty are used to assess how the robustness of facts, or quantitative representations and knowledge claims, changes depending on context. The assessment of uncertainty as a matter of degree poses a criticism to the idea that "matters of fact" once established can be used as such in all contexts and situations. For example, technical knowledge about the functioning and performance of a solar panel developed in a laboratory, cannot be used to assess questions of viability and feasibility of a transition to renewable energies (a research question requiring knowledge of energy demand, energy supply, types of energy carriers, uses and functions of each energy carrier, types of technology and processes supported by each energy carrier, type of social organization and division of labour supported by energy consumption patterns, etc.).

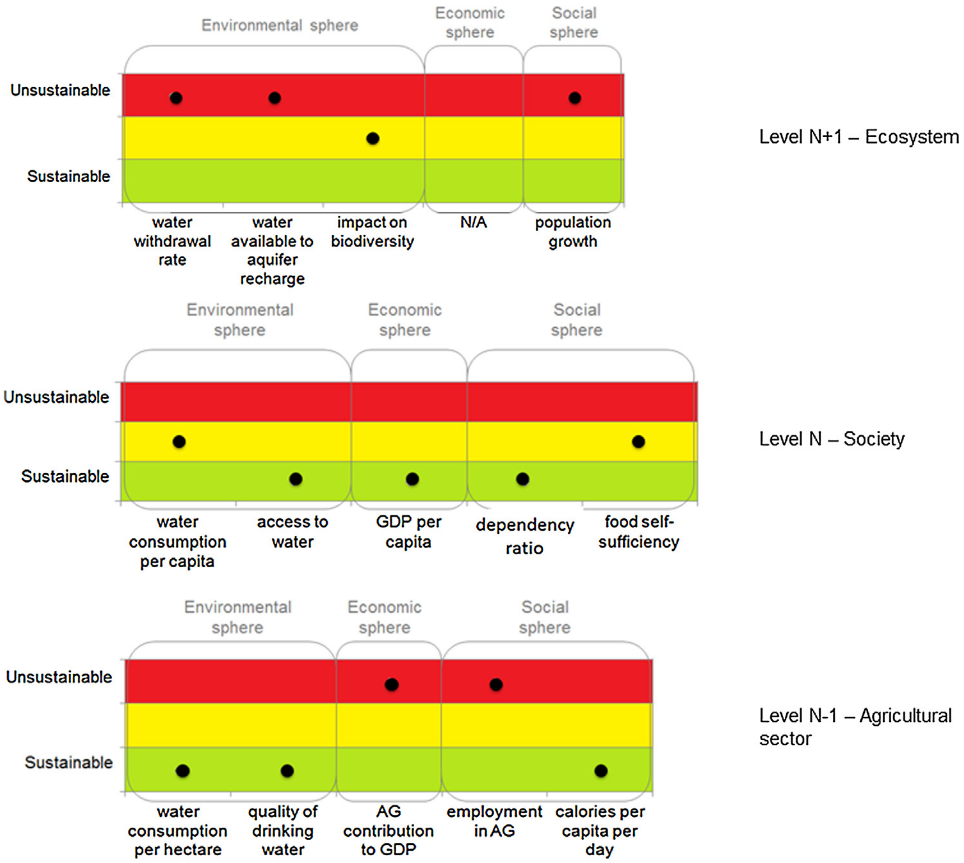

Fig. 1. Multiple scales of analysis for water narratives. Adapted from (Kovacic, 2014).

The debate on smart grids is one where the assessment of uncertainty across scales is necessary to avoid the transposition of insights gained at lower scales of analysis and low levels of uncertainty, to the discussion of challenges regarding higher scales of analysis and irreducible uncertainty. A plurality of definitions, uses and future visions are associated with smart grids. Smart grids are supposed to grant universal access to electricity as a human right, to lead to the decentralisation of the energy system, to change the role of consumers, to improve sustainability and energy security, and to help mitigate climate change (Kovacic & Giampietro, 2015). The label “smart grid” is used to discuss a lot more than a specific technology (the use of information technology in the management of electricity grids). The term assumes a high level of ambiguity as it is associated both with visions that challenge the current energy system (advocating for decentralisation, human rights and empowering consumers) and that seek to increase the efficiency of current energy system.

The ambiguity associated with the use of the “smart grid” label is aggravated by the fact that different visions tap onto different levels of uncertainty. In this context, the use of multi-scale analysis makes it possible to assess the uncertainty associated with different representations. At the level of energy demand, the smart grids narrative refers to the use of smart meters as a means to monitor and potentially manage the demand of electricity through time-of-day pricing. At the level of the electricity grid, smart grids refer to the use of Information and Communication Technology (ICT) as a means to improve the matching of demand peaks and fluctuations in supply, which are exacerbated by the use of renewable energy sources such as solar radiation and wind. At the level of the energy generation sector, the smart grid narrative is coupled with support for the transition towards renewable energy sources and greater sustainability. Even though electric grids are not directly related to the choice of energy sources, the transition narrative is very present in smart grids debates (Kovacic & Giampietro, 2015).

Different levels of uncertainty appear at different scales of analysis. At the level of smart meters, the uncertainty concerns the issue of privacy and data management derived from the collection of data on electricity consumption at the household level. Privacy risks are not intrinsic to electricity use, but rather are an uncertainty that is introduced by the use of ICT. Science and technology are in this case a source of uncertainty that create new governance challenges and the need for regulation and data protection. At the level of the electric grid, the uncertainty concerns the challenge of managing fluctuations in demand and volatility in supply with regard to the integration of renewable energy sources such as wind and solar radiation. In this regard, the use of technology reduces the uncertainty. Science plays the role of providing solutions to practical problems. At the level of electricity generation, the uncertainty concerns issues of sustainability and the challenge of dealing with indeterminacy linked to possible changes in the definition of socio-economic systems, in availability of fossil fuels, in carrying capacity, etc. Science in the latter case is not able to provide definitive answers.

The case of smart grids highlights not only the fact that science plays different roles, but also that these different roles may be attributed to the same set of knowledge claims and may compete with each other. The assessment of the different roles played by scientific knowledge is not only a philosophical concern, but can have practical implications with a bearing on the legitimacy of science.

An indicative case study relevant to this point is that of the informal settlement of Enkanini in the city of Stellenbosch, South Africa. The Enkanini settlement has been the target of an incremental upgrading project (iShack) endorsed by the Municipality of Stellenbosch and funded by the Bill and Melinda Gates Foundation, aimed at providing rooftop solar panels to shack dwellers (Kovacic, Smit, Musango, Brent, & Giampietro, 2016). The project has been at the centre of a social conflict between Enkanini's dwellers and the municipality of Stellenbosch, which culminated in the vandalising of the iShack project facilities in the settlement. Kovacic et al. (2016) explain the conflict in terms of epistemological uncertainty, that is, uncertainty generated by the simplification and reduction of knowledge claims.

Enkanini's dwellers demand for electricity has to be understood as a demand for access to full status citizenship, for formal recognition of the settlement, for connection to the electricity grid and inclusion in formal institutions. The response of the iShack project was to reduce the request for electricity to a technical issue of supply of electricity, and was interpreted by the dwellers as relegating their needs and rights to a status of second-class citizens.

Technical knowledge about the functioning of a solar panel cannot address socio-political challenges associated with the context of application. The existence of multiple legitimate perspectives and high decisions stakes has the power to undermine the legitimacy of science for governance. An example of a crisis of trust and legitimacy in the experts due to the mismanagement of uncertainty is given by Benessia and De Marchi (2017) in relation to the L'Aquila earthquake of 2009.

3. Conclusion

The hype around post-truth politics uncovers the need to produce a better understanding of the role of science in governance. From the point of view of post-normal science, crises of science (see for example Saltelli & Funtowicz, 2017; Saltelli & Giampietro, 2017) can be interpreted as the repeated failure of normal science to adapt to uncertainty, and to engage with multiple epistemologies.

This paper shows that science plays multiple roles in the governance process, including creating ambiguity, creating uncertainty and regulatory needs, reducing uncertainty, providing technologies, analytical tools, and methods, and so on. Science may work along side policy, facilitate governance processes, or be challenged and delegitimised by governance processes, as in the case of Enkanini. The approach of complexity theory explains some of the challenges of science for governance by making sense of multiple representations, multiple definitions of uncertainty, and by providing an interface to engage with multiple facts.

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