Living labs coming of age: reaching urban sustainability goals through extended knowledge advancing

Participative approaches in policymaking by citizens have reached high popularity over the past decade. Though different in aims and structure, living labs are good examples of the use of new participative or collaborative models in policymaking (Almirall et al., 2012; Ansell et al., 2017; Leminen and Westerlund, 2019; Schuurman et al., 2021). While the use of living labs increased enormously in policy practice in the past years, diversity in conceptualization also entered the scene. Some living labs are viewed as an open and flexible learning tool, while others are also aimed at strict planning of design of solutions and upscaling (diffusion) of solutions. With regard to spatial scale, some are conceived as entire regions or cities, while others are limited to learning and experimentation sites, etc. More recently, however, despite the popularity and diversity, several empirically grounded case studies have emerged with a focus on critical challenges and question marks on living labs processes and results in practice. This trend seems a sign of maturation of utilization of the tool.
In the present paper, living labs are seen as learning and design methodology focusing on co-creative experimentation and solutions by citizens and other stakeholders that represent the problem. The 'living' character refers to real-life and real-time environment. The context is that of a dynamic multi-stakeholder situation, with diverse stakeholders' position and power. Since first applications about 20 years ago, living labs have been used in solving a variety of urban sustainability matter, like in sustainable energy, water management and traffic policy. The aim of the present paper is to reflect on four recently forwarded challenges in urban living labs' practice, namely, ex-ante anticipative learning, active participation by representative citizens in learning and design of solutions, use of real-life experimentation places, and ex-post evaluation of living labs' results, particularly outcomes that can be generalized. Examples in the paper will be drawn from sustainable energy solutions.

The paper dwells upon literature study, case study experience and expert opinion, and is structured as follows. First, the rise of living labs is discussed in a wider context of citizen participation, knowledge production, and socio-technical change. Next, the four challenges are elucidated and problematic situations are analysed, one of them an early and sustained participation of representative citizens. Living lab participation requires long-lasting and active commitment which is difficult to maintain when living lab results are below expectations (e.g. Nesti, 2018; Dijk et al., 2019; Companucci et al., 2021). In particular, citizen participation tends to be stronger and longer lasting if citizens observe the difference that can be made by living labs. In addition, the selected site for experimentation needs to be representative for the problem. In a third part of the paper, existing modes of evaluation are presented and a more comprehensive but also focussed evaluation is proposed, given sets of critical performance factors (CPFs) (Ståhlbröst, 2012; Van Geenhuizen, 2018). Emphasis is also put on specificities in

living labs' ex-post evaluation, including dealing with multiple causality and fuzzy data in complex urban environments.

With regard to contribution to literature, the paper fits the critical reflection on living labs today, and is novel in two respects. It presents and structures recently forwarded tension and challenges in application of the methodology. In addition, it explores learning matter and approaches that deserve more attention in living labs' practice. It also contributes to the theory of change, including impacts of uncertainty in design and effectiveness of the tool in a broader policy context (Belcher et al., 2020, Walker et al., 2013). The findings of the present paper support beliefs that a focussed knowledge advancing, including use of artificial intelligence, will strengthen living labs and increase their policy relevance (legitimacy) in urban sustainability and energy transition. However, much is also dependent on the function assigned to living labs in practice, which could be an open learning process versus a strict planning tool. In the remaining abstract, the last situation is briefly illustrated and presented as a normative picture, including some new challenges.

Living lab methodology is often designed as part of a strategy, programme, or plan, with a set of stated needs. In the process of designing of living labs, citizens and other stakeholders decide which of the identified needs will be targeted with the living lab methodology. In the stage of preparation, stakeholders are being identified and characterised in terms of (changing) power positions and networks (stakeholder analysis) (Enserink et al., 2022). SWOT analysis may also contribute in this stage to improve disentangling the multi-causality of the problem at hand. Stakeholders further decide on what should be achieved with the interventions in addressing not only these identified needs, but also, what should be the achievements in the broader policy context/environment. During the living lab design, the types of actions supported with inputs (budget) are defined in order to reach the objectives established. In this part, it is 'obligatory' to clarify expected policy effects: which outputs are expected for the allocated inputs, which results can be generated with these outputs to address the needs of policy beneficiaries, and which impacts the policy may have on the entire policy context/environment. At the same time, a challenge is to identify conditions that are *beyond control of living lab managers* and could cause delay and unexpected results, and to determine how to act upon that. Such attention may require the development of scenarios or use of simulation. Further, formulation of objectives, defined inputs, outputs, results, and impacts are the basis for the decision of which indicators will be utilised to measure the achievement of these objectives and observed effects. Indicators measuring inputs and outputs are then used as monitoring indicators, as well as indicators for ex-post evaluation, though the last encompasses more overarching indicators, like cost effectiveness. The general result from the previous analysis is that strict approaches are systematic and clear, but these can also make the application of living labs vulnerable, and this calls for some new balancing methods.

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