Lessons from transdisciplinary urban research to promote sustainability transformation in real-world labs

Categories, pathways, and key principles for generating societal impact

Real-world labs aim to enhance societal impacts and advance sustainability transformations. Based on the empirical analysis of 48 urban research projects and six in-depth case studies, we present a systematization of these impacts and their connections, and provide key principles on how to design real-world lab projects to encourage sustainability transformations.

Michael Kreß-Ludwig (iD), Oskar Marg (iD), Rieke Schneider (iD), Alexandra Lux (iD)

Abstract

Real-world labs and transdisciplinary urban research aim to initiate and support sustainability transformations. This paper explores the categories of societal impacts and their connections, as well as key principles to facilitate these impacts. The study is based on the empirical analysis of 48 projects by a series of surveys and interviews within an independent, accompanying research program. All projects were conducted under the heading of urban sustainability transformations and pursued a transdisciplinary real-world lab approach. Three categories of societal impacts were identified: 1. social and individual changes, 2. governance changes, and 3. changes in the physical environment. Six of the projects were selected as in-depth case studies, revealing three patterns of impact pathways. The case studies also explore the relationships between processes, results, and impacts leading to key principles for fostering societal impacts and thus, sustainability transformations. The findings enhance the understanding and the promotion of sustainability transformations in urban areas.

Keywords

accompanying research, real-word labs, societal impacts, transdisciplinarity, urban research

Transdisciplinary urban research aims to not only analyse and understand societal changes, but also to initiate, shape, and support these changes. Research projects often respond to this ambition by conducting real-world labs (RwLs) on varying spatial scales – from cities to districts to neighbourhoods. Achieving societal impacts that promote sustainability transformations is thus an essential component of both RwL formats and transdisciplinary urban research projects (e. g., Beecroft et al. 2018, Bergmann et al. 2021, SynVer*Z 2022). As diverse as the challenges of sustainability in the urban context are, so are the societal implications of transdisciplinary research (TDR). Based on an empirical analysis of transdisciplinary urban research projects, this paper addresses three questions:

1. What categories of societal impacts can be found in urban RwLs, and how can they be systematised?
2. How are the categories of impacts related?
3. Which RwL research procedures facilitate these societal impacts?

Real-word labs and societal impacts

The goal of RwLs is to produce and integrate scientific and social knowledge regarding societal transformation processes (Beecroft et al. 2018, Bergmann et al. 2021, Parodi et al. 2018). Experimentation is a key feature of RwLs as they strive to investigate the emergence and the initiation of sustainability transformations, ultimately promoting the societal impacts of RwLs (Luederitz et al. 2017, Schäpke et al. 2018, VanHoose et al. 2022). The TDR

Dr. Michael Kreß-Ludwig (corresponding author) | ISOE – Institute for Social-Ecological Research | Head of Research Unit Transdisciplinarity | Frankfurt am Main | DE | kress-ludwig@isoe.de

Dr. Oskar Marg | ISOE – Institute for Social-Ecological Research | Frankfurt am Main | DE | marg@isoe.de

Rieke Schneider | ISOE – Institute for Social-Ecological Research | Frankfurt am Main | DE | riekeschndr@gmail.com

Dr. Alexandra Lux | ISOE – Institute for Social-Ecological Research | Frankfurt am Main | DE | lux@isoe.de

mode builds a crucial foundation for the activities in an RwL. Both address complex real-world problems by fostering the integration of diverse bodies of knowledge as part of a collaborative process and encourage mutual learning between researchers and practitioners (Bergmann et al. 2021, Schäpke et al. 2018).

For the research questions on societal impacts posed here, it is important to note that the generation of societal impacts is a key feature of RwLs. This characteristic, which also applies to the TDR mode, is relevant here because the focus of this paper is on RwLs as a TDR format. The research questions presented above were aimed at TDR projects that were requested to adhere to an RwL approach (research design). However, they conceptualise and implement this approach in different ways. In this article, the term RwL is used in a way that the diversity of the conceptualisation and implementation of this approach can be captured. The focus is therefore on similarities to the RwL approach, not on the different implementations. As RwLs follow a transdisciplinary approach, our empirical study establishes a direct link between the discourse on societal impacts of TDR and the transformation efforts in RwLs.

The societal impact assessment of TDR and RwLs begins with the difficulty of determining the exact causes of (presumed) societal impacts, and clearly assigning them to the transdisciplinary processes in a project. A key factor is that the systemic complexity makes it difficult to relate individual causes to specific impacts, or to identify causal impact chains. These difficulties are often due to interfering contextual factors. Furthermore, there are temporal and spatial gaps between the interventions and the observable impacts from a project (Schäfer et al. 2021, Lux et al. 2019). Nevertheless, efforts have been made to classify societal impacts of TDR and RwL, and to identify impact pathways. Schäfer et al. (2021) introduced a classification of societal impacts based on their spatial and temporal scales. First-order impacts (e.g., learning and capacity building, network formation, increasing reputation) occur within the temporal and spatial scope of a project. Second-order impacts (e.g., continuation or transfer) are found in the close temporal or spatial context of a project. Third-order impacts (e.g., structural influence on public discourses, laws, and regulations) are changes beyond the project within the wider field of action. In contrast, Augenstein et al. (2022) propose an embedded-agency perspective, which argues for the analysis of impacts across socio-spatial and socio-psychological dimensions. In relating these dimensions, they identify four impact categories: changes in 1. physical space, 2. symbolic meanings and values, 3. practices, and 4. rules and ways of dealing with framework conditions. Recognizing the complexity of creating societal impacts, Schneider et al. (2019) propose three impact-generating mechanisms of TDR: 1. the promotion of knowledge to support informed and fair decision-making, 2. the fostering of social learning for collective action, and 3. the enhancement of competencies for reflective leadership. They advocate combining complementary strategies to activate these mechanisms. This is corroborated by Caniglia et al. (2021), who argue that learning and diversifying knowledge are crucial for transformation. Like-

wise, Kok et al. (2023) support the idea of multiple and complementary strategies for change through RwLs. They demonstrate that transdisciplinary labs foster agency within their settings and increase capacities for change; ultimately affecting the wider systems in which they are embedded.

Parallel to this, a current debate is occurring around project design and its potential to enhance societal impacts, not only within, but also beyond a project (e.g., Erisman et al. 2024, in this issue). Here, the focus is on principles governing successful RwLs and TDR projects (Bergmann et al. 2021, Lux et al. 2019, Engels and Walz 2018), as well as on means to amplify the impacts (Lam et al. 2020, Nagy et al. 2020, Wirth et al. 2019). The relevant literature shows that, alongside decisions within project teams and their partners, certain external factors, such as the funding landscape or the societal discourse in which the project is situated, can limit or enable impact generation (Schäfer et al. 2021, Lux et al. 2019, Belcher et al. 2019). This is taken into account in evaluative and comparative frameworks that attempt to capture the relationship of processes, outcomes, and broader societal impacts within RwLs (Holmén et al. 2022, Luederitz et al. 2017).

Against this background, this article represents a novel addition to the discourse on the societal impact of RwLs. This is achieved by examining a comprehensive empirical dataset from 48 monitored projects and asking our three research questions. In each of the projects, one or more RwL was implemented using different methods. This sets it apart from similar papers that either rely on one or a few RwLs that put more emphasis on their specific contexts (e.g., Holmén et al. 2022), or that are more conceptual and literature-based (e.g., Luederitz et al. 2017).

Research design

The study was conducted as part of the accompanying project *SynVer*Z*, which aims to synthesize and network approximately 50 sustainable urban development projects, funded under two BMBF (Bundesministerium für Bildung und Forschung) funding schemes (BMBF 2015, 2016). Therefore, the projects had similar funding conditions, specifically the implementation of a transdisciplinary RwL approach that includes the creation of common learning spaces. The aim of these projects was to be oriented towards durability through the promotion of cooperation with decision-makers, and the implementation of transfer strategies. Additionally, the accompanied projects had to focus on one or more of the following topical areas: climate-resilient cities, urban cohesion and integration, energy-efficient cities and districts, or urban mobility.[1] Each project established one or more RwLs within their research design.

>

---

1 The authors were not involved in the individual projects, but interacted with the project participants through surveys, interviews, and project-related events. During the research, the authors' project team provided feedback to the supported projects on their intended societal impacts, which thus promoted the opportunity to reflect on this aspect.

For the first step of the research, a survey was sent to the coordinators of all the projects (table 1). The questionnaire covered both intended and achieved societal impacts, as both are relevant for the systematization of impact mechanisms. For the qualitative content analysis in step I, both deductive and inductive approaches were used according to Mayring (2010). The deductive development of an initial category scheme took place during the project application.[2] As part of the analysis of the questionnaires, the categories were then further developed in a comprehensive, inductive manner. In other words, due to the individual case studies, the application was significantly changed.[3]

To improve our understanding of how the societal impacts relate to each other and to the activities of the project, and how they are intended to be facilitated, we selected six in-depth case studies from the total set of accompanied projects for an in-depth analysis (see online supplement, table 1[4]), mainly based on interviews (step II in table 1). The main selection criteria were: the expected knowledge gain regarding the research questions; a fair distribution across the two funding schemes; and the greatest possible sampling diversity across targeted impact categories, topics covered, city types, and the scientific partners and project partners from society. The hope was to obtain the broadest possible database for the best results. The interview guideline included the perceived impacts of the project (up to that point), the general transformation approach, and the impact-relevant methods, procedures, and framework conditions. The impact categories developed in step I were used as a starting point for the interviews and for the questions concerning the perceived impacts of the project. The category scheme proved to be helpful and accurate by the respondents' answers and, as a side effect, was additionally validated by its use in the survey. The other questions were created without a specific background and were formulated very openly. Accordingly, the content analysis based on Mayring

(2010) was carried out using a predominantly inductive procedure. A cross-comparison of the case studies allowed us to derive key principles to generate societal impacts through transdisciplinary RwL (results). To assess its validity, this outcome was discussed with seven of the interviewees.

Results

Categorization of societal impacts
In general, the accompanied projects aim to initiate societal impacts through social and individual changes, changes in governance, and physical changes (figure 1, p. 14). The main category is labelled impact dimension (e.g., social and individual changes), the second level category is the impact field (e.g., learning processes or network effects), and the third level category is the impact form (e.g., system understanding).

Due to limited space, we elaborate only on the impact dimension and their corresponding impact fields; we explain impact forms where necessary (Marg et al. 2019 for further details).

The ***social and individual changes*** dimension refers to all impacts that occur (caused by any project activity or result) among and between individual actors, groups of actors, or institutional actors. It includes the following impact fields:

---

2 Significant sources for this included a previous project on the development of impact potential in TDR (Lux et al. 2019) and the concepts of "solution readiness level" (Schön et al. 2016) and "transition management" (Voß et al. 2009).
3 The previous deductively developed categories of learning processes (based on Lux et al. 2019), network effects, and situation change were retained and further differentiated, while the category of capacity building was dissolved. The other parts of the original concept proved to be unsuitable in this case.
4 *https://doi.org/10.14512/gaia.33.S1.3.suppl*

TABLE 1: Research design and methodology used to analyse 48 urban sustainability transformation projects following a transdisciplinary RwL approach.

STEPS	RESEARCH QUESTIONS	RESPONDENTS/ DATA	DATA COLLECTION METHOD	TIME OF DATA COLLECTION	EVALUATION METHOD	TYPE OF RESULT
I	RQ 1: *What categories of societal impacts can be found in urban RwLs, and how can they be systematised?*	▪ respondents from all accompanied projects (n = 48) ▪ supplementary written project material (e.g., proposals, publications)	▪ written survey by e-mail, mainly qualitative questionnaire ▪ requests for documents were sent to the projects, desk research	2018	qualitative content analysis (Mayring 2010)	systematization of impact dimensions (see figure 1)[a]
II	RQ 2: *How are the categories of impacts related?* RQ 3: *Which RwL research procedures facilitate these societal impacts?*	▪ 42 interviews with scientists and practitioners from six selected case studies ▪ additional project documents	▪ guideline-based expert interview (Meuser and Nagel 2002) ▪ requests for documents were sent to the projects, desk research	2020 – 2022		six in-depth case studies on procedures and framework conditions for generating societal impacts in transdisciplinary research projects[b]

[a] See Marg et al. (2019) for more details on the systematization and description of impact categories | [b] For reasons of confidentiality, the case study reports were only handed over to the respective projects analysed. An exception is Marg et al. (2021), where publication was encouraged by the project.

- *learning processes:* one of the most frequently observed impacts; relates to the acquisition of new knowledge (often by actors with whom the project works directly); differentiation of forms according to different types of knowledge (e.g., problem awareness or system understanding);
- *network effects:* includes all forms of initiating, supporting, and maintaining networking and cooperation between involved actors; often addressed to actors with whom direct cooperation takes place; categorisation according to the target group (e.g., politics/economy, civil society, etc.);
- *behaviours/practices:* all changes in concrete behaviour; often in broader target groups; differentiation according to specific fields of action (e.g., mobility patterns, climate adaption);
- *further social impacts:* impact forms that do not fit into the other categories described above (e.g., social innovations or quality of life/health).

2 The *changes in governance* dimension summarizes all changes in the way systems and institutions are managed, directed, and regulated:
- *municipal governance:* changes in political control and regulation at the municipal level (by political bodies or municipal administrations); frequent aim is to foster climate-friendly or sustainable governance; differentiation according to concrete topic (e.g., evaluation and management tools or participatory governance);
- *innovative economic concepts:* all forms of control and regulation of companies, economic institutions, or sectors; impact forms depend on the perspective of individual institutions or entire economic sectors (e.g., new business models);

3 The *physical changes* dimension includes all impacts on the material (natural, structural, or technical) environment addressed in the projects:
- *settlement structure and buildings:* structural measures; often accompanied by changes in individual behaviour and/or changes in urban governance (e.g., residential buildings or areas, structural resilience measures, etc.);
- *infrastructure of economy:* physical or material level of economic activity; as opposed to the governance category above (e.g., urban production);
- *technological infrastructure:* all changes in material and structural infrastructure (in forms of supply and disposal structures); categorisation according to fields of action (e.g., transport or energy);
- *green and blue infrastructure:* primarily means to increase (climate) resilience, quality of life, and biodiversity (e.g., green spaces/trees);
- *information and communication technologies, and other technological changes:* changes resulting from the further development of applications in the field of information and communication technologies and digitalisation, as well as other technological changes (e.g. implementation of a public, wireless network).

Pathways for impact

In its transformational approach, the first survey revealed that RwLs often address more than one area of impact and that there are numerous interrelationships between the different impact dimensions. Thus, from our sample of six case studies, we observe three distinguishable patterns that reveal these impact dimensions that can be described as pathways to transformation. A "direct" impact (directly triggered by measures) can lead to various "indirect", or mediated impacts. Therefore, to plan and increase societal impacts in a targeted manner, it is necessary to reflect on these different possible impact pathways and their corresponding entry points to decide on suitable methods and approaches. Through the six in-depth studies, we discovered three patterns of impact pathways (figure 2, p. 15).

The most frequent direct social and individual changes in projects are learning processes and networking (i.e., exemplary pathway 1, figure 2). The same applies to the networking of different actors, which is promoted in workshops or other participatory formats. Often this networking then forms the basis for further methods and other impacts, that are subsequently easier to achieve since the actors know and trust each other and the communication barriers have been reduced. Behavioural change is an effect that is often indirectly sought after in projects. It occurs because of internal learning processes ("from knowledge to action") or external changes in the framework conditions (e.g., changes in governance or physical infrastructures).

However, the situation is different when considering specific formats of experiments (i.e., exemplary pathway 2, figure 2). Here, the focus is on doing things jointly but in a different way, even if the interventions are usually temporary and changes in behaviour are, therefore, not yet consolidated. Learning processes occur because of changed behaviour, and then the impact pathway is reversed ("from action to knowledge").
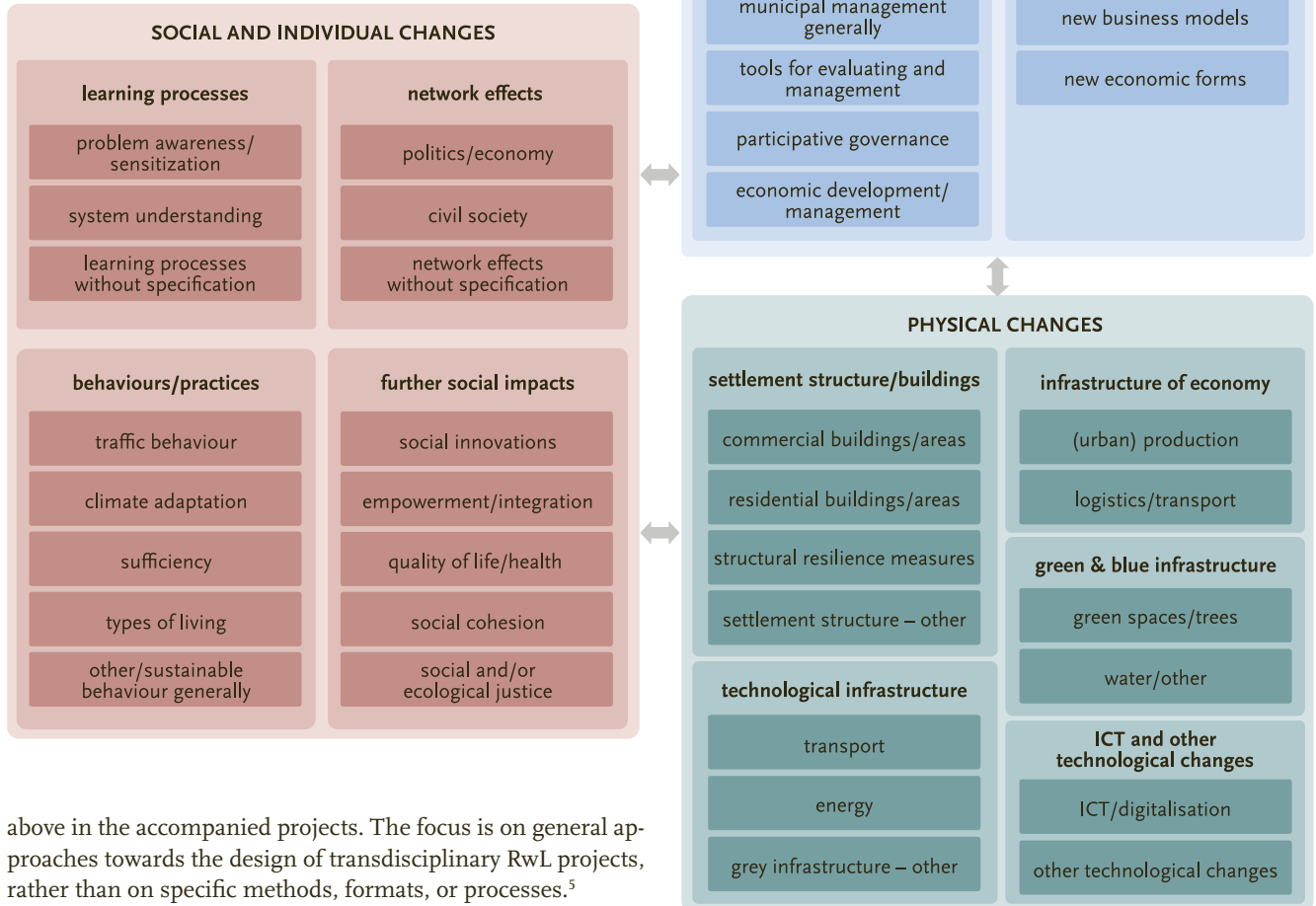
In the third case, the impact path is again different (i.e., exemplary pathway 3, figure 2). Although, as in the first case, the impact path begins with learning and networking, which are also closely linked, the impacts here relate specifically to the municipal administration and its management. Societal and individual impacts are thus closely intertwined with the impacts in municipal governance. In addition to the "culture" of municipal administration, its structures are also simultaneously changed as a direct effect. A municipal planning tool and an associated, more participatory, governance are emerging as central mediating effects. The change in physical infrastructure is also a desirable medium-term effect that emerges as a follow-up to changes in municipal administration, which in turn should lead to changes in behaviour.

Key principles for the generation of societal impacts

The case study approach allowed us to see in detail how the accompanied projects aimed to facilitate their intended societal impacts. The cross-comparison of the case studies indicated overarching principles from these urban RwLs, which have proven to be particularly relevant for enabling the impacts described   **>**

FIGURE 1: Overview of the three impact dimensions with their fields (second level) and forms (third level) (the arrows illustrate the mutual influence of the different dimensions, translated from Marg et al. 2019).

SOCIAL AND INDIVIDUAL CHANGES

learning processes
- problem awareness/sensitization
- system understanding
- learning processes without specification

network effects
- politics/economy
- civil society
- network effects without specification

behaviours/practices
- traffic behaviour
- climate adaptation
- sufficiency
- types of living
- other/sustainable behaviour generally

further social impacts
- social innovations
- empowerment/integration
- quality of life/health
- social cohesion
- social and/or ecological justice

CHANGES IN GOVERNANCE

municipal governance
- municipal management generally
- tools for evaluating and management
- participative governance
- economic development/management

innovative economic concepts
- new business models
- new economic forms

PHYSICAL CHANGES

settlement structure/buildings
- commercial buildings/areas
- residential buildings/areas
- structural resilience measures
- settlement structure – other

infrastructure of economy
- (urban) production
- logistics/transport

green & blue infrastructure
- green spaces/trees
- water/other

technological infrastructure
- transport
- energy
- grey infrastructure – other

ICT and other technological changes
- ICT/digitalisation
- other technological changes

above in the accompanied projects. The focus is on general approaches towards the design of transdisciplinary RwL projects, rather than on specific methods, formats, or processes.[5]

- Considering impacts in their diversity and interdependence at an early stage increases the likelihood of societal impact.
- Building trust and local networks is essential, especially in the early stages of a project.
- Linking a project to existing processes and structures in the field of action facilitates the cooperation between science and practice, and increases the chances of continuation.
- Projects need promoters to support local integration and to increase the likelihood of societal impact.
- Taking advantage of windows of opportunity to actively introduce transformative drivers and paying attention to emerging risks supports the development of societal impact.
- Multi-layered communication processes encourage broad participation. In particular, low-threshold participation enables involvement beyond the "usual suspects".
- Direct and tangible experiences with problems and research objects promote the learning effects and increases the participants' ability to act.

5 An extended and more operative version of the key principles (named as "Gestaltungsthesen") is documented in German in Kreß-Ludwig et al. (2023).
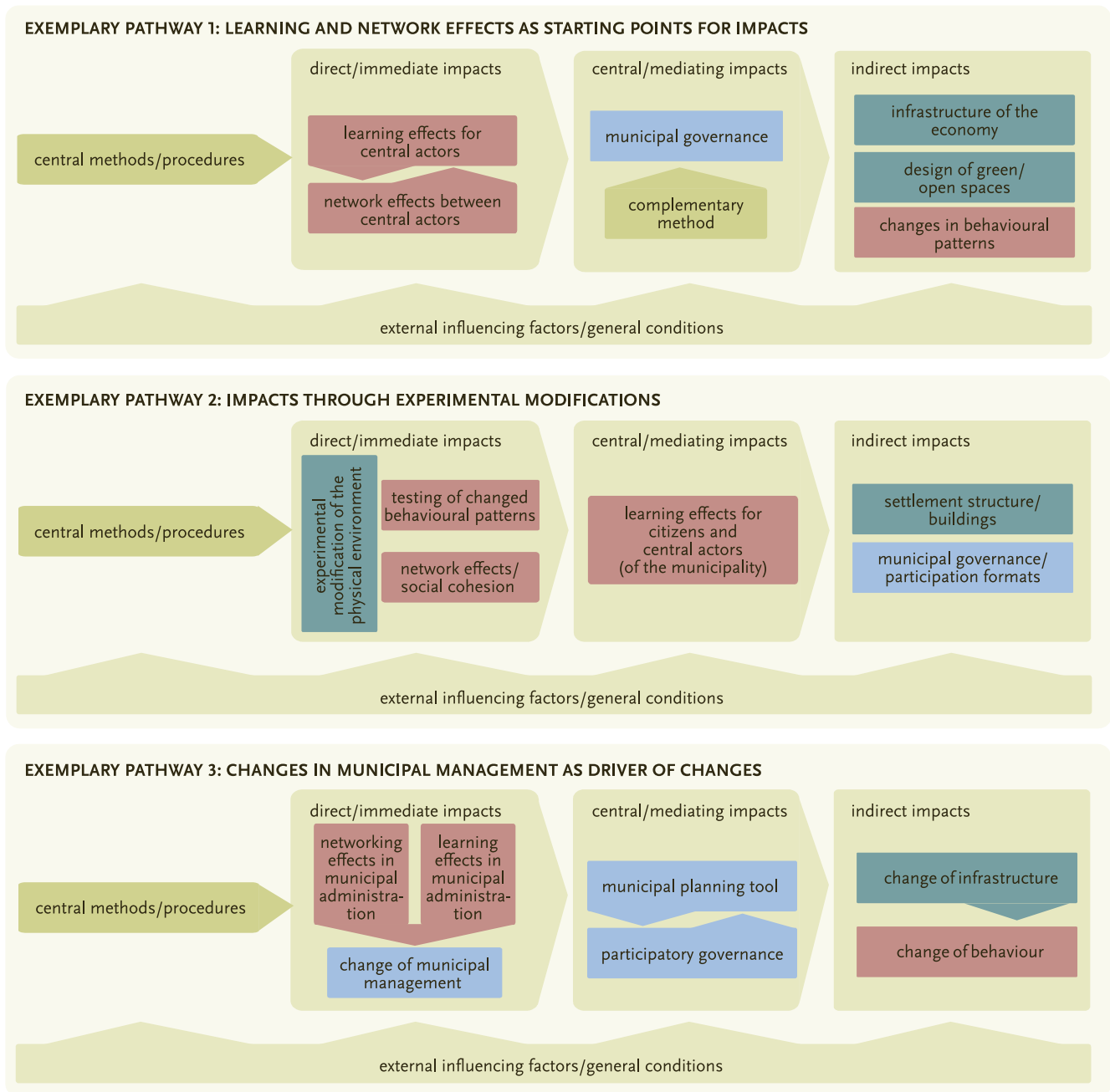
- The experimental approach in RwLs makes it possible to try out innovative measures together for a limited time and to learn from these experiments.
- Cooperation between science and society in transformation processes is challenging and, therefore, requires integrative competences.
- If project experiences and results are to have an impact beyond the specific location and beyond the end of the project, issues of continuity, scalability, and transferability to other contexts need to be actively and continuously addressed from an early stage.

Discussion

The paper seeks to improve the comprehension and advancement of sustainability transformations in urban RwLs by systematizing impacts and designing effective research. The soci-

EXEMPLARY PATHWAY 1: LEARNING AND NETWORK EFFECTS AS STARTING POINTS FOR IMPACTS

direct/immediate impacts   central/mediating impacts   indirect impacts

central methods/procedures

learning effects for central actors

network effects between central actors

municipal governance

complementary method

infrastructure of the economy

design of green/open spaces

changes in behavioural patterns

external influencing factors/general conditions

EXEMPLARY PATHWAY 2: IMPACTS THROUGH EXPERIMENTAL MODIFICATIONS

direct/immediate impacts   central/mediating impacts   indirect impacts

central methods/procedures

experimental modification of the physical environment

testing of changed behavioural patterns

network effects/social cohesion

learning effects for citizens and central actors (of the municipality)

settlement structure/buildings

municipal governance/participation formats

external influencing factors/general conditions

EXEMPLARY PATHWAY 3: CHANGES IN MUNICIPAL MANAGEMENT AS DRIVER OF CHANGES

direct/immediate impacts   central/mediating impacts   indirect impacts

central methods/procedures

networking effects in municipal administration

learning effects in municipal administration

change of municipal management

municipal planning tool

participatory governance

change of infrastructure

change of behaviour

external influencing factors/general conditions

FIGURE 2: Exemplary impact paths in real-world lab projects, illustrated with concretisations of the impact categories (colour code analogous to figure 1).

etal impacts are divided into three dimensions, in response to the first research question: social and individual changes, governance changes, and physical changes (figure 1).

Moreover, three impact pathways are unveiled in response to the second research question (figure 2):

1. from social changes, to governance changes, and on to individual physical changes;
2. from experimental physical and social/individual changes, towards social changes, and further on to persistent physical and governance changes; and,

3. from social changes and governance innovations, to implemented new governance formats, and ultimately to physical and behavioural change.

Finally, the analysis of six in-depth case studies has disclosed the key principles for designing RwL projects with the aim to enhance societal impacts, addressing the third research question.

To begin with, we see comparability between the impact dimensions described here and categorisations in other studies. In particular, the socio-spatial perspective, emphasised by Augen- >

Mission-oriented research funding has the potential to contribute to sustainability transformations – at least in the field of sustainable urban development.

stein et al. (2022), partly overlaps with our impact dimensions, especially regarding the impacts on the physical changes of space and on behaviours and practices. To a certain degree, the impact field categories overlap with already existing approaches (e. g., learning or network building) and are also mentioned by Schäfer et al. (2021). Since the categorization that was revealed in our study is based on projects that are all conducted under a common umbrella (i. e., they share structural and topical similarities), the scope of the categorization of societal impacts is narrower than the ones that have existed to date. This allows us to delve deeper into dimensions, types, and the respective fields of impacts, than would be possible with literature reviews or single case study reports. As all accompanied projects were anchored in an urban context, the results indicate a more precise range of expected impacts in urban RwLs. We therefore expect that the impact dimensions, forms, and fields (figure 1) can be used for exploring potential, intended, or desirable societal impacts during the planning phase of comparable projects or research programmes, as well as in reflective loops during the project or programme implementation.

This is a strong link to the pathways concept (i. e., *Pathways for impact*) and to the key principles (i. e., *Key principles for the generation of societal impacts*), which are both interwoven with the idea of being aware of different types and pathways towards the achievement of impacts. The in-depth case studies revealed pathways that go beyond the scope of Schneider et al. (2019) since, presumably due to the experimental approach of RwLs, it became obvious that time-limited physical changes could also be a trajectory to societal impacts, even without prior learning or network effects. Here, we see a distinct contribution of the research format RwL to opening new impact pathways due to its experimental efforts (at least in urban contexts). However, the validity of our findings regarding impact pathways will have to be further investigated in future studies, which should also consider the differences between urban RwLs and RwLs with other contextual scopes.

In general, the key principles provide an overarching view of how to promote societal impacts in transdisciplinary RwL approaches, with a focus on urban development projects. To some extent, there is an overlap with existing guidelines for "good" TDR projects. However, our study develops them further by embedding them directly into impact mechanisms. In this context, the principle of an early engagement with intended, desirable, and viable societal impacts is in line with findings by Lux et al. (2019). Especially "fostering connectivity" is a shaping field identified by Lux et al. (2019) that helps to promote societal impacts

of TDR. Our findings shed light on how this can be achieved more effectively with the principles relating to the initial phase of a project, and the linkages to existing processes.

Similarly, the principles that address the relevance of windows of opportunity and the competences needed for science-society collaborations offer more details on the relevance of framework conditions and on how to promote active engagement with these framework conditions than earlier studies (e. g., Lux et al. 2019).

Conclusion

The scope of our study with a specific thematic focus on sustainable urban development is, on the one hand, a strength since this is an important field of action for sustainable development in general. On the other hand, the results under this scope still must be validated regarding the transferability to other fields of action (e. g., with greater consideration of environmental or technical aspects – nature protection, waste management, or digitalisation). Overall, we can conclude that mission-oriented research funding – at least in the field of sustainable urban development – has the potential to contribute to sustainability transformations. Similar future funding programmes are recommended to specify their mission in terms of the expected societal impact and to establish systematic accompanying research that will be able to examine the achievement of a mission beyond the duration of an individual project.

References

Augenstein, K., P. M. Bögel, M. Levin-Keitel, H. Trenks. 2022. Wie entfalten Reallabore Wirkung für die Transformation? Eine *embedded-agency perspective* zur Analyse von Wirkmechanismen in Reallaboren. *GAIA* 31/4: 207–214. https://doi.org/10.14512/gaia.31.4.4.
Beecroft, R., H. Trenks, R. Rhodius, C. Benighaus, O. Parodi. 2018. Reallabore als Rahmen transformativer und transdisziplinärer Forschung. Ziele und Designprinzipien. In: *Transdisziplinär und transformativ forschen.* Edited by A. Di Giulio and R. Defila. Wiesbaden: Springer. 75–100. https://doi.org/10.1007/978-3-658-21530-9_4.

Belcher, B. M., R. Claus, R. Davel, L. F. Ramirez. 2019. Linking transdisciplinary research characteristics and quality to effectiveness: A comparative analysis of five research-for-development projects. *Environmental Science and Policy* 101: 192–203. https://doi.org/10.1016/j.envsci.2019.08.013.

Bergmann, M. et al. 2021. Transdisciplinary sustainability research in real-world labs: Success factors and methods for change. *Sustainability Science* 16: 541–564. https://doi.org/10.1007/s11625-020-00886-8.

BMBF (Bundesministerium für Bildung und Forschung). 2015. *Richtlinien zur Förderung von Forschungs- und Entwicklungsvorhaben im Rahmen der Sozial-ökologischen Forschung zum Themenschwerpunkt „Nachhaltige Transformation urbaner Räume" vom 05. März 2015*. Bundesanzeiger: AT 20.03.2015 B7.

BMBF. 2016. *Richtlinien zur Förderung von Vorhaben für die Umsetzung der Leitinitiative Zukunftsstadt vom 18. März 2016*. Bundesanzeiger: AT 01.04.2016 B2.

Caniglia, G. et al. 2021. A pluralistic and integrated approach to action-oriented knowledge for sustainability. *Nature Sustainability* 4: 93–100. https://doi.org/10.1038/s41893-020-00616-z.

Engels, A., K. Walz. 2018. Dealing with multi-perspectivity in real-world laboratories: Experiences from the transdisciplinary research project *Urban Transformation Laboratories*. *GAIA* 27/1: 39–45. https://doi.org/10.14512/gaia.27.S1.10.

Holmén, J., S. Williams, J. Holmberg. 2022. Comparing sustainability transition labs across process, effects and impacts: Insights from Canada and Sweden. *Energy Research and Social Science* 89: 102522. https://doi.org/10.1016/j.erss.2022.102522.

Kok, K. P., M. G. van der Meij, P. Wagner, T. Cesuroglu, J. E. W. Broerse, B. J. Regeer. 2023. Exploring the practice of labs for sustainable transformation: The challenge of "creating impact". *Journal of Cleaner Production* 388: 135994. https://doi.org/10.1016/j.jclepro.2023.135994.

Kreß-Ludwig, M., O. Marg, A. Lux. Forthcoming. *Gesellschaftliche Wirkungen in transdisziplinärer Stadtforschung fördern. Zehn Thesen auf Basis einer begleitenden Wirkungsforschung zur nachhaltigen Zukunftsstadt*. https://www.nachhaltige-zukunftsstadt.de/downloads/SynVerZ_2024_Werkstattbericht_Wirkungen_fordern.pdf (accessed February 27, 2024).

Lam, D. P. M. et al. 2020. Scaling the impact of sustainability initiatives: A typology of amplification processes. *Urban Transformations* 2: 3. https://doi.org/10.1186/s42854-020-00007-9.

Luederitz, C. et al. 2017. Learning through evaluation – A tentative evaluative scheme for sustainability transition experiments. *Journal of Cleaner Production* 169: 61–76. https://doi.org/10.1016/j.jclepro.2016.09.005.

Lux, A. et al. 2019. Societal effects of transdisciplinary sustainability research – How can they be strengthened during the research process? *Environmental Science and Policy* 101: 183–191. https://doi.org/10.1016/j.envsci.2019.08.012.

Marg, O., M. Kreß-Ludwig, A. Lux. 2019. *Wirkungen transdisziplinärer Stadtforschung in den Projekten der Förderlinien „Leitinitiative Zukunftsstadt" und „Nachhaltige Transformation urbaner Räume". Wirkungskategorien, Projektprofile und Handreichung zur Selbstreflexion*. https://orlis.difu.de/handle/difu/281459 (accessed January 14, 2024).

Marg, O., E. M. Troia, M. Kreß-Ludwig, A. Lux. 2021. *Vorgehensweisen und Rahmenbedingungen zur Erzeugung gesellschaftlicher Wirkungen in transdisziplinären Forschungsprojekten. Eine vertiefende Fallstudie anhand des Projekts MobilBericht*. https://doi.org/10.5281/zenodo.7583937.

Mayring, P. 2010. *Qualitative content analysis: Fundamentals and techniques*. 11th edition. Weinheim: Beltz.

Meuser, M., U. Nagel. 2002. ExpertInneninterviews – vielfach erprobt, wenig bedacht. In: *Das Experteninterview*. Edited by A. Bogner, B. Littig, W. Menz. Wiesbaden: VS. 71–93. https://doi.org/10.1007/978-3-322-93270-9_3.

Nagy, E. et al. 2020. Transfer as a reciprocal process: How to foster receptivity to results of transdisciplinary research. *Environmental Science and Policy* 104: 148–160. https://doi.org/10.1016/j.envsci.2019.11.007.

Parodi, O. et al. 2018. Insights into and recommendations from three real-world laboratories: An experience-based comparison. *GAIA* 27/1: 52–59. https://doi.org/10.14512/gaia.27.S1.12.

Schäfer, M., M. Bergmann, L. Theiler. 2021. Systematizing societal effects of transdisciplinary research. *Research Evaluation* 30/4: 484–499. https://doi.org/10.1093/reseval/rvab019.

Schäpke, N. et al. 2018. Jointly experimenting for transformation? Shaping real-world laboratories by comparing them. *GAIA* 27/1: 85–96. https://doi.org/10.14512/gaia.27.S1.16.

Schneider, F. et al. 2019. Transdisciplinary co-production of knowledge and sustainability transformations: Three generic mechanisms of impact generation. *Environmental Science and Policy* 102: 26–35. https://doi.org/10.1016/j.envsci.2019.08.017.

Schön, S., C. Eismann, T. Ansmann, H. Wendt-Schwarzburg. 2016. *Transdisziplinäre Lösungen. Reifegrade und Wirkungskategorien. Arbeitspapier des Wissenschaftlichen Begleitvorhabens „Innovationsgruppen für ein Nachhaltiges Landmanagement"*. Berlin.

SynVer*Z (Synthese- und Vernetzungsprojekt Zukunftsstadt) (Ed.). 2022. *Reallabore für urbane Transformation. Methoden, Akteure und Orte experimenteller und ko-produktiver Stadtentwicklung am Beispiel der BMBF-Zukunftsstadtforschung*. https://repository.difu.de/handle/difu/583672 (accessed January 14, 2024).

VanHoose, K., A. R. de Gante, L. Bertolini, J. Kinigadner, B. Büttner. 2022. From temporary arrangements to permanent change: Assessing the transitional capacity of city street experiments. *Journal of Urban Mobility* 2: 100015. https://doi.org/10.1016/j.urbmob.2022.100015.

von Wirth, T., L. Fuenfschilling, N. Frantzeskaki, L. Coenen. 2019. Impacts of urban living labs on sustainability transitions: Mechanisms and strategies for systemic change through experimentation. *European Planning Studies* 27/2: 229–257. https://doi.org/10.1080/09654313.2018.1504895.

Voß, J.-P., A. Smith, J. Grin. 2009. Designing long-term policy: Rethinking transition management. *Policy Sciences* 42: 275–302. https://doi.org/10.1007/s11077-009-9103-5.

Michael Kreß-Ludwig
Studies in sociology, psychology, and anthropology. 2019 PhD in sociology. Since 2018 researcher at the ISOE – Institute for Social-Ecological Research, Frankfurt am Main, DE. Since 2023 head of the *Research Field Transdisciplinarity*. Research interests: participation and integration in transdisciplinary processes, impact of transdisciplinary research, environmental awareness and behaviour, empirical methods of social research.

Oskar Marg
Studies in sociology, history, and labour science. 2015 PhD in sociology. Since 2016 research associate at the ISOE – Institute for Social-Ecological Research, Frankfurt am Main, DE, in the *Research Field Transdisciplinarity*. Research interests: integration of diverse knowledge, effects of transdisciplinary research on science and society, accompanying research of transdisciplinary projects.

Rieke Schneider
Studies in environmental sciences at Leuphana University Lüneburg, DE, and the University of Freiburg, DE. Intern at the ISOE – Institute for Social-Ecological Research, Frankfurt am Main, DE. Research interests: environmental governance, sustainability studies, transdisciplinary/transformative research.

Alexandra Lux
2009 PhD in economics. Since 2000 researcher at the ISOE – Institute for Social-Ecological Research, Frankfurt am Main, DE. Head of the *Knowledge Processes and Transformations Hub* at ISOE. Member of its executive committee. Research interests: methods and concepts for transdisciplinary integration, effects of transdisciplinarity.