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Governing by models: Exploring the technopolitics of the (in)visilibities of land

Allison Loconto[a,*], Raoni Rajão[b]

[a] Institut National de la Recherche Agronomique (INRA), Laboratoire Interdisciplinaire Sciences Innovations Sociétés (UMR LISIS 1326 - CNRS, ESIEE, INRA, UPEM), Université Paris-Est Marne-la-Vallée, 5 blvd Descartes, 77454 Marne-la-Vallée Cedex 02, France

[b] Laboratório de Gestão de Serviços Ambientais (LAGESA), Departamento de Engenharia de Produção, Universidade Federal de Minas Gerais (UFMG), Av. Pres. Antônio Carlos, 6627 - Pampulha, Belo Horizonte, MG, 31270-901, Brazil

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ABSTRACT

Achieving food security at a global scale while protecting the environment, as envisioned in the Sustainable Development Goals, will require a complex process of collaboration and the integration of analyses at multiple scales. Agricultural and land use models are increasingly being used to bridge the global/local divide, particularly as a means to envision future land access, use and management in different agricultural production systems. This special issue contributes to our understanding of global modeling, governance and land use change. Specifically, it provides insights into the question of: how do the ways of knowing and governing affect the politics of environmental protection and agriculture? The papers in this special issue bring reflexive questions of knowledge production, public policy and civic engagement into the epistemic spaces of scientific and technological development, both as a means to improve the way we model and to understand the implications of governing by models.

1. Introduction

The quantitative revolution (Burton, 1963) and the subsequent widespread use of models in geography, ecology, economics and planning has led to profound transformations in the way land use has been represented and understood in different disciplines. One of the key promises of land use models – understood here as a range of quantitative instruments for understanding, planning and managing the use of land – is the ability (or at least the ambition) to provide comprehensive representations of the world and reveal the underlying 'real' causes of specific land use configurations (e.g., high yields) and changes (e.g., deforestation). From this it is expected that land use models allow governments to devise evidence-based policies that are more effective than those based on traditional political negotiation. Land use modelling builds on a long tradition of cartography as a quintessential instrument of State power (Anderson, 1991; Scott, 1998). But while maps are used mostly to define boundaries and property rights, land use models have a distinctive normative character, presenting a coherent and scaled-down version of a future reality. Thus, it is not surprising that the word "model" originates from "modello", the Italian word for the plan to guide the construction of a complex building, such as a cathedral, before the first brick is laid down. The word "modello" also shares the Indo-European root "MED-" and related meaning with the Latin words for measuring, thinking (i.e. meditating) and governing (i.e. moderating) (d'Hauterive, 1949).[1] As a consequence, since its semantic origins land use models aimed both to represent and to change the world.

The growing importance of land use models and its underlying disciplines did not go unnoticed to critical social scientists. Amongst others, Lefebvre (1974); Harvey (1984), and Soja (1989), dedicated much of their work to criticizing the growing focus of geography on positivist methods. In particular, they pointed out that the positivist epistemology embedded in quantitative geography objectifies a complex social reality into an impoverished abstract space of numbers and symbols. Based on this line of reasoning, there has been a stream of studies that suggest that the overreliance on land-use models might lead to the distancing of government officials from local communities as modelling can lead to selective imaging of communities' social reality. Since what is not represented in the model is often not 'real' to decision-makers, important aspects of social life remain invisible and are not addressed by their policies (Aitken and Michel, 1995; Pickles, 1995; Roberts and Schein, 1995; Taylor and Johnston, 1995).

* Corresponding author.
E-mail addresses: allison-marie.loconto@inra.fr (A. Loconto), rajao@ufmg.br (R. Rajão).

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While confirming many of the epistemological critiques of models, the suite of papers in this special issue offers different ways of engaging with epistemological and ontological gazes through new forms of technopolitics. Each paper addresses a specific land use model in order to refocus the political debates on the technical concerns that constitute them. With the purpose of crossing epistemological and ontological gazes, this special issue analyses the role of land use in relation to increasingly important issues such as deforestation, desertification, biodiversity conservation, and agricultural production. We take a closer look at the scientific practices that contribute to land use policy to show a more nuanced understanding of how the (in)visibilities of models emerge and shape reality. Once we open the black box of land use models and observe them "in the making" it is possible to go beyond the broad critiques on positivism and quantification that has characterized most of the literature.

In the remainder of this introduction, we present the epistemology of models and the ontological turn in science and technology studies (STS). The contribution of the papers in this special issue is to combine these two gazes into a cohesive approach to understanding the governing of land by models. Two transversal themes organize the lessons learned from the articles in this special issue. First, knowledge politics – internal to disciplines and external, across disciplines and user communities – shape the ontological focus of models. Second, scale matters in both what can be modeled and what can be known from modelling. Indeed, the constitution of scale itself is an ontological effect of modelling land use. The consequences of these two aspects of modelling demonstrate the contingent nature of our knowledge of land use, the political forces that can align around convenient results and the importance of reflexivity throughout the process of modelling.

2. The technopolitics of knowledge and (in)visibilities

As models are developed, variables identified, and data collected, there are specific questions of where this knowledge is coming from and how it is legitimated by the modelers as they decide to include or exclude certain elements from their models. These activities are in constant flux as the modelers learn and adjust the models. Thus, studying the interactions between evolving parts means we can only reach approximations. These approximations are effectively compromises or trade-offs where certain elements or effects of the model are exchanged for others. We can describe this work as the emergence of modeled realities (Kahane et al., 2015), which brings with it specific limitations about what the models allow us to see and what remains hidden from external view. However, the choice of what should be represented and what should be left out of models is not merely a technical one. STS scholars have long argued that this invisibilizing power of socio-technical devices, like models, (Bowker and Star, 1999; Lampland and Star, 2009; Loconto, 2014; Rajão, 2013), is a normative value judgement signifying that what is made invisible is irrelevant or worthless.

The articles in this special issue show that even the smallest methodological choice undertaken by modelers is also a deeply political one that has traceable origins and consequences. In the case of the land sparing and land sharing controversy described by Loconto et al. (this issue), ecologists and economists began to pick apart the assumptions of the model and restructure the model with elements that they found of worth, such as economic rebound effects that drive the extension of intensified land use at the expense of preserved land; or the effects of pesticide use on pollinators who are fundamental to biodiversity conservation. However, this did not necessarily affect the instrumentalization of land sparing by large agribusiness. Likewise, Dorin and Joly (this issue) mobilize a history of models that have been used to predict world agriculture's land and resource use since the 1960s to point out how they are hybrid approaches to modelling and have serious limitations in their ability to represent real world diversity. The authors explore an alternative modelling exercise that was developed as a participatory foresight model with the specific intention of supporting public debate, rather than prediction. They argue that when the political stance of using a model as a "learning machine", rather than a "truth machine" is adopted, some virtual realities, processes and actors that were invisible in mainstream predictive models can enter into both the scientific and public debates.

The papers in this special issue also lead us to a more nuanced understanding of the small "p" politics involved in the pragmatic choices that modelers have to take, and their relation to the (in)visibilities and epistemological limitations of models (cf. Moore, 1995). By providing detailed accounts of how scientists work and interact, the articles of this special issue give modelers a human face, as products of a specific social and epistemic context, rather than simply numb instruments of modern Capitalism. This is clear, for instance, when Hecht and Rajão (this issue) show that the colonization of the Amazon was a civilizing dream shared with land use modelers rather than a mindless destruction of nature. In some cases, scientists are aware of the consequences of those trade-offs, but they also must juggle multiple demands and the need to provide objective answers. In this direction, Cheyns et al. (this issue) show that the focus of scientists on carbon sequestration, which brings with it the possibility for participating in markets for carbon as a tradable commodity, has traded off civic notions of justice for the rural palm oil producing communities. In the same line, Wolf and Ghosh (this issue) show that the decisions to optimize a model and market for only one nitrogen management practice in one crop has traded off a range of diverse nitrogen management practices that may be better at reducing nitrogen emissions. Consequently, industrial-scale farming benefits at the expense of both effective climate change mitigation and small farmers' livelihoods. In this way, the (in)visibilities promoted by models only rarely are related to adherence of a specific political (in capital "P") agenda. Instead, models emerge following a series of choices stemming small "p" politics: institutionalized modelling practices and pragmatic research limitations (e.g. it is easier to model a monoculture than a complex agroforestry system).

3. From the epistemological to the ontological techopolitics of models

By emphasizing that the "map is not the territory", this strand of literature provides the basis for an epistemological critique of land use models. However, understanding how land use models produce certain realities is as important as assessing the ability of models to produce valid knowledge about the world. What we argue, and what the papers in this special issue demonstrate, is that to better understand how policy and land use science can contribute to more sustainable land use in practice we must critically examine *how* the map makes the territory, rather than dismissing them as faulty representations.

The move away from an epistemological critique into what we can call an ontological critique of land use models is closely related to the development of this concept within the field of science and technology studies (STS) (Law, 2008; Law and Lien, 2013; Sismondo, 2015). The study of ontology has long roots in philosophical thinking and can be broadly defined as the study of the nature of being or reality. Thinkers such as Descartes and Hume have dedicated many pages of their works arguing over whether reality exists or not independently of a perceiving mind. Similarly, the ontological investigations of Heidegger (1977) strived to identify the essence of technology and modernity. In contrast to this philosophical tradition, social scientists emphasize the need to study reality not as a universal and atemporal being but rather as the outcome of specific contextualized practices (Hui et al., 2017). Furthermore, the ontological turn breaks with the epistemological focus of perspectivism (i.e. a single reality that is perceived and known differently) and proposes the existence of multiple realities and related ontologies (Law and Lien, 2013; Mol, 2002) or, put differently, modes of existence (Latour, 2013). The ontological turn also sets itself apart from the concept of the more relativist social construction of reality

(Berger and Luckmann, 1966) because of its insistence on the historical and material contributions to stabilized realities. By drawing upon actor-network theory, many STS scholars argue that the world is made of not only social actors and institutions but also by material arrangements and non-human actors (Callon, 1986; MacKenzie, 2009). Finally, many studies in this tradition oppose the notion that reality is a static entity, passively waiting to be discovered and understood by our senses. Instead, drawing upon ethnomethodology and Austin's speech act theory, reality is seen as a practical accomplishment that needs to be constantly performed or enacted in order to come into being and remain stable (Callon, 2010; Cochoy et al., 2010).

It is possible to feel the echoes of the ontological turn in STS in the study of land use models and related technologies and disciplines. There is growing interest in the way through which economic theories and models perform reality (Callon, 1998, 1999; MacKenzie et al., 2007; Muniesa, 2014). MacKenzie (2006) provides a good example of the performative aspect of economics in a study of the Black–Scholes model, an influential option pricing formula developed in the 1970s. Based on the observation of how options were sold and bought in the market following the introduction of this model, MacKenzie (2006) argues that economic models should not be understood as "cameras" that reflect reality, but instead as "engines" that perform reality in specific ways. In a similar vein, a growing number of studies have looked at maps and other land use models as world-making practices rather than simplified representations (Kitchin and Dodge, 2007; Leuenberger and Schnell, 2010; Pickles, 2004). This emphasis on the performance of reality (rather than its static nature) has been one of the hallmarks of the ontological turn in STS and in other fields. It also provided new avenues to understand how models not only "frame" a pre-existing reality (as the epistemological approach often assumes) but is a key component in the co-production of this reality (Jasanoff, 2004).

Of course, the ontological effects of models do not affect society as a sort of disembodied invisible force. Land use models are only effective and influential if and when they are enmeshed in practices, networks and data infrastructures stretching from university labs to the centers of power in government and large corporations. In this regard, Rajão and Vurdubakis (2013) provide a detailed example of how geographic information systems are involved in the pragmatics of inscription that are behind the constitution of illegal deforestation in the Amazon rainforest. By focusing on the ontological aspects of satellite images, geographical coordinates and other cartographic representations, instead of their epistemological limitations, their article shows that illegal deforestation becomes "real" only thanks to the practices of forest rangers aiming to render deforestation a stable object of knowledge that is at once singular and coordinated with other objects. Otherwise, farmers would very likely be able to render the same object multiple and irreconcilable (i.e. deny the ownership of the land or the existence of the environmental damage) in order to avoid criminal prosecution. Therefore, this and other studies suggest that under specific social and material circumstances land-use models could contribute to the performance of specific realities, becoming in this way self-fulfilling prophecies.

4. Constituting scale to make land use (in)visible

Beyond the above explained politics demonstrated by the articles in this special issue, they also document the ontological implications of land use models at different scales. Indeed, the idea of working and modelling at a specific scale is a well-recognized constraint imposed on a model by a number of factors, such as the availability of data, the mathematics of its calculations or the politics of the research questions. Scale has constituted a core scientific challenge for the development of the field (Gibson et al., 1998; Marceau, 1999). The result is that the knowledge produced by a model is understandable only at the scale that was modeled, and scaling introduces new uncertainties. This technical concern reinforces our political understanding that 'scale' is a particular way of seeing and being in the world. We find that each of the articles in this special issue also address the politics tied to the scales at which the models work.

Modelling land at the farm level often means that the specificity – and simplicity – used for the model's parameters and variables can be reproduced in farming practices. Wolf and Ghosh (this issue) explore how the Nitrogen Management Protocol Project (NMPP) developed a set of standardized farm management processes that could be used by a farmer to earn offset credits. These credits could then be sold in a voluntary market or in the regulatory compliance market. This protocol used a model of nitrogen emissions that was restricted to only one agronomic practice (reducing synthetic fertilizer application) in one crop production system (rain-fed maize). By analyzing how the NMPP measures nitrogen management and how the markets were constructed, the authors focus on the model's limits. They argue that this definition of 'model' farm management of nitrogen effectively excludes numerous farmers from participating in the carbon markets and discourages the use of a diversity of nitrogen management practices that could be more effective at reducing N_20 emissions.

Loconto et al. (this issue) trace the circulation of an ecological model that has provided evidence to a controversial view that sparing land for nature through intensification of agriculture is the best option for biodiversity. They focus on the model developed by Green et al. (2005) that assumes a convex relationship between yield and biodiversity conservation in individual farm plots. Their analysis demonstrates that this model embodies an underlying compositionalism ethic that envisions humans as separate from nature, as an opposed to the land sharing proposition that demonstrates a functionalism ethic of humans living within nature. This ethical stance is reinforced through the social networks of scientists and funders who continue to support research that furthers a bifurcated approach to the production of scientific knowledge. The authors further argue that the success of this model in agricultural practice and policy is less a result of overt 'interests' and more the fact that the results produced by the modelers fit together nicely with the worldview of agribusiness and sustainability standards, who developed their own techniques to translate the scientific results into quick, user-friendly tools that are effectively changing producers' practices around the world.

When land is modeled at the landscape level there is an uncomfortable fit between land-users' knowledge and the standardized models that assess the effects of landscape changes. Three articles in this special issue deal with how models help to define and intervene in the construction of landscapes. Turner (this issue) offers a detailed analysis of how two models can and cannot offer policy guidance for smallholder agriculture production practices. By examining the rangeland-to-cropland metric and the nutrient balance model he mobilizes two metrics that are meant to identify the comparative degradation of land by measuring soil nutrients in different ways. Turner argues that the abstraction that is built into the way the models work, which is highly appreciated by environmental scientists, in practice emphasizes the resource limits of the regional agricultural system while not offering advice to land managers or policy-makers about what practices could change the rates of land degradation. Moreover, the heavy reliance on the results from these models, contributed to a continued ignorance of smallholder practices and the exclusion of their voices from policy debates over land degradation.

Land use models have been implicated in the transformation not only of social but also biophysical realities. Cheyns et al. (this issue) take the 'high carbon stock' (HCS) standard for redefining forests as a gradient of landscapes. They explore the zero-deforestation policy in the palm oil sector and they trace how 'the forest' was redefined through a new model for vegetation classification based primarily on a threshold of carbon sequestration. The purpose of this method is to identify which forested zones to protect from conversion to agriculture. The authors argue that despite extensive consultations with local communities and the piloting of the tool in Indonesia and Libera, the

HCS has a liberal grammar encoded into its very essence. For example, the specialization of labor and land valued in the model's calculations contrasts with the notion of a multifunctional landscape that is common in many rural areas. This means that despite attempts to include rural dwellers' interests, alongside those of the palm oil industry and governments, the ways in which specific uses of land are valued within the HCS standard dismisses those land uses that do not fit into a liberal market-industrial understanding of the value of land.

At the basin level Hecht and Rajão (this issue) provide a detailed historical account of how a set of land use models – land surveys, economic sectoral valuations and forest inventories – developed between the 1930s and 1960s changed the fate of the Amazon rainforest. The Amazon had historically been seen as an immutable and invincible nature where resources were given elements of natural landscapes. But thanks to the strategic use of this set of land use models, mostly by the United Nations and scientific institutions from Europe and the U.S., the region has been reimagined as an agricultural frontier subject to a technocratic, centralized and authoritarian style of developmentalism. This reimagination, and the proof provided through land use modelling, created a 'legal amazon' that was ready for large-scale colonization projects that would integrate the Amazon into a modern Brazil and protect it from capture by foreign powers.

Beyond the epistemological issues present in each of these cases, the models described at both the farm and landscape level not only represent but also produce small-scale farmers as damaging for the environment, while reinforcing the primacy and necessity of industrial-scale farmers and related green revolution narrative as the "solution" for climate change, land degradation and development more generally. These results are then turned into assumptions when models are invoked in global debates on how to reconcile growing food production and environmental protection.

Dorin and Joly (this issue) focus on composite models that are used to model global food security, climate change, trade flows, agricultural productivity and other environmental concerns of land use within planetary boundaries. Through a historical review of the mainstream models that have been developed since the 1960s, they argue that these are the products of interactions between epistemic communities and institutional strategies. Path-dependency, related to technical devices that support modelling and epistemic communities, creates strong irreversibilities in modelling methods which legitimates a narrow set of solutions for world agriculture and food production problems and, hence, to future land use and access to resources. By exploring the Agribiom model and how its assumptions and variables changed through its use in a foresight exercise focused on different possible land uses (Agrimonde), the authors argue that both the epistemologies and ontologies of land use models could be done differently.

5. Towards more reflexive modelling practices

Heidegger (1977), in his famous essay on the question of technology, points out that the creator is responsible for its creations and their consequences. Yet as models circulate, they take on the characteristics of what Latour (1987) calls "immutable mobiles" - objects that are transferred across communities of practice and which have transformative effects without apparently being transformed themselves" (28). They are essentially black-boxed, which is fundamental to their effectiveness as instruments of knowledge that can consistently produce results that can be trusted. In this context, where do the responsibilities of modelers lay as land use models, while epistemologically limited, are becoming increasingly ontologically relevant?

The papers included in this special issue reflect upon how much we should be questioning the underlying knowledge of the models that we use – in addition to the extent to which we question and challenge their policy prescriptions. We are not proposing a simplistic critique of models and modelers, rather we have demonstrated that the models gain a life of their own where epistemologies and ontologies are difficult to disentangle. We argue that care should be given to how models are used in policy-making around land use, recognizing that often policy-makers must work with instruments that are already imbibed with their own technopolitics of land use. We hope that the empirical and theoretical contributions of this special issue can contribute not only to advancing the debate on the social aspects of land use models, but also improve the relevance of modelling for policy-makers.

As most of the articles contained in this special issue have showed, land use models have indirectly and perhaps unintendedly supported deforestation, desertification, productivist agriculture, and technopolitical interests. This calls for the urgent need of modelers to understand the external politics of models and how they are related to their own internal politics expressed as pragmatic methodological choices and scientific paradigms. As models become policy-making tools able to shape reality, those abstractions and implications are often forgotten. However, modelers are limited in their ability to see the invisibilizing effects of modelling from their position from within. Levidow (1996), citing Beck (1992), argues that even when science 'begins to diagnose its own mistakes, it transforms them into development opportunities for further progress, while generally keeping any critical discussions away from a non-specialized public'.

But even if modelers strived to be more public about the limits of their studies, it is unlikely that this would automatically result in a more reflexive attitude about the consequences of the (in)visibilities of models. The AgriMonde foresight exercise described by Dorin and Joly (this issue) is an example of how bringing the public into the modelling exercise enabled the modelers to see how they were missing key aspects of the world they were representing. Better participatory processes are a start, but modelers and policy-makers should also seek means to become more directly aware and co-responsible for the transformation brought by land use models. It is thus through deliberate, interdisciplinary discussions – critiques from within and outside of disciplines – and a valorization of the range of knowledges about land use that we will be able to begin to be more responsible for the epistemological and ontological effects of modelling.

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