

Article

Living Labs as Adaptive Intermediary Structures Embedded Within Regional Innovation Systems: A Conceptual Framework for Social Transformation in Peripheral Regions

Katarzyna Gizińska and Rita Lankauskienė * 

Lithuanian Centre for Social Sciences, Institute of Economics and Rural Development, 01108 Vilnius, Lithuania; katarzyna.gizinska@ekvi.lt

Highlights

Please indicate how your work links to systems science via your contributions to systems practice, theory, and/or methodology.

- This article conceptualizes Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems rather than merely as open innovation platforms.
- It develops a systems-based conceptual framework linking co-creation, experimentation, behavioural adaptation, institutional learning, and regional transformation through interconnected feedback processes.

What are the main findings and/or the implications of the main findings?

- Living Labs can strengthen regional resilience, social inclusion, innovation adoption, and adaptive governance by enabling feedback-driven learning and adaptation among regional actors.
- The proposed framework provides a conceptual foundation for future empirical assessment of Living Lab impacts, particularly in peripheral and rural regional innovation systems.

Abstract

Regional development increasingly occurs under conditions of uncertainty, complexity, and accelerating socio-economic change, creating a need for adaptive approaches that support learning and transformation. Although Living Labs have gained prominence as environments for co-creation and experimentation, their broader systemic role in regional development remains insufficiently theorized. This article addresses this gap by conceptualizing Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems that facilitate social transformation in peripheral regions. The study adopts a conceptual research design based on integrative theory synthesis, combining insights from Living Lab research, Regional Innovation Systems theory, complex adaptive systems theory, and behavioural approaches to adaptation and institutional learning. The resulting framework identifies four interconnected components: external transformation pressures, Living Lab mechanisms (co-creation, experimentation, stakeholder coordination, and knowledge exchange), feedback processes (trust-building, learning, absorptive capacity, and institutional adaptation), and regional transformation outcomes. The analysis suggests that Living Labs contribute to regional resilience, innovation capacity, adaptive governance, social inclusion, and socio-economic development through feedback-driven learning and adaptation processes. Rather than functioning solely as innovation platforms, Living Labs are interpreted as adaptive intermediary structures that connect experimentation with systemic transformation. The article advances Living Lab scholarship by providing a



Academic Editor: Mitsuru Kodama

Received: 22 June 2026

Revised: 30 July 2026

Accepted: 1 August 2026

Published: 4 August 2026

Copyright: © 2026 by the author.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and

conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

systems-oriented framework and formulates theoretical propositions that can guide future empirical research on regional adaptation and transformation.

Keywords: Living Labs; Regional Innovation Systems; complex adaptive systems; social transformation; regional resilience; adaptive governance; institutional learning; peripheral regions; co-creation; adaptive capacity

1. Introduction

Regional development is increasingly taking place under conditions of uncertainty, complexity, and accelerated socio-economic change. Digital transformation, sustainability transitions, demographic decline, and the restructuring of global production systems have altered the context in which regions pursue economic and social development [1,2]. These processes have exposed the limitations of development approaches that primarily emphasize factor endowments, industrial specialization, or market efficiency. While such factors remain important, growing attention has been directed towards the capacity of regions to learn, adapt, and mobilize collective responses to emerging challenges [3,4].

This shift has contributed to the emergence of new theoretical perspectives that conceptualize regions as dynamic and evolving systems rather than as static territorial units. Within innovation studies, the concepts of innovation ecosystems and Regional Innovation Systems have become particularly influential because they emphasize interactions among firms, universities, public authorities, civil society organizations, and citizens as key drivers of development and transformation [5,6]. Innovation is therefore increasingly understood as a distributed and collaborative process that emerges through networks of actors operating within specific institutional and territorial contexts. From this perspective, regional development depends not only on the availability of resources but also on the quality of relationships, learning processes, and governance arrangements that shape collective action.

These considerations are especially relevant for peripheral regions. Compared with metropolitan centres, peripheral territories often face structural disadvantages associated with weaker innovation infrastructures, lower institutional density, demographic decline, and reduced access to knowledge networks [2,7]. At the same time, such regions are expected to respond to the same pressures associated with digitalization, climate adaptation, and sustainability transitions. This creates a development paradox. Peripheral regions frequently require innovation and institutional adaptation, yet they often possess fewer resources and weaker capacities to support these processes. Consequently, there is growing interest in governance arrangements capable of mobilizing local knowledge, strengthening stakeholder cooperation, and supporting experimentation within place-specific contexts [3,8].

Among the approaches that have attracted increasing attention in this regard are Living Labs. Originally associated with user-centred innovation and real-world experimentation, Living Labs have evolved into collaborative environments that bring together public authorities, firms, researchers, and citizens in processes of co-creation and innovation development [9,10]. Recent studies have highlighted their relevance in areas such as digital innovation, sustainability transitions, public-sector innovation, and regional development [11,12]. By facilitating experimentation under real-life conditions, Living Labs create opportunities to test technologies, services, and governance arrangements while incorporating feedback from users and stakeholders throughout the innovation process.

Despite the growing body of Living Lab research, the literature remains fragmented. Many studies examine Living Labs as innovation methodologies, project environments, or participatory governance instruments [13,14]. Other contributions focus on co-creation practices, stakeholder engagement, and innovation outcomes [15,16]. While these perspectives have generated important insights, they tend to emphasize specific activities or outcomes rather than the broader systemic role that Living Labs may play within regional development processes. As a result, there remains limited theoretical understanding of how Living Labs contribute to long-term adaptation, institutional learning, and socio-economic transformation at the regional level.

This limitation is particularly important in peripheral regions, where Living Labs often perform functions that extend beyond innovation support. They may facilitate interaction among actors who would otherwise remain disconnected, strengthen trust between stakeholders, support knowledge circulation across institutional boundaries, and create opportunities for policy experimentation [11,17]. Their effects therefore cannot be reduced to the production of individual innovations. Rather, Living Labs may influence broader regional dynamics through feedback processes that shape learning, coordination, behavioural adaptation, and governance capacity over time.

A systems perspective offers a promising avenue for addressing this gap. Complex adaptive systems theory provides a conceptual lens for understanding how multiple actors interact, learn, and co-evolve within environments characterized by uncertainty and non-linearity [1,18]. Within such systems, outcomes emerge from interactions among components rather than from the actions of individual actors alone. Regional development exhibits many of these characteristics. Economic, social, institutional, and behavioural processes are interconnected, and changes occurring within one domain frequently generate consequences across others. Understanding regional transformation therefore requires analytical approaches capable of capturing these interdependencies and feedback mechanisms.

The present article argues that Living Labs can be conceptualized as adaptive intermediary structures embedded within Regional Innovation Systems, exhibiting the characteristics of complex adaptive systems. Rather than replacing or representing the regional innovation system as a whole, Living Labs perform adaptive functions by connecting experimentation, stakeholder collaboration, institutional learning, and feedback processes that contribute to broader regional transformation. Rather than viewing Living Labs solely as innovation platforms or co-creation environments, the article positions them as intermediary systems that connect external transformation pressures with regional adaptation mechanisms. In this interpretation, co-creation, experimentation, stakeholder coordination, and knowledge exchange function as system mechanisms that generate behavioural and institutional effects, including trust-building, absorptive capacity, innovation adoption, and collective learning. These processes, in turn, contribute to outcomes such as regional resilience, social inclusion, adaptive governance, and socio-economic development.

Against this background, the article addresses the following research question: *How can Living Labs be conceptualized as adaptive intermediary structures embedded within Regional Innovation Systems that facilitate social transformation in peripheral regions?*

The central argument of this article is that Living Labs should be understood not merely as participatory innovation environments but as adaptive intermediary structures embedded within Regional Innovation Systems, whose systemic value lies in connecting experimentation, stakeholder interaction, institutional learning, and feedback-driven adaptation, thereby supporting long-term regional transformation in peripheral regions. To answer the research question, the article develops a conceptual framework integrating insights from Living Lab research, Regional Innovation Systems theory, behavioural approaches to socio-economic adaptation, and complex adaptive systems theory. The

framework identifies the principal mechanisms through which Living Labs contribute to regional transformation and formulates a set of theoretical propositions that may guide future empirical investigation.

The article contributes to the literature in three ways. First, it advances Living Lab research by proposing a systemic interpretation that moves beyond project-level and methodological perspectives. Second, it integrates behavioural, institutional, and innovation-related mechanisms within a single analytical framework, thereby offering a more comprehensive explanation of Living Lab impacts. Third, it contributes to regional development research by providing a conceptual model that explains how adaptive innovation infrastructures may support transformation processes in peripheral regions facing technological, demographic, and sustainability-related challenges.

The remainder of the article is organized as follows. Section 2 reviews the theoretical foundations of the study and discusses the relationships among Living Labs, Regional Innovation Systems, behavioural adaptation, and complex adaptive systems. Section 3 outlines the conceptual research design and theory synthesis approach. Section 4 develops the proposed systems perspective on Living Labs and identifies the mechanisms linking experimentation, learning, and regional transformation. Section 5 presents the conceptual framework and a set of theoretical propositions. Section 6 discusses theoretical and policy implications, while the final section summarizes the main conclusions and outlines directions for future research.

2. Theoretical Foundations

Understanding the role of Living Labs in regional transformation requires an interdisciplinary perspective. Existing research on Living Labs has developed across several scholarly traditions, including open innovation, Regional Innovation Systems, participatory governance, and sustainability transitions. While these perspectives have generated valuable insights, they are often examined separately, resulting in a fragmented understanding of how Living Labs contribute to broader regional development processes.

To address this limitation, the present study draws on four complementary theoretical perspectives: Living Lab and open innovation research, Regional Innovation Systems theory, complex adaptive systems theory, and behavioural approaches to adaptation and institutional learning. Together, these perspectives provide the conceptual foundations for understanding Living Labs as adaptive *intermediary structures embedded within* Regional Innovation Systems that facilitate learning, coordination, and transformation in peripheral regions.

2.1. From Open Innovation to Living Labs

The emergence of Living Labs reflects broader transformations in how innovation is understood and organized. Earlier innovation models frequently portrayed innovation as a relatively linear process progressing from scientific discovery to technological development and market diffusion. Such perspectives assumed that knowledge was generated primarily within research institutions or firms and subsequently transferred to users through commercialization processes. Although this approach influenced innovation policy and management practice for decades, it has been increasingly criticized for its inability to explain the interactive and distributed nature of contemporary innovation processes [19].

More recent approaches conceptualize innovation as an open and collaborative activity involving multiple actors operating across organizational and sectoral boundaries. The concept of open innovation emphasizes that valuable knowledge is widely distributed and that innovation frequently emerges through interactions among firms, research organizations, public institutions, users, and communities rather than within isolated organizations [5].

Consequently, innovation depends not only on technological capabilities but also on the ability to mobilize diverse forms of knowledge and facilitate collaboration among heterogeneous stakeholders.

Living Labs emerged within this broader transition towards open and participatory innovation. While definitions vary, Living Labs are generally understood as environments in which innovation is developed, tested, and refined through collaboration among multiple stakeholders under real-life conditions [9]. Their distinguishing characteristic lies in the integration of users into innovation processes as active contributors rather than passive recipients. Through co-creation, experimentation, and iterative feedback, Living Labs seek to align technological development with practical needs, local knowledge, and contextual realities.

This participatory orientation distinguishes Living Labs from more traditional innovation support structures. Conventional innovation systems often concentrate on technological development and commercialization, whereas Living Labs place greater emphasis on interaction, learning, and experimentation. Innovation is treated as a socio-technical process shaped by relationships among actors, institutional contexts, and user experiences [15]. The significance of Living Labs therefore extends beyond the production of new technologies. They also create opportunities for collective learning, stakeholder engagement, and institutional adaptation.

Recent scholarship increasingly positions Living Labs within broader innovation ecosystems. Innovation ecosystems consist of interconnected actors and institutions whose interactions facilitate knowledge creation, exchange, and application [5,6]. Within such ecosystems, Living Labs may perform intermediary functions by connecting actors that would otherwise remain weakly linked. [11] describe Living Labs as orchestrators within regional innovation ecosystems because they facilitate communication, coordinate experimentation activities, and support knowledge circulation across institutional boundaries.

The intermediary role of Living Labs extends beyond the functions typically associated with conventional intermediary organizations. While intermediary organizations generally facilitate collaboration, knowledge exchange, and connections among actors within innovation processes, Living Labs provide collaborative environments in which stakeholders jointly identify challenges, co-create solutions, experiment under real-world conditions, and collectively learn through iterative feedback processes [9,15]. Recent research further emphasizes that Living Labs act as orchestrators within regional innovation ecosystems by coordinating interactions among public authorities, businesses, researchers, civil society organizations, and citizens while facilitating knowledge circulation across institutional boundaries [11]. Consequently, Living Labs should be understood not merely as organizations performing intermediary functions but as *adaptive intermediary structures* embedded within Regional Innovation Systems. Their distinctive contribution lies in integrating stakeholder coordination, experimentation, behavioural and institutional learning, and feedback-driven adaptation into broader regional transformation processes [12,13]. This intermediary role becomes particularly relevant in contexts characterized by institutional fragmentation or limited innovation capacity. In peripheral regions, innovation challenges frequently stem not only from resource constraints but also from the absence of mechanisms capable of connecting stakeholders and mobilizing collective action [7]. Under such conditions, Living Labs may contribute to innovation processes by creating structured spaces for interaction among public authorities, businesses, research institutions, and citizens. Their value therefore lies not solely in generating innovations but also in strengthening the relational infrastructure through which innovation becomes possible.

The growing interest in Living Labs has also been accompanied by an expansion of their functional scope. Initially associated with technological experimentation, Living Labs

are increasingly employed in sustainability transitions, public-sector innovation, digital governance, and regional development initiatives [12,13]. This evolution suggests that Living Labs should not be viewed merely as project-based innovation instruments. Rather, they appear to operate as adaptive socio-institutional arrangements capable of supporting experimentation and learning across multiple domains of regional transformation.

Despite these developments, much of the literature continues to focus on specific Living Lab activities, governance models, or project outcomes. Comparatively less attention has been devoted to understanding how Living Labs influence broader regional development dynamics over time. Existing research provides substantial evidence regarding co-creation processes and stakeholder participation, yet the mechanisms through which Living Labs contribute to adaptation, resilience, and systemic transformation remain less clearly articulated [17].

This limitation is particularly important when considering the challenges faced by peripheral regions. Innovation in such contexts frequently depends on the capacity to coordinate dispersed actors, facilitate learning processes, and generate feedback between local experimentation and regional governance. These functions suggest that Living Labs may be understood not only as open innovation environments but also as components of wider adaptive systems. Such an interpretation shifts attention from individual projects towards the relationships, feedback mechanisms, and learning processes that connect experimentation with regional transformation.

From this perspective, Living Labs represent more than instruments for producing innovation. They constitute institutional settings through which knowledge exchange, co-creation, and experimentation become embedded within regional development processes. This interpretation provides the first building block for the framework developed in this article. Living Labs are conceptualized as system mechanisms that facilitate interaction, learning, and adaptation within broader Regional Innovation Systems.

2.2. Regional Innovation Systems in Peripheral Regions

The concept of Regional Innovation Systems (RIS) emerged from the recognition that innovation is embedded within specific institutional and territorial contexts. Rather than being generated by individual organizations acting independently, innovation is understood as the outcome of interactions among firms, universities, research centres, public authorities, intermediary organizations, and other regional actors [20,21]. The RIS perspective therefore shifts analytical attention from individual innovators to the broader structures and relationships that facilitate knowledge creation, exchange, and utilization.

A central assumption of RIS theory is that regional development depends on the quality of interactions among system participants. Innovation is not merely a function of technological capabilities or financial resources but also of institutional arrangements, governance structures, and opportunities for collaboration [22]. Regions characterized by dense networks, strong institutional coordination, and effective knowledge exchange tend to demonstrate greater innovative capacity and adaptability. Conversely, regions with fragmented networks and weak institutional linkages often experience difficulties in generating and diffusing innovation.

The RIS literature has traditionally focused on regions characterized by relatively strong innovation ecosystems and diversified economic structures. However, growing attention has been directed towards peripheral and less-developed regions, where innovation processes frequently unfold under markedly different conditions [2]. Such regions often face structural challenges, including demographic decline, limited research and development capacity, weaker institutional density, and reduced access to national and international knowledge networks [7]. In this article, *peripheral regions* refer to territories

characterized by a combination of geographical remoteness, lower population density, weaker innovation ecosystems, limited institutional capacity, and reduced connectivity to national and international knowledge networks. These characteristics do not imply uniform underdevelopment but rather indicate structural conditions that constrain innovation, collaboration, and adaptive governance while increasing the importance of locally embedded learning and stakeholder cooperation. Such conditions can constrain both innovation performance and the ability to respond to emerging socio-economic challenges.

At the same time, peripheral regions should not be viewed solely through the lens of deficiency. Recent studies emphasize that such territories possess distinctive assets, including localized knowledge, strong community ties, cultural resources, and place-specific capabilities that may support alternative pathways of development [1,8]. The challenge is therefore not simply to replicate innovation models developed in metropolitan centres but to identify mechanisms capable of mobilizing endogenous resources and strengthening regional learning capacities.

This perspective has contributed to a broader shift from competitiveness-oriented approaches towards place-based development strategies. Place-based approaches recognize that development outcomes emerge from interactions between local assets, institutional structures, and governance processes operating within specific territorial contexts [23]. Innovation policies are consequently expected to reflect regional diversity rather than apply uniform solutions across different territories. Such thinking has become increasingly influential within European regional policy, particularly in relation to smart specialization, rural innovation, and sustainability transitions.

Nevertheless, the RIS framework encounters certain limitations when applied to processes of regional transformation. Although it provides valuable insights into institutional structures and knowledge networks, it often offers a relatively static representation of regional systems. Much of the literature focuses on system components and relationships while paying less attention to dynamic processes such as adaptation, learning, feedback, and co-evolution [1]. As regions confront increasingly complex and interconnected challenges, there is a growing need for analytical perspectives capable of capturing how regional systems evolve over time and respond to changing external conditions.

In this article, an *adaptive Regional Innovation System (adaptive RIS)* is understood as a regional innovation system characterized by continuous learning, feedback, institutional adaptation, and the capacity to reorganize relationships among actors in response to changing socio-economic and environmental conditions. Unlike traditional RIS perspectives, which primarily emphasize institutional structures and knowledge flows, the adaptive RIS perspective focuses on dynamic processes of co-evolution, experimentation, and recursive learning that strengthen regional resilience and transformation.

This issue is particularly relevant in peripheral regions, where development trajectories are frequently shaped by uncertainty and structural change. Digital transformation, demographic shifts, climate-related pressures, and evolving policy environments create conditions in which adaptation becomes as important as innovation itself. Understanding regional transformation therefore requires attention not only to the actors and institutions that constitute Regional Innovation Systems but also to the mechanisms through which these systems learn, adapt, and reorganize in response to new circumstances.

Within this context, Living Labs may be interpreted as intermediary structures operating within Regional Innovation Systems. By facilitating stakeholder interaction, experimentation, and knowledge exchange, they can contribute to strengthening regional learning processes and enhancing adaptive capacity. However, explaining these contributions requires a theoretical perspective that moves beyond the structural emphasis of traditional RIS approaches and considers regions as evolving systems characterized by

feedback, emergence, and non-linear change. Such a perspective is provided by complex adaptive systems theory, which forms the next building block of the framework developed in this article.

2.3. Understanding Regional Transformation Through Complex Adaptive Systems

The increasing complexity of regional development challenges has stimulated growing interest in theoretical approaches capable of explaining processes of adaptation and transformation. While Regional Innovation Systems theory provides valuable insights into the institutional and organizational structures that support innovation, it is less explicit in explaining how regional systems evolve under conditions of uncertainty and change. This limitation has become increasingly apparent as regions confront interconnected pressures associated with digital transformation, climate change, demographic restructuring, and shifting economic landscapes.

Complex Adaptive Systems (CAS) theory offers a useful framework for understanding such processes. Originating in the natural sciences and later adopted across the social sciences, CAS theory conceptualizes systems as collections of interconnected agents whose interactions generate patterns and outcomes that cannot be fully understood by examining individual components in isolation [18]. System behaviour emerges from continuous interactions among actors, institutions, and environmental conditions, often producing non-linear dynamics and unexpected outcomes.

Several characteristics of complex adaptive systems are particularly relevant for regional development. First, adaptive systems are composed of multiple actors whose decisions influence one another through formal and informal interactions. Second, these systems evolve through learning processes in which actors modify their behaviour in response to new information and changing circumstances. Third, system outcomes emerge through feedback mechanisms that reinforce or alter existing patterns of behaviour. Finally, adaptive systems exhibit co-evolution, meaning that actors, institutions, and environments change simultaneously and influence one another over time.

Regional development displays many of these characteristics. Regions consist of diverse actors operating within interconnected economic, social, and institutional environments. Firms respond to policy changes, public authorities adapt governance arrangements, citizens alter behavioural patterns, and organizations revise strategies in response to emerging opportunities and constraints. Development trajectories therefore emerge from interactions among multiple actors rather than from the actions of any single organization or institution. This perspective challenges linear interpretations of development and highlights the importance of feedback, learning, and adaptation.

Recent contributions to regional studies increasingly acknowledge these dynamics. Ref. [1] argues that regional development is shaped by evolutionary processes through which regions continuously reconfigure their knowledge bases, institutional arrangements, and economic structures. Similarly, resilience research emphasizes the capacity of regions to absorb disturbances, reorganize resources, and adapt to changing conditions rather than merely return to previous states of equilibrium [18]. These perspectives suggest that regional transformation should be understood as an ongoing process of adaptation rather than as a predetermined outcome of policy interventions or economic investments.

From a systems perspective, innovation itself can be interpreted as an emergent property of adaptive interactions. Innovations frequently arise from experimentation, collaboration, and knowledge exchange among actors possessing different experiences, resources, and perspectives. Their diffusion depends on network structures, institutional conditions, and behavioural responses that evolve over time. Consequently, innovation systems cannot be fully understood through static descriptions of actors and institutions.

Attention must also be directed towards the processes through which learning occurs and new configurations emerge.

This interpretation has important implications for understanding Living Labs. Existing research frequently describes Living Labs as environments for co-creation and experimentation. However, such descriptions often focus on activities rather than system dynamics. A complex adaptive systems perspective shifts attention towards the interactions and feedback processes generated through Living Lab activities. Co-creation becomes a mechanism for knowledge exchange, experimentation generates opportunities for learning, and stakeholder engagement contributes to the formation of new relationships and institutional arrangements. The significance of Living Labs therefore lies not only in the innovations they produce but also in their capacity to influence the adaptive properties of regional systems.

Viewed in this way, Living Labs may be conceptualized as adaptive spaces embedded within broader regional systems. They connect actors who possess different forms of knowledge, facilitate experimentation under real-world conditions, and generate feedback that may influence future behaviour and decision-making. Their contribution to regional transformation is therefore indirect as well as direct. Alongside tangible innovation outcomes, Living Labs may strengthen regional learning capacities, improve coordination among stakeholders, and support institutional adaptation.

The complex adaptive systems perspective thus provides a theoretical foundation for understanding how Living Labs contribute to regional transformation beyond individual projects or technological innovations. It introduces a dynamic interpretation in which experimentation, learning, and feedback become central explanatory mechanisms. This perspective also highlights the importance of behavioural and institutional adaptation, which represent essential processes through which system-level change occurs. These issues are examined in the following subsection.

2.4. Learning, Adaptation, and Institutional Change

Adaptation is a central characteristic of complex social systems. While Regional Innovation Systems and complex adaptive systems perspectives provide important insights into the structures and dynamics of regional development, they offer only partial explanations of how change occurs at the level of individual and collective behaviour. Understanding regional transformation requires attention not only to institutions and networks but also to the processes through which actors learn, modify their actions, and respond to new circumstances. Behavioural adaptation and institutional learning therefore represent critical mechanisms connecting innovation activities with broader system-level change.

Behavioural adaptation refers to adjustments in attitudes, decision-making processes, and patterns of action resulting from new information, experiences, or environmental conditions. In socio-economic systems, actors rarely possess complete information and often operate under conditions of uncertainty. Decisions are shaped by bounded rationality, social norms, cognitive biases, and previous experiences [24,25]. As a consequence, innovation adoption and organizational change depend not only on technological feasibility but also on the willingness and capacity of individuals and organizations to alter established routines and behaviours.

These considerations are particularly relevant in regional development contexts. The introduction of new technologies, governance arrangements, or development strategies frequently requires stakeholders to revise existing practices and assumptions. Resistance to change may emerge even when innovations offer potential benefits because actors interpret risks and opportunities differently. Consequently, regional transformation is often influenced as much by behavioural factors as by economic or technological conditions.

Processes that facilitate learning, trust-building, and knowledge exchange can therefore play a crucial role in supporting adaptation.

Institutional learning represents a complementary dimension of adaptation. Institutions are not static structures but evolve through processes of experimentation, reflection, and collective problem-solving. Public authorities, intermediary organizations, firms, and civil society actors continuously interpret experiences and adjust their practices in response to changing conditions [26]. Through such processes, new governance arrangements may emerge, existing policies may be revised, and organizational capacities may be strengthened. Institutional learning is therefore closely linked to the ability of regional systems to respond effectively to uncertainty and complexity.

The relationship between behavioural adaptation and institutional learning is inherently reciprocal. Changes in individual behaviour may stimulate organizational transformation, while institutional reforms can alter incentives, expectations, and opportunities for action. Regional development consequently involves multiple feedback processes operating across different levels of analysis. Learning occurring within organizations may influence regional governance, while changes in governance arrangements may reshape the behaviour of individual actors and stakeholder networks. This co-evolutionary dynamic represents an important mechanism through which adaptive capacity emerges within regional systems.

Recent studies increasingly recognize that innovation processes are embedded within such learning environments. Knowledge creation is not limited to technological development but also involves the generation of new social practices, collaborative arrangements, and governance mechanisms [12,13]. Innovation therefore becomes closely connected to experimentation and reflection. Actors learn from successes and failures, revise expectations, and develop new forms of cooperation. These processes are particularly important in contexts characterized by uncertainty, where predetermined solutions are often unavailable.

Living Labs provide a setting in which behavioural adaptation and institutional learning can occur simultaneously. Their emphasis on co-creation and real-life experimentation creates opportunities for stakeholders to engage with new ideas, test alternative solutions, and evaluate outcomes collectively. Participation in such processes may influence perceptions, increase trust among actors, and facilitate the exchange of knowledge across organizational boundaries [11,17]. At the same time, insights generated through experimentation can inform policy design, governance practices, and institutional arrangements.

The importance of Living Labs therefore extends beyond the production of innovations. Through repeated cycles of interaction, experimentation, and feedback, they may contribute to the development of adaptive capacities within regional systems. Learning becomes distributed across stakeholders rather than concentrated within individual organizations. New relationships emerge, institutional barriers may be reduced, and collective problem-solving capacities can be strengthened. Such effects are particularly relevant in peripheral regions, where limited institutional density and fragmented stakeholder networks often constrain opportunities for collaboration and innovation.

From this perspective, behavioural adaptation and institutional learning function as key feedback mechanisms connecting Living Lab activities with regional transformation outcomes. They explain how localized experimentation can generate wider systemic effects and why the influence of Living Labs may extend beyond specific projects or technological innovations. This interpretation completes the theoretical foundations of the present study and provides the basis for the conceptual synthesis developed in the following sections.

Taken together, the four theoretical perspectives discussed in this section provide complementary rather than competing explanations of regional transformation. Living Lab research explains collaborative innovation and experimentation; Regional Innovation Sys-

tems theory situates these processes within regional institutional structures; complex adaptive systems theory accounts for feedback, emergence, and adaptation; and behavioural and institutional learning perspectives explain how changes in stakeholder behaviour and governance accumulate over time. Their integration provides the theoretical foundation for conceptualizing Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems that facilitate regional social transformation.

3. Materials and Methods

The development of conceptual frameworks requires methodological transparency regarding the selection, integration, and interpretation of theoretical perspectives. Although conceptual studies do not rely on empirical data collection in the same manner as quantitative or qualitative research, they nevertheless require a systematic approach to theory building and synthesis. Accordingly, this study adopts a conceptual research design that combines insights from several complementary bodies of literature in order to develop an integrated framework for understanding Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems. The following subsections outline the research design, literature synthesis approach, and framework development process that underpin the proposed model.

3.1. Research Design

This study adopts a conceptual research design aimed at developing a theoretical framework for understanding Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems. Conceptual research plays an important role in advancing scientific knowledge by integrating existing theories, identifying relationships among concepts, and generating new explanatory perspectives [27]. Rather than testing predefined hypotheses through empirical observation, conceptual studies seek to clarify underlying mechanisms and establish theoretical foundations that may guide future empirical investigation.

The present article addresses a theoretical gap in the Living Lab literature concerning the relationship between innovation activities and broader processes of regional transformation. Existing studies provide valuable insights into co-creation, stakeholder participation, innovation ecosystems, and governance arrangements [26]. However, less attention has been devoted to explaining how Living Labs influence adaptive capacities, institutional learning, and systemic change within regional contexts. To address this limitation, the study develops a conceptual framework that combines insights from Living Lab research, Regional Innovation Systems theory, complex adaptive systems theory, and behavioural approaches to adaptation and learning.

The objective is not to propose a universal model applicable to all territorial contexts. Rather, the framework is intended as an analytical tool that helps explain how Living Labs may contribute to transformation processes in peripheral regions facing economic, social, technological, and environmental challenges. In this sense, the study follows an explanatory theory-building approach that focuses on identifying mechanisms and relationships rather than establishing causal effects through empirical testing.

3.2. Literature Selection and Synthesis

The framework was developed through an integrative review and synthesis of scholarly literature drawn from four interconnected research domains: Living Labs and open innovation, Regional Innovation Systems, complex adaptive systems, and behavioural adaptation and institutional learning. The literature was identified through searches of major scientific databases, including Scopus and Web of Science, supplemented by

backward and forward citation tracking of influential publications. Search combinations included terms such as “Living Labs”, “regional innovation systems”, “complex adaptive systems”, “behavioural adaptation”, “institutional learning”, “regional transformation”, and “peripheral regions”. The review focused primarily on peer-reviewed journal articles published during the last decade while also incorporating seminal theoretical contributions that established the conceptual foundations of the four research domains. The objective was not to achieve exhaustive coverage but to identify conceptually relevant literature capable of supporting the development of an integrated explanatory framework. Integrative literature reviews are particularly suitable for conceptual research because they enable the combination of perspectives originating from different disciplinary traditions and facilitate the development of new theoretical interpretations [28].

The literature selection process was guided by the objective of identifying theoretical concepts relevant to understanding regional transformation in peripheral contexts. Particular attention was devoted to studies addressing co-creation, stakeholder interaction, innovation ecosystems, regional resilience, adaptive governance, learning processes, and institutional change. Priority was given to peer-reviewed journal articles, scholarly books, and influential theoretical contributions that have shaped contemporary debates within their respective fields. Although the review was not conducted as a formal systematic literature review, the literature selection followed transparent conceptual criteria. Publications were identified based on their theoretical relevance, scientific influence, and contribution to one or more of the four conceptual domains underpinning the framework. Preference was given to recent peer-reviewed studies that advanced contemporary debates on Living Labs, Regional Innovation Systems, complex adaptive systems, and behavioural adaptation, while also incorporating seminal theoretical works that established the foundations of these research streams.

Rather than conducting a systematic review intended to evaluate empirical evidence, the study adopts a theory synthesis approach. Theory synthesis seeks to integrate concepts and propositions from multiple theoretical traditions in order to construct a more comprehensive explanatory framework [29]. This approach is appropriate because the phenomena examined in this article extend across several domains of inquiry and cannot be adequately explained through a single theoretical perspective.

3.3. Conceptual Framework Development

The conceptual framework was developed through an iterative process of theoretical integration. First, Living Lab research was examined to identify the principal mechanisms associated with co-creation, experimentation, stakeholder engagement, and knowledge exchange. Second, Regional Innovation Systems theory was used to establish the territorial and institutional context within which these mechanisms operate. Third, complex adaptive systems theory provided a dynamic perspective emphasizing feedback processes, adaptation, and emergence. Finally, behavioural adaptation and institutional learning perspectives were incorporated to explain how interactions within Living Labs may influence regional transformation over time. Rather than treating these theoretical perspectives independently, the synthesis involved a cross-analysis of their complementary explanatory roles. Living Lab research explains collaborative innovation mechanisms; Regional Innovation Systems theory provides the territorial and institutional context; complex adaptive systems theory explains dynamic processes of feedback, emergence, and adaptation; and behavioural adaptation and institutional learning clarify how interactions generate changes in stakeholder behaviour and governance practices. Their integration enables a more comprehensive explanation of regional transformation than any individual perspective alone.

This cross-analysis also highlights the incremental theoretical contribution of the proposed framework. While Living Lab research explains collaborative innovation processes, Regional Innovation Systems theory provides the institutional and territorial context, complex adaptive systems theory captures the dynamic processes of feedback and adaptation, and behavioural perspectives explain how learning and institutional change emerge over time. Their integration makes it possible to conceptualize Living Labs not simply as innovation environments but as adaptive intermediary structures that connect these complementary processes into a coherent explanation of regional social transformation, particularly in peripheral regions.

The synthesis of these perspectives led to the identification of three interconnected analytical dimensions. The first dimension consists of Living Lab mechanisms, including co-creation, experimentation, stakeholder coordination, and knowledge exchange. The second dimension comprises feedback processes such as trust-building, learning, absorptive capacity, and institutional adaptation. The third dimension encompasses regional outcomes, including resilience, adaptive governance, innovation capacity, social inclusion, and socio-economic transformation.

The resulting framework conceptualizes Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems. Their influence is understood as emerging through feedback-driven learning processes that connect local experimentation with broader regional development dynamics. The framework serves as the foundation for the theoretical propositions presented in the following sections.

3.4. Scope, Assumptions, and Limitations

The conceptual nature of this study creates both opportunities and limitations. The proposed framework enables the integration of multiple theoretical perspectives that are often examined separately within the literature. By combining insights from Living Lab research, Regional Innovation Systems theory, complex adaptive systems theory, and behavioural approaches to adaptation, the study seeks to provide a broader understanding of the mechanisms linking innovation activities with regional transformation.

At the same time, the framework has not been empirically tested. The relationships and propositions presented in the article should therefore be interpreted as theoretically informed assumptions requiring further validation through qualitative, quantitative, or mixed-method research. Moreover, the framework is primarily designed to explain transformation processes in peripheral regions and may require adaptation when applied to metropolitan or highly specialized innovation environments.

A further limitation arises from the interdisciplinary nature of the study. While theory synthesis facilitates the integration of diverse perspectives, it inevitably involves selective interpretation of complex bodies of literature. Alternative conceptualizations of innovation, adaptation, and regional development may emphasize different mechanisms or causal relationships. Consequently, the framework should be viewed as a contribution to ongoing theoretical discussions rather than as a definitive representation of Living Lab dynamics.

4. Results: Developing a Systems Framework for Regional Transformation

Building upon the theoretical foundations and conceptual synthesis presented in the previous sections, this section develops a systems-based framework that explains how Living Labs contribute to regional transformation through interconnected processes of experimentation, learning, adaptation, and institutional change.

4.1. Responding to Transformation Pressures

Regional development increasingly unfolds within environments characterized by multiple and interconnected transformation pressures. Digitalization, climate change, demographic restructuring, and shifting economic conditions create challenges that frequently exceed the adaptive capacity of traditional governance and innovation structures [1,2]. Peripheral regions are particularly exposed to such pressures because they often possess fewer institutional resources, weaker innovation infrastructures, and more limited access to external knowledge networks [7].

These pressures should not be interpreted solely as external constraints. They also create incentives for institutional innovation, organizational learning, and new forms of stakeholder collaboration. Regional adaptation increasingly depends on the ability of diverse actors to collectively identify problems, experiment with potential solutions, and adjust development strategies in response to changing conditions. Consequently, transformation becomes less a question of implementing predefined policies and more a process of continuous learning and adaptation.

Within this context, Living Labs may be interpreted as institutional responses to growing environmental complexity. Their emphasis on experimentation, co-creation, and stakeholder engagement creates opportunities to address emerging challenges under real-world conditions. Rather than attempting to reduce uncertainty through centralized planning, Living Labs provide mechanisms through which uncertainty can be explored, interpreted, and managed collectively. This function becomes particularly relevant in peripheral regions where development challenges frequently cut across sectoral, organizational, and policy boundaries.

4.2. Activating Regional Learning Through Living Labs

A defining characteristic of Living Labs is their capacity to facilitate interaction among actors who possess different forms of knowledge, experience, and institutional perspectives. Through co-creation activities, experimentation processes, and collaborative problem-solving, Living Labs create environments in which knowledge can be exchanged, combined, and transformed into new solutions [9,11].

From a systems perspective, these activities should be interpreted as learning mechanisms rather than isolated innovation practices. Learning occurs when stakeholders acquire new information, revise assumptions, and adapt their behaviour in response to experimentation outcomes. Importantly, such learning is not limited to individual participants. Knowledge generated within Living Labs may circulate through regional networks, influencing organizations, governance arrangements, and policy processes.

The contribution of Living Labs therefore extends beyond innovation outputs. By facilitating repeated interactions among stakeholders, they strengthen the relational infrastructure necessary for collective action. Trust, shared understanding, and collaborative capacities emerge gradually through participation in co-creation processes. These relational resources can subsequently support future innovation activities and enhance the overall adaptive capacity of regional systems.

This interpretation aligns with recent discussions emphasizing the importance of social and institutional dimensions of innovation ecosystems [6,12]. Innovation is not solely the result of technological capabilities but also depends on the quality of relationships that connect actors within a regional system. Living Labs contribute to these relationships by creating structured environments for interaction, experimentation, and mutual learning.

Beyond facilitating co-creation and experimentation, Living Labs may also perform intermediary functions within Regional Innovation Systems. These functions include stakeholder brokerage, knowledge translation, coordination of collaborative activities, and the

orchestration of interactions among actors with different interests, capabilities, and institutional backgrounds. Through these intermediary roles, Living Labs help connect otherwise fragmented actors and support the circulation of knowledge across organizational and sectoral boundaries.

4.3. Generating Feedback and Adaptive Capacity

The transformative potential of Living Labs emerges through feedback processes that connect local experimentation with broader regional dynamics. Feedback mechanisms play a central role in complex adaptive systems because they influence how actors interpret information, adjust behaviour, and modify institutional arrangements over time [18,30].

Several feedback processes appear particularly relevant in Living Lab environments. First, experimentation generates knowledge regarding the effectiveness of proposed solutions. Second, stakeholder interaction contributes to trust-building and the development of shared expectations. Third, repeated engagement may enhance absorptive capacity by improving the ability of organizations and institutions to recognize, interpret, and utilize new knowledge. Finally, learning outcomes can influence governance practices and policy decisions, creating opportunities for institutional adaptation.

These processes are mutually reinforcing. Increased trust may facilitate knowledge exchange, while improved knowledge exchange may strengthen collaborative relationships. Similarly, institutional learning can create conditions that support further experimentation and innovation. Through such interactions, Living Labs contribute to the development of adaptive capacities that extend beyond individual projects.

The importance of adaptive capacity is particularly evident in peripheral regions, where uncertainty and resource constraints often limit the effectiveness of conventional policy interventions. Under such conditions, resilience depends less on stability and more on the ability to learn, reorganize, and respond to emerging challenges. Living Labs may support this process by creating feedback-rich environments that facilitate continuous adaptation.

The feedback processes (see F1–F5 in Figure 1) generated through Living Lab activities may operate at several interconnected levels. Experimentation supports learning from practical experience, stakeholder interaction encourages behavioural adaptation, and repeated reflection on outcomes contributes to institutional learning and institutional adaptation. Through reflexive monitoring and evaluation, knowledge generated during experimentation can be continuously interpreted and incorporated into subsequent actions, thereby reinforcing recursive cycles of learning and adaptation.

4.4. From Experimentation to Regional Transformation

The preceding discussion suggests that Living Labs influence regional development through a sequence of interconnected processes. Transformation pressures create the need for adaptation. Living Labs provide mechanisms for experimentation, co-creation, and stakeholder coordination. These mechanisms generate feedback processes that support learning, trust-building, absorptive capacity, and institutional adaptation. Over time, such processes contribute to broader regional outcomes, including resilience, innovation capacity, adaptive governance, social inclusion, and socio-economic transformation.

This interpretation differs from project-oriented perspectives that evaluate Living Labs primarily through immediate innovation outputs. A systems perspective highlights the cumulative and relational effects of Living Lab activities. Regional transformation emerges not from individual innovations alone but from the capacity of regional actors to learn, coordinate actions, and adapt to changing conditions.

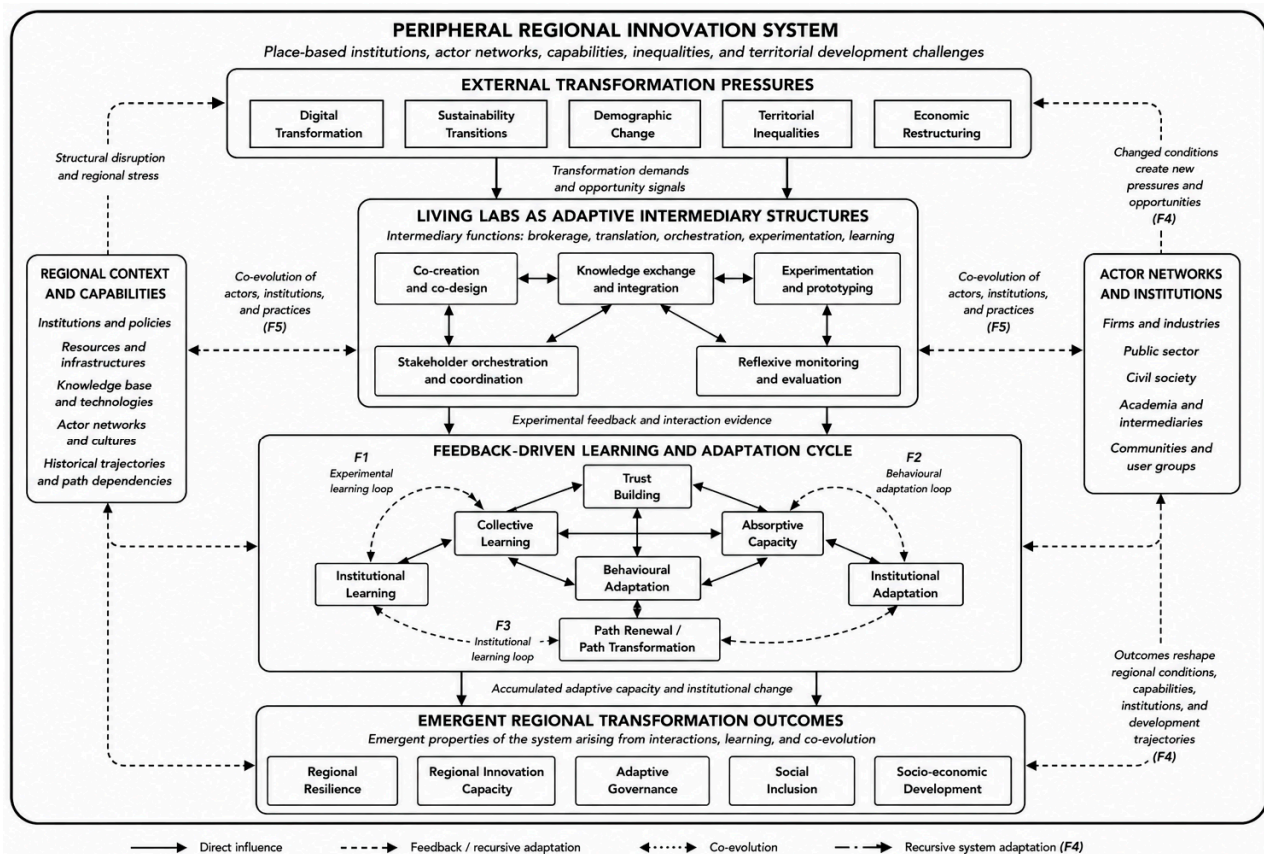


Figure 1. Conceptual framework illustrating the operational processes through which Living Labs function as adaptive intermediary structures embedded within Regional Innovation Systems, enabling regional transformation.

Accordingly, Living Labs can be conceptualized as adaptive intermediary structures embedded within Regional Innovation Systems that connect experimentation with transformation through feedback-driven learning processes. This interpretation provides the foundation for the conceptual framework and research propositions presented in the following section.

The transformative effects of Living Labs are shaped by the broader regional context, including institutional arrangements, actor networks, available resources, and historically developed development trajectories. As learning and adaptation accumulate, regional systems may experience processes of path renewal or path transformation that alter existing patterns of development. These outcomes, in turn, reshape regional conditions and influence future opportunities for experimentation, creating co-evolutionary dynamics between actors, institutions, and territorial development processes.

4.5. Integrating the Framework Components

The preceding analysis suggests that the contribution of Living Labs to regional transformation cannot be adequately explained through isolated innovation outcomes or individual stakeholder activities. Rather, Living Labs operate through interconnected processes that link regional challenges, collaborative experimentation, feedback mechanisms, and adaptive responses. A systems perspective makes it possible to conceptualize these relationships as part of a broader transformation process occurring within Regional Innovation Systems.

The framework developed in this article identifies four interconnected analytical components. The first component consists of external transformation pressures, including

digitalization, demographic change, sustainability transitions, and territorial inequalities. These pressures create conditions that require adaptation and stimulate the search for new development pathways.

The second component comprises the core mechanisms associated with Living Lab activities. These include co-creation, experimentation, stakeholder coordination, and knowledge exchange. Through these mechanisms, Living Labs create structured environments in which actors can collectively explore challenges and test potential solutions under real-world conditions.

The third component consists of feedback processes that emerge through repeated interaction and experimentation. Trust-building, learning, absorptive capacity, and institutional adaptation function as mechanisms through which knowledge generated within Living Labs becomes embedded within regional systems. These processes connect localized experimentation with broader patterns of behavioural and organizational change.

The fourth component encompasses regional transformation outcomes. These include enhanced resilience, strengthened innovation capacity, adaptive governance, social inclusion, and broader socio-economic development. Importantly, these outcomes are not interpreted as final states. They may generate new learning processes and alter regional conditions, thereby creating feedback loops that influence future adaptation processes. Across all components of the framework, the characteristics of peripheral regions influence the operation and intensity of these relationships. Structural constraints such as weaker institutional density, fragmented stakeholder networks, and limited access to external knowledge may moderate the effectiveness of Living Lab mechanisms, while strong local social capital and place-based collaboration can enhance learning, trust-building, and adaptive capacity. Consequently, the proposed framework should be interpreted as particularly relevant for understanding how adaptive processes unfold under peripheral regional conditions.

Taken together, these components support the interpretation of Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems. Their primary significance lies not in the production of individual innovations but in their capacity to facilitate learning-oriented interactions that strengthen regional adaptive capacity.

To facilitate the synthesis of the proposed framework, Table 1 summarizes the principal components and their functions within the adaptive regional innovation system perspective developed in this study. Importantly, the relationships among these components are not linear but recursive, as learning, adaptation, and co-evolution generate feedback cycles that continuously reshape both regional conditions and future experimentation processes.

Table 1. Operational mechanisms through which Living Labs enact their adaptive intermediary role within Regional Innovation Systems.

Framework Component	Elements	Function within the System
External Transformation Pressures	Digitalisation, sustainability transition, demographic change, territorial inequalities	Generate adaptation challenges and trigger regional responses
Living Lab Mechanisms	Co-creation, experimentation, stakeholder coordination, knowledge exchange	Facilitate collaborative problem-solving and innovation development
Feedback Processes	Trust-building, learning, absorptive capacity, institutional adaptation	Transfer knowledge and support behavioural and institutional change
Regional Transformation Outcomes	Resilience, innovation capacity, adaptive governance, social inclusion, socio-economic development	Reflect adaptive responses and system-level transformation
Feedback Loops	Continuous interaction between outcomes and future experimentation	Enable system evolution and adaptive learning

Source: Authors' conceptualisation.

The framework integrates external transformation pressures, Living Lab mechanisms, feedback processes, and regional transformation outcomes into a coherent systems-based structure. Together, these components explain how experimentation and stakeholder interaction generate learning and adaptive capacities that contribute to long-term regional transformation.

5. Conceptual Model and Research Propositions

The systems perspective developed in the previous section is synthesized into a conceptual model that explains how Living Labs contribute to regional transformation through interconnected mechanisms of experimentation, learning, adaptation, and feedback. Based on this framework, a set of theoretical propositions is formulated to guide future empirical research.

5.1. Conceptual Model

The framework proposed in this article conceptualizes Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems and operating within broader regional transformation processes. The model integrates four interconnected components identified through the preceding theoretical synthesis.

The first component consists of external transformation pressures. These pressures include digitalization, sustainability transitions, demographic change, territorial inequalities, and other forms of socio-economic restructuring that require regions to adapt to changing circumstances. Rather than acting as isolated challenges, these pressures create conditions that stimulate experimentation and the search for alternative development pathways.

The second component comprises the core mechanisms associated with Living Lab activities. These mechanisms include co-creation, experimentation, stakeholder coordination, and knowledge exchange. Through these activities, Living Labs provide structured environments in which diverse actors can collectively explore challenges, develop solutions, and test innovations under real-world conditions.

The third component consists of feedback processes that emerge through stakeholder interaction and repeated experimentation. Trust-building, learning, absorptive capacity, and institutional adaptation function as intermediary mechanisms connecting Living Lab activities with broader regional effects. These processes enable knowledge generated within local experimentation environments to become embedded within regional governance structures, organizational practices, and stakeholder networks.

The fourth component encompasses regional transformation outcomes. These outcomes include enhanced resilience, strengthened innovation capacity, adaptive governance, social inclusion, and broader socio-economic development. Importantly, these outcomes are not interpreted as final states. As adaptive systems evolve, transformation outcomes influence future behaviours, institutional arrangements, and development conditions, thereby generating new cycles of learning and adaptation.

Figure 1 depicts the operational processes through which Living Labs function as adaptive intermediary structures embedded within Regional Innovation Systems and contribute to regional transformation.

Figure 1 illustrates how external transformation pressures activate Living Lab mechanisms that collectively enact their adaptive intermediary role. Rather than representing isolated activities, these mechanisms facilitate stakeholder collaboration, coordinate real-world experimentation, promote iterative learning, and support adaptive governance through continuous feedback processes. In doing so, they generate behavioural adaptation, institutional change, and recursive learning that collectively contribute to regional transformation. The framework therefore emphasizes that regional transformation is not a linear

process but an iterative and adaptive dynamic shaped by continuous interactions among actors, institutions, and environmental conditions.

5.2. Research Propositions

The conceptual model suggests that regional transformation emerges through a series of interconnected and feedback-driven relationships linking Living Lab activities with adaptive regional outcomes. To make these relationships explicit and to support future empirical validation, five theoretical propositions are derived from the framework. The propositions specify the principal mechanisms through which co-creation, experimentation, learning, trust-building, and institutional adaptation are expected to influence the transformative capacity of Regional Innovation Systems. They are derived directly from the relationships represented in the conceptual framework (Figure 1). Within this framework, trust-building and institutional learning function as mediating feedback mechanisms through which Living Lab activities contribute to regional transformation outcomes, whereas regional connectivity is conceptualized as a contextual condition that influences the effectiveness of these mechanisms and, consequently, the transformative potential of Living Labs within Regional Innovation Systems.

Proposition 1 (P1): *Living Labs enhance regional learning capacity through iterative stakeholder interaction and collaborative experimentation.*

The co-creation processes characteristic of Living Labs facilitate the exchange of knowledge among diverse actors and create opportunities for collective learning. Repeated interaction contributes to the development of shared understandings and strengthens the capacity of regional stakeholders to identify, interpret, and respond to emerging challenges.

Proposition 2 (P2): *Trust mediates the relationship between Living Lab participation and the diffusion of innovation within regional systems.*

The effectiveness of innovation processes depends not only on technological quality but also on the willingness of stakeholders to collaborate, share knowledge, and engage in collective action. Trust-building generated through Living Lab activities facilitates these processes and supports the broader adoption of innovative practices and solutions.

Proposition 3 (P3): *The relationship between Living Lab experimentation and regional transformation is mediated by institutional learning processes.*

Experimentation generates knowledge regarding the effectiveness of alternative solutions and governance arrangements. When such knowledge becomes incorporated into organizational routines, policy processes, and institutional practices, Living Lab activities may contribute to wider regional transformation.

Proposition 4 (P4): *Living Labs strengthen regional resilience by facilitating feedback-driven adaptation among regional stakeholders and institutions.*

Resilience emerges from the capacity of regions to learn, reorganize resources, and respond to changing conditions. Through continuous feedback and stakeholder engagement, Living Labs contribute to the development of adaptive capacities that support long-term regional resilience.

Proposition 5 (P5): *The transformative potential of Living Labs depends on the quality of connectivity within Regional Innovation Systems.*

The effectiveness of Living Labs is influenced by the density and quality of relationships among participating actors. Regions characterized by stronger stakeholder connectivity and more effective knowledge exchange are likely to experience greater transformative effects from Living Lab activities than regions with fragmented institutional structures.

Table 2 provides a concise overview of the theoretical propositions and the principal system relationships identified within the proposed framework. The table highlights the expected pathways through which Living Lab mechanisms and feedback processes contribute to regional transformation outcomes.

Table 2. Research propositions and expected system relationships.

Proposition	Core Relationship	Expected Regional Effect
P1	Living Lab participation → collective learning	Enhanced regional learning capacity
P2	Trust-building → innovation diffusion	Greater stakeholder cooperation and innovation adoption
P3	Experimentation → institutional learning	Improved governance adaptation and policy innovation
P4	Feedback-driven adaptation → resilience	Stronger capacity to respond to external shocks
P5	Network connectivity → transformative impact	More effective regional transformation outcomes

Source: Authors' elaboration based on theoretical synthesis. Arrows mean direction of relationship, e.g., Living Lab participation leads to collective learning.

Collectively, the propositions highlight the feedback-driven and adaptive nature of Living Labs within Regional Innovation Systems, emphasizing their potential role in facilitating resilience, learning, and long-term socio-economic transformation. Future empirical studies may further investigate the strength and context-dependency of these relationships.

6. Discussion

The framework developed in this article advances the understanding of Living Labs by positioning them within a broader systems perspective on regional transformation. Rather than conceptualizing Living Labs primarily as innovation platforms, co-creation environments, or participatory governance instruments, the proposed framework interprets them as adaptive intermediary structures embedded within Regional Innovation Systems that facilitate learning, feedback, and institutional adaptation. This perspective contributes to several strands of literature and offers new insights into the role of Living Labs in peripheral regional development.

6.1. Theoretical Contributions

The first contribution concerns the Living Lab literature itself. Existing research has generated substantial knowledge regarding user involvement, co-creation processes, governance arrangements, and innovation outcomes [9,11,15]. However, much of this work remains focused on project-level activities and innovation processes. The framework proposed in this article extends these perspectives by emphasizing the systemic functions of Living Labs within regional development contexts. In this interpretation, Living Labs are not only sites of experimentation but also intermediary structures through which learning, trust-building, and institutional adaptation become embedded within broader regional systems.

A second contribution relates to Regional Innovation Systems theory. Traditional RIS approaches have demonstrated the importance of institutions, networks, and knowledge exchange in shaping regional development trajectories [21,22]. Nevertheless, these approaches have often been criticized for providing relatively static representations of regional structures. The framework developed here introduces a more dynamic interpretation by highlighting the role of feedback mechanisms, behavioural adaptation, and continuous learning. This perspective complements existing RIS research by drawing attention to the processes through which regional systems evolve and respond to changing conditions.

The third contribution concerns the application of systems thinking to regional transformation. Drawing on complex adaptive systems theory, the article conceptualizes regional development as an emergent process shaped by interactions among actors, institutions, and environmental pressures [1,18]. Within this context, Living Labs function as adaptive spaces that connect experimentation with system-level change. The framework therefore contributes to ongoing discussions regarding how innovation infrastructures influence resilience, adaptation, and transformation within complex socio-economic systems.

Taken together, these contributions support a shift from outcome-oriented interpretations of Living Labs towards a process-oriented understanding of regional transformation. Innovation outcomes remain important, but they are understood as part of broader adaptive processes through which regions learn, reorganize resources, and develop new capacities for responding to uncertainty and change.

The novelty of the proposed framework lies in its integration of four theoretical traditions that have largely evolved in parallel within the existing literature. Previous studies have typically examined Living Labs from the perspectives of open innovation, governance, or innovation ecosystems, while Regional Innovation Systems, complex adaptive systems, and behavioural adaptation have rarely been combined within a single explanatory model. By synthesizing these perspectives, the framework provides an incremental theoretical contribution that explains not only how Living Labs support innovation but also how they facilitate adaptive regional transformation through interconnected processes of experimentation, feedback, learning, and institutional change. Unlike previous conceptualizations, which typically examine these processes separately, the proposed framework explains how they interact through the intermediary role of Living Labs, thereby providing an integrated systems-based explanation of regional transformation.

6.2. Understanding Living Labs as Adaptive Intermediary Structures Embedded Within Regional Innovation Systems

The framework developed in this article suggests that the significance of Living Labs lies less in their capacity to generate individual innovations and more in their ability to strengthen adaptive processes within regional systems. This distinction is important because regional transformation rarely occurs as the direct consequence of a single technological solution, policy intervention, or innovation project. Instead, transformation emerges through cumulative processes of learning, experimentation, and institutional adjustment that unfold over time.

From this perspective, Living Labs can be understood as intermediary structures that facilitate interactions among actors operating within different institutional and organizational environments. Their contribution is not limited to connecting knowledge producers with users. Equally important is their ability to create conditions under which diverse stakeholders can collectively interpret challenges, negotiate priorities, and explore alternative development pathways. Such processes are particularly relevant in situations characterized by uncertainty, where solutions cannot be fully specified in advance.

The proposed framework also highlights the importance of feedback processes in understanding Living Lab impacts. Existing evaluations frequently focus on measurable

outputs, such as prototypes, services, or collaborative projects. While these outcomes remain important, they may capture only part of the influence that Living Labs exert within regional systems. Trust-building, learning, and institutional adaptation often develop gradually and may produce effects that become visible only over longer time horizons. Consequently, the success of Living Labs should not be assessed solely through immediate innovation outputs but also through their contribution to the adaptive capacity of regional stakeholders and institutions.

This interpretation aligns with broader discussions concerning resilience and adaptive governance. Regions increasingly face challenges that are dynamic, interconnected, and difficult to predict. Under such conditions, the capacity to continuously learn and adapt may be more valuable than the ability to optimize existing structures. Living Labs may contribute to this capacity by creating environments in which experimentation is possible and where failures can generate knowledge rather than merely represent unsuccessful outcomes. Their role therefore extends beyond innovation support and encompasses broader processes of institutional and societal adaptation.

6.3. Implications for Peripheral Regions

The systems perspective developed in this article is particularly relevant for peripheral regions, where development challenges frequently extend beyond economic performance and innovation capacity. Many such regions experience demographic decline, labour market constraints, institutional fragmentation, and limited access to external knowledge networks [2,7]. These conditions often reduce the effectiveness of conventional development strategies based primarily on investment attraction or technological modernization.

The framework therefore assumes that peripherality shapes the conditions under which Living Lab mechanisms operate rather than determining their outcomes. In other words, the same processes of co-creation, experimentation, and institutional learning may produce different regional effects depending on the degree of institutional capacity, stakeholder connectivity, and access to external knowledge characteristic of peripheral regions.

The framework suggests that regional transformation in peripheral contexts depends not only on the availability of resources but also on the capacity to mobilize local knowledge, strengthen stakeholder connectivity, and support collective learning processes. In this regard, Living Labs may provide institutional environments through which dispersed actors can develop shared understandings of regional challenges and experiment with context-specific solutions. Their value therefore lies in facilitating processes that are often difficult to achieve through traditional governance arrangements.

At the same time, the framework cautions against assuming that Living Labs automatically generate positive outcomes. Their effectiveness is likely to depend on existing institutional conditions, stakeholder engagement, governance quality, and the capacity to translate local experimentation into broader regional learning. In regions characterized by weak institutional trust or limited organizational connectivity, Living Lab activities may encounter substantial barriers. This observation reinforces the importance of viewing Living Labs as components of wider regional systems rather than as isolated policy instruments.

The framework also has implications for contemporary policy debates concerning smart specialization, place-based development, and sustainability transitions. These approaches increasingly emphasize experimentation, stakeholder participation, and locally grounded innovation processes. By conceptualizing Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems, the article provides a theoretical explanation for why such approaches may contribute to regional transformation and under what conditions their impacts are likely to emerge.

6.4. Directions for Future Research

As a conceptual contribution, the framework proposed in this article requires further empirical examination. Future studies may test the propositions developed in Section 5 through comparative case studies, longitudinal analyses, survey-based approaches, or mixed-method research designs. Such investigations would help clarify the relationships among Living Lab mechanisms, feedback processes, and regional transformation outcomes.

Particular attention should be devoted to understanding the temporal dimensions of adaptation. Many of the mechanisms identified in this framework, including trust-building, institutional learning, and absorptive capacity development, emerge gradually and may not be observable within short project cycles. Longitudinal research could therefore provide valuable insights into how Living Labs influence regional development trajectories over time.

Future research may also explore variations across territorial contexts. Although the framework was developed primarily with peripheral regions in mind, the proposed mechanisms may operate differently in metropolitan regions, specialized innovation clusters, or regions characterized by different governance traditions. Comparative studies could therefore help identify context-specific factors that influence the effectiveness of Living Labs as adaptive intermediary structures embedded within Regional Innovation Systems.

Finally, further theoretical work may extend the framework by incorporating additional perspectives from social innovation, sustainability transitions, network governance, and evolutionary economic geography. Such developments could contribute to a more comprehensive understanding of the mechanisms through which innovation infrastructures support regional adaptation and transformation under conditions of increasing complexity and uncertainty.

7. Conclusions

This article set out to address the question of how Living Labs can be conceptualized as adaptive intermediary structures embedded within Regional Innovation Systems that facilitate social transformation in peripheral regions. Drawing upon Living Lab research, Regional Innovation Systems theory, complex adaptive systems theory, and perspectives on behavioural adaptation and institutional learning, the study developed a conceptual framework that explains how Living Labs contribute to regional transformation through interconnected processes of experimentation, learning, feedback, and institutional adaptation.

The proposed framework advances existing understandings of Living Labs in several respects. Rather than treating Living Labs primarily as innovation platforms or participatory governance arrangements, the framework positions them as adaptive intermediary structures embedded within broader regional systems. In this interpretation, the contribution of Living Labs extends beyond the generation of innovation outputs and includes the strengthening of regional learning capacities, stakeholder coordination, trust-building processes, and adaptive governance mechanisms.

The framework also contributes to regional development research by highlighting the importance of feedback processes in shaping transformation outcomes. Regional resilience, innovation capacity, social inclusion, and socio-economic development are conceptualized not as isolated outcomes but as emergent properties of adaptive systems characterized by continuous interaction among actors, institutions, and environmental conditions. This perspective shifts attention from linear models of innovation towards a more dynamic understanding of regional change.

The article further contributes to systems-oriented research by integrating multiple theoretical perspectives within a coherent explanatory model. By connecting transforma-

tion pressures, Living Lab mechanisms, feedback processes, and regional outcomes, the framework provides a foundation for analysing how innovation infrastructures support adaptation under conditions of uncertainty and complexity.

As a conceptual study, the framework remains subject to empirical validation. Future research should examine the proposed relationships across different territorial contexts and explore the mechanisms through which learning, trust, and institutional adaptation influence regional development trajectories over time. Comparative and longitudinal studies may be particularly valuable in assessing how Living Labs contribute to adaptive capacity in regions facing diverse socio-economic and environmental challenges.

In an era characterized by accelerating technological, social, and environmental change, regional development increasingly depends on the ability to learn, adapt, and coordinate collective responses to uncertainty. The framework proposed in this article suggests that Living Labs may play an important role in these processes by acting as adaptive intermediary structures embedded within Regional Innovation Systems that connect experimentation with transformation through continuous cycles of learning and feedback.

Author Contributions: Conceptualization, K.G. and R.L.; methodology, K.G. and R.L.; software, K.G. and R.L.; validation, K.G. and R.L.; formal analysis, K.G.; investigation, K.G. and R.L.; resources, K.G. and R.L.; data curation, K.G. and R.L.; writing—original draft preparation, K.G.; writing—review and editing, K.G. and R.L.; visualization, K.G. and R.L.; supervision, R.L.; funding acquisition, K.G. and R.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Acknowledgments: During the preparation of this manuscript, the authors used OpenAI's ChatGPT (GPT-5.5) to assist in the preparation of preliminary text drafts and conceptual framework drafting. The generated outputs were critically reviewed, revised, and edited by the authors. All interpretations, theoretical arguments, conclusions, and final editorial decisions were made by the authors, who take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Boschma, R.; Martin, R. Constructing an evolutionary economic geography. *J. Econ. Geogr.* **2007**, *7*, 537–548. [\[CrossRef\]](#)
2. Rodríguez-Pose, A.; Ganau, R. Institutions and the productivity challenge for European regions. *J. Econ. Geogr.* **2021**, *22*, 1–25. [\[CrossRef\]](#)
3. Bianchi, G.; Matti, C.; Pontikakis, D.; Reimeris, R.; Haegeman, K.H.; Miedzinski, M.; Sillero Illanes, C.; Mifsud, S.; Sasso, S.; Bol, E.; et al. *Innovation for Place-Based Transformations*; Publications Office of the European Union: Luxembourg, 2024. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Rust, B.; Rust, S. Place-based innovation for sustainable and resilient human systems. *Sustain. Earth Rev.* **2024**, *7*, 19. [\[CrossRef\]](#)
5. Autio, E.; Thomas, L. Innovation ecosystems. In *The Oxford Handbook of Innovation Management*; Dodgson, M., Gann, D., Phillips, N., Eds.; Oxford University Press: Oxford, UK, 2014; pp. 204–288.
6. Stam, E.; van de Ven, A. Entrepreneurial ecosystem elements. *Small Bus. Econ.* **2021**, *56*, 809–832. [\[CrossRef\]](#)
7. Trippel, M.; Tödting, F. Place-based transformative innovation policies. *Sustain. Reg. Restruct.* **2025**, 11–26. [\[CrossRef\]](#)
8. Chamusca, P. Public policies for territorial cohesion and sustainability in Europe: An overview. *Sustainability* **2023**, *15*, 6890. [\[CrossRef\]](#)
9. Schuurman, D.; De Marez, L.; Ballon, P. The impact of living lab methodology on open innovation contributions and outcomes. *Technol. Innov. Manag. Rev.* **2016**, *6*, 7–16. [\[CrossRef\]](#) [\[PubMed\]](#)

10. Leminen, S.; Nyström, A.-G.; Westerlund, M.; Kortelainen, M.J. The effect of network structure on radical innovation in living labs. *J. Bus. Ind. Mark.* **2016**, *31*, 743–757. [\[CrossRef\]](#)
11. Fauth, J.; De Moortel, K.; Schuurman, D. Living labs as orchestrators in the regional innovation ecosystem: A conceptual framework. *J. Responsible Innov.* **2024**, *11*, 2414505. [\[CrossRef\]](#)
12. Valkokari, K.; Hyytinen, K.; Leväsluoto, J. Living Labs as Enablers for Collaborative Innovation—Exploring Success Factors and Impacts. *J. Innov. Manag.* **2024**, *12*, 158–174. [\[CrossRef\]](#) [\[PubMed\]](#)
13. Fuglsang, L.; Hansen, A.V.; Mergel, I.; Røhnbæk, M.T. Living labs for public sector innovation: An integrative literature review. *Adm. Sci.* **2021**, *11*, 58. [\[CrossRef\]](#)
14. Gago, D.; Rubalcaba, L. Co-creation for public innovation: The role of living labs and user-engagement methodologies. *Public Money Manag.* **2025**, *45*, 604–614. [\[CrossRef\]](#)
15. Puerari, E.; De Koning, J.; von Wirth, T.; Karré, P.M.; Mulder, I.; Loorbach, D. Co-creation dynamics in urban living labs. *Sustainability* **2018**, *10*, 1893. [\[CrossRef\]](#)
16. Chapagain, M.R.; Mikkelsen, B.E. Is a Living Lab also a learning lab? Exploring co-creational power of young people in a local community food context. *Youth* **2023**, *3*, 753–776. [\[CrossRef\]](#)
17. Fierăscu, S.I.; Schuurman, D. A systematic bibliometric and network analysis of the Living Labs knowledge base. In *ISPIM Innovation Symposium Proceedings*; International Society for Professional Innovation Management: Manchester, UK, 2025; pp. 1–26.
18. Martin, R.; Sunley, P. On the notion of regional economic resilience: Conceptualization and explanation. *J. Econ. Geogr.* **2015**, *15*, 1–42. [\[CrossRef\]](#)
19. Godin, B. The linear model of innovation: The historical construction of an analytical framework. *Sci. Technol. Hum. Values* **2006**, *31*, 639–667. [\[CrossRef\]](#)
20. Cooke, P.; Uranga, M.G.; Etzebarria, G. Regional innovation systems: Institutional and organisational dimensions. *Res. Policy* **1997**, *26*, 475–491. [\[CrossRef\]](#)
21. Asheim, B.T.; Boschma, R.; Cooke, P. Constructing regional advantage: Platform policies based on related variety and differentiated knowledge bases. *Reg. Stud.* **2011**, *45*, 893–904. [\[CrossRef\]](#)
22. Doloreux, D.; Porto Gomez, I. A review of (almost) 20 years of regional innovation systems research. *Eur. Plan. Stud.* **2017**, *25*, 371–387. [\[CrossRef\]](#)
23. Barca, F.; McCann, P.; Rodríguez-Pose, A. The case for regional development intervention: Place-based versus place-neutral approaches. *J. Reg. Sci.* **2012**, *52*, 134–152. [\[CrossRef\]](#)
24. Kahneman, D. Maps of bounded rationality: Psychology for behavioral economics. *Am. Econ. Rev.* **2003**, *93*, 1449–1475. [\[CrossRef\]](#)
25. Ostrom, E. Collective action and the evolution of social norms. *J. Econ. Perspect.* **2000**, *14*, 137–158. [\[CrossRef\]](#)
26. Carayannis, E.G.; Grigoroudis, E.; Campbell, D.F.J.; Meissner, D.; Stamati, D. The ecosystem as helix: An exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models. *R&D Manag.* **2018**, *48*, 148–162. [\[CrossRef\]](#)
27. Argyris, C.; Schön, D.A. *Organizational Learning II: Theory, Method, and Practice*; Addison-Wesley: Boston, MA, USA, 1996.
28. Snyder, H. Literature review as a research methodology: An overview and guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [\[CrossRef\]](#)
29. Jaakkola, E. Designing conceptual articles: Four approaches. *AMS Rev.* **2020**, *10*, 18–26. [\[CrossRef\]](#)
30. Webber, D.J.; Healy, A.; Bristow, G. Regional growth paths and resilience: A European analysis. *Econ. Geogr.* **2018**, *94*, 355–375. [\[CrossRef\]](#)

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.