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Journal of Environmental Policy & Planning

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cjoe20

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To cite this article: Kristof Van Assche, Martijn Duineveld, Raoul Beunen, Vladislav Valentinov & Monica Gruezmacher (2022) Material dependencies: hidden underpinnings of sustainability transitions, Journal of Environmental Policy & Planning, 24:3, 281-296, DOI: 10.1080/1523908X.2022.2049715

To link to this article: https://doi.org/10.1080/1523908X.2022.2049715

Published online: 21 Mar 2022.

JOURNAL OF ENVIRONMENTAL POLICY & PLANNING
2022, VOL. 24, NO. 3, 281–296
https://doi.org/10.1080/1523908X.2022.2049715

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RESEARCH ARTICLE

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Material dependencies: hidden underpinnings of sustainability transitions

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ABSTRACT

This paper presents a framework for analysing the different ways in which materiality impacts environmental policy and governance. It draws on notions from the wider literature on materiality and integrates relevant insights into a theory on policy and governance. Building on a key distinction between the material and the discursive dimensions of governance, it develops the concepts of material events and material dependencies. Material events bring attention to the linkages between material changes and their observation and interpretation in governance. The concept of material dependencies is useful for analysing the different ways in which materiality structures the evolution of governance systems. The paper ends with some methodological considerations for mapping and analysing material dependencies and suggestions for further research.

ARTICLE HISTORY
Received 25 August 2021
Accepted 1 April 2022

KEYWORDS
Materiality; sustainability; environmental governance; discourse; socio-technical transition theory

Introduction

A growing number of researchers are analysing and explaining the need for sustainability transitions, possible forms and pathways of such transitions, and the variety of obstacles on the way (Kern et al., 2019; Turnheim & Nykvist, 2019). Several new fields and old disciplines have jumped on this theme of overriding importance. Numerous factors are identified that hamper the sustainable use and management of natural resources, the care for biodiversity and landscapes, and last but not least the stability of political and economic systems aiming at social-ecological sustainability (Van Assche et al., 2017). Much attention has been paid to the actions and strategies of various actors (e.g. Meijerink & Huitema, 2010, p. 38; Mintzberg, 1987), to institutional capacity and adaptability (e.g. Armitage, 2010; Bettini et al., 2015; Healey et al., 2017), to financial incentives, legal regulation, economic and environmental modelling, innovation processes, transition management (e.g. Patterson et al., 2015; Shove & Walker, 2010; Voß & Bornemann, 2011). And to this list one can also add: power dynamics (e.g. Van Assche et al., 2017), transformative experiments (e.g. Pereira et al., 2018; Williams & Robinson, 2020) and environmental services and accounting (e.g. Pope et al., 2017; Schaltegger & Burritt, 2017).

While the diversity of approaches to sustainability, transition and resilience is staggering, one essential connection remains woefully understudied: the relation between materiality and governance. Not only has interest in academia been rather minimal (some notable exceptions are: Benson, 2019; Birch, 2016; Geels, 2005;

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Hansen & Coenen, 2015; Houston et al., 2018; McFarlane, 2011; Myers, 2017; Wieczorek, 2018), the practices of governance have also paid limited attention to the way materiality has shaped patterns of actors and institutions, power and knowledge, and the dependencies that develop in evolving governance. In contrast, the other direction, the impact of governance on materiality, has been much more thoroughly studied, in the disciplines of planning, design, administration and the field of environmental studies, and environmental impact assessments are part and parcel of many policy practices. Besides the weak engagement with materiality in the policy-related disciplines, one can say that the existing conceptualizations of materiality are inadequate to grasp and manage the complexity of governance and the sustainability transitions needed today.

Materiality in many disciplines is considered to be inert, passive, mechanistic, deterministic, or reductionist (if associated with the reduction to the level of physics) (Coole & Frost, 2010; Gregson & Crang, 2010; Van der Tuin & Dolphijn, 2012; cf. Acemoglu & Robinson, 2012). For example, the renowned institutional economists John R. Commons, writing in the first half of the twentieth century, saw a point of departure of the genuinely institutional economics in the radical decoupling of the social meaning of ownership from the material objects being owned (cf. Commons, 2005). While this decoupling helped to overcome some of the reductionisms of the (then and now) prevalent neoclassical economics, it turned a blind eye to the whole range of ecological concerns related to the materiality of the strained natural environment. Thus, new understandings of materiality are needed today (Huijbens, 2021), particularly in the way materiality affects governance.

The limited engagement with materiality within governance studies is surprising given its prevalence in its neighbouring disciplines, where materiality has been hailed as the forgotten driver, the dark matter of social life, and the overlooked key concept of the social sciences. The so-called new materialism in geography, anthropology, organization studies, and science and technology studies pushed the role of the material, or of 'non-humans' into the spotlight in the social sciences and the humanities (Anderson & Wylie, 2009; Bennett, 2013; Coole & Frost, 2010; Duineveld et al., 2017; Latham & McCormack, 2004; Latour, 2006; Pottage, 2012; Ren, 2011; Valentinov, 2017; Van der Tuin & Dolphijn, 2012; Whatmore, 2006). These new materialists are, as Bergthaller summarizes,merely trying to articulate the consequences for the humanistic disciplines of some of the major transformations which the scientific understanding of the world has undergone over the last few decades, in the name of such new fields of research as complexity studies, systems biology, and cognitive science (…). (Bergthaller, 2014, p. 38)'New materialism' or 'the new materialists' do not refer to a unified academic discourse (Pellizzoni, 2014). The only consensus we could observe is that materiality matters. How it matters, why it matters, what its ontology is, and how it can be observed, remains input for countless debates between the object-oriented otologists, the phenomenologists, neo-Marxists and more than human geographers, to name a few.

Whereas many have rediscovered the material world and its influence on discursivity and human practices, the links with governance are not fully developed, as scholars working on materiality often have a modest interest in the worlds of politics, policy and administration, beyond broad ideological categories (such as neo-liberalism and socialism). In the policy-related disciplines, post-structuralism and other versions of constructivism took a long time to break through (Flyvbjerg, 1998). In planning and environmental studies, and classic development studies, modernist, engineering-dominated perspectives on infrastructure and environment have been pervasive for a long time (Acemoglu & Robinson, 2012, pp. 48–56). These perspectives in which experts play a central role assume direct feedback loops between places 'asking' for infrastructures and interventions and policy systems perfectly responding to those signals. This has over-emphasized direct influence of materiality on policy and understudied it, as other pathways of materiality into policy were not considered (Björkman & Harris, 2018).

The concept of social-ecological systems (and its relatives and variants) has brought attention to the interrelations between the social and material worlds, yet it often does so from perspectives that essentialize both the social and the material (cf. Berkes et al., 2008; Folke et al., 2005; Ostrom, 2009, 2009). The approach does not usually focus on the various ways in which materiality impacts governance, nor take advantage of the rich body of post-structuralist literatures that offer insight in the power/knowledge processes through which social systems make sense of their environment (Hornborg, 1996; Pottage, 1998; Van Assche et al., 2014). At best it is recognized that different stakeholders have different perspectives or 'frame' objects and places differently,

leaving many of the more subtle and structural power/knowledge processes out of sight. Such limitations matter if one is interested in the impact of materiality on governance. Other approaches explicitly focus on the different discourses that influence governance, but not how these discourses are influenced by materiality (Colebatch, 2009; Howarth & Torfing, 2005; Schmidt, 2011).

We therefore believe a new mapping of this terrain, particularly aiming at environmental policy and planning, is urgent and necessary. In this paper we aim to develop a framework for analysing the impact of materiality on governance, and specifically policy, administration, and planning, drawing on the different perspectives on materiality that have emerged over the years in neighbouring disciplines.

In the next section, we briefly discuss different perspectives on materiality (which are related, but not always compatible). We clarify which aspects of these theories we consider useful for the analysis of environmental policy and governance. Then we deepen our understanding of the relations between materiality and governance by introducing the concepts of material dependencies and material events. We see material dependencies as the effects of the material environment on governance, and material events as the temporalities through which this plays out. After considering the variety of pathways through which the material world can affect governance systems, we outline a method for mapping such pathways, a mapping of material dependencies in governance. This expanded conceptual apparatus can serve to rethink sustainability governance aiming at societal change (be it transitions, transformation, systemic change, and so on). In the conclusion, we focus on the implications of mapping dependencies for governance theory and practice. We argue for making explicit the often-hidden material constraints for change and the potential of materiality for bringing about change.

Perspectives on materiality

The basic distinction between discourse (Luhmann would speak of social systems) and environment is the starting point for the development of our framework. We acknowledge that this distinction is conceptual, not ontological, as we can never be certain about the validity of that distinction (Jacobs & Van Assche, 2014). Sometimes discourse and materiality fold into each other and their boundaries can only be assumed, not observed. Governance can shape, alter and create materiality and is shaped by it. There can be all kinds of 'feedback loops', surprising returns (Barba Latta, 2017, pp. 87–93; Barba Lata & Duineveld, 2019), visible to a social system and invisible, by which materiality alters governance and its path. If governance evolves, materiality evolves and vice versa. Materiality can enable and constrain change in governance. Only when material changes wipe out all communications, one can speak of an end to evolving discourses (Duineveld et al., 2017, p. 381).

A discourse is a system of communications that is operationally closed, yet structurally open. It exists in relation to a certain environment (Luhmann, 1989). That environment is everything else. The elements that constitute governance are discursively constructed: institutions, ideologies, narratives, actors and so on (Van Assche et al., 2013). Furthermore, the elements in the environment of a particular discourse can be discursive and/or material. The materiality that is observed and made sense of matters, yet only through processes of observation and meaning making (Luhmann, 1989). Third, the temporal dimension is important. Governance, its constitutive elements, and their interrelations evolve over time and create governance paths, marked by specific events and outcomes that are the input for further evolutions (Van Assche et al., 2013). The constant interplay between discourses and materiality has an effect on this governance evolution.

In line with Luhmann, we argue that discourses are self-referential social systems in which symbolic interactions or communications always respond to previous communications. Symbolic or material changes external to a system of communications, can be observed, but only according to the logic of that particular observing social system (Felder et al., 2015; Fuchs, 2001; Luhmann, 1987; Van Assche et al., 2013). Just as a rock can never become part of one's consciousness – as one will lose consciousness if one tries – nothing external to a discourse can become (part of) that discourse. This might sound completely logical yet it is often overseen by some of the academic branches of new materialism (Bergthaller, 2014).

Deepening our understanding of the role of materiality in governance and envisioning a framework and methodology to analyse material dependencies therefore asks us to rethink the relations between governance and materiality without giving up the basic distinction between the material and the discursive. We stress this point, as it represents a difference with recurring positivist theories which objectivize, essentialize, and harden materiality. Things for us exist, they offer resistance to certain uses and descriptions; they differ from discourse yet are grasped through discourse while affecting its formation and functioning. In the next paragraphs, we briefly present a selection of frameworks that can be seen as the basis for the new materialists and we indicate which insights and elements from these theories we use for developing our framework. We don't intend to compare, relate, or deconstruct these theories: we borrow what is useful and neglect issues that are less relevant for the analysis of governance. This further clarifies our position on the material/discursive distinction, and it starts building the framework to analyse materiality and governance.

Marx

For Marx and Marxist interpreters, materiality was never absent from their theorizing on society (Laclau & Mouffe, 1987). Their material conception of history highlights the many dependencies of societies on the material conditions that are seen as crucial for their survival. Materiality is fundamental to their historical materialism yet materiality is essentialized, as they would point out that inherent value in nature exists, and that power relations develop around those assets (Foster, 2000; cf. Edwards, 2021)

Foucault

Foucault, who transformed many Marxist assumptions in his post-structuralist theories, de-essentialized Marx (Foucault, 2008, 1984; Pottage, 1998). From a Foucauldian perspective, one can emphasize the role of power in and of discourse and the fact that discourses about the environment never escape power relations. The way some material things become assets for some and not for others, the ways in which discourses render certain realities more real than others, or the foregrounding of certain aspects of the environment over others, can all be understood and analysed thanks to Foucault's intellectual legacy (Van Assche et al., 2017). Foucault problematized the relationship between power and materiality, mainly in his book Discipline and Punish (Foucault, 1978a) where he used the panoptic prison to illustrate the power of the gaze, which led him to considerations of managing space and planning cities for control. Space, beyond its discursive construction, and into its use by powerful and marginal groups (see also the concept of *heterotopia*) had his attention regularly, and while materiality is never maligned or rejected, it does not have a central place in his works (cf. Elden & Crampton, 2007). We draw on Foucault for our basic concept of discourse.

Lacan/Zizek

For Lacanian psycho-analysis three orders of reality are distinguished: the symbolic, the imaginary, and the Real. The imaginary is what we observe as reality, the symbolic order are the discourses constituting reality and the real is that which we can assume to exist, but which escapes the imaginary and the symbolic (Zizek, 2008). The Real, (which is not to be confused with reality), can be an important building block for rendering materiality more present in governance. The Real is part of both internal and external environments, as externality is always folded into individuals and discourse (Eyers, 2012). The Real can only be assumed and only symptoms of the Real can be reflected in discourses. The concept of the Real helps us to conceptualize the way the environment can strike back and how policies can trip over the Real (Gunder & Hillier, 2016). Imaginary and symbolic functions are never adequate to grasp the agency and resistance of the material Real, all the more so because they are themselves subjected to a 'folding' of the external world into their constructions (Hook, 2017). Materiality can alter discourses and thus governance in ways that escape direct observation, that are unpredictable, or in ways that put an end to the reproduction of discourses.

Deleuzian materialism

For Deleuze (cf. Buchanan & Lambert, 2005), reality continually comes into existence, out of an encounter between material and discursive entities. Reality is not describing materiality, it *is* materiality, yet, as with Lacan, the measure of materiality in what appears as real (including what appears as material) can never be fully ascertained. Of special interest for us is the degree of creativity which Deleuze ascribes to this continuous creation. Deleuzian materialism, and its numerous offshoots in terms of new materiality, non-representationalism, embodiment and mobility theories, help us to emphasize the surprise element, both positive and negative, when nature strikes back, when our entanglement with a particular material environment produces something new, whether that is a new power relation, a new story, identity, or a new materiality (cf. Massey, 2005). Deleuzian materialism reveals new aspects of the interweaving of materiality and discourse. Materiality can fold into the social in a manner unobserved by anybody and still have major repercussions for the social, for reproduction for discourse and hence for governance. Deleuzian materialism helps to (at least conceptually) map out the surprising pathways of the Real (Deleuze & Guattari, 1989). It also elucidates how the tools of control available to governance cannot only obscure what is happening in our environment (as they tend to be molar concepts, cf. Olsson et al., 2006), yet also how they suppress the individual and societal creativity that comes with a freeing up of desire. Damage to the environment and damage to (the potential of) society to fix or more respectfully deal with our environment, can thus easily come from the governance systems supposed to protect the environment.

Social-ecological systems

From the thinking on social-ecological systems, we borrow the idea that one can speak of adaptive and polycentric governance systems which are required for system survival, but which hinge on previous histories of adaptation to social and ecological environments (Olsson et al., 2006). There are pathways of influence from material and other environments to decision-making, as an array of system-environment relations (Van Assche et al., 2019). The basic idea of social-ecological systems with a history of mutual adaptations between the social and the ecological which are only partly predictable and governable, helps to grasp societies' dependence on their material environment. It also highlights, resonating with Deleuze, the need to continuously explore and create new forms of knowledge to explore and manage that environment (Berkes et al., 2000).

Social systems theory

Social system theory is partly rooted in the same conceptual fields as the theories on social-ecological systems (systems theory and biology), but has over the years become much more attuned to ideas that emerged in the social sciences and the humanities (De Berg, 2001; Fuchs, 2001; Luhmann, 1989). Although the role of materiality in affecting social systems remains understudied, social systems theory help us to understand that the agency of materiality is relational and cannot be assumed a-priory to any relation.

The notion of relationality is usefully contrasted with the social systems theory's focus on boundary drawing which is not at all characteristic for approaches giving primacy to the interdependence and organic interconnectedness of reality (cf. Hernes, 2007, p. 94). Thus, one type of influence of materiality on the life of social systems arises out of repercussions of incisions and dissections introduced by systemic boundaries into the material world, which, no less importantly, is characterized by hierarchies of emergent socio-material discourse (Bergthaller, 2014; cf. Farías, 2014). From the moment subject and object are delineated within discourse, as they are rendered real, more real than other delineations, hierarchies come into existence.

Functional differentiation (Luhmann, 1987), the gradual emergence of specialized social systems of law, politics, etc, makes central steering by politics challenging, thus questioning some of the transition approaches that adopt a modernist style. Yet functional differentiation retains the notion of hierarchy just presented. In fact, the distinction between real and not real is in most function systems not shaded; it is either-or. An additional distinction, of relevant/irrelevant, for the logic of the system, can introduce more degrees in the

hierarchy, and more easily give cognitive access to certain aspects of the material world, and more potential effects of those materialities.

Another important lesson we take from Luhmannian social systems theory is the idea that a discourse is operationally closed, as it reproduces itself based on previous communications within that discourse. The fact that discourses are always a reduction of what can be observed in the environment, makes it impossible to be completely aware and adaptive to material changes in that environment. In this sense, there is always a void between the discursive and the material that could potentially harm, hamper or undo a social system (Valentinov, 2017, p. 324). This void points to the important role of human engagement that remains understudied in the Luhmannian theory, namely the human capacity for immersive engagement with their material and socio-cultural surroundings. This engagement enables people to develop sensitivities to the precarious aspects of syste--environment relations to which systems remain blind in view of their operational closure. Contemporary management scholarship suggests that this engagement could be at the core of unique dynamic capabilities of competing firms (Nayak et al., 2020). We suspect that human contact with, and sensitivities to, their empirical surrounding could play a crucial role in helping systems navigate the precarious voids in the fraught system-environment relations.

New materialism

Along with Karen Barad (Barad, 2007) and Rosi Braidotti (Braidotti, 2006), Jane Bennet was one of the key figures in the 'early years' of the so-called material turn, the years after 2000. In her book *vibrant matter*, Bennet conceives matter as forces and forms. It is a (un)predicable actor among human actors. 'I believe it is wrong to deny vitality to nonhuman bodies, forces, and forms […]. I believe that encounters with lively matter can (…) expose a wider distribution of agency, and reshape the self and its interests' (Bennett, 2013, p. 122). For Bennet and other proponents of the new materialisms, the material is never reducible to the chemical or physical. They often distinguish between matter and materiality, where the latter term denotes a force, a vitality or a difference that makes matter active and creative. They believe that a renewed thinking is needed regarding the 'location and nature of capacities for agency' (Coole & Frost, 2010, p. 9).

New materialists come in many shapes and forms. Some imply a return to positivism and the idea of a direct knowledge of the material, others declare (in a twist on Foucault) the death of the subject once again, this time by handing it over to the objects (Johnston, 2020). Yet others draw on Deleuze or open up post-structuralism to the various forces and presences of the material in the social and hence the political. We place ourselves in that tradition and trace the implications for governance in a time of severe stress on our ecological surroundings.

Actor-network theory

That matter is vital and vibrant in shaping the world resonated with the works of the actor-network (ANT) theorists like John Law, Bruno Latour and Annemarie Mol who argued for a social science that takes into account non-human agency. Machines, microbes, and particles enact realities (Abrahamsson et al., 2015; Law, 2009, 2004; Mol, 2002). Within ANT agency of humans and non-humans is always relational. Similar to the Foucauldian conceptualization of power (Foucault, 1978b), agency is relational. It is always the result of contingent relations between elements that enact each other as subject or object (or hybrid). So there is no material agency outside of the relations in which agency takes shape and affordances only exists as an ascription by an observer, an observer who might want to do something in the world. One might presume that a high mountain affords less, has more agency as a boundary, compared to a paper wall. Still, its agency can only be observed in a particular relation. The paper wall could symbolize an injunction, and stop many from trespassing, while the mountain becomes an invitation to conquer it.

Some actor network theorists, inspired by Foucault and other post-structuralists, are very explicit about the multiplicity of reality. For Annemarie Mol a hospitalized body is multiple; it comes into existence as different, but partly overlapping ontologies in different hospital settings (Mol, 2002). In this line of thought, the vibrancy

of matter is a site-specific effect of a particular network or mode of ordering (ANT term for discourse as social material network).

For our analysis of governance and materiality, the ANT concept of black-boxing can be useful, as it can entail a forgetting in the governance system of the material causes, features and effects of any of its elements, and as it can represent a forgetting of the material conditions shaping governance configurations. Sustainability itself can be black-boxed in governance, lifted out of context, becoming an unquestioned goal and tool, making it hard to recognize as contingent production (Rice, 2011). Only some materialities are recognized, shaped or targeted by a sustainability concept and black-boxing and generalizing 'sustainability' makes other relations invisible.

In the previous paragraphs, we highlighted the elements from different literatures that we seek to incorporate in our emerging framework. Summarizing, we can say that materiality doesn''t think or conduct politics, yet discourses (and hence institutions and modes of conduct) can be nested into the material (Latour & Woolgar, 1986; Mosse, 2004). Materiality can affect governance in many, sometimes-surprising, ways. Discourses, and hence governance systems, can endure because of their materialization and they can be undermined by the ways in which they are materialized; like an old, once expensive machine in a laboratory it enables certain observations, but can also hamper innovation because (by definition) it overlooks that what is not observed (Latour & Woolgar, 1986). Materiality can play a more observable role in governance when it is turned into an object recognized in governance (Duineveld et al., 2013), but this does not exhaust the possible pathways of influence. In the next sections, we will analyse this diversity in pathways.

Material dependencies and material events

To understand how materiality affects governance and to enable a concise mapping of the roles of materiality we introduce the concepts of material dependency and material events.

Material dependencies

In political science and public administration, path dependencies have been widely recognized (Avid, 2007; Garud et al., 2010; Mahoney, 2000; Pierson, 2000), but they are not usually highlighted as starting from the material environment, and do not usually extend into other aspects of governance, beyond institutions, actors, and arenas (Borup et al., 2006; Kay, 2005; Thelen, 2012). Cognitive path dependencies, and other path dependencies in the realm of power/knowledge, such as patterns of inclusion/exclusion and privileging of different expert knowledges and local and traditional knowledges have received more attention. Less has been written about the pathway of transformation, and mutual shaping of histories of thinking and histories of organizing, and even less so about the effects of the physical environment on those entwined paths.

We derive from evolutionary governance theory, or EGT (Beunen et al., 2015), the idea of *dependencies* as rigidities in the evolution of governance systems: those systems evolve but are constrained by certain features which we call dependencies. EGT distinguishes three types of dependencies: path dependencies, as various legacies of the past shaping the current functioning of governance; interdependencies, between actors and institutions and between actors; and goal dependencies, or effects of visions or ideas about the future on the current reproduction of the governance system. In order to give due weight to the role of materiality in governance, we add the concept of material dependencies, to indicate the effects of both natural and human-made physical realities on the taking of collectively binding decisions (Van Assche et al., 2017, 2019, p. 2020)

Materiality can create and/or relate to paths, inter- and goal dependencies, just as path dependencies can create inter- and goal dependencies can lead to new path dependencies (Van Assche et al., 2013). Material dependencies can be distinguished as a separate type of dependency as here, uniquely, the boundary between the discursive and material worlds is invoked. While for EGT, discourse triggers organization and vice versa (cf. Czarniawska, 1998; Leonardi et al., 2012), here we consider the input from the non-discursive into the production of both discourse and organization. The other dependencies will create obstacles and openings for particular materialities to affect the system, while once material dependencies are established, they

spawn further interactions and contribute to the production and modification of the other dependencies (cf. Van Assche et al., 2021).

Material dependencies are formed directly and indirectly, through different pathways, and their influence is not always noticed or reflected upon by actors. These dependencies can be encoded in institutions (which can entail black-boxing), work through discourses embraced by actors, through infrastructures of organizing, of policy implementation, etc. They can alter power relations, affect dominant discourses or inclusion of knowledges, and from there power relations, and they can affect both economic and social values, which again can alter configurations of governance. All features of the relation between the discursive and the material, discussed in the previous section, including its Real surprises and opacities, can play out and pathways into governance have to be numerous. Each of the pathways can be shaped in relation to others (as positive or negative feedback loops; von Bertalanffy, 1968). They must be discerned empirically in each case, and an accumulation of empirical studies adds detail to the map of possible pathways.

Material events

The term 'event' denotes the time dimension of material effects on governance. Matter is always there, it changes, but the temporality of its effects on governance differs from the temporality of governance. Following Deleuze and Luhmann, we see realities as continuously reproduced, and the unit of reproduction is the event. A material event occurs when materiality alters something, sparks or creates something in governance. That something can be a collapse, and it can be (following Deleuze again) an atmosphere at a meeting which sets the tone and guides key decisions.

Material events can be slow or fast, can cause a shock or not, and the effect can be substantive, or subtle. As we noticed with climate change and more recently COVID-19, changes in the physical environment are not always immediately observed within governance and when they are observed they do not always trigger coordinated responses (hence the risk of collapse; Scheffer et al., 2012). When they are not observed they can still engender effects that escape observation (Luhmann, 1989; Valentinov, 2014). As a manifestation of the Lacanian Real, they can alter discourses, psychic systems, governance, or the material world itself without anybody being aware (Eyers, 2012). When events are not observed within governance, one can speak of silent events; when they are catastrophic and halt all communications, one can speak of deadly events (Duineveld et al., 2017). What is silent, is always silent for a specific observer or group of observers. So silent events can be observed with hindsight (cf. Seidl, 2016), when at one point in time observers become aware that the mysterious ruptures of nature can be explained by a parasitic fungus. Such typology of events can be useful to distinguish and analyse the different ways in which discourses observe material events (Duineveld et al., 2017).

The agency of materiality, reflected in its apparition as a material event and its triggering of material dependencies, is therefore not an intrinsic quality or affordance of matter, but something that emerges in the interplay between the discursive, the organizational, and the material. A deadly event is only deadly when it puts a halt to all communications. A silent event, in the order of the Lacanian Real, is transformed once it becomes part of the imaginary or symbolic order: once observed it is no longer silent. When unexpected things happen or become suddenly visible, environmental policy and planning can suddenly appear in a new light, either as more necessary, or as a waste of precious time.

A typology: human-made, hybrid and natural material dependencies

To sharpen the observation of pathways of materiality and material events, we propose a typology of material dependencies that can be useful in research and practice. Material dependencies will be different per resource, per context and also, per strategy or vision. This simply means that what is understood as and works out as a material dependency hinges on what a community wants to do, and what it values (cf. Boyce, 2001). Material dependencies, in other words, are never absolutes.

We can distinguish between *human-made, natural, and hybrid material dependencies*. For each category, a further distinction can be made between enabling and disabling and between positive and negative. Human-

made material dependencies stem from material objects and structures created by humans, such as all kinds of infrastructures, landscape change and pollution, climate change, etc. Natural material dependencies can include ecosystem transitions, drought cycles, population fluctuations, soil formation, etc. Often a clear separation between human-made and natural is difficult to make. Thus, hybrid material dependencies are confronted all the time, and the exact nature of their hybridity is often not clear, because of a long history and complex pattern of huma–nature interactions (Richardson, 2016) (Figure 1).

Enabling and disabling material dependencies are enabling and disabling in reference to what a community wants to do. Materialities can be enabling directly, e.g. as when a road enables development (which can be assessed negatively if that development threatens a valued ecosystem). Once effects in governance become visible, i.e. material dependencies in the more precise sense, those can be enabling or disabling. The road can have installed a pro-development lobby which enables further development (and this, again, can be seen as positive or negative depending on the values adopted).

Nayak et al. (2020) discuss the notion of environmental affordances which guide the orientation of corporate decision-makers engaged in strategy finding. Drawing inspiration from their work, we suggest that material dependencies may generate material affordances and hindrances that have to be assessed by individuals embedded within the thick textures of socio-cultural practices. Material affordances and hindrances may themselves be entangled in particular cases, just as material dependencies can be entangled with the other dependencies distinguished (path, inter- and goal dependencies). Institutional and cognitive path dependencies will aggravate, mediate or transform material path dependencies, as when habitat protection is already accepted and functional, and can now be used to create marine reserves. Material dependencies can be entangled with goal dependencies, as when multi-functional forests envisioned in a comprehensive plan reduce the dependency on timber, and as when the plan for climate change adaptation hits the wall of economic dependency on natural resources and its effects on governance over time. Actors keeping each other in place in relations to interdependence will also affect the pathways through which material environments can create material events in governance and from there, possibly material dependencies. Networks of interdependent actors and institutions can keep forms of knowledge in place which hamper the adoption of plans which could positively transform material dependencies.

Mapping material dependencies: observing materiality -governance relations

The typology of human-made, natural and hybrid material dependencies and the associated concepts of pathways and material events are the basis of our perspective on materiality/governance relations. It is a selective concretization of theories on materiality that are hard to integrate in conceptualizations of governance. The selectivity was guided by our own ontological position (specifically the relation between discourse and material environment) and by our intention to make the implications of the new materialisms in governance visible. A co-evolutionary approach to governance which gives central place to the relation between thinking and organizing (such as EGT; Beunen et al., 2015), offers a particularly fertile ground, as it already presents a map of governance in which many pathways, events, and dependencies can be located (cf. Leonardi et al., 2012; Richardson & Weszkalnys, 2014).

To further increase the utility of a materiality perspective for governance analyses, we build on our initial frame to introduce some methodological notions helpful in mapping the roles of materiality in concrete governance systems and situations.

Mapping materiality-governance relationships, where to start?

In research practice, an analysis of materiality in governance is likely to be part of a broader study of governance processes. Since many elements and processes are deeply entangled in evolving governance processes, there is no a priori starting point for a study of material effects (an observation made by Luhmann (1987) himself, when discussing the construction of systems theory). We can distinguish several *possible* starting points, and acknowledge that there are also many other alternative approaches:

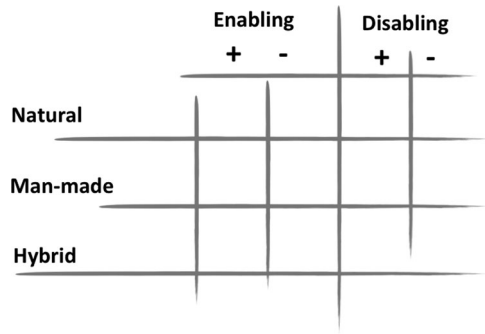

Figure 1. Material dependency typology.

- One could start with the observation of events in the world and see if they trigger material events and material dependencies in governance. A volcanic eruption can wipe out a village, it can trigger competing discursive constructions in the community and the governance system and/or reshuffle power relations.
- The dependencies in governance which structure the response to the event can be traced, and later the material dependencies installed by the event and response.
- Material events and material dependencies can be starting points for the analysis, as well as (key) variables that help explaining governance systems, their evolution and their social and environmental impact. In more integrated studies, they are both.
- An analysis can start with a policy, law or plan, its impact on the environment, and then try to discern how materiality has affected the genesis of this institution.
- One can start with the governance system as a whole and identify key material dependencies. The analysis can then be deepened by asking which of those dependencies are recognized within the system, and the effects of recognition of some and non-recognition of others.
- In interdisciplinary fashion, one can take the social-ecological system as a starting point, consider problematic aspects of the social affecting the ecological, and then reconstruct the dependency of the social on the ecological, and the dependencies in governance rendering adaptation seemingly difficult.

First- and second-order mapping

Mapping is observation and we can also typify observation by means of a distinction between first and second orders (Fuchs, 2001). Mapping as first-order observation can elucidate materiality in the ongoing evolution of a governance system *within the distinctions used by the governance system observed*. In other words: how is the system reconstructing the effect of its environment on its own evolution? One can observe the governance system explaining to itself how materiality is affecting the rise and fall of certain institutions, the emergence of new actors in governance or the altering of relations between actors. Mapping as second-order observation, renders the conditions under which discourses relate to their (material) environment more transparent. It enables a mapping of system and environment and the way the system observes its environment. It enables comparison between responses by different systems to 'the same' environment and between historical trajectories of coevolution's between materiality and discourse (Demuth, 2019). It can map out the differences between what is observed and what remains overlooked by a particular social system – through comparing first and second-order observation.

Mapping material dependencies as second-order observation takes time. Reconstructing how an environment affected a system, including its observation and management of that environment, can focus on historical analysis of social-material relations (cf. Richardson & Weszkalnys, 2014), on spatial analysis of relations in social-ecological systems (Massey, 2005; Olsson et al., 2006), or it can primarily draw on layering and diversification of discursive contexts: more, different, broader perspectives, which can render transparent the naturalizations of the governance system (cf. already Barthes, 1957).

Not all the effects of materiality on governance are observable, neither by first- or second-order observation. Materiality can affect decision-making processes whilst completely escaping observation in a community, its governance system, or its academic apparatus (Magris, 2016). Any mapping thereof is therefore an impossibility. Anticipation of these unknown unknowns might remain possible. Speculation, creativity and fiction, even conspiracy, could be ways to sensitize and prepare ourselves for what escapes observation (cf. Bryant & Knight, 2019; Dunne & Raby, 2013; Hunt, 2019; Mills, 2019; Morrison, 2018). Claudio Magris, grappling with the impact of the Danube and the spaces it created on the cultural and political life of the Danubian Monarchy, resorted to a hybrid form, essay and fiction, collage rather than sustained reasoning. It may be well to recall in this context that Chester Barnard, a business leader and scholar of the first half of the twentieth century, believed that managing a corporation relies heavily on 'non-logical thought processes', comprising intuition, hunches, and gut feelings. A manager, Barnard tells us, is someone who must have a mystical sense of the whole allowing her to judge business opportunities, discriminate strategic factors, and reconcile the irreconcilable (cf. Barnard, 1968). Modern organization theorists associate these extraordinary human capacities with the non-cognitivist view of organizational learning which is informed by human close-quarter encounters with the surrounding material world (Nayak et al., 2020).

Conclusion

Material dependencies can now be identified as hidden underpinnings of sustainability transitions. We did not focus, deliberately, on existing conceptualizations of sustainability transitions. Not as a form of critique, but to draw the attention to the underlying and understudied issue of the relation between governance and the material world. Our analysis of the various effects of materiality on governance, including the governance of the environment, is an argument for making explicit the often- hidden material constraints for change and the potential of materiality for bringing about change.

Governance systems function in particular physical environments. This environment can affect attempts to coordinate action to preserve or transform it in many different ways. We need to go beyond understandings in which materiality is objectified and essentialized, beyond perspectives that only focus on the way humans impact their environment. Neither is it sufficient to only focus on processes of observation, interpretation and meaning making. It is important to explore how those social processes are in many ways influenced by their material environment. The concepts of material events and material dependencies help to grasp those linkages between the social and the material and the way they influence processes of governance. We spoke of thinking, organizing, and materiality as co-evolving in governance. The dependencies which develop in a governance path can render adaptation to ecological change tougher, yet grasping material and other dependencies can also offer opportunities for change, by clarifying system relations, assets and leverage points.

A mapping of material dependencies in environmental governance can render visible material factors, in past and present, which are often not accounted for, and which shape the responses to environmental change and the possibilities to work towards sustainability transitions. Many sustainability or transition recipes do not work as anticipated, and it is becoming clearer that the challenges are not only institutional or cultural, but also material or physical. Investments in certain techniques and the infrastructures that accompany them make a shift towards alternative ones difficult, as for example seen in energy sector (Dominković et al., 2018) or the automobility domain (Urry, 2004). Materiality, both natural circumstances as well as human-made infrastructures can in many ways form obstacles for sustainability transformations, often in conjunction with dominant discourses, power-relations and important institutions.

The analysis of environmental governance in terms of material dependencies and their interrelation with the other dependencies can shed a new light on the rigidity in governance evolution, on the pattern of influences that keep a system in place, limiting its observation and its capacity to coordinate action and manage its environment. It adds to the existing literature by identifying and emphasizing the various ways in which material effects are observed or overlooked and how that is reflected in governance. Sustainability transitions represent a pinnacle of steering ambition through governance, a tour de force of policy coordination and integration which at the same time needs to be utterly sensitive and adaptive to changes in the environment. More

attention to rigidities in governance, and to the triadic influences between organizing, knowing and materiality, helps to clarify opportunities and limits to steering and policy coordination, and to grasp the inevitable trade-offs when organizing policy integration around transition (and not something else) and sustainability in a particular understanding (and not another one).

It is clear from the abundant literatures on sustainability, resilience and transition that adaptation and reflexivity are essential preconditions for any form of sustainability transition. Our contextual analysis of material dependencies, can enhance reflexivity and reveal unexpected flexibilities. While the current ecological and climate crises can accurately be understood as a revenge of the Real, a revelation of unobserved material effects and dependencies, a turn towards sustainability and transition as new hegemonic concepts can hide as much as it reveals. In order to do it right, the effects of hegemonic concepts in governance, including their potential undermining of checks and balances, of discursive and institutional diversity, their neo- positivist bent, can not only obscure why people organize themselves, shape and are shaped by their environment in particular ways, but also do real damage, as the new unity in governance under the new flags is of the order of the Imaginary (Gunder & Hillier, 2016; Hook, 2017). Taming the Real has to rely more on the careful reconstruction of material events and dependencies through second order observation.

Communities have to maintain themselves in an environment, an environment they partially made themselves. Mapping material dependencies can increase the awareness of relations with that environment, awareness moreover of flexibility and rigidity in altering those relations. What these relations should be, is a matter of deliberation for the communities themselves.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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