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Framing REDD+: political ecology, actor–network theory (ANT), and the making of forest carbon markets

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Abstract. This paper discusses the opportunities and challenges of integrating science and technology studies (STS), especially the variant based on actor–network theory (ANT), into fields of human geography with a critical research tradition. Drawing on the experiences of political ecology and empirical research on carbon markets, it uses the example of reducing emissions from deforestation and forest degradation (REDD+) to show how the turn towards such STS impacts has changed the "framing" of REDD+: from analysing REDD+ as an example of the "neoliberalization of nature" and a focus on the impacts on human forest users to detailed accounts of infrastructures and practices of making markets. Discussing the consequences of these observations and different proposals brought forward to combine ANT with political ecology, the paper argues for a conscious and reflective use of ANT-inspired STS approaches to benefit from the additional insights this approach allows while keeping the critical potential of geography alive.

1 Introduction

How to avoid dangerous climate change has become one of the most crucial political questions of the 21st century. Since the 1990s, various instruments and measures have been implemented on different political levels to reduce carbon. Especially carbon-offset projects in the Global South have been controversially debated since the 1990s (Lohmann, 2011; Bumpus and Liverman, 2008). They have often been violently contested by local communities (Cavanagh and Benjaminsen, 2014; Dunlap, 2018) and criticized as "carbon colonialism" (Agarwal and Narain, 1991; Bachram, 2004). While the effectiveness of these instruments in reducing emissions is questioned (Cames et al., 2016), their implementation can have far-reaching effects for both the socio-economic structures of the places where they "touch ground" and the relations between human actors and their non-human environments.

The ability to grasp the impacts of climate policies in an adequate way requires theoretical approaches reaching beyond the social, allowing research on both human and non-human systems as well as their interplay. Since the 1980s, political ecology as an academic field has studied environmental issues, mainly in the Global South, in relation

to power and economic structures (Blaikie and Brookfield, 1987; Watts, 1983). This research perspective, originally grounded in political economy, has been broadened since the 1990s, integrating feminist, decolonial, and poststructuralist approaches (Demeritt, 2005; Gregory, 2005; Rocheleau et al., 1996). At the same time, science and technology studies (STS) and similar approaches of "new materialist thinking" have become increasingly influential in the social sciences and humanities. Over the last 2 decades, they have had a profound effect on research directions in human geography (Whatmore, 1999; Murdoch, 1997; Anderson et al., 2012). Recently, calls have been made to integrate STS into development studies, with the hope that STS might provide "new inspiration for a theoretically inclined development geography" (Schurr and Verne, 2017:125).

The shift to different STS approaches or their attempted integration into existing research frameworks affects research foci, practices, and thus results of (empirical) studies. An STS approach like the one based on actor–network theory (ANT) – one of the most prominent theories in geography – allows researchers to integrate actors into the analysis who were previously often "invisible" and to highlight ignored or under-researched relations, especially between humans and

non-humans. Nonetheless, a closer analysis shows that many of the basic theoretical foundations of ANT, especially if applied in a radical form, contradict or can come into conflict with theoretical assumptions that have guided research in engaged research traditions like political ecology or development studies over the last few decades. The "flat" networks proposed by ANT make it difficult to conceptualize power relations or hierarchies – to shed light on such has long been a central objective of political ecology. The focus on single case studies and the rejection of any form of generalization dominant in ANT make it impossible to work in a comparative way or to refer to overarching categories like capitalism or neoliberalism; furthermore, ANT's methodological concentration on a mere description of elements and their linkages contrasts sharply with the aim of political ecology to explain the underlying structures of ecological problems. While I do not object to the integration of STS approaches into these fields, I argue that it is important to openly address their ambivalence and inconsistencies to allow researchers to consciously choose how to deal with these.

In this paper, I work towards such a self-reflective analysis by drawing on the experiences of political ecology and on my own empirical research. In political ecology, STS and ANT have been incorporated from the early 2000s on, earlier than in many other sub-disciplines of human geography. In the introduction to the volume *Remaking Reality*, editors Braun and Castree (1998:32) welcomed STS and ANT for their innovative contributions: "tracing networks is where political hope lies". Seven years later, Castree and MacMillan (2005:213) argued that "a symmetrical perspective is the only one that is viable". These calls to integrate STS and ANT approaches into geographical research were addressed over the following years by a wide range of scholars studying environmental questions (for an overview, see Braun, 2008, and Bakker and Bridge, 2016).

This move towards the new materialist approaches has affected both political ecology as a research field and the way environmental problems are framed. In this paper, I use the example of reducing emissions from deforestation and forest degradation (REDD+), a controversial climate policy instrument to integrate forests of the Global South into international carbon reduction schemes, to show how research approaches have changed with the integration of an ANT-based approach and how the new theoretical frameworks might challenge previous research practices and foci. Drawing on a review of existing studies on REDD+ and on my own ANT-inspired empirical research on REDD+ projects in the Mediterranean region, I discuss which opportunities and challenges the new approaches provide, which proposals have been brought forward to overcome specific problems like the conceptualization of power, and what this means for critical geographical research in the future.

This paper proceeds as follows. In the following section, I give a broad overview of the theoretical foundations of both political ecology and ANT. I show which conflicts might arise when they are combined and what effect the integration of these approaches has had in the field of political ecology. In Sect. 3, I turn to the example of REDD+. I show how REDD+ has been framed in studies from a political ecology perspective and how this framing and the foci of the studies have shifted with the emergence of new "materialist" approaches, from analyses within the framework of global tendencies like the "neoliberalization of nature" towards in-depth case studies of the "making" of markets on the ground. In Sect. 4, I discuss the consequences of these observations, asking what can be learned from these experiences and which proposals have been brought forward to overcome problems that arise when ANT is combined with critical geographic research. In Sect. 5, I conclude with some reflections on what these results mean for critical geographical research in the future.

2   STS in political ecology

Political ecology has undergone relevant changes over the last few decades. From the 1970s on, scholars considering themselves political ecologists started to research problems like environmental degradation, deforestation, and droughts, mainly in the Global South (Peluso, 1992; Watts, 1983). Blaikie and Brookfield (1987:17) defined political ecology as an approach that "combines the concerns of ecology and a broadly defined political economy". These studies focussed on the economic structures and power relations of conflicts considered "environmental" and tried to explain the underlying structures of the observed phenomena. Since the 1990s, the integration of poststructural, feminist, and postcolonial approaches broadened the theoretical and methodological basis of the field. Political ecology is a heterogenous field; still, there have been various attempts to define what its core elements are (Robbins, 2011; Perreault et al., 2015). Despite their differences, studies from a political ecology perspective remain defined by their focus on (unequal) power relations and the consideration of broader political and economic structures. Bridge et al. (2015) see the coherence of the field as having emerged from three commitments: a "theoretical commitment to critical social theory and a post-positivist understanding of nature", a "methodological commitment to in-depth, direct observation involving qualitative research" (Bridge et al., 2015:7) and methodological plurality, and a "normative political commitment to social justice and structural political change" (Bridge et al., 2015:8).

Starting at the end of the 1990s, STS and similar approaches of new materialist thinking have been taken up in (Anglophone) political ecology (Whatmore, 1999; Braun, 2002; Bakker, 2003; Robbins, 2007) and later also in German-speaking geography (Mattissek and Wiertz, 2014; Becker and Otto, 2016). Science studies in a broader sense have inspired Forsyth's (2003) *Critical Political Ecology* as a critic of the production of environmental knowledge. Actor–

network theory (ANT), which evolved as a theoretical foundation for STS, was especially influential in political ecology. Originating in the sociology of science and the laboratory studies of the 1980s, earlier works focussed on a critical assessment of the production of scientific knowledge (Callon et al., 1986; Knorr-Cetina, 2002). The approach was soon broadened; central to it became the dilution of dichotomies and categories like nature–culture or human–non-human. To overcome the "modern constitution", the separation of the world into the two spheres of nature and society (Latour, 2004, 2017a), ANT and related approaches propose a radically symmetric approach, treating human and non-human actors (at least a priori) the same, with a relational conceptualization of agency and a focus on analysing entities as heterogenous, hybrid networks. In political ecology, the integration of ANT approaches has led to a reconceptualization of the approach towards the non-human world, visible in the appearance and use of new terms like *social nature*, *socionatures*, or *naturecultures* (Castree and Braun, 2005; Swyngedouw, 2007; for the German expression, see Gesing et al., 2019).

However, the turn towards ANT-based STS carries implications reaching beyond a critical reformulation of "nature" and "science". Latour and other proponents of the ANT frame their work explicitly as political interventions (Latour, 2004, 2017b), and the theoretical and methodological assumptions their approach is based on are, in many regards, at odds with the basic principles that have long defined political ecology or critical geography in general. Beyond their different concepts of power or the social, working within an ANT frame can make it more difficult to conceptualize power dynamics or structural injustices, and ANT generally rejects generalization and the reference to overarching categories like capitalism or neoliberalism that have been central elements of a political ecology approach to environmental problems of the last few decades. The (proposed) integration of ANT and STS provoked thus, at the beginning, controversial debates not only within political ecology, but also in the wider field of critical geography (Castree, 2002, 2003; Fine, 2003). Castree and MacMillan (2005:221) pointed towards the "ontological problem . . . arising from the assumption that each actor-network is unique and qualitatively distinct", and in urban geography, Brenner et al. (2011:235) criticized the "naive objectivism" of assemblage approaches "that is difficult to reconcile with the basic questions about power, inequality, injustice, politicization, struggle and mobilization that lie at the heart of critical urban theory".

These critical debates did not, at least in political ecology, continue for long. Instead, political ecology became "split" into two fractions, without much exchange between them. One group of scholars continued working from a political economy or other "critical" perspective while more or less ignoring the new approaches, while another group adopted the new frameworks, calling to make them, in the form of "more-than-human geography" (Whatmore, 2002), the basis

of a new political ecology. This gap, I argue, is important to address, not only because it hinders the analysis of contemporary processes and the development of new theoretical approaches, but also because the turn towards STS – or the avoidance of such – does have effects on empirical studies that need to be taken into account. In the following section, I will show this with the example of REDD+.

3   Framing REDD+

3.1   An introduction to REDD+

REDD+ emerged as a climate protection instrument in the 2000s, following ongoing discussions within international climate policy around whether and how forests should be integrated into carbon trading and carbon accounting. In 2005, REDD+ was created as a new mechanism within the UN to support the protection of forests in the Global South; forest owners or users should thus be remunerated for their climate protection efforts in the form of result-based payments. Forest-based projects are common in voluntary carbon markets used to "offset" emissions by consumers or companies. Within the UN system, however, REDD+ has not been operable to date (Angelsen et al., 2017), and many "official" carbon markets, like the European Union Emissions Trading System, exclude forest-based projects or just allow them on a very limited basis due to ongoing technical problems in calculating the stored carbon (UNFCCC, 2020). However, REDD+ has become an important instrument in development policy, and both bilateral aid institutions and international institutions like the World Bank are funding projects and programmes to "prepare" countries for REDD+.

3.2   A political ecology perspective: REDD+ as neoliberalization of nature

From the beginning, REDD+ has been studied intensively in geography and related fields. In political ecology, REDD+ has, in most cases, been framed as an example – or even *the* example – of the neoliberalization of nature (Leach and Scoones, 2013; Asiyanbi, 2019), referring to the debate on changing forms of governing non-human environments from the 1990s onwards (Heynen et al., 2007; Castree, 2008a, b). In geography, this form of framing REDD+ shows three specific features:

1. It researches REDD+ as a form of *commodifying nature*. Studies show how market-based forms of governing nature replace or interact with preexisting social relations, values, and forms of relating to the non-human world (Osborne and Shapiro-Garza, 2017); how "carbon" is brought into being as a commodity (Gutiérrez, 2011); and which abstractions, narratives, and (discursive) formations are necessary for this process (Lansing, 2011; Liverman, 2009).

2. It focusses on the actual or expected effects on the *human actors*, mainly the local forest communities. Studies have shown that REDD+ projects can lead to the eviction of forest communities (Nel and Hill, 2014) and increased militarization (Asiyanbi, 2016) and that they can support shifts in power structures, such as a recentralization of forest governance (Agrawal et al., 2010). Many studies have asked who bears the costs of the projects and who gains or loses access to forest resources (Beymer-Farris and Bassett, 2012), and they have often focussed on conflicts and the resistance of local communities to REDD+ projects, like the "spectacular failure" of a reforestation programme aimed at offsetting travel emissions in Uganda because of growing political tensions after the eviction of local users (Cavanagh and Benjaminsen, 2014).

3. It relates to developments on the *global scale*, either economically or discursively. Most articles from a political ecology perspective deal at least in part with the international environmental and climate policy since the 1990s, its history, and its implications, for instance by relating REDD+ to questions of global justice or by showing how economic and political structures on the international or national level influence how projects are implemented on the ground (Liverman, 2009; Gutiérrez, 2011).

3.3   A marketization approach to REDD+

With STS approaches becoming more widespread, scholars have increasingly used these to frame research on REDD+ and on carbon markets in general (Callon, 2009; Ehrenstein and Muniesa, 2013). A Scopus search does not show any results for "REDD" and "STS" before 2004, shows 5 results between 2004 and 2014, shows 14 between 2015 and 2020, and shows 9 alone in 2021.[1] A closer look at recently published geographic research on REDD+ shows that many authors directly or indirectly refer to these approaches (Nel, 2017; Pascoe, 2018; Asiyanbi and Lund, 2020). Among those who frame their research from a STS or ANT perspective, several changes can be observed.

First, these studies focus on the *internal* characteristics of the markets and on the practices and infrastructures of knowledge production involved, such as computer models or project-related reporting systems (Asiyanbi and Massarella, 2020; Gupta et al., 2012), and less on their embeddedness in wider social, political, and economic structures (Myers et al., 2018). Second, the focus of the studies shifts from human actors and the effects projects might have on them to

the role of *non-human actors* like carbon (Bumpus, 2011) or portable GPS devices (Lansing, 2012), and project failure is attributed to unintended effects of the marketization process or "overflow" (Blok, 2010) rather than to conscious objection or organized contestation. Finally, the *scale and the scope* of the analysis and the location of agency have often shifted, from reference to global economic or political structures to a detailed and rather technical analysis of singular case studies; these, however, do not necessarily refer to the forest itself but, increasingly, to the site of relevant practices of calculation or market making (Lovell and MacKenzie, 2011; Lovell and Liverman, 2010).

3.4   Reflecting on my own research

For my dissertation project, I studied how the (prospective) integration of forests in the southern Mediterranean into global carbon markets changed these forests and their governance. From 2012 to 2016, a project financed by the French Facility for Global Environment (FFEM) and run by the FAO and Plan Bleu tried to implement REDD+ in Morocco, Algeria, Tunisia, Lebanon, and Turkey. In Morocco, the pilot site of the project was the Maâmora Forest, an extended cork oak forest north-east of the country's capital Rabat, the field site of my research. Through qualitative interviews with project managers and partners, foresters, and "experts"; an analysis of documents; and several months of fieldwork between 2016 and 2019, I explored which effects the implementation of REDD+ programmes or, rather, the preparation for these had on nature–society relations in the forests and on the physical appearance of the forests themselves. For the analysis I used theoretical insights and methods from both political ecology and an ANT-inspired version of STS. Reflecting on my research experience from this background, I can draw three main conclusions.

3.4.1   From politics to markets

The ANT-inspired approach allowed me to show the complicated infrastructures and practices and the immense "work" necessary to make markets (Callon, 2007). My work, in this sense, was inspired by the social studies of marketization (Çalışkan and Callon, 2009) and the geographies of marketization that have introduced these concepts into geography (Berndt and Boeckler, 2009; Ouma, 2015). Unlike classical economic theory that considers markets something that naturally develop on their own or just takes them as given – assumptions also common in parts of political economy and ecology, as Braun (2008) criticizes – proponents of marketization studies or geographies of marketization show that markets are constantly "performed", made, and sustained by human and non-human actors.

This perspective was useful in three ways: it could, first, explain the effort, time, and resources invested in the *"making" of a common market* that had not existed before, through

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[1]Based on a Scopus search on 25 April 2022, limited to "social science" and "environmental science"; results not related to REDD+ were manually excluded. A search for "REDD" and "assemblage" in social science shows a similar development, with 1 or fewer publications before 2008 but 43 in 2021.

a plethora of meetings and studies and the creation of maps defining and delimiting this space. REDD+ had previously only been implemented in countries with tropical forests, on a project level. Now, according to new rules on the UN level, it was meant to be implemented as a programme by the nation state. This shift made it necessary to create a new calculative space and, at the same time, to translate previous REDD+ experiences into the physical realities of the Mediterranean.

The marketization perspective was also useful to analyse the *production of knowledge* necessary to create the new commodities and the infrastructures and non-human actors involved. The carbon credits REDD+ deals with are produced through complicated calculations comparing two different future scenarios (the project scenario and the baseline scenario), calculated and sustained by satellite images and other forms of remote sensing, along with practices of data collection and computer modelling. The "value" of the REDD+ project is sustained through what Ehrenstein and Muniesa (2013) describe as "counterfactual display", the "articulation of a difference between two possible and plausible realities: one controlled by the project under valuation, and one in which this project is absent" (Ehrenstein and Muniesa, 2013:180).

The STS perspective on markets, finally, was crucial to explain the *failure* of the project. While Tunisia and Morocco have officially joined the UN-REDD facility, they so far have not undertaken efforts to establish respective programmes. The other partner countries left the project or turned towards different programmes; a second funding phase of the FFEM project was not approved. Unlike in other REDD+ projects, there was no open resistance by forest users to the installation of REDD+ in the Maâmora Forest, despite critical assessments of its potential effects (Vanuxem, 2016). The failure can, however, be explained by the inability to create a market space and a respective commodity: despite all efforts, the project was able neither to develop a common methodology to calculate a form of "Mediterranean forest carbon" nor to establish the notion of a common Mediterranean forest space. The actors involved all related to very different spatial imaginaries that were not compatible with the project's aims; the efforts undertaken to measure and calculate emission reductions were not enough to produce the complicated time-spaces necessary to stabilize the respective commodity.

3.4.2 A shift in relevant actors

As suggested above, using an assemblage or ANT approach shifts the focus of the research away from a sole focus on human actors to infrastructures and non-human actors. This shift observed in the literature was also apparent in my research. While I had planned to research the effects of the project on both the forest itself and its human users, I soon realized that in order to do in-depth research, I had to focus on one of these aspects. This might be true for most research

projects: empirical research is, even under the best circumstances, constrained by limited time and resources. The decision to conduct a study based on detailed ethnographies of knowledge production, related practices, and non-human actors means there is less time to study the human actors and will, like in my case, in the end focus on those human actors who act as "gatekeepers" to non-humans: scientists, project managers, and different groups of "experts". While these groups might play important roles in deciding on the outcome of such projects, this entails, at the same time, a turn away from marginalized or "subaltern" groups and towards human actors in rather privileged positions.

The shift away from a sole focus on the human and the increased interest in the non-human (and the gradual dissolution of this distinction between the two realms) did, however, not only comprise a methodological or practical issue; a change in the role different groups of humans and non-humans play in the process of valuation and commodification could also be observed in the management of the Maâmora Forest over the last decade – an observation that others in the field have made (Braun, 2008). Compared to earlier improvement schemes in the 1970s and 1990s, the role of human actors and how they were approached in the conception and implementation of the FFEM project have considerably shifted. The aim of poverty alleviation or the issue of poverty at all was rarely mentioned in project documents and meetings, and forms of community forestry that had dominated forest governance since the end of the 1990s played only a minor role in the project. Its focus lay on the forest and the services it provided, the installation of monitoring tools, the generation of data, and new forms of decision-making in relation to forest management; and the role of the humans in the forest was instead assessed in regard to how they facilitated or hindered the provision of these services.

3.4.3 Limits: how, but not why

The ANT-inspired variant of STS I have used has proven to be useful in describing and analysing *how* things – like the marketization process – work in practice; it turned out to be crucial for explaining the work process, outcome, and failure of the project. It was, at least from an ANT perspective, more difficult to pinpoint the *reasons* or *explanations* behind the turn towards the new forms of forest management: why did these changes occur, why did they occur at that specific moment, and why did they occur in this form and not another? Political economy approaches, or a macro-economic perspective in general, had to offer more explanations here. Discussed from a perspective of the neoliberalization of nature and against the background of macro-economic changes, the new forms of environmental governance and projects that emerged in the southern Mediterranean in the late 2000s can be considered part of the reaction to the financial and the Euro crisis, changing investment practices, and an increased demand for (green or land-based) investment opportunities

(Fairhead et al., 2012; Bracking, 2019; Sullivan, 2013). This hypothesis is supported by the project documents that repeatedly point to the need to offer investment opportunities to institutional and private investors and by the call to make landscapes "ready for investment" (FAO and Global Mechanism of the UNCCD, 2015:16).

At the same time, the project was characterized by various forms of unequal power relations. Morocco being a former French colony, the project leaders and "experts" dominating it were all white, all French, and mostly male. Their networks were self-sustaining: they repeatedly called in additional experts they knew, and contracts and orders were given without official tenders. While these relations can be framed as colonial or imperial forms of dominance or, if one wants, criticized as networks of corruption, a more radical form of ANT with its refusal to rely on such "generalizations" and its "categorical denial of structural inequalities" (Lave, 2015:218) makes such a (partly normative) stance more difficult.

4   Dealing with opportunities and challenges

As shown in the previous sections, the integration of STS approaches – especially in the form of their ANT variant – into political ecology brings along certain challenges. Exponents of a strong reading of ANT have argued that these STS approaches are not compatible with the Marxist-inspired approaches of left geographies (Whatmore, 1999) and have called to go "beyond" the latter ones (Bakker, 2010); Holifield (2009) has similarly argued against a synthesis of ANT with political ecology and highlighted the "distinctive contributions" ANT can make (Holifield, 2009:655). On the other side, political ecologists have pointed to the "deep incompatibilities between political ecology's core commitments" and these approaches, concluding that "it is time to retire ANT as a core element of the political ecology tool kit" (Lave, 2015:221). Besides these fractions, various authors have searched over the years for ways to combine STS, and also the ANT version of if, with political ecology. In this section, I present some proposals that have been put forth to deal with the difficulties mentioned above and get an idea of in which direction the debate and further research can lead.

4.1   A weaker version of ANT

Several authors have vowed to include ANT in the repertoire of political ecology but to do so using a "weaker" version of it. Such a weaker version, Castree (2002:135) argues, would

> remain critical of binarist thinking, of asymmetry, of limited conceptions of agency and of centred conceptions of power. However, at the same time, it would concede the following points: that many actor networks are driven by similar processes, notwithstanding their other differences; that these processes might be 'global' and systematic even as

they are composed of nothing more than the ties between different 'localities'; that these processes are social and natural but not in equal measure, since it is the 'social' relations that are often disproportionately directive; that agents, while social, natural and relational, vary greatly in their powers to influence others; and that power, while dispersed, can be directed by some (namely, specific 'social' actors) more than others.

The call for a weaker (and less dogmatic) version of the respective theory applies not only to ANT, but also to political ecology. Christophers (2014:18) argues that ANT and eco-Marxist conceptualizations of economization "are only incompatible if one works with especially 'strong' versions of one or both".

4.2   A distinction between object, method, and ontology (and political readings)

In urban studies, Brenner et al. (2011) have distinguished between three different articulations of the new approaches (Brenner et al., 2011:231): *empirical* – as a turn towards new sites and research objects, like technological or material infrastructures; *methodological* – as a research concept focussing on "previously neglected dimensions of capitalist urbanization", like material flows or the production of socionatures; and finally, *ontological* – as "alternative ontology for the city" (Farías and Bender, 2010:13). While they welcome the first two aspects for the productive insights they have generated, they reject the latter, the replacement of political economy approaches with assemblage thinking as the new ontological foundation of urban theory. "Ontological approaches to assemblage analysis", they argue, "deprive themselves of a key explanatory tool for understanding the sociospatial, political–economic and institutional contexts in which urban spaces and locally embedded social forces are positioned" (Brenner et al., 2011:233).

This debate has not been taken up in political ecology; its core questions, however, are relevant for any field dealing with new materialist thinking: to which strands of the heterogeneous field of STS are authors calling to integrate them referring? And how exactly are they going to be used – as an inspiration or as an empirical or methodological supplement? Or might they be seen as a fundamental reformulation, a new ontological foundation, replacing existing research frameworks?

4.3   Bridging the divide: suggestions to combine ANT and political ecology

Finally, there have been various suggestions for using a third theoretical strand to function as a "bridge" between the two approaches. In my research I have used a materialistic reading of Foucault's *governmentality* concept (Foucault, 2006a, b); this perspective allowed me to analyse the

changing structures and dynamics of governing nature over time. Governmentality has been used in various other cases as a tool to frame ANT-inspired case studies in political ecology (Schmitt, 2016; Asiyanbi, 2016; Gupta et al., 2012). The value of the concept in this regard lies, on one hand, in the fact that in human geography, a tradition of combining questions of political ecology with governmentality analysis is well established (Cavanagh, 2018; Fletcher, 2017; Rutherford, 2017; Mattissek and Wiertz, 2014). On the other hand, the "dispositives" Foucault has based his analysis on, resemble in many ways the socio-material networks ANT is working with – Law (2008:145) himself has referred to actor networks as "scaled-down versions of Michel Foucault's discourses or epistemes", and the concept of governmentality, despite being used in German human geography mostly in relation to discourses, has a profoundly materialistic basis (see Lemke, 2014).

The concept of *performativity* is another example here. Performativity, originating in speech act theory, is a core concept of ANT-based marketization studies. Christophers (2014) uses it as a departing point for a conversation between these and Marxist political economy approaches, concluding, certain pre-conditions given, "that the two literatures in question not only are not (as is frequently suggested) incompatible but, as presently configured, substantially need one another" (Christophers, 2014:19–20). Performativity, however, can be interpreted and used in different ways, and to further investigate its political dimensions, as Blok (2011) suggests, might be a fruitful departing point for a re-framing and, possibly, re-politicization of the concept by opening up the investigation beyond the performative act itself.

Butler (2010), in a critical examination of the way performativity is used in ANT-based marketization studies, argues that entities and structures like markets are not brought into being by (economic) science alone but that these processes of knowledge production themselves are embedded in broader structures. To assume that performativity is not taking place in an empty, "neutral" space but that speech acts are performed themselves under structural constraints opens up the space for a multi-dimensional and nestled, instead of a flat, imaginary. Not to fall into shortened explanations, it is necessary not to restrict the analysis to the inner functioning of the processes but to extend the research to the conditions enabling or structuring these – to deliver not empty descriptions of the mechanics of production processes but content-rich explanations of the direction of change.

5   Conclusion – a call for content

In this paper, I have discussed the opportunities and challenges arising out of the integration of ANT into political ecology. As I show, the turn towards ANT-inspired research has changed the framing of the forest-based climate instrument REDD+: from REDD+ as an example of the neoliberalization of nature to the role of knowledge, infrastructures, and non-human actors in the making of (carbon) markets. The use of ANT-inspired marketization approaches, as both the literature review and my case study show, allows me to highlight aspects of processes (e.g. marketization) that would be difficult to grasp otherwise but at the same makes it more difficult to conceptualize power relations, interests, and the effects of underlying political and economic structures.

This is not meant to keep STS in general, or even its ANT variant, out of political ecology or development studies. It is, though, important not to overlook the different theoretical foundations of ANT and critical geographic approaches. When using ANT, one needs to be aware of the consequences its use might bring for both the individual research project and the direction of research in the field in general. Summarizing the arguments of this paper, I would suggest turning to an ANT approach under three conditions.

1. First, ANT is a useful tool when the approach relates to the *research question* or *object*, p.e. when the research focusses on or includes the role of non-human actors, infrastructures, or processes of knowledge production. In relation to the latter, however, it is important to keep in mind two points: first, to acknowledge that *science and technology studies*, especially their ANT variant, not only and not even mainly are about science but also bring far-reaching political and epistemological consequences with them. Second, ANT or even STS in its broader sense is neither the first nor the only and probably not always the most appropriate theoretical tool with which to research knowledge production. The critical analysis of (scientific) knowledge has been a central issue in critical geography and related fields like anthropology for many decades, be it from a perspective of feminist political ecology (Carey et al., 2016), postcolonial or poststructuralist thought (Demeritt, 2005), or Marxist philosophy (Rudy and Gareau, 2005). The use of ANT has certain advantages – for example, it is particularly useful to capture the unintended or unforeseen consequences of projects or programmes – but it might not be the best theory available in other cases.

2. Second, when using ANT, it is important to do so in a *conscious and self-reflective* way, aware of possible consequences of the theoretical and methodological choices, asking what can be highlighted, what might be overlooked or excluded, and where inconsistencies with other theoretical approaches might arise.

3. Finally I would recommend to *combine* ANT approaches with earlier political ecology approaches *instead of replacing* them, working further to actively develop theoretical contributions that can help to combine the two approaches. This also means actively working to overcome the split between scholars working from

political economy and STS perspectives and to foster a dialogue between both. In a time of increased social inequality and the growing relevance of the non-human to the capitalist value-making process, it is crucial to have at one's disposal theoretical tools and methods to grasp social and economic dynamics on a general level as well as their functioning and outcomes for both humans and non-humans in concrete cases.

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