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Labs in the Real World: Advancing Transdisciplinary Research and Sustainability Transformation

Mapping the Field and Emerging Lines of Inquiry

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Guest Editors

There is a strong trend towards research in society-based laboratories, especially in relation to sustainability. Semantic analysis reveals related discourses and emerging lines of inquiry, namely transformative potential, transdisciplinarity and learning. Real-world laboratories are a dynamic example of this research. Contributions of how to deepen and broaden their analysis are presented.

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Mapping the Field of Sustainability-Related Lab Research in the Real World

Research approaches establishing laboratories in real-world contexts (LRWs) have gained popularity. These approaches use different terms, build on different research traditions and are applied in multiple research contexts. Yet, the collaboration of scientific and societal actors, their embeddedness in real-world contexts and use of experimentation, seem to be common.

The salience of approaches is also evident in the sharply increasing number of publications (figure 1)[1]. In the last ten years, the use of LRWs, with a topical relation to sustainability issues, has increased disproportionally. In 2017, approximately 36 percent of overall LRW publications were sustainability-related, which include, for instance: urban living labs, socio-technical experiments and transition arenas. Arguably, these LRWs aim to produce evidence on solutions to societal challenges (Caniglia et al. 2017) and support change towards sustainability (Voytenko et al. 2016). As part of this broader "experimental turn" in sustainability science (Overdevest et al. 2010), real-world laboratories (RwLs; German: *Reallabore*) have lately witnessed an increasing popularity (figure 1), particularly evident in the German speaking discourse. As RwLs often originate from research policy initiatives (e. g., funding lines in Baden-Württemberg), they are met with high expectations and critical voices, demanding a thorough discourse.

The multitude of terms bears the risk of obscuring key topics addressed and potential contributions made by the different LRW approaches. This might hinder learning processes within the respective scientific communities and beyond. To provide an overview on the discourse, we used a semantic mapping[2] tool to reveal frequently used terms and interrelations between them. Subsequently, we mapped publications dealing with LRWs in two consecutive steps: we present semantic clusters for LRWs in general (A), before presenting those with relation to sustainability (B). This also allows us to embed debates on RwLs into a broader context and to show the development of the discourse.

The semantic map of ***all LRW settings*** (figure 2, p. 10) shows a dominant cluster around the terms of ***living labs and (open)***

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1 Annual LRW citations increased from 82 in 1997 to 403 in 2007 and 2030 in 2017. We did a literature search in the *Scopus* database, building on a prior, qualitative screening of relevant approaches (see online supplement *MET* for detailed methodology). We provide respective lists of highly cited publications identified in the online supplement *LIT (A)*, *LIT (B)* and *LIT RwL*. The supplement is available at *www.oekom.de/supplementary-files.html#c11350*.

2 We used the software *VosViewer* (*www.vosviewer.com*) for semantic clustering, building on occurence and co-occurence of terms in the identified literature (see supplement *MET*)[1].

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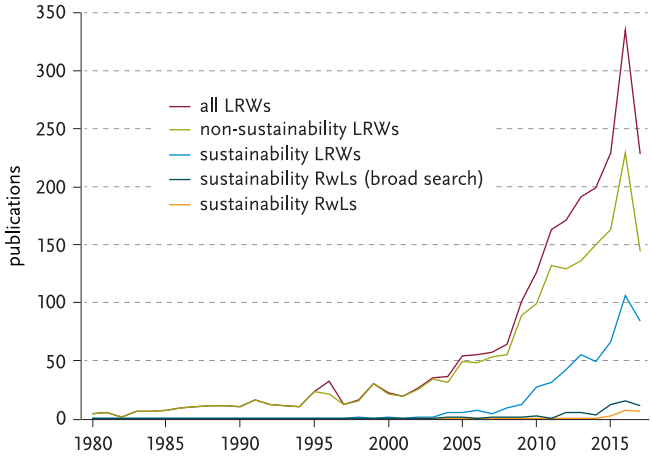

FIGURE 1: Number of annual publications on laboratories in real-world contexts (LRWs) (and with a topical relation to sustainability issues) in peer-reviewed journals and peer-reviewed books. Publications were identified via a *title, keywords and abstracts* search in the *Scopus* database. For *RwL (broad search)*, a second full text search was done to trace earlier roots of the respective discourse.

innovation (red/Ra). Therein, various subclusters can be identified. These include *living labs, smart homes* and ambient intelligence, smart grids, and ICT. Other subclusters relate to *living labs and learning,* education and experiments or to *living labs and governance,* sustainability, climate change, and transition management. This living lab cluster is complemented by three clusters centering around:

1. ***computing (green/Ga),*** future internet, virtual reality, smart cities, and experimental design,
2. ***evaluation (yellow/Ya),*** simulation, project management and services,
3. ***transdisciplinarity (blue/Ba),*** co-design, RwLs and experimentation.

In the semantic map of ***LRW related to sustainability*** (figure 3, p. 11) three clusters emerge:

1. the living labs, ***energy, technology/ICT and infrastructure cluster (dark red/Drb),*** which relates living labs to topics such as electric vehicles, smart cities, future internet and energy efficiency;
2. the living labs, ***sustainability and societal change cluster (orange/Ob),*** which situates living labs in connection to systemic perspectives on societal change, such as transitions, sustainable innovation, education and governance related to climate change as well as normative concepts such as resilience and sustainability;
3. the ***laboratory settings cluster (blue/Bb),*** which brings together various lab-like approaches related to sustainability and transitions. This includes urban living labs, urban transitions labs, strategic niche management, and transition arenas. The terms of transdisciplinary (td), experiments and RwL appear, accompanied by research policy.

Comparing both maps, the sustainabiltiy-related discourse on LRWs appears nested within broader LRW debates. Yet, differentiations and focuses within the former become visible. The abundant and unspecific use of living labs as a concept in (A) witnesses a more differentiated use in (B), either being related to a clear research area (Drb) or oriented towards normative concepts (Ob). In contrast, formerly separated discourses around transition management, socio-technical transitions and smart cities (Ra), and on transdisciplinarity, RwLs and research policy (Ba), merge into one cluster (Bb). This indicates a certain convergence of two discourses: one originating in science and technology studies, innovation and complexity studies; and the other in philosophy of science, collaborative and sustainability research. Therein, the terms of sustainability transitions, experiments and learning operate as interlinking elements of joint interest. Finally, the clusters centering around computing (Ga) and evalutation (Ya) do not re-occur in (B). Both either suggest a limited relevance with regards to sustainability related labs, or an underexplored topic.

Differentiating the temporal occurence of terms in (B) allow "hot topics" to be identified with highest occurence in latest years (see supplement *SMR-Temp*)[1]. This includes RwLs, transdisciplinarity, and research policy, urban living labs in relation to sustainability and energy transitions, experimentation related to learning and transition management. Interestingly, formerly identified interlinking elements re-appear as hot topics underpinning their importance for the discourse development. Semantic analysis of topics broadly discussed in RwL publications (supplement *SMR-RwL*)[1] reinforced named hot topics, adding terms around transformative research. In sum, the RwL discourse mirrors salient key debates in the broader sustainability LRW discourse. Thus, RwLs appear as a suitable, dynamic example contributing to the development of the broader field.

Emerging Lines of Inquiry

Building on the above, we propose two basic directions for strengthening the discourse on RwLs and sustainability related LRWs: 1. deepening the discourse by elaborating on RwLs as an example of LRWs focusing sustainability, including experiences from Baden-Württemberg and beyond; 2. broadening and integrating the discourse, by relating RwL debates to international debates around other LRW approaches.

In this special issue, we bring together articles that allow us to both build bridges in the diversified field of sustainability-related LWRs, and advance knowledge on key topics in RwL practice. Taking into account the semantic analysis and hot topics identified, we have clustered the contributions into four areas:

Transformative potential: Proposed as "ideal-type" of transformative research, RwLs are at the centre of controversial discussions revolving around topics such as the "the third mission of universities" or "the responsibility of research to contribute to societal transformations". Critical questions address the transformative >

impact of LRWs, their practical facilitation and assessment, as well as research policies to promote transformative research:

- ***Schneidewind et al. (pp. 12–17)*** develop a structural perspective on RwLs, portraying them as a new type of large-scale research infrastructure creating spaces for transformation.
- ***Heiskanen et al. (pp. 60–67)*** analyze underlying Theories of Change in European RwLs from the area of households' energy practices, to identify design logics suitable for transfer and broader application.
- ***Defila and Di Giulio (pp. 97–104)*** present a typology and discuss add-on value and success factors of accompanying research to support the implementation of innovative research formats like RwLs.
- ***Nowotny (pp. 6–7)*** portrays past and current developments within the science system and places LRWs within a bigger picture including mode 1, 2 and transformative research.

Transdisciplinarity: There is a fundamental debate on the relation of LRW settings to transdisciplinary (td) research approaches, including questions of successful practice to realize co-creation, co-production and co-design:

- ***Pregernig et al. (pp. 32–38)*** empirically analyze critical design junctions as deliberate intervention points in the procedural setup of RwLs, to employ interdisciplinary and td research.
- ***Rogga et al. (pp. 18–22)*** provide a conceptual comparison of RwLs and td research, and identify RwLs as possible extension of td research processes towards testing solutions to sustainability challenges.
- ***Menny et al. (pp. 68–77)*** investigate processes of co-creation via user involvement in four urban living labs, exploring the link between user involvement and transformative potentials.
- ***Engels and Walz (pp. 39–45)*** explore strategies to address challenges of multi-perspectivity amongst stakeholders in an urban transformation laboratory.

Learning: LRWs contribute to capacity development, new scientific insights and societal learning, building on iterations of experimentation and reflection. Questions tackle labs as educational settings, tools and processes for knowledge integration, experimental and transformative learning.

- ***Singer-Brodowski et al. (pp. 23–27)*** apply a systematic perspective from the discourse on education for sustainable develop-

FIGURE 2: Semantic clusters of publications on all LRW settings (core section of overall map, full map in supplement)[1]. Size of bullets represents frequency of occurrence of terms, size of arrows depict frequency of co-occurrence. Colours indicate different clusters of highly co-occuring terms.

ment to differentiate learning processes occurring in RwLs.

- ***Krütli et al. (pp. 46–51)*** introduce the prototype of a sustainability learning lab established in global South-North collaboration, and reflect realized teaching activities including td case studies (tdCS).
- ***Scholl et al. (pp. 78–84)*** present insights from four urban labs on the action research approach of "transitioning", applying learning and reflexivity practices to transform classical innovation into transition experiments.

Overarching conceptualizations: RwLs can be understood as a combination of characteristics, such as transformative potential, td collaboration and learning. Characteristics are interdependent. Questions include promising combinations for shaping different characteristics, synergies and trade-offs.

- ***Parodi et al. (pp. 52–59)*** empirically compare three RwLs along the topics of interior design, sustainable development, transformation and learning, and provide recommendations for RwL practice.
- ***Engels and Rogge (pp. 28–31)*** elaborate fundamental tensions in RwLs relating to participation, temporality and space, and show how participants in two case studies perceive and deal with them.
- ***Schäpke et al. (pp. 85–96)*** identify core characteristics of RwLs and draw recommendations for RwL design from a characteristics-based comparison of RwLs, urban transition labs, sustainability living labs, and transformation labs.

As this special issue demonstrates, RwLs are a dynamic example in the expanding field of research in labs oriented towards sustainability. They promise to advance td research and sustainability transformation. Nevertheless, more conceptual and empirical development such as evaluation or the role of computing in RwLs appears needed. Further articles complementing this special issue will appear in *GAIA*.

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FIGURE 3: Semantic clusters of publications on LRW settings with relation to sustainability (core section of overall map, full map in supplement)[1]. Size of bullets represents frequency of occurrence of terms, size of arrows depict frequency of co-occurrence. Colours indicate different clusters of highly co-occuring terms.