Taking politics seriously.

Evaluating Real-world laboratories (RwLs) as drivers of urban transformations

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Abstract

Cities are seen as central to achieving the UN Sustainable Development Goals. It is argued that policy agendas are easier to implement at the local level than at the national or supranational level. The potential of cities is increasingly recognized at a time when impacts of the climate crisis are becoming more tangible and global efforts to proactively address the causes have been insufficient. Accordingly, there has been a growing debate on how to initiate urban transformations. In Germany, Real-world laboratories (RwLs) have attracted a considerable amount of attention in this context. RwLs, in which scientific actors work together with non-scientific actors to develop and test sustainability solutions, are seen both in the funding landscape and in the scientific literature as an opportunity to initiate sustainability transformations in urban areas.

While the potential of RwLs in the context of urban transformations has been discussed and early experiences have been accumulated, a systematic examination of RwLs as drivers of political urban transformations is missing. Building on RwLs that involve actors from city administrations, a political turn in sustainability science, and literature that describes urban transformations as inherently political, this dissertation addresses the evaluation of RwLs in the context of political urban transformations. Through the inclusion of four research articles, the cumulative dissertation aims to answer the following question: *How can we evaluate Real-world laboratories (RwLs) as drivers of urban transformations?*

The dissertation adopts a qualitative research approach. In the four research articles included, I have applied empirical, conceptual and reflective approaches to evaluation[1]. The four articles are based on a shared epistemological understanding. They use natural, pre-existing data to evaluate RwLs.

The initial question, 'How can we evaluate RwLs as drivers of urban transformations?' is answered in three steps that focus on different components of the initial question and bring together the findings of the included research articles. First, the role of the evaluator is addressed. The combination of different bodies of knowledge is transferred from the level of the transdisciplinary working group to the individual level of the transdisciplinary researcher conducting the evaluation. I discuss how transdisciplinary researchers can combine and make transparent the knowledge they bring from their academic affiliation and the experimental knowledge they gain from the practical implementation of the RwLs and the associated exchanges with the other actors involved in the RwLs (articles #1 and #4).

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[1] For the purpose of my dissertation, I use the I-perspective. However, where I use 'I' or 'my' in relation to the four articles involved in the cumulative dissertation, I deeply acknowledge and value the work and contributions from my co-authors.

Second, I approach what is being evaluated. Based on my articles #2 and #3, I assess how RwLs are connected to urban transformations. I introduce RwLs as governance networks, and as changers of urban governing systems. Thus, I perceive RwLs in terms of the process as well as the outcome understanding of urban transformations (articles #2 and #3).

Third, I elaborate and describe conceptual counterparts to the practical evaluation of RwLs. These can serve as guiding principles for the development of RwL evaluation, particularly in the context of urban transformations. They have been developed based on the evaluations I have designed and conducted in the case-based articles #2, #3 and #4.

In this way, the contribution of the dissertation lies in three areas. First, I hope to contribute to a discourse on RwLs that pays attention to the different bodies of knowledge of transdisciplinary researchers, and that considers existing, natural documents in the evaluation of RwLs. I also aim to contribute to a stronger connection between RwLs and governance approaches. The view of RwLs as contexts for learning and trialing practical sustainability solutions can be expanded to include governance perspectives. Finally, I attempt to inform practical evaluations. The proposed conceptual counterparts function as design choices for the conceptualization of empirical evaluations.

Keywords: Real-world labs, urban transformations, evaluation, transdisciplinary research, societal impact, political impact

Zusammenfassung

Städten wird zur Erreichung der UN-Nachhaltigkeitsziele eine zentrale Bedeutung zugesprochen. So wird argumentiert, dass politische Vorhaben auf lokaler Ebene einfacher umzusetzen sind als auf nationaler oder supra-nationaler Ebene. In Zeiten, in denen die Auswirkungen der Klimakrise spürbarer werden und globale Bemühungen, den Ursprüngen der Klimakrise pro-aktiv zu begegnen, bisher unzureichende Wirkung gezeigt haben, wird vermehrt auf dieses Potential von Städten gesetzt. Es wird diskutiert, wie urbane Transformationen angestoßen werden können. Als ein möglicher Katalysator werden transdisziplinäre und transformative Forschungsansätze betrachtet. In Deutschland haben in diesem Zusammenhang Reallabore verstärkt Aufmerksamkeit erfahren. In Reallaboren arbeiten wissenschaftliche Akteur*innen mit nicht-wissenschaftlichen Akteur*innen zusammen, um Nachhaltigkeitslösungen zu entwickeln und zu testen. Sowohl in der Förderlandschaft als auch in wissenschaftlicher Literatur werden Reallabore als Chance betrachtet, Nachhaltigkeitstransformationen im städtischen Raum anzustoßen.

Während mögliche Potentiale von Reallaboren im Zusammenhang mit urbanen Transformationen bereits diskutiert und erste Erfahrungsberichte gesammelt wurden, steht eine systematische Beschäftigung mit Reallaboren als Treiber (politischer) urbaner Transformationen noch aus. Aufbauend auf Reallaboren, in denen Akteur*innen aus Stadtverwaltungen beteiligt sind, einem *political turn* in den Nachhaltigkeitswissenschaften und Literatur, die urbane Transformationen als inhärent politisch beschreibt, beschäftigt sich die vorliegende Arbeit mit der Evaluation von Reallaboren im Zusammenhang mit politischen urbanen Transformationen. Durch den Einbezug von vier Forschungsartikeln hat die kumulative Dissertation das Ziel die folgende Frage zu beantworten: *Wie können wir Reallabore als Treiber urbaner Transformationen evaluieren?*

Hierbei verfolge ich einen qualitativen Forschungsansatz. In den vier Forschungsartikeln, die dieser Dissertation zugrunde liegen, habe ich empirische, konzeptionelle und reflektive Evaluationsansätze angewandt[2]. Die Forschungsartikel fußen auf demselben epistemologischen Verständnis. Die Artikel stützen sich auf natürliche, bereits bestehende Daten zur Evaluation von Reallaboren.

Die Ausgangsfrage „Wie können wir Reallabore als Treiber urbaner Transformationen evaluieren?" beantworte ich in drei Schritten. Dabei konzentriere ich mich auf verschiedene

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[2] Im Rahmen meiner Dissertation verwende ich die Ich-Perspektive. Wenn ich "ich" oder "mein" in Bezug auf die vier Forschungsartikel, auf denen diese Dissertation beruht, verwende, verweise ich hiermit auch auf die Arbeit meiner Mitautor*innen.

Bestandteile der Ausgangsfrage und bringe die Ergebnisse der vier Forschungsartikel zusammen.

Im ersten Schritt steht die evaluierende Person im Fokus. Ich übertrage die Kombination verschiedener Wissensbestände von der Ebene der transdisziplinären Arbeitsgruppe auf die individuelle Ebene der transdisziplinär Forschenden. Ich diskutiere, wie transdisziplinär Forschende ihre Wissensbestände, die sie aus akademischer Anbindung besitzen, sowie Erfahrungswissen, das sie durch die praktische Umsetzung des Reallabors und dem Austausch mit beteiligten Akteur*innen haben, verbinden und transparent machen können (Artikel #1 und #4).

Im zweiten Schritt betrachte ich das Objekt der Evaluation. Basierend auf meinen Artikeln #2 und #3 erarbeite ich, wie Reallabore mit urbanen Transformationen in Verbindung stehen. Dabei betrachte ich Reallabore einerseits als Governance Netzwerke und beleuchte andererseits die Auswirkungen von Reallaboren auf städtisches Regieren. Folglich begreife ich Reallabore sowohl im Sinne des Prozess- als auch des Ergebnis-Verständnisses urbaner Transformationen (Artikel #2 und #3).

Zuletzt stelle ich im dritten Schritt Begriffsgegenstücke der Reallaborevaluation vor. Diese können als Leitprinzipien für die Entwicklung von Reallaborevaluation, insbesondere im Zusammenhang mit urbanen Transformationen, dienen. Sie wurden basierend auf den Evaluationen, die ich in den Artikeln #2, #3 und #4 entworfen und durchgeführt habe, entwickelt.

Der Beitrag der Dissertation liegt damit in drei Bereichen. Zum einen möchte ich zu einem Reallabor-Diskurs beitragen, der auf den verschiedenen Wissensbeständen der transdisziplinär Forschenden aufbaut, und bereits bestehende, natürliche Dokumente bei der Evaluation von Reallaboren mitberücksichtigt. Zum anderen strebe ich an, zu einer stärkeren Verbindung von Reallaboren und Governance beizusteuern. Der Blick auf Reallabore als Ort des Lernens und als Rahmen, in dem praktische Nachhaltigkeitslösungen getestet und evaluiert werden, ist um Governance Perspektiven erweiterbar. Zuletzt soll diese Dissertation einen Beitrag für praktische Evaluationen leisten. Die vorgeschlagenen Begriffsgegenstücke stellen *design choices* für die Konzeption empirischer Evaluationen dar.

Schlagworte: Reallabore, Urbane Transformationen, Evaluation, Transdisziplinäre Forschung, Gesellschaftliche Auswirkungen, Politische Auswirkungen

1. Introduction

Cities around the world are seen as the key arenas for solving sustainability challenges (Castán Broto 2017; Roebke et al. 2022; Grainger-Brown et al. 2022; Wolfram et al. 2016; Torrens et al. 2021). The design and implementation of policies that address sustainability issues are considered more feasible at the city level than at the nation-state level (Sassen 2015). The narrative of urban transformations[3] has become an aspirational theme for sustainability science (Hölscher & Frantzeskaki 2021; Elmqvist et al. 2019; Scoones et al. 2020; Bentz et al. 2022). The topic has gained momentum of attention, and a peer-reviewed journal, *Urban transformations*, was established a couple of years ago, 'invit[ing] contributions that address transformative urban change in the global North and South, and help to practically shape it towards sustainability' (Urban Transformations 2024). Urban transformations are seen as a prerequisite for achieving global sustainability and reaching the Sustainable Development Goals (Grainger-Brown et al. 2022; Krellenberg & Koch 2021; Ansell et al. 2022). Based on this promising potential in times of increasingly tangible effects of the climate crisis (IPCC 2023), approaches to catalyze urban transformations are widely discussed, often including those based on experimentation and inter-institutional cooperation (Bylund et al. 2022; Bulkeley et al. 2023; Evans 2016; Torrens et al. 2021; Eneqvist & Karvonen 2021). One of these approaches is Real-world laboratories (RwLs), which has received considerable attention, particularly in German-speaking countries (Wagner 2017; Kern & Haupt 2021; Hahne 2021).

In RwLs, science actors work together with actors from other societal sectors to develop and trial sustainability solution options in the form of experiments (Schäpke et al. 2018). As transformative and solution-oriented research endeavors, RwLs are associated with societal hopes (Barbarino 2021; Kok et al. 2023). They are explicitly linked to the prospect of urban transformations (Kraaz et al. 2022; Pärli et al. 2022; Huning et al. 2021; Libbe & Marg 2021). This nexus has also been transported through public funding lines (Deutscher Bundestag 2018). RwLs are therefore approached as drivers for urban transformations in both scientific research communities as well as in funding policies. However, little is known about *how* RwLs actually contribute to urban transformations and how this contribution can be evaluated (Lawrence et al. 2022; Huning et al. 2021). The lack of evaluations found in this context is consistent with the finding that evaluation approaches for RwLs in general are scarce (Geiger et al. 2017; Kok et al. 2023), especially those that focus on the societal impacts of RwL activities (Wanner et al. 2023; Schäpke et al. 2024).

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[3] In the literature, both the plural as well as the singular forms of urban transformation(s) are used. In this dissertation, I will mostly use the plural urban transformations, as RwLs are conducted in and affect multiple urban areas. However, with reference to the concept and theory behind (urban) transformation, I will occasionally use the singular form.

At the same time, limited attention has been paid to the political dimensions of RwLs (Böschen 2022; Engels et al. 2019). The specific potential of RwLs co-implemented by incumbent city regime actors has not yet been sufficiently addressed. Political-administrative actors representing public institutions, such as city administrations, have formal power to enable political change by building upon their experiences in the transdisciplinary and experimental setting of a RwL (Grin 2020). This premise holds great significance for urban transformations, considering that 'urban transformation depends on who has the power to act' (Romero-Lankao et al. 2018, 754). Accordingly, I follow approaches that understand transformations as inherently political (Scoones et al. 2020; Pichler 2023), and that transformations are shaped and enabled by political decisions (Blythe et al. 2018), which also inspired the title of my dissertation, 'taking politics seriously' (Scoones et al. 2020, 70).

Based on the common distinction between the different spheres and interdependencies of transformation, namely the practical, the political, and the personal (O'Brien & Sygna 2013), this dissertation focuses on the effects from RwLs in the political sphere of transformation. More specifically, it focuses on how to evaluate the contributions of RwLs in the political sphere of urban transformation. Therefore, the dissertation forms part of a political turn in sustainability science (Johnstone & Newell 2018; Knappe et al. 2019), as it concentrates on RwLs involving political-administrative actors who 'make binding decisions that cannot be made by the market or non-state actors' (Johnstone & Newell 2018, 74). Recognizing the role of politics in both RwLs and urban transformations, this dissertation aims to answer the question:

How can we evaluate RwLs as drivers of urban transformations?

This dissertation contains four articles which I either co-authored as first author (articles #1, #2 and #3), or where I was a contributing author (#4). All four articles are influenced by my experiences as a transdisciplinary researcher involved in the RwL Lüneburg 2030+ conducted in Lüneburg, Germany. This RwL was carried out between members of the city administration, university, and civil society. To address the main question of how we can evaluate RwLs as drivers of urban transformations, and to cope with the complexity of this question, I formulated three focused research questions (RQs). These RQs emphasize different components of the main question. They provide an answer to the fundamental question that needs to be clarified before any evaluation takes place, namely: who evaluates what and for what purpose (Wiechmann et al. 2012)? The RQs therefore represent a gradual approach to the main question, as presented in figure 1.

How can we evaluate RwLs as drivers of urban transformations?

RQ3   RQ1   RQ2
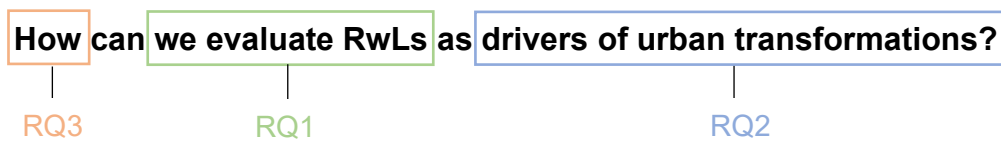
RQ 1: How to evaluate RwLs as transdisciplinary researchers?

Focus on: **Who** conducts the evaluation.

Articles #**1** & #**4**

RQ 2: How do RwLs drive urban transformations?

Focus on: **What** is being evaluated.

Articles #**2** & #**4**

RQ 3: How to design the evaluation for RwLs as drivers of urban transformations?

Focus on: **How** it is being evaluated.

Articles #**2**, #**3** & #**4**

Figure 1 The gradual approach to the main question of the dissertation.

In addressing RQ1 'How to evaluate RwLs as transdisciplinary researchers?', I focus on the role of the transdisciplinary researcher conducting the evaluation in a RwL. Based on two of my articles (#1 and #4) and the transdisciplinary understanding of RwLs and their evaluation, I draw on the different types of knowledge that are embodied in RwL researchers and shape the (reflective) evaluation of RwLs.

In responding to RQ2 'How do RwLs drive urban transformations', I approach the specific object of evaluation. I discuss how different understandings of governance in the context of RwLs introduce an understanding of RwLs as drivers of urban transformations (articles #2 and #3).

RQ3 'How to design the evaluation of RwLs as drivers of urban transformations' is approached by introducing five counterparts of RwL evaluation (articles #2, #3 and #4). I discuss their function as guiding principles for designing and implementing evaluations directed to RwLs and their contribution to urban transformations.

In doing so, I position the contribution of my dissertation at the crossroads of three fields, as shown in figure 2. By focusing on the types of knowledge embodied in RwL researchers conducting evaluations, I contribute to RwL evaluation discourses that are not necessarily

linked to urban transformations. By assessing how RwLs drive urban transformations both as governance networks and governance changers, I discuss an additional view of RwLs that goes beyond testing practical solutions and establishing university-centered collaborations. Drawing upon the case-based articles (#2, #3 and #4) and reflecting on the ways I developed and applied evaluation approaches for RwLs myself, I aim to provide an overview of five conceptual pairs that inform the design of evaluations, focusing on RwLs and their contribution to urban transformations.
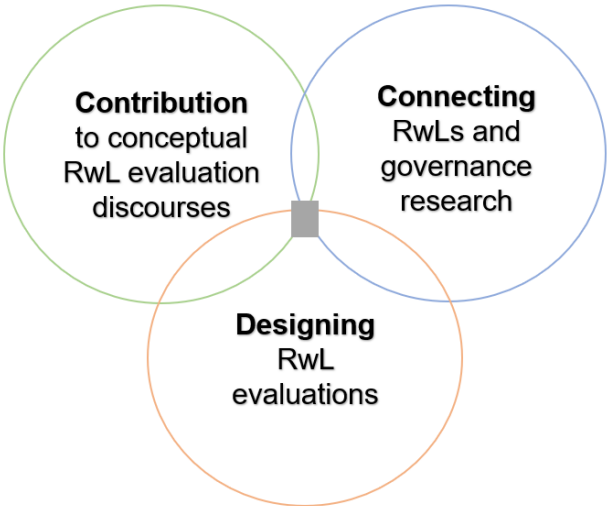

Figure 2 The aimed-for contribution at the interface of three thematic areas.

This dissertation is structured as follows. Section 2 presents the theoretical background on which this dissertation is based. This includes a description of RwLs as transdisciplinary experimental research settings, and the introduction of how I use the term urban transformation. In section 3, I present the research design of this dissertation. I provide an overview of the methodological approaches I used in the four articles. I critically position my work in one school of qualitative research. Further, an overview of the included articles is provided. The section concludes with a presentation of the RwL cases I focused on in my articles #2, #3 and #4. Section 4 is the results section and includes the four research articles. In section 5, I synthesize the findings in three steps, guided by the three research questions presented above. First, I discuss the role of the transdisciplinary researchers evaluating RwLs, building on different knowledge types that they possess. Second, I present governance perspectives applicable to RwLs in order to approach them as drivers of urban transformations. Third, I derive five juxtapositions of RwL evaluation that inform evaluations directed at RwLs and their contribution to urban transformations. Section 6 concludes by reflecting on the key insights gained and suggesting avenues for future research.

2. Theoretical background

2.1 Real-world laboratories

RwLs are jointly established research settings, in which scientific actors and members from other societal sectors work together to confront real-world problems collaboratively (Hahne 2021). The actors jointly develop, trial, and evaluate sustainability solution options through experimentation (Seebacher 2021). Experiments are the core elements of RwLs (Hahne 2021; Böschen 2022; Rogga et al. 2018). Schäpke et al. (2018) introduced five key characteristics of RwLs, namely, 1) contribution to transformation, 2) experiments as research method, 3) transdisciplinarity as research mode, 4) long term-orientation, scalability, and transferability of results, as well as 5) learning and reflexivity. Additionally, scholars have brought forward different perspectives to encounter RwLs. Prominent examples are structural (Schneidewind et al. 2018), processual (Rose et al. 2018) or actor-oriented (Seebacher et al. 2018) perspectives on RwLs. To generate an impression of the RwLs which I focus on here, I approach RwLs by their, a) actor-specific, as well as b) structural characteristics, drawing on the proposed key characteristics, 1) contribution to transformation, 2) experiments as research method, and 3) transdisciplinarity as research mode.

An actor-oriented perspective on the RwLs in focus

RwLs build upon transdisciplinary principles. Transdisciplinarity is generally described as a research mode where knowledge of real-world problems is not only produced through academia but originates from the collaborative processes between scientific and non-scientific actors (Rigolot 2020; Schäpke et al. 2018; Lang et al. 2012). Accordingly, the role of science actors as co-leaders of RwLs is a requirement (Seebacher et al. 2018; Kanning et al. 2021). While scientific partners in RwLs and the different tasks they perform throughout the course of RwLs have previously been discussed in the literature (Hilger et al. 2018), there has been less focus on the other societal actors involved in RwLs (Wagner 2017).

The scope in this dissertation is on RwLs that represent a 'second generation of initiatives' (Grin 2020, 683). These RwLs are actively shaped by members of city administration. These incumbent regime actors hold the formal power to enable or hinder long-term urban transformation (Evans et al. 2021; Peris & Bosch 2020). The specific roles and power relations associated with the involvement of political-administrative actors in RwLs is underrepresented in the literature (Wagner 2017; Kronsell & Mukhtar-Landgren 2018). This observation aligns with the identified lack of adequate consideration for power distributions in research settings that share strong similarities with RwLs, such as (experimental) transdisciplinary research formats (Fritz & Binder 2020; de Geus et al. 2023; Grandin et al. 2018), sustainability

interventions (Romero-Lankao et al. 2018), and transformative spaces (Pereira et al. 2020a). Drawing on the insights of these scholars, I argue that RwLs in which members of city administrations are active partners require different evaluation approaches to assess their contributions to transformation. These evaluation approaches need to consider issues of formal power - especially for assessing impacts in the political sphere of transformation.

The RwLs I focus on in this dissertation consist of members from university, civil society, and city administration. The special expression of their transdisciplinary collaboration is shown in figure 3, which also emphasizes the contexts in which these RwLs are located.

The scope of my dissertation is RwLs as drivers for transformations in their immediate geographical contexts, in most cases the city in which they are physically embedded (Frantzeskaki et al. 2018). However, cities and municipalities do not exist in a vacuum. They are influenced by and also influence their direct geographical surroundings (Kern 2023). Further, they are embedded in vertical multilevel governance contexts (Ehnert et al. 2018). Accordingly, even though I focus specifically on the urban contexts where the RwLs are located, both physically through their offices as well as through their thematic scope and their site-based actors, I am aware of their embeddedness in other political and geographical contexts.
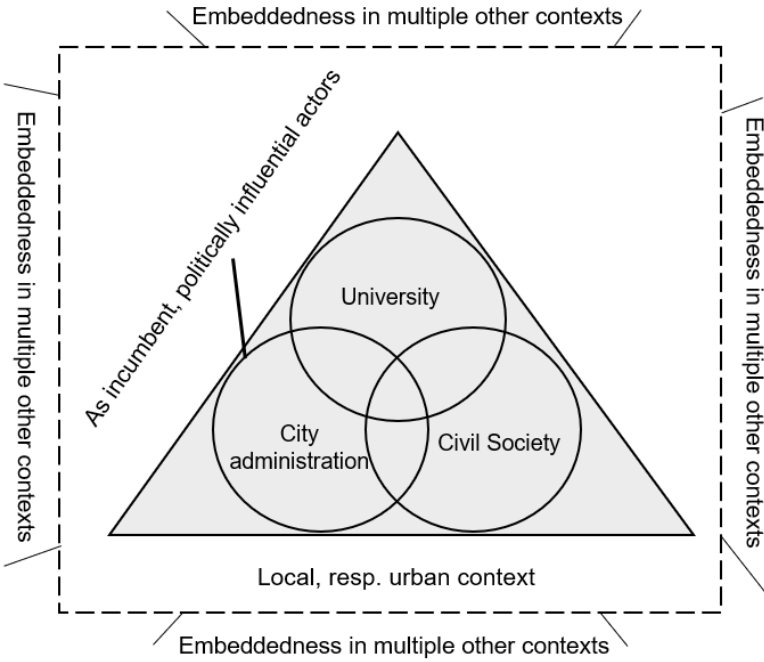

Figure 3 Actor-centered view of the RwLs I focus on.

A structural perspective on the RwLs in focus

My RwL understanding strongly aligns with structural perspectives on RwLs as described by Schneidewind et al. 2018. RwLs consist of an overall lab context, in which experiments are embedded, which are described as their core research method (Schäpke et al. 2018). Following Beecroft et al. (2018), real-world experiments initiate and accompany tangible transformation processes, especially through interventions. Experiments yield insights into the intricacies of such processes. Accordingly, real-world experiments consist of interventions, which are seen as actions that induce (temporary) change in real-world contexts (Caniglia et al. 2017; Wanner et al. 2018; Hahne 2021).

Article #1 presented the modular understanding of RwLs. In all four articles involved in this dissertation, I made it transparent which component(s) the focus is on. The findings derived from the scoping literature review conducted in article #1 suggested that evaluations focusing on labs, experiments and interventions follow different logics. Article #2 developed an evaluation approach applied to one single experiment conducted within a RwL. In article #3, RwLs were evaluated to assess impacts linked both to the overall lab contexts as well as to single real-world experiments. Article #4 focused on the evaluation of labs, actively excluding the focus on experiments and their outcomes (figure 3).
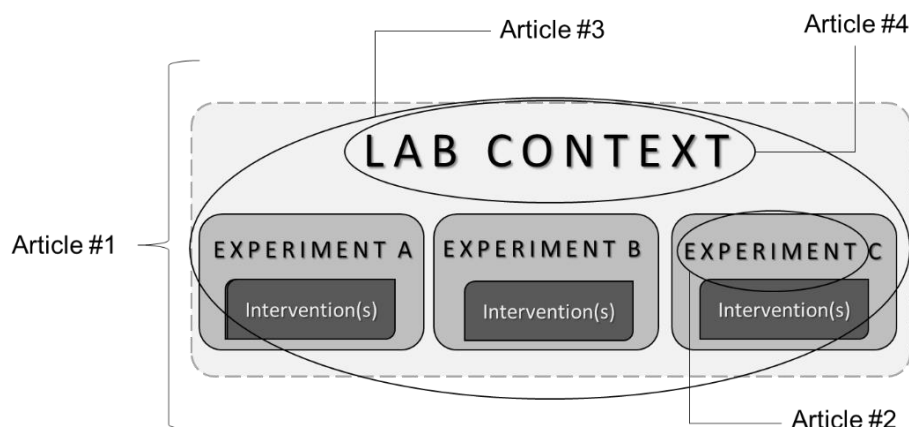
Figure 4 Modularity of RwLs and foci of the involved articles (based on Kampfmann et al. 2022, modified).

In the case-based evaluations conducted in articles #2, #3 and #4, I directed my attention towards experiments and lab contexts rather than interventions for two reasons. First, experiments and lab contexts depend on collaborations between different societal actors (Peng et al. 2019; Eneqvist & Karvonen 2021; Beecroft et al. 2018). Accordingly, real-world experiments and lab contexts are better suited to evaluations that recognize the opportunities for urban transformations that arise from the involvement of city administration actors than interventions. Second, interventions have often been linked to individual behavior and attitude changes (Romero-Lankao et al. 2018; Pärli et al. 2022), reflecting RwL research strands that

emphasize individual sustainability (Böschen 2022). This dissertation aims to embed evaluations of RwLs in broader societal and political contexts. Therefore, there is little emphasis on individual agency, as this focus 'may distract attention from ways of activating political and collective agency for system change' (Vogel & O'Brien 2022, 654). By focusing on experiments and lab contexts and their specific effects, I aim to highlight the set of effects that 'represent the ultimate aspiration of solution-oriented sustainability research, namely real-world change in the form of structural change and action' (Wiek et al. 2014, 122).

2.2 Urban transformations

The concept of urban transformation has no conclusive definition (Kronvall et al. 2023; Maassen & Galvin 2019; Grainger-Brown et al. 2022). I do not intend to provide a comprehensive definition of the concept that encompasses all relevant approaches in the field. Rather, I aim to be transparent about how I use the term urban transformations in this framework paper and the literature from which this meaning is derived.

The term transformation is used to describe 'change as an emerging process of pluralistic and politically contested reconfigurations of the status quo' (Goetz et al. 2020, 338). This definition emphasizes both the process and the outcome of achieving change. Accordingly, following Hölscher & Frantzeskaki (2021), the term urban transformations is directed to the processes of change that take place *in* cities as well as to the changes *of* cities. The outcome perspective of urban transformations (changes *of* cities) emphasizes the traceable changes of urban systems, which may include changes in infrastructure systems, service delivery institutions and governance (Elmqvist et al. 2019).

In addition to the understanding of urban transformations as processes and outcomes for change, I draw on its normative meaning, as discussed in the Introduction. The concept of urban transformations includes a normative orientation that emphasizes the need for change (Hölscher & Frantzeskaki 2021; McCormick et al. 2013).

Building on the definition of Goetz et al. 2020, I do not consider urban transformations - seen as processes and outcomes - to be necessarily radical. Rather, I use the term urban transformations to capture changes *of* cities on their way to becoming more sustainable, with an emphasis on changes *in* the way societies are governed (Caniglia et al. 2021). My view of urban transformations therefore encompasses, a) the normative orientation toward sustainability, b) the processes of achieving changes, and c) the actual, traceable outcomes of such processes.

Building upon the work by Hölscher & Frantzeskaki (2021), my dissertation offers evaluation approaches for RwLs that capture the processes and dynamics that drive place-based

transformations *in cities* as well as the effects transformations have on their urban (sub-) systems *of cities*. Hölscher & Frantzeskaki (2021) also introduced the perspective of transformation *by cities*, focusing on how change dynamics in cities impact their hinterland and other distant territories. Although I am aware of this transformation possibility, which I acknowledged theoretically in chapter 2.1, it is not (empirically) addressed in the four articles involved in this dissertation.

From the perspective applied in this thesis, urban transformations are brought forward through both novel collaborations building upon the combination of different knowledge systems, as well as formal political changes (Vogel & O'Brien 2022). Therefore, I follow scholars who describe urban transformations as driven and induced by urban governance (Patterson et al. 2016; Friend et al. 2016; Burch et al. 2018). Urban transformations 'focus attention on the planning and governance dimensions of change, placing a strong emphasis on strategies and policies that trigger radical change in multiple urban systems' (Burch et al. 2018, 308). At the same time, I stress that the processes leading to those changes resulted from transdisciplinary working mechanisms established in RwLs.

3. Research approach

3.1 Overview of approaches used

To answer the overall question of how to evaluate RwLs for urban transformations, I applied and combined different methodological approaches, drawing on different types of empirical data. In the first article #1, I conducted a scoping literature review. I identified empirical studies in which the different components of RwLs, namely labs, experiments and interventions were evaluated. This encompassed studies from various academic fields, such as public health and educational science. I conducted a qualitative content analysis using deductive categories (Mayring 2000). These codes were derived from the field of evaluation research (e.g., focusing on methodological approaches, time scopes and research objectives) as well as from RwL research discourses (e.g., concentrating on the role of the researcher and the involvement of participants in evaluation).

In article #2, I developed an evaluation framework that is informed by models from transdisciplinary and governance research. The framework is applicable for evaluating real-world experiments as contexts where governance networks between public and non-public actors are established. This conceptual approach was supplemented through the exemplary empirical application of the framework directed at one real-world experiment conducted within the RwL Lüneburg 2030+. In this way, the framework served as a deductive category system

for analyzing material produced throughout the course of the real-world experiment, such as minutes of meetings.

In article #3, I conducted a policy document analysis for eight German cities in which city administrations co-implemented RwLs. First, I identified suitable documents provided by the respective city council information systems, in which RwLs were cited as reasons for political changes implemented through governmental bodies. This body of material included, for example, resolutions and budget plans. After identifying suitable documents from the body of material provided by city council information systems, I conducted a deductive-inductive qualitative content analysis (Gläser & Laudel 2009).

Article #4 was inspired by reflective research approaches (Schneider et al. 2023; Roux et al. 2010). By examining the process and the design features from the RwL Lüneburg 2030+, emergent impacts were identified. This approach was guided by literature on societal impacts resulting from transdisciplinary research (Schäfer et al. 2021), as well as by the concept of emergent impacts (Jahn 2021).

The four articles included in this thesis differ regarding their research foci. Combining them offers support to answer the main question of how to evaluate RwLs as drivers of urban transformations. The three RQs that were formulated in the Introduction offer a gradual approach to the main question. These are answered through the following combinations of articles.

RQ1: How can we evaluate RwLs as transdisciplinary researchers?

The combination of articles #1 and #4 provides the basis for discussing the role of the transdisciplinary researcher involved in the RwL as evaluator. Through the combination of findings from the scoping literature review together with those from reflective evaluation approaches focusing on societal impacts from RwL processes, I assess the knowledge types that researchers involved in RwLs possess. I reflect on how to evaluate RwLs as researchers who are involved in both transformative and action-oriented as well as disciplinary, institution-based research.

RQ 2: How do RwLs drive urban transformations?

Building upon articles #2 and #3, it is discussed how RwLs function as drivers of urban transformations. Articles #2 and #3 applied different forms of qualitative content analyses. The groups of documents they analyzed differ. The process applied in article #2 is largely based on non-public documents that were accessible to me due to my involvement in the RwL and the corresponding real-world experiment. The empirical approach used in article #3 only included publicly available documents provided by city councils. Articles #2 and #3 also applied

different understandings of governance to RwLs. Both understandings were developed from the literature and were empirically supported through the results of the empirical analyses conducted. Taken together, a holistic governance-oriented view on RwLs as urban transformation drivers will be provided.

RQ 3: How to design the evaluation for RwLs as drivers for urban transformation?

Through a triangulation of the work from articles #2, #3 and #4, key counterparts for designing evaluations are proposed. These are based on the experiences I gained while developing heterogenous case-based evaluation approaches for RwLs and their components.

3.2 Positioning my work in qualitative transdisciplinary research

The methodological approaches used in the four articles involved in this dissertation build upon the same understanding of qualitative research. Flick (2002) proposed three research perspectives in qualitative research: a) approaches to assess subjective viewpoints, b) description of the making of a social situation, or c) hermeneutical analysis of underlying structures. The perspective applied throughout all four articles is located in b) the description of the making of social situations. Accordingly, all four articles build upon the theoretical positions of ethnomethodology and constructivism (ibid.). They share the same epistemological understanding, which has been considered challenging for transdisciplinary research (Lawrence 2015).

Data collection in this school of qualitative research is characterized by an attempt to make use of natural data without using explicit, reconstructive methods such as interviews (Flick 2002). The term natural data refers to existing documents that are non-reactive (Salheiser 2014; Hoffmann 2018). The material I used in all four articles was not created artificially to answer my research questions (Ackel-Eisnach & Müller 2012; Bowen 2009). Rather, the material my analyses were based on, was selected out of a body of pre-existing documents, that were originally created for other purposes (Hoffmann 2018). Accordingly, individual viewpoints of the societal actors involved in the RwLs have not been explicitly captured in the four articles of this dissertation. While the overall evaluation of the RwL Lüneburg 2030+, in which I was involved as a researcher, was informed by data derived from interviews and surveys, I decided not to draw on this type of material to answer the question of how to evaluate RwLs for urban transformations. I decided to only draw on natural data due to the following considerations:

First, natural documents hold the possibility to function as proof for causal linkages between RwLs and effects. It is considered difficult to derive clear cause-effect chains for transdisciplinary research formats (Nagy & Schäfer 2021; Bergmann et al. 2017). In article #3,

I analyzed official documents provided by city council information systems in which RwLs (and single experiments conducted within them) served to justify political changes implemented in the city by public bodies. Accordingly, cause-effect chains became transparent and traceable.

Second, the selection and analysis of natural data aims to avoid well-known biases associated with interviews and face-to-face surveys. Prominent examples of these are social desirability bias (Bergen et al. 2020) and inadequate recollection by the interviewees. Work on transdisciplinary and action-oriented research suggests that participation bias is quite common in related evaluations, resulting in low response rates (Zscheischler et al. 2018; Hahn et al. 2023). The focus on participation bias goes hand-in-hand with a critical assessment of which stakeholder groups have the time and resources to participate in evaluation interviews or similar settings.

Third, the decision to focus exclusively on natural data stems from my experience as a transdisciplinary researcher collaborating with civil society actors. For some evaluation questions, it is sufficient to use existing data sources. Such an approach takes into account the time constraints of (unpaid) civil society actors.

Fourth, studies assessing *perceived* impacts exist both for transdisciplinary research settings (de Jong et al. 2016; Fritz et al. 2019; Schäfer et al. 2021) and for RwLs (Bergmann et al. 2021; Libbe & Marg 2021). These works drew on the opinions formulated by actors involved in these research contexts. I argue that focusing on pre-existing data is a promising addition. It does not put more pressure on single individuals involved in RwLs (Ochsner 2023). To connect this understanding to urban transformations, I refer to Sassen (2015), who stated that a focus on the 'urban' should not be limited to a concentration on individual behavior and households.

3.3 Overview of articles

The evaluation approaches applied in the case-based articles #2, #3 and #4 differ in terms of their evaluation objectives, methodological approaches and the type of empirical data used. However, all the four studies involved in this dissertation build on the same modular understanding of RwLs that was first presented in article #1. Thereby, the articles evolving around concrete cases (#2, #3 and #4) complement each other. The evaluation foci shift from real-world experiments (article #2) to RwLs including labs and experiments (article #3), to the sole focus of the overall lab process where findings from experiments were actively excluded (article #4). The fruitful combination of the case-based articles, building on shared epistemological understandings, supports the provision of an answer to the overall research question of how to evaluate RwLs as drivers of urban transformations (figure 5).
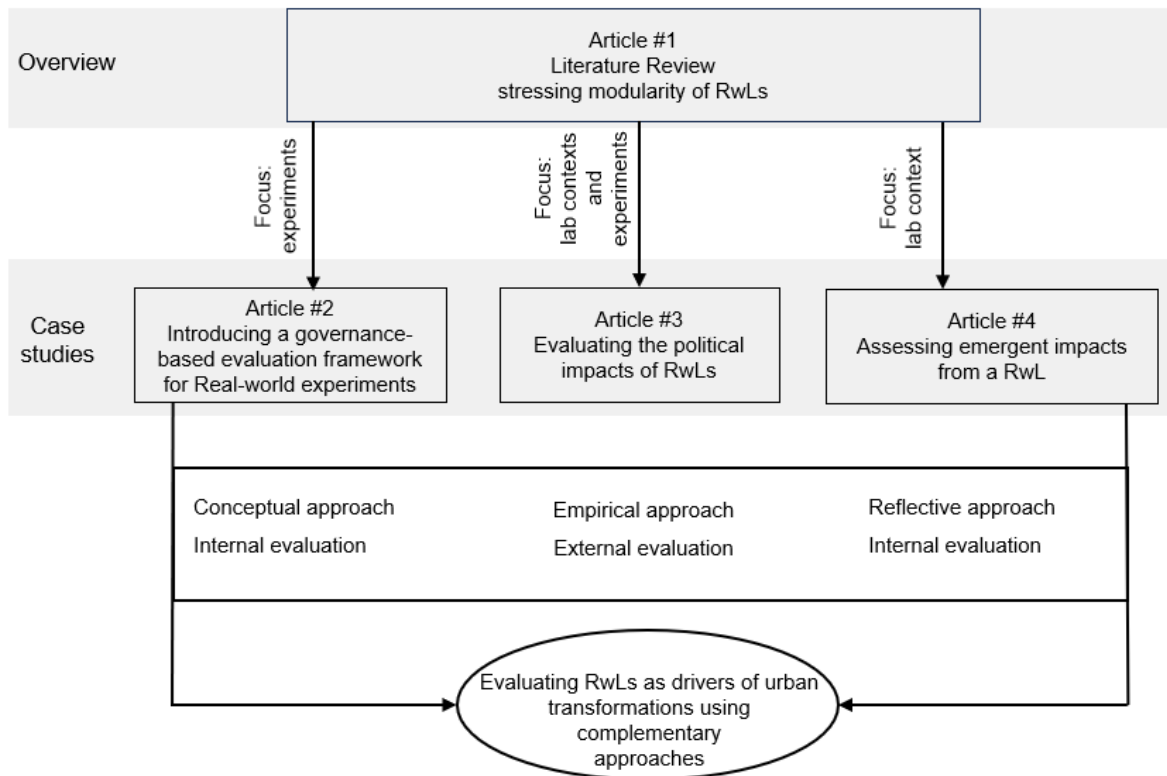
Figure 5 Overview of the relationship between the included articles.

While the case-based studies (articles #2, #3 and #4) refer to outcomes and impacts of the RwLs and experiments, they differ in what they link these outcomes and impacts to. Articles #2 and #4 assess outcomes and impacts that can be traced back to processes and collaborations. The RwL impacts discussed in article #3 are not linked to process characteristics. In this article, I identified political impacts resulting from RwLs and discussed possible links between these impacts and the design features of the respective RwLs (such as the level of funding and thematic scope of the RwLs). Following Belcher et al. 2019, the term outcomes as it is used here refers to changes that occur within the sphere of influence of the real-world experiment (article #2), while the term impacts refers to changes that occur outside the sphere of influence of the RwLs (article #3, #4).

The approaches used in articles #2 and #4 are strongly influenced by my active involvement in the RwL and real-world experiment. The approach used in article #3 differs. The study provides only limited insights into processes and actor constellations. Rather, the main contribution of article #3 is to offer a traceable, replicable empirical approach to identifying real-world political impacts of RwLs based on an external evaluative approach. The article thus explains how the impacts of RwLs in the political sphere of urban transformation can be demonstrated in a comprehensible way.

In order to gain a deeper understanding of the four articles, table 1 provides an overview, including their links to the specific research questions formulated in the Introduction and their implications for the dissertation.

Table 1 Overview of the four involved research articles.

	Article #1	Article #2	Article #3	Article #4
Title	Toward a modular evaluation approach of Real-world laboratories: Findings from a literature review	Governance for urban sustainability through Real-world experimentation – Introducing an evaluation framework for transformative research involving public actors	Analyzing the political impact of Real-world laboratories for urban transformation in eight German 'Cities of the Future'	Impacts beyond experimentation – Conceptualising emergent impacts from long-term Real-world laboratory processes
Journal	Research Evaluation	Cities	Environmental Science and Policy	GAIA - Ecological Perspectives for Science and Society
Status in Journal	Published	Published	Published	Published
Article specific research question	How have evaluations of interventions, experiments, and labs been conducted in different academic disciplines?	How can real-world experiments be evaluated as governance networks?	Which political impacts have the RwLs from the 'Cities of the future' had?	Which impacts emerge from long-term Real-world laboratory processes?
Research approach and methods	Literature Review, Deductive content analysis, Qualitative type construction	Conceptual work, (Exemplary) deductive content analysis	Policy document discourse analysis, Deductive-inductive content analysis	Conceptual work, Participatory reflection approach
Role in Research	External approach	Participatory approach	External approach	Participatory approach
Main results	Evaluations conducted in various academic fields are useful for designing evaluations for the different components of RwLs.	The evaluation framework informs evaluating (real-world) experiments, RwLs and other transdisciplinary formats regarding the governance networks formed.	Public documents provided by city council information systems provide a fruitful basis for capturing political changes justified with RwLs and experiments conducted in them.	An additional understanding of RwL impacts is proposed. Examples for outcomes are available and presentable. These add up to different groups of impact.

Addressed research gap	1) How to evaluate RwLs as transdisciplinary researchers?	2) How do RwLs drive urban transformations? 3) How to design the evaluation for RwLs as drivers of urban transformations?	2) How do RwLs drive urban transformations? 3) How to design the evaluation for RwLs as drivers for urban transformation?	1) How to evaluate RwLs as transdisciplinary researchers? 3) How to design the evaluation of RwLs as drivers of urban transformations?
Implications for this dissertation	Introducing a modular understanding of RwLs (lab contexts, experiments, and interventions) as a guiding principle for RwL evaluations. Evaluations follow different logics regarding what their evaluation focus is on (labs, experiments, interventions).	Discussing an approach to how RwLs and experiments function as governance networks if public actors are involved. Developing a process-oriented evaluation approach for real-world experiments that is also usable for RwLs, stressing the network governance practices established.	Offering a transparent, rigorous methodological procedure for capturing political impacts of RwLs. Showing that RwLs are linked to tangible changes in urban-wide polities, politics, and policies.	Using reflective participatory approaches for assessing impacts from a long-term RwL.

3.4 The RwL cases: 'Cities of the Future'

As described in chapter 2.1, I focused on RwLs that were co-led by city administrations. All cases I drew upon in the articles #2, #3 and #4 were RwLs conducted in Germany. They originated from the German-wide competition line called 'Cities of the Future', funded by the German Federal Ministry of Education and Research (BMBF 2023). The eight-year funding line supported municipalities in the participatory development and trialing of sustainability solutions. In the first phase, visions for the year 2030 (and beyond) were created collaboratively among different city actor groups accompanied by research partners (2015-2016), then solution approaches for achieving such visions were developed in phase 2 (2017-2018). The third phase consisted of the implementation of the developed measures in the form of RwLs (2019-2022/23), with the city administrations being the main partners. While the first phase started with 51 German cities and smaller municipalities, only eight RwLs received funding in the third phase (BMBF 2023). These eight cities were Bocholt, Dresden, Friedrichstadt, Gelsenkirchen, Lüneburg, Norderstedt, Ulm, and Peenetal/Loitz.

In contrast to the other seven cities, Peenetal/Loitz is not administratively classified as city, but is an association between three former independent municipalities, and encompasses several smaller villages and towns. The municipality Peenetal/Loitz handles the administrative tasks for all member municipalities. Although Peenetal/Loitz is therefore not a city, I use terms such as 'city administration' and 'urban' in connection to all eight RwLs. In this way, the influential role of public administrations both for municipalities (in the sense of an association between smaller villages and towns) as well as cities is stressed. They all discuss, initiate, and implement local politics (Frank et al. 2017; Drobek & Tran 2017). In general, city administration consists of a democratically legitimized decision-making body – usually called a city council - and the employees of the administration, who are led by democratically legitimized mayors (Fliedner 2019). However, I am aware that city administrations in Germany are heterogenous and vary regarding their structure, tasks, and financial resources (Schulte 2015), which is, for example, connected to population size.

Indeed, the cities where the RwLs were conducted differ in terms of size. Of the eight cities, Dresden is the biggest, with more than 500.000 inhabitants. In contrast, Friedrichstadt has around 2500 inhabitants. The eight RwLs were also thematically heterogenous. They concentrated on different aspects of sustainable urban development (BMBF 2023). The RwLs also presented different understandings of RwLs. Although this would be an interesting point for further investigation, this is not the focus of the analysis. The RwLs were officially phrased as RwLs through the funding line (BMBF 2021), and they were co-led by city administrations, which made them suitable for analysis.

In article #3, I focused on all eight RwLs. I made use of the city council information systems in each city where the RwLs were conducted. I identified and analyzed policy documents in which the RwLs served as arguments for implementing political changes in cities.

Articles #2 and #4 are based on one specific RwL. The RwL Lüneburg 2030+ was a promising case due to my involvement as transdisciplinary researcher. I could draw on insights gained through my involvement in the RwL and in the experiments. I applied participatory evaluation approaches, one at the level of experiments (article #2), and one at the level of the lab context (article #4).

Despite being involved as a researcher in the RwL Lüneburg 2030+, I only used documents for analysis in article #3 that I identified through the transparent and rule-guided search strategy applied for all RwLs. I did not include any background information that I had due to my involvement in the RwL Lüneburg 2030+ but relied on policy documents that were publicly available, as in the other cities.

4. Results

This section entails the four research articles (articles #1, #2, #3 and #4) that are part of this cumulative dissertation. Two of them (4.1 and 4.2) are the versions as published by the journals. The articles presented in 4.2 and 4.3 are the versions that have been resubmitted to the journals after revision processes.

4.1 Toward a modular evaluation approach of real-world laboratories: Findings from a literature review

Teresa Kampfmann, Philip Bernert, Daniel J. Lang (2022)

Research Evaluation

OXFORD

Toward a modular evaluation approach of real-world laboratories: Findings from a literature review

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Abstract

The number of real-world laboratories (RwLs) as research settings to address sustainability problems by using collaborative and experimental approaches has been growing steadily over the past years. RwLs are widely considered promising settings for the production of action-orientated knowledge in order to contribute solving wicked real-world problems such as climate change. However, empirically tested evaluative approaches are rare. We argue that evaluations within RwLs are crucial for ensuring high-quality and impactful research, amplifying tested solution approaches, and driving innovative forms of transdisciplinary collaboration. At the same time, evaluations within RwLs seem difficult due to the multilayered structure of RwLs. In order to provide guidance regarding the evaluation in RwLs- for researchers and practitioners, we conduct a scoping literature review that encompasses a comprehensive understanding of RwLs. We identify studies in which the specific components of RwLs lab context, experiments, and interventions—are empirically evaluated. Drawing on our findings, we derive different types of approaches that can be used for evaluating RwLs in practice. Based on how labs, experiments, and interventions in real-world settings have been evaluated in practice so far, we suggest to design evaluation approaches depending on (1) what should exactly be evaluated in the specific RwL, (2) for which purpose, and (3) by whom. We hope this targeted, modular evaluation approach based on evaluation types found in literature will help actors engaged in RwLs to make evaluations more feasible and impactful.

Key words: real-world laboratories; evaluation; transdisciplinary sustainability research; RwLs; transformation research

1. Introduction

In light of sustainability challenges, such as climate change, loss of biodiversity, or problems associated with ongoing and rapid urbanization, science is asked to not only describe and analyze such problems (Wiek and Lang 2016) but also contribute transforming them through the codevelopment of action-oriented knowledge: i.e. the 'knowledge how' (Caniglia et al. 2021; Hölscher et al. 2021). Sustainability science and especially the field of transdisciplinary (td) sustainability research have brought forward a number of diverse approaches to generating such knowledge through different kinds of interventions (Bernstein et al. 2016; Wiek and Lang 2016; Taïbi, Antheaume and Gibassier 2020). In this context, transformative research in real-world laboratories (RwLs) has gained significant momentum (Wanner et al. 2018; Räuchle 2021).

As part of the ongoing discussions around definitions and methods of RwL research (Parodi 2019; Wagner and Grunwald 2019; Bergmann et al. 2021), the essential need for evaluation of and in these research settings has been pointed out repeatedly (Rose, Wanner and Hilger 2019). The evaluation of RwLs and tested sustainability solutions are crucial in terms of scaling-up and amplifying tested sustainability options (Lam et al. 2020a; Lang and Wiek 2022). At the same time, RwLs are described as learning environments. In these ways, the evaluation processes become important not only when assessing the approach to a sustainability problem or discussing related dissemination approaches but also when focusing on learning processes in RwLs (Singer-Brodowski, Beecroft and Parodi 2018).

Despite the importance of evaluations of RwLs, the actual implementation of evaluative approaches is considered to be difficult

(Schäpke et al. 2017). This is partly due to the complex structure of RwLs and their embeddedness in diverse contexts. If one follows common definitions, RwLs are research settings where experiments in the sense of contextualized interventions are conducted (Schneidewind 2014). RwLs comprise aspects of lab design, experiments, and interventions. We therefore argue that in the context of RwL evaluations these different levels as well as their interactions need to be recognized. We use the term levels to disambiguate an RWL's context, i.e. its social structure and the experiments and interventions carried out by and typically within the lab. The levels therefore follow no hierarchical order and could be seen as nested in each other. Depending on the focus of the evaluation, the emphasis may be on one particular level or several. Accordingly, evaluative approaches can be designed in a variety of ways. While some theoretical approaches are available to evaluate RwLs (Bergmann et al. 2021) and associated real-world experiments (Luederitz et al. 2017; Williams and Robinson 2020), little is known about how evaluation has been conducted in practice. To the best of our knowledge, there are no overview studies yet that outline how evaluations of RwLs and their components were empirically conducted. However, such an overview could inform the practices when faced with the task of evaluating an RwL or individual elements of it.

While RwL research has gained increasing attention in sustainability science, similar approaches to test and evaluate real-world solutions within a defined context have been used in other fields for a long time. In the field of public health, for instance, there are numerous approaches to real-world experiments and interventions and how they can be evaluated (Franzkowiak 2015). Looking at these fields as well and learning from their practices seems to be very promising to inform RwL research.

In this article, we therefore take a comprehensive approach in two ways. On the one hand, we adopt a comprehensive view of RwLs. We acknowledge the multidimensional structure of this research setting with the levels 'lab context', 'experiment', and 'intervention'. Second, we take a comprehensive approach in including studies across academic disciplines. In this way, we follow the transdisciplinary understanding of RwLs (Wanner et al. 2018). RwLs deal with a variety of topics on real-world (sustainability) problems which can be addressed by several disciplines as 'wicked problems'. Noting this, we do not limit the number of scientific fields that provide examples for empirical evaluations of labs, experiments, and interventions in real-world contexts. RwLs aim to produce socially robust knowledge by integrating knowledge from various scientific and societal sources (Huning, Räuchle and Fuchs 2021). This research paradigm has to be maintained in evaluation processes in RwLs as well. Knowledge on evaluating components of RwLs can be derived from multiple scientific fields.

We aim to analyze how empirical evaluations have been conducted so far and what can be learned for future evaluation of (aspects of) RwLs. For this, we systematically collect, analyze, and structure studies that evaluate (1) labs, (2) experiments, or (3) interventions in real-world settings. In doing so, an overview is given on how practical evaluation has been carried out at these different levels. This article aims to answer the following research questions: How has evaluation of interventions, experiments, and lab designs been conducted in different academic disciplines? What methods have been used for evaluation? What insights and recommendations for action can be gained from these evaluation studies regarding the evaluation of an RwL and its levels?

We first look at the terms 'intervention', 'experiment', and 'lab'. In doing so, we approach the question of how these terms are related to each other in RwLs (Section 2). In the next section, we describe the methodological approach used in our study. We present how studies have been identified and selected. Subsequently, we outline how the extraction of the studies took place. In the fourth section, we provide an overview of the identified studies. We then discuss the definitions offered by the authors of the identified studies. The main findings are presented in the sixth section. This results in a typology of the evaluation approaches that helps identifying which evaluation study might be helpful for someone's own RwL-based research. The article concludes with a discussion.

2. Acknowledging structure: a comprehensive perspective on lab, experiments, and interventions

When it comes to evaluation, we suggest to acknowledge the different components of an RwL, as suggested in literature. The concept of RwLs is often explained by using the concept of experiments (Beecroft and Parodi 2016; Parodi 2019; von Wirth and Levin-Keitel 2020). These experiments are referred to as real-world experiments (Schneidewind 2014) or transformative experiments (Parodi et al. 2016). Rogga, Zscheischler and Gaasch (2018) assume '(t)he core methodology of conducting an RwL appears to be experimentation in social contexts'. Interventions are defining aspects of the experiments in RwLs (Schneidewind 2014), as experiments primarily consist of interventions (Caniglia et al. 2017; Schäpke et al. 2017). Interventions are referred to as 'actions that can induce change in the objects investigated' (Caniglia et al. 2017). An established understanding is that real-world experiments use interventions to generate evidence on sustainability solutions. These experiments are conducted in RwLs as research settings, which leads to an intertwined structure pictured below (Figure 1). This understanding is crucial to respond to the different foci of evaluative approaches found in the literature.

Although lab, experiment, and intervention are key concepts of td sustainability research, less attention is given defining these terms exactly. While clear definitions of these terms would be helpful for better understanding the existing research projects following an RwL approach, we recognize a lack of clarity in the literature with regards to the disambiguation of the terms lab, experiment, and intervention. For the purpose of our review, we therefore follow the definitions used by the authors of the papers we included in our study.

3. Methods

3.1 Scoping literature review

The scoping review conducted here is based on the Joanna Briggs Institute methodology for Scoping Reviews (Peters et al. 2015). Scoping reviews follow a similar approach to systematic reviews. But they answer broader questions that go beyond those related to the effectiveness of treatments or interventions (Munn et al. 2018). As Munn et al. suggest, Scoping Reviews are especially suitable for examining 'how research is conducted on a certain topic or field'. Similar to systematic reviews, in scoping reviews, the preferred reporting items and the transparent reporting as well as the meta-analyses 'PRISMA' flowchart is used (Peters et al. 2015).
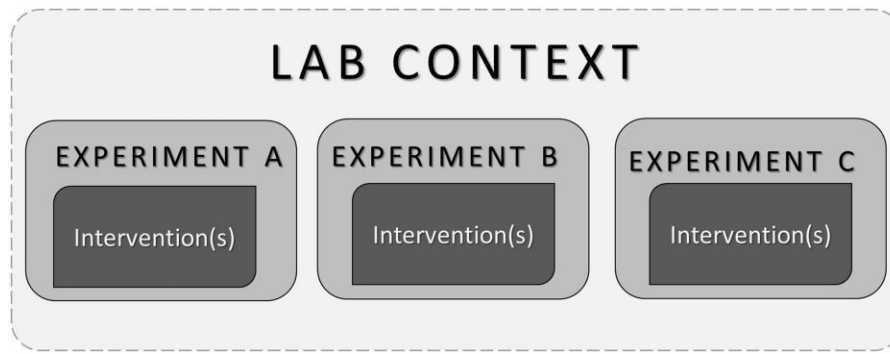
Figure 1. Three-layered understanding of an RwL.

Table 1. List of search themes, and terms used for the search strategy

Search themes	Search terms	Search strategy
1 Labs	'real-world lab*', 'innovation lab*', 'home lab', 'transition lab*', 'urban laborator*',[a] 'campus lab', 'living lab*'	Title/abstract
2 Experiment	'real-world experiment*', 'transition experiment*', 'sustainability experiment*', 'niche experiment*', 'socio-technical experiment*', 'urban experiment*'	Title/abstract
3 Intervention	'real-world intervention*'	Title/abstract
4 Evaluation	Evaluation, evaluative	Title/abstract

[a]In order to avoid results regarding urban labor market, the ending laborator* was used.

3.2 Search strategy

This scoping review aims to systematically identify studies in which different types of laboratories, experiments, and interventions have been empirically evaluated. Studies in which evaluation concepts have just been theorized are excluded. Only studies in which the process of evaluation has been explained methodologically are included in the review.

The search was performed in Ebsco, Web of Science, and Scopus with date of publication no later than September 2020. We combined four search themes with Boolean Operators (Table 1). Search Themes 1–3 have been connected with an OR to build Block A. Block A is combined with an AND with Search Theme 4.

3.3 Study selection

Following the literature search, the screening procedure was based on predefined inclusion and exclusion criteria and consisted of two consecutive phases. First, titles and abstracts were screened to exclude articles that did not meet the eligibility criteria. In a second step, full texts were reviewed. Eligible studies included articles that

1. were peer-reviewed journal articles
2. written in the English language
3. reported on the evaluation of a specific lab, experiment, or intervention
4. were empirically conducted.

A total of 1,340 articles were retrieved during the database search. After removal of duplicates, 925 articles were screened by title and abstract. 128 articles were included in the full-text screening. Where it was not clear from the title and abstract alone if the study met the inclusion criteria, the full text of the study was retrieved to enable the second stage of screening. The inclusion criteria were met by 27 articles (Figure 2).

3.4 Data extraction

Data were extracted into an *a priori* developed and pretested extraction form. A random sample of 10% of the data extraction was done by two reviewers independently for quality reasons. Discrepancies were resolved by discussion, with the involvement of a third reviewer if necessary.

The extraction form consists of three parts. One part includes codes giving an overview of the studies (e.g., author, year, evaluation object divided in intervention, experiment, and lab and used definition, country where the object is located). In the second part, we consider central TD research discourses regarding evaluation (codes TD1 and TD2). The third division of the extraction form relates to general premises of evaluation research (codes E1 and E2). TD research considerations and general evaluation aspects have overlaps. One regarding methods can be seen in Code TDE. Bellow, the codes TD1, TD2, TDE, E1, and E2 are explained in more detail.

3.4.1 TD1: The role of the evaluators

In TD research contexts, researchers cover a broad spectrum of roles (Schneidewind and Singer-Brodowski 2015; Rose, Wanner and Hilger 2019; Verwoerd et al. 2020). For evaluating RwLs, it is considered important to constantly reflect on the evaluator's roles (Huning, Räuchle and Fuchs 2021). Wittmayer and Schäpke (2014) distinguish five ideal-type roles for researchers in process-oriented sustainability science. The ideal-type reflective scientist, self-reflexive scientist, knowledge broker, process facilitator and change agent differ in terms of ownership, action, and power. The intensity with which they drive transformative research, and the ways in which they are involved in it, varies considerably (Figure 3).

Based on these ideal types, we distinguish which role the evaluators in the identified studies most closely correspond to. We coded
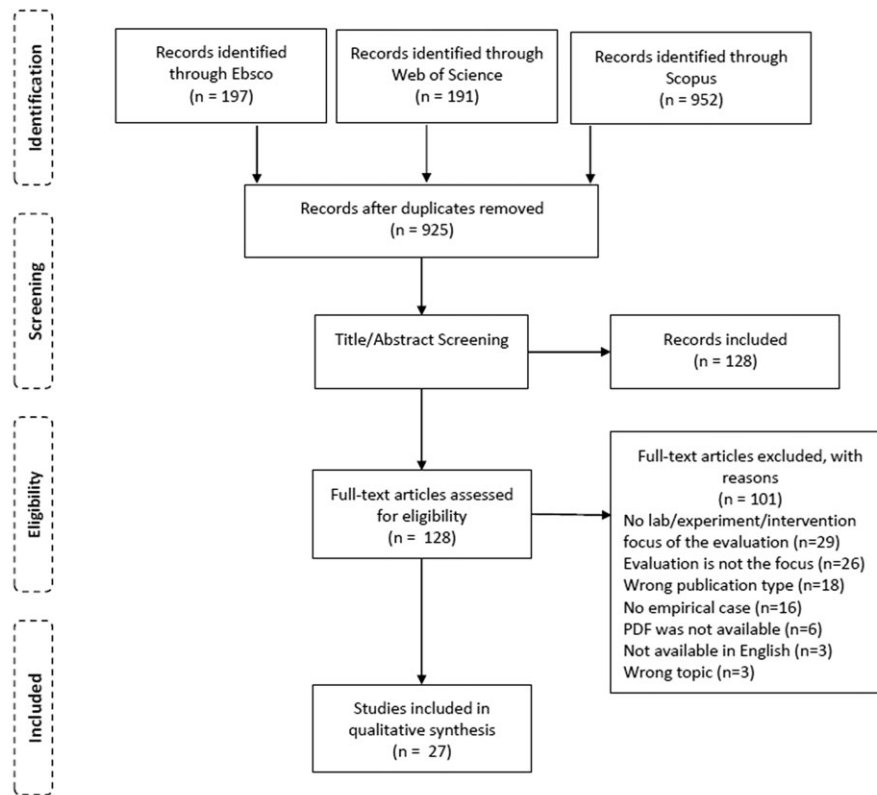
Figure 2. Study flow diagram according to PRISMA statement (Page et al. 2021, modified).
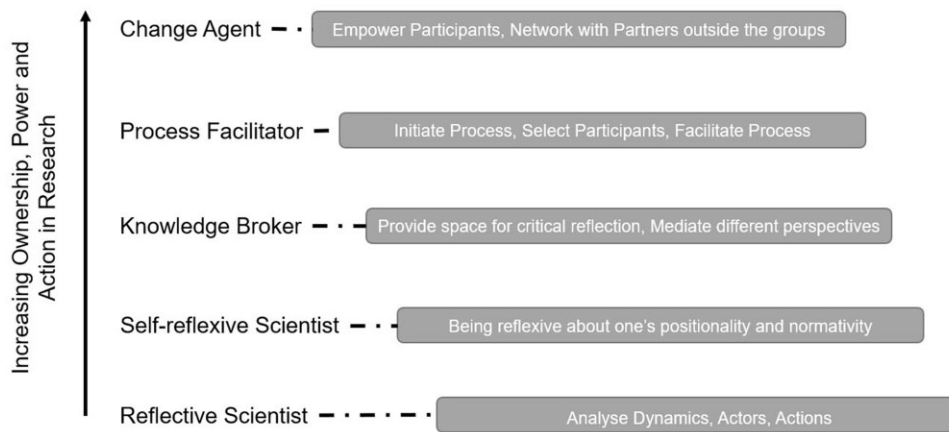

Figure 3. Ideal-type roles of researchers (Wittmayer and Schäpke 2014, modified).

passages of text in the studies that indicated which of the five ideal types the evaluators most closely matched.

3.4.2 TD2: Participants involvement in the evaluation

Seebacher, Alcántara and Quint (2018) emphasize the importance of practitioners' involvement for the success of RwLs. Similarly, Rose, Wanner and Hilger (2019) argue with respect to the evaluation of RwLs. Like other authors in the TD context, they suggest reintegration of knowledge and formative evaluations with the involvement of both science and practice as suitable paradigm of RwL

research. We use the approach of Stauffacher et al. (2008) which is based on Arnstein's (1969) ladder of citizen participation to distinguish different intensities of participants involvement in evaluation. We use the term participants involvement in order to describe the way nonscientific actors are in involved in carrying out evaluations within the specific labs, experiments, and interventions. Stauffacher et al. (2008) demarcate different intensities of participation in transdisciplinary research processes from a science perspective. The proposed distinction of participants' involvement consists of information, consultation, cooperation, collaboration, and empowerment (Figure 4).

3.4.3 TDE: Methods used

There is an ongoing discussion on suitable methods in td research, especially in evaluating RwLs (Defila and Di Giulio 2019; Hölscher et al. 2021). At the same time, the methodology chosen to evaluate is a central component for all kinds of evaluative approaches (Döring 2019). Therefore, we will extract the entirety of methods the authors chose for the evaluation of labs, experiments, and interventions.

3.4.4 E1: Criteria

In addition to evaluative methods used, a key component of evaluation studies is criteria that determine what exactly is being evaluated (Heinrich 2018; Döring 2019). As chosen criteria are highly contextualized and depend on the purpose of the evaluation (OECD DAC Network on Development Evaluation (EvalNet) 2021), we decided not to analyze what criteria were exactly chosen, but focus if the chosen criteria were linked to literature or were developed based on the case characteristics. Accordingly, we code if the evaluation studies rely on theory-based or exploratory criteria.

3.4.5 E2: Temporality

A common distinction to differentiate evaluation studies is the division into summative (usually ex-post) and formative evaluation (usually during the entire process) (Döring 2019). Summative evaluation pursues the goal of a final assessment. Formative evaluation provides results that are intended to serve the improvement of the object of evaluation. Since we deliberately kept our search for studies open, and studies from disciplines such as education science are to be expected, we also introduced Pre–Post assessment (Sanders 2019). Here, measurements were taken before the evaluation objective was carried out and again afterwards. Thus, the before–after condition is compared.

4. Overview of the identified studies

A total of 27 articles published from 2007 to 2020 were included in the final analysis. The fields of study include information and technology (n = 8), public health and health care (n = 7), sustainability science (n = 5), political and social sciences (n = 5), and educational science (n = 2). Studies were assigned to specific disciplines based on the journal in which the studies were published. All studies have in common that they are limited to only one evaluation object. This means that the studies focus on either lab(s), experiment(s), or intervention(s).

Identified studies from the field of educational science only covered evaluations on the intervention level. Given our search query as

well as the inclusion and exclusion criteria, we developed in Section 3, the discipline of sustainability science emerges as the only discipline that comprise studies that focused on the evaluation of all three objectives interventions, experiments, and labs (Table 2). The majority of the identified studies concentrate on labs (n = 15), followed by interventions (n = 7) and experiments (n = 5).

In seven studies, the authors evaluated not only one specific case but also focused on several labs resp. experiments in real-world settings. In six studies, multiple labs were evaluated. Hubeau, Marchand and van Huylenbroeck (2017) evaluated several experiments within one study.

The evaluation studies that were identified focused on labs, experiments, and interventions conducted in 24 countries. The majority of the 27 identified studies evaluated labs, experiments, or interventions that were located in Europe. Only about one-fourth of the evaluation studies focused on research objects situated in countries of the Global South.

The labs, experiments, and interventions in the identified studies cover a broad spectrum of thematic areas (Table 3).

5. Definitions used

In this article, we analyze studies that evaluate labs, experiments, and interventions in real-world contexts, i.e. research that is not conducted in closed lab settings. As described before, the terms interventions, experiments, and lab lack commonly used definitions. Therefore, we describe the definitions the authors have been used in the 27 identified studies. While differences regarding the conceptualizations are apparent and can be attributed to the various disciplines present in our sample, across the cases (within the three groups of labs, experiments, and interventions), we consider the conceptual understandings to be close enough for a comparison. Our analysis carries a notion of comparatively aggregating and structuring methods and approaches of evaluation of an emerging research practice that spans disciplinary boundaries.

Table 2. Overview of the 27 identified studies

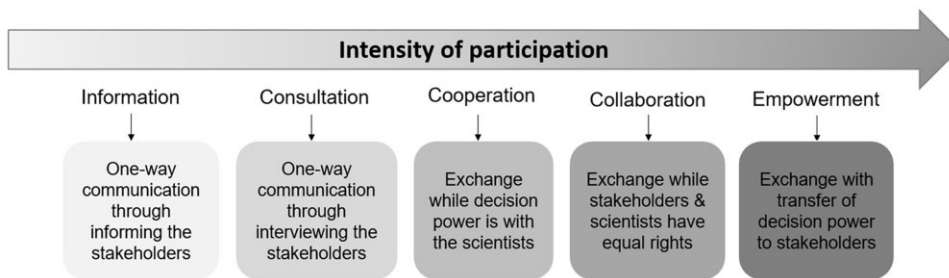| Discipline	Lab	Experiment	Intervention	Total
Information and Technology	6	2	–	8
Public Health/Health Care	3	–	4	7
Sustainability Science	2	2	1	5
Political Science	4	1	–	5
Educational Science	–	–	2	2
Total	15	5	7	27

Figure 4. Intensity levels of participation (Stauffacher et al. 2008, modified).

5.1 Interventions

Studies, in which interventions were evaluated, rarely offered definitions of interventions in real-world settings. One of the occasional definitions that can be found was provided by Nastasi and Hitchcock (2009) in the field of public health. They base their understanding of interventions on a concept from psychology that was originally developed by Schensul and Trickett (2009). Here, an intervention is described as a 'specific strategy designed to incur behavioral or social change in individuals, groups or larger structures or settings'. For their research, Nastasi and Hitchcock specified the intervention they evaluated as *multilevel intervention* that aims to incur (or cause) change at two or more levels.

Not only the explanation by Caniglia et al. (2017) introduced in Section 2 but also the approaches within the other six intervention-based studies identified here, match this definition, irrespective of their different disciplines. In all studies evaluating interventions, a specific strategy is tested in order to incur behavioral or social change, whether in individuals (Massey, Boroughs and Armstrong 2007; Kaida and Kaida 2015; McClain Burke et al. 2019), groups (Bellei 2013; Dubuy et al. 2014), or both in the form of multilevel intervention (Wood et al. 2013).

5.2 Experiments

Studies evaluating experiments in real-world contexts provided more exact definitions of terms related to experimentation. The studies differentiated between transition experiments (Porter, Claassen and Timmermans 2015), sustainability experiments (Hubeau, Marchand and van Huylenbroeck 2017), collaborative experimentation (Andersson 2015), experiments (Doyon et al. 2020), and real-world experiments (Cats, Reimal and Susilo 2014). Nevertheless, despite their specific terminology and that these studies come from different disciplines, a common understanding of what constitutes experimentation in real-world contexts is apparent.

Transition experiments were described as 'innovative, small-scale experiments that are conducted in practice to address persistent societal problems, based on the core notion that sustainable development requires searching, learning, and experimenting. Hence, transition experiments are not a goal in themselves, but an instrument to explore and learn about sustainable ways of meeting societal needs, for current and future generations' (Porter, Claassen and Timmermans 2015).

For Hubeau, Marchand and van Huylenbroeck (2017), a *sustainability experiment* means 'a highly innovative initiative to improve the sustainability state of the whole chain through new arrangements of collaborations'.

Doyon et al. (2020) adopt Luederitz' et al. (2017) general definition for *experiments* in the field of political science as 'small-scale initiatives that are research endeavors as they produce evidence regarding both the persistent unsustainability of dominant regimes and the possible solutions that are replicable, transferable, and scalable to society at large'.

In terms of literature references and accuracy, the concepts adopted in the other two studies differ greatly from the three already mentioned. Andersson (2015) defines collaborative experimentation in the field of sustainability science by stressing that 'the scope of experimentation [...] goes beyond mere technology demonstration, with the process of inquiry in itself becoming equally as important as its specific outcomes'. Cats, Reimal and Susilo (2014) provide no definition at all for the experiment they have evaluated in the field of information/technology.

5.3 Labs

The authors of the studies that evaluated (different forms) of labs in real-world contexts mostly provided definitions for the specific lab approach that was focus of the evaluation. The framing of labs consisted of living lab, policy lab, public innovation lab, urban living lab, and rehabilitation living lab.

Regarding the term living lab, we can see minor differences match the different foci of the analyzed studies: They all share a strong recognition of the real-world settings, in which living labs operate. Some of the authors highlight the innovation aspect. Within their definitions of living labs, the authors emphasize that something innovative is cocreated and validated within the labs (Brankaert, den Ouden and Brombacher 2015; Ley et al. 2015; Paskaleva and Cooper 2018; Ondiek and Moturi 2019; Plaisier et al. 2019; Mačiulienė and Skaržauskienė 2020). Apart from that, the collaboration and learning between different stakeholders coming from different institutional settings are stressed (Falk-Kessler, Benson and Witchger Hansen 2007; Brankaert, den Ouden and Brombacher 2015; van Geenhuizen 2018; Plaisier et al. 2019; Mačiulienė and Skaržauskienė 2020, Mastelic, Sahakian and Bonazzi 2015). These cited studies cover a wide range of academic disciplines. They originate from the fields of information and technology, sustainability science, political science, and public health/health care.

Most of the authors using the term Living Lab provided literature-based definition. The term policy lab used in the study from Whicher and Crick (2019) has no literature references as well. They describe policy labs as 'multi-disciplinary government teams developing public services and public policies using innovation methods to engage citizens and stakeholders at multiple stages of the development process'. This understanding contrasts public innovation labs, urban living labs, and rehabilitation living labs. The latter two are not explained in general terms in the associated studies and are very case-specific.

6. Findings

In the following, we present the main findings of our study according to the codes defined in Section 3.4. All subfindings are differentiated for the specific components of RwLs (Section 2). This means we compare lab, experiment, and intervention-related evaluation studies according to the above-mentioned aspects. We reveal in which categories evaluation studies regarding lab, experiment, or intervention resemble and differ.

6.1 The role of evaluator(s)

Based on ideal-type roles for researchers that Wittmayer and Schäpke (2014) developed, we distinguish which role the evaluators in the identified studies most closely represented. In the majority of the studies analyzed, the evaluators did not operate like researchers instantiating and driving the intervention, lab, or experiment. In 20 of the studies, the evaluators rather took on the role of observing researchers, acting most likely as ideal-types reflective and self-reflexive scientists. They evaluated from an observer role and interpreted results. In several cases, the evaluators representing the ideal-type reflective scientists conducted research from external

Table 3. Overview of the 27 identified studies, sorted according to the level of implementation

Authors (year)	Study focus	Country setting	Discipline	Topical area
Bellei (2013)	Intervention	Chile	Educational Science	Intervention in low-performing schools in Chile to increase academic achievement.
Dubuy et al. (2014)	Intervention	Belgium	Public Health/Health Care	Intervention promoting positive dietary habits and physical activity for socially disadvantaged children.
Kaida and Kaida (2015)	Intervention	Sweden	Sustainability Science	Real-world intervention policy of traffic congestion charging that impacted various pro-environmental behaviors.
Massey, Boroughs and Armstrong (2007)	Intervention	USA	Educational Science	Two programs that address violent and disruptive behaviors in schools.
McClain Burke et al. (2019)	Intervention	Mozambique	Public Health/Health Care	Economic and social empowerment intervention to reduce girls' vulnerability to HIV in rural Mozambique.
Nastasi and Hitchcock (2009)	Intervention	India	Public Health/Health Care	Evaluating multilevel interventions, using as an example a public health project
Wood et al. (2013)	Intervention	Australia	Public Health/Health Care	Use hand drumming as medium enabling participants in schools to explore connections between making music together as a group and the development of healthy relationships.
Andersson (2015)	Experiment	Uganda	Sustainability Science	Use of human urine as a crop fertilizer within an experiment with local farmers in Uganda.
Cats, Reimal and Susilo (2014)	Experiment	Estonia	Information and Technology	Test Fare-free public transport (FFPT) in Tallinn.
Doyon et al. (2020)	Experiment	Australia	Political Science	The Council Alliance for a Sustainable Built Environment (CASBE) as an urban experiment seeking to influence development and planning decisions.
Hubeau, Marchand and van Huylenbroeck (2017)	Experiment	Belgium (case studies)	Sustainability Science	The developed Sustainability Experiment Systems Approach (SESA) is tested on case studies of sustainability experiments in the agri-food system in Flanders.
Porter, Claassen and Timmermans (2015)	Experiment	The Netherlands	Information and Technology	The Framework by Bosch-Ohlenschlager is applied to evaluate the WGM program and the Eenhoorn project as transition experiment.
Brankaert, den Ouden and Brombacher (2015)	Lab	The Netherlands	Information and Technology	Lab cases that take place in the homes of people with dementia and their caregivers.
Dabaieh et al. (2019)	Lab	Egypt	Information and Technology	Testing Trombe Walls in Sinai, Egypt, as a retrofitting solution in a remote desert area in a real urban living lab.
Falk-Kessler, Benson and Witchger Hansen (2007)	Lab	USA	Public Health/Health Care	Creating a living lab in one study course at university to gain an insight how an experimental lab can help students learning.
Kovács (2016)	Lab	Austria, Hungary	Political Science	Introducing the evaluation methodology of Living Labs in the field of renewable energy industry.
Ley et al. (2015)	Lab	UK, Germany	Information and Technology	Evaluating and Comparing two 4-year Living Lab projects within the domain of Social TV.
Mačiulienė and Skaržauskienė (2020)	Lab	Lithuania, Portugal, Italy, Belgium	Sustainability Science	Research how Living Labs are being applied as a mechanism to open up the innovation processes through online and offline collaborations between the urban policymakers, nonprofit organizations, citizens and other stakeholder groups.
Mastelic, Sahakian and Bonazzi (2015)	Lab	Switzerland	Information and Technology	Explore how Living Labs might be evaluated based on criteria that build on the current efforts of the ENoLL.

(continued)

Table 3. Continued

Authors (year)	Study focus	Country setting	Discipline	Topical area
Mazer et al. (2015)	Lab	Canada	Public Health/Health Care	The RehabMaLL is designed to study how to best address the needs of persons of all ages with physical, sensory and cognitive disabilities.
Ondiek and Moturi (2019)	Lab	Kenya (case studies)	Information and Technology	Find out why the Living Labs in Kenya are not sustainable.
Paskaleva and Cooper (2018)	Lab	UK, Belgium, Germany, Italy	Information and Technology	Development and trialing of a novel Co-evaluation Framework, indicators and reporting categories, used to support the co-production of smart city services in an EU-funded project.
Plaisier et al. (2019)	Lab	Nigeria	Sustainability Science	Reducing postharvest losses in tomato value chains in Nigeria to improve food security in the country.
Ramey et al. (2019)	Lab	Canada	Public Health/Health Care	Innovate example of youth engagement for youth health, findings and challenges of this.
van Geenhuizen (2018)	Lab	The Netherlands, Denmark, Canada	Political Science	The study draws on the extended literature on living labs, general literature on evaluation and boundary-spanning or intermediation, and on six (four concrete) case studies of living labs.
Whicher and Crick (2019)	Lab	UK	Political Science	Northern Ireland Public Sector Innovation Lab (iLab) is evaluated.
Zurbriggen and González Lago (2019)	Lab	Uruguay	Political Science	Development of an experimental evaluation tool for public innovation as part of an action-research process in a laboratory within the Uruguayan Government.

positions and were not involved in the intervention, experiment, or lab design implementation at all.

Depending on whether the evaluation focus was on labs, experiments, or interventions, we notice differences with regards to the role evaluators take on (Table 4). Evaluators focusing on interventions in the selected studies, only acted as reflective (n = 5) or self-reflexive scientists (n = 2). They did not shape the interventions they evaluated. In these studies, the evaluators most likely took the roles of 'traditional' researchers. Evaluators focusing on experiments and labs represented a more diverse sets of roles. Two out of five evaluation studies with experiment focus were conducted by researchers that took reflective scientist roles (Cats, Reimal and Susilo 2014; Hubeau, Marchand and van Huylenbroeck 2017). In one study, the evaluators acted as self-reflexive scientists (Doyon et al. 2020). In one experiment evaluation, the evaluators acted as knowledge broker (Porter, Claassen and Timmermans 2015). Andersson (2015) took a process facilitator role in evaluating an experiment. Lab evaluation studies were conducted by researchers representing all ideal-type roles. It stands out that the ideal-type change agent, which is involved most intensely in the research process, is only recognizable among evaluators involved within labs (Falk-Kessler, Benson and Witchger Hansen 2007). In this case, the lab was created, modified as well as proactively evaluated by the authors (together with the students), led by the goal to actively confront a real-world problem.

6.2 Criteria used

We grouped the criteria that were used in the evaluation of the specific labs, experiments, or interventions in the 27 selected studies. We examined if the authors referred to a theoretical approach in order to derive criteria for their specific evaluation or if they used an exploratory approach. If authors started implementing their studies based on

theory-based criteria and then supplemented them with exploratory criteria, these studies were also assigned to applying theory-driven criteria. About half of the studies draw on existing theoretical concepts (n = 14), for example SWOT analysis (Andersson 2015). In 13 studies, criteria were chosen for the evaluation that were not linked to theoretical approaches. They were more or less exploratory (e.g., Falk-Kessler, Benson and Witchger Hansen 2007).

Here, we took a look on differences between labs, experiments, and interventions as well. Out of seven identified intervention evaluation studies, five studies used exploratory criteria. Experiments were more often evaluated using theory-based criteria. Only in one evaluation study focusing on an experiment, exploratory developed criteria were applied (Cats, Reimal and Susilo 2014). Within the labs evaluated, theoretically derived and exploratory criteria were used in roughly equal numbers (Table 5).

In the studies reviewed here, the type of criteria used for evaluation did not influence whether authors make practical recommendations for the audience. In most of the studies that analyzed not only one but several cases, theory-based criteria were applied within the evaluation. In five out of six studies that evaluated several labs, the evaluators used theory-driven criteria (Kovács 2016; Paskaleva and Cooper 2018; van Geenhuizen 2018; Ondiek and Moturi 2019; Mačiulienė and Skaržauskienė 2020). In the study by Hubeau, Marchand and van Huylenbroeck (2017), in which several experiments were evaluated, the authors used a theory-based category scheme for the evaluation, too.

6.3 Methods used

In total, 14 evaluation studies applied a qualitative approach. In seven studies, a quantitative approach was used. Six studies were

Table 4. Ideal-type roles of evaluators by level of implementation

Focus of evaluation	Reflective scientist	Self-reflexive scientist	Knowledge broker	Process facilitator	Change agent
Intervention	5	2	–	–	–
Experiment	2	1	1	1	–
Lab	7	3	2	2	1

Table 5. Criteria for evaluation by level of implementation

Focus of evaluation	Theory-driven criteria	Exploratory criteria
Intervention	2	5
Experiment	4	1
Lab	8	7

conducted utilizing a mixed-methods approach (Massey, Boroughs and Armstrong 2007; Nastasi and Hitchcock 2009; Mazer et al. 2015; Kovács 2016; Plaisier et al. 2019; Mačiulienė and Skaržauskienė 2020). Mixed-methods approaches refer to the combination of qualitative and quantitative methods (Flick 2011).

Methodological approaches differ depending on whether labs, experiments, or interventions were evaluated (Table 6). In the identified studies, interventions never were evaluated using a purely qualitative approach. In contrast, the evaluation of labs and experiments was most often carried out using purely qualitative data.

In most of the studies more than one method was used to evaluate the corresponding intervention, experiment, or lab. Nevertheless, few authors explicitly designate this approach as triangulation or mixed-methods (exceptions are Doyon et al. 2020; Falk-Kessler, Benson and Witchger Hansen 2007; Hubeau, Marchand and van Huylenbroeck 2017; Mazer et al. 2015; Nastasi and Hitchcock 2009; Zurbriggen and González Lago 2019).

Over the 27 studies, multiple methods were used for the evaluations. They range from traditional surveying methods such as interviews to rare ones, like reflective journals and diaries. Methods for data gathering as well as methods for data analysis that were used in the identified studies are listed below (Table 7).

Previously, we showed that methodological approaches (qualitative, quantitative, mixed-methods) in evaluations differed depending on what is being evaluated. This is also evident if we take a closer look at the methods that were used. In evaluation studies that focus on interventions, descriptive statistics approaches were used much more often. In general, interventions were evaluated using a less diverse set of methods, compared to experiments and labs (Figure 5).

6.4 Temporality

Concerning when the evaluation in the identified studies was performed, differences can be seen regarding the foci of evaluation studies. Evaluations of labs were exclusively formative. A different picture emerges for the evaluations of interventions and experiments. Although more than half of these were also evaluated formatively, there are cases of pre–post assessments and ex-post evaluations as well (Table 8).

The aspects of methodological approach and temporality of evaluation seem to be related. Evaluations using only qualitative data were conducted formatively in most cases (Table 9). Qualitative evaluation studies never followed a pre–post approach and only in a few cases an ex-post investigation. The two qualitative

evaluation studies following an ex-post approach only focused on experiments (Andersson 2015; Doyon et al. 2020).

6.5 Involvement of participants in evaluation

After the discussion of who (role of evaluator) evaluated how (criteria, methods) and at what point in time, we focus on how participants of the lab, experiment, and intervention were involved in the evaluation. As described before, by the term participants, we mean non-scientific actors who were involved in the evaluation of the specific interventions, experiments, and lab. Depending on the evaluation focus, the involvement of participants in the evaluation differs. Lab evaluations particularly stand out. In the context of experiment and intervention evaluation studies, there is at least one case each in which participants were only informed about the evaluation. In these examples, there was no exchange on how the participants personally experienced the intervention (Bellei 2013) or the experiment (Cats, Reimal and Susilo 2014). According to the model of Stauffacher et al. (2008), this represents the level of information (Section 3.4). In the labs that were evaluated, the participants were never only informed about the evaluation. The participants were involved in the lab evaluation more intensely. In evaluation studies with lab focus, the lowest form of involvement was consultation. The highest form of involvement, empowerment, was only perceivable within lab evaluations. In evaluation studies regarding interventions or experiments, participants were never involved to this high degree (Table 10).

The methodological approach chosen to evaluate and the involvement of participants in the specific evaluation are closely related. Qualitative schemes do not include evaluations in which participants were only involved on the lowest level, i.e. information. Qualitative evaluations were conducted with a higher degree of participants involvement than quantitative evaluation studies (Table 11).

Lastly, we address the link between participants involvement and ideal-typical roles. Evaluators coded as reflective scientists or self-reflexive scientists enable any form of participants involvement in the studies we identified. The situation is different for evaluators acting as process facilitators or change agents (Table 12). The studies show that evaluators representing these ideal types tend to involve participants more: They evaluate together on levels of collaboration (Falk-Kessler, Benson and Witchger Hansen 2007 for labs; Andersson 2015 for experiments) and empowerment (Plaisier et al. 2019; Ramey et al. 2019 both for labs).

7. Designing a typology of evaluation studies

Based on our findings in Section 5, we classified the studies according to the approach of Kluge (2000) in different types. Kluge describes four steps for the empirically grounded construction of types in qualitative social research. After having the relevant comparison dimension between studies already established within our extraction of the identified studies (Section 3.4), we grouped the cases and searched for empirical regularities. As step 3, we analyzed

Table 6. Methodological approach used for evaluation by level of implementation

Focus of evaluation	Qualitative research	Mixed-methods research	Quantitative research
Intervention	–	2	5
Experiment	4	–	1
Lab	10	4	1

Table 7. Frequency of the methods used in the evaluation studies

Interviews	20
In-depth, semistructured, unstructured, expert, individual, random walking, follow-up, quantitative, key informant and telephone interviews	
Descriptive statistics	17
Logistic regression model, regression-based difference-in-difference approach, repeated measures analysis of variance, multivariate analysis, matching procedure/control and intervention group, before-after analysis of data, exploratory factor analysis, secondary data analysis, Cramer-index	
Field observations and notes	15
Visual observations, summaries of meetings, written record of operations, output of workshops and conference meetings, case records, monitoring protocol, written feedback, participant observation, self-report measure/ethnographic survey	
Questionnaires	12
Self-administered, baseline and follow-up, structured, online and hard copy questionnaires	
On site monitoring/testing	9
Temperature and humidity measurements, measurement tool (impact on weight and quality), data log that measured the activity, probe method, digital monitoring, medical testing for STIs (sexually transmitted infections), Rosenberg self-esteem scale, Social Development Program Evaluation for each participant, field tests	
Literature review	8
Collection and analysis of web data, desk-based research, analysis of related policy documents, extensive, systematic literature reviews	
Workshops	7
Evaluation workshop, design game workshop, timeline workshop, eye-opener workshop, participative visioning and back-casting,	
Group discussions	7
Focus Group, Reflection	
Systematic analysis	5
Of Project Documents, cross case, content analysis, open and axial coding, thematic	
Reflective journals, diaries	2
Surveys	2
Household, structured	
Participatory diagramming	1
Ranking tools	1

contextual meaning and formed the types. Last, we characterized the types formed. We formed six types of studies, two for each level.

We formed two superordinate evaluation types (A and B—Table 13). On the one hand, there is an evaluation type that follows a narrow scope. On the level of interventions, this means that direct results and effects of the intervention are measured—primarily quantitatively (Massey, Boroughs and Armstrong 2007; Bellei 2013; Wood et al. 2013; Dubuy et al. 2014; McClain Burke et al. 2019). Narrow-focus evaluations of experiments refer to performance and collaboration in the context of the experiment (Cats, Reimal and Susilo 2014; Hubeau, Marchand and van Huylenbroeck 2017; Doyon et al. 2020). Evaluations with narrow focus on labs aim to increase working mechanisms within the labs, e.g. for future actions that are planned or for improving collaboration within the labs (Falk-Kessler, Benson and Witchger Hansen 2007; Brankaert, den Ouden and Brombacher 2015; Ley et al. 2015; Mazer et al. 2015; Dabaieh et al. 2019; Ramey et al. 2019; Zurbriggen and González Lago 2019). All evaluation studies of type A have in common that internal aspects are in the foreground.

Studies of the second type B comprise evaluations with a broader focus. For linked evaluations focusing on interventions, this indicates that not only the direct effects are considered but also a distinction is made between effects at different levels and/or spillover effects are evaluated (Nastasi and Hitchcock 2009; Kaida and Kaida 2015). Broad focus evaluations which analyze experiments, link their results closely to a real-world problem. The identified real-world problem marks the initiation of the experiment and is referred to in the evaluation as well (Andersson 2015; Porter, Claassen and Timmermans 2015). Type B evaluation studies that focus on labs use evaluation to provide an overview of specific labs or to test an evaluative model (Kovács 2016; Paskaleva and Cooper 2018; van Geenhuizen 2018; Ondiek and Moturi 2019; Whicher and Crick 2019; Mačiulienė and Skaržauskienė 2020). Mostly, type B evaluation studies focusing on labs follow a theory-driven criteria approach. All evaluation studies of type B design the evaluation beyond the respective individual intervention, experiment, or lab.

8. Discussion

In this review, we aimed at providing a systematic overview of approaches used to evaluate labs, experiments, and interventions in
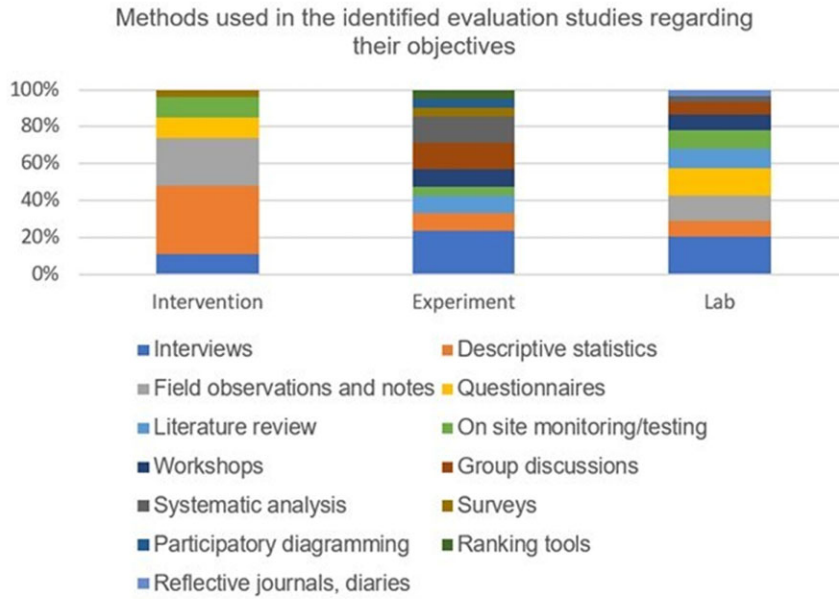
Figure 5. Methods used in the identified evaluation studies regarding focus on labs, experiments, or interventions.

Table 8. Temporality of evaluation according to the level of implementation

Focus of evaluation	Pre-post	Formative	Ex-post
Intervention	3	4	–
Experiment	1	2	2
Lab	–	15	–

Table 9. Temporality of evaluation according to the methodological approach

Methodological approach	Pre-post	Formative	Ex-post
Qualitative	–	12	2
Quantitative	3	4	–
Mixed-methods	1	5	–

real-world contexts in sustainability research and neighboring fields. In the following discussion, we highlight the inherent complexity of evaluation as a crucial practice in RwL research. Furthermore, we point out the learning opportunities that approaches and practices from other fields bear for advancing evaluative practices in the RwL research context and beyond. Finally, we discuss some of the limitations of our review and propose further research.

8.1 Evaluation of RwLs: a complex task in an emerging research field

RwLs as spaces designed, managed, and used by a multitude of actors from different backgrounds are complex social structures with a high degree of context dependency (Schneidewind et al. 2018; McCrory et al. 2020). Through evaluative approaches, researchers and practitioners are enabled to better understand the processes of their joint research as well as the performance of the interventions and experiments realized in the respective labs (Lang

et al. 2012). At the same time, evaluation findings are crucial for exploring the scalability and transferability of tested sustainability solutions (Schäpke et al. 2017; Lam et al. 2020b).

The need for evaluations of complex RwLs (or at least components of them) is undisputed. However, the actual implementation of these evaluation approaches is difficult. This is partly due to the multidimensional structure of an RwL. Several processes take place in parallel. In addition, there are numerous actors from different institutions and backgrounds simultaneously involved. In this article, we tried to break down this complexity. Just as we saw different evaluation approaches for interventions, labs, and experiments in real-world contexts, we appeal to address the different components of RwLs with different evaluation logics. In doing so, evaluations of RwLs can be conducted in a modular way.

Evaluations of interventions can be conducted differently than evaluations of experiments or labs. In our analysis, we found that scientists evaluating interventions are generally less involved in action-oriented processes and act in more traditional way of research practice. Experiment focused evaluators take more diverse roles—reaching from reflective scientist to process facilitator. What stands out here is that evaluators explicitly bridging the evaluation to the real-world problem are involved to a higher degree than evaluators concentrating on internal experiment findings. Regarding lab evaluations, we noted an even wider range of roles that evaluators take (ranging from reflective scientist to change agent). Evaluators analyzing several labs within one study become more likely to represent the more traditional role as a researcher—representing only the types reflective and self-reflexive scientists in five out of six studies. The one exception is found within the study from Ley et al. (2015). In the only evaluation study focusing on several experiments, the evaluators also acted as reflective scientists (Hubeau, Marchand and van Huylenbroeck 2017). What stands out from all analyzed evaluation studies except for one (mixed-methods approach), is that in the studies with highly involved evaluators (change agent, process facilitator, knowledge broker) only qualitative approaches were used.

Table 10. Participants' involvement in evaluation according to the level of implementation

Focus of evaluation	Information	Consultation	Cooperation	Collaboration	Empowerment
Intervention	1	5	–	1	–
Experiment	1	–	2	2	–
Lab	–	4	4	2	5

Table 11. Participants' involvement in evaluation according to the methodological approach

Methodological approach	Information	Consultation	Cooperation	Collaboration	Empowerment
Qualitative	–	2	5	3	4
Quantitative	2	5	–	–	–
Mixed-methods	–	2	1	2	1

Table 12. Participants' involvement in evaluation according to ideal-type roles of evaluators

Ideal-type roles	Information	Consultation	Cooperation	Collaboration	Empowerment
Reflective scientist	1	8	1	1	2
Self-reflexive Scientist	1	1	3	1	1
Knowledge broker	–	–	2	1	–
Process facilitator	–	–	–	1	2
Change agent	–	–	–	1	–

Table 13. Evaluation types formed

Type A: Narrow Evaluation Focus		
Intervention	Experiment	Lab
Identify immediate impact, effectiveness or results of the intervention.	Concentrate on internal experiment aspects: collaboration, processes, performance.	Evaluation is directed on the lab itself, with focus on improvement in future.
Type B: Broad Evaluation Focus		
Intervention	Experiment	Lab
Measure more complex results: spillover effects, multilevel evaluation.	Address an identified real-world problem with experiment findings.	Identify success conditions for several labs, test evaluation concepts

The evaluation of components of RwLs can also differ regarding the set of criteria, as our findings suggest. Interventions often followed an explorative approach while on the level of the experiment more often theory-based approaches were applied. Within the evaluation studies focusing on labs, there is no dominance of a preferred categorical system. In cross-case evaluation studies, whether focusing on experiments or labs, theory-based category systems were used in most cases. The use of criteria for evaluation studies based on theoretical approaches seems to facilitate the comparison of the analyzed labs resp. experiments within cross-case studies.

Regarding methods used, we see remarkable differences between intervention, experiment, and lab-focused evaluation studies. The method set applied in the evaluation of interventions is less diverse than the sets used to evaluate experiments and labs. This can possibly be explained by the increasing complexity of the different levels from intervention to lab. Connecting these findings to the role of researchers in these evaluation studies, it seems like evaluations of interventions tend to follow more traditional, already proven

concepts of research compared to the evaluation studies focusing on experiments and labs. This could partly be due to the disciplinary context of the intervention focused evaluation studies analyzed here: Out of seven studies, six are attributable to the fields of educational science and public health. These disciplines encompass long tradition of implementing and evaluating interventions in real-world contexts with well-established (quantitative) methods (Craig et al. 2017; Outhwaite, Gulliford and Pitchford 2020).

In terms of when the evaluation is conducted, evaluation studies differ considerably according to what is being evaluated. Labs were evaluated formatively without exception. For interventions and experiments a more heterogenous picture emerges. The reason that labs are invariably evaluated formatively could possibly be due to the fact that mutual learning processes are in the foreground—and thus the participants of the lab are involved to a higher degree. Another explanation might be that evaluation processes seem to be closely linked to the other activities in labs. Evaluation processes are considered as an integral (rather than subsequent) aspect of labs.

The proclaimed higher involvement of participants in the evaluation of labs can be seen in two points: First, information as the weakest form of involvement according to Stauffacher et al. (2008) could not be identified within the lab evaluation studies analyzed here. In contrast, there have been intervention and experiment focused studies that did not aim to involve participants at all (Bellei 2013; Cats, Reimal and Susilo 2014). Second, only within the evaluation studies of labs, the level empowerment for participants to shape evaluation approaches was addressed. For intervention as well as experiment focused evaluation studies, collaboration was the highest form of participants' involvement. Out of seven evaluation studies focusing on interventions, Nastasi and Hitchcock (2009) are the only ones to involve participants on collaboration level. Regarding the evaluation of experiments, collaboration is represented in two out of five studies (Andersson 2015; Hubeau, Marchand and Van Huylenbroeck 2017). There was no case, where participants of experiments were empowered to shape the evaluation study.

8.2 Findings from empirical evaluation cases: approaching the concepts of lab context and real-world experiments

While the diversity of evaluative approaches we found is a rich knowledge base for developing appropriate evaluative approaches for a given case, the lack of clarity regarding the disambiguation of laboratories, experiments, and interventions leads to a certain vagueness in the discussion around evaluation in this research field. It would be important to establish common terms so that experiments and labs are strengthened as contexts for trying out solutions to (sustainability) problems as interventions in system. In the studies considered here, not all authors provided definitions for the evaluation objects lab, and experiment (which are vaguer then the term intervention). We have tried to synthesize the definitions that were given in some of the studies in order to provide an orientation.

Combining the definitions that had been given, we suggest to frame lab context within RwLs as following:

In cocreational processes (Ondiek and Moturi 2019; Mačiulienė and Skaržauskienė 2020) challenges are addressed in an innovative manner (Brankaert, den Ouden and Brombacher 2015; Paskaleva and Cooper 2018; Ondiek and Moturi 2019; Zurbriggen and González Lago 2019) by developing and applying experimental (Plaisier et al. 2019; Whicher and Crick 2019; Zurbriggen and González Lago 2019) as well as participatory mechanisms (Brankaert, den Ouden and Brombacher 2015; Mastelic, Sahakian and Bonazzi 2015) in real-life contexts in order to foster collaborative learning (Falk-Kessler, Benson and Witchger Hansen 2007) and innovation (Ley et al. 2015; Kovács 2016; Paskaleva and Cooper 2018; van Geenhuizen 2018; Ondiek and Moturi 2019).

Based on the definitions that were given, real-world experiments (within RwLs) could be described as follows:

Experiments are small-scale (Porter, Claassen and Timmermans 2015; Doyon et al. 2020) initiatives where actors collaboratively (Hubeau, Marchand and van Huylenbroeck 2017) respond to specific societal problems (Porter, Claassen and Timmermans 2015) by testing possible solutions (Doyon et al. 2020) in order to generate usable knowledge (Andersson 2015) which is transferable and scalable (Doyon et al. 2020).

While some similarities regarding the definitions of experiments and labs are noticeable, we stress the aspects in which they differ according to the synthesized definitions:

- Experiments are described as being small scale, labs are not. The latter seem to cover broader contexts.
- In labs, experimental mechanisms are applied, which strengthen our multilayered understanding and the intended relationship between labs and experiments.

As conceptual ambiguities still exist, we suggest to define central concepts transparently before starting the (co-)evaluation. A precise distinction between interventions, experiments, and the lab process, which is jointly made by the actors in the to-be-evaluated RwLs, is crucial for small scale component evaluation.

8.3 Addressing complexity by learning from neighboring scientific fields

In sustainability oriented RwLs, sustainability solutions are experimentally developed and tested in order to initiate transformation processes and to perpetuate corresponding scientific and social learning processes (Parodi et al. 2016). Thereby, transdisciplinary collaboration is central (Wanner et al. 2018), in which researchers from different disciplines as well as actors outside academia work together. In our view, this essential working mechanism has to be considered in evaluation activities as well, as evaluation processes are described as an essential phase of RwLs (Rose, Wanner and Hilger 2019).

Besides our suggesting to apply smaller scale modular evaluation approaches by addressing the prior identified components of RwLs differently, we suggest to learn from fields that are not considered that close to the field of td sustainability science. The fields of information and technology science, public health/health care as well as educational Science are disciplines that provided studies in which labs, experiments, and intervention in real-world context are empirically evaluated. Although many of the studies that are located in these disciplines used 'common methods' that are also applied in works from td sustainability research—for example document analysis, semistructured interviews, workshops, and/or observations (e.g. Falk-Kessler, Benson and Witchger Hansen 2007; Porter, Claassen and Timmermans 2015; Ramey et al. 2019), we see study examples in which evaluation methods were applied that are less frequently utilized in the field of td sustainability research. In studies focusing on interventions in real-world contexts from the disciplines of public health as well as educational science, approaches to evaluate interventions by forming control and intervention groups in order to work with comparative models were applied. Dubuy et al. (2014) as well as Massey, Boroughs and Armstrong (2007) implemented and evaluated interventions within a small group of pupils. They compared the attitudes and behavior of students who were affected by the intervention with those of students who did not experience the intervention. A similar approach was applied within the evaluation of an educational intervention by using larger datasets of pupils' characteristics (Bellei 2013). The effectiveness of these interventions was assessed through comparison between intervention and control group(s).

Another mechanism we have seen in studies from the field of public health as well as information and technology is baseline and follow-up measurement in order to evaluate interventions (Bellei 2013; Wood et al. 2013; Dubuy et al. 2014) and experiments (Cats,

Reimal and Susilo 2014). Dubuy et al. (2014) and Wood et al. (2013) collected baseline and follow-up measurements within a relatively small group prior and after the intervention. Cats, Reimal and Susilo (2014) used larger data sets. In their study, before and after numbers of extensive automatic vehicle location and automatic passenger counts within a fare-free public transport experiment were analyzed. Bellei (2013) compared student- and school level data before and after the intervention took place.

For evaluating interventions and experiments in real-world settings, forming control and intervention groups as well as assessing baseline and follow-up measurement might be suitable. Other methods that studies from these 'neighboring fields' suggest, are on-site monitoring. This includes approaching the effectiveness of new, tested interventions in real-world context in the field of information and technology studies (Brankaert, den Ouden and Brombacher 2015; Dabaieh et al. 2019) or medical examinations (Nastasi and Hitchcock 2009).

8.4 Limitations and further steps

Due to our search query as well as the inclusion and exclusion criteria we applied, we analyzed 27 studies in which labs, experiments, and intervention in real-world settings were evaluated. This number is too small to draw general conclusions from this study population. Nevertheless, the studies support the approach of a small-scale, modular evaluation with the inclusion of empirical experiences from other fields than td sustainability science. It also suggests that empirical studies evaluating interventions, experiments, or labs in real-world context that are specifically named as such are rare—at least in the field of peer-reviewed studies. When systematically analyze grey literature, this could result in identifying a larger number of studies in which interventions, experiments, and labs in real-world settings are evaluated. One challenge we encounter within this approach is the transparent and structured selection of studies. Nevertheless, this could be a promising approach for future research.

The various evaluation approaches at the three levels in the RwL (which differ, e.g. in terms of choice of method, time frame, and evaluator role) would pave the way to be a methodologically sound overall evaluation for the RwL when brought together. However, the aspect how these single evaluation studies within one RwL can and should be connected needs to be further explored. One suggestion still under discussion can be to review the single small-scale evaluation studies that were conducted within RwLs, led by their different foci. Similarly, as mentioned above, we take the position that RwLs are not generic, they differ contextually, in content and organization. This means a conclusive answer to the question is not possible (so far).

9. Conclusion

Evaluating RwLs, especially when they consist of multiple experiments and sometimes even more interventions, can be a giant task, not manageable with the resources typically available through current funding schemes. Finding ways to deal with this challenge is possible. One can take advantage of the multilayered structure of RwLs. There are several components that can be evaluated using various approaches. At the same time, one can draw on more than just studies from td sustainability research to evaluate lab context, experiments, and interventions that are part of RwLs. Transdisciplinary research seeks to cross the boundaries between disciplines, as well as between academia and other societal domains. We should apply this paradigm to evaluation studies as well.

In our article, we revealed that empirically conducted evaluation studies related to lab contexts, experiments, and interventions in real-world settings each follow different logics. Based on these findings, we have formed an evaluation study typology. Analyzed evaluation approaches—while diverse—can be distinguished by having a narrow or broad scope (related to all three highlighted components of RwLs). Furthermore, we aimed to provide a practicable application.

For transformative td research, we need to think holistically and learn from other disciplines—especially when we aim to explore amplification possibilities of sustainability solutions tested in RwLs. These solutions are more urgent today than ever before. Concomitantly feasible and thorough evaluations of interventions, experiments, and RwLs are increasingly needed. We hope this article contributes to accommodating this need.

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4.2 Governance for urban sustainability through real-world experimentation – Introducing an evaluation framework for transformative research involving public actors

Teresa Kampfmann, Philip Bernert, Daniel J. Lang, Stefanie Drautz (2024)

Cities
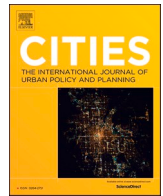
Governance for urban sustainability through real-world experimentation – Introducing an evaluation framework for transformative research involving public actors

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ABSTRACT

Transformative transdisciplinary research settings such as real-word laboratories (RwLs) provide infrastructures for collaboratively testing sustainability solutions in cities. Existing evaluations have focused on learning through experimentation and the tested interventions. Here, we provide an additional focus on the collaboration mechanisms established in real-world experiments. Through the involvement of political-administrative actors, university actors, and civil society actors, real-world experiments can function as initiators for governance networks that drive urban sustainable development, potentially beyond the formal end of real-world experiments. We therefore propose a framework that encompasses governance and transdisciplinary approaches, which can be used to evaluate real-world experiments as new modes of urban governance. The framework was applied to retrospectively evaluate a real-world experiment conducted within a RwL in a German city. We argue that while the framework serves as an evaluative scheme for assessing and comparing real-world experiments, it could also be used to evaluate RwLs as well as transdisciplinary research projects, by emphasizing the governance arrangements formed in those settings. Including this governance perspective expands the debate surrounding the impacts of transdisciplinary sustainability projects.

1. Introduction

The role of cities in a global sustainability transformation is increasingly acknowledged (Berisha et al., 2022; Nilssen & Hanssen, 2022). While urban environments face a multitude of challenges, they are also spaces in which promising new sustainable living arrangements can be developed (Wiedmann & Allen, 2021; Wolfram & Frantzeskaki, 2016). In this context, the field of sustainability science has brought forward a variety of innovative action-oriented approaches that aim to generate robust knowledge regarding the design and effectiveness of urban sustainability solution approaches (Frantzeskaki, 2022). Novel, promising examples of such research settings are Real-world laboratories (RwLs) (Schäpke et al., 2018; Wanner et al., 2018), and similar 'sustainability-oriented labs in real-world contexts' (McCrory et al., 2020), such as urban living labs (Bulkeley et al., 2019). These transformative research environments create settings for transdisciplinary collaboration and experimentation (Huning et al., 2021; Schneidewind

et al., 2018). By integrating knowledge from a variety of scientific and societal bodies, their goal is to develop solution options to confront 'wicked' societal problems (Lang et al., 2012). Sustainability interventions in the form of real-world experiments are collaboratively developed, trialed, and evaluated in a specific context with the involvement of civil society (Parodi et al., 2016). RwLs are jointly established research settings, in which scientific actors and members from other societal sectors work together to confront real-world problems through experimentation (Hahne, 2021). Considered as one format of transdisciplinary research (Bergmann et al., 2021), the role of science actors as co-leaders of RwLs is a requirement (Defila & Di Giulio, 2020; Kanning et al., 2021; Parodi et al., 2021; Seebacher et al., 2018; Wagner, 2017). However, the specific shape of these transdisciplinary constellations does not follow a blueprint schematic, but is highly context dependent, and influenced by numerous socio-political and cultural conditions (Belcher et al., 2016; Lam et al., 2021).

As 'development hubs', universities play a key role in educating

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'decision-makers of tomorrow in both public and private sectors' (Hansen & Lehmann, 2006, 822). Their involvement in sustainability endeavors is considered crucial (Loorbach, 2022). The background contexts of the other actors involved in RwLs are more vague. Frequently, the actors that conduct RwLs with universities represent civil society and city administrations (Kanning et al., 2021; Räuchle, 2021). In this sense, local governments provide an environment in which public sustainability issues can be addressed collaboratively by actors from different institutional backgrounds (Brink et al., 2018; Clement et al., 2022). The collaboration established in RwLs between city administration members, civil society and science actors (e.g., Engels & Walz, 2018) fits common definitions of governance, such as that advocated by Lange et al. (2013, 406), who define governance as 'a process of—more or less institutionalized—interaction between public and/or private entities ultimately aiming at the realization of collective goals'. This also fits the widely shared assumption that experimentation is an innovative form of urban governance (Ehnert, 2022; Frantzeskaki et al., 2018; Hölscher et al., 2019; Kivimaa et al., 2017; Kohler et al., 2021; van der Heijden, 2018).

We, the authors of this paper, were part of a real-world experiment conducted by a city administration, university, and civil society actors in Lüneburg, Germany. Although there are existing approaches for the evaluation of real-world experiments (Lüderitz et al., 2017; Williams & Robinson, 2020), to the best of our knowledge there is no analytical tool to assess the governance processes established throughout real-world experiments. We argue that a focus on the governance arrangements formed within real-world experiments is beneficial in several ways. First, an evaluative framework focusing on governance practices would widen the view on experiments beyond developing sustainability solution options (Caniglia et al., 2017) and providing spaces for learning (Parodi, 2019). Secondly, such a framework would contribute to a better understanding of the nexus between governance and experiments, considering that a systematic understanding of this relationship is still missing (Huitema et al., 2018; Laakso et al., 2017). Third, the currently underrepresented political dimension of real-world experiments, especially as they affect cities and communities (Ehnert, 2022; Voß & Simons, 2018), would be critically addressed. Furthermore, the formal power of political-administrative actors in real-world experiment constellations would be acknowledged (Jones & Evans, 2006; Kronsell & Mukhtar-Landgren, 2018; Torrens & von Wirth, 2021).

Accordingly, this article introduces an evaluation framework to capture governance processes established in real-world experiments. It has been developed based on theories and models introduced by governance and transdisciplinarity scholars, therefore we first introduce the concepts that were integrated into the framework. We then present the analytical framework and provide methodological examples of its application. For illustrative purposes, we apply the framework to a real-world experiment case study. We show how the framework helped to uncover specific forms of collaborative governance that were developed throughout the experiment. In the discussion, the framework is critically examined, and further contexts in which the framework could be used are suggested. In conclusion, we assess how our analytical framework contributes to new insights in the field of urban planning policies.

2. Towards the evaluation of governance arrangements in real-world experiments

This section first introduces concepts from RwL research, governance, and transdisciplinary discourses. These were used to develop the framework to evaluate experiments from a governance perspective. This framework will be introduced in chapter 3.

2.1. Defining the phases of real-world experiments

For both the development and application of the framework, we draw on the different phases established throughout real-world experiments. The differentiation between such phases is considered difficult, as they do not evolve in a linear manner (Roebke et al., 2022). However, several existing approaches identify different phases of real-world experiments. Fingerle (2019) differentiates three phases for both RwLs and real-world experiments: (1) co-design, (2) co-production, and (3) co-evaluation. During the (1) co-design phase, the transdisciplinary team jointly agrees on an identifiable problem, applies thematic and spatial restrictions, and generates ideas for interventions. This is followed by phase (2) co-production, in which interventions to be trialed are finalized. They are implemented involving reflection opportunities and adjustments. In the final Co-evaluation phase (3), results are recorded, jointly interpreted and transferred. Puttrowait et al., 2018 distinguish between the phases in a similar way, but introduced an additional phase to develop their real-world experiment collaboratively: 1) identification phase, in which central actors are identified and ideas for interventions are jointly developed, 2) implementation planning phase of the intervention(s), 3) implementation of the real-world experiment and its interventions together with their evaluation, and 4) assessment. Fingerle (2019) and Puttrowait et al. (2018) thus offer two options to distinguish between the phases of real-world experiments. Accordingly, we argue that applying the evaluation framework to specific phases holds two benefits. Firstly, an evaluation focusing on the individual phases of experiments is compact and feasible. Secondly, changes in governance mechanisms formed throughout the experiment are captured. In the section'Illustrative application' below, we outline how we identified the phases of the exemplar real-world experiment, based on the work of Puttrowait et al. (2018).

2.2. Modes of governance

In the field of governance, work often focuses on the collaboration between different institutions, with one institution being a state actor (Peters & Pierre, 2012; Wolfram et al., 2019). Lange et al. (2013, 406) define governance 'as a process of - more or less institutionalized - interaction between public and/or private entities aiming at the realization of collective goals'. Following these authors, we locate our work and the understanding of the term governance as described by Frantzeskaki et al. (2023, 243): 'Governance is about the different processes in which policies, plans, and legislation are negotiated, discussed, contested, formulated, and implemented, and how they gain legitimacy and deal with accountability. It is thus about how various actors and their different interests are brought together in a dialectic space, and how their diverse expertise and knowledge are included in strategic and operational activities of steering towards commonly desirable outcomes'. To highlight the nuances of governance and established collaboration mechanisms, Hysing (2009) introduced five modes of governing along three dimensions: instrument and styles, public and private partnership, and policy levels. For the evaluation framework introduced in this article, we adapted Hysing's differentiation between governing modes regarding the second dimension, **public and private partnership**. Accordingly, we draw on the network character of governance arrangements. Hysing (2009) proposed five grades in the ways the partnership between political and non-political actors (understood as a broad range of societal bodies, such as organizations, companies, researchers, and civil society), are shaped (Fig. 1), reaching from the ideal-types of government to governance on the continuum. Through the ideal-type government, monocentric, hierarchically organized political institutions are seen as the prime governors of society. Non-political actors have clearly defined roles: to participate through elections and lobbying (pluralism), or through highly-institutionalized public–private governing arrangements (left side of the continuum in Fig. 1). On the other side of the continuum (right side in Fig. 1), collaboration, deliberation, and interaction between public and private actors is in the foreground. Private actors are more deeply integrated into the policy process. Instead of a governing structure based on institutionalized and hierarchical interactions between public and
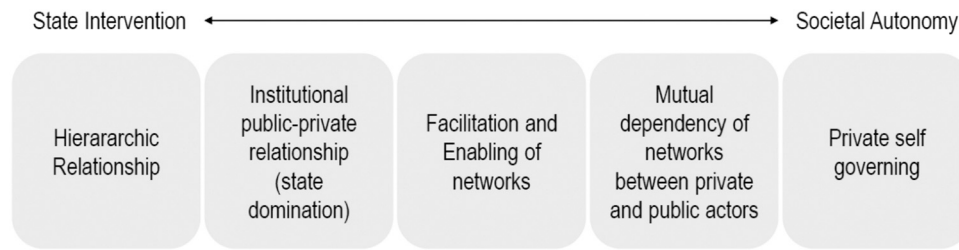
State Intervention ←——————————————→ Societal Autonomy

| Hierararchic Relationship | Institutional public-private relationship (state domination) | Facilitation and Enabling of networks | Mutual dependency of networks between private and public actors | Private self governing |

Fig. 1. Modes of Governing regarding public-private relationships (Hysing, 2009, modified).

private actors, networks based on resource interdependency and trust characterize the relationships between political and non-political actors. In these networks, the capacity of a state agency to steer is limited. Thus, non-political and voluntary actors perform self-governing.

A variety of approaches define governance by emphasizing the collective decision-making process (Doberstein, 2016; Wang & Ran, 2021). For the framework, we therefore derive the specific governance mode for real-world experiments by identifying and assessing the most important decisions that were made in the individual phases of the experiment. Based on how political and non-political actors shaped these decisions, the mode of governance according to Hysing (2009) is detected. It has to be determined whether forms of governance are present in the experimental phase at all, or whether a 'traditional' form of government with unilateral power from the side of the political actors is reproduced. If the political actors had sole decision-making power and control, the chances of a hierarchical relationship in the sense of government are high. At the other pole of the continuum, self-governing would mean that non-political actors made the decision, with state actors functioning as enablers from a distance. Between those poles there are three gradations, where state actors decreasingly, and non-state actors increasingly, shape decisions.

2.3. Actor constellations in transdisciplinary research settings

Transdisciplinarity is generally described as a research mode where knowledge is produced not only through academia but in the collaborative processes between scientific and non-scientific stakeholders (Rigolot, 2020). Transdisciplinary research projects begin with and focus on 'wicked' real-world problems. These problems are therefore not (only) part of scientific debate, but also affect people outside academia - individuals, and communities - and at the same time relate to unsolved scientific questions. To address these issues, transdisciplinary teams develop solution options that provide insights that are transferable into both scientific and practical discourses and action (Lang et al., 2012; Wada et al., 2021).

Scholz and Steiner (2015) distinguish (idealized and simplified) three types of actor groups engaged in transdisciplinary projects: Actors from the scientific community, legitimized decision-makers, and the public at large (identified stakeholders, e.g., those affected by a real-world problem). Odume et al., 2021 name this type of constellation a transdisciplinary *'science-policy-society helix'* (Fig. 2). Actors from governmental bodies, research institutions such as universities, and people from civil society join a transdisciplinary research project and form the 'science-policy-society helix'.

In addition to identifying the groups of actors involved in transdisciplinary research projects, some literature also examines the intensity of the participation of non-scientific actors (Elzinga, 2008; Mayrhofer, 2018; Sonnberger & Lindner, 2021). Viewing non-scientific actors as one group tends to underestimate the influence of government agencies through their formal decision-making power (Kronsell & Mukhtar-Landgren, 2018). Scholz and Steiner (2015) and Odume et al. (2021) provide approaches in which the group of non-university actors is divided into both political-administrative and civil society actors.

Drawing on previous work, investigating actors in transdisciplinary
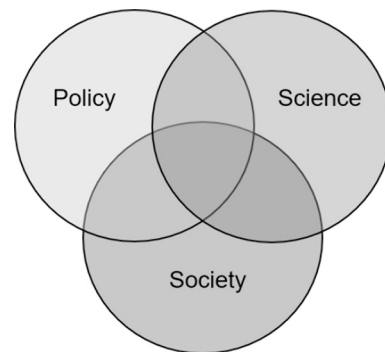

Fig. 2. 'Science-policy-society helix' within transdisciplinary projects (Odume et al., 2021, modified).

research settings, it is central for application of the framework to identify which actors are participating in the real-world experiment phases and to which actor group they can be allocated, using the science-policy-society helix. Accordingly, a subdivision is made between actors drawn from city administration (policy), university (science) and civil society (society).

2.4. Participation in governance processes

Newig (2011) discussed the concept of participation in governance processes. Participation of non-state actors in governance process occurs differently in practice, and one way to describe the extent of participation is through the assessment of the participation process along five criteria (Table 1).

According to Newig and Kvarda (2012), the following conditions must be fulfilled to speak of participation at all. The first necessary feature is that the decisions made are applicable for a larger group of people (public realm). The second is co-determination, meaning that people in charge of decisions do not make them on a regular basis. The three remaining criteria - cooperation, sharing of power and representation - vary in the extent they are met (Newig, 2011). These five criteria support more detailed description of the participation of non-state actors

Table 1

Features of participation in governance processes (Newig & Kvarda, 2012, modified).

Core Element	Short Description
Cooperation	Joint problem solving, consensus building within the decision-making process.
Public Realm	Decisions made in the participation process apply to a larger group of people and imply rules for future behavior.
Co-Determination	Participation of groups of people in decision-making, who do not routinely make such decisions.
Sharing of Power	Participation implies a transfer of power to the non-political groups of people involved.
Representation	Circle of people involved sufficiently represents those with a legitimate concern.

in governance arrangements in real-world experiments.

3. Introducing a framework to evaluate real-world experiments from a governance perspective

Based on these theoretical foundations regarding modes of governance, transdisciplinary actor constellations and participation in governance processes, we developed a three-step evaluation framework. The framework offers a set of criteria for evaluating real-world experiments from a governance-orientated perspective, focusing on collaboration.

The framework is designed for the evaluation of real-world experiments that involve actors from city administrations, university/academia, and members of civil society, and requires a sufficient availability of data. Sufficient data in this case means that for each phase of the experiment there are documents available that contain passages about the decisions made and the actors involved. The framework should be applied by researchers involved in the experiment to allow for mutual reflection and sensemaking of the working phases and sequence of actions.

As stated above, the framework is applied to the individual phases of a real-world experiment, noting that distinguishing the different phases in real-world experiments is highly context-specific: an identification phase, implementation planning phase, implementation phase, and evaluation phase (Fingerle, 2019; Puttrowait et al., 2018; Trenks et al., 2018).

For the analysis of the governance networks established in real-world experiments, the framework provides the following steps for each phase of the real-world experiment: 1) *Determine* the mode of governance and clarify whether governance is present at all, 2) *Identify* the actor groups involved, 3) *Assess* how and to what extent science and/or society actors participatorily shaped the experiment phase and respective outcomes (Fig. 3) from a governance perspective.

The experiment-related documents used for the application of the framework is grouped according to the phases of the real-world experiment. Then the first step is to determine the mode of partnership between political-administrative actors and the other stakeholders involved in the phase of the real-world experiment. This first step should be based on the most important decisions that were made in each phase. To what extent were these decisions determined by political-administrative actors? If these decisions have been made entirely by political-administrative actors, there is a high probability that there is a hierarchical relationship with the political-administrative actors in power (referring to hierarchic relationship in step 1 in Fig. 3). In this case, usually no further steps for the specific experiment phase are required, as these top-down power relations reflect neither governance arrangements nor transdisciplinarity.

If one of the other four governance modes provided in step 1 is applicable (institutional public-private relationship (state domination), facilitation and enabling of networks, mutual dependency of networks between private and public actors and private self-governing) then the focus in step 2 will be on the actor groups involved in the experimental phase. This step aims to describe who represents the groups of state actors, science and civil society. This is followed by the third and final step. Step 3 examines the extent of participation of non-political actors in the specific phase in more detail. The governance arrangements established in the real-world experiment are described based on five elements of participation (public realm, co-determination, cooperation, sharing of power, representation). In some cases, it is suitable to examine participation intensities for the groups of civil society and science within the same phase of the real-world experiment, but in other cases, it is advisable for only one of the two groups, e.g., if only science or civil society actors had a certain degree of influence in the governance setting.

Data for the analysis is existing material, such as minutes of real-world experiment meetings, emails, transcripts of workshops, and
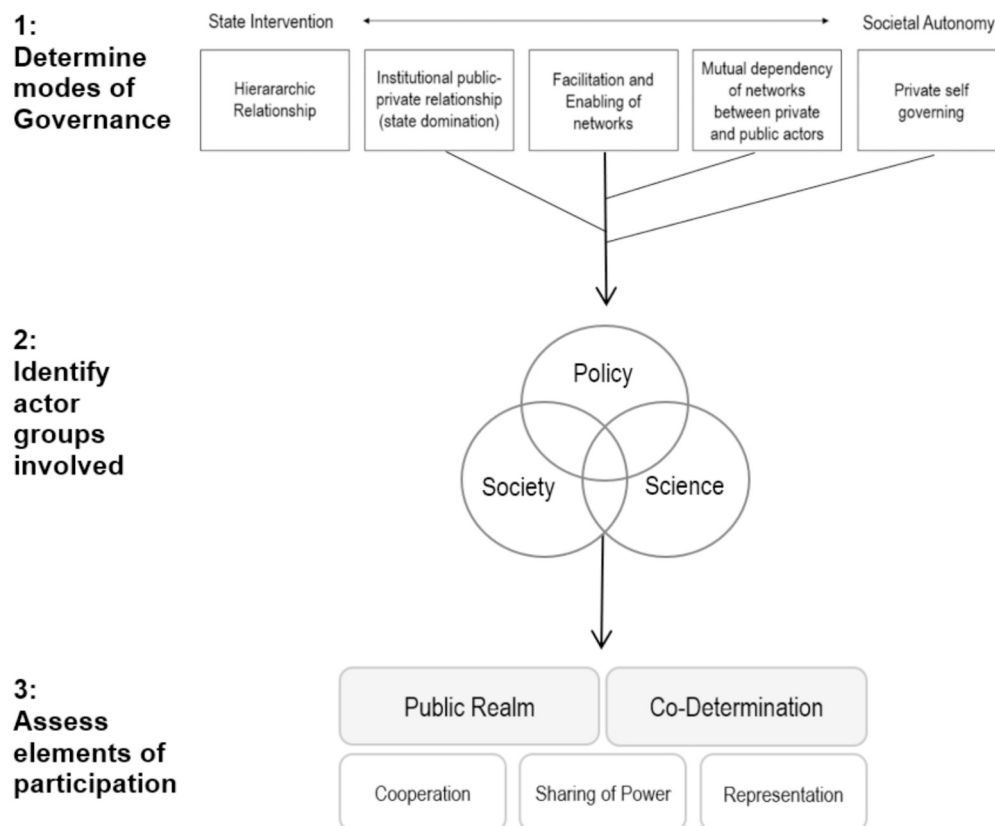

Fig. 3. Framework for evaluating governance networks in real-world experiments.

publicly available data such as the experiment's own online presentation and the presentation of the experiment in public discourse (e.g. local newspapers). This material is analyzed by deductive codes developed through the framework.

Deductive content analyses of the material based on the framework is carried out; ideally through several coders for intercoder reliability. Once all the phases of the real-world experiment have been worked through, the results for the different phases become comparable, to show how the governance networks developed over time.

4. Illustrative application

In the following, we exemplify the application of the framework using a case study to evaluate a real-world experiment within the RwL project *Zukunftsstadt Lüneburg 2030+* located in the medium-sized Hanseatic city of Lüneburg, Germany.

The RwL was established in 2020. Since then, 15 real-world experiments have been carried out, addressing the 17 Sustainable Development Goals. The RwL is managed jointly by members from the local university and city administration, as well as from civil society (Lüneburg 2030a, n.d.). An office was provided for representing the RwL in the city center. This gives the RwL a physical address (Parodi et al., 2016), where the workplaces of the RwL members, who are employed by the city administration, are also located. Within the framework of the RwL, transdisciplinary cooperation between the city administration, the university and civil society was institutionalized. For the duration of the RwL, 10 part-time project positions were created in the city administration and university.

Out of the 15 experiments of the RwL Zukunftsstadt Lüneburg 2030+, the experiment Favorite Places was regarded as the most suitable case study for an exemplary post-hoc application of the framework because it met the requirements of involvement of municipal actors, sufficient data for an illustrative application, and the involvement of the authors as transdisciplinary researchers in the original experiment.

The focus of *Favorite Places* was the joint, temporary redesign of public spaces in the city center of Lüneburg. The real-world experiment explored options to address SDG 11, *'make cities and human settlements inclusive, safe, resilient and sustainable'* (UN, 2023) in the local context. One of the places redesigned in the experiment was the public square in front of the theater in Lüneburg, in summer 2022. Actors from the university, city administration as well as (directly affected) members from civil society jointly worked together. As a working group, they decided what interventions were trialed, that is, what temporary measures were implemented on the theater square and how these changes were evaluated.

We used data that was easily accessible to us due to our involvement in the RwL and/or in the real-world experiment. We used documents (*n* = 20) encompassing minutes, endorsements, and authorization for alternative use of the 'Place', as well as publicly available sources derived from websites. In this way, we applied the framework to already existing documents (as described above).

As a first step, we used the documents to distinguish between the phases of the experiment *Favorite Places* (emphasis on theater square). The documents were grouped into, (i) the identification phase, in which the basis for the experiment was laid, (ii) the implementation planning phase, in which the experiment's interventions were planned, (iii) implementation, and (iv) the intervention evaluation phase (Appendix A). As a next step, we applied the framework to each phase of the real-world experiment, through deductively coding the document groups aligned to the four phases.

4.1. Applying the framework to the real-world experiment's four phases

4.1.1. Identification phase

As described above, the real-world experiment analyzed in the following sections was established in the context of the RwL *Lüneburg*

2030+. A transdisciplinary steering group was formed to co-develop the RwL (Bernert et al., 2016), and actively shaped its work. The steering group was composed of members of the local university and city administration, as well as civil society actors, and usually met once per month. From this steering group, a working group for the real-world experiment *Favorite Places* was established, formed with members from the city administration, university and civil society actors.

The transdisciplinary working group met several times in order to, 1) identify specific public places in the city where experimental participative redesign could be tested, 2) discuss methods for the collection of ideas for redesign measures, and 3) clarify responsibilities.

The working group agreed upon three sites on which the experiment should be conducted. All three were squares which were publicly accessible and centrally located in the city of Lüneburg (Fig. 4). These squares have not previously been used as places to rest, but rather as places to transit.

We applied the framework to the documents grouped in the identification phase of the experiment. As first step, we assessed the mode of governance formed throughout this phase. The main decision made was agreement on the specific sites on which the experiment should take place. Of the three squares that were agreed upon, members from city administration were strong advocates for one of them. The two other places were proposed by non-state actors, who knew suitable locations from their private contacts outside the RwL setting. As these locations were identified based on involvement in social networks outside the lab, the governance arrangement formed in this real-world experiment identification phase mostly matches **facilitation and enabling of networks**.

In the working group, members of all three societal sectors (city administration, university, civil society) were involved. Table 2 provides an overview of the stakeholders representing the three actor groups, and is our response to step 2 of the framework.

The final step of the application of the framework for this identification phase is to assess participation in this governance process in more detail. The criterion 'public realm' is met because the most important decision made applies to a considerable number of people who live in the city and use the squares, whether on a regular or non-regular basis. The aspect 'co-determination' implies that people who are not usually involved in such decisions act as co-decision makers. Here, civil society members as well as researchers from the university were actively involved in the decision-making process. Normally, the design of such areas is the responsibility of the city administration resp. political
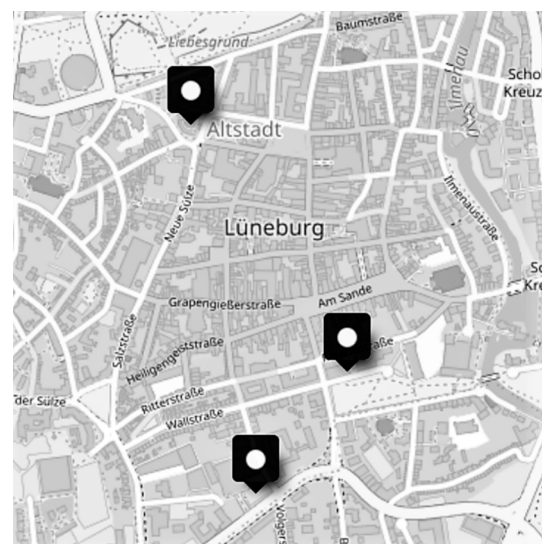

Fig. 4. The three squares in Lüneburg chosen in the real-world experiment Favorite Places, based on OSM 2022.

Table 2

Overview of actors during Identification Phase.

Actor Group	Actors in Identification Phase
Society	Civil Actors engaged in the RwL (involved in steering group)
Science	Members of the RwL (employed at university)
Policy	Members of the RwL (employed at city administration)

decision-makers. A joint problem-solving approach was evident throughout the working group meetings, with voices from all non-political actors being actively considered (cooperation). The working group jointly agreed on the specific squares in the city serving as test spaces (surrender of power). However, in this identification phase of the experiment, people directly affected by the decision on the specific squares (for example because they live there) were not part of the discussions and decision, therefore, the aspect of representation was not met.

4.1.2. Implementation planning phase

As three specific squares were identified, subgroups were formed, each focusing on one square. In this exemplary analysis we focus on the real-world experiment conducted in the theater square. The cornerstone of this phase was the establishment of contact between the university members of the experiment working group and the responsible persons from the theater. The main decision in this phase was agreement on redesign measures that should be tried out on the theater square. For this purpose, ideas were publicly collected on-site, followed by workshops with members from the university, theater and city administration. There were two other meetings as well as several informal exchanges. All people that were attached to the square and engaged with the place on a regular basis (e.g., because they work there) were actively invited to get involved. The main decision on redesign measures that should be implemented was mostly made by non-state actors, but city administration also played a crucial role. Members of the city administration, responsible for urban green spaces and parks (and not employed as members of the RwL project team), were involved in this process. They pointed out what they considered to be practical in means of law and regulation. Based on this working constellation, an agreement on ideas about the square was made. Accordingly, the relationship in this phase can be classified as **mutual dependency of networks between private and public actors**.

As part of a seminar, students from the university, together with members from the theater and the city administration, held an event to collect ideas from the public for the square on-site. The ideas (both written and drawn) were recorded by the students on printed maps and small cards. By adopting this performative citizen participation method by Mackrodt and Helbrecht (2013), a low-threshold offer was created to participate and share ideas.

During the event, more than 300 ideas were collected. It was suggested to redesign the space by establishing green areas, in some cases in connection to biodiversity. The suggestion to provide more seating areas was the second most mentioned proposal, followed by gastronomic offers, sports- and/or playgrounds and outdoor events. The ideas collected formed the basis for a subsequent workshop, to which employees from the theater, members of the working group and employees from the city council responsible for urban green spaces and parks were invited. Members from the university led the preparation and moderation of the workshop. In the workshop, the collected ideas were ranked, additional ideas were identified and a timeline for the experiment was defined. As a result, workshop participants agreed on ideas that should be tested for redesigning the space.

Applying the second step of the framework, we derive that a society-science-policy helix in the sense of Odume et al. (2021) could be seen, but that the composition within the individual groups changed compared to the prior identification phase (Table 3).

With the inclusion of theater employees, all participation elements

Table 3

Overview of actors during Implementation Planning Phase.

Actor Group	Actors in Implementation Planning Phase
Society	Members from the local theater, civil society actors engaged in the RwL process, participants of the performative citizen participation event on-site
Science	Members of the real-world lab (employed at the university), undergraduate students
Policy	Members of the real-world lab (employed by the city administration, employees of the city administration not directly attached to the RwL project

were addressed in this implementation planning phase. The people who were most affected by the changes to the place were integrated into the decision-making process: people who were employed at the theater were actively invited to the workshop, as well as to the following meetings. They actively shaped the decision of which ideas should be tested for improving the square (not in their working hours but in their spare time). People who were interested but may not be affected by immediate proximity were invited to share their ideas and express reservations during the performative citizen participation event on-site. The time period of the experiment on the theater square was determined by the university as well as civil society members, which meets co-determination. The space is open to the public, and accordingly the decisions made in this phase hold in the sense of public realm effects for a (potentially) large amount of people. Additionally, sharing of power as well as cooperation, in the sense that there was mutual agreement on which measures should be trialed as interventions, became evident throughout the workshop and subsequent working group meetings.

4.1.3. Implementation phase

In the implementation phase, the ideas that had been mutually agreed were put into on-site redesign measures. Civil society actors from the theater built benches, including one that also served as stage for open air events. With the help of a gardener, existing green spaces were transformed into more biodiverse ones. Furthermore, trees in planters were rented and placed in the square for the duration of the experiment to demonstrate what impact green can generate for the reduction of heat-island effects (Fleckenstein et al., 2022), as well as for aesthetic reasons. Last, free cultural outdoor events were agreed and organized by the non-state actors. During the events, gastronomic services were offered. Accordingly, based on the documents representing this phase, we identified passages representing the governance mode **private self-governing**. The most important decisions regarding the square design, contracting and event arrangements were made by non-state actors. Non-political actors obtained the necessary approvals that were needed for interference with the public space. They solicited offers from multiple service providers. The meetings on-site (for example with the gardener) and auxiliary work, as well as watering the green areas, were organized by the members from the theater without the involvement of city administration members. City administration representatives facilitated this kind of self-organization from a distance (Hysing, 2009) by providing city maps, accompanying public relations work, and also signed official approvals.

In this working group constellation (Table 4), members of civil

Table 4

Overview of actors during Implementation Phase.

Actor Group	Actors in Implementation Phase
Society	Members from the local theater, (service providers)
Science	Members of the real-world lab (employed by the university)
Policy	Members of the real-world lab (employed by the city administration), employees of the city administration not directly attached to the RwL project

society and science took ownership of nearly all tasks. They negotiated and met with service providers. Due to the commitment of the theater employees in their spare time, green spaces and trees could be preserved. Invitation and supervision of artists who performed at the events were also responsibilities fulfilled by civil society members from the theater. Accordingly, all aspects of participation in governance processes are fulfilled to a high degree during the implementation phase. Through the application of the framework, a shift regarding a surrender of power between the phases is identifiable.

4.1.4. Evaluation phase of the intervention

During the implementation phase, the different measures were tested, framed as place-based interventions, and evaluations were conducted regularly. The methodological evaluative approach consisted of participatory observation, surveys, and participatory photo interviews (modified approach based on Kolb, 2008). The evaluation was conducted by members of the university before, during and after the interventions on-site. Although all actor groups involved were fully aware of the evaluation, members from the university took all decisions regarding the methodological design of the evaluation. The responsibility for evaluating the experiment's interventions lay with the researchers. This is often the case in RwL evaluation. (Holewik, 2022).

Another reason for the dominance of university members in this phase was the heavy workload and limited time the theater members had, because of their influential role throughout the collaboration (Gramberger et al., 2015). Due to the high number of small-scale decisions, the relatively small group of civil society actors (about 10 people) were highly occupied.

Evaluation findings were forwarded to the theater administration and the city department for urban green spaces and parks. The results of the evaluation are not binding. Even if certain tested measures have proven to be particularly popular, this does not mean that they will be established in the long term. Either way, few measures still continue to exist on the square.

Based on the documents included in this fourth and final evaluation phase of the experiment, no governance mode could be derived, as no state actors were involved. Accordingly, the framework could not be assessed.

4.2. Governance arrangements established throughout the real-world experiment

In the previous sections, we applied the framework to four phases of the real-world experiment, offering an actor-centered and process-oriented qualitative evaluation. In three of the phases, identification, implementation planning and implementation phase, governance arrangements between the three actor groups were built and evolved. Non-political actors had increasing influence regarding the redesign of the public square (Table 5).

In the identification phase of the experiment, power was distributed relatively equally among the three actor groups. The decision about the squares to be experimented on was made together. However, actors directly affected by possible changes in the square became increasingly involved. The application of the framework showed that the three groups forming the experiment were no self-contained homogeneous groups. Respective compositions changed between the phases. Therefore, it is crucial to describe each actor group precisely for each phase. Further, we identified how governance arrangements changed and developed. During the two subsequent phases implementation planning and implementation, civil society actors were instrumental in determining the ideas to be tried out, and were highly involved in the actual implementation of the interventions on-site. The real-world experiment offered the context in which governance arrangements were formed. Civil society actors were largely autonomous in deciding which measures should be tested in public and for how long. University members took responsibility for administrative tasks. Only through the

Table 5
Overview of governance established throughout the real-world experiment Favorite Places.

Governance Mode	Actor Groups Involved	Participation of non-state actors
Phase 1: Identification		
Facilitation and enabling of networks	Civil Society Actors from the RwL's steering group, RwL team members both employed at university as well as city administration	**Public realm** – decision on squares as test spaces affects citizens' living surroundings; **co-determination** - civil society members as well as members from university were actively involved in the decision-making process which is normally the responsibility of the city administration and political decision-makers; **cooperation** - joint problem-solving approach was evident throughout the working group meetings; **sharing of power** - jointly agreed on the specific squares in the city serving as test spaces; **representation** – not applicable
Phase 2: Implementation Planning		
Mutual dependency of networks between private and public actors	Civil Society actors as members from the local theater, civil society actors engaged in the RwL process, participants in the performative participation on-site, RwL members employed at university, undergraduate students, RwL members from city administration, employees from city administration (parks department)	**Public realm** – decision on measures to be trialed that will reshape the square; **co-determination** – civil society/university actors highly influenced decisions regarding physical appearance of the square as well as the period; **cooperation** and **sharing of power** established through workshops and meetings as decisions were made together, performative participation on-site was open to everybody; **representation** - members of the theater who were mostly affected shaped the process and decisions significantly.
Phase 3: Implementation		
Private Self-Governing	Members from the local theater, (Service Providers), RwL members employed at university, RwL members employed at city administration, employees from city administration (parks department)	**Public realm** – decisions on how measures will be implemented and how the place will change exactly; **co-determination** – meeting with service providers & contracts shaped by non-political actors; **cooperation** and **sharing of power** - through empowering non-political actors in taking responsibilities, political actors as enablers for the other actors, **representation** – members of the theater who were mostly affected decided how to implement measures to a high degree.

commitment of civil society actors events for enlivening the space could be offered, and measures such as trees and biodiverse green spaces were preserved. The implementation of the real-world experiment did not start as a bottom-up initiative initiated by civil society, but the opportunities that were made available to civil society actors to drive the experiment and interventions were utilized. In this real-world experiment, governance constellations were formed in which groups of civil society actors gained increasing decision-making power, while at the same time members of the city administration acted as enablers for self-governing from a distance.

5. Discussion

In this article we have proposed a framework to capture governance arrangements formed within real-world experiments. Urban governance as well as science institutions are considered to play crucial roles in advancing sustainable development worldwide (Dick, 2016; Keeler et al., 2019; Schneider et al., 2023; Smith & Wiek, 2012). In RwLs and associated experiments both premises are connected. While being implemented jointly between science, political-administrative and civil society actors, real-world experiments offer opportunities for initiating governance arrangements. So far, this possibility has received little attention in literature. With the framework introduced here, we aimed to close this research gap. In the following, we first discuss how the framework benefits other research endeavors by offering transparent evaluation criteria for capturing governance-related aspects in multiple contexts. Further, we present learnings we derived from the application of the framework to our case study.

5.1. A framework to capture governance processes in various settings

While the idea for the framework originated from our experiences as transdisciplinary researchers involved in a real-world experiment, we argue that the framework is usable in multiple contexts. It offers a transparent set of criteria to capture how governance networks unfold, and therefore it could also be applied to assess RwLs and transdisciplinary projects where political-administrative actors are involved. The framework offers ways to approach actor constellations within the groups of science, policy, and civil society more precisely, considering that they are not self-contained homogeneous groups. Respective compositions can change. The framework emphasizes this possibility and provides a transparent and theory-based set of criteria for evaluating different contexts where public authorities are involved in these settings. It provides ways to assess the political nature of such formats. The framework also addresses the criticism that the criteria for case studies are too vague (Adler et al., 2018).

RwLs normally consist of multiple experiments, and through the use of the framework, several real-world experiments within one RwL can be compared along pre-defined criteria. In this way, comparisons and derivations are possible within one RwL, even if the real-world experiments have diverse thematic scopes. While we have only applied the evaluation framework to one real-world experiment within a RwL, further research could further test the framework and apply it to multiple real-world experiments within one RwL. In order to validate or further adapt the framework, a subsequent application is needed. Further, the framework is also applicable to transdisciplinary research projects, which are increasingly conducted in many countries all over the world to establish science-society-policy interactions (Schneider et al., 2023). The framework offers criteria for evaluating these science-society-policy interactions as governance practices formed throughout transdisciplinary research. The framework consists of a rigorous set of criteria that contribute to transdisciplinary case study research (Adler et al., 2018). Last, the framework is applicable for 'second generation experiments' (Grin 2020). Grin used this phrase to describe experiments that are initiated and shaped by local governments. The framework is applicable to an increasing number of experiments in sustainability

science and related fields such as planning studies (Eneqvist & Karvonen, 2021) and climate governance research (Bulkeley, 2023), that are established for 'testing new and unconventional ways of dealing with societal issues in real-world settings' (Suitner & Krisch, 2023, 3).

While the chances associated with experiments and projects that are conducted transdisciplinary between state and non-state actors have been highlighted, these transdisciplinary settings imply 'open, plural and democratic politics, with central roles not just for policy, but also for mobilization, critique and political challenge' (Scoones et al., 2020, 69). The establishment of such projects as well the following application of the introduced evaluation tool is not possible everywhere but depends on the prerequisites introduced by Scoones et al. (2020) as well as 'the political, cultural and social contexts of a city in both national and urban settings' (Lnenicka et al., 2024).

5.2. Learnings from the application of the framework to our case study

As we can see, the framework does not aim to capture impacts resulting from the real-world experiment. Neither can it be used to evaluate trialed interventions within the experiment. A comprehensive evaluation of real-world experiments encompasses approaches to evaluating interventions, which is highly context-specific and relies on their thematic scope. In the case study experiment Favorite Places, an evaluation of the interventions was conducted independently from the application of the framework. By focusing on the modes of collaboration developed in the experiment, there is less pressure on the tested intervention(s). Even if the intervention was less successful or could not be tested to the extent intended, the framework can still be applied (as long as the main requirement of cooperation between state and non-state actors is met).

Due to the character of transdisciplinary research and its iterative process, it is complicated to distinguish between the phases of a real-world experiment. Although we provided insight from existing literature that fits our case study, the differentiation of the individual phases is highly context-specific. Future application of the framework could also provide insights into how governance networks might be formed during the evaluation phase of an experiment, which we could not further assess in our exemplary analysis. Further, we did not consider phases established within transdisciplinary research projects or urban experiments that we suggest as other potential contexts for the framework's application.

Based on its illustrative application we provided first insights into how to make use of already existing data. This data body was not generated based on the framework. However, in future applications, a second group of material could include intentionally developed documents that are generated based on the framework. These might be used to, e.g., deductively develop questions for interviews with actors in experiments. The criteria shown in the framework could also inform guidelines for (participatory) observations of real-world experiment group meetings. While we cannot yet give empirical insight on how to *design such* data collection based on the framework, through a planned application of the framework from the beginning of an experiment, a better database could be created. For us, this was not possible, as the experiences during the real-world experiment formed the initial trigger for us to conceptualize the framework. Accordingly, its application could only be made after the experiment, drawing on existing data.

The application of the framework was a meaningful exercise for reflecting on the governance arrangements formed throughout the case study experiment. The analytical framework captures a specific evaluative aspect, applying actor-specific and process-oriented perspectives. Through its application, governance networks and their development throughout real-world experiments are captured.

6. Conclusion

In this article we presented and illustratively applied an analytical

framework for evaluating governance practices developed in real-world experiments. By applying the framework, we observed how different types of governance networks emerged during a real-world experiment. Using the framework to evaluate real-world experiments highlights their potential for creating new governance practices in cities. Investigating experiments and transdisciplinary research settings through governance theories also adds insights to the field of participatory urban planning. Citizens should have the right to participate in decision-making processes that directly affect their living conditions (Geekiyanage et al., 2021; Nop & Thornton, 2020). As reservations on public participation in urban planning exist both for urban planners as well as civil society actors (Åström, 2020; Li et al., 2020), transdisciplinary research formats such as RwLs as well as (real-world) experiments can serve as windows of opportunity for these groups to come into contact with one another. Here, the short-term character of experiments (Torrens & von Wirth, 2021) is a crucial characteristic, as neither group needs to make long-term commitments. Real-world experiments hold the possibility to function as contact initiators between non-political and city administration actors, conducting joint actions serving civil society members' interests (Méreiné Berki et al., 2017). These contacts could facilitate further co-planning processes in which not only the 'usual suspects' participate (Lang et al., 2012). Interesting foci of further research could be how the involved civil society actors perceive urban planning processes following their experience in the experimental governance network, and whether and how the governance arrangements formed in (real-world) experiments and transdisciplinary research projects continue beyond their formal ending.

CRediT authorship contribution statement

Teresa Kampfmann: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Philip Bernert:** Writing – review & editing, Methodology, Conceptualization. **Daniel J. Lang:** Writing – review & editing, Methodology, Conceptualization. **Stefanie Drautz:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

Appendix A. Overview of documents included in the framework-based exemplary analysis

Date	Availability	Type	Applied to phase
07/09/2021	Non-Public	Minutes RwL steering group	Identification
24/11/2021	Non-Public	Minutes experiment working group	Identification
01/12/2021	Non-Public	Minutes experiment working group	Identification
13/12/2021	Non-Public	Minutes experiment working group	Identification
17/01/2022	Non-Public	Minutes experiment working group	Identification
21/02/2022	Non-Public	Minutes experiment group- theater	Implementation Planning
26/02/2022	Non-Public	Documentation on publicly collected ideas	Implementation Planning
28/04/2022	Non-Public	Minutes experiment group – theater	Implementation Planning
13/05/2022	Non-Public	Minutes experiment group – theater	Implementation Planning
n.d.	Public	RwL website (Lüneburg, 2030b)	Implementation Planning
18/05/2022	Non-Public	Application for alternative use	Implementation Planning
01/06/2022	Non-Public	Authorization for alternative use	Implementation
12/06/2022	Non-Public	Endorsement	Implementation
13/06/2022	Non-Public	Endorsement	Implementation
14/06/2022	Non-Public	Endorsement	Implementation
25/06/2022	Non-Public	Endorsement	Implementation
n.d.	Public	Theater Website (Theater Lüneburg, n.d)	Implementation
29/06/2022	Public	Leuphana Website (Leuphana, 2022)	Implementation
n.d.	Public	RwL Website (Lüneburg, 2030c)	Evaluation of the Intervention
21/03/2023	Non-Public	Master Thesis	Evaluation of the Intervention

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4.3 Analyzing the political impact of Real-world laboratories for urban transformation in eight German 'Cities of the Future'

Teresa Kampfmann, Daniel J. Lang, Annika Weiser (2024)

Analyzing the political impact of Real-world laboratories for urban transformation in eight German 'Cities of the Future'

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ABSTRACT

Real-world laboratories (RwLs) provide research settings to develop and test sustainability solution options and have gained considerable attention in the field of sustainability research since the early 2010s. RwLs, especially those in which urban municipalities are involved as partners, have been linked to promises for fostering sustainable urban development, but they are also critically discussed, e.g., for being used as proof for already doing 'enough' in terms of sustainability and citizen participation. However, these assumptions are rarely empirically investigated. This paper applies a traceable methodological approach. We focus on long-term RwL processes in eight German cities, that were all part of the Cities of the Future funding program (2015–2022/23). Based on policy documents provided in city council information systems, we conducted a qualitative content analysis. By applying deductively and inductively developed codes, we capture the ways in which the RwL processes were a) linked to changes in urban polity, politics and policy, and b) strategically used by city officials. Our findings suggest that most of the RwLs had political impacts in several ways. Further, attempts of strategic use were particularly visible for politically highly impactful RwLs.

1. Introduction

Experimental approaches are considered promising for contributing to urban transformations towards sustainability (Scholl and de Kraker, 2021; Torrens et al., 2019). One specific format in this field that has gained considerable prominence since the last 10 years are real-world laboratories (RwLs) (Schäpke et al., 2017; McCrory et al., 2020). RwLs have been established as settings for transdisciplinary research and joint experimentation towards sustainability (Schneidewind et al., 2018; Bergmann et al., 2021). While many approaches exist for capturing change towards sustainability on the local and national level (Geels et al., 2016; Oates, 2021), the effects of RwLs on cities as political systems have not yet been empirically studied (Kern and Haupt, 2021). Effects resulting from RwL approaches have been addressed on individual levels (Singer-Brodowski et al., 2018; Franke et al., 2022; Albiez et al., 2016). Impacts that go beyond micro levels were introduced conceptually (Augenstein et al., 2022), but have not been captured in the political sphere of urban transformation.

RwLs hold the potential to drive changes on meso and macro levels (Marg et al., 2019), and to create political-institutional transformations towards more sustainability (Schneidewind and Rehm, 2019). There is a need to investigate if, and in which ways, those changes occur in practice (Parodi et al., 2021; Wanner et al., 2023). Therefore, in this paper, we empirically analyze the political impacts of eight RwLs. We analyze political decisions made by public authorities that were justified through RwLs. In doing so, we (i) address the often-articulated need to assess the societal impacts of transformative research formats in practice (Stelzer et al., 2018; Turnheim et al., 2018); (ii) stress the importance of political action for achieving change towards sustainability with less pressure on individual decisions (Grunwald, 2012; Neckel, 2021), and (iii) consider calls for a stronger connection between (neo-) institutional theory and sustainability transitions (Fünfschilling, 2019; Parris et al., 2022). Additionally, we consider arguments that critically reflect on those experimental sustainability formats (e.g., Torrens and von Wirth, 2021; Lawrence et al., 2022). We investigate how RwL processes have been strategically used through underlying statements that claim they demonstrate cities' improved sustainability efforts. In this way, we follow the view that while RwL projects can have demonstrable impacts, they can also be utilized by city officials to strengthen an argument.

In this study, we analyzed policy documents provided by city council information systems such as resolutions, budget plans and minutes, in which RwLs were linked to altered policy, polity and politics in eight

municipalities. These municipalities were part of a seven-year 'Cities of the Future' programme (2015–2022/23) to establish and conduct urban RwLs in Germany, funded by the Federal Ministry of Education and Research (BMBF). With the ending of this funding programme, we see an opportunity to investigate how far these eight RwLs were drivers for change towards more sustainability in the respective urban governance contexts. We aimed to capture effects of the RwL processes at the administrative-political level. We selected suitable documents and conducted a qualitative content analysis by applying and developing deductive and inductive codes. We thus followed an empirical, traceable approach to capturing effects linked to urban policy, polity and politics resulting from RwL processes.

The paper is structured as follows. In the next chapter, we discuss literature that suggests effects of transdisciplinary research formats on the political-institutional level, from which we later formed our deductive codes for the qualitative content analysis. In the third chapter, we give a structured overview on the eight German cities and their respective RwL processes. Chapter 4 introduces our methodical approach. We present how the policy documents were selected and provide an overview of them. This is followed by the presentation of our coding process, where we also introduce the inductively developed codes. In chapter 5, our results are presented, which are critically approached and linked to recommendations and further research in the discussion.

2. Theoretical background

One core characteristic of RwLs is their aim to contribute to societal transformations (Schäpke et al., 2018). Ways to evaluate this kind of contribution need to be further explored (Wanner et al., 2023; Augenstein et al., 2022; GAIA, 2023). One approach in this endeavor could be to distinguish between different spheres of transformation and to further address the impacts of RwLs in each domain of transformation. O'Brien and Sygna (2013) discuss three (interdependent) spheres of transformation. These include the personal, political, and practical sphere of transformation, approaching changes in personal views and values, political shifts towards sustainability as well as actions and practices towards sustainability. This article uncovers impacts from RwLs in the political sphere of transformation. To be more precise, the study focusses on impacts of RwLs in the political sphere of urban transformation. Several works that study effects from transdisciplinary research projects in general, as well as from urban sustainability experiments in particular, serve as a useful basis for deriving categories of impacts that are observable on the urban governance level. Thereby, we follow approaches that understand RwLs as one format of transdisciplinary research (Bergmann et al., 2021), as well as perspectives that consider experiments as central components of RwLs (Schneidewind et al., 2018). We draw on literature that uses the terms *effects* or *impacts*, and we use the terms synonymously in this article. To analyze the successes and shortcomings of the RwLs on urban governance, we take up the proposal discussed by Kivimaa et al. (2017). They suggest drawing on articulations of urban policy, polity, and politics to approach successes and shortcomings of experimentation. Accordingly, we use the

differentiation between policy, polity, and politics (Fig. 1) for structuring the effects RwLs (might) have on cities.

2.1. Articulations of policy: content-wise changes

Schäfer et al. (2021) proposed a model for systematizing societal effects of transdisciplinary sustainability research. One category identified is the influence those projects can have on laws and regulations. For the field of sustainability experiments, Karvonen (2018) emphasized the possibilities of informing long-term policies. Schreiber et al. (2023) connected urban experiments to changed urban planning policies. All these works have in common that the effects of transformative research projects target the content of urban policy. Building on this, our analysis includes capturing text passages in which decisions regarding policies are linked to experiences from RwL processes.

2.2. Articulations of polity: institutional change within city administration

Another effect identified by Schäfer et al. (2021) is structural effects created by transdisciplinary research projects, such as the establishment of novel staff positions. The call to investigate the effects of experiments on institutional refiguration is quite broad. It encompasses not only formal institutions such as city administrations and their respective departments, but also values, norms, and social configurations in the sense of networks (Fünfschilling et al., 2019). We decided to adapt a narrow institutional view in our analysis, and to concentrate on altered structures within the city administration as an institution. Following the understandings of Kivimaa et al. (2017) and Bulkeley et al. (2015), we concentrate on changes in the system of the urban municipality. Our analysis encompasses capturing discursive links and effects of RwLs on existing organizational structures within the public administration, as well as changes in city administration as an organization.

2.3. Articulations of politics: citizen participation & inter-institutional collaboration

Using the notion of participatory governance, Marg et al. (2019) discussed possible changes occurring from transdisciplinary research formats, such as novel or improved participation opportunities for citizens offered by municipalities. RwL processes, in which civil-society actors were active partners, could lead to a higher appreciation of citizen participation on the city level. As suggested by Marg et al. (2019), as well as Borner and Kraft (2018), this experience could be implemented by public administrations in developing and offering new and improved formats for citizen participation. At the same time, there is a growing body of literature which stresses the function of urban experiments for fostering networks between city administrations and non-state actors (Hildén et al., 2017; Ehnert, 2023). Following transdisciplinary principles, RwLs are shaped by the collaboration between scientific actors and actors from other societal sectors (Parodi et al., 2016). The potentially strong partnership that emerges in these RwL settings between science and municipality has been subject to previous research (Marquardt, 2019). In the eight RwL cases presented here, the urban municipality

Policy	Polity	Politics
Emphasis on **Content**	Emphasis on **Structure**	Emphasis on **Processes & Actors**
Goals, strategies, measures, instruments	Institutions, organizations, norms	Decision-making, coalition building, negotiations

Fig. 1. Overview of the political dimensions of policy, polity and politics, based on Bernauer et al. (2022), modified.

was always one of the partners. Accordingly, in our analysis we draw on suggested impacts of transdisciplinary research regarding network effects (Marg et al., 2019) and university-city partnerships (Withycombe Keeler et al., 2019). We analyze, a) how citizen participation was improved and strengthened, and b) how collaborations between urban municipalities and research bodies such as universities were stressed as results of the RwL experience.

2.4. Utilization of RwLs

While RwLs have been recognized for their significant potential in achieving sustainability, there is also a growing awareness of the complexities involved in transdisciplinary research projects (Lawrence et al., 2022; Parodi and Seebacher, 2023) and sustainability experiments (Beukers and Bertolini, 2023; Coenen and Morgan, 2020; Von Wirth and Levin-Keitel, 2020). One aspect highlighted by Lawrence et al. (2022) is that transdisciplinary research projects can sometimes be used 'to serve particular interests, such as dominating the political discourse or gaining support from a membership or voter basis' (ibid, 50). Emphasizing individual sustainability projects to present cities as sustainable per se fits into green city marketing strategies (Chicca et al., 2022). There is a risk of *greenwashing*, for being approached as a sustainable, green city (Andersson and James, 2018). We aimed to include these considerations in our analysis to capture instances where RwL processes are strategically utilized.

3. RwLs for future cities

With the 'Cities of the Future' competition launched in 2015, the German Federal Ministry of Education and Research (BMBF) supported teams consisting of local politics and administration, research institutes, citizens and industry to transform their cities and municipalities into more livable and sustainable environments through three phases (BMBF, 2015). In the first phase, visions for the year 2030 (and beyond) were created collaboratively among different city actor groups accompanied by research partners (2015–2016), then solution approaches for achieving such visions were developed in phase 2 (2017–2018). The third phase consisted of the implementation of the developed measures in the form of real-world labs (2019–2022/23), with the municipalities being the main partners. While the first phase started with 51 cities and municipalities, only eight municipalities received funding in the third phase (FONA, 2023). These eight cities' respective municipalities were Bocholt, Dresden, Friedrichstadt, Gelsenkirchen, Lüneburg, Norderstedt, Ulm and Peenetal/Loitz. The RwLs (and similar settings) implemented in the cities/municipalities concentrated on different aspects of sustainable urban development (BMBF, 2023).

Table 1 provides an overview of the cities and their respective RwL projects in phase 3. We introduce classifications for each category that help to identify similarities and differences between the cities and their projects. These classifications are used to interpret and discuss the results in chapter 6.

Table 1
Overview of the eight Cities of the Future and their real-world lab projects.

City	Population and city classification (according to BBSR, 2023)	Content and thematic breadth of the real-world lab project	Scientific partners and spatial proximity to them	Funding (according to FONA, 2021)
Bocholt	71.000 **medium-sized town**	A project called 'Breathing, moving Bocholt 2030+', with several real-world labs in the areas of education, health, quality of life, mobility and internationalization linked to urban development measures. **broad thematic variety**	University of Wuppertal, German Institute of Urban Affairs (Berlin) **medium spatial proximity**	1,7 million € **≥ 1 million €**
Dresden	554.000 **major-sized town**	A citizen lab with 19 citizen projects, also called transformative experiments, covering the areas education, civil knowledge and participation, energy, culture, mobility, neighborhood, urban space, and economy. **broad thematic variety**	Leibniz Institute of Ecological Urban and Regional Development (Dresden) TU Dresden **close spatial proximity**	2 million € **≥ 1 million €**
Friedrichstadt	2500 **small town**	A project with five 'fields of action': economy, tourism and culture, participation, housing, and the provision of an urban infrastructure for the surrounding area. **medium thematic variety**	HafenCity University of Hamburg **medium spatial proximity**	0,6 million € **< 1 million €**
Gelsenkirchen	263.000 **major-sized town**	A project called 'Learning City! Education and participation as strategies of socio-spatial development', with four real-world labs: 'places of learning and learning laboratories', 'participation in the neighborhood', 'digital city', and 'city and science', conducted in 16 modules in total. **Medium thematic variety**	University of Applied Sciences and Arts Dortmund, Freie Universität Berlin **medium spatial proximity**	1,6 million € **≥ 1 million €**
Lüneburg	76.000 **medium-sized town**	One real-world lab with 15 experiments in four thematic areas: green city, living and working, promoting volunteerism and participation; and economy and urban development. **Broad thematic variety**	Leuphana University Lüneburg **close spatial proximity**	1,4 million € **≥ 1 million €**
Norderstedt	83.000 **medium-sized town**	A project that focused on sustainable housing. **narrow thematic variety**	Advanced Sustainability Studies (IASS) in Potsdam **little spatial proximity**	0,8 million € **<1 million €**
Ulm	129.000 **major-sized town**	A real-world lab with the guiding principle, 'Internet of Things for ALL!'. The real-world lab is applied through four fields of application: mobility, education, administration, and demography. **medium thematic variety**	Zeppelin University (Friedrichshafen), Neu-Ulm University of Applied Sciences, Ulm University of Applied Sciences, Fraunhofer Institute for Industrial Engineering and Ulm University **close spatial proximity**	1 million € **≥ 1 million €**
Peenetal/ Loitz	6000 **small town**	Implemented as four 'real world labs' in order to tackle the increasing shrinkage of the region: 1) the participation lab, 2) the generation quarter, 3) the real-world lab 'build your house' and 4) the real-world lab 'creative strength' **small thematic variety**	University of Applied Sciences in Neubrandenburg **medium spatial proximity**	0,9 million € **<1 million €**

4. Data and methods

To capture direct links between RwLs and citywide changes adopted by public authorities, we make use of increased transparency regulations for political decisions and discussions (Fischer and Kraus, 2020; Wagner, 2023; Manoharan et al., 2021), which lead to more documents being available to the public. Transparency regulations concern different political levels, including the municipal level. In the following, we will first present the council information systems that we used to derive data. We will then explain the search strategy used to identify suitable documents.

4.1. Council information systems as a data source

A promising way to obtain transparent information on the objectives and work of urban municipalities is the use of council information systems. Cities' council information systems are used as a medium for providing access to all public documents (Piesold, 2021). An increasing number of German municipalities offer these kinds of systems to make a variety of documents and information concerning the council's work accessible to the public. The documents presented in council information systems encompass not only official resolutions with binding character (Birghan et al., 2019). The systems also provide access to preparatory documents for meetings of city council and committees as well as associated minutes. Further, they encompass requests and responses as well as documentation on budgeting.

By using the broad array of data found in such council information platforms, we widen the view on policy documents. In doing so, we acknowledge not only cities' official outcomes (such as resolutions), but also focus on the process that led to those outcomes (Barnickel and Klessmann, 2012). We also consider that the funding of the eight Cities of the Future projects has expired recently. Final policy papers may still be under discussion, and not yet adopted. But such discussions - if documented in the minutes - are accessible by focusing on the documents provided in council information systems.

While bigger cities usually offer digital formats of council information systems, smaller municipalities often do not provide such systems (Laxa, 2023). Documents such as minutes of meetings are then published in analog ways, such as notices in the town hall, or in municipal gazettes. Two of the eight Cities of the Future, Peenetal/Loitz and Friedrichstadt (the smallest of the eight cities), do not provide digital council information systems. Friedrichstadt provides access only to minutes from city council and committees meetings online. Peenetal/Loitz publishes a monthly municipal gazette, both analog and digital. Table 2 provides an overview from where we derived our data.

To avoid bias and unbalanced interpretation, we only included data derived from the websites displayed in the table and excluded background knowledge that we possessed due to our involvement as researchers in one of the RwL processes.

4.2. Search strategy

Based on the official web pages of each City of the Future project, we derived the project designations. All of them used the term City of the Future ('Zukunftsstadt') in combination with the respective name of the city. Some used additional names (Bocholt, Gelsenkirchen, Ulm, Peenetal/Loitz, Lüneburg). We then searched in each city council system or other website (as presented in Table 2) for those terms between 1/1/2014 and 16/05/2023. In Table 3, we provide an overview of how many results were found before the subsequent selection process.

As presented in Table 3, there are remarkable differences regarding the number of results between the cities. The seemingly simplest explanation would be that in some cities, the RwL process was discussed more frequently. But it should also be considered that the cities are subject to different requirements regarding what they (must) publish (Fischer and Kraus, 2020). Often, the cities' activities are influenced by laws on the federal state level (Bocholt, Friedrichstadt, Gelsenkirchen, Norderstedt, Ulm, Peenetal/Loitz), which differ significantly according to the requirement for transparency (Vos, 2022). In some cases, transparency laws on the federal state level do not exist (Lüneburg) or the federal state laws explicitly do not apply to municipalities (Magoley, 2022), while some municipalities actively implement their own laws about transparency of documents (Dresden, 2012). In the case of Dresden, this results in an increased transparency. Accordingly, more documents become available.

4.3. Selection process

Before conducting the qualitative content analysis, we determined the entirety of articles eligible for further analysis (Pickel and Pickel, 2018). Based on our aims to identify, 1) effects of the RwL processes, and 2) how those processes were used as form of proof, we formulated the following inclusion criteria.

Documents are included in which:

- the RwL project is linked to any kind of decision made by public bodies, such as the city council or thematic political committees.
- the RwL project is linked to statements regarding cooperation with other institutions and citizens.
- the RwL project is used to strengthen arguments.

While most of the documents were selected based on the inclusion criteria by one reviewer alone, the beginning of the selection process (nearly 10 % of the documents) was conducted by two reviewers for quality reasons. A total of 85 documents were identified for analysis (table4).

Overall, we excluded a considerable group of documents in which (single) activities of the Cities of the Future projects were merely described. We also excluded documents in which procedures and day-to-day activities were discussed, and documents which were not duplicates in a narrow sense (e.g., they were different document types), but

Table 2
The eight cities and their respective websites for accessing policy documents.

City	Website	Limitations
Bocholt	https://bocholt.ratsinfomanagement.net/	-
Dresden	https://ratsinfo.dresden.de/info.asp	-
Friedrichstadt	https://rathaus-friedrichstadt.de/protokolle/	Only minutes are provided
Gelsenkirchen	https://ratsinfo.gelsenkirchen.de/ratsinfo/	-
Lüneburg	https://ratsinfo.stadt.lueneburg.de/bi/yw020.asp	-
Norderstedt	https://buergerinfo.norderstedt.de/ratsinfo/sessionnet/buergerinfo/info.php	-
Ulm	https://buergerinfo.ulm.de/suchen01.php	-
Peenetal/Loitz	https://www.loitz.de/buergerservice/loitzer-bote/	Municipal gazettes

Table 3
Number of results for the eight cities (before selection process).

City/Municipality	Number of results
Dresden	368
Bocholt (additional name: breathing Bocholt)	177
Lüneburg (additional name: LG2030+)	74
Gelsenkirchen (additional name: learning Gelsenkirchen; learning city)	57
Norderstedt	56
Peenetal/Loitz (additional name: small town awakening)	54
Ulm (additional name: digital city)	46
Friedrichstadt	38
Total	**870**

encompassed repetition.

While seven of the eight cities provided only documents resulting from processes within the city administration, Peenetal/Loitz published official documents from public administration in municipal gazettes, which also consist of other article types. Accordingly, for Peenetal/Loitz we also excluded documents that were not produced by the municipality.Table 4

4.4. Short overview of the selected documents

The results vary between years (Fig. 2). The highest number of results was identified for 2022.

The 85 selected documents can be assigned to different types, and include meeting minutes from committees and city councils, resolutions, and resolution controls (usually issued through the mayor), budget plans and associated speeches, requests and replies, as well as internal notifications (Fig. 3).

4.5. Coding process

We used both deductive and inductive codes to extract relevant sections to answer questions about the effects of RWLs on the urban governance level, as well as about strategic use. This procedure is based on the work of Gläser and Laudel (2010), who suggest first formulating categories based on theoretical considerations. Passages of the documents that fit into those categories will be extracted. At the same time, the entirety of codes is open to modification during the extraction process if information emerges in the documents that is essential to answer the research question, but is not captured by the deductively established codes (ibid.).

The deductive codes were developed from the theoretical background in chapter two. In this chapter, we linked literature discussing effects and impacts for transdisciplinary research, RwLs and experiments in the political sphere of transformation to the articulations of polity, politics and policy. Accordingly, originating from the theoretical background in chapter two, we formed the five codes changes in policies (content wise), structural changes, strengthened inter-institutional collaboration, strengthened civil participation options as well as arguments of proofs. The 85 documents identified contain passages that point to further political effects and forms of strategic use of the RwLs beyond the deductive categories. Consequently, we introduce three inductive codes, which have been developed based on our text material. These are physical changes in the cityscape, drawing on real-world lab expertise and favorable positioning as a city. Fig. 4 provides an overview of how the selection and coding process are linked.

In this way, our analysis was led by two areas of interest (effects of RwL processes and attempts of strategic use of the RwL processes) and their respective codes (Table 5).

5. Results

The presentation of results is structured along the areas of interest, a) effects, and b) strategic use of RwL processes. According to the

Table 4
Number of documents included in the content analysis.

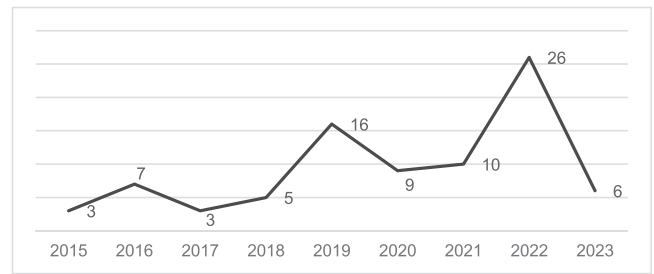| City/Municipality	Number of Documents included
Dresden	34
Bocholt	20
Lüneburg	14
Gelsenkirchen	7
Ulm	5
Friedrichstadt	2
Norderstedt	2
Peenetal/Loitz	1
Total	**85**

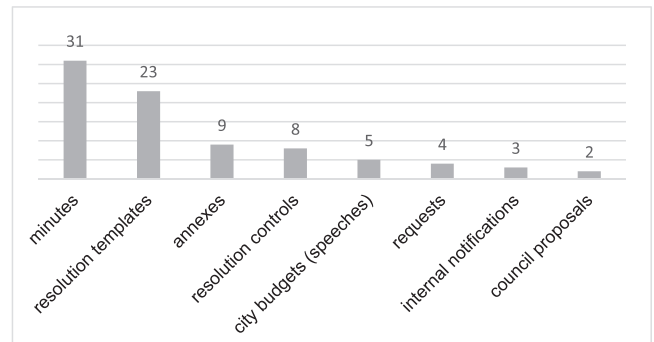**Fig. 2.** Number of included documents per year.

Fig. 3. Number of included document types.

documents we analyzed, none of the RwL processes had all kinds of effects at once. For seven out of the eight cities, we derived indications that the RwL processes conducted had some kind of documented effect on urban policy, politics and/or polity. Similarly, forms of strategic use were discovered in the documents of all cities except for one (Friedrichstadt).

5.1. Effects of the RwL processes

Following work that discusses a modular RwL structure that consists of the components lab context, real-world experiments, and interventions (Schneidewind et al., 2018; Kampfmann et al., 2022), Table 6 provides information on whether the political decisions and statements in the selected documents were more frequently justified by a link to individual experiments or to the entire RwL. In the following presentation of our findings, we will move from the political effects of RwLs that have been identified for the most cities to those that have been identified for the fewest cities.

Effect 1: structural changes in the city adminstration

Changes on urban polity were the type of reported effects that were visible for the largest group of cities. In five cities, the RwLs induced structural changes in the city administration.

In Bocholt, the mayor's department was structurally changed to improve the possibilities for project-based working after the funding for the RwL process had ended (Bocholt 2022a). In Ulm, the 'creative space' for employees of the city administration trialed in the RwL continued to exist in the administration's structure so that creative aspects of the concept of new work could be further implemented (Ulm 2022a). In Lüneburg, novel staff positions were planned to sustain employees and their respective expertise from the RwL (Lüneburg 2022a). Dresden planned to implement the RwL approach in the areas of citizen concerns and participation in one specific department (Dresden, 2023). In Norderstedt, two positions were planned to be established based on the city's budget, one for the coordination of the Cities of the Future process between its different phases, and another for the promotion of urban biodiversity (Norderstedt 2016a).
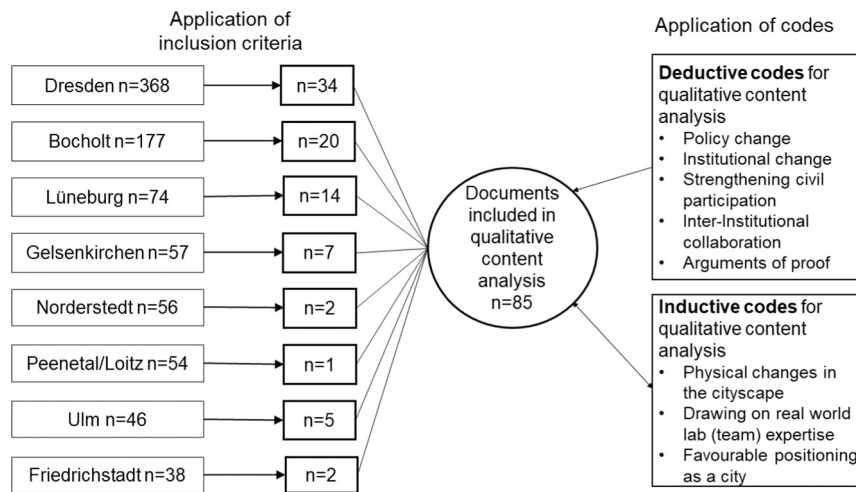
Effect 2: strengthened inter-institutional collaboration

Fig. 4. Presentation of the selection and coding process within the qualitative content analysis.

Table 5
Categories for content analysis according to areas of interest.

Areas of interest	Deductive Codes	Inductive Codes
Effects of RwL processes	Changes in policy	Physical changes in the cityscape
	Structural changes in the institution city administration Inter-institutional collaboration	Drawing on RwL (team) expertise for other ventures
	Strengthening civil participation options	
Strategic use of RwL processes	Use of the RwL process as proof	Favorable positioning as city

Table 6
Overview of the (frequency of) effects and their linkages to RwL components experiment & lab (total number of linkages can be higher than number of RwLs as some labs had several variations of the effects).

Type of effects	Number of RwLs showing the effects	Linked to RwL components	
		Experiments	Labs
Structural changes in city administration	5	1	5
Strengthened inter-institutional collaboration	4		4
Strengthened civil society participation	4		8
Physical changes in the city scape	4	5	3
Drawing on RwL team expertise	4		4
Changes in policies	3	4	4

Effects on urban politics were identifiable for half of the cities for each of our codes. Based on our material, indicators for strengthened inter-institutional collaboration could be identified for Ulm, Lüneburg, Gelsenkirchen and Bocholt.

In both 2016 and 2023, it was emphasized in Ulm that the City of the Future process had encouraged the city to deepen its collaborations with the university, as well as with business and civil society. After phase 1, a novel transdisciplinary project in which the city administration and university closely worked together was introduced (Ulm 2016a). With the ending of phase 3, it was stated that based on the experiences from the RwL, the city of Ulm will continue to strengthen and consolidate its cooperation with local scientific institutions (Ulm 2022b). In Lüneburg, the inter-institutional collaboration established within the City of the Future process was transferred to a new project focusing on resilient city centers. Here, participants of associated workshops as well as possible steering group members were selected from the inter-institutional

advisory board of the City of the Future in phase 3 (Lüneburg, 2021). In Bocholt's city budget plan for 2023, the City of the Future process and associated collaborations were linked to future negotiations on the city's strategy and branding. Those negotiations should be undertaken collaboratively with actors from local businesses, sports, churches, and social life (Bocholt 2022a). Gelsenkirchen attempted to increase efforts for strengthening new contacts with actors outside the city administration as learning from phase 1 (Gelsenkirchen, 2015).

Effect 3: intensification of civil participation possibilities

Very closely linked to strengthened inter-institutional collaboration is the intensification of civil participation possibilities as another effect of the RwL processes, linked to altered politics.

Dresden's plan to host the national garden show in 2033 is, for instance, strongly shaped by citizen participation. This decision was discursively linked to experiences gained within the RwL process (Dresden 2022a). Dresden also planned to apply for additional federal state funding to become a citizen municipality. This funding line supports restructuring city administrations to increase the possibilities for civil participation and joint decision-making. The mayor based this decision on the aim to transform the City of the Future RwL approach into a broad, city-wide format that fosters civil-society participation (Dresden, 2023). In a city budget speech held by a council member in Bocholt, numerous proposals for more civil participation as an experience from the RwL process were discussed (Bocholt (2022b), and partially addressed in the adopted city budget plan for 2023, where digital and analog participation formats are planned to be further implemented (Bocholt 2022a). In a meeting of the council committee for finances in Lüneburg in 2022, the mayor stated the importance and further strengthening of citizen participation in reference to the City of the Future process (Lüneburg 2022b). In Ulm, citizen participation will be further advanced through a newly-developed municipal online platform (Ulm 2022b).

Effect 4: physical changes in the city scape

Our material suggests that for four of the cities, the RwL processes led to physical changes made in the cityscape. We captured this type of effect by introducing an additional inductive code. By applying this code, we extracted text passages text that indicate how ideas developed within the RwL processes concerning design and construction in cities were implemented through other funds. These Cities of the Future processes had impacts on the long-term physical shape of cities. The funding of all Cities of the Future projects did not encompass the funding for investment measures, meaning that long-term changes (e.g., for a more attractive city space) were not fundable through the project itself (BMBF, 2015). Rather, application sketches for phase 3 suggest that applicants were encouraged to connect RwL proposals with the Urban

Development Support program (Leipzig, 2017); a federal program for 'supporting municipalities in urban development adaptation processes alongside the federal states' (BMWSB, 2020).

At least two cities decided to link future city processes to Urban Development Support programs (Bocholt 2019a; Gelsenkirchen, 2019). In Bocholt, public spaces and several street sections were redesigned based on citizens' opinions and participation. These changes should improve walkability, bikeability and meeting opportunities between citizens (Bocholt 2019b). Further, demands expressed within the City of the Future project were implemented in other construction projects (Bocholt 2020a). In Lüneburg, a resolution was passed that the city administration will formulate three options to permanently redesign a public square based on citizens' proposals developed throughout one of the real-world experiments (Lüneburg 2022c). In Friedrichstadt, measures on the cityscape were also linked to the RwL activities (Friedrichstadt, 2016).

Effect 5: drawing on real-world lab (team) expertise for other ventures

For four cities, we found indications in the selected documents that the project team's (sustainability) expertise was used beyond the City of the Future projects. Accordingly, the code drawing on real-world lab expertise was introduced to identify text passages that describe how and where the expertise of the project team was used for ventures not directly linked to Cities of the Future project activities. In this way, the RwL process shaped other activities on the urban level.

In Bocholt, plans for renovation of the town hall should be modified after obtaining expertise from the team of the RwL on including more participative elements in the renovation process (Bocholt 2017a). In both Friedrichstadt and Lüneburg, decisions on topics related to housing and ecological sustainability were passed to the respective RwL teams (Friedrichstadt, 2020; Lüneburg 2019a). In Gelsenkirchen, the RwL team was actively included in events to develop a venue concept for the UEFA European Championship 2024. Here, the Gelsenkirchen City of the Future team accompanied workshops from the German Football Association (Gelsenkirchen, 2020) and were part of the group within the city administration that elaborated the concrete Host-City plan for the UEFA European cup (Gelsenkirchen, 2021).

Effect 6: new policies

New policies resulting from RwL processes could be identified for three cities. These can be differentiated into changes resulting from the overreaching topic of the specific RwL, and those that go back to experiments trialed within RwLs.

In 2020, the municipal council of Ulm passed a resolution for a data ethics concept which was elaborated during the RwL process (Ulm 2022a, 2022b). It 'contains ethical guidelines for the design, programming and operation as well as for the use of data, applications and IT systems by the City of Ulm' (Ulm 2022b), with emphasis on citizens' access to data. In Bocholt, demands expressed in the City of the Future project were implemented in the Integrated Mobility Concept 2035 (Bocholt 2020b). Dresden applied for a funding line for the development of smart cities; here the officials repeatedly referenced their experience with the conduct of the RwL process (Dresden 2021a,b). Several examples of the consolidation of experiments, or single components of RwL, were found for Dresden and Ulm. A model apartment in a clinic, where elders and relatives can test and discuss innovative technologies, as well as a show garden for sensor-based solutions, were part of the RwL in Ulm, and are now being funded by the city (Ulm 2022b). In Dresden, promotions of several urban district funds were approved until 2024 (Dresden 2022b; Dresden, 2023), after they were trialed within the RwL. Individuals and civil society associations from the districts can apply for funds.

5.2. Forms of strategic use

In addition to the documented effects of the RwLs we addressed in our analysis, we also intended to capture the ways RwL processes were

strategically used by city officials. In nearly every city, we found indicators in the documents that at least one of the two forms of utilization of the projects had been used (the exception is Friedrichstadt).

In five cities, RwL processes and associated results were used to present the respective cities in favorable positions in comparison to other cities and regions. In Lüneburg, the RwL process was linked, for instance, to being a role model for other cities in terms of sustainability (Lüneburg, 2015). This was also stated for Gelsenkirchen (Gelsenkirchen, 2022). Further, RwL processes were described as flagship projects or attractive site factors characterizing the associated cities (Gelsenkirchen, 2016; 2019c). In Ulm, the RwL process was linked to an anticipated economic growth of the whole city (Ulm 2016b).

We found indicators for using the RwL processes as arguments of proof based on the documents of four cities. The code 'favorable positioning as a city' aims to capture text passages in which the RwL process is invoked with a positive portrayal of the city – often in distinction from other cities and regions. By applying this code, we extracted text passages in which the City of the Future project is used as evidence for an attractive, in some way positively connoted, site factor of the city. There were passages suggesting overall urban sustainability 'is given' through the RwL processes (Peenetal/Loitz, 2016; Lüneburg 2019b). On various occasions, the projects were used to prove the city's efforts for environmental sustainability (Dresden, 2018; Lüneburg, 2020; Norderstedt 2016b). Finally, RwL processes were utilized on several occasions to demonstrate a strong local democracy and participation culture in the city of Dresden (Dresden, 2019; Dresden 2021b, 2022c).

6. Discussion

In the following, we first discuss the political impacts of RwLs and their differences before we address the possibilities of RwLs for transformative urban governance. We then touch upon critical appraisals of RwLs and critically reflect on the methodological approach of our study.

6.1. The political impacts of RwLs, and their differences

Throughout the empirical analysis, we found that in all eight cities, representatives and/or employees dealt with RwLs in ways that go beyond just discussing day-to-day activities. For seven out of the eight cities we found that the respective RwLs had some kind of impact on the political-institutional level. The RwLs had clear links to the adoption of novel policies, altered structures in the city administration, strengthened collaborations with other institutions, fostered civil participation options, and contributed to participatorily developed changes in physical spaces. Furthermore, the RwL project teams influenced other ventures of the city.

The codes developed on the basis of the literature, as well as those derived from the analyzed documents, provide entry points for further analysis in the field of RwL impact evaluation in the political sphere of transformation. The introduction of the inductive codes is not only based on the material analyzed but is also supported by literature. The use of the code physical changes in the cityscape is supported by work on urban living labs, which share strong similarities with RwLs (McCrory et al., 2020). Among others, the works of Von Wirth et al. (2019) suggest that the embeddedness in and altered physical structures to be one core principle of ULLs. Augenstein et al. (2022) also considered changes in the physical structure as one impact dimension of real-world experimentation in RwLs. Another recurring aspect of RwL impact is the use of the RwL process expertise for other ventures that cities foster. The findings can be linked to literature discussing the role of boundary objects in transdisciplinary research settings. Boundary objects are seen as shared space between diverse groups (Star, 2010; Mattor et al., 2014). Applied to the identified text passages, this means that the RwLs served as boundary object for city administration members that were not necessarily attached to the RwL. RwLs were used by them to handle emerging (sustainability) challenges by drawing on the RwL team's

expertise. The code 'favorable positioning as a city' is linked to the code 'argument of proof' but is connected to the *external* performance of the city. The introduction of this code is supported by literature discussing that urban competitiveness is increasingly based on communicated sustainability successes of cities (Carrizo Moreira et al., 2023; Komasi et al., 2023).

Nonetheless, we also found notable differences between the RwLs in the sample. Based on the selected documents, three of the eight RwLs brought forward effects in all political dimensions (policy, politics, and polity). While we cannot draw general conclusions from this, our small sample showed that these projects have in common that they received funding starting at 1 million €, the RwLs dealt with at least a medium variety of topics, the cities worked with scientific partners in rather close proximity, and that the cities were not small sized.

While within the Cities of the Future funding line no differences between city sizes were made, more recent German funding schemes on RwLs are specifically designed to target the particularities of small-sized towns and villages (Kesselring et al., 2022; Schmidt, 2023), suggesting that funding schemes need to be adapted according to the geographical context, as well as responding to accusations of underrepresentation of small-sized towns in research policies (Porsche, 2019). Small-sized cities face specific challenges for realizing RwLs (Rhodius et al., 2016). They need more financial resources, possibly because system knowledge must first be created for many small-town contexts, as certain data sets are only available for bigger towns in Germany (Mitchell et al., 2022a). RwLs in small-sized cities have also been described as needing more staff resources, because their municipal staff cannot build on previous experiences in the field or do not yet have the resources to handle tasks that go beyond day-to-day operations (Mitchell et al., 2022b).

The finding of fewer effects for the RwLs carried out in small cities should also be seen in the light of the fact that little data was available for these RwLs. These cities did not offer the same council information systems as the larger cities. From the standpoint of democratic theory, this can be critically discussed. It means that citizens in small cities do not have the same digital, remote access to documents in which political decisions are announced and discussed as citizens in larger cities. From a research perspective, this implies that the political impact of RwLs or other transdisciplinary research projects will be easier to identify for larger cities that have a digital council information system. This also could imply that larger cities have an advantage in terms of funding (Porsche, 2020), as the allocation of funds for transformative, transdisciplinary research projects is often linked to the measurable assessment of the resulting societal impacts (Krainer and Winiwarter, 2016).

6.2. Implications for sustainable urban governance through RwLs

While we demonstrated the limitations of this analysis for smaller cities, we argue that the approach used in this study can be an important contribution to the discussion on how to capture and how to differentiate the political effects of RwLs. We linked RwLs to the political sphere of transformation at the city level, strengthening the prospect that RwLs lead to societal transformations towards sustainability (Schäpke et al., 2018; Barbarino, 2021; Kok et al., 2023), drawing on the crucial role of local governments in achieving sustainability (Sassen, 2015; Neckel, 2021).

RwLs hold the potential to be used by politicians, employees of urban municipalities and other actors to support certain arguments. They can be utilized to put the city in a positive light and can be presented as an attractive site factor of the city. But these attempts of strategic use do not necessarily diminish the potential such RwLs hold for advancing tangible changes. We rather tend to argue that arguments brought forward in the context of 'marketing' a respective RwL could also support convincing city councils and municipalities to conduct ambitious RwLs and similar transdisciplinary projects. Based on the identified effects that RwLs have on the political level, we should rather expand our efforts in critically discussing and strengthening their democratic

legitimacy (Asenbaum and Hanusch, 2021; Jahn and Keil, 2016), as changes made within or as an outcome of RwLs affect the daily lives of many citizens, involving groups of citizens who were not involved in the implementation of the RwLs.

Based on our findings, we argue that RwLs can lead to transformative governance, especially those in which thematically heterogenous experiments were conducted – implying an adequate funding volume. Further, our analysis suggests that impacts in all political fields were more likely to be generated by RwLs with scientific partners in close spatial proximity to the RwL. This hypothesis is supported by prior research on RwLs that highlights the importance of overcoming spatial distance between researchers and the other partners in RwLs (Kohler et al., 2021; Marquardt and Gerhard, 2021a), as RwLs deal with topics that are influenced by the spatial contexts and their specifics (Marquardt and Gerhard, 2021a). As many small-sized towns and villages cannot access scientific institutions in their direct geographical area, we thus support the implementation of novel funding lines that take such contextual conditions into account, as discussed above. Various arrangements could not only support obtaining knowledge of the local system, but also build the basis for relationship work on site (Mager and Wagner, 2022), such as the provision of more travel expenses for researchers, temporary offices for them in small-sized towns.

6.3. Methodological reflections

While studies that analyze council information system data do exist for other disciplines (Raschke, 2021; Neumann, 2020), to the best of our knowledge, the impacts of RwLs and other transdisciplinary research formats have not been linked to this data source before. The analysis presented in this paper seems to be beneficial for identifying the political impacts of RwLs empirically. The transparent selection of documents that are available for the public as well as the subsequent qualitative content analysis overcome the limitations that have often been associated with analyzing the societal effects of transdisciplinary research. In numerous studies, these were assessed through mechanisms of self-reporting, such as surveys and interviews. Accordingly, only the *perceived* effects of actors that were involved in transdisciplinary research settings were captured (De Jong et al., 2016; Fritz et al., 2019; Schäfer et al., 2021). By making use of council information systems, impacts with a temporal and thematic diversity that probably no single actor could have a complete overview of, become visible. A linkage between these approaches could lead to a comprehensive impact evaluation. Nevertheless, the amount of data provided by cities is neither uniform nor comprehensive, as discussed above. Beyond that, there may be many more impacts resulting from RwLs, that were, a) not made publicly available, b) were not political impacts. Further, we did not delve into the underlying political processes that led to the outcomes described, involving negotiations between different parties and other contextual conditions. Nor did we explore the aspect that local authorities applying for funding to develop and implement RwLs that address sustainability issues already appear to be quite ambitious in their sustainability efforts. It would be interesting to ascertain what kind of political changes toward sustainability would have been sought without RwLs. To describe the characteristics of the RwLs, we only considered the facts that were publicly available. In doing so, we did not capture process-related elements such as actor constellations and collaboration culture, which are described as being strongly intertwined with impacts (Lux et al., 2019; Pärli, 2023). To address political changes from RwLs in further research, it seems beneficial to also take process characteristics of the RwLs into account.

7. Conclusion

This article aimed to capture effects of real-world labs on urban policy, polity and politics while also addressing the ways in which they were strategically used by city officials. This study was the first attempt

at using city council information data for showing how real-world lab processes directly foster sustainable and collaborative urban development. Critical approaches were actively included in the analysis, demonstrating that real-world labs can both be presented as showcase projects while developing direct, easily traceable political impact.

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CRediT authorship contribution statement

Annika Weiser: Writing – review & editing, Writing – original draft, Funding acquisition. **Daniel J Lang:** Writing – review & editing, Writing – original draft, Methodology, Funding acquisition, Conceptualization. **Teresa Kampfmann:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

All the policy documents analysed and cited are in the reference list.

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4.4 Impacts beyond experimentation – Conceptualising emergent impacts from long-term real-world laboratory processes

Philip Bernert, Annika Weiser, Teresa Kampfmann, Daniel J. Lang (2024)

Impacts beyond experimentation – Conceptualising emergent impacts from long-term real-world laboratory processes

Real-world laboratories are settings for joint experimentation on sustainability challenges, through the transdisciplinary collaboration of diverse actor groups. By approaching a real-world laboratory from three perspectives, this paper uncovers the emergent impacts of a long-term collaborative process.

Philip Bernert ⓘ , Annika Weiser ⓘ , Teresa Kampfmann ⓘ , Daniel J. Lang ⓘ

Abstract

Real-world laboratories have become a recognised research format for addressing sustainability challenges. In these transdisciplinary settings, actors from civil society, local government, and academia work together using a transdisciplinary research approach to jointly experiment and learn about sustainability transformations. While these labs are considered to have potential, their impact has not yet been fully measured. Therefore, in our paper we explore the case of the *Zukunfts-stadt Lüneburg 2030+* process to uncover the impacts that this long-term effort has generated over the past eight years. By examining the process and its design features from three analytical perspectives, we identify emergent impacts in three dimensions: education, governance, and the lab as an actor for sustainability. Based on our case study, we suggest that real-world labs contribute to sustainability on a local level, beyond the intentional experiments, through impacts that emerge over the course of the joint operation of the lab.

Keywords

emergent impact, process design, real-world laboratory, transdisciplinary sustainability research, transformative research

Real-world laboratories (RwLs) are widely recognised and established as settings for collaborative and transdisciplinary research (Bergmann et al. 2021, Kanning et al. 2021, Parodi et al. 2021, Schäpke et al. 2018, Schneidewind et al. 2018). They are characterised by their orientation towards sustainability, and their long-term, transdisciplinary mode of collaboration, which provides a setting for the exploration of sustainability transformations through experimentation (Schäpke et al. 2018, McCrory et al. 2020). As settings in which different actors from science and society come together to collaborate, RwLs have been associated with a variety of benefits (Kok et al. 2023, Pärli et al. 2022). However, we view the discussion around the impacts of such research projects as being centred around the idea of an impact resulting directly from an intervention – as in the case of real-world experiments. While this perspective may be appropriate for real-world experiments, where the goal is to find causal links between interventions or sustainability solutions and outcomes, it is not necessarily suitable for assessing the impact of RwLs. Although there is a body of research into approaches for assessing the impacts of real-world experiments (e. g., Luederitz et al. 2017, Williams and Robinson 2020), the impacts generated as part of the collaborative RwL processes have not been studied in the same way.

In an attempt to fill this research gap, we suggest a revised approach for assessing RwL impacts based on our experiences in designing and participating in an eight-year RwL process in the city of Lüneburg. This approach is intended to complement the prevalent framing and understanding of impact, and to high-

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TABLE 1: Three analytical perspectives for assessing the impacts of the real-world laboratory (RwL) *Zukunftsstadt Lüneburg 2023+*. The analytical perspectives result from eight categories of impact[a] suggested by Schäfer et al. (2021) and from the benefits of RwLs, as proposed in the literature.

CATEGORIES OF IMPACT	PROPOSED BENEFITS OF RWLS	ANALYTICAL PERSPECTIVES FOR ASSESSING THE RWL PROCESS
learning and capacity building	RwLs as places to facilitate learning (Singer-Brodowski et al. 2018, Beecroft 2018)	**focus on educational features**
■ network formation ■ influence on law and regulations ■ further structural effects	RwLs as places to establish inter-institutional collaborations (Marquardt 2019, Libbe and Marg 2021, Marg et al. 2019)	**focus on collaborative governance features**
■ increase in reputation ■ continuation of activities in the project context ■ new concepts ■ influence on public discourse	interactions and roles in transdisciplinary sustainability research, such as RwLs (Wittmayer and Schäpke 2014, Hilger et al. 2021)	**focus on public interaction features**

[a] Two of the ten impact categories from Schäfer et al. (2021) are only relevant at the level of experiments or interventions and are therefore not applicable at the RwL level. As such, the following two categories have been removed from our investigation: 1. improving the situation; and 2. transfer to other spatial contexts.

light its specific meaning in the context of long-term collaborative RwL processes. We start with the observation that the joint process of operating an RwL comprises many different iterative design features, such as activities, events, features, and actions, all of which follow their own purpose and achieve their own outcomes. Going beyond this, however, we are suggesting that the greater impact that these collaborative processes (and all their elements) make is better understood when approached as emergent; namely as an impact achieved through the combination and interplay of many individual design features and actions.

We aim to address the following research question: what impacts emerge from RwL processes? To investigate this question, we present the case of the RwL *Zukunftsstadt Lüneburg 2030+,* an RwL established in the city of Lüneburg by members of Leuphana University Lüneburg, the local city administration, and actors from civil society. The RwL was initiated in 2015, as part of the *Zukunftsstadt* funding programme[1] of the German Federal Ministry of Education and Research (BMBF), and was developed over three project phases: 1. a joint sustainability visioning process; 2. the collaborative development of solution ideas; and 3. the experimentation in an RwL setting.

We approach the lab process from three perspectives: 1. the lab as a space for learning and education; 2. the lab as a space for new governance structures; and 3. the lab as a public actor for sustainability, all of which we investigate as dimensions of potential impact. Through our approach, we identify and describe impacts that the joint work of the RwL has created in the Lüneburg context. We offer a novel perspective that complements the understanding of impacts as direct or indirect effects of intentional interventions. We conceptualise the impacts achieved in our RwL as emerging from different design features and their complex interplay as developed and implemented during the RwL process.

Approaching the impacts of real-world labs

The impacts of RwL processes are not easily identified. RwL processes are typically designed collaboratively, and they evolve over the course of their duration, adapting new goals, trying and failing with different actions and design features (Bergmann et al. 2021). Moreover, the many and diverse features of an RwL process are not all selected and implemented in pursuit of a larger impact goal. In many cases, the RwL adapts to the needs of the actors involved at any given point in the process. Consequently, a pre-post evaluative methodology is in many cases neither suitable, nor possible (Walter et al. 2007).

Therefore, our analytical approach integrates a number of theoretical understandings to approach these impacts (figure 1, p. 20). First, we adopt the understanding of transdisciplinary research impacts by Schäfer et al. (2021), as well as the proposed benefits of RwLs as discussed in the recent literature (McCrory et al. 2020, Schäpke et al. 2018, Singer-Brodowski et al. 2018). Further, we adopt the analytical understanding by Wiek et al. (2014a). This approach recognises collaborative processes as drivers of impacts and aims to attribute these impacts to the participatory events of a given process. Integrating these understandings enables us to conceptualise the impacts that have emerged over the course of the long-term RwL process *Zukunftsstadt Lüneburg 2030+*.

In our case study, we present exemplary lab features as identified by the research team through joint reflection, building on the experiences from the research process, as well as synthesising available case data from the project documentation and communications throughout. To focus our investigation on the lab process, we disambiguate the lab process and the experiment following the approaches of Kampfmann et al. (2022) and Bernert et al. (2023): they view "experiments" as processes closely linked to the concept realisation of interventions, whereas "lab" describes the broader collaborative process that forms the conceptual context within which experiments are conducted.

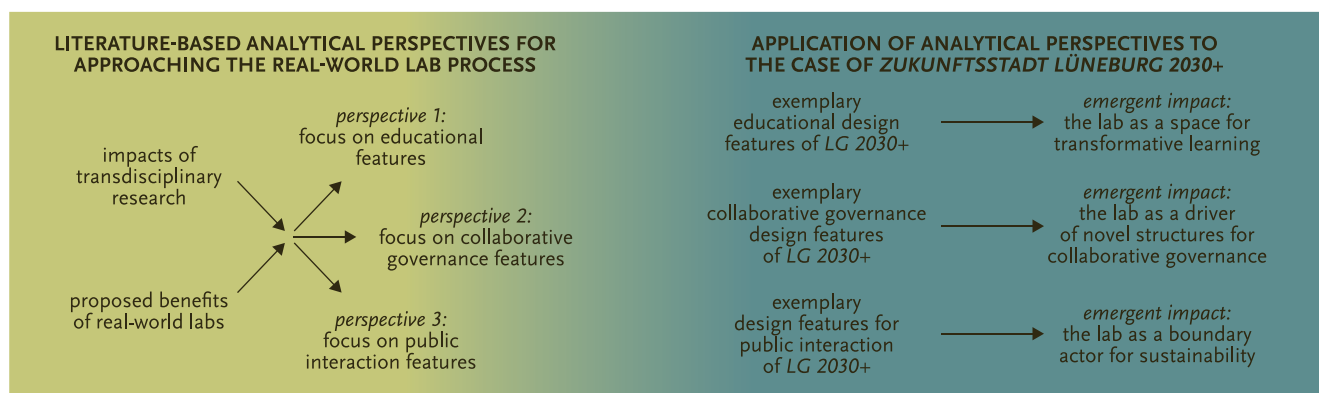1 *www.fona.de/de/massnahmen/foerdermassnahmen/wettbewerb-zukunftsstadt.php*

FIGURE 1: The research approach for uncovering and conceptualising impacts from the real-world lab process of *Zukunftsstadt Lüneburg 2030+* in Lüneburg, Germany. The perspectives are derived from the literature and then applied to our case to identify emergent impacts of the long-term process.

Societal impacts of transdisciplinary research: Three analytical perspectives for investigating real-world lab processes

Previous analytical papers on RwLs have focused on aspects such as the role of structuration (Schneidewind et al. 2018) or success factors (Bergmann et al. 2021), but they have not attempted to evaluate the impacts generated by operating a lab. Therefore, we base our understanding of such impacts, and their appraisal, on a number of approaches that have been put forward in the context of transdisciplinary and transformative research (e.g., Lux et al. 2019, Schäfer et al. 2021). Schäfer et al. (2021) systematise categories for approaching the societal effects of transdisciplinary research that can be differentiated as first, second, and third order effects depending on how closely the observed effects may be linked to the project under investigation. From this set of categories, eight are particularly suitable for assessing the impacts of the RwL itself (as opposed to the experiment level). Summarising these categories into three analytical perspectives enables us to describe the impacts of the *Zukunftsstadt Lüneburg 2030+* RwL (table 1, p. 19).

As shown (table 1), the impacts of transdisciplinary research identified by Schäfer et al. (2021) are matched with literature on the proposed benefits and qualities of RwLs to form the three perspectives on which we base our investigation. These benefits cover the notion that RwLs are spaces that facilitate different types of learning, which might "profit from a differentiated educational perspective for their methodological development, by systematically including learning as a characteristic of their design" (Singer-Brodowski et al. 2018). Moreover, RwLs create contexts in which governance arrangements (in the sense of inter-institutional collaborations between state and non-state actors) are established (Marquardt 2019) to foster societal problem-solving (Wolfram et al. 2019). By institutionalising transdisciplinary research in local contexts, the actors within RwLs may also represent diverse roles associated with this mode of research (Wittmayer and Schäpke 2014, Hilger et al. 2021).

Table 1 summarises our identification of the three analytical perspectives that stem from the impact categories by Schäfer et al. (2021) and the proposed benefits of RwLs. We focus our investigation of the *Zukunftsstadt Lüneburg 2030+* RwL process through the lens of these perspectives. In the following case study section (box 1, p. 21), we identify three exemplary process features for each of the perspectives. These features are then used as a reference for the emergent impacts that we conceptualise in each of the three perspectives.

Case study: Uncovering emergent impacts through three perspectives

In the following sections, we approach the *Zukunftsstadt Lüneburg 2030+* RwL process through the three perspectives as outlined above. We briefly introduce these perspectives, drawing on the RwL literature, and the impact categories suggested by Schäfer et al. (2021). We then reconstruct the process by presenting exemplary design elements. From these design elements and their individual contributions, we then abstract and conceptualise the related emergent impacts.

Perspective 1: Educational features of the lab process

The RwL process of *Zukunftsstadt Lüneburg 2030+* is characterised by the *close connection of activities in the lab with teaching and learning at the local university*. This aspect was central throughout the three project phases, and it unfolded in diverse ways, as demonstrated by the *inclusion of many educational features throughout the lab's process*. We present and describe three such features in the table below (table 2, p. 21).

Emergent impact 1: The real-world lab as a novel space for transdisciplinary and transformative education and learning.

The experiences undergone in the *Zukunftsstadt Lüneburg 2030+* RwL address several levels of learning within RwLs, as conceptualised by Singer-Brodowski et al. (2018). The long process (over many years) leading to the creation of the *Zukunftsstadt Lüneburg 2030+* RwL opened up a window of opportunity for the development of students' individual competences (i.e., system and anticipatory thinking), which was strongly fostered through ex-

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BOX 1: The *Zukunftsstadt Lüneburg 2030+* real-world laboratory (RwL)

Lüneburg is a medium-sized town of about 80,000 residents, located within the Hamburg metropolitan area. The *Zukunftsstadt Lüneburg 2030+* RwL was established as a result of a long-standing and continuously evolving collaboration between actors from the city administration, the civil society, and the university (Bernert et al. 2016). Due to the logic of its public funding line, the RwL consisted of three subsequent phases: 1. from 2015 to 2016, a large-scale visioning process for a sustainable city in the year 2030 and beyond; 2. from 2017 to 2018, the participatory and transdisciplinary development of 17 sustainability solution strategies; 3. from 2019 to 2023, the realization of 15 real-world experiments building on the solution strategies. As of 2019, the process was closely linked to, and officially intertwined with, the formation of a city-wide integrated development concept (ISEK), initiated by the city council of Lüneburg[a] (Hansestadt Lüneburg 2019).

Despite its inherently open and evolving character, the *Zukunftsstadt Lüneburg 2030+* RwL was designed along general principles, including a strong sustainability orientation due to the framing of the project as a local implementation and interpretation of the *Sustainable Development Goals*. The establishment of a steering group, tasked with democratically making all the basic project decisions, was a key feature of the overall project design. The steering group consisted of members from the city administration, the university, and the civil society.

The collaborative process of *Zukunftsstadt Lüneburg 2030+* in all three project phases combined open work phases in different group constellations (e.g., sharing visions for the future in student-stakeholder teams), as well as work steered and conducted by the project team (e.g., to integrate interim results). Each phase ended with a large-scale participatory event (the so-called *Zukunftstadt-Tag*). Students from the local university were closely involved in all the stages, and they contributed their own perspectives from their studies in different areas. In parallel to the project, a case study office was installed to support the students' research and the teaching endeavours (Kirst et al. forthcoming).

The 15 real-world experiments conducted in the third phase were designed to address a variety of sustainability issues in the city, such as sustainable logistics and mobility in the local economy, youth participation for sustainability, supporting biodiversity efforts of civil society initiatives, or the sustainable design of public spaces.

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[a] Christ et al. (2024, in this issue) present an evaluation of another long-term urban RwL in Flensburg, Germany.

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perience-based (Caniglia et al. 2016) and project-based (Wiek et al. 2014b) teaching and learning settings. This also facilitated social learning processes that supported collective meaning-making and reflexivity (Singer-Brodowski et al. 2018). The normative orientation created learning opportunities for both students and other actors in the project, in the sense of individual learning (e.g., normative thinking), as well as social learning (as it potentially led to a higher level of reflexivity) and the capability to jointly deal with mistakes in an iterative collaborative process (Singer-Brodowski et al. 2018). The strong focus on linking the RwL with teaching activities at the local university was a key design feature in this respect, and one that led to emergent impacts in both directions within the educational-research sphere. The RwL created a fruitful learning environment for the students in- **>**

TABLE 2: Exemplary educational design features of the real-world lab (RwL) process for *Zukunftsstadt Lüneburg 2030+*.

DESIGN FEATURES	DESCRIPTION	DIRECT OUTCOMES	LITERATURE[a]
higher education teaching continuously embedded in the project	■ continuous student involvement based on inter- and transdisciplinary study model ■ experience-based teaching alongside real-world developments in the RwL (e.g., co-developing sustainability visions; supporting the realisation of experiments)	■ >1500 students of all levels were involved in project-related teaching ■ many results are documented in a case study database	Barth et al. 2017, Weiser et al. 2023
development of new teaching formats relating to the RwL	■ lab as context for the development of new teaching formats, in established curricula and new learning modules (e.g., the *Transformative Innovation Lab*)	■ new teaching models and seminar designs deeply involving students in lab and experiments ■ principles for the design of transformative teaching	Bernert et al. 2022, Wanner et al. 2021, 2020
capacity-building around sustainability as a reoccurring lab activity	■ capacity-building for sustainability among the core project members and with external actors and visitors ■ continuous reflection of sustainability understandings in context of current developments in Lüneburg (e.g., COVID-19 pandemic) ■ regular visits from researchers (e.g., tdAcademy; PostDoc Academy, international consortia) as capacity-building formats and to support reflexivity within the project team	■ capacity-building with three cohorts of 20 participants each in the Postdoc Academy ■ adaptable teaching materials as introductions to the RwL approach within the project	Postdoc Academy for Transformational Leadership[b]

[a] Further readings and project-related sources related to the design feature. | [b] *www.bosch-stiftung.de/en/project/postdoc-academy-transformational-leadership*

volved, while the students' activities also helped to support and advance the RwL itself. At times, these activities developed their very own dynamic that contributed to social learning processes far beyond the classroom. In this way, the RwL established a space for fostering transformative transdisciplinary learning and further developing teaching approaches.

Perspective 2: Design features fostering collaborative governance

The RwL process of *Zukunftsstadt Lüneburg 2030+* is characterised by *close collaboration between members of the city administration, the civil society, and the university*. This aspect was central throughout the three project phases and unfolded in diverse ways (table 3). Together, these developments have created an emergent impact that can be conceptualised as establishing the *Zukunftsstadt Lüneburg 2030+* RwL as a *novel institutionalised form of collaborative governance* (for sustainability) in its surrounding local context.

Emergent impact 2: The real-world lab as a driver of novel structures for collaborative governance

While the collaboration between the civil society, the city administration, and the university has a long-standing history in the city of Lüneburg, the RWL process of the *Zukunftsstadt Lüneburg 2030+* has institutionalised and deepened this mode of joint collaborative governance. The RwL has helped to establish both formal and informal networks between state and non-state actors, as well as fostering political plans and structural changes. *Zukunftsstadt Lüneburg 2030+* can be seen as a context in which urban stakeholders could expand their capacities for advocating for urban sustainable development in the future. Through their engagement in the RwL process, members of Lüneburg's city administration were able to gain experience in the fields of inclusive, multiform, urban governance, as well as creating visions for the future and experimenting with sustainability solutions.

Both are crucial components of the urban transformative capacity framework (Wolfram et al. 2019, Castán Broto et al. 2019). The *Zukunftsstadt Lüneburg 2030+* RwL created impact through forming, as well as consolidating, urban transformative capacity, which in turn led to the creation of informal networks, influenced political agendas, and altered the formal structures for fostering sustainability and citizen engagement.

Perspective 3: Design features for public interaction

The RwL process of *Zukunftsstadt Lüneburg 2030+* is characterised by the *close involvement of Lüneburg residents* throughout the three project phases. This involvement was enabled through many design features, which unfolded in a variety of ways. These are presented in this section (table 4, p. 23). Together, these developments created impacts that can be conceptualised as establishing the *Zukunftsstadt Lüneburg 2030+* RwL as a *novel boundary actor for sustainability in its local context.*

Emergent impact 3: The real-world lab as a boundary actor for sustainability

Due to its implementation of diverse activities with a strong focus on public involvement in the context of sustainability questions, we argue that the RwL gained the role of a public boundary actor for sustainability during the project. As a boundary actor, the lab was able to foster active networking among local actors and support numerous sustainability-oriented initiatives by civil society actors, as well as local businesses. By facilitating (and occasionally mediating) the public exchange on sustainability issues, the lab acted as a hub to connect actors with administrative representatives, researchers, and other actors and initiatives. Complementing the efforts of a diverse landscape of sustainability initiatives, the lab institutionalised many of the roles attributed to transdisciplinary researchers (Wittmayer and Schäpke 2014, Hilger et al. 2021).

TABLE 3: Exemplary design features of the *Zukunftsstadt Lüneburg 2030+* real-world lab (RwL) process fostering collaborative governance.

DESIGN FEATURES	DESCRIPTION	DIRECT OUTCOMES	LITERATURE[a]
joint leadership of the RwL process	the RwL process is carried out by the city administration, the university, and local civil society	decisions on structural changes in the city administration were discursively linked to the RwL process	Purschwitz 2023
biannual advisory board meetings	■ the RwL board consisted of members of political parties on the city council, interest groups, and university representatives ■ RwL experiments and further work were discussed at meetings	transdisciplinary working approach and group composition were transferred to a novel project focusing on a resilient city centre	Hansestadt Lüneburg 2021
connected to the Integrated Urban Development Process (ISEK)	RwL and ISEK processes were intentionally linked to each other (e.g., represented in one brand)	■ learning from evaluations of the events held during the RwL process ■ ISEK events were located in isolated city districts to gather the opinions of residents from those areas	Hansestadt Lüneburg 2019

[a] Further readings and project-related sources related to the design feature.

TABLE 4: Exemplary design features of the *Zukunftsstadt Lüneburg 2030+* real-world lab (RwL) process for public interaction.

DESIGN FEATURES	DESCRIPTION	DIRECT OUTCOMES	LITERATURE[a]
large-scale public events	■ large public events (e.g., *Zukunftsstadttage*) during all project phases to educate about the project and invite actors to participate ■ during the COVID pandemic, *Zukunftsstadt-magazine:* broadcast events involving experts and local representatives discussing sustainability in Lüneburg and beyond	■ different event formats have reached up to 2,000 people ■ the opening day of the third phase was attended by 300 to 400 people	*Zukunftsstadt-magazine* avalaible on *www.youtube.com/ @Leuphana*
RwL as a service agency	■ both steering committee and lab activities were designed to be open to citizens and actors interested in collaborations ■ RwL promoted direct connections with local actors and occupied a central position between the actor groups, the city administration, and the university ■ realisation of this role was supported through formats such as open-office days	■ support for new alliances and initiatives (e. g., *Tauschregal,* setting up open exchange shelves for unused goods) ■ recognition of *Zukunftsstadt* as a strong local actor	internal meeting minutes
continuous information about the project's sustainability activities and cooperation with other actors	■ regular information through newsletters and monthly pages in the local newspaper, *Landeszeitung,* to report on project activities and sustainability initiatives in Lüneburg ■ creation of the shared brand *Lüneburg. Die Zukunftsstadt.* for the RwL and ISEK process ■ social media presence on Instagram to inform about the project's progress and activities in Lüneburg	■ continuous information of general public about sustainability activities using diverse channels of communication (e. g., newspaper with a circulation of over 20,000, Instagram page with over 1,500 followers)	Purschwitz 2023

[a] Further readings and project-related sources related to the design feature.

Towards an understanding of emergent impacts of real-world labs

In our case study, we identified several impacts of a long-term RwL process. By reflecting on the eight-year process of the *Zukunftsstadt Lüneburg 2030+* project, we uncovered and conceptualised the impacts in three dimensions.

1 *Emergence as an inherent quality of the impacts of collaborative processes.* The impacts we identified, while not accidental, were not planned for at the beginning of the process and were not achieved due to a specific experiment or intervention. Instead, they emerged from a continuous, collaborative process between the city administration, the civil society, and Leuphana University Lüneburg. All of these participants brought their interests, motivations, and capacities to the process of jointly operating a lab that aimed to contribute to a local sustainability transformation. As we have illustrated in our case study, the process of operating a lab comprises many diverse and small-scale design elements that together build the long-term complex process that is *Zukunftsstadt Lüneburg 2030+*.

However, approaching these single design elements from a cause-and-effect perspective would not enable a reflection of these larger impacts that are, in our view, crucial for answering the question: "Why use RwLs?". We are aware that the concep-

tual impact understanding we offer may not meet the desire to quantify the impacts of RwL research. Explicitly recognising emergent impacts may, however, serve to complement such a perspective, providing a space to reflect upon "success" (in the sense of local contributions and transformative change enabled through its operation) and the transferability of process features. Furthermore, the recognition of RwL impacts beyond the experiment supports their further development as institutions that are not just experimental extensions of transdisciplinarity, or spaces for innovation testing (Parodi 2019).

2 *Using an emergent impact understanding in RwL design.* Future labs may use descriptions of emergent impacts from other labs, not to rebuild the exact same process, but to formulate more differentiated understandings of desired impacts. This could support a deeper shared understanding of the interests, perspectives, and capacities present among actors in the lab to develop a more future-oriented guiding perspective. Thus, while the impacts at the lab level may remain difficult to grasp from a cause-and-effect perspective, the practice of describing and conceptualising these impacts may make them more tangible. This could serve to better align certain design choices with, on the one hand, day-to-day realities (e.g., semester planning, "Vereinsarbeit" or voluntary work, the daily tasks of a city administration) and, on the other hand, with the overall objectives of the RwL.   >

While the impacts that have emerged from the *Zukunftsstadt Lüneburg 2030+* case are strongly intertwined with the local context, we argue that the dimensions in which these impacts lie – labs as spaces of transformative learning, labs as collaborative governance arrangements, and labs as boundary actors – are also relevant for better understanding the value and contribution of RwL processes in other contexts. Moreover, by presenting the design features in addition to the emergent impacts, we have also aimed to provide insights regarding the "knowledge how" (Caniglia et al. 2020).

3 **Developing new methods for impact assessment.** The methods for capturing and conceptualising emergent impacts of RwLs need to be further refined and integrated with similar approaches (Marg et al. 2019, Schäfer et al. 2021). Our tentative analysis has integrated different theoretical considerations to identify impacts by adopting three perspectives. This should be further explored in close cooperation with other RwLs to identify further emergent impacts. Future research could also focus on adequate approaches for the creation of stronger evidence bases for such impacts. However, we are convinced that one strength of our tentative analysis lies in the recognition of the crucial design features of RwL research.

With our contribution to the debate around the impacts of RwL research, we hope to highlight the value of engaging with the emergent impacts of RwLs. We look forward to future developments in this field and to the creation of effective tools for capturing and further conceptualising these impacts.

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5. Synthesis

This section summarizes the overall findings of this dissertation and its implications. It is organized as follows. First, I address the findings focusing on the role of the evaluators as transdisciplinary researchers (articles #1 and #4). Chapter 5.2 delves into the intersection of RwLs and urban governance (articles #2 and #3). These understandings provide the basis for understanding RwLs in relation to urban transformations. The third chapter builds upon my experiences in designing evaluation approaches directed at RwLs (articles #2, #3, #4). I discuss five counterparts of RwL evaluation that support designing evaluation approaches to assess RwLs as drivers of urban transformations.

5.1 Who evaluates? – Transdisciplinary researchers and their different types of embodied knowledge

The question, 'How can we evaluate RwLs as drivers of urban transformations?' is in the first step approached by focusing on the person conducting the evaluation. Following Wiechmann et al. (2012), the choice and design of an evaluation methodology depends fundamentally on *who* is evaluating. In the following, emphasis is on the transdisciplinary researcher who (co-) evaluates the RwL. Article #1 suggested that the role of the evaluator varies strongly in the empirical evaluation approaches studied for labs and experiments in real-world contexts. In addition, article #1 identified reflective approaches as one of the methods used to evaluate labs and experiments. Article #4 applied a reflective approach to assess the impacts of a RwL. The reflection used in article #4 drew on the different types of knowledge we had as RwL researchers, without explicitly discussing them in depth. The combination of articles #1 and #4 provides an understanding of the different types of knowledge embodied in the RwL researchers who were involved in the evaluation, considering the epistemological paradigm of critical rationalism (Popper 1935), and emphasizing that researchers' personal values and subjective assumptions can never be completely eliminated from scientific work.

Roux et al. (2010) proposed reflection as an additional activity in the overall evaluation of transdisciplinary research projects. The authors characterized reflection as calm, lengthy and intent considerations. There is a considerable body of literature building upon reflective approaches to assess transdisciplinary research projects (Carew & Wickson 2010; Schmidt et al. 2020; Schäfer et al. 2021) and RwLs in particular (Bergmann et al. 2021; Libbe & Marg 2021). In transdisciplinary sustainability literature, the roles of (different) knowledge types have been discussed frequently (Caniglia et al. 2021; Brandt et al. 2013), often differentiated between the different actor groups (Verwoerd et al. 2020), and linked to possible tensions and dilemmas resulting from the combination of different knowledge types (Arnold 2022). Following

Jacobs and Nienaber (2011), I suggest that different knowledge types are not only approachable at the group level, but also at the individual level. In addition to the consideration of the combination of knowledge types in a transdisciplinary team, the combination of knowledge types embodied in researchers should also be considered. Personal experiences of transdisciplinary research should also be included (Berger 2015). Researchers involved in RwLs possess knowledge regarding the RwLs' processes and societal impacts due to their regular involvement and frequent exchanges with the other actor groups, as presented in article #4. They hold experiential knowledge. In most cases, the researchers involved in RwLs hold not only responsibility for co-implementing RwLs, but they are also connected to academic knowledge institutions (Arnold 2022; Sellberg et al. 2021 for transdisciplinary contexts; Hilger et al. 2018; Engels & Walz 2018 for RwL contexts). They hold academic knowledge due to their work as researchers, presenters and/or lecturers attached to the university system (Felt et al. 2016). Their academic knowledge influences the way they perceive, discuss and structure the societal impacts of the RwLs that they co-conduct in practice. Experiential and academic knowledge are thus intertwined. However, the role of knowledge types embodied in transdisciplinary researchers who shape evaluations has not been sufficiently explored (ibid.). The transfer of experiential knowledge that was gained by researchers within transdisciplinary research projects has been underrepresented in research (Wuelser et al. 2021). A deeper understanding of subjective and embodied experiences of transdisciplinary researchers is therefore needed (Augsburg 2014).

Academic knowledge can be made transparent easily, drawing on existing data and literature as 'proof'. But the situation for experiential knowledge is more complex (Roux et al. 2017) and challenging (Fazey et al. 2006). Identifying ways to transport experiential knowledge gained throughout research projects is considered crucial (Wuelser et al. 2021). One strategy to make experimental knowledge transparent is to incorporate the logics of academic knowledge. In this way, experiential knowledge on RwL impacts can be made capturable if this knowledge is connected to existent and accessible data (Fam et al. 2020). This means assessing existing natural data matching the reflections' findings, and making the involved researchers' experiential knowledge understandable to a wider audience. The benefits of the use of natural data for evaluation purposes has been described in chapter 3 of this dissertation.

The inclusion of academic knowledge before (through existing studies) and after the reflection (by referring to natural data confirming the impacts, such as political documents and articles) is promising. It engages with criticism about a lack of coherent approaches for capturing impacts of RwLs (Pärli et al. 2022; Parodi et al. 2022; Kok et al. 2023) while it values the importance of reflection (Roux et al. 2010), experiential knowledge (Wuelser et al. 2021) and the combination of knowledge types embodied in transdisciplinary researchers (Jacobs &

Nienaber 2011). Focusing on the 'who' to answer the main question goes beyond the sole focus on RwLs as drivers for urban transformations. Moreover, researchers involved in RwLs (and similar transformative, action-oriented research settings) embody knowledge types that inform evaluations of the societal impacts resulting from these research contexts. The approach described here, strongly based on #articles 1 and #4, is an attempt to inform reflective evaluations explicitly directed at researchers, by valuing the interdependencies of experiential and academic knowledge and making use of existing natural data.

5.2 What is being evaluated? – RwLs as drivers of urban transformations

This chapter dives into the description of the evaluation object of the overall question of how we can evaluate RwLs as drivers of urban transformations. It discusses the nexus between RwLs and urban transformations. Based on the conceptual work and empirical approaches applied in articles #2 and #3, the scope of this chapter is the description of how RwLs function as drivers of urban transformations. Following the prior stated emphasis on the political sphere of transformation, the nexus between RwLs and urban transformations is approached by building upon and combining different governance understandings. The crucial role of state and politics for urban transformation towards sustainability (Rosenbloom & Meadowcroft 2022; Vogel & O'Brien 2022) is highlighted.

In the two articles #2 and #3, different conceptions of governance were connected to RwL contexts. There are alternative views on governance (Castán Broto 2017). The following differentiates between RwLs as urban governance networks, as introduced in article #2, and RwLs as urban governance changers, as investigated in article #3. The view of RwLs as urban governance networks is applicable for evaluating RwLs for urban transformations if urban transformations are seen as processes. The view on governance as the formal arrangement of urban policy, politics, and polity is the basis for evaluating RwLs leading to urban transformations seen as outcomes (Hölscher & Frantzeskaki 2021). In the following, the two different understandings are presented. Finally, a holistic view on the interplay between RwLs, governance and urban transformation is proposed.

RwLs as institutionalized governance networks

The view of RwLs as governance networks is consistent with a process-oriented view of urban transformations, which focuses on the dynamics that produce changes *in* cities (Hölscher & Frantzeskaki 2021). RwLs are seen as governance networks because they are 'structures of interdependence' (Wang & Ran 2022, 1189), where state and non-state actors collaborate, 'ultimately aiming at the realization of collective goals' (Lange et al. 2013, 406). These actors activate resources to pursue the common goal to conduct a RwL, which matches key features

of network governance (Wang & Ran 2022). This perspective can inform evaluations of RwLs as governance networks, using criteria, models, and instruments from (urban) governance literature, as presented in article #2. This perspective offers entry points for evaluations that examine the actor constellations and power relations throughout the RwLs' course. In this sense, a governance network view of RwLs builds on enabling approaches to transformation, as suggested by Scoones et al. 2020. Enabling approaches to transformation shift focus on the processes and power dynamics of transformations, especially on the local level (ibid.).

Understanding RwLs as governance changers

Even though the governance networks described above and in article #2 exist, this 'does not mean that traditional and hierarchical steering mechanisms would disappear' (Heinrichs & Laws 2014, 2628). While non-political actors can initiate transformations, the contribution of governments also needs to be considered (Meadowcroft & Bregha 2009), which matches literature highlighting the role of the state for sustainability governance (Heinrichs 2022). The view of RwLs as governance changers builds upon this consideration. The perspective of RwLs as governance changers highlights the role and responsibility of (local) governmental bodies for achieving urban transformations.

In this way, RwLs in which city administration members are involved can result in changes implemented by local government bodies (Scoones 2016; Sack 2012). In article #3, I investigated this. Policy documents provided by city council information systems showed that RwLs were discursively linked to decisions made for (altered) urban polity, politics, and policies. The view of RwLs as governance changers is linked to the perspective of urban transformations seen as outcomes. Urban transformations are seen as an accumulation of official political changes on the urban level that were implemented by public authorities discussed in reference to the RwL experiences. This view focusses on the transformation *of* cities (Hölscher & Frantzeskaki 2021). Addressing RwLs as governance changers follows a systemic approach to transformation towards sustainability (Scoones et al. 2020). It highlights realpolitik decisions. Features of the city system are seen as targets for focused change (ibid.), such as infrastructure and service delivery institutions (Elmqvist et al. 2019).

Towards a complementary approach

In the beginning of this dissertation, the role of politics both for urban transformation as well as for RwLs has been laid out. The understandings presented above drew on these prospects. They take politics as well as the role of the state seriously, both through the focus on public actors involved in RwLs (RwLs as governance networks) as well as through assessing political changes justified through RwLs (RwLs as governance changers). Through the synthesis of articles #2 and #3, the underlying logics are made transparent.

There are two reasons for the need to consider both perspectives. First, the different aspects of governance in RwLs support assessing urban transformations as both outcomes and processes (Hölscher & Frantzeskaki 2021). Two, the different aspects of governance in RwLs support approaching transformations both as enabling and systemic (Scoones et al. 2020), as well as citizen- and state-led (Scoones 2016). Drawing on both governance perspectives in RwL research acknowledges that there are multiple trajectories that lead to urban transformations. It considers transformative change modulated by state bodies (systemic approach) as well as civil society action (enabling approach). Furthermore, transformation towards sustainability is understood as both citizen-led and state-led (Scoones 2016). Subsequently, citizen-led urban transformation is approached by understanding RwLs as governance networks between citizens and state actors. The state-led transformation perspective is used to assess RwLs as governance change facilitators. Accordingly, RwLs are contexts in which at least two different ways of achieving (urban) transformations can be realized.

Table 2 Understanding of RwLs and their (possible) contributions to urban transformations.

Understanding of RwLs	**Link to (urban) transformations**	
	Based on Hölscher & Frantzeskaki (2021)	*Based on Scoones et al. (2020) and Scoones (2016)*
RwLs as governance networks	Urban transformation as process	Enabling approach to transformation – Focus on citizens
RwLs as governance changers	Urban transformation as outcome	Systemic approach to transformation - Focus on state

The view of RwLs as governance networks as well as governance changers contributes to the ongoing discussions on the power of civil society actors in driving sustainability. On the one hand, civil society actors can inform sustainability (Frantzeskaki et al. 2016; Hölscher et al. 2019), for example through their involvement in governance networks (Buijs et al. 2023), which was presented above for RwLs. On the other hand, there is a considerable body of literature emphasizing the role of state institutions and formal governing leading to transformation to sustainability (Patterson et al. 2016; Ansell et al. 2022). By combining the two governance understandings of RwLs, the crucial role of civil society actors is validated, while the power of the local political system is held accountable.

5.3 How is it being evaluated? – Introducing five counterparts for designing evaluative approaches

While I did not develop and apply a case-based evaluation approach in article #1, articles #2, #3 and #4 encompassed the presentation of the design, the application and the results of evaluations directed towards RwLs (article #3) and their respective components (article #2 – experiment, article #4 - lab context). The evaluation approaches are the result of a variety of decisions that I had to take as an evaluator. Both the fields of evaluation research as well the body of work on evaluations of RwL and transdisciplinary research projects offer a multitude of options for designing evaluation strategies. The possibilities evolving around the design of evaluation strategies are diverse, including contradictory and mutually exclusive counterparts.

In the following I present five counterparts of RwL evaluation. The counterparts presented shaped the design of my case-based evaluation approaches (articles #2, #3 and #4). Accordingly, the counterparts are not directed at the evaluations of interventions. Based on my experiences as a transdisciplinary evaluator, and based on my articles #2, #3, and #4, I argue that these counterparts function as the basis for developing case-specific evaluation approaches directed towards RwLs. They serve as guidance points in the design process. Combining all the 10 single elements of the counterparts could inform development of an integral and comprehensive evaluation directed to the collaborative elements of RwLs. While the five counterparts could inform RwL evaluations generally, I give more detailed descriptions of the counterparts regarding RwLs as drivers of urban transformations.

Figure 6 presents an overview of the counterparts. The elements of the pairs are not necessarily mutually exclusive. Either an evaluation is able to cover both aspects, or they function like a continuum along which the evaluation can be designed.
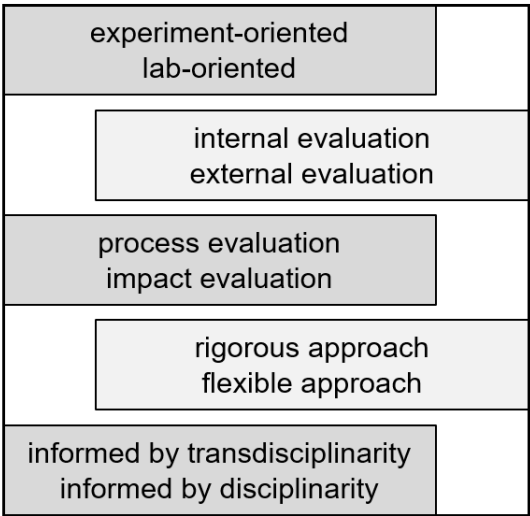

Figure 6 Counterparts in designing RwL evaluation approaches.

The first conceptual pair evolves from the field of RwL research. Parodi et al. (2022) pointed out the challenge to develop an evaluation approach that can both assess **experiment** as well the **lab** level within RwLs. This perception fits my modular understanding of RwLs as presented in article #1. The differentiation between the components of RwLs was used as the guiding principle in all my case-based evaluations. I argued that evaluation approaches found in the literature apply different logics regarding their focus on labs and experiments. Accordingly, the approaches developed in #2, #3, #4 are applicable to both experiments and labs if they are modified accordingly. The evaluation framework presented in article #2 was applied to the different working phases of a real-world experiment. In the discussion section of article #2, I argued that it is also applicable to RwLs and their phases. For both RwLs and real-world experiments, governance networks established between public and non-public actors can be captured using the framework. Article #3 applied an empirical approach capturing political decisions that were discursively linked to RwLs and to individual experiments conducted within them. It is also possible to adapt this approach. The search strategy needs to be modified regarding the evaluation focus. For a focus on one specific real-world experiment conducted within RwLs, this would mean using the name(s) of the real-world experiment as search phrase(s) in the city council information system. At the same time, a sole focus on the lab context is also possible. The name(s) of the RwL will then be used as search terms. The inclusion criteria would be different to the approach applied in article #3, adding criteria to exclude results in which the political decisions were linked to single experiments and not the overall RwL. Accordingly, while the evaluation approaches used can be easily modified depending on whether they focus on real-world experiments or the overall RwLs, the question of where the focus should lie must be a matter of prior clarification.

Another guiding principle identified is the decision between **internal or external evaluation** approaches. I understand internal evaluation as evaluation that can only be conducted through involvement in the co-design and co-implementation of RwLs or their experiments. Drawing on the concept of natural data, an internal evaluation would mean relying on meeting minutes and similar documents that are only accessible to those involved in the RwL activities. Internal perspectives have often been applied to evaluate RwLs (Rhodius et al. 2016; Parodi et al. 2018; Engels & Walz 2018). They are closely linked to transdisciplinary co-evaluation approaches (Schneider et al. 2019). External approaches can be carried out even if the researcher was not involved in the RwL or the implementation of an experiment. They rely on publicly available data, as presented in article #3. Both document types that were used in articles #2 and #3 have advantages and disadvantages. A robust, integral evaluation could be informed by both perspectives. This would mean a researcher involved in RwL settings drawing on internal documents for analysis while also using public documents, which refers to the approach applied in article #4 and described in chapter 5.1.

The next juxtapositions addressed are **process and impact evaluation**. While there are existing evaluative approaches linking process characteristics to impacts resulting from transdisciplinary research projects (Pärli 2023; Schneider et al. 2019), the differentiation between evaluations focusing on processes established in RwL contexts or impacts induced through them still is evident (Meyer et al. 2021). This goes back to a long-standing history in evaluation research, where it is common to distinguish between process and impact evaluation (Döring 2019). Article #4 can be seen as an attempt to mix process and impact evaluation. Article #2 was strongly directed on processes, while article #3 focused on impacts and provided no insights on processes. An integral evaluation scheme would consider both processes and impacts. A connection from processes to impacts could be drawn. This connection can inform others in designing impactful RwLs, as insights into both process characteristics as well as impacts connected to these are provided. Since urban transformations are considered in the literature as both a processes and an outcomes, a comprehensive evaluation of RwLs as drivers of urban transformations would link both process and impact evaluation, as discussed in the previous chapter 5.2.

The next conceptual pair is **disciplinarity and transdisciplinarity**. Disciplinarity and transdisciplinarity refer to the evaluation criteria and methods. Article #3 strongly drew on disciplinary principles regarding its methodological proceedings, drawing on empirical approaches derived from political science discourse analysis. On the other hand, the deductive criteria were strongly informed by literature from the field of sustainability transdisciplinary research. The evaluation criteria developed in article #2 in the form of the proposed evaluation framework was informed both by scholars from the field of governance as well as transdisciplinary approaches. The empirical process to illustratively apply the framework followed a strong transdisciplinary understanding. The majority of involved documents were accessible for consideration due to the involvement in the RwL and experiment. Article #4 applied an evaluation exclusively informed by transdisciplinary core understandings. Studies from other disciplines for designing the evaluation were not used. Urban transformations are understood as inherently political in the present work. RwLs are transdisciplinary research contexts. Accordingly, selected criteria and methods can be developed according to disciplinarity and transdisciplinarity to meet both approaches.

The final conceptual pair addressed is **flexibility and rigor**. Flexibility is considered crucial for RwL research (Bergmann et al. 2021). Accordingly, 'devising and applying evaluative criteria or schemas for an approach that is recognized as necessarily tailored, flexible and evolving' (Carew & Wickson 2010, 1146) remains challenging. Article #3 applied a rigorous approach, following a rule-guided sequence of document identification and coding. Articles #2 and #4 differed, involving more flexible approaches.

As presented above, the last three of the five conceptual pairs presented are somehow interconnected. It seems to be that transdisciplinary, internal as well as flexible approaches often come along together. At the same time, evaluative approaches informed by other disciplines, external evaluation as well as rigorous approaches seem to be more connected. This impression stresses the need to consider all 10 aspects in designing comprehensive evaluation approaches directed at RwLs and their experiments to assess the resulting societal impacts. As RwLs are formats of transdisciplinary research, their flexible, context-specific, evolving character should not be neglected in evaluations. The counterparts introduced build upon this character. Designing an evaluative approach along these counterparts could be an answer to the challenges addressed for societal RwL evaluation research (Kok et al. 2023; Wanner et al. 2018).

Accordingly, the question of how we can evaluate RwLs as drivers of urban transformations is answered through building upon the knowledge types embodied in RwL researchers, in assessing RwLs both as governance networks and changers, as well as through developing evaluative approaches oriented on the 10 presented principles for RwL evaluation. For the ongoing discussions on RwL evaluations, firstly, consideration of the evaluator as a transdisciplinary person could be a contribution. Also, an increased use of natural data could benefit RwL evaluations. Secondly, a holistic understanding of RwLs as drivers of urban transformations was provided, considering literature stressing different aspects of (urban) transformations. These understandings offer points of entry for evaluation, focusing on governance networks and/or changes implemented through governance. Thirdly, practical recommendations for the design of evaluations were discussed.

5.4   Reflections and Limitations

While the dissertation offers conceptual and practical contributions for RwL understandings and evaluations, especially in connection to urban governance and transformations, ambiguities and limitations remain. In the following, I reflect on three constraints found. The central aspect of this work was the focus on urban transformations, linked to the idea that cities hold great potential to foster global sustainability (Sassen 2015; Ansell et al. 2022). The perspective resulting from this and applied throughout this dissertation needs further critical consideration. One, I assess the German-centric view used in this dissertation. Two, the finite political power of cities is considered. Third, the limited view of impacts that are merely located in the political sphere of transformation is critically discussed. Finally, a reflection on the overall methodological process is provided.

The cities where the RwLs were conducted and on which I focused are all located in Germany. Whilst this offered me easier access as a researcher (articles #2, #3 and #4), the analyses I

presented are German-centric. They do not involve any focus on administrative structures from other countries. I only applied political-administrative concepts of what urban means in German contexts. For the emerging discourse on RwLs in the global south (e.g., Krütli et al. 2018; Mukute et al. 2018; Pereira et al. 2020b), my work might be – due to its concentration of German city governance systems – of limited use.

Many countries have implemented laws that require policymakers to publish minutes, resolutions, and other government documents (Wagner 2023; Manoharan et al. 2021). These documents are usable for discovering the impacts RwLs have in the political-administrative sphere. Still, RwLs imply 'open, plural and democratic politics, with central roles not just for policy, but also for mobilization, critique and political challenge' (Scoones et al. 2020, 69), something that is hardly given in each and every country. Given the recent discussions on the federal law on RwLs in Germany that would result in the institutionalized dissemination of RwLs all over the country (BMWK 2023), I argue that research approaches following a particular focus on German contexts would be needed, something to which I have contributed with this dissertation. Still, I exclusively addressed the impacts resulting from RwLs at the city level. In future work it might be beneficial to assess if RwLs attached to the urban contexts could have impacts at the federal state or national level (Augenstein et al. 2022).

Although cities (in Germany) have decision-making power in many policy areas and therefore have great opportunities to generate transformational change towards sustainability (Sassen 2015), they cannot legislate on all aspects that are relevant in the 'wicked' area of sustainability (Johnson et al. 2015). While I highlighted the influential role of authoritative bodies in achieving transformational change towards sustainability, one should also be aware of the limitations of the power that state bodies have due to liberalization and declining state capacity (Scoones 2016).

The focus of this work was the prospect RwLs hold for the political sphere of transformation. Still, this is not the only sphere of transformation, and there are also practical and individual ones (Vogel & O'Brien 2022). All three are intertwined and influence each other. I did not explicitly address these relationships. Building upon work from Wolfram (2016), it would have been promising to consider urban transformative capacity developed by individual actors representing city administrations, as it could be argued that this capacity led to political changes. However, the restricted focus on individual capacity is explained by my chosen methodological approach. Through the usage of natural, pre-existing data, I did not produce data within my dissertation on shifts in individual mindsets and changed attitudes which could provide information on the effects occurring in the personal sphere of transformation.

While offering novel ways to capture the impacts of RwLs, the usage of only one type of data holds limitations. This data type only represents one aspect of the documented reality (Schulz

et al. 2020). Their creation followed specific rationales (ibid.). The data used throughout the included articles were highly processed. Analyzed minutes or resolutions gave no information on how far the discussions reproduced in the documents were abbreviated. We have no way of knowing what went on behind the scenes. Still, using these types of documents avoids common errors in the establishment of artificial data such as the transcripts of interviews (Hoffmann 2018). The results of the analyses show that ways exist for capturing impacts from RwLs that are replicable and traceable. It was shown that these impacts can be seen within the course or directly beyond the formal end of RwLs. Based on these documents it has been made visible that RwLs can lead to state- as well as citizen-led transformations (Scoones 2016) in cities.

6.   Conclusion and Outlook

Linking RwLs to the prospect of urban transformation is not the first attempt to assess cities as places of hope and optimism. A rich history of linking cities to a brighter future – both for individuals as well as for whole societies - has been subject to research and policy previously (Siebel 2012). The governmental systems of cities have been described as the leading entities for achieving the SDGs (Ansell et al. 2022). Still, the implementation of policies, politics and polities that foster sustainability is considered challenging due to a lack of sufficient resources (Johnson et al. 2015). Further, while challenges first become visible at the city scale (Sassen 2015), the large number of interconnected and interdependent problems, which are unique in their social and environmental impact (van Breda et al. 2016; Bulkeley et al. 2023) can become overwhelming. RwLs as third-funded research contexts concentrating on multiple thematic aspects can confront the overstrain. They are an opportunity for cities to mitigate long-term changes. Political changes that are justified with RwLs and enforced through the power of state bodies are unique. The changes go back to collaborations between multiple actor groups representing different sectors of society. In this way, political decisions linked to RwLs and real-world experiments could experience greater acceptance (Graf et al. 2023; Augenstein et al. 2022), or at least become more explainable. Moreover, RwLs as context-dependent infrastructures shaped by local actors seem to be exactly what is needed to encounter the intrinsic logic of cities (Berking & Löw 2008; Hahne 2021). 'Cities are so different, so contingent, that it does not make sense to build cities on a common global objective or shared recipes for best practice' (Castán Broto 2017,11). RwLs are designed and implemented by building on exactly these differences and intrinsic logics of cities.

This dissertation has offered an additional understanding of RwLs, building upon the involvement of city administration actors. This approach draws attention to political and social structures for sustainability (Jahn 2023), overcoming the dominating focus on the capacity of

individuals to adopt appropriate behaviors (Romero-Lankao et al. 2018), while stressing the responsibility of public political institutions in creating sustainability transformations (Mock 2020; Brand 2021). The dissertation assessed how RwLs are approached by different governance understandings for assessing them as drivers for urban transformations. It provided insights on how this contribution can be evaluated. Still, a range of new questions arose. These include how urban transformations resulting from RwLs influence their hinterland. Could we think beyond the city scale and establish RwLs encompassing larger geographical scales, acknowledging that climate-related losses and events do not care about the artificially constructed city borders at all? What should actor-constellations look like in these multi-scale RwLs? How could these RwLs build upon the different intrinsic logics of socio-cultural entities?

RwL research faces many challenges and uncertainties. But it is characterized by great potential for transdisciplinary researchers. It is almost an obligation to be curious and to be inspired by other bodies of knowledge, both academic and non-academic. For me, this is the key advantage for further attempts to answer the above and many other open questions in the field of RwL evaluation. Accordingly, I will end this work with a quote from Burch et al. 2018 (322): 'In a post-Paris Agreement world, it is the task of urban scholars to cast their conceptual and empirical nets widely, to explicitly acknowledge the complex politics of urban innovation, to explore models of governance that are inclusive and adaptable, and to delve into the power of a multitude of actors to effect change'.

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8. Appendix

Overview of articles included in the doctoral thesis

(in accordance with the Guideline for cumulative dissertations enacted at the Faculty of Sustainability in January 2012)

Article No.	Bibliography	Publication Status	Specific contribution	Weighing Factor
1	Kampfmann, Teresa; Bernert, Philip; Lang Daniel J. (2022): Toward a modular evaluation of Real-world labs. Findings from a literature review	Published in *Research Evaluation*, peer-reviewed journal	Co-author with predominant contribution	1
2	Kampfmann, Teresa; Bernert, Philip; Lang Daniel J.; Drautz, Stefanie (forthcoming): Governance for urban sustainability through real-world experimentation – Introducing an evaluation framework for transformative research involving public actors	Published in *Cities*, peer-reviewed journal	Co-author with predominant contribution	1
3	Kampfmann, Teresa; Lang Daniel J.; Weiser Annika (forthcoming): Analyzing the political impact of Real-world laboratories for urban transformation in eight German 'Cities of the Future'	Published in *Environmental Science and Policy,* peer-reviewed journal	Co-author with predominant contribution	1
4	Bernert, Philip; Weiser, Annika; Kampfmann, Teresa; Lang Daniel J. (2024): Impacts beyond experimentation – Conceptualising emergent impacts from long-term real-world laboratory processes	Published in *GAIA - Ecological Perspectives for Science and Society*, peer-reviewed journal	Co-author with important contribution	0,5

Declaration (according to § 16 of the guideline for cumulative dissertations)

I avouch that all information given in this appendix is true in each instance and overall.

Hamburg, 27.03.2024

Explanatory Notes:

Articles included in a cumulative doctoral thesis can also be conference contributions or book chapters besides papers published in journals.

Bibliography: Author(s) – Title – Journal / Book / Conference contribution – Date of publication – DOI (if available)

Specific contribution of PhD candidate submitting the doctoral thesis / Author status according to § 12 of the guideline for cumulative dissertations

- Single author = own contribution amounts to 100%.
- Co-author with predominant contribution = own contribution is greater than the individual share of all other co-authors and is at least 35%.
- Co-author with equal contribution = (1) own contribution is as high as the share of other co-authors, (2) no other co-author has a contribution higher than the own contribution, and (3) the own contribution is at least 25%.
- Co-author with important contribution = own contribution is at least 25%, but is insufficient to qualify as single authorship, predominant or equal contribution.
- Co-author with small contribution = own contribution is less than 20%.

Weighing Factor according to § 14 of the guideline for cumulative dissertations

Single author	1.0
Co-author with predominant contribution	1.0
Co-author with equal contribution	1.0
Co-author with important contribution	0.5
Co-author with small contribution	0