

Indirect Land-Use Change and Biofuels: The Contribution of Assemblage Theory to Place-Specific Environmental Governance

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Abstract

The blending of liquid biofuels into road transport fuel has been supported by legally binding targets in Europe since 2009. Concerns over the extent to which these targets might engender indirect land-use change (ILUC), however, have an equally long history. Brought about when biofuel production displaces existing agricultural activity into new territory, ILUC has the potential to exert deleterious impacts upon the global climate, biodiversity, water and soil quality, food security, and even land rights. This paper begins by illustrating how current approaches to addressing this problem, predicated on equilibrium modelling and the concept of emissions 'factors', effectively detach its impacts from their place-specific contexts. Drawing on a relational view of space, the paper then advances an alternative, assemblage-based approach to conceptualising ILUC. By emphasising ILUC's fluidity, indeterminacy and complexity, this approach questions the logic of relying solely on abstractive science and policy tools to address the problem. The paper concludes by advocating an alternative approach to remedying ILUC – one that imbricates both place-specific and globally-aggregated representations of the problem. The paper has implications for research across multiple disciplines addressing the sustainable governance of transport biofuels and wider bioenergy systems as a whole.

Keywords

Biofuels, indirect land-use change (ILUC), assemblage, place-specific knowledge, environmental governance

1. Introduction

Over the course of the past decade, conceptualisations of space in the social sciences have become increasingly sophisticated. Within human geography for instance, traditional, Euclidean views of space have been critiqued by scholars who advocate a more post-structuralist, relational treatment of the concept. For relational scholars, spaces serve not as an inert backdrop to the study of more dynamic processes and entities, but as “the product of interrelations...[and] as always under construction” (Massey, 2005: 9). In short, spaces are not pre-existing, but fundamentally constituted by the interactions of social and material phenomena. Many have explored the theoretical and practical implications of this relational approach, especially in urban (Amin, 2012; Jacobs, 2012; McFarlane, 2011) and economic (Sunley, 2008; Yeung, 2005) geography. Human geographers exploring the politics of environmental sustainability, however, have arguably been less engaged with these theoretical developments. This is a potentially significant oversight, particularly given that much sustainability science (especially relating to carbon dioxide emissions and climate change) is ostensibly unconcerned with place-specific data, instead generating abstracted, fungible forms of knowledge to be incorporated into ‘top-down’, global governance frameworks. Focusing on recent European attempts to govern sustainable biofuels, this paper outlines how a relational approach to space, in emphasising the value of place-specific knowledge, might yield epistemological and practical improvements in the sustainability sciences.

Transport biofuels have occupied a central role within the European Union’s renewable energy and climate change mitigation policy portfolio for over a decade, embodied in 2003’s *Biofuels Directive* (EC, 2003) and latterly 2009’s *Renewable Energy Directive*. Comprising renewable fuels derived from a variety of biological feedstocks¹, biofuels were initially promoted on the basis of their purported ability to mitigate climate change (by replacing carbon-intensive fossil fuels), enhance the EU’s energy security (by diversifying fuel supply), and stimulate rural development (by offering an additional income stream for farmers) (see for instance EC, 2001, page 87)². By the mid-2000s however, the image of biofuels had in many places deteriorated considerably, with a

¹ These feedstocks include a number of staple food crops such as wheat, oil palm, rapeseed oil, soya and sugar cane, as well as bespoke energy crops such as jatropha and miscanthus.

² Some would argue that reform of the European Common Agricultural Policy was the *primary* driver of political interest in a biofuels mandate.

diversity of actors questioning their sustainability credentials (Dunlop, 2010; Palmer, 2010)³. Concerns raised in this period included the potentially deleterious effects of biofuel production on biodiversity (Danielsen *et al.*, 2008; Howarth *et al.*, 2009), on water and soil quality (Gerbens-Leenes *et al.*, 2009; Howarth *et al.*, 2009), on food security (Pimentel *et al.*, 2009; Runge and Senauer, 2007), and even on land rights (Borras Jr. *et al.*, 2010; Dauvergne and Neville, 2010; Sassen, 2013).

Since the passing of the *Renewable Energy Directive*, arguably the most complex and controversial issue associated with biofuel production has been indirect land-use change (ILUC). Initially highlighted by papers published in *Science* (Searchinger *et al.*, 2008; Fargione *et al.*, 2008) this process occurs when biofuel production takes place on pre-existing agricultural land, causing farmers to “convert forest and grassland to new cropland to replace the grain [that has been] diverted to biofuels” (Searchinger *et al.*, 2008: 1238). Complexity surrounding the issue stems from the diverse range of potentially negative impacts that it might bring about (Palmer, 2012) – including not only those listed above but also potentially significant emissions of greenhouse gases (GHGs), firstly as a ‘pulse release’ owing to landscape conversion (Clift and Mulugetta, 2007), and then subsequently in the form of foregone carbon sequestration. Controversy, meanwhile, emanates empirically observed, and must therefore be rendered ‘visible’ through modelling.

In spite of this complexity and controversy, modelling work has shown ILUC to be capable *in theory* of generating significant GHG emissions, which in some cases could be significant enough to render biofuels’ carbon footprint *double* that attributable to petrol or diesel over a 30-year period (Searchinger *et al.*, 2008)⁴. Nonetheless, the European Commission has remained committed to biofuels and, in April 2009, replaced the *Biofuels Directive* with a *Renewable Energy Directive* (EC, 2009a) instituting legally binding targets for 10% of road transport fuel to come from renewable resources by 2020⁵. Whilst the potential significance of ILUC did not, therefore, prevent the passing of this directive, its presence was acknowledged in a legal requirement for the Commission to undertake a full impact assessment by the end of 2010. Specifically, such a report would have to address the impact of ILUC upon biofuels’ GHG emissions footprint (with a proposal for legislation to follow if appropriate).

³ Amongst those voicing concern in the UK were non-governmental organisations (Greenpeace, 2007; RSPB, 2008), scientific bodies (Royal Society, 2008) and a UK Parliamentary committee (EAC, 2008).

⁴ The precise nature of such modelling work will be discussed in greater detail in section 3.

⁵ The majority of this 10% target is expected to be met through biofuel blending (rather than through the use of electric vehicles or other renewable propulsive technologies) (Al-Riffai *et al.*, 2010; Bowyer, 2010)

The approach taken by the European Commission to fulfilling this legal requirement constitutes the central empirical focus of this paper. Data underpinning the study were derived from in-depth analysis of documentary sources and semi-structured interviews. Documentary data included official policy documents, scientific and independently published reports and studies, speech transcripts, public consultation responses, and a number of other forms of grey literature. Alongside this, thirty-three interviews were conducted with actors engaged in debates about ILUC, including policy-makers working at member state and EU levels (10), expert scientists and consultants (12), representatives of the biofuel and fossil fuel industries (6), and officials working for various environmental non-governmental organisations (5). All interviews were conducted between March 2010 and March 2011, and lasted between 40 and 90 minutes.

The core of the paper proceeds as follows. In section 2, the European Commission's attempts to convert ILUC into a tractable regulatory issue – primarily through the use of equilibrium modelling and ILUC 'factors' – will be outlined. The central argument made is that the dominant scientific approach taken to ILUC, and by affiliation all policy proposals tabled in relation to the issue, have neglected to consider the place-specific dimensions of the process, embracing only an aggregate view of its impacts. Subsequently, section 3 will examine the manifestation of ILUC in greater detail, focusing specifically on its indeterminate geographical footprint. By adopting a relational approach to space, it will be argued that each occurrence of ILUC can best be understood as an emergent *assemblage* that effectively constitutes, rather than simply occupies, a particular space on the world map.

Though geographical work on assemblage offers no coherent conceptual definition of the term, the emphasis that is placed within this research tradition on the co-constitutive agencies of ostensibly separate elements, drawn together in ways that "unsettle distinctions between near and far, the planetary and the molecular" (McFarlane and Anderson, 2011: 163), opens up alternative avenues for both understanding and attempting to remedy the negative consequences of ILUC. The possible implications of a relational view of ILUC for future research into the sustainable governance of bioenergy production - and for more effective and place-sensitive policy-making – will therefore be elaborated as conclusions in section 4.

2. Rendering ILUC technical: Carbon accounting and ILUC factors

Following the passing of the *Renewable Energy Directive* in 2009, several actions were undertaken by relevant directorates-general (DGs) of the European Commission in a bid to address ILUC. Some

were intended to ensure that a sufficient body of scientific knowledge pertaining to the issue was assembled prior to taking any political decision. Here, three in-depth scientific modelling reports were commissioned (Al-Riffai *et al.*, 2010; Blanco-Fonseca *et al.*, 2010; Edwards *et al.*, 2010), while the Directorate General for Energy also undertook a literature review of existing research on ILUC (DG Energy, 2010). Other actions, meanwhile, were designed to ensure that all relevant expertise and opinion on ILUC could be incorporated into wider discussions prior to the taking of a final political decision. To this end, two separate public consultations were designed and administered in the space of fifteen months, two official stakeholder meetings were held in Brussels in late 2010, and a two-day expert workshop was convened in Italy in November of the same year. Against this backdrop, this section aims to outline how the Commission negotiated the inherent complexities of ILUC; in short, to examine how the Commission ‘rendered ILUC technical’, by “extracting from the messiness of the social world...a set of relations” amenable to systematic assessment and regulatory action (Li, 2007: 265).

In line with the scope of the legal obligation set out in the *Renewable Energy Directive*, the European Commission’s scientific reports and wider knowledge-gathering activities on ILUC were designed only to improve knowledge of the GHG emissions resulting from this process (and not of other potentially deleterious social or environmental impacts). In this way the Commission effectively subscribed to a view of ILUC as a carbon accounting error, in that it was deemed primarily to comprise unforeseen GHG emissions (Levidow, 2013; Palmer, 2012). When asked to defend and justify this approach to ILUC however, Commission officials were often compelled to refer, intriguingly, to the supposedly superior ‘quantifiability’ of GHG emissions vis á vis other forms of impact. For one scientist involved in the production of several reports on ILUC, for instance:

“It’s bad enough to come to any agreement about the greenhouse gas effects, let alone biodiversity, which is hardly measureable! It’s just that the greenhouse gas is something which in principle is easier to quantify.” (Interview, Expert Scientist)

Similarly, for one Commission official who had worked on biofuel policy for several years:

“The thing we’re required to [measure] is already very difficult and it isn’t [biodiversity]... and the tools that are available to do that are even more unconvincing than the tools available to do the things we are required to do.” (Interview, Commission Official)

Such justifications for an exclusive focus on ILUC’s GHG emissions importantly draw their credibility not simply from the absence of any legal requirement to examine wider impacts, but also from the

alleged fact that such emissions were eminently more measurable than impacts on biodiversity, land rights, food prices, or other domains.

Foreclosing consideration of ILUC's wider impacts represents only one part of the process of 'rendering technical' the problem, however. Even with this specific focus, policy-makers still required a method capable of pinpointing ILUC-related GHG emissions in a way that would facilitate regulatory intervention to reduce their magnitude. The approach taken by the Commission to this second task is found in the attribution of specific 'ILUC factors' to different types of biofuels, articulated as a standard volume of GHG emissions incurred per unit of energy derived from each biofuel in question. The calculation of ILUC factors, achieved through equilibrium modelling, permits the categorisation of biofuels according to the feedstock from which they were derived and the broad geographical location of their production. In short, once established, ILUC factors can be retrofitted onto pre-existing calculations of the total carbon footprint of different types of biofuel. The approach therefore effectively interprets emissions arising from ILUC as nothing more than an additional variable to be incorporated into such calculations, one whose existence had not been anticipated.

The central role played by ILUC factors in the Commission's attempts to address ILUC is well evidenced by official guidance documents provided to stakeholders participating in public consultations on ILUC. In its pre-consultation document (EC, 2009b) for instance, whilst the Commission sought stakeholders' views on the feasibility of a range of potential policy responses, the most sophisticated of these would have relied directly upon the accurate and reliable calculation of 'ILUC factors'. A year later, in its full public consultation document (EC, 2010), the Commission again identified several 'courses of action' that might be taken in response to ILUC, but only in the case of one of these ('discouraging the use of certain categories of biofuel') were illustrative 'example' policies set out, with particular emphasis again placed on options that would require the accurate calculation of ILUC factors.

Crucially, for scientists and experts engaged in modelling ILUC, the Commission's desire to attribute 'factors' to distinct *types* of biofuel had the effect of removing any imperative to allocate aggregated quantifications of the total area of land involved in this process geographically, over space (see Palmer, 2014). Rather than seeking to 'map' ILUC, modellers therefore sought only to allocate aggregated estimates of its total scale amongst distinct production pathways, effectively constructing attendant GHG emissions as embodied in the material fabric of biofuels themselves. By settling on the 'factor' as a systematic metric through which to render ILUC technical, the

Commission thereby exonerated itself from having to consider the place-specific dimensions of this process. Indeed, in some cases the very absence of a requirement to know *where* ILUC was taking place was even used by Commission officials to justify the initial decision to place GHG emissions, and not other impacts, at the centre of the regulatory exercise in the first place:

“It’s hard enough to say what the GHG impacts will be but then when you come onto the biodiversity impacts, the problem is it matters where exactly the land is being converted. How can you begin to know?” (Interview, Commission Official)

Overall then, knowledge claims about the magnitude and significance of ILUC can be said to have emerged from both expert scientists’ and policy-makers’ attempts to find “a way of acting upon the real, a way of devising techniques for inscribing it in such a way as to make the domain in question susceptible to evaluation, calculation and intervention” (Miller and Rose, 1990: 7). This is not to deny the material reality of GHG emissions emanating from ILUC: the process inevitably *does* lead, in many cases, to the emission of greenhouse gases, sometimes in significant quantities. Nonetheless, in order to render ILUC susceptible to intervention, it was necessary for politicians and scientists to bring “into sharp focus *certain limited aspects* of an otherwise far more complex and unwieldy reality” (Scott, 1998: 11, emphasis added). In short, ILUC had to be ‘rendered technical’ by considering the question only of a putative ‘ILUC factor’ and its magnitude in relation to different types of biofuel. Crucially for the purposes of our argument, this approach detached ILUC – an intrinsically geographical process – from the physical places in which it actually occurs; it conceptualised the process as “something that exists independently from social and economic considerations, that is ‘placeless’ and that can be reduced to metrics and calculations” (van der Horst and Evans, 2010: 190).⁶ As we now go on to argue, the limitations of this spatially impoverished approach to ILUC, both for science and for policy, are potentially profound.

3. Viewing ILUC relationally: Indeterminacy, assemblage and the role of place

In *For Space*, the geographer Doreen Massey (2005) sets out a compelling case for space to be conceptually reassessed as fundamentally relational. Far from seeing space, in Euclidean fashion, as a pre-existing container *within which* processes take place, Massey (*ibid*: 9) instead promotes a

⁶ This elimination of spatiality from knowledge is not unique to ILUC; many aggregative indicators, indices, and concepts relating to sustainability and the environment suffer from the same problem. Hulme (2009), for instance, makes much the same point about the use of global average surface temperature as an indicator of climate change, whilst a significant number of the 34 sustainability indicators published annually by the UK’s Office for National Statistics (ONS, 2014) also provide little information about geographical variations in the phenomena which they measure.

tripartite view of space as: (1) *the product of* interrelations; (2) a sphere of coexisting, heterogeneous trajectories; and (3) a domain that is always under construction. This view of course owes much to the wider post-structuralist turn in the social sciences, evidenced most obviously by a proliferation of writing on networks (e.g. Castells, 2010).⁷ More recently however, relational approaches to space – particularly in human geography – have increasingly turned away from network-based analysis and towards the concept of *assemblage*, inspired in particular by the ideas of Deleuze and Guattari (1987).⁸ Briefly, whereas network-based approaches to space tend to emphasise fixed, settled relations underpinning relatively durable states of affairs, assemblage-based thinking instead emphasises “indeterminacy, emergence, becoming, processuality, turbulence, and sociomateriality of phenomena” (McFarlane, 2011: 653), and takes as its subject altogether more fluid, evolving and innately *unsettled/unsettling* sets of relations. Rather than attributing a fixed, pre-given function to the different elements of a particular system, work on assemblage emphasises *functional capacity* – the potential for different modes of co-functioning to occur among the same composite elements. Assemblages are therefore defined not by the properties of their various component parts, but by the always-provisional interactions that exist amongst those components (*ibid.*). In subscribing to these ideas, work on assemblage prompts us to reassess the European Commission’s regulatory practice of attributing ILUC ‘factors’ to different types of biofuels. In what follows, the implications of such work will be teased out through a detailed explication of the diverse factors impacting on whether ILUC does (or does not) in fact occur in specific places.

When non-agricultural land is converted specifically for the purpose of growing biofuels, attributing the resulting impacts to those biofuels is relatively uncontentious. By contrast, since ILUC propagates invisibly through geographically dissipated agricultural markets, attributing its impacts to specific instances of biofuel production elsewhere is inherently uncertain. To date, almost all estimates of the magnitude of ILUC brought about by increased demand for biofuels in Europe have been derived from equilibrium models. These models seek to quantify ILUC resulting from biofuel production by successively addressing questions about (1) the quantity of additional arable land required to fulfil future demand for biofuels in the European Union⁹, (2) the extent to

⁷ This turn includes research in the tradition of actor-network theory (ANT) (Latour, 2005a).

⁸ This concept of ‘assemblage’ is importantly distinct from Latour’s (2005b) concept of ‘assembly’, which connotes the gathering of publics around diverse ‘matters of concern’.

⁹ As compared with demand for agricultural land in a hypothetical ‘baseline’ scenario where the *Renewable Energy Directive* does not exist (DG Energy, 2010).

which different types of landscapes (e.g. rainforest, grassland, peat lands, wetlands, or ‘marginal’ agricultural land) will be involved in land-use change, and (3) the significance of the impacts that will result. A schematic illustration of this modelling approach – in this case oriented towards quantifying GHG emissions impacts - is provided in figure 1.

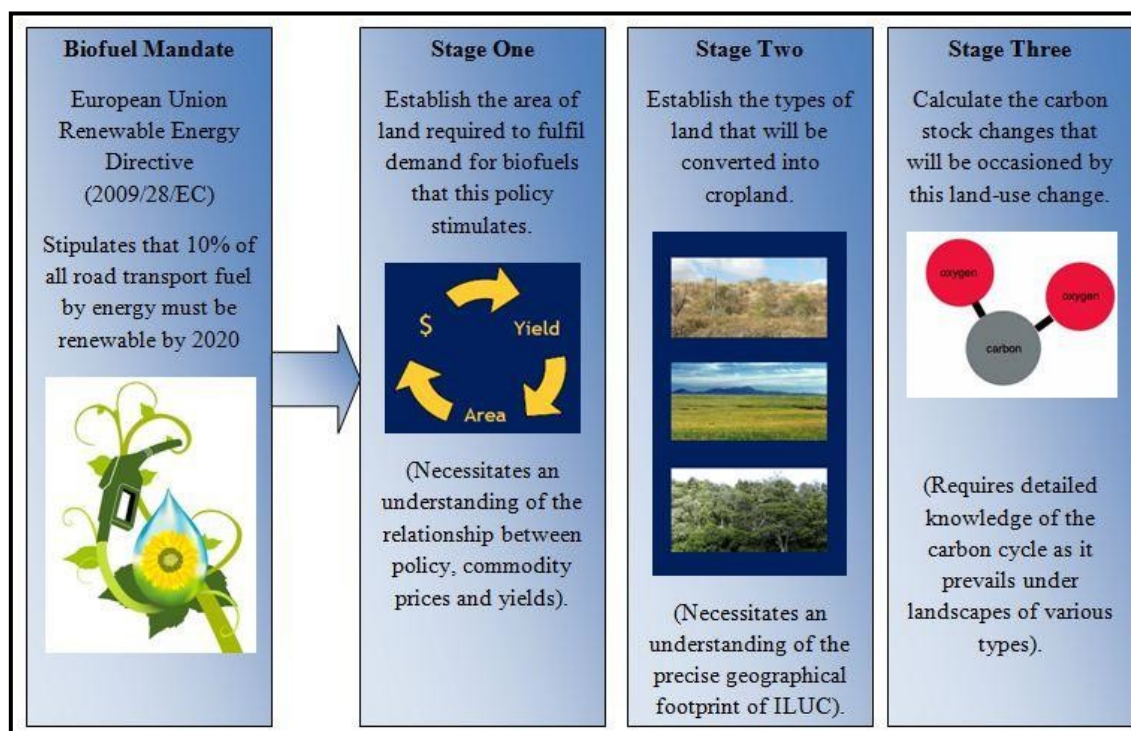


Figure 1: Schematic diagram of an ILUC model designed to estimate GHG emissions (adapted from Cornelissen and Dehue, 2009: 11).

Unfortunately, the answers that equilibrium models are able to supply to each of these three critical questions are far from certain. Determining the quantity and types of land that will be implicated in ILUC as a result of increased demand for biofuels in Europe (that is, answering the first and second questions), requires in the first instance a detailed understanding of the relationships operating between that increased demand and prevailing global food commodity prices. From an economic perspective, it may seem natural that changes in one location either in the end use to which a crop is put, or indeed in the scale of its output, might exert an influence over the prevailing market prices not just of that crop, but also of its co-products (and consequently of products that could conceivably be used as substitutes for them).¹⁰ These price changes will, moreover, impact not just on the outputs of other crops, but also on levels of livestock cultivation (since animals are

¹⁰ As an example, if Brazil's exports of soy were to fall, some demand for soy oil in China would go unfulfilled, leading consumers to resort to alternatives such as palm oil.

fed with agricultural produce), and on wider food consumption patterns more generally (since some populations will be forced to alter their diets in the face of changing prices). The complexity of knock-on impacts and feedback loops that must therefore be modelled is quite profound (see figure 2).

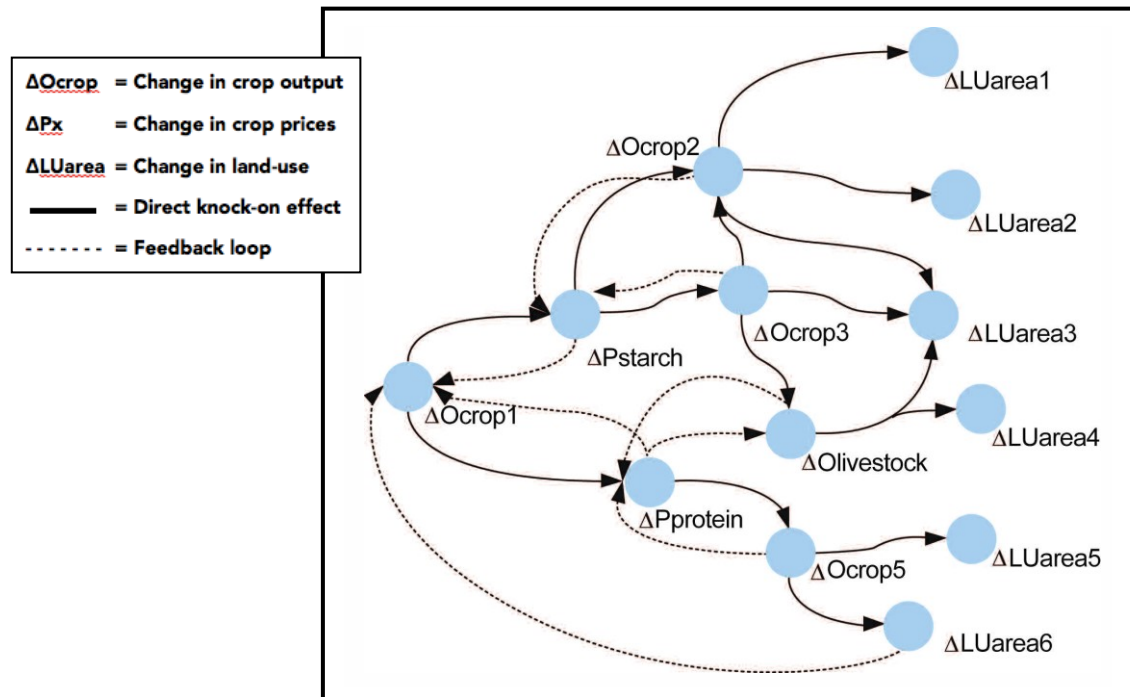


Figure 2: Schematic diagram of knock-on impacts and feedback loops mediating between changes in crop output, crop prices and land-use change (source: Tipper *et al.*, 2009: 3).

Beyond these immediate economic relationships, additional variables further complicate the task of discerning how far crop prices might respond to shifting demand for biofuels. Amongst other things, these variables include the prevailing structure of agricultural subsidies (whether national or regional in scope), movements in the price of crude oil (dictating the affordability of fertilisers, pesticides and fuel), wider shifts in demand for food or animal feed (beyond those occasioned by biofuel policy), the effects of climate change upon agricultural outputs (both locally and non-locally), and the operation of ‘futures’ markets (through which market speculation can distort the prevailing price of many basic agricultural inputs and outputs). Moreover, even if a perfect understanding of the impact of these variables on crop prices could be attained, more prosaic matters would still need to be considered in order to establish how farmers might actually respond to changing price signals. These factors might be socio-economic in nature; for instance a farmer’s prevailing level of wealth or access to credit might dictate whether fertilisers or new

agricultural equipment are affordable, whilst their ability to join up with existing supply chains for some crops will render some planting regimes more viable than others. Alternatively, they might be biophysical; for example the nature of the specific geographical terrain within which a farmer is operating will determine the ease with which adjacent landscapes can be converted to arable land, whilst the quality of local soils and climatic conditions will constrain a farmer's ability to grow certain types of crop, even if they might theoretically offer enhanced revenue.

Ultimately, it is the combined influence of all of these factors that determines farm-level planting decisions, where responses to changing price signals might include (1) doing nothing, (2) intensifying production within the confines of existing land, (3) expanding production onto new land, (4) intensifying and expanding production at the same time, or (5) choosing to grow different crops altogether. From an assemblage-based perspective, each of these variables – whether economic, social, political or environmental; physically present or absent; distant or proximate in origin - can be conceptualised as a distinct element of an assemblage, as one trajectory within a fluid and emergent system whose overall form governs whether ILUC does or does not in fact occur in a particular place. Since a change in the relationships between any one of these elements and the others has the potential to affect the whole assemblage, each element effectively has the potential to either facilitate or preclude any putative, place-specific ILUC 'event'. In this way, places are effectively constituted by an emergent assemblage of interrelations among these diverse elements, in a manner that is fluid, contestable, unsettled and always open to future reconfiguration.

From this assemblage-based perspective, using equilibrium modelling to render ILUC visible appears deficient in three distinct ways. Firstly, and especially given that many of the elements outlined above are intrinsically dynamic, this approach fails to account for the unavoidably provisional nature of the assemblages that determine whether or not land-use change will occur in specific places. As the senior scientist of one major environmental non-governmental organisation explains:

"It will be a dynamic and evolving social and economic system which you're attempting to quantify... there is a point beyond which I think it is going to be a fool's errand to try and say "here is the definitive ILUC standard and here is the definitive sustainable biofuel"."

(Interview, Expert Scientist)

Similarly, for one oil industry official with experience of working with equilibrium models:

“It’s hard to write a policy on a model if you need to keep updating it, because things change in the market...we have Russian harvest problems and all these sort of things that might have an impact on prices, you need to remodel that and say “what’s the indirect land use change level for this week?” It’s too much to control.” (Interview, Oil Industry Representative)

In short, efforts to determine specific ILUC ‘factors’ for different types of biofuel can succeed only by imposing artificial fixity and stability upon intrinsically dynamic, and therefore provisional, sets of relations. The approach therefore erroneously assumes that ILUC assemblages are possessed of fixed function, rather than of a functional capacity which might engender multiple end scenarios.

At another level, equilibrium models are also unable to distinguish between the correlation of overall demand for biofuels with levels of overall land-use change, and genuine causality in which the former is responsible for the latter. As one oil industry official explains:

“Most of the big [impacts], the greatest proportion of that is because somewhere, at the end of the line, somebody’s clearing a forest with high carbon stock. But what’s not known is if we took biofuels away altogether, would somebody still be clearing that forest and growing stuff there. And that’s what the model doesn’t really understand.” (Interview, Oil Industry Official)

Even if it were possible to determine with certainty the fluctuations of each element of a putative ILUC assemblage in advance, this would not necessarily permit a full understanding of the relationships operating amongst those elements; indeed, such relationships may not be linear or amenable to formal quantification in the first place. Since it cannot fully represent this complexity of interrelations among different elements, equilibrium modelling is therefore unable to account for the possibility that some proportion of aggregate forecast ILUC might in fact be driven by other components of a place-specific assemblage (beyond those directly related to the introduction of a European biofuel mandate).

Finally, the assemblage-based perspective also reveals that attempts to address ILUC by attributing specific emissions ‘factors’ to different types of biofuels are limited by their failure to recognise that GHG emissions – like biofuels themselves – are always the inextricable product of a unique, place-specific assemblage. Consequently, ILUC emissions cannot be viewed as intrinsic characteristics of particular *types* of biofuels at all. Instead, both GHG emissions and the biofuels to which they are supposedly tethered will always represent separate, independent products of a

place-specific set of complex interrelations and co-dependencies. As one interviewee concisely summarised:

‘An ILUC emissions factor cannot be a characteristic of a biofuel [because it results from] the interaction of that biofuel with the global system’ (Interview, Policy Analyst, Dutch Environmental Assessment Agency).

The implication here, in short, is that any effort made to establish general principles by which certain types biofuels will always be associated with a certain level of ILUC are flawed from the outset in assuming that such a causal link exists.

Taken together, these points demonstrate that the present approach to rendering ILUC technical, premised on equilibrium modelling and the attribution of ILUC factors, whilst undoubtedly successful in offering one specific means of ‘acting upon the real’ (Miller and Rose, 1990: 7), critically overlooks the highly provisional, complex and place-specific nature of the relations that constitute that reality. From an assemblage-based perspective therefore, the twin tasks of developing knowledge about ILUC and intervening to help remedy its negative effects, arguably require a more nuanced approach than that which has been practised by the European Commission since 2009. The possible nature of that alternative approach – one that we argue must appraise the defensibility and utility of both abstracted *and* place-specific representations of ILUC – forms the focus of the following, final section of the paper.

4. Towards assemblage-based science and policy?

This paper began by outlining the European Commission’s approach to ‘rendering technical’ (Li, 2007) the problem of ILUC, noting that the deployment of equilibrium modelling and the calculation of ILUC ‘factors’ had decoupled this process from its place-specific contexts. In the previous section, the cogency of this approach was challenged through an explication of the fundamentally relational nature of ILUC. Under this perspective, ILUC always represents the product of a place-specific assemblage whose function is not pre-determined or fixed, and in which the effects of EU biofuels policy represent just one of many diverse elements (or trajectories). More fundamentally, since the impacts of ILUC and biofuels both represent the contingent outcomes of these interrelations, any attempt to establish general principles by which those impacts can be tethered to particular *types* of biofuels (e.g. through the application of ILUC ‘factors’) will also inevitably be flawed.

In highlighting these various limitations, an assemblage-based perspective also gives rise to several recommendations for more effective engagement with ILUC, both at the level of knowledge gathering and at the level of practical environmental governance. Dealing with knowledge gathering first, the indeterminate, provisional and dynamic nature of ILUC assemblages suggests that no single representation of the interrelations generating (or suppressing) this phenomenon will ever be perfect. Local-level, place-specific representations of ILUC should therefore be appraised, alongside macro-level, globalised representations, as potentially legitimate sources of knowledge about the precise enabling and constraining factors that govern the manifestation of this process. Regional monitoring of land-use change patterns in a moderately sized area (c.2.1m ha) of Argentina's Rio de la Plata grasslands ecosystem, for instance, has allowed researchers to glean in-depth insights into not only the scale of land-use change taking place in this area, but also the diversity of variables that might contribute to the process in individual, local cases (Tipper and Viergever, 2009). Underpinned by a combination of remote sensing and local field observations, such work does not simply offer another means of quantifying GHG emissions associated with ILUC.¹¹ More importantly, by pinpointing place-specific assemblage elements that might have a disproportionate bearing on ILUC's manifestation, it also promises to facilitate 'on-the-ground', "landscape level carbon management" (Tipper and Viergever, 2009: 23).

By assessing the robustness of knowledge obtained from both local monitoring and generalised equilibrium modelling in a more complementary and reflexive manner, policy-makers could also legitimately begin to deploy a wider range of tools and measures to help tackle the problem of ILUC. Far from simply retrofitting model-based ILUC factors onto existing carbon accounting calculations, this more balanced approach might involve incentivising inter-cropping or the cultivation of crops whose co-products can be used in alternative agricultural sectors (such as for animal feed) (Lywood *et al.*, 2009); raising producer and consumer awareness of the diverse negative consequences of land-use change; enhancing land-use planning processes at the regional level, for instance through 'agro-ecological zoning' (Schut *et al.*, 2010); or working with local communities to better protect high-carbon or species-rich landscapes from conversion to agriculture in the first place. In providing an aperture for place-specific knowledge to enter the

¹¹ Whilst this approach can provide such estimates, it cannot resolve the problem - also inherent in equilibrium modelling - of being unable to distinguish between correlation and causality (when increased biofuel demand occurs in one location and increased land-use change in another). In Tipper and Viergeven's (2009) Argentinian study, for instance, whilst expanding soybean production was identified as a probable driver of some observed land-use change, the precise nature of any causality involved remained uncertain.

policy-making process moreover, such an approach could also potentially serve to tackle not just the GHG impacts of ILUC, but also its wider social and environmental effects – for instance on biodiversity, soil and water quality, and land rights.

Rajao's (2013) perceptive analysis of environmental policy in the Amazon highlights how aggregated scientific representations of deforestation – by ostensibly offering a 'view from nowhere' (Shapin, 1998) – have gained political legitimacy and authority at the near-total expense of local representations, whose meaning is always contingent on place-specific contexts. The arguments made here about ILUC - and its treatment by EU policymakers - are of a similar nature; only by appraising the utility of both global and local representations of this process will policy-makers be in a position to "accept the unruly nature of environmental problems and create solutions in an experimental and emergent manner" (Rajao, 2013: 69). The challenge for the sustainability sciences today then, exemplified by ILUC, should be not only to provide local, place-specific representations of complex environmental problems alongside global ones, but also to critique governance frameworks that dismiss local representations out of hand as an intrinsically inferior basis for envisioning and constructing more sustainable environmental futures.

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