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Towards a multi-scalar perspective on transition trajectories

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ABSTRACT

This paper contributes to the geography of transitions literature by conceptualizing transition trajectories from a multi-scalar perspective. It combines an institutional perspective of transitions with conceptions of scale from human geography to derive a framework which explicates how (de-)institutionalization and re-scaling mechanisms condition different transition trajectories. Our conceptual elaborations show that the traditional local-global niche cumulation and upscaling trajectory can be complemented with two alternative trajectories that build on analytically different sequences of institutionalization and re-scaling processes. This is illustrated through a case study of technology standardization in the sanitation sector, more specifically the development of the ISO 30500 standard for non-sewered sanitation systems, which was initiated by a consortium led by the Bill and Melinda Gates Foundation. The observed transition trajectory departs from key assumptions of the local-global niche model, with actors engaging in direct institutionalization at the global level, followed by re-scaling global rationalities into different (sub-)national contexts.

1. Introduction

A fundamental claim in transition studies is that socio-technical systems are rigid and inert, promoting incremental innovation rather than radically new technological solutions (Geels, 2002; Markard and Truffer, 2008). Such stability is typically attributed to the presence of socio-technical regimes, made up by highly institutionalised formal and informal rules that have co-evolved with technologies over extended periods of time and stabilized into a locked-in development trajectory that is hard to fundamentally transform (Kemp et al., 1998; Markard and Truffer, 2008; Smith et al., 2010). Traditionally, the boundaries for analysing socio-technical transitions have been set at national, regional or even urban spatial scales, based on the (often implicit) argument that the relevant alignment of technical and social elements and relevant policy interventions happen at the level of nation states, regions and/or cities. As a consequence, also the empirical focus of transition studies has largely been regime transformations in pre-set spatial containers (i.e. the 'German energy transition', the 'hygienic transition in the Netherlands' or the 'transition to water-sensitive urban design in Melbourne') (Geels, 2006; Ferguson et al., 2013; Strunz, 2014).

This 'containerized' view on the spaces and scales at which transitions play out has increasingly attracted critiques from geographers (Binz et al., 2020; Coenen et al., 2012; Murphy, 2015). At a most generic level, authors have argued that both regimes and niches are multi-scalar structures that may be conditioned by dynamics in various places and at different levels of governance at once (Binz et al., 2016b; Fuenfschilling and Binz, 2018; Sengers and Raven, 2015). A first critical contribution to the literature was thus the

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development of a geographically more nuanced understanding of the 'local-global niche model' (Sengers and Raven, 2015). A second stream of theorizing has conceptualized socio-technical regimes as global constructs, referring to the semi-coherent guiding institutional rationalities in a sector that often get legitimised beyond single territorial contexts (Fuenfschilling and Binz, 2018). In this view, regimes tend to develop global actor networks and institutional rationalities that are codified into international rules, standards and best practices of a sector, which become influential beyond their immediate context of origin.

These specifications were an important first step in improving our understanding of how multi-scalar niche-regime interactions may influence where radical change happens and under which structural preconditions actors may be able to engage in strong agency that re-shapes regimes not only in (sub-)national contexts, but also in globalized sector structures (Fuenfschilling and Binz, 2018; Duygan et al., 2019; Bauer and Fuenfschilling, 2019). Yet, several important gaps also remain in this line of thinking, two of which will be the focus of this paper.

First, there is a need to develop a truly multi-scalar view on niche-regime interaction, which is inspired by the literature on scale in human geography. Current scholarly work still distinguishes quite coarsely between 'global' regime and niche structures and various 'national' or 'local' variants thereof. Yet, in reality, the spatial scales at which relevant social structures and dynamics play out may be more complex and subject to considerable temporal dynamics and strategic agency (Coenen et al., 2012; Lawhon and Murphy, 2012; Sengers and Raven, 2015). At which scales relevant transition dynamics play out is furthermore likely to fundamentally differ between sectors and points in time (Bauer and Fuenfschilling, 2019). For example, the water sector today may have a very strong and influential global regime structure, while the transport sector may splinter into a patchwork of internally coherent national (service) regime configurations with limited supra-national coordination (Fuenfschilling and Truffer, 2014; Truffer et al., 2017; Van Welie et al., 2018). Identifying the relevant scales at which regimes get institutionalized and challenged thus necessitates a conceptual and methodological approach that follows actors, networks and socio-spatial processes to wherever they may lead instead of setting scalar boundaries a priori (Coenen et al., 2012). It also requires one to look into strategic agency by niche and regime proponents translating problems and solutions between spatial scales in attempts to support or hinder transition processes (Coenen et al., 2012; Murphy, 2015).

Second, the translation mechanisms between various scales at which regime structures exist, have not yet been conceptualized in any detail. We here refer to the translation of institutional rationalities between various scales in the socio-technical system as 're-scaling'. If one assumes that global regimes are based on semi-coherent institutional rationalities that are continuously challenged and reproduced at various spatial scales, it becomes crucial to understand how institutional field logics, technical best practices or core values are taken from their immediate local, regional, national or trans- local/national, contexts and re-scaled into global regime structures, and by whom. In most sectors, the global regime will not equally represent all competing socio-technical configurations and rationalities that exist in a field, but rather constitute a subset of technical and social elements that got institutionalized at this level by specific actors that are in a structurally superior position to re-scale local ideas into global rationalities. At the same time, one also needs to better understand how rationalities that have taken a dominant position in global sector structures are then re-scaled back into various (sub-)national levels and influencing change in contexts with highly diverse structural preconditions.

This paper aims at further developing this multi-scalar perspective on transition trajectories, by developing a novel conceptual framework and applying it to a case study in the sanitation sector. It traces the global standardization process of a transformative innovation in sanitation, namely creating stand-alone toilets that do not rely on any external water supply and sewer systems. While the basic idea of modular, on-site, small-scale sanitation and water reuse systems has existed in the sector for a long time (Binz et al., 2014; Hoffmann et al., 2020), its application remained relegated to experimental niche projects in a few spatially delimited contexts (examples can be found in Australia, Africa, India, China and the US). Only more recently did a consortium of actors led by the Bill and Melinda Gates Foundation (BMGF) aspire to institutionalize the idea at the international level by codifying the main tenets of the 'future toilet' into a global ISO standard (ISO 30500). We argue that this constitutes an emblematic case of a multi-scalar transition process in which a problem and solution was re-scaled and institutionalized at the global (proto-)regime level. The manifold contestations between several competing niche logics and regime incumbents in this process provide a unique illustration of the many ways in which the re-scaling of rationalities between layers in the socio-technical system may shift their initial meanings and influence transition trajectories in largely unpredictable ways.

Our argument will be elaborated as follows. We will first review the literatures on global socio-technical regimes and scale in human geography to derive an analytical framework that conceptualizes transitions as the (de-)institutionalization and re-scaling of rationalities in multi-scalar socio-technical systems. We will then illustrate the analytical purchase of this framework with an in-depth qualitative case study of the ISO 30500 standardization process and the ways in which re-scaling mechanisms enabled the institutionalization of an emergent socio-technical configuration in the global regime of the sanitation sector with far reaching consequences to transition trajectories in various parts of the world. The concluding section will discuss our contribution to the literature and outline the contours of a research agenda that puts multi-scalarity centre stage in the analysis of transition trajectories.

2. Conceptual framework

In building our conceptual framework, we will depart from the literature on global socio-technical regimes, connect it to conceptions of scale from human geography and ultimately apply a combined view to technology standardization processes as a key arena for scalar agency and institutionalization processes.

2.1. Global socio-technical regimes

Socio-technical regimes can be conceptualised as the semi-coherent, yet dominant institutional rationality of a socio-technical

system (Fuenfschilling and Truffer, 2014; Thornton et al., 2012). They produce stability through lock-in, isomorphism, mimetic pressures, legal and moral sanctions, etc. Regimes are semi-coherent, since they tie a diverse set of actors and their networks, institutions and material artefacts (infrastructure, technologies, etc.) into a socio-technical configuration 'that works', which in most fields is contested by one or several competing visions of how the very same sector may work (Kemp et al., 1998). For example, in the Australian water sector, three competing field logics (hydraulic, water market, water sensitive) were identified, each of which is a unique bundle of institutional sector logics, key values, technologies, actors, funding mechanisms, etc. (Fuenfschilling and Truffer, 2014). These competing field logics differ in their degree of institutionalization. The hydraulic rationality being the most deeply institutionalized, taken-for-granted, structure in most places, while water market and sensitive field logics are more loosely institutionalized alternatives that compete for dominance by trying to de-institutionalize certain elements of the incumbent regime and institutionalizing new core values or technologies (Fuenfschilling and Truffer, 2014; Fuenfschilling and Truffer, 2016; Heiberg et al., 2020b).

The socio-technical system of a given organizational field is thus not a monolithic, deterministic structure, but rather a patchwork of competing institutional field logics, which differ in the relevant actor networks, types of technologies, values and organizational forms, and which may show considerable spatial variation in their degree of institutionalization. For example, the socio-technical system in the sanitation sector is structured differently in Switzerland and India. In Switzerland, one deeply institutionalized regime structure (based on large-scale centralized infrastructure and a hybrid hydraulic/water-market field logic) exists that almost completely outrules any form of radical change (Eggimann et al., 2015; Lieberherr, 2012). In India, in contrast, two competing field logics (centralized infrastructure, based on a hydraulic logic and on-site infrastructure with a water sensitive logic) largely coexist in a poly-centric regime structure (Van Welie et al., 2018), with each serving different strata of society (Heiberg et al., 2020a). Some even argue that one can distinguish between variants of regime structures at sub-national scales and in the cultural fabric of cities (Fratini and Jensen, 2017; Jensen et al., 2016). At the same time, the observable variation in regime structures is arguably not endless, but revolves around a surprisingly narrow set of technologies and institutional structures globally (Fuenfschilling and Binz, 2018). In the water sector, one can observe many variants of the same basic principles, i.e. most countries implement their own characteristic mix of hydraulic, market and water-sensitive rationalities, but radical departures from these basic organizing principles are hardly visible.

Apart from exploring the variation of regimes in different cultural and economic contexts, one thus also needs to explain why the relevant field logics look similar in various parts of the world. Here it is important to note that socio-technical regimes may feature relevant structures at international and potentially global scales, referring to standards, core values and professional arrangements that get legitimized in a sector beyond single territorial contexts. Global regimes were accordingly defined as "the dominant institutional rationality in a socio-technical system, which depicts a structural pattern between actors, institutions and technologies that has reached validity beyond specific territorial contexts, and which is diffused through internationalized networks." (Fuenfschilling and Binz, 2018: 739). Global regimes thus closely relate to actor networks, value chains and organizational arrangements that are standardized at an international sector level. That is, if an organizational field has matured, it is likely to have developed a distinct professional culture, codes of conduct, technology standards and so on, as well as large and dominant key actors that take up a central position in the relevant networks and value chains in various places around the world.

The institutional rationalities that have become dominant in this global regime structure are likely to be institutionalised and anchored in various places around the world through local routines, practices, technologies and standards (Fuenfschilling and Binz, 2018). Global regimes will be strongest in socio-technical systems whose dominant rationality has been translated into international standards and norms and where powerful actors exist that may translate it back into a variety of spatial contexts.

2.2. *Multi-scalar interactions in socio-technical systems*

Recent research in the transitions field has laid important groundwork for the multi-scalar perspective envisioned in this paper. Initially, research on socio-technical transitions tended to distinguish between 'regimes' and 'niches' as analytical categories with, implicit or explicit, geographical characteristics. These range from largely a-spatial conceptions of niches and regimes in early work, to the more recent development of a research agenda concerned with the geography of sustainability transitions (Hansen and Coenen, 2015; Raven et al., 2012; Truffer et al., 2015). This literature is increasingly rejecting the idea that niches are by definition local, geographically confined spaces, and promoting a conceptualisation of niches as consisting of multi-scalar actor networks and discourses unfolding at several places at the same time (Binz et al., 2016a; Raven et al., 2012; Sengers and Raven, 2015). As discussed above, also socio-technical regimes are increasingly understood as a multi-scalar arrangements of institutional field logics, which are institutionalised and anchored to different degrees across space (Fuenfschilling and Binz, 2018).

To further develop this conceptualization, more explicit reference to human geography is needed (Binz et al., 2020; Murphy, 2015), since the concept of 'scale' lies at the core of contemporary theorizing in this discipline. The 1990s and early 2000s experienced a vivid academic discussion on the social construction of scale and contested scalar transformations (Swyngedouw, 2004). This debate largely rejected the perception of spatial scales, such as 'the region' or 'the nation', as taken-for-granted 'containers' of social and economic activities, and argued for the perpetual redefinition, contestation and restructuring of spatial scales in terms of their extent, content, relative importance, and nested or hierarchical properties (Swyngedouw, 1997: 141). Scalar configurations should hence be seen as the outcome of socio-spatial processes that regulate and organise socio-economic activities (Swyngedouw, 2004; Brenner, 1998; Smith, 1993). A core argument is that it is "often not scale per se that is the prime object of contestation between social actors, but rather specific processes and institutionalized practices that are themselves differentially scaled" (MacKinnon, 2010: 23). This means that attention should be given to the processes through which the relevant scale is determined: the nature of the networked ordering of the economy (being simultaneously globalised and regionalised), and the nested relationships between institutional arrangements in

territorially organised economic arenas (such as regions or nations) (Swyngedouw, 2004).

For transition studies, this implies that 'scalar configurations' and their dynamic evolution must be approached as an analytical dimension of the socio-technical system, as it is not possible to take for granted that the boundaries of relevant spatial scales are identical across different systems, and across different points in time. To this end, it has been argued that both regimes and niches depend on multi-scalar actor networks. While niches are often characterised by emergent, loosely structured actor networks in disperse spatial configurations, the actor-structure of a regime typically reflects global production networks in mature sectors with a clearly structured value chain and resourceful lead actors that coordinate activities globally (Fuenfschilling and Binz, 2018). However, rather than using the regime-niche dichotomy as point of departure, we bring forward a conception of spatial scales in socio-technical systems defined as the structure of actor-networks in combination with the territorial anchoring of the institutional arrangements underpinning regime (and niche) rationalities in the system. Together, these actor-networks and associated institutions form 'layers' in the socio-technical system with different spatial properties. This specification helps to solve the conceptual tension between (potentially global) regime structures and their concrete manifestation and variation in (sub-)national territorial contexts.

In other words, we contend that there is an international sector-level structure (a global regime) with its own set of dominant actors, standards, norms, and routines, that evolves in an analytically somewhat distinct trajectory from the plethora of (sub-)national, territorially and socio-politically embedded spatial subsystems. Key mechanisms in global layers will revolve around creating a professional culture, scripts, standards and planning paradigms that guide the sector as a whole and define the most legitimate courses of action, actor types, etc. In layers with territorially embedded institutional arrangements and actor-networks, the relevant mechanisms will in turn revolve more centrally around finding solutions for local needs and debating the priorities of technology implementation in territorially embedded policy battles (Heiberg et al., 2020a).

Various translation processes will then constantly mediate between these global (sector) and territorially embedded (national, regional, urban, etc.) layers in the socio-technical system (depicted in Fig. 1). Global rationalities will have to be contextualized and specified to fit with prevailing context conditions, in order to be relevant for actors in territorially embedded layers of the socio-technical system. A sector will institutionalize a guiding rationality internationally, for example, through international events, prizes, 'early career' networks, etc. In the case of the water sector, also technology and quality standardization, financial intermediation, urban planning or consulting are key arenas in which actors translate institutional scripts and ideas between territorial subsystems and the global sector structure. In many cases, global standards, professional norms and guidelines will be based on a narrow selection of 'best practices' from some places, which have been de-contextualized and institutionalized at a global level by powerful and well connected actors. Understanding transitions (i.e. deep, structural transformations of sectors) thus by definition requires a structured view on the dynamics in both territorially embedded subsystems and global regimes. In this perspective, a transition in one isolated territorial subsystem does not automatically imply that the related sector has been structurally transformed. This would only apply if the structurally transformed socio-technical configuration of the respective territorial subsystem would be translated into global regime structures.

This means that socio-technical transition dynamics are not only limited to processes of (de-)institutionalization, but also subject to a set of mechanisms that relates to the re-scaling of processes and institutionalized practices. Both socio-technical regimes and niches develop, diffuse and are reinforced through interactions between social agency and layers of scaled institutional rationalities in particular spatial configurations. The reconfiguration of these set-ups may be an important transition mechanism which has been overlooked in previous studies.

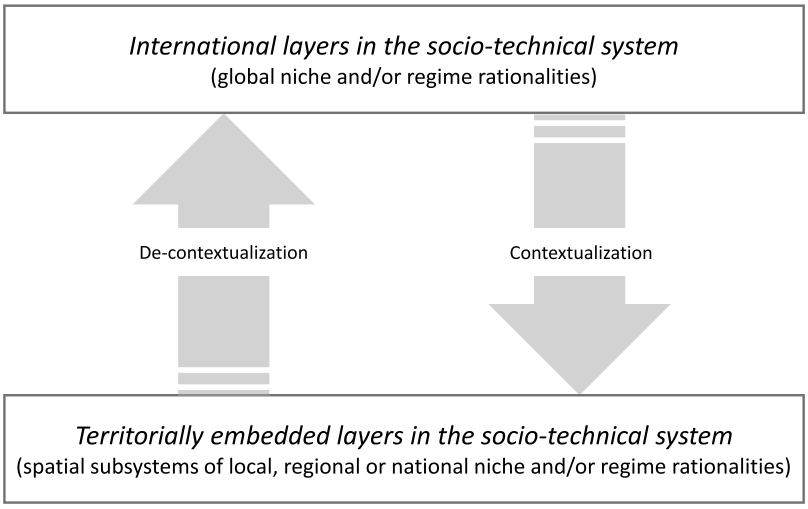

Fig. 1. Conceptual distinction between global and territorially embedded layers in a socio-technical system. Source: Own elaboration, based on an initial draft by Andri Brugger.

2.3. Transition mechanisms: (de-)institutionalization and re-scaling of rationalities

Based on the above considerations, we can now elaborate on the importance of two interrelated transition mechanisms. First, processes of (de-)institutionalization are crucial in order to formulate and mobilize support for the codification of a certain socio-technical configuration and its underlying institutional rationalities into formal rules, material structures, and practices. The higher the degree of institutionalization, the more a regime configuration will be perceived as unparalleled, and hence the more work will be needed for institutionalizing alternative rationalities that challenge prevailing regime logics in a transition process. In this perspective, transitions are essentially processes of institutional change, where elements of regimes are gradually de-institutionalized and replaced with increasingly institutionalized alternative configurations (Fuenfschilling and Truffer, 2016; Fuenfschilling, 2019).

However, in order to understand how socio-technical transitions unfold, it is also crucial to understand processes through which the scaling of relevant practices and activities is altered, and how technologies, practices, norms and values prevailing in one layer in the socio-technical system are translated in to the regulatory, normative and cultural-cognitive structure of other layers and eventually alter the global socio-technical regime (Bauer and Fuenfschilling, 2019). Actors may deploy strategies across different scales in order to realise their interest and re-align activities, for example from 'the local' to 'the national' or 'the global', and systematically challenge fixed assumptions of what kind of activities fit properly at respective scales (Smith, 2004; Brenner, 2004). This has the potential of resulting in relative changes in power dynamics between actors in different layers of the socio-technical system. While niche actors are sometimes expected to try to diffuse their alternative solutions across countries and regions, activities targeting the global level, such as developing international technology standards, formulating global agreements or treaties, or influencing professional training curricula, are often beyond their reach. For example, transition studies have highlighted that while different local actor networks managed to standardise charging plugs for electric vehicles locally (successful institutionalization), the failure to translate these institutionalization processes to the global level became a strong hindrance for niche aggregation and subsequent transitions in the

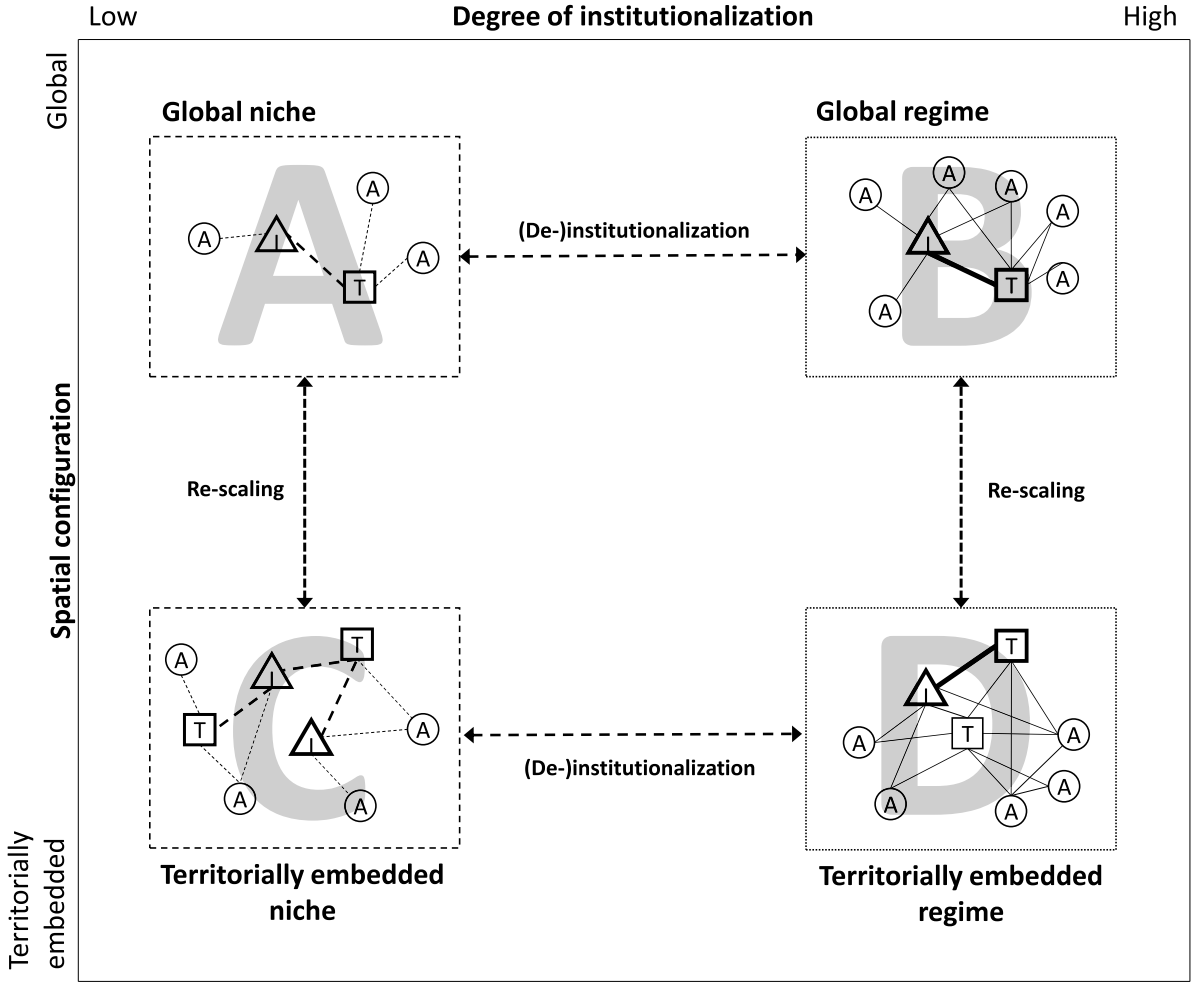

Fig. 2. Conceptual framework (own elaboration).
I – Institutions, A – Actors, T – Technologies. Bold, solid lines indicate a deeply institutionalized configuration of institutions and technologies, dotted lines represent a more emergent, less institutionalized alternative socio-technical configuration. Source: Own design.

transportation sector (Bakker et al., 2015). We therefore introduce re-scaling as a second key mechanism in our framework, referring to how actors alter the scaling of specific processes and institutionalized practices, often by translating rationalities between different layers in the socio-technical system.

As we will outline in our empirical case, the transformative potential and importance of such re-scaling efforts may be substantial. In sectors with global regime structures, it is therefore adamant to explore re-scaling mechanisms in tandem with (de-)institutionalization mechanisms, focusing on how institutional rationalities shaping the socio-technical system are re-scaled so that the scope and scale of their influence is altered. The process of re-scaling is then not a direct, linear transposition of certain rationalities between two scales, but rather an active construction process in which certain parts of a rationality will have to be altered, translated and/or combined with new logics in order to fit the relevant audiences at another scale.

The conceptual framework is summarized in Fig. 2. We focus here on two dimensions, namely the degree of institutionalization (the x-axis) of rationalities, and the spatial configuration (the y-axis) of associated actor-networks. For conceptual clarity, we here somewhat simplistically distinguish between 'territorially embedded' and 'global' layers in the socio-technical system, but the framework can (and should) be used for more fine-grained analyses of differently scaled rationalities, for example by further specifying urban, regional, national, or any other relevant layers, respectively. The two transition mechanisms are denoted by vertical and horizontal arrows in our framework; the institutionalization of rationalities implies a move from the left to the right, and re-scaling from territorially embedded to global layers is represented by a move from the bottom to the top.

Quadrants C and D accordingly represent the territorially embedded layers in the socio-technical system that have been analysed expansively in transitions literature. I.e. quadrant D depicts an institutional rationality and related actor network that are deeply institutionalized in a given country / region / city, etc. (i.e. a 'local regime'). Quadrant C represents an alternative, less deeply institutionalized rationality that is supported by a more emergent actor network that is advocating for a transition in the same, territorially defined subsystem (a 'local niche').

Quadrants A and B, in turn, depict the layers of relevant rationalities and actor networks in the internationalized sector structures discussed above. A global regime (quadrant B) can be thought of as the guiding rationality in a given sector that is supported by the lead actors in global production networks and codified into standards and norms that are permanently re-enacted in international arenas. Quadrant A could in turn be thought of as an alternative rationality, which challenges some key tenets of the global regime and which is supported by a set of (often intermediary) actors that operate at an international scale and aim at institutionalizing alternative ways of doing things in the sector. This layer relates to the 'global niche' level as outlined by Geels and Raven (2006) in the sense that it comprises actors and networks of an emergent field forming around technologies and guiding rationalities that diverge from the incumbent regime. At the same time, we diverge from their conceptualization by focusing exclusively on the actors that are embedded in and working on global expert discourses rather than concrete local implementation projects. An illustrative example could be the network of international NGOs that try to institutionalize fair trade practices in the global agro-food or apparel businesses.

2.4. Outlining three ideal-type, multi-scalar transition trajectories

To date, most work in transition studies has covered the processes that take place in 'local transition trajectories', i.e. contestation between territorially embedded (mainly national) regimes and niches (niche-regime interplay between C and D in Fig. 2), assuming that changes to (sub-)national regimes will eventually (and somewhat automatically) cumulate and scale up to change in the global regime (C→D→B) (Geels, 2002; Geels and Raven, 2006). This argument is built around the idea that place-specific actor networks

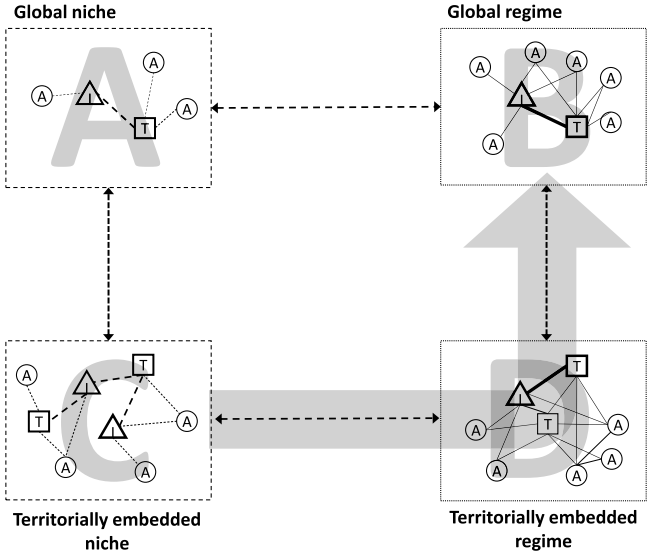

Fig. 3a. Niche cumulation and upscaling (own elaboration). Source: Own design.

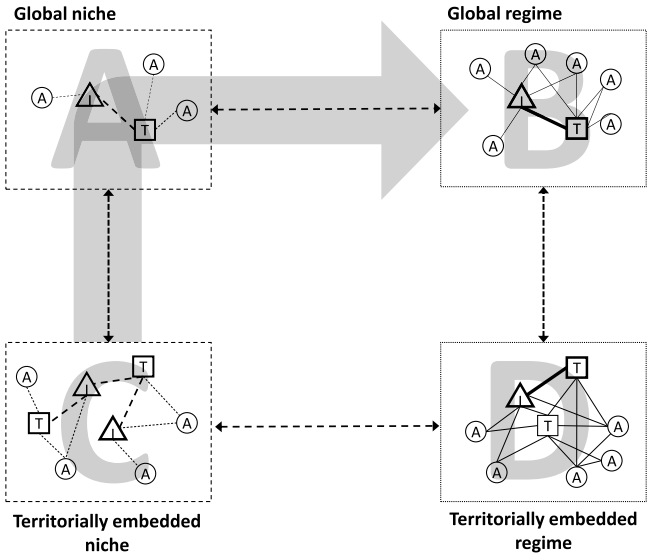

Fig. 3b. Multi-locational diffusion (own elaboration). Source: Own design.

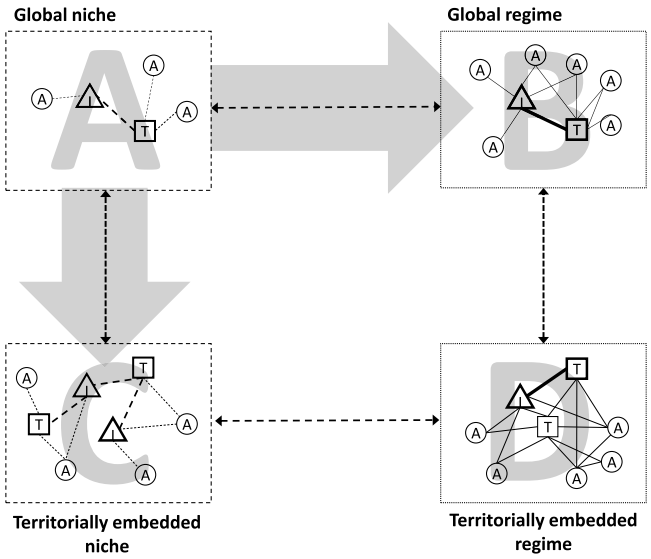

Fig. 3c. Global advocacy (own elaboration). Source: Own design.

generate practical knowledge and generic lessons that are increasingly aggregated into the shared rules of an emerging field and subsequently institutionalized into regime structures at higher spatial scales (Geels and Raven, 2006; Sengers and Raven, 2015). The emblematic example for this 'niche cumulation and upscaling' model is the energy transition, which initially evolved differently in various national subsystems (i.e. the energy transition in Germany, the UK, USA, China, etc.), but was eventually increasingly institutionalized at a global scale through international treaties (the Kyoto protocol, Paris agreement) and organizations (IPCC, IRENA, etc.) (Geels et al., 2016; Markard, 2018; Newell, 2019).

This model of niche cumulation and upscaling (Fig. 3a) has increasingly been criticized for giving ontological priority to local and national levels (Smith et al., 2010; Binz et al., 2020; Coenen et al., 2012). Based on our analytical framework, one can argue that structural change in a sector can also take place in at least two other, analytically distinct transition trajectories.

First, a trajectory might materialize in which an alternative socio-technical configuration is developed in one or several 'local niche' contexts, but then directly re-scaled to a 'global niche' level (re-scaling C→A), without a prior transformation of local regime structures or extended aggregation and/or cumulation activities. Global niche actors may then start challenging the global regime rationality (institutionalization A→B) without a full transition having materialized in any national regime context (Fig. 3b). An emblematic example of such 'multi-locational diffusion' trajectories was coined by Sengers and Raven (2015) and their reconstruction of the global mushrooming of bus rapid transfer (BRT) systems. In this case, pioneering actors in South American cities (Curitiba and Bogota)

successfully created a new socio-technical configuration that worked, which was then diffused very quickly into other parts of the world, leading to the institutionalization of BRT as a legitimate solution in urban transport. In a first phase, technology experts, consultants, NGOs, investment banks and high-profile individuals like the mayors of Curitiba and Bogota successfully re-scaled problem definitions as well as success stories from a local to a global niche level. In a second step, these actors mobilized 'best practices' from pioneering cities to diffuse BRT systems around the world. As a result of the global mushrooming of this new socio-technical configuration, taken-for-granted structures in the global regime of the urban transport sector could increasingly be challenged (Sengers and Raven, 2015).

In addition, a third transition trajectory is conceivable, in which the basic features of a new socio-technical configuration are constructed in the international expert networks of a global niche and then re-scaled downwards into local niche contexts (re-scaling A→C) and in parallel institutionalized in global regime structures (institutionalization A→B) (Fig. 3c). This 'global advocacy' trajectory has been relatively neglected in transitions literature so far, but still appears highly relevant. An example for this trajectory is the global diffusion of a smart city rationale (Carvalho, 2015; Hayat, 2016). The concept of smart cities was initially framed and pushed by a global actor (IBM) with a commercial interest in diffusing and institutionalizing this particular socio-technical configuration (Söderström et al., 2014). The frame subsequently got quickly taken up in various urban planning documents and infrastructure interventions as well as in global regime discourses, even though no 'smart city' had ever existed (and still does not).

Whilst these are ideal types, both alternatives to the niche cumulation and upscaling trajectory point to the complementary role played by institutionalization and re-scaling mechanisms. The empirical case study will illustrate the mechanisms underpinning these alternative multi-scalar transition trajectories, and in particular the 'global advocacy' trajectory.

2.5. Standardization as a lens for assessing institutionalization and re-scaling processes

A key contribution by our framework is to highlight that international sector structures may provide important arenas in which actors can voice their criticism of the existing regime structures and frame diverging socio-technical alternatives. In the water sector, such arenas are constituted by international expert conferences and trade fairs; the actions by multinational companies or international NGOs; by infrastructure programs of large donors, engineering consultants or investment banks; or by actors and events that define global paradigms in urban planning. While this list is certainly not exhaustive, we here decided to focus on 'technology standardization' as an arena that can perfectly illustrate both institutionalization and re-scaling processes.

The degree of institutionalization within a global regime structure strongly correlates with the existence of international standards reflecting, and thus reinforcing, a certain set of institutional rationalities in various places (Fuenfschilling and Truffer, 2014). A standard is an 'instrument of control' (Brunsson and Jacobsson, 2010) that facilitates coordination, joint expectations and sanctions (Slager et al., 2012). In a review of the effect of standardization on innovation, Blind (2016) highlighted that technology standardization can have a positive effect on research and innovation, in particular in some fields of science and technology, and when the standardization process is characterised as open and transparent. Furthermore, his review showed that technology-neutral and performance-based standards increase the likelihood of a positive impact on innovation.

In many cases, standards may incur only normative pressures to the actors in a field, but in the water sector, many public health, technology and management standards exist, that have legal or semi-legal status and thus confer directly to legal sanctions in the case of non-compliance (Schellenberg et al., 2020). In addition, standards tend to follow a nested, hierarchical scalar structure, in which generic international standards, for example the ones codified and sanctioned by the World Health Organization (WHO), International Organization for Standardization (ISO), or the Comité Européen de Normalisation (CEN) build the backbone of more specific national standards. In many cases, national standardization bodies have to ensure compliance with standards set at higher spatial scales before a new and/or adapted national standard is published (Delmas, 2002).

International standards are often developed through consensus-based multi-stakeholder processes that mobilize global expertise through consultancies and participation in technical committees (ISO, 2019). International standards thus not only reflect technological best practices in a field, but also represent and reproduce the prevailing dominant field logic in the global regime. Global (ISO) standards denote an emblematic global regime structure, i.e. a set of normative rules that is institutionalized beyond any territorial context. At the same time, standardization is one of the ways through which interested actors can exert pressures on the (global) regime (Fuenfschilling and Binz, 2018). Standardization can thus be considered a key process both in terms of underpinning the existing global regime, and in terms of constructing, diffusing and institutionalising 'new' (proto-) regime rationalities through niche actors' participation in standardization processes. Yet, with a few exceptions (Manning and Reinecke, 2016; Kivimaa et al., 2019), the role of standardization in socio-technical transitions has not been given focused attention in transitions literature.

3. Case selection and methods

Our empirical case selection is based on the practice of 'theoretical sampling' (Siggelkow, 2007) and is aimed at identifying a case which can shed light on issues of theoretical interest (Yin, 2013). The sanitation sector represents an emblematic 'critical' case (Flyvbjerg, 2006) which is representative for the category of events outlined in our conceptual framework. In other words, it is suitable for illustrating and testing our conceptual framework, since this sector features both a very strong global regime structure, as well as some spatial variation in its local niche- and regime configurations, thus inherently asking for a multi-scalar approach when analysing transitions.

At a global level, the sector is dominated by large multinational companies and a highly institutionalized 'hydraulic' field logic, which promote conventional large-scale sewage networks, centralized water treatment, and utility-based operation and maintenance.

This taken-for-granted configuration has historically been diffused into various parts of the world, and currently constitutes the 'gold standard' for urban sanitation with key decision makers in highly diverse contexts (Fuenfschilling and Binz, 2018; Sedlak, 2014; Nilsson, 2016). At the same time, climate change, rapid urbanization and the UN's sustainable development agenda make the shortcomings of this infrastructure paradigm increasingly visible. Today, approximately 2.5 billion people are estimated not to have access to safe and affordable sanitation globally (United Nations, 2018). In booming megacities, it furthermore remains very difficult to plan centralized systems in the right dimensions, thus leading to expensive over- and under-capacities that are hard to correct ex-post (Maurer, 2009).

Many experts thus argue that there is a need to develop radically different, more decentralized, adaptive, flexible and modular infrastructure solutions, which take local preconditions and not a global gold standard as point of departure (De Haan et al., 2015; Lieberherr and Fuenfschilling, 2016; Gambrill et al., 2020). Actors engaging with these alternative socio-technical configurations advocate not only for a new technological paradigm, but also for rationalities that follow 'sustainability', 'community-based' or 'water-sensitive' logics (Fuenfschilling and Truffer, 2014). Solutions comprise, for example, 'water sensitive urban design' in Australia, 'on-site non-potable water reuse' in the US (SFPUC, 2017), and various forms of 'small scale sanitation' in India and China (Binz et al., 2016b; Wong and Brown, 2009; Reymond et al., 2020).

For decades, a key barrier to a transition in the sanitation sector was associated with a lack of re-scaling these emergent water-sensitive configurations beyond local contexts. A persistent lack of standards for the diverse technologies developed in particular local 'niches' has made it very hard to transfer insights from one local initiative to another one or to re-scale certain solutions to a global niche and/or regime level. Despite recent efforts led by academics and the World Bank promoting the idea of 'inclusive city-wide sanitation' (Lüthi and Narayan, 2018; Gambrill et al., 2020), the global water sector is arguably still far from achieving broad structural change in the direction of these alternative socio-technical configurations.

In the remainder of this paper, we will focus on a recent initiative that diverged from the above situation by explicitly targeting global regime change through the development of an international standard for alternative, on-site sanitation solutions. More specifically, we trace the process which led up to the global ISO 30500 standard for non-sewered sanitation systems, and present our finding with regards to instances of institutionalization and re-scaling that proved instrumental in pushing for this structural change in the global regime.

The empirical case study is based on an extensive analysis of secondary data (newspaper articles, archived web pages, reports, policy documents and technical documents) in combination with 17 interviews with key actors involved in the standardization process. Due to the impact of the Covid-19 pandemic during year 2020, 14 out of the 17 interviews were conducted using video conferencing software. The interview partners represent the private sector, international NGOs, consultancies and research organizations, which are located in Africa, Asia, Europe and North America (see Appendix for an anonymised list of interviews). The identification of interview partners started with a mapping of relevant actors involved in the standardization process based on secondary data and was followed by a 'snowballing' sampling method (Valentine, 2005) through which additional interview partners were identified by triangulating referrals with findings from the analysis of secondary data. This process continued until it reached a point where 'data saturation' (Glaser, 2017) had been achieved, that is, a point where no additional information was conveyed by additional interviews.

Informed by the theoretical discussion, the interviews were semi-structured and designed to cover institutionalization and re-scaling processes in different stages of the standardization process. The interviews started with broad open questions and continued with detailed questions about specific phases in the standardization process: identifying the need for an international standard, preparing a first draft standard, the ISO standardization process, and implementation and outlook. All interviews were recorded and transcribed. Approximately half of the interviews were attended by both authors, the other half were conducted by the first author. The first author consequently coded both secondary and primary using a theory-driven approach in three steps (Boyatzis, 1998). First, thematic categories were derived from the conceptual discussion and we coded for actors and rationalities, as well as excerpts describing institutionalization and re-scaling processes. Second, the material was coded 'in vivo' by iterating between theory-led expectations and the empirical material, allowing for the identification of nuances and generic patterns in the data material. During the second step, three phases of development were outlined, the material was coded with scalar references (e.g. 'territorial' and 'global'), and contested issues and other relevant points were identified. Third, the outcome of the two prior steps were layered on top of each other in a data matrix that was used to identify areas where an in-depth exploration and triangulation of relevant data points provided the basis for the narratives, illustrations and descriptive summaries that are presented in the empirical results section. As such, the empirical analysis reduced potential "single source bias" (Nielsen et al., 2020) through data triangulation between different interview partners, and between interview data and secondary material (Denzin, 1970). Moreover, the consistency of the empirical analysis was cross-checked between the authors and contrasting interpretations were taken into account in the final presentation of results (Nielsen et al., 2020).

As a result of our single case study design, the direct generalizability of our results will be limited (Flyvbjerg, 2006). However, the empirical case study will serve as a first step towards an analytical generalization of our framework, by applying it to a particular set of re-scaling and institutionalization processes (related to technology standardization) in a particular sectorial and geographical context (the global sanitation sector). In order to expand the framework's explanatory potential, it could be applied to a broader range of (de-) institutionalization and re-scaling processes in other sectors.

4. Standardising non-sewered sanitation systems globally

The story behind the introduction of the ISO 30500 standard can be roughly structured into three consecutive, albeit partly overlapping, phases which will now be characterized in more detail.

4.1. Phase 1: Re-scaling the problem to a global level and introducing a diverging rationality

Our interviews and secondary information suggest that the key ignition point for this standardization process was the Bill and Melinda Gates Foundation (BMGF) deciding to move into the sanitation field and strategically supporting the idea of small-scale, non-sewered sanitation. One of the first initiatives in this context was the Reinvent the Toilet Challenge (RTTC), a project with the explicit goal of developing a toilet that operates "off the grid" without connections to water, sewer, or power outlets. The move of a prestigious and well-funded actor such as the BMGF into the on-site sanitation field re-scaled the inherent problems of conventional sanitation infrastructures and potentially superior non-sewered alternatives from a (sub-)national to a global level (Interview 5, 12, 13). With the launch of RTTC and strategic framing activities, the problem formulation was brought from the scale of informal settlements in low-income countries to be framed as a major global development issue to be tackled by multinational actors.

In the RTTC project, grants were awarded to 16 research organisations that were developing novel non-sewered sanitation technologies. The guidelines of the project stated that the reinvented toilet should remove germs from human waste, recover valuable resources (energy, clean water and nutrients) and cost less than 0.05 USD per user per day. It highlighted financial profitability, in terms of the services and business that operate in poor settings, and user experience, in terms of developing a toilet that "everyone will want to use – in developed as well as developing nations" (BMGF, 2011).

Interestingly, the BMGF approach to on-site sanitation did not start from the water-sensitive, community-based and low-tech solutions that had been promoted in many local niche contexts for decades. Instead, it emphasized a somewhat diverging market-oriented rationality, with core values being financial profitability, economic efficiency and consumer preferences (Interview 6). This is reflected not the least in statements by Bill Gates himself, emphasising that the role of the BMGF is to "lower barriers and risk for the private sector and for governments to adopt new solutions to solve big problems" (Bill Gates in a speech at the Toilet Expo in Beijing, November 2018). This implies that in this first instance of re-scaling between local and global layers in the socio-technical system, the guiding rationality around alternative sanitation solutions was transformed in non-trivial ways.

In essence, the RTTC diverged from both the hydraulic logic prevailing at the global regime level, as well as the water-sensitive logic advocated in local niches, and created a new hybrid logic, which emphasized sustainability, but in which toilets are comparable with other household appliances which are mass-produced and cheaply sold on global markets (Interview 6, 12, 15). Furthermore, the BMGF promoted a technology-optimistic agenda, pushing for a truly aspirational high-tech solution to the problem of urban sanitation which should not only represent a 'niche solution' but a transformative guiding principle for all non-sewered sanitation systems (Interview 6, 13). This hybrid rationality initially emerged in the context of the RTTC and will thus be referred to as "RTTC rationality" from here on.

Within the RTTC, it became quickly apparent that a key barrier for diffusion of on-site sanitation was the lack of commonly agreed specifications of on-site systems internationally. Interviewees with a broad variety of expertise all expressed that the variation in existing standards across countries proved highly challenging (Interview 2, 4, 5, 15, 17). The lack of standards also meant that there was a lack of expectations in terms of what the developed technologies should actually achieve:

> *"I pointed out the challenge linked with [the lack of] set requirements for successful testing [of novel on-site technologies]. In India, we were like, okay, we should follow this set of standards, but then, in China, there is another set of standards. In the US, there's a thousand standards."* (Interview 8)

In an effort to survey these challenges, BMGF commissioned research on the role of standards in on-site sanitation systems and identified problems with an abundance of assessment methods in the field, leading to prejudices among decision makers against non-sewered toilets (Starkl et al., 2015). These types of scouting activities laid the groundwork for subsequent institutionalization processes and in particular the standard development process leading up to ISO 30500 (Interview 4, 5), which can be seen as an attempt of institutionalizing the newly created hybrid water-market / sensitive rationality in order to achieve global regime change.

4.2. Phase 2: The emergence of a new layer in the socio-technical system

Our analysis revealed that an international actor-network was formed at an early stage of the standardization process, configured around the RTTC rationality. The process leading up to ISO 30500 was characterised by a truly global approach taken by lead actors from the very beginning, and was as such not particularly influenced by, nor anchored in, any particular geographical context. This network comprised actors that were skilful at managing global processes, most notably the BMGF, the global technology consultancy TÜV SÜD, the American National Standards Institute (ANSI) and the ISO organisation. In an early phase of development, a 'global niche' layer was thus constructed in the socio-technical system, which consequently worked on the institutionalization of elements reflecting the RTTC rationality.

After establishing the general need for an international standard, the technology consultancy TÜV SÜD was commissioned to develop a 'private technical standard'; essentially a technical specification which resembles an ISO standard but that has been collaboratively developed by commercial actors (Interview 4, 7). This can be seen as the first instance of institutionalization of the RTTC rationality with the ambition of achieving changes to the institutional framework beyond the RTTC itself.

The scope of the proposed private technical standard clearly reflected another rationality than the one guiding activities by actors in territorially embedded niches (Interview 6, 12, 13, 14), but still targeted the same underlying problem formulation and the issue of providing safe and affordable sanitation across the world. One interviewee highlighted how the RTTC rationality did not align with

'low-tech' solutions developed locally, for example by explicitly rejecting solutions which require the transportation of sludge:

> *"The scope of the standard was [developed] in discussion with the foundation. They said they don't want anything that has to be transported. If we have to pump it out and transport it elsewhere to treat, then it doesn't fall under Reinvent the Toilet Challenge."* (Interview 10)

Our results also point to the fact that the involved actors were intentional when it came to pursuing an international ISO standard directly, rather than first developing national standards or guidelines in selected countries.

In addition to framing the private standard, TÜV SÜD was also commissioned to survey the field of standards and technologies relevant for non-sewered sanitation globally. The purpose of this exercise was, according to our interviews, not to incorporate features of existing technologies developed locally, but to understand how to better diffuse the RTTC rationality into different national contexts (Interview 4). In other words, the approach was not aimed at upscaling locally developed alternatives, but to provide a roadmap of how to promote the new RTTC rationality in various territorially embedded layers of the socio-technical system. One interview partner involved in the process expressed that:

> *"We traveled to Africa, India, China, [in order to] find out what is the current status quo for non-sewered sanitation. There are options out there. Why are they not working? [...] You have all these pit latrines or you have anaerobic digestion technology that only treat the effluent but they have to remove the sludge and treat it somewhere else. But that's not where the innovation is."* (Interview 4)

At the same time, it is possible to observe how elements of prevailing rationalities were re-scaled from various national contexts, most primarily specifications regarding health and safety requirements found in guidelines by the United States Environmental Protection Agency (EPA), and shaped how the RTTC rationality was turned into concrete specifications and requirements. These were however sometimes incompatible with the locally adapted on-site sanitation solutions being developed in a number of, particularly low-income country, contexts (Interview 6, 13).

4.3. Phase 3: Standardization, PC 305 and ISO 30500

In parallel with the work to develop the private technical standard, the BMGF and ANSI had already taken first steps towards developing an International Workshop Agreement (IWA 24:2016), which is the normal starting point for the formal ISO process. The private technical standard and subsequently IWA 24:2016 represented first instances of the codification of the RTTC rationality to commonly agreed, global specifications for non-sewered sanitation systems. Yet, to have a substantial impact across different contexts, a crucial step was bringing the suggested specifications through the formal ISO standardization process. After establishing the IWA, an ISO project committee (PC 305) was formed[1]. The ISO standard-development process follows a highly formalized protocol which clearly specifies the steps that need to be taken to establish a global standard. It is organized in technical or project committees which involve groups of international experts from different domains (consumer associations, academia, NGOs and government) who "negotiate all aspects of the standard, including its scope, key definitions and content" (ISO, 2019). It is a complex, political and consensus-based process which aims at taking into account comments from a wide range of stakeholders.

Our interviewees highlighted that the PC 305 differed from many other ISO project committees in two important ways (Interview 7). First, the process was essentially geared towards the institutionalization of a technology that did not yet exist. In other words, the RTTC rationality played a crucial role as a guiding principle for what should be specified in the standard. As a consequence, few 'vested interests' by incumbent actors in the water sector were present and trying to influence the discussions in the PC 305. Second, the process deviated from the typical way through which international standards are developed, with regards to being initiated globally. One respondent expressed that:

> *"The typical case is a private organization doing something, then spreading this way of doing it at the regional and country level, and ending up at the international level. This project was totally in reverse."* (Interview 7)

The formal ISO process was staged in plenary meetings in Washington DC (2016), Durban (2017) and Kathmandu (2018), where the proposed specifications were discussed among all involved stakeholders. Almost by definition, these meetings served as arenas for the further institutionalization of the RTTC approach to non-sewered sanitation. In the meetings, the RTTC rationality was confronted with some of the competing rationalities prevailing in local layers of the socio-technical system. A telling illustration is how discussions about certain effluent performance indicators were subject to contestation from two sides (Interview 4, 5, 6). On the one hand, some actors from high-income countries argued that suggested thresholds were too low and did not live up to the existing safety standards in their national contexts. On the other hand, some actors argued that the thresholds were too high and would hamper the development of more low-tech, locally adapted alternatives in low-income countries. As such, the discussions in the PC 305 plenary meetings had to deal with the need to de-institutionalize elements of prevailing national standards, while at the same time proposing solutions that could be re-scaled into various local contexts without too much friction with (primarily national) regime structures in territorially embedded layers.

In addition to debates about the thresholds for certain safety parameters, the discussions within the PC 305 were centered on other aspects related to the 'content' of what was being institutionalized, that is, the technical specifications and requirements laid out in the

[1] A full list of participants can be found on this archived version of the ANSI website: https://web.archive.org/web/20210117192715/https://sanitation.ansi.org/Participation

standard. Transition literature would usually assume incumbent regime actors to be most concerned with shaping this institutionalization process so that their vested interests and guiding rationalities are reflected in the outcome. Interestingly, apart from the example highlighted above, our empirical analysis revealed only relatively weak resistance from established commercial actors in the general discussions within PC 305. One possible explanation can be found in the degree of aspiration of the suggested specifications; ISO 30500 specifies a technology that does not yet exist and thus do not pose any direct threat to incumbent regime actors' activities. Instead, discussions revolved around the very fact that the standard was forward-oriented and highly aspirational, and reflected a particular rationality. It was also highlighted in our interviews that the scope of the standard was extended during the standardization process, from being concerned with 'reinvented toilet' technologies to becoming a standard for all on-site sanitation technologies. One interview partner expressed that:

> *"[..] in the beginning it was really about 'reinvent the toilet' [..], to have the standard for this reinvent the toilet technology. So it was [about] really ambitious new technologies which are really different to everything we have. In the end it became a standard for all on-site technologies. And this is not the same."* (Interview 10)

In other words, an important source of contestation in the standardization process was directly related to issues of re-scaling of rationalities. Rather than originating from regime incumbents, this critique came from actors operating in territorially embedded layers in the socio-technical system, who argued against the proposed technical specifications out of fear that they would render current, locally developed, and more low-tech solutions irrelevant (Interview 6, 10, 12, 13, 14). In particular, the mass-market logic, and degree of technological aspiration embedded in the draft standard, were argued to be unattainable for existing local solutions, and as such potentially hindering the development of more pragmatic, context-sensitive alternatives. One interview partner expressed that:

> *"If [the construction of an urban sanitation system] has to be done according to ISO 30500, then the vast majority of all reasonable, good solutions, which are maybe low-tech, will never be able to fulfil ISO 30500, they'll just fall out of any possible solution there."* (Interview 14)

The BMGF furthermore granted funding for participation in the PC305 committee, which allowed an unusually high number of delegates from low-income countries to participate in the plenary meetings and other discussions (Interview 5, 6). This strategy proved instrumental for supporting re-scaling activities. According to our interviews, a common problem when it comes to re-scaling an international standard into low- and middle-income country contexts is the lack of adaptation, as international standards are often directly institutionalized at the national level, without further tailoring to concrete local contexts (Interview 1, 2, 3, 16). Active participation in the standardization process could thus be an important mechanism for ensuring that the standard is more effectively incorporating inputs from (and being able to diffuse into) as diverse contexts as possible. At the same time, some interviewees also criticized that the distinct features of the RTTC rationality and the high technical aspiration of the standard made it harder to target specific features of the standard from a water-sensitive / low-tech perspective without being accused of negating the developing world access to the best available future technologies (Interview 13).

Similar to the examples of contestation highlighted previously, some re-scaling processes led to contestation between territorially embedded actors, ranging from national standardization bodies and other national regulators to local sanitation industry experts, and the global actor network pushing for new rationalities. For example, ANSI and the BMGF had to deal with critique from local sanitation experts in the US, who emphasized the many incompatibilities that exist between the mass-market logic inherent in ISO 30500 (which has been adopted as a national standard in the US as of late 2019) and the long-established, complex regulative frameworks in the US water sector that draw heavily on professional, civil engineering logics and a key role for public agencies and utilities in ensuring public health. Implementing this standard at sub-national jurisdictions in the US water sector is thus likely to induce considerable institutional complexities and friction. Furthermore, the Indian delegation expressed concern throughout the ISO process about requirements being too stringent, and ended up with voting against the final specification of the standard. There were also concerns raised by some country delegates that the application of the proposed specification may be misinterpreted when implemented by decision-makers and national standardization bodies, leading to a situation where existing low-tech, community-managed sanitation solutions were not implemented despite being safe and customised for the local context (Interview 10, 12, 16). In other words, some sanitation experts were largely sympathetic towards the ambition of the initiative, but raised doubts in terms of how the re-scaling process of such a highly aspirational technological specification would work in practice.

A final example of a relevant re-scaling mechanism is the establishment of local experimentation projects that are running field tests with technologies adhering to the suggested specifications of the standard. In September 2017, the testing of four 'reinvented' toilet prototypes developed according to the suggested standard began in South Africa. Other emerging economies like China and India have also been pro-active in establishing national standardization initiatives and experimentation projects according to ISO 30500 specifications. Again, the re-scaling process followed a reversed logic if compared to conventional transitions theory. Instead of connecting to existing local projects, the RTTC rationality was becoming institutionalized at the global level and re-scaled to local contexts, rather than the other way around.

At the end of the complex institutionalization and re-scaling processes outlined above, the ISO Final Draft International Standard (FDIS) was finalized in 2018, encompassing inputs from representatives of 48 countries, and all ISO member countries were given the opportunity to vote on the final draft. The ISO 30500 standard was finally published in October 2018 and announced by Bill Gates himself at a high-level reinvent the toilet event in Beijing, China. Since then, proponents of the approach have engaged heavily in promoting the standard and supporting re-scaling into various national/local contexts (Interview 16).

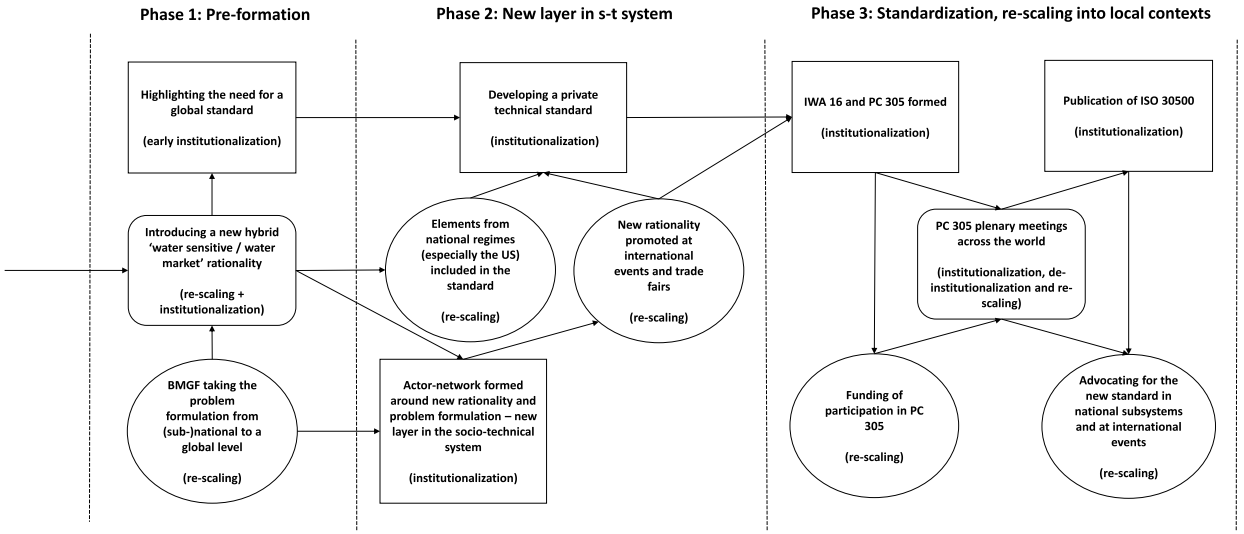

Fig. 4. Summary of the empirical analysis – re-scaling (circles), (de-)institutionalization (boxes) and combinations (rounded boxes). Source: Own design.

5. Discussion

Our empirical findings point to the complementary role played by re-scaling and institutionalization mechanisms in the discussed standardization process and for transition trajectories more broadly. The ratification of ISO 30500 at the end of 2018 represents an institutionalization of a new rationality in the water sector's global regime, which diverges both from prevailing global regime- and from emerging local niche rationalities. This meant that in addition to challenges associated with the institutionalization of the RTTC rationality at the global level, it was of key importance to re-scale this rationality across different scales and contexts, both of which caused significant changes to the proposed technologies and institutional rationality, leading to momentous contestation, especially with local niche actors in different parts of the world pursuing a water-sensitive, community-driven rationality for on-site sanitation systems.

Fig. 4 visualizes the three phases outlined in the empirical analysis and the links between the sub-processes comprising (de-) institutionalization and re-scaling mechanisms. It illustrates that while the institutionalization process was rather straightforward in the ISO process (the interlinked boxes at the top of the figure), it was complemented by a more complex set of re-scaling and institutionalization processes at other spatial scales that both preceded and succeeded the steps taken towards institutionalizing a new standard in the global regime.

In essence, the process outlined in Fig. 4 resembles most the 'global advocacy' transition trajectory outlined in section 2.4, while also containing some elements of the 'multi-locational diffusion' model. As shown in our case study, a network of private, governmental and NGO actors operating at an international scale was most instrumental in making structural change to the global regime happen. Many of the key rationalities put into the standard were constructed in this network, without much reference to concrete territorially embedded niche contexts. Interestingly, a key feature of this trajectory was that institutionalization and re-scaling processes took place before a proof-of-concept had been development. The case study thus explicates how technology standardization can precede actual technological development in niches, by setting an aspirational and globally relevant goal of what future technologies should achieve. At the same time, certain pre-existing standards (i.e. EPA regulations from the USA) were translated into ISO 30500 without further problematization. Our examples thus perfectly illustrates a transition trajectory in which the solutions and rationalities that got institutionalized into the global regime did not primarily represent knowledge and experiences accumulated in particular territorially embedded (niche) layers of the socio-technical system, but rather the priorities of actors with the capacity to influence and orchestrate standardization processes in a global arena.

6. Conclusion

This paper aimed at further conceptualizing and empirically exploring transition trajectories from an explicitly multi-scalar perspective. By combining an institutional take on transitions with insights from human geography, we could derive a framework that explicates how (de-)institutionalization and re-scaling processes condition different types of transition trajectories. Our conceptual elaborations showed that the traditional 'niche cumulation and upscaling' trajectory that is proposed in most transitions thinking and in particular in the conventional 'local-global niche model' can be complemented with at least two alternative trajectories that build on analytically different sequences of institutional and scalar agency.

Our empirical case study in the global sanitation sector illustrated a transition trajectory that features elements of the two alternative 'multi-locational diffusion' and 'global advocacy' trajectories. In our case, rather than a gradual upscaling of alternative socio-technical configurations through regional, national and ultimately international scales, we observe a direct institutionalization of a new field logic that is driven by a global actor network. The BMGF and a select number of other involved actors with a global reach strategically created a global standard for alternative sanitation system that was highly aspirational, going beyond 'state of the art' socio-technical configurations that were developed on the ground. As such, this actor network was able to directly institutionalize a new field logic in the global regime, while 'down-scaling' the proposed technical solutions and new proto-regime rationality into (sub-) national contexts only ex-post.

As a result of the involved actor groups and concrete standardization process, the final ISO standard does not reflect the water-sensitive logic of many emergent socio-technical configurations that are being implemented in various territorial subsystems around the world, but rather a novel, hybrid mix of water-sensitive and water market field logics, which reflect the priorities of the most influential actors in the standard-setting process. In essence, what can be observed in our empirical case is not niche-regime contestation in a local setting, but contestation between different scaled layers in the socio-technical system. The argument coming from actors in territorially embedded layers of the socio-technical system was that the ISO 30500 standard hampers the innovation and implementation potential of existing on-site sanitation technologies, which can both be seen as 'state of the art' in their respective contexts, and at the same time not being able to fulfil the requirements set out in ISO 30500.

In terms of policy implications, our results thus point to the ambivalent role that standardization processes can have on transition trajectories. On the one hand, ISO 30500 represents a successful institutionalization of a potentially transformative innovation in the global regime, a feat that local niche actors could not achieve even after two decades of local niche experimentation and failed cumulation/upscaling. On the other hand, the jury is still out on whether ISO 30500 will have a deep transformative effect on the global sanitation sector at large or whether actors at (sub-)national scales will ultimately resort to developing their own, locally adapted standards. In many related emerging clean-tech fields, well-endorsed intermediary actors like BMGF, who are in a structural position to re-scale promising local niche solutions beyond (sub-)national scales and institutionalize them in global arenas, are missing. In principle, innovation and development policies at national levels (or by supra-national bodies like the EU) could play a more pro-active role in supporting the needed re-scaling activities, e.g. by co-funding standardization activities or supporting the formation of global niche structures in areas that are of strategic importance for sustainable development. In addition, our results also imply that a technical 'proof-of-concept' is not in all cases a necessary condition for successful institutionalization. In some cases, transition processes may be induced based on skillful advocacy and key actors converging on aspirations. Further exploring this trajectory also for (sub-)national transitions could be highly relevant, not the least from a policy perspective.

The empirical case study also points at a number of aspects not reflected in the presented conceptual framework. First, while this paper highlighted the importance of looking into non-conventional multi-scalar transition trajectories, the two alternative trajectories in our paper could certainly be further specified by including processes at intermediate (regional, national multi-locational) scales and potentially even be complemented with additional trajectories. Furthermore, we covered a critical case in a sector with a particularly strong global regime structure and multi-scalar transition dynamics. Future studies should work to identify cases in other sectors in order to refine and revise the framework and increase its generality. Sectors differ in the type of multi-scalar transition trajectory that is most plausible and it remains to be specified how sector characteristics influence the most likely transition trajectories. The ISO 30500 case highlights a set of specific institutional elements associated with technology standardization, re-scaling processes in other sectors may naturally involve other types of formal and informal institutional elements.

Second, there are compelling reasons to explore the role of agency and power in re-scaling processes in much more detail. While there is an extensive body of literature dealing with power in transitions (Avelino and Rotmans, 2009), as well as the role of agency in institutionalization (Fuenfschilling and Truffer, 2016), transition studies have not dealt with the strategies adopted by actors in re-scaling processes and their impact on transition trajectories in much depth. Future studies should therefore theorize types and modes of agency targeting the re-scaling of practices and how scales emerge and are reshaped through active social construction. When looking into issues of power and politics and how they play out in the discussed global arenas, it appears interesting to focus specifically on a certain category of intermediary actors or 'generalized others' like BMGF, TÜV SÜD, or engineering consultants, who are well-positioned in territorially embedded and global layers of the socio-technical system at once and thus able to strategically re-scale technologies and rationalities between relevant layers of the socio-technical system. Our results suggest that it is not necessarily actors with most coercive power (like MNCs or national governments) that are most influential in inducing structural change. Rather, well-endorsed intermediaries like the BMGF, which occupy a very particular network position, seem to be able to write novel scripts for the global sector by orchestrating highly complex institutionalization and re-scaling processes.

Last but not least, our conceptual framework and empirical results have deep implications for explaining whether, where and how sector transitions may come about. At a most basic level, we argued that a local transition in a spatially confined subsystem does not automatically lead to a transformation of the respective sector structure, which might be institutionalized at supra-national levels. To really challenge the taken for granted field logic(s) in a global sector, proponents of alternative socio-technical configurations will have to engage with strategic institutionalization and re-scaling activities. The factors that lead to success of failure in such attempts, what sort of actor types are most susceptible for institutionalization and re-scaling processes and whether and how policy makers may consciously support such processes are key questions that justify a major future research agenda in this realm.

Declaration of Competing Interest

The authors have no conflict of interests to declare.

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Appendix

No.	Interviewee	Date
1	Researcher; Water sector expert	Jun 2020
2	Researcher; Water sector expert	Jul 2020
3	Researcher; Water sector expert	Jul 2020
4	Consultant; Involved in the ISO-process	Jul 2020
5	Research engineer; On-site technology expert; Involved in the ISO-process	Aug 2020
6	Researcher; Involved in the ISO-process	Aug 2020
7	Standardization expert; Involved in the ISO-process	Aug 2020
8	Researcher; Water sector expert	Aug 2020
9	NGO representative	Aug 2020
10	Researcher; Water sector expert; Involved in the ISO-process	Sep 2020
11	Industry association representative	Sep 2020
12	Consultant/Entrepreneur; Involved in the ISO-process	Sep 2020
13	Entrepreneur; Involved in the ISO-process	Sep 2020
14	Entrepreneur; Involved in the ISO-process	Sep 2020
15	Entrepreneur; Active in the on-site sanitation field	Dec 2020
16	NGO representative; Water sector expert	Dec 2020
17	Researcher; Water sector expert	Feb 2021

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