# Seedbeds, harbours and battlegrounds: on the origins of favourable environments for urban experimentation with sustainability

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## Abstract:

Motivated by the contemporary interest in urban experimentation (UE) as a means for enacting transformations towards sustainability, we address two questions: how does the extant litearture conceive of the contexts in which experimentation emerge, and what dynamics are thought to be inplicated in reconfiguring these contexts into favourable environments for experimentation? For that we critically review the research is this domain, which flourished recently but still lacks theoretical coherence. Much research has borrowed from strategic niche management the understanding of how protective spaces for experimentation form. However, in that perspective, socio-technical trajectories that cut across multiple localities are usually set in the foreground, while places and their transformations are in the background. There is an unattended assumption that most places may accommodate such protective spaces, and act as 'seedbeds' that shield and nurture radical innovations. Most recently, studies began questioning how particular cities become experimental, and why distinctive styles of experimentation emerge, suggesting that other dynamics may be at play. We approach our task combining a method for problematisation and a critical interpretive synthesis, to examine the central assumptions of different strands of research. We articulate a suit of three lenses - seedbeds, harbours and battlegrounds – which make clear different perspectives and highlights distinct understandings of the urban context, revealing that protection is one among many avenues for the development of favourable environments for UE. Based on our findings, we argue in favour of re-engaging with other perspectives to develop plural accounts of how experimentation thrives in some places. Awareness of such plurality could support more effective strategies for fostering urban transformations. We contribute with a way 'to follow' the co-evolution between experiments and their environment, paying attention to interactions between protection, connectivity and conflict.

Keywords: Urban experimentation; Sustainability transitions; Strategic Niche Management; Geography of Transitions; Geography of experimentation

## 1. Introduction:

Urban experimentation (UE) is central to recent discourses about smart, green, resilient and liveable cities. It is seen as a means for contending with the uncertainty and ambiguity that arise when introducing new technologies to the city, facing wicked problems such as climate change, or bringing about wider transformations. Proponents argue that UE can facilitate learning, catalyse innovation, promote reflexive forms of governance, and widen participation. Experiments and laboratories are proliferating quickly, as new means of governing the city. As a consequence, the governance of climate change and sustainability in cities is arguably becoming experimentalist (Hoffman 2011, Bulkeley et al. 2013, Bulkeley et al. 2015, McGuirk et al. 2016, Swilling and Hajer 2017). A recent scholarship highlighted widely diverse practices, framings and expectations associated with UE (Kullman 2013, Bulkeley and Cástan Broto 2013, Evans 2016, Evans et al. 2016). Experiments are widely varied, and so are the attempts at characterising them (c.f. Sengers 2015, Kivimaa et al. 2017, Ansell and Bartenberger 2016, Weiland et al. 2017).

Our study addresses two salient questions: how does the extant literature conceive of the contexts in which experimentation emerge, and what dynamics are thought to be implicated in reconfiguring these contexts into favourable environments for experimentation. These are relevant because at present, the rapidly expanding literature lacks theoretical coherence and thus treats the contexts in which experimentation emerge inconsistently.

We problematise the fact that, within transition studies, there has been a tendency to conflate niches and the urban context for experimentation, and to cities as seedbeds which provide protection and resources to novel experiments (Geels 2011, Arentzen et al. 2014), or as laboratories where protection is supplemented with formal learning processes (c.f. Neven et al. 2013, Karvonen and van Heur, 2014, Evans and Karvonen 2014, Voytenko et al. 2016, Bulkeley et al. 2016). Early on, experimentation had been identified as a crucial driver for

promoting system innovation and socio-technical change towards sustainability (Schot et al 1994, Verheul and Vergragt 1995, Kemp et al 1998, Grin et al. 2010, Markard et al. 2012, Loorbach et al., 2016; Sengers et al., forthcoming). Experimentation is seen as necessary to circumvent the obduracy of existing socio-technical systems and foster path-breaking alternatives. The strategic niche management (SNM) strand of this field has been used extensively to analyse the formation of niches, conceived as protective spaces for experimentation (Schot and Geels 2008, Smith and Raven 2012). Developing niches has been posited as a strategy for nourishing and scaling up radical innovations with potential sustainability gains, in both social and technological domains (Schot et al. 1994, Verheul and Vergragt 1995, Kemp et al. 1998, Hoogma et al. 2002). Similarly, the transition management strand argued for the establishment of 'transition areas', where frontrunners and researchers could envision alternatives and initiate experiments to concretise them (c.f. Nevens et al. 2013, van den Bosch and Rotmans 2010). However recent contributions took on place-based approaches, revealing complex journeys through which places become favourable environments for experimentation emerge and develop path-dependant styles of experimentation (Longhurst 2015, Raven et al., 2017, van Heiligenberg et al., 2017, Torrens et al. 2018).

We also contend that understanding urban contexts as behaving primarily as protective spaces could obscure other potentially relevant dynamics and politics (see also Bulkeley et al. 2014, Torrens et al. 2018). Other strands of work also suggest a more plural approach is necessary. For example, a geographical turn has been challenging the spatial assumptions of transitions studies (c.f. Hodson and Marvin 2010, Bulkeley et al., 2011, Wolfram et al. 2016, Frantzeskaki et al. 2017), indicating that the formation of favourable environments for experimentation may be associated with dynamics arising from embeddedness in territorial, sectoral, and transnational structures (Truffer et al. 2015, Sengers et al. 2015, Wieczoerec et al. 2015). Others demanded more attention to the politics of experimentation, arguing that contestation is at the core of what makes experiments transformative (Bulkeley et al., 2015, Murphy 2015).

We therefore hypothesise that the literature already encompasses multiple conceptions of the contexts for UE, and various dynamics that influence their evolution, which are nevertheless left implicit or frequently ignored due to the lack of an encompassing framework. To redress this situation, we engage with the literature's assumptions and recurring critiques, as generative material for theoretical development (c.f. Alvesson and Sandberg 2011). We take on this task through an iterative process of literature review and scholarly discussion.

To begin, we put forward the definition of urban experiments that we used to orient our review and discuss the present understanding of contexts for experimentation in the transitions field. Section 3 outlines our methodology and analytical framework. Section 4 presents the results, which we articulate as three *lenses*[1]: internally coherent set of assumptions which guide particular ways of understanding how urban contexts became favourable environments for experimentation. We label these lenses seedbeds, harbours and battlegrounds; each focus attention on plausible recurring 'contextual dynamics'. Section 5 presents a synthetic argument which brings these lenses together, and discusses our research questions, governance implications, and limitations of our work. We conclude by considering how to advance a plural understanding of UE in research and practice.

### 1.1. Defining urban experiments

Experiments have been defined variably. For the purposes of this paper, we combine the conceptualisations from transitions and climate governance literatures, to adopt an encompassing definition of urban experiments:

- as initiatives, projects or interventions 'delivered by or in the name of an existing or imagined urban community' (Castán Broto and Bulkeley 2013)
- which embody practice-based, learning-oriented and challenge-led approaches to addressing sustainability challenges under conditions of uncertainty and ambiguity (Sengers et al. Forthcoming)
- which involve multiple societal actors and contribute to social learning (Brown and Vergragt 2008)
- and which are 'highly novel' because they differ from 'dominant, conventional ways of satisfying social needs and preferences within a specific context' (Wieczoerck et al. 2015 pp.151).

These experiments are unlike classical and natural science experiments, because they take place in real-world settings which cannot be tightly controlled, involve societal actors in initiating and caring out the experiments (rather than only experts), and focus on learning about what the system ought to be and how to

[1] They could also be understood as different framings or perspectives. The advantage of lenses is that it makes it clear that different lenses may be justaposed, while the other terms suggest they are mutually exclusive.

achieve such transformation (Weiland et al 2017)[2]. They are best understood as attempts at developing viable socio-technical configurations, which share technological and social dimensions, 'where learning is not confined to technological learning, but includes changes in practices, services, user behaviour, institutions, ways of organising' (Wieczoereck et al 2015, pp.151). Experiments tend to emerge outside traditional channels of policy making and planning (Hoffman 2011), but this is changing with many cities developing specific units or laboratories to support such activities. Other definitions emphasise experiments that aim at climate change mitigation and adaptation (Castán Broto and Bulkeley, 2013, Kivimaa et al. 2017). Here, we adopt a broader perspective as the proponents of such activities often contend with multiple challenges that are specific to the contexts in which they are being embedded and have to navigate non-sustainability-oriented objectives and interests (e.g. developing novel bus-rapid transit systems addressing traffic, air-pollution, climate change, and affordability of public-transportation infrastructures, c.f. Sengers and Raven 2015). In our view, UE are not necessarily aimed at systemic impact (e.g. grassroots innovations aimed at community empowerment) but are often enlisted in narratives about potential urban transitions or transformations.

### 1.2. Contexts for urban experimentation

Within the transitions literature, conceptualisations of the nature of experimental settings have been heavily influenced by the notion of niches and protective spaces. This literature understood niches as spaces with a distinct selection environment, which afforded temporary protection for emerging technologies, enabling learning, and technological development that deviates from the rules of a dominant socio-technical regime (Kemp et al. 1998, Hoogma et al. 2002).

Lately, with the introduction of the so called Local-Global model (Fig. 1a), there was a shift towards understanding that niches emerge from and are reinforced by learning from a sequence of experiments, in multiple localities (Geels and Raven 2006, Smith and Raven 2012). In this perspective, the aggregation of lessons and their articulation by intermediaries allows the development of a set of shared rules, expectations and social networks, which in turn support further initiatives; experiments and the spaces in which they thrive are linked by recursive and potentially self-reinforcing dynamics (van den Bosch et al. 2008). Accordingly, various studies approach UE from a perspective of niche formation (e.g. SNM, transition management, grassroots innovation), thus assuming that the dynamics involved in the formation of environments for experimentation and transitions in cities are best described as part of a process of niche formation at a global/trans-local scale.

However, when considering UE, we should pay specific attention to places that concentrate experiments in multiple domains (Figure 1b) and try to understand how and why these became favourable environments for UE. Individual experiments are unlike to produce major-breakthroughs in and of themselves. In urban settings, multiple socio-technical systems co-exist and intersect (Schwanen 2015, Hodson et al. 2017) and a multiplicity of experiments have to be aligned to create sufficient momentum and arrive at robust socio-technical configurations and concrete sustainability gains. Hodson et al. (2017) for example, suggests studying how multiple socio-technical experiments, governance arrangements and social interests are being aligned in reconfiguring the context itself. Recent studies have proposed explicitly place-based approaches to understand the evolution of specific contexts in which UE flourishes (e.g. Longhurst 2015, van Heilingberg et al. 2017, Raven et al. 2017, Torrens et al. 2018), highlighting dynamics which are not reducible to that of niche formation.

Instead of a priori conflating the urban contexts with niches, we argue that we should attend to the possibility that other dynamics, aside the formation of a protective space, are salient in the formation of favourable environments for UE.

[2] Along these lines, another set of contributions advanced various transdisciplinary approaches and tools to initiate, monitor and evaluate specific initiatives (e.g. Raven et al. 2010, Luederitz et al. 2017).

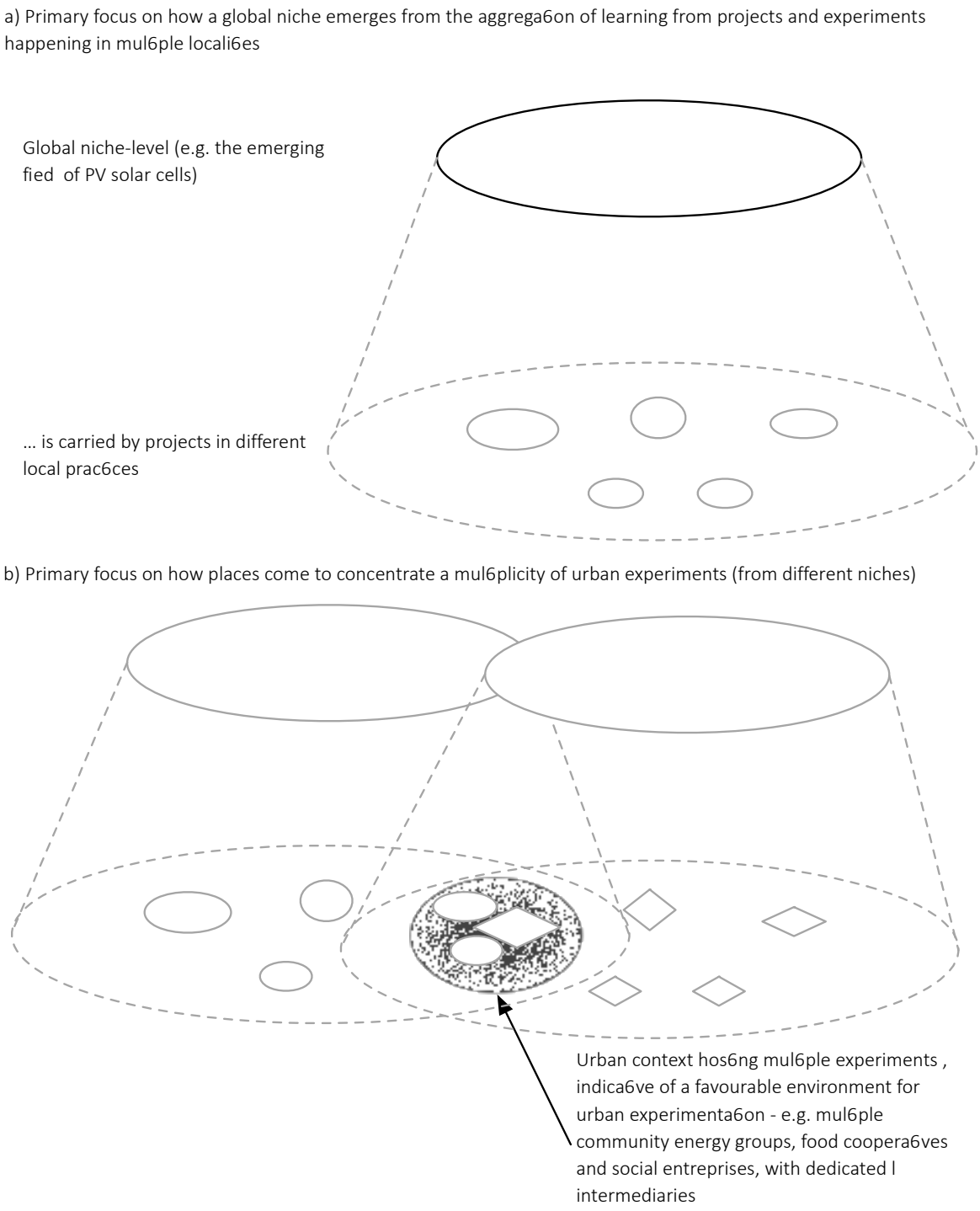


*Figure 1. Different perspectives on niche formation: a) local projects contributing to global niche-level formation (adapted from Geels and Raven 2006). b) focusing attention on contexts which concentrate experiments from multiple domains*

There are also good reasons not to assume a priori that the primary loci of UE are found in protective spaces created purposively or formally instituted as laboratories. Emphasis on constructing protective spaces and setting up laboratories can lead to a neglect of situations in which UE emerge organically in a particular city, i.e. outside spaces designated, explicitly framed and resourced to support experimentation. For example, when studying the development of a favourable environment for experimentation with civic energy activities in Bristol (Torrens et al. 2018), we observed that political efforts to frame and equip the city as a 'laboratory for change' were a recent development in a longer history of engagement with UE, with constant exchanges between

grassroots groups and local government. While the dynamics highlighted by SNM certainly played a role in that city's developments, others were salient but downplayed by that theory.

Moreover, placing formalised experiments or laboratories in the spot light, but neglecting unruly practices emerging from within the urban context, and the dynamics implicated in sustaining experimentation overtime, the literature is at risk of seeing experimentation happening 'on places' rather than 'in places' (Hodson et al. 2015). This would imply that most cities can come to accommodate a niche or a laboratory, which is sharp contrast with the very empirical domain of the literature, which has centred around places with a high concentration of UE (e.g. Bristol, Totnes, Fribourg, Gratz, Amsterdam, etc), which suggest that such spaces may be far from being evenly distributed[3].

Thus, we place our conceptual focus on the urban context and the dynamics which may explain their development. To interrogate these processes, we expand on the idea that experiments and their contexts are linked by a recursive dynamic (van den Bosch 2012). We define contextual dynamics[4] (CDs) as the recursive and potentially self-reinforcing processes through which the context in a particular city enables urban experimental processes, which in turn reconfigure or reinforce that context as to form a favourable environment for UE.

In the remainder of this article, we examine how these contexts are and what CDs are implicated in the formation of favourable environments for UE.

## 2. Methodology and analytical framework

This work emerged from studying the evolution of a favourable environment for experimentation with civic energy alternatives in Bristol (Torrens et al. 2018). Our investigation in that context and contact with case studies in cities with a similar profile of persistent grassroots mobilisation (e.g. Totnes and Berlin, see Longhurst 2015 and Blanchet 2015) exposed us to distinct understandings of why conducive environments for UE emerge. At the same time, it became clear that no coherent theoretical position could account for the various dynamics which were involved in shaping that context.

Along these lines, we identified a method for problematising the literature and another to support the synthesis, which we present below. Both allow us to work with extant literature to identify and critique different theoretical positions and contribute towards theoretical development. Acknowledging that entrenched theoretical positions may represent specific facets of a multifaceted concrete phenomena (Sayer 1984), we argue that articulating the distinctive understandings stemming from the literature could sensitise researchers to take on a more encompassing view of how favourable environments for UE are formed.

### 2.1. A method for problematising the literature

We approach the nascent literature on UE with a problematisation, which we take to be a 'dialectical interrogation of one's own familiar positions, other stances, and the domain of literature targeted for assumption challenging' (Alvesson and Sandberg, 252). As a research method, problematisation[5] aims on illuminating and challenging the assumptions that underpin existing theories, opening up new avenues for research. It can be applied to different kinds of assumptions (see table 1).

*Table 1. Typology (adapted from Alvensson and Sandberg, 2011). We focus on the first three categories.*

| Type of assumptions | Characteristics | Strategy for identification |
|---|---|---|
| In-house | Assumptions that exist within a specific school of though | Scrutinising internal debates and the interfaces between groupings of related authors |
| Root metaphor | Broader images of a particular subject matter underlying existing literature | Identifying basic image or metaphors used to represent the social reality in question |
| Paradigm | Ontological, epistemological and methodological assumptions underlying existing literature | Requires familiarity with alternative world views and efforts to map alterative paradigms |
| Ideology | Political-, moral- and gender-related assumptions underlying existing literature | n/a |
| Field | Assumptions about a specific subject matter that are shared across different theoretical schools | n/a |

[3] This pattern is also suggestive of a bias towards studying frontrunners, which has not yet been adressed critically.
[4] We use this term to differentiate from transition dynamics more widely.
[5] The concept of problematisation is also developed extensively by Faucault, who was particularly concerned with how and why, in a given circumstance, phenomena are studied and regulated, and others are not (see Deacon, 2000). We work here with the operationalisation proposed by Alvesson and Sandberg because it focuses on more circumscribed domains of research.

In this article, we focus on the in-house, root metaphors and ontological assumptions (part of paradigmatic assumptions) for two reasons. First, a focal area has emerged in recent years, and these three sets of assumptions can be seen to be in flux, and thus worthy of articulation and critical scrutiny. This is evident in how persistent emerging critiques have emerged but not been translated into full-fledged alternative theorisations. Second, because the ideology and field assumptions have been scrutinised for the wider field of sustainability transitions elsewhere (e.g. Avelino 2010, Smith 2010, Geels 2011, Stirling 2014).

To operationalise such problematisation, we seek to 'scrutinising internal debates and the interfaces between groupings of related authors, who use similar narratives and vocabulary', (Alvesson and Sandberg, 2011). For that, we to use a series of guiding questions, the relevance of which can be found in previous studies (Table 2). We expand particularly on in-house assumptions of different groupings of the literature, because there has been substantial debate recently about these topics. Aside from contextual dynamic, which we introduced above, the other in-house assumptions have been a staple of discussions in the field. These dimensions were then used for thematic coding using Nvivo® 11 software.

*Table 2. Analytical framework derived by expanding on the idea of problematisation.*

| Category of analysis | Category in Alvesson and Sandberg (2011) | Guiding questions for the analysis of the grouping of papers | Examples of the relevance |
|---|---|---|---|
| Root-metaphors for the context | Root metaphor | What metaphor is used to describe the urban context in its relationship with experimentation? | Geels (2011), Arentsent et al. (2014), Sekulova et al. (2017) |
| Commonly used descriptors | Root metaphor | What other metaphors are used to refer to processes associated with the development of the context? | |
| Conception of the urban context | Paradigmatic | What is the (explicit or implicit) assumption about the constitution of the urban context? | van Heilingenberg et al. (2015), Longhurst (2015) |
| Role played by the urban context in urban transitions | Paradigmatic | What role does the development of the urban context play in sustainability transitions? | Hodson and Marvin (2010), Moloney and Horne (2015) |
| Contextual dynamics | In-house | Which recursive or self-reinforcing processes are thought to enable experimentation in the context and reinforce the context? | Hoogma et al. (2002), Van den Bosch (2008) |
| Prevalent forms of knowledge and learning | In-house | What forms of knowledge and what processes of learning are foregrounded? | Smith et al. (2016) |
| Role ascribed to intermediaries | In-house | What functions are intermediaries assumed to play regarding this contextual dynamic? | Gliedt et al. (2018), Matschoss and Heiskanen (2017) |
| Political dimensions | In-house | What are the central concerns regarding the politics of experimentation? | Bulkeley et al. (2015) |
| Oversights | n/a because derived from persistent critiques | What critiques are levied against this perspective, in terms of what is left out or underplayed? | Murphy (2015), Truffer et al. (2015) |

## 2.2. Identifying the relevant domain of the literature

A necessary step first for problematisation is identifying, sorting and delimiting a specific domain of the literature associated with our research question, and different groupings within this domain. Compared to research concerned with identifying and filling gaps, this typically involve a narrower literature coverage and more in-depth readings of key texts (Alvesson and Sandberg, 2011). In order to achieve this objective in a transparent and reflexive manner, we mobilise in this article a Critical Interpretive Synthesis (CIS) (Dixon-Woods et al., 2006a, 2006b). This is a method which adapts aspects of systematic literature reviews to applications where interpretation, synthesis and assumption challenging is required.

Within the social sciences, systematic reviews have been used extensively to explore particular concepts or to identify gaps that persist despite a wide range of research on a subject (Pettigrew and Roberts 2008). They are aimed towards a comprehensive treatment of the literature, with attention to the quality of the research included, a clear and systematic approach to synthesising the data, generally following a rigorous and transparent processes (Victor 2008). This kind of review was pioneered in medicine, where they are conventionally deployed to collect evidence and test 'what works', appraised according to a strict hierarchy of evidence that privileges randomised control trials and tended to exclude other research designs and qualitative evidence (Dixon-Woods et al., 2006a, 2006b). To that objective, conventional the method requires strictly staged protocols suited for generating an aggregative synthesis that summarises data along concepts (categories and variables) that are assumed to be 'largely pre-specified, secure and well defined' (Dixon-Woods et al., 2006b, p.36).

In the sustainability transitions field, however, systematic reviews (e.g. Sengers et al. forthcoming, Kivimaa et al. 2017) have been used instead to explore and contrast understandings of particular concepts, to enable theoretical refinement and identify areas for further development. For that reason, scholars adopted more interactive procedures (rather than staged), combined with an interpretive stance necessary to realign the reviews with the constructivist perspective on scientific knowledge (e.g. Sengers et al. forthcoming). Within other communities, similar concerns inspired the development of various methods for the synthesis of qualitative research (cf. Weed 2005, Barnet-Page and Thomas 2009).

A review with emphasis on aggregative synthesis would not meet our interest in problematising this nascent literature, which is currently in flux, with concepts are not consistently labelled, defined and interpreted with multiple competing arguments over the conceptualisation of experimentation (c.f. Sengers et al. Forthcoming, Caproti 2017, Kivimaa et al. 2017, Weiland et al. 2017) and equally diverse understandings over the contexts for experimentation (c.f. Longhurst 2015, van Heilingenberg et al. 2017, Torrens et al. 2018).

Instead, we adopt the method of critical interpretive synthesis that aims explicitly at theoretical development, circumventing some of the strictures of systematic reviews (Dixon-Woods et al., 2006a). In our understanding, CIS makes explicit the adaptations which scholars in the transitions field were already adopting. Its key processes are as follows (Dixon-Woods et al., 2006a, p.10)

- To start, a research question is formulated, but it may be revisited and refined
- Rather than a staged process, searching, sampling, and critique and analysis proceed iteratively, and are considered 'dynamic and mutually informing processes'
- Search is approached with a broadly defined strategy, rather than a strict protocol, and may include purposive selection of material known to be relevant
- Ongoing selection of potentially relevant sources is informed by the emerging theoretical framework, and may require additional searches
- Appraisal of sources privileges their relevance and theoretical contribution, rather than adherence to a strict hierarchy of evidence
- Procedures for extracting data may be useful but are not an essential feature

CIS complements well the notion of problematisation with an explicit method for handling the literature review. Its ideal output is the formulation of a synthesising argument which integrates the evidence from across the corpus of research into a 'coherent theoretical framework comprising a network of constructs and the relationships between them' (Dixon-Woods et al. 2006 p.5). This may require the generation of 'synthetic constructs' that stem from interpreting the evidence included in the review, and which mobilise various facets of the phenomenon at hand. For that, CIS invites engagement and critique with the assumptions, research traditions and meta-narratives which lay behind research reviewed. As it relies on an interpretive approach, CIS does not lend itself to full auditability and reproducibility expected of systematic reviews. Nevertheless, CIS strives for methodological transparency, embracing the authorial dimension to the research and demanding constant reflexivity by the authors of the review.

To adapt CIS to our objectives, and focus on problematisation, we carried out a search on Scopus® database for studies concerning UE with sustainability (see appendix A for detail on the initial searches). From this initial corpus, we identified literature reviews (n=8), and traced their references and citations. Removing duplicates, excluding conference papers (which quality varies considerably) and screening the abstracts for relevance to our question, we limited the search to 99 entries. We then assessed the introduction of these papers, to confirm that they placed sufficient emphasis on the contexts for experimentation to justify a full-text reading. JT was mainly responsible for handling the literature review, co-creating the strategy with the other co-authors and discussing intermediary results.

Finally, our interpretive synthesis has been influenced by a wider dialogue established with scholars in this field when presenting this work in multiple instances over the past two years (Eu-SPRI 2016, IST 2017, Hamburg workshop on Urban Energy Transitions 2017, acceleration workshop in DRIFT 2018, NEST conference 2018), which helped refine our interpretation of different frameworks and synthesis and better reflect the extant literature.

## 3. Results:

Table 3 presents the metaphors and descriptors that allowed us to cluster the contributions of the literature (see also Appendix 2 for the specific works composing each grouping). In the coming sections, we explore the different assumptions and seek to articulating them into a synthetic argument (based on CIS) to identified three distinctive lenses, a coherent of assumptions and understandings about the nature and

processes of development of favourable environments for UE, that that could potentially be used to interrogate empirical cases.

*Table 3. Root metaphors and commonly used descriptors that facilitate the identification of works with similar representations of the urban context for experimentation*

| Label of grouping | **Seedbeds** | **Harbours** | **Battlegrounds** |
|---|---|---|---|
| Root-metaphors for the context | Evolutionary and ecological, invoking protection and separation and growth: Niche, protective space, habitat, fertile soil, breeding space, seedbed | Maritime, travel, and communication metaphors invoking mobility, flow, connectivity, communication and cosmopolitan sensibilities: Alternative milieu, hub, nexus, nodes, buzz, pipelines | Conflict, confrontation, and performance, invoking friction, tension and strategic action: arenas, fields, |
| Commonly used descriptors for processes | protecting, embedding, seeding, shielding, nourishing, nurturing, growing, replicating, scaling up, fertilizing | harbouring, connecting, networking, migrating, anchoring, transferring, circulating | mobilizing, resisting, struggling, gaining traction, entrenching, challenging, empowering, mediating |

### 3.1. Seedbeds

This group can be identified by the use of evolutionary and ecological metaphors to describe the urban context, such as niches, seedbeds, habitats, and fertile soil; most studies in this group built on the SNM literature. These metaphors convey the understanding that the urban context (or specific places within the city) is characterised by specific configurations of actors, values, technologies and institutions which offer distinctive conditions, creating protection from otherwise harsh environments that enable experiments to germinate, grow and flourish[6]. Conversely, these metaphors also indicate that this protection is not absolute, as the experiments are seen to be 'exposed to the elements' of real world contexts. To encompass both meanings, but avoid conflation with the concept of niches[7], we labelled this lens as seedbeds[8].

According to this evolutionary reading of UE, the formation of favourable environments for UEs is thought to be analogous to the formation of niches, in that particular places or cities may give rise to situated 'protective spaces' for experimentation. As in SNM, these spaces are primarily conceptualised as alternative selective environments relative to the dominant socio-technical regime. For protection to emerge, different dynamics are at play that allow for variation to emerge, and for novel sociotechnical configurations to develop through sequences of experiments. Three key dynamics that have been summarised by Smith and Raven (2012) and cited by multiple works in this grouping.

First, the emergence of a protective space depends on shielding, which refers to processes involved in modulating the pressures exerted by mainstream selection environments (Smith and Raven 2012). This is thought to passive shielding, where this is due to a contingent combination of favourable conditions which predates the strategic intent, and active shielding, where proponents of a certain innovation or experiment deliberately and strategically seek to create protective spaces (e.g. demonstration projects, urban laboratories, urban living labs). In the former, a growing literature has identified a series of place-specific conditions or 'success factors' which can contribute to the emergence of experiments (e.g. van Heilingenberg 2015, Feola 2017, Hansen and Coenen 2015).

Second, the urban context may enhance nurturing, the processes that support the development of innovations: assisting learning, articulating expectations and for strengthening social networks (Schot and Geels, 2008). Local networks are implicated in such activities; the breadth and inclusivity of these networks is understood as a crucial factor for the development of the context. In line with the local-global model (Geels and Raven, 2006), intermediaries are seen to play a key role in framing local activities and aggregating/codifying the knowledge so that it finds wider applicability, and in creating further protection for new experiments.

[6] To a large extent, these methaphors are also present in the grassroots innovation literature, which also draws from SNM (e.g. Seyfang et al. 2007)

[7] The concept of niches has been expanded in multiple direction, and there have been multiple proposals for typologies which we cannot cover here.

[8] Geels (2011) also used this methaphor as one possible role of cities low-carbon transitions, when cities act as the intial locations for niches that go on to expand elsewhere, forming national-regimes (e.g. various niches associated with electrification), contrasted to cities not playing a part, or acting as key as agent in national level transitions.

A third dynamic has been identified, which concerns the empowerment of initiatives – the discursive processes through which actors involved in a given protective space argue for the wider applicability of those experiments (Smith and Raven 2012). Here, actors may develop the competitiveness of niche (fit-and-conform) or by restructuring the wider selective environment (stretch-and-transform). In both cases, the very accumulation of experiments in a particular place may reconfigure the context as to favour further experimentation, thus creating a self-reinforcing dynamic (Hodson et al. 2017, Torrens et al. 2018).

In this understanding of the context, learning is primarily derived from practical activities (learning-by-doing) associated with introducing novel socio-technical configurations in a particular context. Whether knowledge is primarily situated or brought-in from other contexts seems to be an empirical question (c.f. Holm et al. 2011, Schreurer et. 2010). According to Heiskanen et al. (2015) there has been a tendency to neglect the knowledge accumulation that happens locally, in a 'the multi-interest' context (Heiskanen et al., 2015). Along these lines, a complementary understanding can be found in studies which characterise creative cities. Cohendet et al. (2010, p.108, our emphasis), for example, suggests that a set of distinct organisations with different interests may in fact be necessary to sustain learning processes in a particular city. Based on a case of Montreal's creative milieu, they describe how a 'delicate, subtle and fragile local ecology of knowledge, where creative processes nourish themselves' can emerge from the repeated exchanges between three groups: underground (i.e. artists, activists, bohemians primarily involved in exploring and experimenting with radical ideas; the upperground, i.e. companies, multinationals, concerned primarily with exploiting commercial opportunities, and the middleground, intermediaries invested in developing the local scene.

Politically, this understanding of the context highlights contention around ensuring the viability of policies supporting protection, and the allocation of resources to nourish initiatives. Also, fit-and-conform strategies for empowerment raise concern over capture, particularly when the priorities of national or municipal governments differ (Shreurer et al. 2010), or when municipalities are seeking to support grassroots initiatives and risk overriding their priorities (c.f. Wolfram 2018, Torrens et al. 2018).

Two oversights justify the need for other analytical lenses. First, as pointed in recent geographical critiques, it is 'problematic to assume that 'tacit knowledge transfer is confined to local milieus whereas codified knowledge may roam the globe almost frictionless' (Bathelt et al. 2004, p.31 apud Sengers & Raven 2015). This is aggravated by neglecting other non-local relationships which co-constitute the urban context (Späth and Rohracher, 2012). Second, this lens risks 'naturalising' the mechanisms through which certain interests prevail over others, depoliticising how urban contexts are mobilised and positioning as a privileged site for experimentation with particular forms of sustainable technologies and practices (Heiskanen et al., 2015). Moreover, privileging a localised dynamic of learning and creativity and emphasising consensus building downplays the potential conflict in attempts to reconfigure the city, and masks incongruent visions of how the city ought to develop and who is to decide (Bulkeley et al. 2014, Hodson and Marvin, 2009, 2010).

### 3.2. Harbours

The second group encompasses works that deploy a variety of geographically informed conceptualisations, recognisable by their various maritime and travel and communication metaphors alluding to connectivity, circulation, flow, movement, transport, transmission and transnational links. Despite considerable theoretical diversity, this group is distinctive because of its reliance on geographic relational conceptions of place that highlight the co-constitution[9] of situated and translocal relationships and structures. Implied in these accounts, is a dialectic between that which is mobile and fixed: "mobilities cannot be described without attention to the necessary spatial, infrastructural and institutional moorings that configure and enable mobilities" (Hannam et al. 2006, p.3). Thus, to label this group, we use the metaphor of harbours[10].

The urban contexts are understood as hubs for connections, passages, mobilities and flows, nodes in a wider network of cities and places, which foster diverse place-specific but connected subjectivities. As Blok and Tschötschel (2012), rather than emphasising the solely the fixity of metropolis, they should be seen as 'a particular nexus of situated and transnational ideas, institutions, actors, and practices that may be variously

[9] Some of these studies draw from primarily from assemblage urbanism theories, thus inherinting both relational geographic understandings of place and flat-ontologies from actor-network theory (Block 2014).

[10] This alludes to places of priviledged connectity, which arise from both favourable geographical characteristics, insfrastructural assets and historical developments, that are enrolled in wider networks of circulation, and which develop particular cultures as a result (e.g. multicultural, tolerant to diversity, cosmopolitan, etc). This is not restricted to actual port cities, even if global port cities epithomise this framing (e.g. Block and Tschötschel 2016).

drawn together for solving particular problems' (Ong 2011 pp. 4). Regarding the prospects of transitions, places are understood variably as passage points to multi-locational innovation journeys (c.f. Sengers and Raven 2015), members of wider cosmopolitan communities which share risks and jointly pursue opportunities (Blok and Tschötschel 2016) or as enrolled in demonstrating the agenda of powerful transnational interests (Silver 2017).

Under this perspective, the contexts are favourable to experimentation when they draw in like-minded individuals, facilitates encounters, and enables anchoring and (re)discoveries of various tendencies. In turn, experiments are seen to be particularly important means to reconfigure the flows or linkages. A particular city can become a privileged site for experimentation if it attracts, retains and facilitates the circulation of resources and embodied expertise (experts, activist, social entrepreneurs, etc.), while at the same time offering a receptive context for ideas and concepts (including but not restricted to technology).

This lens focuses attention on how the contexts are reconfigured through their connectivity and exposure to other contexts. It opens research on how place-specific and proximal aspects are shaped by networks and processes 'beyond the local', through a variety of actor-, knowledge-, capital-, institutional-, and technological-transnational linkages and flows (Wieczoerck et al. 2015). Two salient dynamics are salient in the literature.

First, Longhurst (2015) and Torrens et al. (2018) indicates a recurring dynamic involving cultural alterity, openness and experimentation in the formation of an alternative milieu[11], defined as a 'geographically localised concentration of countercultural practices, institutions and networks can create socio-cognitive 'niche' protection for sustainability experiments'. The (pre-) existence of non-mainstream identities and practices is thought to contribute to welcoming and sustaining other counter-hegemonic identities and practices. In turn, this cognitive protection and openness helps reinforce claims of cultural alterity. This dynamic is crucial for the emergence and renewal of positive socio-spatial imaginaries (i.e. actors assume that the context is a good one for trying novel and radical ideas). Similarly, Amin et al. (2002) discussed the importance of developing and reinforcing an outward- and forward-looking sense of place, characterised by a:

> readiness to avoid a politics of place based around an inward-looking local sense of place (e.g. a culture of 'we have always done it this way', or 'our field of engagement ends at the city boundary'). Instead, we see a politics *in* place that is not reducible to a local sense *of* place, one that draws on a wider field of connections, resources, and ideas (...) (p.121)

Second, a recursive dynamic involves experiments enabling or reinforce transnational linkages, and develop place-reputations, and vice-versa. Powerful actors and often foreign actors (e.g. donors, intermediary organisations, expert networks) are particularly drawn to iconic experiments which promise to further transnational linkages and increased pull for flows of people, capital, technology (Blok 2014). Moreover, the reputation of local institutions (e.g. grassroots exemplars, leading universities, local think-thanks, well stablished firms) and different shades of place-reputations - 'green', 'bohemian', 'creative', 'alternative', 'entrepreneurial' - which emerge organically can become prised assets which municipal governments seek to build-on and leverage (Hodson et. 2007, Torrens et al. 2018). They are crucial to attract migration of likeminded individuals and mobile experts, new knowledge, resources and capital. Increasingly, local stakeholders are engaged in quotidian efforts to shape, advertise and instrumentalise their reputations, for which sustainability activities are a prime substrate. Networks of consultants, journalists, city networks, prizes and international challenges are involved in locating, branding, ranking and celebrating 'best places', 'best practices' and national exemplars (Hodson and Marvin, 2007; McCann, 2013; McCann, 2004; Ward, 2000). The active promotion by mayors and local authorities signals an 'extrospective' stance, with an 'explicitly stated global orientation that encourages both competition and cooperation with other cities for "greenest," most "liveable" status' (Mccann, 2013, p. 11). Furthermore, place-reputations may enable access to privileged communicative channels implicated in the circulation of knowledge. Building and maintaining these linkages and channels require dedicated efforts, expertise and resources which are unevenly distributed (Bathelt et al., 2004, Sengers and Raven, 2015).

Here, learning is conceptualised as happening primarily across multiple localities, and through a combination of cosmopolitan and situated ideas, designs, and interests. This highlights the process of de-embedding, translation and re-embedding of lessons and experiences across places and scales, for which there is considerable conceptual (see Geels and Raven 2006, Sengers and Raven 2015, Blok 2014). It is consensual that these processes are neither automatic nor neutral politically, in the sense that what is mobilised is inflected by the interests of the actors involved in the transfer, e.g. consultants, traveling bureaucrats, mobile knowledge

[11] Notably, the experiments presented in this paper had all been conceived elsewhere but were brought to Totnes because of the supposed suitability of that context.

workers, and 'experts-cum-advocates' (Blok 2014, Wieczorect et al. 2015, Sengers and Raven 2015). Elsewhere, the importance of the capacity of cities to 'anchor' more global policy change has been noted (Carvalho et al., 2012).

Politically, a variety of issues ensue. Centrally, power relationships are enacted through transnational linkages, mobilities and flows, and therefore research should attend to "the ways in which these re-configure (or reinforce) local structures in receiving geographical contexts and how they shape the design and outcome of socio-technical trajectories" (Wieczorect et al. 2015, pp. 154). Illustrates that this may entail a 'partial dislocation of urban authority' face new mobile urban policy elites. Blok (2014) illustrates how models of eco-urbanism tend to be constituted through dominant strategic and commercial interests, and to be dominated by global cities 'able to exert control over critical resources in competition with more ordinary cities'. Similarly, the dynamics described entail 'new moral geographies of inclusion and exclusion (…) as certain world cities emerge as hubs in new 'green' flows of technical and policy expertise on urban sustainability', forming 'cosmopolitan risk communities' (Blok and Tschötschel 2016). For cities at the margins, experiments are often initiated from 'top-down' with tightly prescribed priorities and guidelines from funding agencies and international donors, e.g. privileging private service delivery over community ownership, and thus prematurely shut down alternative progressive or inclusive pathways (Silver 2017). In each of these cases, studies flag that experimentation is not without contestation and conflict, which may open new spaces for politicization at the city level.

Two oversights are evident here. First, although this perspective is critical of power asymmetries associated with transnational linkages, but less explicit about other forms of contention that arise with experimentation. Also, an emphasis on connectivity and exposure as avenues for developing favourable environments for UE places much hope for transitions on cities that are already in a privileged position and which for that reason may be those most strongly aligned with incumbent interests.

### 3.3. Battlegrounds

Here the urban contexts are understood as arenas or fields[12] where political contestation, struggle, cooperation are staged. Both these metaphors highlight an understanding of social ordering marked by a temporary, situational and actor-dependent character, with moving boundaries and new entrants, in which apparently stable situations may be destabilised by crises or surprises. Conflict is seen as generative of change, highlighting processes of building coalitions, alliances or mediation. In some cases, metaphors are also used to convey a sense of performance[13], in the sense that actors (especially social movements) may use tactics such as protests, occupations, and media campaigns to draw attention to their struggles (e.g. Jørgessen 2012). For all these reasons, we summarise this group under the label battlegrounds.

A variety of theoretical positions are salient here. Works associated with this lens tend to dispense with the levels proposed in the multi-level perspective, favouring instead actor-centric accounts which foreground constellations of actors and their efforts for collective sense making and placemaking (e.g. Jørgessen 2012, Murphy 2015, Håkanson 2018). This focuses attention on how apparently powerless actors may be liberated from entrenched institutional or cognitive frames, opening up for alternative visions, interpretations, contestation and thus different courses of strategic action. Accounts of the struggles faced by grassroots and local energy initiatives (Fuchs and Hinderer 2014, Blanchet 2015), for example, adopt theorisations of 'strategic action fields' (Fligstein and McAdam, 2011). This conceptualisation highlights interdependence and competition between actors embedded in a 'socially constructed arenas within which actors with varying resource endowments vie for advantage' (Fligstein and McAdam, 2012, p. 3). Periods of episodic contention between actors can give way to 'settlements', periods of relative stability which re-establish collaboration and orderliness in which a dominant frame of what is at stake and what are acceptable forms of intervention become entrenched (Fligstein and McAdam, 2011).

This lens foregrounds the controversies, crisis and tensions between divergent interests, around which coalitions and social movements organise, which may or not escalate into overt conflict. It focuses attention on particular situations, events or episodes which create openings for change, rather than on the long-term development of stable structures. While still concerned with experiments, this perspective opens up the analysis to episodic contentious and unruly politics, demanding an examination of the processes implicated in the reconfiguring infrastructures or governance arrangements and how they can expedite or hinder

[12] Arenas tend to be used in conceptualisations drawing from Actor Network Theory, while fields are used in conceptualisations emphasising institutional understandings (e.g. Fligstein and Mcaddam 2011).

[13] Notions of tactical urbanism and gerrila gardening seem particularly interesting examples to be examined with this lens.

sociotechnical change. This includes how social movements and political movements organise to resist particular developments, and clashes between distinct coalitions and alliances around particular policy decisions, e.g. between local and central governments, political parties or environmental movement and polluting industries. Such conflicts are thought to be both caused by and potentially generative of UE and grassroots initiatives (Blanchet 2015, Håkanson 2018). For example, Jørgessen (2012) highlights an instance where squatters organised a series of protests to resist the construction of a highway in Copenhagen, drawing on alliances with other sectors of the city, and ultimately derailing the plans while creating space for deliberation around alternatives to automobility. Along these lines, Murphy (2015, p.84), for example, has called for:

> analyses of the competing place-frames associated with sustainability initiatives and the networks and actor- or institution-specific positionalities that stabilize, obstruct, and/or promote development visions.

One contextual dynamic regards how restructuring governance arrangements open or foreclose the possibility of experimentation in particular directions, and vice versa. Torrens et al. (2018), for example, draws from Ward (2000) and Fligstein and McAdam (2011) to study settlements - 'periods with stable constellations of actors and prevailing framings of what is at stake, resulting (…) different patterns of experimentation (…) and modes of governing this activity' (p.7). Such settlements are thought to arise from temporary standoffs between distinct coalitions of actors or between different local and national government. In contexts with multiple experiments, this may create selectivity, supporting some initiatives but curtaining others. Settlements may become entrenched through institutionalisation or might unravel that conflicts and controversies external to a CUE may (see Fligstein and McAdam 2011). One example of such a dynamic is found in Mclean et al. (2016), who argue:

> the 'opening up' of cities as experimental nodes is contributing to a restructuring in socio-technical urban governance, with the creation of new spaces for targeted private investment and the responsibilities of conservation efforts delegated down to an environmentally conscious citizenry.'

Another contextual dynamic regards how actors participating in conflict and confrontation may develop the capacities to act politically and increase their ability to carry out UE. This dynamic overlaps with the 'stretch-and-transform' empowerment described in the SNM literature (Smith and Raven, 2012)[14]. This concerns processes that 'create capabilities and attract resources that empower participation in political debates over the future shape of institutions and regime selection pressures' (Smith and Raven, 2012, p. 1032). For example, when grassroots initiatives may encounter structural impediments to their objectives; being confronted with institutional misfits, economic and social structures and incumbent interests, lacking infrastructures, these actors may develop critical knowledge and political acumen about the wider structures which constrain their activities (Smith et al., 2014). Similarly, disputes over how sustainability issues are being framed (issue-frames) intractable controversies around narratives, visions or imaginaries of what a place can or ought to be (place-frames) advanced by it, may lead to the sort of societal learning often attributed to experiments themselves, challenging fundamental assumptions and spurring the search for other visions and narratives about change. Actors involved in such disputes may develop 'social skill', the ability of individual or collective actors 'for reading people and environments, framing lines of action, and mobilizing people in the service of these action 'frames'' (Fligstein and McAdam, 2011, p. 7). Skilled actors are better equipped for advancing their interests by mediating and convincing others and forming coalitions and alliances. Works in this vein challenge assumption of gradual aggregation of learning locally.

This lens places the politics of urban transitions front and centre, highlighting the struggles over the future development and questioning how experiments are enrolled in restructuring wider socio-technical governance of cities, emphasising the ambivalent character of experiments 'both as a means through which to orchestrate potentially progressive and effective socio-technical change and as a means through [which] existing interests can contain the challenges of 'low-carbon' urbanism' (Bulkeley et al. 2014, pp.1472). Thus, the outcomes and objectives of experiments are treated as ambiguous rather than progressive. Various works highlight contestations around supposedly green urban experiments which enact neoliberal framings (e.g. Silver 2017), or further gentrification (Håkansson 2017). To understand the varied ways in which, Bulkeley et al. (2014)

[14] This is one example of the overlap between the lenses. Here empowerment takes on a more overtly confrontational tone.

proposed that it is paramount to investigate how notions of justice are articulated, practiced and contested through experiments. Without such considerations, there is a risk that incumbents may use experimentation primarily as means of socio-spatial and socio-technical control over the development of the city and the systems that compose it. Even when this is the case, however, actors involved in setting up experiments may well be aware of these dynamics and act strategically to reposition and continue to challenge incumbent structures. For example, Gopakumar et al. (2014) highlight how experiments advancing the marketisation of water supply inadvertently help coalescing oppositional networks of activists, which go on to set up counter-experiments that embody other logics and visions.

This lens redresses important oversights of the previous lenses, but it is equally partial in focusing primarily on framing disputes and empowerment. One should avoid the pitfall of assuming binary conflicts between coalitions of local actors and non-local actors, or niche-actors and incumbents (c.f. Blanchet, 2015). Instead, the richness of this lens lies in considering how actors mobilise alliances to advance particular framings or visions. Considering whether these alliances form stable settlements avoids overemphasising conflict where there is evidence substantial collaboration and interdependence.

## 4. Synthesis and discussion:

With our methodology, we sought to move past an aggregative review towards a synthetic approach. We articulate the arguments we reviewed into coherent lenses (Table 4). These lenses may help researchers to be more reflexive about their implicit assumptions about the context, and to expand the suit of dynamics they consider when studying the formation of favourable environments for experimentation.

*Table 4. Lenses articulating the different assumptions encountered in the literature*

| Lens | Seedbed | Harbour | Battleground |
|---|---|---|---|
| Conception of the urban context | A configuration of place-specific factors and resources that creates a distinctive selective environment | A hub of connections and passages, embedded in wider networks and circulations of resource, people and knowledge, which sustains a socio-cognitive milieu | An arena of disputes between political coalitions, which act strategically to advance their objectives |
| Role of urban context in sustainability transitions | Protect emerging socio-technical configurations, allowing them to develop and grow despite the pressure of the incumbent regime (through shielding, nurturing and empowerment) | Facilitates encounters, anchoring and (re)discoveries of various tendencies, increasing their exposure to transnational developments while offering a socio-cognitive form of protection for sub-cultures | Act as places where confrontation between incumbent and challengers are play-out, making disputes visible and allowing for the reconfiguration of governance arrangements |
| Contextual dynamics emphasized | Evolutionary<br>Emerging practices, innovations and experiments are shielded from harsh selective forces, nurturing local variation and learning-by-doing | Relational<br>Formation of a well-connected, reputable place, which draws in resources while offering exceptional socio-cognitive opportunities and protection | Institutional/Conflictive<br>Empowerment and encounters with structural impediments<br>Restructuring governance arrangements |
| Prevalent forms of knowledge and learning | Tacit knowledge from experiments being retained locally<br>Local ecology of knowledge | Trans-local learning<br>Access to privileged communicative channels<br>Migration of embodied expertise | Learning through confrontation/ contestation (critical knowledge) |
| Political dimensions | Negotiating protection<br><br>Ensuring protection and negotiating resource allocations despite entrenched interests | Navigating connectivity<br><br>Power relations enacted through translocal linkages | Strategising conflict<br><br>Negotiating across incongruent interests to achieve substantial institutional reforms or dislodge dominant interest |
| Role of intermediaries | Framing of local projects, aggregation of learning, harnessing local resources<br>Mediating between individuals and institutions/firms | Primarily as transfer agents, connecting to global networks, harnessing resources from afar, promoting place-reputations, translating and codifying notions | Mediating confrontation and controversies, re-framing activities, building alliances, mobilizing |

| | | | |
|---|---|---|---|
| Key oversights | Unrealistic 'localism' of a containerised view of urban contexts<br>Assumes a shared vision | Tensions in bringing novelty to context<br>Who represents the milieu? | Risk of exaggerating the role of conflict in enabling transitions |

We sought to balance the trade-off between two efforts: expanding our literature searches beyond the familiar remit of SNM to counter the bias towards protection and treating the corpus in a way that allowed for a meaningful problematisation. That involved starting with ample search parameters and following two rounds of triage, and then grouping articles with deploying similar root-metaphors and apparent framings. What followed was a process of interpreting the different assumptions held in each of these groupings with the basis of our analytical framework (Table 2).

Each of the lenses is associated with a set of coherent in-house assumptions. Taken individually, different papers rely on some of these assumptions but not others. Taken collectively, the different groupings gave as a clearer sense of the salient arguments and critiques reoccurring in the literature.

### 4.1. How does the extant literature conceive of the favourable environments for urban experimentation?

Our results confirm our initial hypothesis, that there are very distinct understanding of the urban context and the dynamics of formation of favourable environments for UE. Despite the importance of UE in current discussions about urban transformations, and various examples of how a multiplicity of experiments is involved in bring about such processes, few articles dealt directly with the evolution of the settings in which such experimentation occurs. The ones that did, considered place-based accounts which expanded on the notion of niches (e.g. Longhurst 2015, Torrens et al. 2018). Nevertheless, a large number of articles alludes to the contexts for experimentation, or to theoretical concepts about these concepts, which we sought to scrutinise.

The works that informed the seedbed lens were relatively cohesive, drawing from similar sources and using a shared set of concepts that are well established in the SNM literature, an evolutionary understanding of the contextual dynamics. Many individual studies have sought to expand on SNM, suggesting conceptualising urban contexts as situated protective spaces for experimentation. We noticed a risk of overly expanding what is understood as protection, encompassing everything that is good for experimentation. We concur with a more specific understanding of protection as in relationship to a dominant socio-technical regime (e.g. Smith and Raven 2012) but go on to suggest that other facets of urban context also play a role in modulating the emergence of UE. We therefore argued in favour of clearly distinguishing different understandings of the context.

Both the harbours and battlegrounds lenses rely on work that is more recent, and so no singular theoretical perspective predominates (see Appendix B). Overall, works associated with the harbour aimed at more spatially and mobility attuned accounts of UE and drew primarily from geographical traditions. Those associated with the battlegrounds lens foregrounded actor centred and conflict aware accounts of UE and drew from theories such as political ecology and social movement theories. Such concerns have been addressed by a variety of social science schools, so the conceptual diversity is not surprising. Our objective here was not to reconcile such drastically different conceptions, but to make evident the different assumptions which they carry.

These lenses have distinct strengths when paired with the appropriate contexts. The seedbed lens seems appropriate in cities where UE is being driven actors embedded locally which tap into shared or at least popular visions, and where policy action to support experiments is not particularly controversial (e.g. pilot projects for electric buses developed by local consortiums and supported by local governments, local food networks founded by grassroots organisations and supported by other stakeholders).

The harbour lens is more appropriate in contexts where experimentation is driven through the mobilisation of interests, visions, and resources from elsewhere, or aimed at, for example, iconic eco-housing buildings aimed at international notoriety, eco-district developments in world port cities, development projects financed through foreign aid.

The battleground lens highlights the role of conflict, controversy and struggle in resisting or opposing particular developments, which may in turn spur experimentation, such as protests against highway constructions followed by experiments in cycle mobility, struggles against evictions stimulating alternative visions of social housing provision.

These are obviously stylised examples which fit 'neatly' into a particular lens - reality is much messier. So rather than applying a particular lens, we suggest that analysts would benefit from interrogating situations from various angles. These lenses do not substitute theories, but nevertheless highlight particular features of a

context, guiding the analysis in different directions and helping scholars problematise their own positions (Alvesson and Sandberg 2011) or to scope different options for theoretical triangulation (Sovaccol and Hess 2018).

### 4.2. Contextual dynamics

Our analysis identified a variety of contextual dynamics associated with the development of favourable environments for experimentation, broadly associated with evolutionary, relational and institutional or conflictive understandings of how change comes about. Our approach highlights the potentially self-reinforcing characteristic of these processes. This seems pertinent given that the literature has only began to explain why particular places come to concentrate and sustain UE over long periods.

Framing this discussion around contextual dynamics forces us to consider that contexts are constantly evolving. It draws us away from the notion of success factors which is generally static: either places have or not such factors at a given time, with little no clarity on how factors arise in the first place. Instead, our approach centred on asking how experiments co-constitute their environments, which we see as promising for research on urban transformations. It may be worthy enquire whether certain success factors are good indicators a given CD is in place and develop tools for assessing the development of the context.

Several of the articles reviewed highlight dynamics appertaining more than one lens and seem to suggest these interactions are highly context specific. We therefore concur with Smith et al. (2016) understanding of different perspectives on grassroots innovation, which argues that different perspectives and the processes they identify need to be 'in dynamic relations with one another' (p.22).

It is plausible that a particular context has multiple co-occurring dynamics. For example, Longhurst (2015) and Torrens et al. (2018) showed that inward migration associated with the growing reputation of an alternative milieu could exacerbate the socio-cognitive protection in a given city and further diversify experimentation. Capturing all possible interactions is an elusive task for which to date there are no systematic study. When considering particular cases, it may be useful to consider whether these processes occur in sequence or simultaneously, and whether they reinforce or disrupt one another.

Other dynamics might be of relevance, so we would welcome other studies exploring this space.

### 4.3. Governance implications

Given the complexity of the processes involved in the formation of favourable environments for experimentation, our approach may be of help to actors involved in governing experiments in three different ways. We assume that actor's implicit understanding of the context, and the metaphors they use when referring to it, are likely to shape particular governance responses.

Firstly, for someone involved in initiating experiments, it is important to assess what dynamics have been at play in a given context, and the extent to which proposed experiments are in a good 'fit'. It is necessary to consider the effect different dynamics have on development of different kinds of experiments, and whether particular experiments require certain dynamics to thrive. Tentatively, we suggest that contexts in which seedbed-like dynamics are present may be particularly conducive to experiments requiring intense learning associated and adaptation to highly localised practices and preferences (e.g. eco-housing, see Holm et al. 2011) or dependent of high-degrees of trust and collaboration (e.g. energy cooperatives, community gardens). Contexts with harbour-like dynamics, marked by high connectivity and exposure, might be conducive to experiments that assemble multiple elements of various emerging transnational technological trajectories, such as in the case of Smart Cities (see Raven et al. 2017). Alternatively, contexts with battleground-like dynamics, marked by entrenched political divisions and controverted visions, may be conducive to radical social innovation but less so for technological development. Our contribution is a small step towards more systematic assessment of such selectivities, which may help explore the development of path-dependant styles of experimentation and understand why certain experiments fail in certain places but succeed in others.

Secondly, for intermediaries and different governance actors, the framework may be useful to identify what roles they are likely to play in, as a way of continuously reflecting about the intermediation needs of a given context and what forms of learning and political action to support. It may be hard to identify what activities might be necessary when, and what forms of learning to support, so interrogating the context with different lenses may be useful as part of a reflexive practice. This may give raise to distinctive strategies, which complement the known tools of SNM with more targeted tools for developing exposure and connectivity, and for finding constructive tactics to navigate conflict.

Thirdly, for those involved in supporting experimentation, it may be useful to consider different avenues through which experiments may have an influence in a process of urban transformation. Not all experiments evolve into full-fledged systems which challenge existing regimes, nor into innovations that

circulate widely, or new institutional arrangements. Having a plural understanding of experimentation and its relation to the context should inform forms of evaluation that are commensurate with different kinds of experiments and contexts.

### 4.4. Limitations of this study

As the terminology used in the literature is not fixed nor subject to strict convention, searches on databases are necessarily biased by the search terms used. We tried to circumvent that problem combining different search terms and including articles citing and cited by other literature reviews (Appendix A). Nevertheless, it is possible that we missed other references covering the topic of interest. However, given that we have also inspected the references of the articles that were included in triage, and included then when relevant (see CIS) we believe that missing references would have little effect on our interpretation.

Grouping different works by using their metaphors proved to be useful but not trivial. Some articles use metaphors explicitly and reflectively, while others use them interchangeably. In the case of the seedbeds metaphor, for example, Geels (2011) proposed the term when studing how cities can contribute to urban transitions, which was then adopted by various authors deploying and expanding on that idea. However, when we use the metaphor in our tables, they are derived from the grouping of papers, and not from a single study; we also used them as handles to summarise a broader set of assumptions which have a degree of internal coherence and which represent at least partially how that grouping treats UE.

Each of these groupings are not homogeneous or easily separated from the others, as the individual works that compose them draw from diverse influences and interpret core concepts from different angles (Appendix B). In various cases, articles show a degree of overlap between different dynamics and framings. We sought to move beyond discussing differences in terminology to highlight the key differences between distinct perspectives that co-exist in the literature. These are substantial because they derive from paradigmatic understandings of the nature of the urban context and its change, and a large number of in-house assumptions that risk being taken for granted by practitioners and scholars alike. By problematising these assumptions without attempting to provide a single synthetic approach, we hope to foster more constructive and plural understanding and debate about the formation of favourable environments for UE.

We do not claim to be comprehensive because we focused on literature that discussed experimentation in the urban context or that had informed directly such discussions, albeit with diverse terminologies. In hindsight, our corpus had few examples on grassroots innovations that don't use experimental terms. We noted where similar arguments are being held in that community (e.g. Smith et al. 2014). We concur with recent contributions on the intersections between the urban and grassroots domains in recognising that this is a promising area of research (e.g. Håkanson et al. 2018, Wolfram 2018).

Our searches and method also downplayed the importance of the socio-material context for urban sustainability transitions, in both infrastructural (e.g. Hodson et al. 2011, Routerford and Coutard 2014) and socio-ecological sense (e.g. Ernestson et al. 2010). It has been argued experiments require a continual remaking of experiments (e.g. Castán Broto and Bulkeley 2013, Bulkeley et al 2015). Our approach does not substitute those discussions, but hopefully helps to pluralise them in ways that support studies on the long-term evolution of the environments in which UE takes place. When considering infrastructures or socio-ecological systems, there a risk of a priori assuming which factor is determinant in enabling or constraining experimentation. For example, a city with obdurate infrastructure may still develop a context conducive to experimentation with other domains (e.g. novel business models for energy distribution, c.f. Blanchet 2015).

When interpreting the Harbours lens, we struggled with the fact that most of those works take on a distinct unit of analysis, focusing on transnational and cosmopolitan contexts processes, such as with multi-location trajectories and networks. We believe that dedicated studies observing how particular places are crisscrossed by multiple such trajectories would be a fruitful addition to the literature. We made an effort to transpose their conceptualisations and what they mean to a particular place, but that is likely to require further conceptualisation.

Moreover, any representation such as ours misses the granularity of the individual works. Each of the in-house assumptions we discussed is subject to entire strands of the literature dedicate to them, as for example, studies concerning the role of intermediaries (c.f. Hodson et al. 2009, Hodson et al. 2013, Hargreaves et al. 2013, Giedlt et al. 2018). We therefore do not presume to have a heuristic that substitutes the underlying literature. Nevertheless, when discussing this work in various conferences, we found that articulating these lenses instigated other researchers to consider other framings and emerging conceptualisations, and to attend to the radically different ways favourable environments can emerge.

## 5. Conclusions and research agenda:

Our study contributes to pluralising the present debate on UE in two ways. First, we articulated different lines of argument hitherto obscured by considerable theoretical fragmentation in this domain. Second, we highlight the emerging place-based accounts of how situated experimental settings emerge organically. By focusing on the urban context, problematising the assumptions of the literature, and trying to articulate distinct lenses, our work highlights various facets of the contexts in which UE emerge, and identifies the dynamics that may explain their evolution.

The recent interest in UE has produced a growing fragmentation on the theoretical positions, empirical and methodological approaches, which may hinder the practical application of concepts and a critical engagement with the actually-existing forms of experimentation. By charting different lenses, we hope to facilitate theoretical advancement by clarifying the lines of argument which seem to be emerging and opening up a debate about which CDs actually shape the contexts for experimentation in particular cities.

When engaging with urban experiments, which are uncertain and sometimes risky endeavours, actors have to believe that their place is a favourable environment for experimentation or a special place worthy of their efforts (Longhurst 2015). Understanding what motivates these practices and the different forms of learning involved should be of greater concern for the literature. It should not assume that urban experiments are being initiated over homogenous concerns over climate change, global sustainability, low-carbon transitions, or renewable energy, but instead inquire into how different worldviews and visions of sustainability are invoked in conjuring experiments, arguing for their relevance and making them possible (Block 2014, Hodson et al. 2018). Which dynamics matter in a given city is both place and issue specific.

Early on, we identified the risk of overemphasising the creation of designated spaces for experimentation, either as laboratories or as strategic niches, and thus focused our efforts on exploring the dynamics involved in the organic development of experimental settings. Space being limited, we could not treat that former strand in detail. It may be fruitful to explore the discourse around laboratories and contrast their assumptions with three lenses we presented, using a similar analytical approach.

Further research should explore the applicability of the seedbeds, harbour, and battleground lenses to case-study research, empirically refining the characterisation of CDs and explore their practical consequences (c.f. Smith et al. 2014, 2016). This could involve, for example, recasting the notion of embeddedness in dynamic terms, by considering which CDs are manifest in a particular context and which experiments are more likely to succeed when aligned in those situations. Understanding these different selectivities could help explain the emergence of path-dependant styles of experimentation (c.f. Heilingenberg et al. 2017, Raven et al. 2017), and the challenges faced by grassroots innovations in different contexts (c.f. Wolfram 2018).

Our approach may be useful for those involved in initiating, steering and evaluating urban experiments, pluralising their understanding of the relationship between experimentation and the urban context. Without critical reflection, current UE research may be at risk of repeating the predicament of early SNM scholars who, according to Hoogma et al. (2002), had been 'over-optimistic' about the potential of that tool to foster transitions, noting that

> the positive circles of feedback by which a technology comes into its own and escapes a technological niche are far weaker than expected and appear to take longer than expected […] the contribution of the projects to niche development appear to be small (pp. 195)

To avoid that predicament, strategies used to foster urban transformations would benefit from empirically mapping the diverse contextual dynamics and assessing their relevance in particular socio-spatial contexts. For example, using participatory methods to discuss the history of a context and assess its development through different lenses could become a part of transdisciplinary approaches aimed at harnessing UE to build urban transformative capacity.

If research on experimentation is to play a part in urban transformations towards sustainability, is paramount 'to follow' the development of the contexts in which it happens and take seriously the generative effects of interactions between protection, connectivity and conflict.

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## Abbreviations

CDs – Contextual dynamics
CIS – Critical Interpretive Synthesis
SNM – Strategic niche management
UE – Urban experimentation

## Appendix A – Details of the search procedure

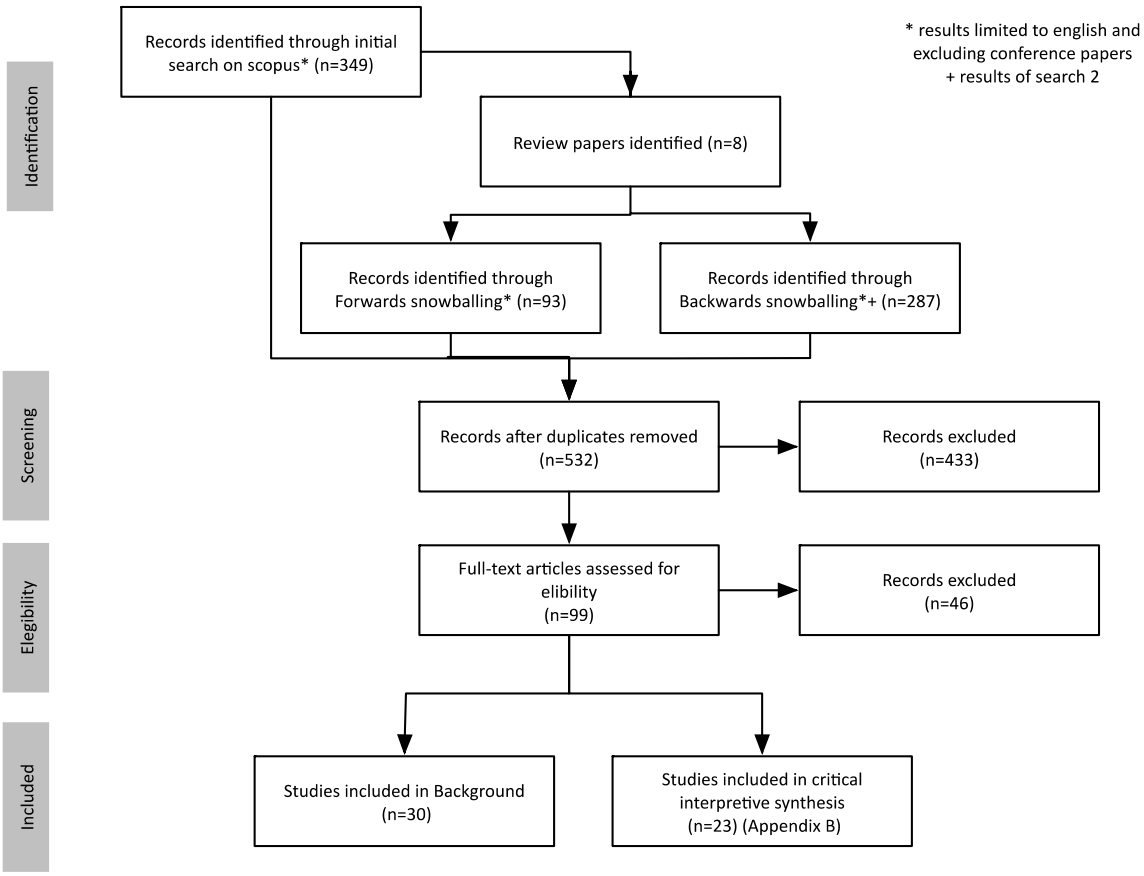


*Figure A1. Workflow of the literature review.*

Figure  represents the procedure we followed for our research. We began the effort to identify a suitable corpus for analysis with a search on the Scopus database, by combining searches for different terms referring to experimentation, and a search regarding terms associated with sustainability and climate change. Each time, we focused on the title, abstract and keywords of documents (TITLE-ABS-KEY command). The search command W/3 (within three words) was used to ensure that variations and permutations of the search terms were found, such as urban sustainability experiment or urban climate change experiments. The combined search string also limited results to English documents only and excluded conference papers (see Table 5).

The bibliographical information of these results was exported to MS Excel®, where a table was created to handle the results. We then examined the abstracts and identified 8 relevant literature reviews.

*Table 5. Search string used in Scopus for the initial search.*

```
TITLE-ABS-KEY (((urban* OR local* OR socio-technical OR sociotechnical OR niche* OR govern* OR grassroot*) W/3 (experiment*)) AND (sustainability OR "sustainable development" OR "climate change")) AND (LIMIT-TO(LANGUAGE,"English")) AND (EXCLUDE(DOCTYPE,"cp"))
```

* Scopus' wildcard for 'any number of characters'

On the second and third stage, we proceeded with a search of all the articles citing those reviews (forward snowballing), and all the articles cited by those reviews (backwards snowballing). For the backwards search, we refined the results by searching for terms related to experimentation (string on table 3). The results were added to the same table and the duplicates removed (using the MS Excel® function). When possible, missing abstracts were completed with the help of extra searches.

*Table 6. Search string used to refine results of the backward snowballing*

```
TITLE-ABS-KEY(nich* OR experiment* OR lab OR  labs OR laborator*)
```

* Scopus' wildcard for 'any number of characters'

Screening of the abstracts led us to disregard entries which were not associated with our topic. We excluded, for example, irrelevant entries focused on experiments used primarily as a method of enquiry in environmental and sustainability sciences, and geography (e.g. fieldwork). After the screening, 99 records were considered for a second triage. Initially, we read the introduction of the and conclusions of the articles, selecting those studies which foregrounded the relationship between the urban context and experimentation. Regarding articles dealing with niche construction, for example, we included studies that made clear questions of embeddedness, the influence of place-specific factors, and institutional settings, but excluded studies focusing primarily on niche-regime interactions that were not specific to the urban context. This led to 23 studies concerning the development of favourable environments for experimentation (included in the CIS, see appendix B) and 30 articles which informed the background.

## Appendix B

The tables below summarise the key points, theoretical underpinning (aside interest in experimentation) and methodologies of the papers considered in each of the groupings.

*Table B.1 Grouping of papers which informed Seedbed lens*

| Reference | Main concern | Theoretical underpinning | Method | Overlaps with other lens |
|---|---|---|---|---|
| Coenen et al. (2010) | Argues proximity advantages could help explain local niche experimentation | SNM<br>Geography of innovation (proximity) | Case study of aquifer thermal storage in the Netherlands | Harbour |
| Holm (2011) | How experiments in sustainable housing in Denmark became situated transition arenas and what role did municipalities play | SNM | Four cases of situated niches of eco-construction in Denmark | |
| Schereuer et al. (2010) | Issues arising when embedding experiments in cities | Constructive Technology Assessment,<br>SNM | Case study in fuel-cell technology in the city of Graz | |
| van den Heiligenberg et al. (2010) | Assessment of the success factors for experimentation, and typology of habitats for experimentation | Transition Management, SNM, Regional Innovation Systems | Survey of 56 experiments in Europe. | |
| Wolfram (2018) | Role cities play in emergence and formation of grassroots niches | SNM, grassroots innovations, urban social innovations | Case study of Seoul efforts to support grassroots initiatives | |

*Table B.2 Grouping of papers which informed Harbour lens*

| Reference | Main concern | Theoretical underpinning | Method | Overlaps with other lens |
|---|---|---|---|---|
| Blok (2014) | Suggests an alternative vocabulary and method with which to study and compare eco-housing experiments | Assemblage Urbanism, Worlding Cities, Cosmopolitics | Multi-site ethnography of eco-housing experiments in Kyoto, Copenhagen and Surat | |
| Blok, Tschötschel (2016) | Argues that Asian and European world port cities are forming a | Cosmopolitan risk communities | Survey of experiments in 16 world port cities and analysis of experiment databases | |
| Longhurst (2015) | Highlights the role of alternative milieu in creating socio-cognitive protection for sustainability experiments | Geography of sustainability transitions; Territorial innovation models | In-depth case study of alternative milieu in Totnes | Seedbeds |
| Sengers and Raven (2015) | Development of a spatial perspective on niche-formation | Geography of sustainability transitions<br>Buss-Pipelines<br>Global Production Networks<br>Policy mobilities | Case-study of BRT systems in multiple Thailand cities considering web data, interviews and ethnographic work | Seedbeds |
| Silver (2017) | How global actors are increasingly involved in local-carbon restructuring, using places at the margins to experiment and dominate governing, sparking contestation | Urban Political Economy | Case-study of waste-management experiment in Mbale, Uganda | Battlegrounds |
| Wieczoerck et al. (2017)* | Development of a typology for transnational linkages | Geography of sustainability transitions | Analysis of 200 solar PV projects in India | Harbours |

*Table B.3 Grouping of papers which informed the battleground lens*

| Reference | Main concern | Theoretical underpinning | Method | Overlaps with other lens |
|---|---|---|---|---|
| Bulkeley et al (2014) | Proposes a typology to examine how justice is articulated, practiced and contested in climate change experiments | Climate justice<br>Climate Change Experiments | 5 case-studies of experiments in Bangalore, Monterrey, Hong Kong, Philadelphia and Berlin | |
| Fuchs and Hinderer (2014) | New approach to analyse emergent forms of governance brought about by local energy initiatives | Strategic Action Fields | Comparative Case-studies in 4 German regions | |
| Gopakumar (2014) | Emergence of public-private partnerships as laboratories for marketisation of water supply | Science and Technology Studies<br>Political Ecology | Case study of a water-supply partnership in Bengaluru (India) | |
| Håkansson (2012) | How do grassroots initiatives take shape in particular contexts | Place making<br>Gentrification | Ethnographic case study in Peckan (South London, UK). | Seedbeds |
| Jørgenses (2012) | Proposes Arenas of Development as an alternative understanding of | Arenas of Development<br>Actor-Network Theory<br>Sense Making | Three illustrative cases including city resistance to highway development in Copenhagen | |
| Mclean et al. (2016) | Explore the use and consequences of UE in restructuring governance and opening up new spaces for private investment | Climate Change Experiments | In-depth case study of a smart energy grid project in Austin, Texas | Seedbeds |

In a few instances, we included references to works which were not included in the initial searches, but which illustrated the lenses very clearly (Table below).

*Table B4 - Relevant empirical studies included in the analysis, that were not found in the searches but were cited by works in the corpus*

| Reference | Main concern | Theoretical underpinning | Method | Associated lens |
|---|---|---|---|---|
| Condehet (2010) | Understanding how a creative milieu emerges | Creative Cities | Two Case studies in the city of Montreal | Seedbeds |
| Torrens et al. (2018) | Unpacking the formation of a favourable environment for experimentation with civic energy alternatives | SNM, Contextual reconfiguration | In-depth case study in Bristol | Seedbeds, Harbours |
| Amin et al. (2002) | Understanding the uneven distribution of the social economy | Relational urban geography | Four case studies in UK cities concentrating multiple initiatives in social economy | Harbours |
| Carvalho et al. (2012) | Understanding the mobility of green urban transport policies | Economic geography and innovation studies | Case studies in Curitiba, Göteborg and Hamburg | Harbours |
| Blanchet (2015) | Why do grassroots initiatives emerge around energy distribution in cities, and how do they influence the governance of urban energy systems? | Strategic Action Fields<br>Grassroots Innovations | Case study of conflicts around ownership of Berlin's electric grid | Battlegrounds |
| Murphy (2015) | Explores the promise of human geography to complement transition studies | Relational place making | Illustrative case-study of conflicts surrounding smart growth initiatives in Boston Metropolitan Regions | Battlegrounds |

## References


Ansell, C.K., Bartenberger, M., 2016. Varieties of experimentalism. Ecological Economics 130, 64–73. doi:10.1016/j.ecolecon.2016.05.016

Alvesson, M., Sandberg, J., 2011. Generation Research Questions Through Problematization. Academy of Management Review 36, 247–271. doi:10.5465/AMR.2011.59330882

Amin, A., Cameron, A., Hudson, R., 2002. Placing the Social Economy. Routledge, London and New York.

Arentsen, M., Bellekom, S., 2014. Power to the people: local energy initiatives as seedbeds of innovation? Energy, Sustainability and Society 4, 2. doi:10.1186/2192-0567-4-2

Avelino, F., Rotmans, J., 2009. Power in Transition: An Interdisciplinary Framework to Study Power in Relation to Structural Change. European Journal of Social Theory 12, 543–569. doi:10.1177/1368431009349830

Barnett-Page, E., Thomas, J., 2009. Methods for the synthesis of qualitative research: A critical review. BMC Medical Research Methodology 9. doi:10.1186/1471-2288-9-59

Bathelt, H., Malmberg, A., Maskell, P., 2004. Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. Progress in Human Geography 28, 31–56. doi:10.1191/0309132504ph469oa

Blanchet, T., 2015. Struggle over energy transition in Berlin : How do grassroots initiatives affect local energy policy-making ? Energy Policy 78, 1–9. doi:10.1016/j.enpol.2014.11.001

Blok, A., Tschötschel, R., 2016. World port cities as cosmopolitan risk community: Mapping urban climate policy experiments in Europe and East Asia. Environment and Planning C: Government and Policy 34, 717–736. doi:10.1177/0263774X15614673

Blok, A., 2014. Worlding cities through their climate projects?: Eco-housing assemblages, cosmopolitics and comparisons. City 18, 269–286. doi:10.1080/13604813.2014.906715

Brown, H.S., Vergragt, P.J., 2008. Bounded socio-technical experiments as agents of systemic change: The case of a zero-energy residential building. *Technological Forecasting and Social Change* 75, 107–130. doi:10.1016/j.techfore.2006.05.014

Brown, H.S., Vergragt, P., Green, K., Berchicci, L., 2003. Learning for Sustainability Transition through Bounded Socio-technical Experiments in Personal Mobility. Technology Analysis & Strategic Management 15, 291–315. doi:10.1080/0953732031000160149 6

Bulkeley, H., Castán Broto, V., Hodson, M., Marvin, S. (Eds.), 2011. Cities and Low Carbon Transitions, Cities and Low Carbon Transitions. Routledge, London. doi:10.4324/9780203839249

Bulkeley, H., Castán Broto, V., 2013. Government by experiment? Global cities and the governing of climate change. Transactions of the Institute of British Geographers 38, 361–375. doi:10.1111/j.1475-5661.2012.00535.x

Bulkeley, H., Castán Broto, V., Maassen, A., 2014. Low-carbon Transitions and the Reconfiguration of Urban Infrastructure. Urban Studies 51, 1471–1486. doi:10.1177/0042098013500089

Bulkeley, H., Edwards, G.A.S., Fuller, S., 2014. Contesting climate justice in the city: Examining politics and practice in urban climate change experiments. Global Environmental Change 25, 31–40. doi:10.1016/j.gloenvcha.2014.01.009

Bulkeley, H., Castán Broto, V., Edwards, G.A.S., 2015. An Urban Politics of Climate Change: Experimentation and the Governing of Socio-Technical Transitions. Routledge, London. doi:10.1017/CBO9781107415324.004

Caprotti, F., Cowley, R., 2017. Interrogating urban experiments. Urban Geography 1–10. doi:10.1080/02723638.2016.1265870

Carvalho, L., Mingardo, G., Van Haaren, J., 2012. Green Urban Transport Policies and Cleantech Innovations: Evidence from Curitiba, Göteborg and Hamburg. European Planning Studies 20, 375–396. doi:10.1080/09654313.2012.651801

Castán Broto, V., Bulkeley, H., 2013. A survey of urban climate change experiments in 100 cities. Global Environmental Change 23, 92–102. doi:10.1016/j.gloenvcha.2012.07.005

Castán Broto, V., Bulkeley, H., 2013. Maintaining climate change experiments: Urban political ecology and the everyday reconfiguration of urban infrastructure. International Journal of Urban and Regional Research 37, 1934–1948. doi:10.1111/1468-2427.12050

Coenen, L., Raven, R., Verbong, G., 2010. Local niche experimentation in energy transitions: A theoretical and empirical exploration of proximity advantages and disadvantages. Technology in Society 32, 295–302. doi:10.1016/j.techsoc.2010.10.006

Coenen, L., Truffer, B., 2012. Places and Spaces of Sustainability Transitions: Geographical Contributions to an Emerging Research and Policy Field. European Planning Studies 20, 367–374. doi:10.1080/09654313.2012.651802
Cohendet, P., Grandadam, D., Simon, L., 2010. The Anatomy of the Creative City. Industry & Innovation 17, 91–111. doi:10.1080/13662710903573869
Cugurullo, F., 2018. Exposing smart cities and eco-cities : Frankenstein urbanism and the sustainability challenges of the experimental city. Environment and Planning A 50, 73–92. doi:10.1177/0308518X17738535
Dixon-Woods, M., Cavers, D., Agarwal, S., Annandale, E., Arthur, A., Harvey, J., Hsu, R., Katbamna, S., Olsen, R., Smith, L., Riley, R., Sutton, A.J., 2006. Conducting a critical interpretive synthesis of the literature on access to healthcare by vulnerable groups. BMC Medical Research Methodology 6, 1–13. doi:10.1186/1471-2288-6-35
Dixon-Woods, M., Bonas, S., Booth, A., Jones, D.R., Miller, T., Sutton, A.J., Shaw, R.L., Smith, J.A., Young, B., 2006. How can systematic reviews incorporate qualitative research? A critical perspective. Qualitative Research 6, 27–44. doi:10.1177/1468794106058867
Ernstson, H., Leeuw, S.E.V. Van Der, Redman, C.L., Meffert, D.J., Davis, G., Alfsen, C., Elmqvist, T., 2010. Urban transitions: On urban resilience and human-dominated ecosystems. Ambio 39, 531–545. doi:10.1007/s13280-010-0081-9
Evans, J., 2016. Trials and Tribulations: Problematizing the City through/as Urban Experimentation. Geography Compass 10, 429–443. doi:10.1111/gec3.12280
Evans, J., Karvonen, A., 2014. "Give Me a Laboratory and I Will Lower Your Carbon Footprint!" - Urban Laboratories and the Governance of Low-Carbon Futures. International Journal of Urban and Regional Research 38, 413–430. doi:10.1111/1468-2427.12077
Evans, J.P.M., Karvonen, A., Raven, R. (Eds.), 2016. *The experimental city, Routledge Research in Sustainable Urbanism*. Routledge, London.
Feola, G., Nunes, R., 2014. Success and failure of grassroots innovations for addressing climate change: The case of the Transition Movement. Global Environmental Change 24, 232–250. doi:10.1016/j.gloenvcha.2013.11.011
Fligstein, N., McAdam, D., 2011. Toward a general theory of strategic action fields. Sociological theory 29, 1–26. doi:10.1111/j.1467-9558.2010.01385.x
Fligstein, N., McAdam, D., 2012. A theory of fields. Oxford University Press, Oxford, UK.
Frantzeskaki, N., Broto, V.C., Coenen, L., Loorbach, D. (Eds.), 2017. Urban Sustainability Transitions. Routledge, London.
Geels, F.W., 2011. The roles of cities in technological transitions: analytical clarifications and historical examples, in: Bulkeley, H., Castán Broto, V., Hodson, M., Marvin, S. (Eds.), Cities and Low Carbon Transitions. Routledge, Oxon, pp. 13–28.
Geels, F.W., 2011. The multi-level perspective on sustainability transitions: Responses to seven criticisms. Environmental Innovation and Societal Transitions 1, 24–40. doi:10.1016/j.eist.2011.02.002
Geels, F.W., Raven, R., 2006. Non-linearity and Expectations in Niche-Development Trajectories: Ups and Downs in Dutch Biogas Development (1973–2003). Technology Analysis & Strategic Management 18, 375–392. doi:10.1080/09537320600777143
Gliedt, T., Hoicka, C.E., Jackson, N., 2018. Innovation intermediaries accelerating environmental sustainability transitions. Journal of Cleaner Production 174, 1247–1261. doi:10.1016/j.jclepro.2017.11.054
Gopakumar, G., 2014. Experiments and counter-experiments in the Urban laboratory of water- supply partnerships in India. International Journal of Urban and Regional Research 38, 393–412. doi:10.1111/1468-2427.12076
Grin, J., Rotmans, J., Schot, J., 2010. Transitions towards sustainable development. KSI-book series part I, Routledge Publishers, UK.
Håkansson, I., 2017. The socio-spatial politics of urban sustainability transitions: Grassroots initiatives in gentrifying Peckham. Environmental Innovation and Societal Transitions. doi:10.1016/j.eist.2017.10.003
Hansen, T., Coenen, L., 2015. The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. *Environmental Innovation and Societal Transitions* 17, 92–109.
Hannam, K., Sheller, M., Urry, J., 2006. Editorial: Mobilities, immobilities and moorings. Mobilities 1, 1–22. doi:10.1080/17450100500489189
Hargreaves, T., Hielscher, S., Seyfang, G., Smith, A., 2013. Grassroots innovations in community energy: The role of intermediaries in niche development. Global Environmental Change 23, 868–880.

Heiskanen, E., Jalas, M., Rinkinen, J., Tainio, P., 2015. The local community as a "low-carbon lab": Promises and perils. Environmental Innovation and Societal Transitions 14, 149–164. doi:10.1016/j.eist.2014.08.001
Hodson, M., Geels, F.W., Mcmeekin, A., 2017. Reconfiguring Urban Sustainability Transitions , Analysing Multiplicity. Sustainability 9, 20. doi:10.3390/su9020299
Hodson, M., Marvin, S., 2009. Cities mediating technological transitions: understanding visions, intermediation and consequences. Technology Analysis & Strategic Management 21, 515–534. doi:10.1080/09537320902819213
Hodson, M., Marvin, S., 2010. Can cities shape socio-technical transitions and how would we know if they were? Research Policy 39, 477–485. doi:10.1016/j.respol.2010.01.020
Hodson, M., Marvin, S., Bulkeley, H., 2013. The Intermediary Organisation of Low Carbon Cities: A Comparative Analysis of Transitions in Greater London and Greater Manchester. Urban Studies 50, 1403–1422. doi:10.1177/0042098013480967
Hodson, M., Marvin, S. and Späth, P., 2015. Subnational, Inter-scalar Dynamics: The Differentiated Geographies of Governing Low Carbon Transitions — With Examples from the UK, in Brauch, H. G., Oswald Spring, Ú., Grin, J., and Scheffran, J. (eds) *Handbook on Sustainability Transition and Sustainable Peace*. Springer, pp. 1–13.
Holm, J., Stauning, I., Søndergård, B., 2011. Local climate mitigation and eco-efforts in housing and construction as transition places. Environmental Policy and Governance 21, 183–198. doi:10.1002/eet.569
Hoffmann, M.J., 2011. Climate Governance at the Crossroads: Experimenting with a Global Response after Kyoto, Climate Governance at the Crossroads: Experimenting with a Global Response after Kyoto. doi:10.1093/acprof:oso/9780195390087.001.0001
Hoogma, R., R. Kemp, J. Schot, B. Truffer. 2002. Experimenting for sustainable transport: the approach of strategic niche management. Spon Press, London, Great Britain.
Jørgensen, U., 2012. Mapping and navigating transitions — The multi-level perspective compared with arenas of development. Research Policy 41, 996–1010. doi:10.1016/j.respol.2012.03.001
Karvonen, A., van Heur, B., 2014. 'Urban laboratories: Experiments in reworking cities', *International Journal of Urban and Regional Research*, 38(2), pp. 379–392. doi: 10.1111/1468-2427.12075.
Kemp, R., Schot, J., Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. Technology Analysis & Strategic Management 10, 175–198. doi:10.1080/09537329808524310
Kivimaa, P., Hildén, M., Huitema, D., Jordan, A., Newig, J., 2017. Experiments in climate governance – A systematic review of research on energy and built environment transitions. Journal of Cleaner Production 1–13. doi:10.1016/j.jclepro.2017.01.027
Kullman, K., 2013. Geographies of Experiment/Experimental Geographies: A Rough Guide. Geography Compass 7, 879–894. doi:10.1111/gec3.12087
Longhurst, N., 2015. Towards an 'alternative' geography of innovation: Alternative milieu, socio-cognitive protection and sustainability experimentation. Environmental Innovation and Societal Transitions 17, 183–198. doi:10.1016/j.eist.2014.12.001
Loorbach, D., Frantzeskaki, N., Avelino, F., 2017. Sustainability Transitions Research: Transforming Science and Practice for Societal Change, Annual Review of Environment and Resources. doi:10.1146/annurev-environ-102014-021340
Luederitz, C., Schäpke, N., Wiek, A., Lang, D. J., Bergmann, M., Bos, J. J., Burch, S., Davies, A., Evans, J., König, A., Farrelly, M. A., Forrest, N., Frantzeskaki, N., Gibson, R. B., Kay, B., Loorbach, D., McCormick, K., Parodi, O., Rauschmayer, F., Schneidewind, U., Stauffacher, M., Stelzer, F., Trencher, G., Venjakob, J., Vergragt, P. J., von Wehrden, H. and Westley, F. R. (2016) 'Learning through evaluation - A tentative evaluative scheme for sustainability transition experiments', *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2016.09.005.
McLean, A., Bulkeley, H., Crang, M., 2016. Negotiating the urban smart grid: Socio-technical experimentation in the city of Austin. Urban Studies 53, 3246–3263. doi:10.1177/0042098015612984
Matschoss, K., Heiskanen, E., 2017. Making it experimental in several ways: The work of intermediaries in raising the ambition level in local climate initiatives. Journal of Cleaner Production 169, 85–93. doi:10.1016/j.jclepro.2017.03.037
Mccann, E., 2013. Policy Boosterism, Policy Mobilities, and the Extrospective City. Urban Geography 34, 5–29. doi:10.1080/02723638.2013.778627
McGuirk, P., Dowling, R., Brennan, C., Bulkeley, H., 2015. Urban Carbon Governance Experiments: The Role of Australian Local Governments. Geographical Research 53, 39–52. doi:10.1111/1745-5871.12098

Moloney, S., Horne, R., 2015. Low Carbon Urban Transitioning: From Local Experimentation to Urban Transformation? Sustainability 7, 2437–2453. doi:10.3390/su7032437
Murphy, J.T., 2015. Human geography and socio-technical transition studies: Promising intersections. Environmental Innovation and Societal Transitions 17, 73–91. doi:10.1016/j.eist.2015.03.002
Nevens, F., Frantzeskaki, N., Gorissen, L., Loorbach, D. A., 2013. Urban Transition Labs: co-creating transformative action for sustainable cities. *Journal of Cleaner Production* 50, 111–122. doi: 10.1016/j.jclepro.2012.12.001.
Ong, A. 2011. Introduction: Worlding Cities, or the Art of Being Global. In Roy, A., Ong, A. (eds.) Worlding cities: Asian experiments and the art of being global. John Wiley & Sons.
Petticrew, M., Roberts, H., 2008. Why Do We Need Systematic Reviews?, in: Systematic Reviews in the Social Sciences. Blackwell Publishing Ltd, Oxford, UK, pp. 1–26. doi:10.1002/9780470754887.ch1
Raven, R., Bosch, S. Van den, Weterings, R., 2010. Transitions and strategic niche management: towards a competence kit for practitioners. International Journal of Technology Management 51, 57. doi:10.1504/IJTM.2010.033128
Raven, R., Schot, J., Berkhout, F., 2012. Space and scale in socio-technical transitions. Environmental Innovation and Societal Transitions 4, 63–78. doi:10.1016/j.eist.2012.08.001
Raven, R., Sengers, F., Spaeth, P., Xie, L., Cheshmehzangi, A., de Jong, M., 2017. Urban experimentation and institutional arrangements. European Planning Studies 1–24. doi:10.1080/09654313.2017.1393047
Romero-Lankao, P., Dodman, D., 2011. Cities in transition: Transforming urban centers from hotbeds of GHG emissions and vulnerability to seedbeds of sustainability and resilience. Introduction and Editorial overview. *Current Opinion in Environmental Sustainability* 3, 113–120. doi:10.1016/j.cosust.2011.02.002
Sayer, A., 1984. Defining the urban. GeoJournal 9, 279–284. doi:10.1007/BF00149040
Schot, J., Hoogma, R., Elzen, B., 1994. Strategies for shifting technological systems. The case of the automobile system. Futures 26, 1060–1076. doi:10.1016/0016-3287(94)90073-6
Schot, J., Geels, F.W., 2008. Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. Technology Analysis & Strategic Management 20, 537–554.
Schreuer, A., Ornetzeder, M., Rohracher, H., 2010. Negotiating the local embedding of socio-technical experiments: A case study in fuel cell technology. Technology Analysis and Strategic Management 22, 729–743. doi:10.1080/09537325.2010.496286
Schwanen, T., 2015. The Bumpy Road toward Low-Energy Urban Mobility: Case Studies from Two UK Cities. Sustainability 7, 7086–7111. doi:10.3390/su7067086
Sekulova, F., Anguelovski, I., Argüelles, L., Conill, J., 2017. A “fertile soil” for sustainability-related community initiatives: A new analytical framework. Environment and Planning A 49, 2362–2382. doi:10.1177/0308518X17722167
Sengers, F., Raven, R., 2015. Toward a spatial perspective on niche development: The case of Bus Rapid Transit. Environmental Innovation and Societal Transitions 17, 166–182. doi:10.1016/j.eist.2014.12.003
Sengers, F., Wieczorek, A.J., Raven, R., 2016. Experimenting for sustainability transitions: A systematic literature review. Technological Forecasting & Social Change. doi:10.1016/j.techfore.2016.08.031
Silver, J., 2017. The climate crisis, carbon capital and urbanisation: An urban political ecology of low-carbon restructuring in Mbale. Environment and Planning A 49, 1477–1499. doi:10.1177/0308518X17700393
Smith, A., Fressoli, M., Thomas, H.H., 2014. Grassroots innovation movements: Challenges and contributions. Journal of Cleaner Production 63, 114–124. doi:10.1016/j.jclepro.2012.12.025
Smith, A., Seyfang, G., 2007. Grassroots Innovations for sustainable development: Towards a new research and policy agenda. Environmental Politics 4016, 37–41. doi:10.1080/09644010701419121
Smith, A., Hargreaves, T., Hielscher, S., Martiskainen, M., Seyfang, G., 2016. Making the most of community energies: Three perspectives on grassroots innovation. Environment and Planning A 48, 407–432. doi:10.1177/0308518X15597908
Smith, A., Raven, R., 2012. What is protective space? Reconsidering niches in transitions to sustainability. Research Policy 41, 1025–1036. doi:10.1016/j.respol.2011.12.012
Smith, A., Voß, J.-P., Grin, J., 2010. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. Research Policy 39, 435–448. doi:10.1016/j.respol.2010.01.023
Späth, P., Rohracher, H., 2012. Local Demonstrations for Global Transitions—Dynamics across Governance Levels Fostering Socio-Technical Regime Change Towards Sustainability. European Planning Studies 20, 461–479. doi:10.1080/09654313.2012.651800
Sovacool, B.K., Hess, D.J., 2017. Ordering theories: Typologies and conceptual frameworks for sociotechnical change. Social Studies of Science 47, 703–750. doi:10.1177/0306312717709363

Stirling, A.C., 2014. Emancinpating Transformations: From controlling “the transition” to culturing plural radical progress. STEPS Centre Working Paper, Brighton, UK.
Swilling, M., Hajer, M., 2017. Governance of urban transitions: towards sustainable resource efficient urban infrastructures. Environmental Research Letters 12, 125007. doi:10.1088/1748-9326/aa7d3a
Torrens, J., Johnstone, P., Schot, J., 2018. Unpacking the Formation of Favourable Environments for Urban Experimentation: The Case of the Bristol Energy Scene. Sustainability 10. doi:10.3390/su10030879
Truffer, B., Murphy, J.T., Raven, R., 2015. The geography of sustainability transitions: contours of an emerging theme. Environmental Innovation and Societal Transitions 17, 63–72. doi:10.1016/j.eist.2015.07.004
van den Heiligenberg, H.A.R.M., Heimeriks, G.J., Hekkert, M.P., van Oort, F.G., 2017. A habitat for sustainability experiments: Success factors for innovations in their local and regional contexts. Journal of Cleaner Production 169, 204–215. doi:10.1016/j.jclepro.2017.06.177
van den Bosch, S., Rotmans, J., 2008. Deepening, Broadening and Scaling Up: A framework for Steering Transition Experiments, Knowledge Centre for Sustainable System Innovations and Transitions (KCT)
Verheul, H., Vergragt, P.J., 1995. Social experiments in the development of environmental technology: a bottom-up perspective. Technology Analysis & Strategic Management 7, 315–326. doi:10.1080/09537329508524215
Victor, L., 2008. Systematic reviewing. Social Research Update 1–4. doi:ISSN: 1360-7898
Voytenko, Y., Mccormick, K., Evans, J., Schliwa, G., 2016. Urban living labs for sustainability and low carbon cities in Europe : towards a research agenda. Journal of Cleaner Production 123, 45–54. doi:10.1016/j.jclepro.2015.08.053
Ward, K.G., 2000. State licence, local settlements, and the politics of “branding” the city 18, 285–300. doi:10.1068/c3m
Weed, M., 2005. “Meta Interpretation”: A Method for the Interpretive Synthesis of Qualitative Research. Forum: Qualitative Social Research 6.
Weiland, S., Bleicher, A., Polzin, C., Rauschmayer, F., Rode, J., 2017. The nature of experiments for sustainability transformations : A search for common ground. Journal of Cleaner Production 169, 30–38. doi:10.1016/j.jclepro.2017.06.182
Wieczorek, A.J.A.J., Raven, R., Berkhout, F., 2015. Transnational linkages in sustainability experiments: A typology and the case of solar photovoltaic energy in India. Environmental Innovation and Societal Transitions 17, 149–165. doi:10.1016/j.eist.2015.01.001
Wolfram, M., Frantzeskaki, N., Maschmeyer, S., 2016. Cities, systems and sustainability: status and perspectives of research on urban transformations. Current Opinion in Environmental Sustainability 22, 18–25. doi:10.1016/j.cosust.2017.01.014
Wolfram, M., 2018. Cities shaping grassroots niches for sustainability transitions : Conceptual reflections and an exploratory case study. Journal of Cleaner Production 173, 11–23. doi:10.1016/j.jclepro.2016.08.044