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SCALING LIVING LABS IN EGYPT THROUGH THE QUINTUPLE HELIX: FUTURE POLICY OPTIONS FROM A FUZZY DELPHI STUDY**Mohamed Ramadan A. Rezk¹, Leonardo Piccinetti², Donatella Santoro³, Nahed Salem⁴, Trevor Uyi Omoruyi⁵, Solomon E. Uhunamure⁶, Mohammed Mahgoub Hassan⁷, Alaa A. El-Bary⁸**^{1,4}Academy of Scientific Research and Technology (ASRT), 11516, Cairo, Egypt²Sustainable Innovation Technology Services Ltd, Ducart Suite, Castletroy, Ireland³REDINN, Italy⁵Chester Business School, Queens Park Campus, Chester, United Kingdom⁶Institute for Humanities in Africa, University of Cape Town, Cape Town 7700, South Africa⁷National Center for Research, Ministry of Higher Education and Scientific Research, Sudan⁸Arab Academy for Science, Technology and Maritime Transport, P.O. Box 1029, Alexandria, EgyptE-mails: ¹mramadan79@gmail.com; ²leonardo@sinnovations.org; ³donatella@sinnovations.org;⁴nahedelashkar.asrt@gmail.com; ⁵t.omoruyi@chester.ac.uk; ⁶Solomon.uhunamure@uct.ac.za; ⁷mohkadis74@gmail.com;⁸aaelbary@aast.edu

Received 18 November 2025; accepted 6 March 2026; published 30 March 2026

Abstract. This study explores how Egypt's Living Labs can transition from isolated, fragmented pilot projects to a scalable and institutionally integrated system within the Egyptian innovation ecosystem. While current research often focuses on developing and studying the various types of living labs already integrated into the innovation ecosystems of many countries, this paper examines the issues of scaling up within the Egyptian innovation ecosystem. It adopts a Quintuple Helix framework that conceptualizes government, industry, academia, civil society, and the natural environment as interdependent actors shaping sustainable development. The research follows a three-phase design: (i) a structured literature review to generate an initial set of 40 policy options; (ii) translation of these options into a Delphi questionnaire, refined through expert review; and (iii) evaluation using the Fuzzy Delphi Method with a purposive panel of 20 experts representing the five helix domains. Policy options were retained only when they satisfied all predefined criteria ($d \leq 0.2$, expert consensus $\geq 75\%$, and defuzzification score $A \geq 0.5$). The results show a high level of agreement overall. In total, 34 of the 40 proposed policy options were retained, corresponding to an overall validation rate of 85.0%. The strongest alignment appeared in Academia/Research and Civil Society/NGOs, where all 8 of 8 options were retained (100.0%). In Government/Public Sector, Industry/Business, and Environment/Sustainability, 6 of 8 options were retained in each domain (75.0%). Taken together, the findings indicate that scaling Living Labs in Egypt depends on a coherent policy setup one that emphasizes clear governance arrangements, reliable public funding, shared evaluation standards, institutional learning, routes to commercialization, broad and inclusive participation, and stronger integration of environmental priorities. Overall, the study offers an empirically supported, policy-focused model to help embed Living Labs more firmly within Egypt's innovation system and support their long-term growth.

Keywords: Living Labs; Quintuple Helix; Fuzzy Delphi Method; policy scaling; sustainable innovation; Egypt

Reference to this paper should be made as follows: Rezk, M.R.A., Piccinetti, L., Santoro, D., Salem, N., Omoruyi, T.U., Hassan, M.M., El-Bary, A.A. 2026. Scaling Living Labs in Egypt through the Quintuple Helix: future policy options from a Fuzzy Delphi study. *Insights into Regional Development*, 8(1), 139-162. <http://doi.org/10.70132/s3752576959>

JEL Classifications: O1, O32, O35

1. Introduction

Egypt is increasingly challenged to develop an innovation system that is economically productive while also socially inclusive, responsive to regional needs, and environmentally sustainable. These demands are further intensified by the country's parallel efforts to advance economic modernization, institutional reform, digital transformation, and greater climate resilience. At the policy level, Egypt Vision 2030 positions innovation, scientific research, and technology as fundamental drivers of national competitiveness and sustainable development, while also emphasizing the importance of participatory governance, balanced regional development, and institutional effectiveness (Egypt Vision 2030, 2016). The strategy states that by 2030 Egypt aims to build "a competitive, balanced, and diversified economy, based on knowledge and innovation," supported by a "just, inclusive, and participatory society" and a sustainable ecosystem (Egypt Vision 2030, 2016). Within this policy context, the significance of Egypt's national strategies lies not only in defining broad development and innovation priorities, but also in the pressing need to identify practical mechanisms capable of translating these ambitions into effective action. Although Egypt Vision 2030 and related frameworks strongly endorse the advancement of a knowledge-based economy, social equity, digitalization, and sustainability, the key challenge remains the implementation of these goals through participatory and context-sensitive approaches.

In this regard, living labs offer a particularly relevant model, as they function as an applied interface between strategic policy objectives and innovation in practice (Almeida & Deutsch, 2025). By fostering collaborative environments that connect government, academia, industry, and civil society, living labs enable the co-creation, testing, and refinement of solutions in real-life settings, making innovation more responsive to local needs and more closely aligned with Egypt's broader development agenda. At the same time, while many institutions have increasingly moved toward supporting living-lab-type initiatives, this expansion is not always accompanied by sufficient conceptual clarity regarding what living labs entail. In many cases, the term is used loosely or interchangeably with other formats, such as innovation hubs, accelerator spaces, or pilot environments, without fully reflecting the defining features of the living lab approach, including experimentation in real-world contexts, active user involvement, and structured multi-stakeholder collaboration. Consequently, the challenge in the Egyptian context is not only to expand support for innovation initiatives, but also to establish a clearer and more consistent understanding of the living lab concept so that it can be applied in a meaningful and effective manner.

1.1. Living Labs as a Mechanism for Collaborative Innovation

Living labs have increasingly gained prominence as an important approach for understanding how innovation can be developed through participatory, context-sensitive, and practice-oriented processes. In the literature, they are described as real-life platforms or environments for collaborative innovation that emphasize the active engagement of users and stakeholders in innovation activities (Fuglsang & Hansen, 2021; Gascó, 2016; Dekker et al., 2019). They are also conceptualized as user-centered, open innovation ecosystems built on systematic co-creation, integrating research and innovation processes within real-life communities and settings (Ballon et al., 2005). In this sense, living labs function not only as spaces for experimentation, but also as collaborative frameworks that support open innovation, citizen co-production, and the co-creation and testing of solutions in real-world contexts (Paskaleva & Cooper, 2021). Moreover, they are organized as open-innovation networks in which multiple stakeholders collaborate to generate shared value through interaction, experimentation, and collective learning (Leminen et al., 2012).

The practical significance of living labs lies in their capacity to bring together diverse actors including public institutions, private sector organizations, academic institutions, civil society, and end users to co-create, prototype, validate, and test technologies, services, products, and systems under real-world conditions (Riaño-Herrera et al., 2025; Sarkki et al., 2025). They also facilitate open knowledge exchange and direct communication, often reducing conventional hierarchies and fostering a shared vision among participants (Stuckrath et al., 2025), while providing platforms for experimentation and iterative learning through continuous testing and refinement based

on stakeholder feedback (Arioz et al., 2024). Reflecting this flexibility, living labs have been applied across a wide range of domains, including urban and rural development (Leminen et al., 2021; Almeida & Deutsch, 2025), healthcare (Shin et al., 2025; Fan et al., 2025), environmental and agricultural sustainability (Beaudoin et al., 2022; James et al., 2025), and higher education and campus sustainability (Masseck, 2017; Choe & Kim, 2024). At the same time, literature highlights important conceptual and practical challenges, particularly the lack of a unified definition, which complicates the systematic development and evaluation of living labs (Ceseracciu et al., 2023), as well as ongoing concerns regarding their scalability, long-term sustainability, and the effective integration of their outcomes into policymaking and broader institutional systems (Fuglsang & Hansen, 2021).

The scaling of living labs remains a significant issue in literature, as many initiatives struggle to progress from localized experimentation to broader and more durable forms of institutionalization. A major obstacle is governance complexity, since successful scaling often depends on enabling institutional arrangements that can support the wider diffusion of innovations developed within living lab settings. In this respect, supportive governance structures, including the concept of a “living lab within a lab,” have been identified as important mechanisms for facilitating the scaling of digital innovations (Mukherjee et al., 2023). At the same time, ambiguity in the internal operations and emergence processes of living labs complicates replication and scaling, contributing to their characterization as obscure, ad hoc, and eclectic forms of innovation practice (Herth et al., 2024). This lack of procedural clarity reduces the transferability of living lab models and constrains systematic scaling across contexts.

The challenge is further compounded by temporal, organizational, and systemic constraints. In particular, the relatively short duration of many living lab projects often does not align with the long-term nature of the societal and institutional issues they seek to address, thereby undermining both scalability and sustainability (Pisello et al., 2025). Moreover, prior research indicates that the sustainability and scalability of living labs are strongly dependent on the quality of the learning processes they generate and the environments in which they operate (Hossain et al., 2018). More broadly, scaling living labs in emerging innovation systems is understood as a multidimensional challenge involving governance, stakeholder engagement, sustainability, standardization, knowledge transfer, and methodological coherence. Consequently, although many living lab initiatives achieve success at the project level, they often fail to scale institutionally, financially, or territorially (Blezer & Abujidi, 2021). The issue, therefore, extends beyond replication alone and concerns whether local experimentation can become embedded within governance systems, policy routines, funding mechanisms, and evaluation frameworks, thereby strengthening the broader policy influence of living labs (Bhatta et al., 2025).

1.2. Integration of Living Labs within the Quintuple Helix Framework

The integration of Living Labs within the Quintuple Helix framework has become increasingly prominent in contemporary innovation and sustainability literature. Living Labs are widely recognized as practical applications of the Quintuple Helix model because they create real-world environments in which diverse stakeholders, including actors associated with the natural environment, can actively participate in collaborative innovation processes (Almeida & Deutsch, 2025). The Quintuple Helix model extends the earlier Triple Helix and Quadruple Helix frameworks by explicitly introducing the natural environment as a fifth subsystem, alongside academia, industry, government, and civil society (Maruccia et al., 2020). Through this expansion, the model broadens the understanding of innovation systems by positioning the ecological sphere as both a driver of innovation and a beneficiary of innovation outcomes. In this way, the framework is closely linked to sustainable development and to broader socio-ecological transitions in both economic and societal contexts (Dewika et al., 2024; Yang & Park, 2025).

A central contribution of the Quintuple Helix perspective is that it emphasizes the importance of ecological balance and sustainability in innovation processes (Lin et al., 2025). Although Living Labs have traditionally operated within a Quadruple Helix structure primarily involving academia, industry, government, and civil

society there is a growing movement toward embedding the Quintuple Helix approach, particularly in sustainability-oriented Living Labs and those focused on nature-based solutions (Bhatta et al., 2023). This shift reflects an increasing recognition that environmental concerns should not remain external to innovation systems but instead should be integrated into their core logic and practice. What distinguishes the Quintuple Helix model is its explicit treatment of the natural environment as a central component of the innovation system. This aligns closely with the evolution of Living Labs toward sustainability-oriented approaches, in which ecological processes and environmental benefits are embedded within innovation activities. As such, the model reinforces the argument that Living Labs, especially those inspired by nature-based or eco-social approaches, are particularly well suited to addressing environmental and societal challenges while advancing sustainable development. In this sense, the Quintuple Helix further highlights the need for ecological balance and sustainable innovation (López-De-Alba et al., 2026).

The Quintuple Helix framework conceptualizes the environment as an equal stakeholder rather than merely as a contextual factor or external constraint. Instead, the natural environment is understood as an active participant that both shapes and drives innovation dynamics (Maruccia et al., 2020). Accordingly, Living Labs operating under this model bring together a broad constellation of stakeholders including academia, industry, government, civil society, and environmental actors to collaboratively design, test, and implement innovations in real-life settings (He et al., 2025). In addition, the Quintuple Helix model provides an important basis for the scaling and wider dissemination of Living Labs. It supports the creation and expansion of Living Labs across sectors and regions, often through collaborative networks and funding initiatives that facilitate their development and replication (Riaño-Herrera et al., 2025). At the same time, it offers a valuable framework for aligning Living Lab strategies with sustainable development goals and for strengthening the evaluation of their contributions to sustainability (Maruccia et al., 2020).

This makes the framework especially relevant to Egypt. Current national policies already link innovation with sustainability, competitiveness, and better quality of life. At the same time, climate and development agendas increasingly require planning that brings together both economic and environmental priorities. For this reason, a Living Lab model that focuses only on institutional collaboration, without clearly considering ecological systems, would be incomplete. In contrast, a Living Lab model based on the Quintuple Helix framework is more suitable for Egypt's actual policy context, where innovation needs to support economic development, social inclusion, and environmental resilience at the same time.

Although Quintuple Helix provides a strong conceptual lens, translating it into actionable policy requires a method capable of handling uncertainty, multiple stakeholders, and partially conflicting judgments. This is particularly important when the goal is not merely to describe an existing system, but to identify future policy options for scaling Living Labs. In such settings, empirical evidence may be fragmented, institutional pathways may be evolving, and expert knowledge may be distributed across disciplines and sectors. The Fuzzy Delphi Method offers a suitable methodological response. Delphi-based approaches are widely used to structure expert judgment, identify priorities, and build consensus in areas where direct evidence is incomplete or where decisions involve complex future-oriented choices (Tuni et al., 2023). The fuzzy extension improves this process by incorporating fuzzy set theory, allowing the method to capture ambiguity, linguistic uncertainty, and gradations of expert opinion more effectively than binary or rigid consensus techniques. For the present study, this makes the Fuzzy Delphi Method especially appropriate for evaluating and prioritizing policy alternatives related to governance, institutionalization, stakeholder engagement, financing, and sustainability (Bui et al., 2019).

1.3. Research Gap and Aim of the Study

In the Egyptian case, this situation poses a central question for policy: how can Living Labs transcend the short-termism of pilot projects to become a sustained dimension of national innovation governance? An adequate response to this question involves more than simply supporting co-creation as an ideal; it requires an operational

concept that can effectively govern the alignment of stakeholders, inter-ministerial policy coordination, financial sustainability, and legitimacy and continuity. While Living Labs are generally described as collaboration spaces involving multiple actors, the analytical and governance foundations for scaling up Living Labs are often not sufficiently defined, particularly in the face of environmental stressors and complex multi-level governance systems. This points to the value of a more comprehensive, system-oriented approach (Von Wirth et al., 2018)

While the scope of the Living Lab research has been broadened considerably, much of the research remains focused on place-based applications, project-level experimentation, and/or co-creation logics. In turn, there has been less attention paid to the direct question of how Living Labs can be scaled as a form of sustainable governance, especially for new and developing innovative systems that require consideration of sustainability from the outset (Criado et al., 2020). At the same time, the Quintuple Helix model has emerged as a prominent framework for innovation and sustainability studies, though it has yet to be adopted as a scaling framework for Living Labs in the context of Egyptian governance. In turn, there exists a discernible space for research that brings together theoretical, governance, and anticipatory future policy analysis traditions. To address this gap, this paper advances a Quintuple Helix informed framework to guide the scaling of Living Labs in Egypt and evaluates future policy options using the Fuzzy Delphi Method. The study aims to strengthen a systemic pathway for institutional diffusion, coordinated policymaking, and sustained societal impact. In doing so, it positions the Quintuple Helix within Egypt's current innovation and development agenda while demonstrating how Delphi-based foresight can structure expert judgment and prioritize policy pathways under uncertainty. Ultimately, the paper offers strategic future policy directions for policymakers, universities, industry, civil society, and local communities seeking to embed Living Labs as a stable, scalable instrument within Egypt's evolving innovation ecosystem.

2. Living Lab Activity in Egypt: Emerging Practices and Institutional Applications

Living lab activity in Egypt is still developing and currently appears mainly through university-led sustainability initiatives, applied urban experimentation, and community-oriented innovation pilots, rather than through an established nationwide living lab system. In the Egyptian context, living labs generally function as real-world experimental environments in which universities, researchers, public institutions, and local communities collaboratively design, test, and refine solutions within their actual settings. Recent academic work has identified the living lab approach as a valuable governance and innovation framework for strengthening university–society linkages through civic participation and multi-helix collaboration (Rageh, 2024).

A large share of these initiatives is based on higher education institutions. At The American University in Cairo, the campus has served as a “Living Learning Laboratory” for sustainability-focused applied research, especially in areas such as environmental performance, green campus operations, and student engagement. The university's sustainability infrastructure and research centers have also functioned as practical settings for experimentation and for generating wider community impact in Egypt (AUC, 2014). In architectural and environmental design education, the British University in Egypt provides another clear example. Its work describes living labs as hands-on learning environments where green building practices, climate-responsive design, and post-occupancy evaluation can be tested and refined. Using real or near-real built environments to assess low-energy construction techniques and user experience, such initiatives illustrate core living lab principles, most notably co-creation and context-sensitive experimentation (Dabaieh et al., 2018).

In agriculture, the El-Boghdady Living Lab in Luxor illustrates a practical model of participatory agricultural innovation in Egypt. This initiative brought together farmers, representatives from the University of Aswan, regional governmental bodies, and non-governmental organizations, demonstrating the multi-actor collaboration that defines the living lab model. The discussions addressed two important local value chains: cereals for household consumption and sugarcane for public supply. While field visits revealed key constraints, including

water scarcity, soil salinity, and low profitability. In response, participants identified agroecological practices such as crop rotation, soil-moisture conservation, and on-farm water storage. This case highlights the potential of living labs to foster knowledge exchange, strengthen farmer participation, and co-produce locally relevant sustainability solutions in rural Egypt (NATAE, 2025). Similarly, the Egypt Living Lab established within the SUS-SOIL project, known as the Sekem Living Lab, provides a relevant example centered on regenerative agriculture and sustainable soil management. It serves as a collaborative platform for testing soil restoration practices and encouraging stakeholder interaction around local agricultural challenges. In this way, it shows how living labs in Egypt can enable experimentation, facilitate knowledge sharing, and support the co-creation of more sustainable land-use practices within Mediterranean agricultural systems (Sekem, 2025).

Another notable example is the SEEDS Living Lab, launched in Cairo in 2024, which focuses on improving the resilience of Egypt's grain supply chain. The initiative convened actors from government, academia, research institutions, and the private sector within a collaborative framework aimed at addressing food security challenges, including reliance on imports, post-harvest losses, and exposure to external market disruptions. This case demonstrates how living labs can promote cross-sector coordination and support the joint development of context-sensitive strategies for more resilient agri-food systems in Egypt (SEEDS Project, 2025). Living lab activities in Egypt are still at an early stage, yet existing examples show clear potential. Current initiatives in universities, design education, and agriculture demonstrate that living labs can support co-creation, practical experimentation, and stakeholder collaboration in addressing local sustainability challenges. With stronger institutional and policy support, this approach could become a more established component of Egypt's innovation landscape.

3. Methodology

3.1 Research Design

This study employed a three-phase research design to identify future policy options for scaling Living Labs in Egypt, with the policy dimensions derived from the Quintuple Helix framework. In the first phase, a structured literature review was undertaken to identify policy options related to the scaling of Living Labs across the five Quintuple Helix dimensions: Government, Industry, Academia, Civil Society, and the Natural Environment. This review considered the institutional, regulatory, financial, social, and environmental conditions influencing Living Lab scaling and resulted in the identification of 40 policy options, with eight policy options assigned to each dimension. These policy options formed the preliminary policy framework for the study. In the second phase, the identified policy options were translated into a Delphi questionnaire and reviewed by two senior experts to improve the wording, relevance, content validity, and completeness of the instrument. Based on their feedback, the questionnaire was revised before wider distribution.

The Delphi questionnaire consisted of three parts: expert profile, the 40 policy options, and optional comments. For each policy option, participants were asked to rate its suitability for Egypt using a five-point Likert scale and to indicate the most appropriate policy instrument for implementation. In the third phase, the revised questionnaire was distributed to 20 purposively selected experts with relevant experience in innovation policy, Living Labs, digital transformation, sustainability, public-sector reform, and community engagement. To reflect the Quintuple Helix framework while accounting for the practical realities of the Egyptian innovation ecosystem, the panel included 20 experts distributed across the five sectors based on current landscape density: academia/research (n=6), government/public sector (n=5), civil society/NGOs (n=4), industry/business (n=3), and environment/sustainability (n=2). Participation was voluntary, and responses were collected confidentially. The survey responses were then analyzed using the Fuzzy Delphi Method (FDM) to determine which policy options achieved sufficient consensus to be retained in the final policy framework, applying the established thresholds for consensus $d \leq 0.2$, expert agreement $\geq 75\%$, and defuzzification $A \geq 0.5$.

3.2 Fuzzy Delphi Procedure and Policy Option Validation

The responses obtained from the 20 experts were analyzed using the Fuzzy Delphi Method (FDM) to assess and refine the proposed policy options across the five dimensions of the Quintuple Helix framework. Consistent with the exploratory and generative objective of the study namely, to construct a comprehensive portfolio of future policy pathways rather than to impose a highly restrictive selection the acceptance criteria were calibrated to allow moderate variation in expert judgment while maintaining analytical rigor. The FDM procedure comprised three main steps. First, expert ratings were transformed into triangular fuzzy numbers (TFNs) to account for the uncertainty and imprecision inherent in subjective evaluations (Santos, 2026). Each of the 40 policy options was rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). These ordinal responses were converted into TFNs according to the predefined linguistic scale presented in Table 1.

Table 1. Conversion Scale from Linguistic Variables to Triangular Fuzzy Numbers (TFNs)

Likert Scale Value	Linguistic Term	Triangular Fuzzy Number (n_1, n_2, n_3)
1	Strongly Disagree	(0.00, 0.00, 0.25)
2	Disagree	(0.00, 0.25, 0.50)
3	Neutral	(0.25, 0.50, 0.75)
4	Agree	(0.50, 0.75, 1.00)
5	Strongly Agree	(0.75, 1.00, 1.00)

Note: n_1 = minimum, n_2 = medium, n_3 = maximum (triangular fuzzy number).

Second, the individual TFNs were aggregated across the 20 experts to derive group fuzzy values (m_1, m_2, m_3) for each policy option. These values represent the collective minimum, most plausible, and maximum assessments, respectively. Third, three decision criteria were applied to determine the retention of each policy option: the threshold value (d), the level of expert consensus, and the defuzzification score (A). The threshold value measured the degree of dispersion between individual expert judgments and the group average. In line with the study's generative orientation, the acceptable threshold was set at $d \leq 0.2$, thereby permitting moderate divergence while preserving substantive convergence. Expert consensus was defined as the proportion of experts whose threshold value for a given item did not exceed 0.2, with a minimum consensus level of 75% required for acceptance. The defuzzification score was calculated using the centroid method, expressed as

$$A = \frac{1}{3}(m_1 + m_2 + m_3)$$

A minimum defuzzification value of $A \geq 0.5$ was established to ensure that retained policy options reflected an overall positive orientation among the expert panel (Rahman & Kamauzaman, 2022). Accordingly, a policy option was retained in the final framework only if it satisfied all three criteria: a threshold value of $d \leq 0.2$, expert consensus of at least 75%, and a defuzzification score of $A \geq 0.5$. These parameters were intended to ensure methodological transparency and internal consistency while supporting the identification of a diverse, forward-looking set of policy alternatives suitable for the Egyptian context. In addition to the quantitative assessment, experts provided open-ended responses identifying the most appropriate policy instrument for implementing each option. These qualitative responses were analyzed separately using content analysis and were not incorporated into the fuzzy computations. For each retained policy option, the most frequently suggested instrument was identified as the preferred implementation mechanism. Through this integrated approach, the Fuzzy Delphi Method served not only as a validation tool but also as a structured mechanism for identifying practically relevant and implementable policy pathways

4. Results and Discussion

4.1 Respondent Characteristics

The Delphi survey was conducted using a digital instrument distributed to 20 experts to assess and prioritize future policies for scaling up Living Labs in Egypt, following the Quintuple Helix approach. To ensure a comprehensive representation of the innovation ecosystem, the expert panel was strategically drawn from the five dimensions of stakeholder involvement, with a distribution reflecting the current density of the Egyptian innovation landscape: Academia/Research (n=6), Government/Public Sector (n=5), Civil Society/NGOs (n=4), Industry/Business (n=3), and Environment/Sustainability (n=2). With respect to professional experience, the panel demonstrated a high level of seniority: 13 experts possessed more than 15 years of experience in their respective fields, while 7 experts reported between 6 and 15 years of experience. The experts' self-reported areas of expertise covered a broad spectrum of the innovation landscape, including innovation policy (n=15), Living Labs (n=14), digital transformation (n=11), strategic management (n=8), citizen engagement (n=12), and sustainability/climate policy (n=9). All participants met strict eligibility criteria, requiring direct involvement in policymaking, innovation systems, or large-scale implementation within Egypt or comparable emerging markets. The survey instrument contained an initial pool of 40 policy options, structured equally across the five Quintuple Helix dimensions Government (GOV), Industry (IND), Academia (ACA), Civil Society (CIV), and Environment (ENV) with eight policy statements per dimension. Each policy statement was assigned a unique code (e.g., GOV-P1 to GOV-P8) to facilitate systematic screening, retention decisions, and comparative ranking across dimensions. By utilizing a diverse but targeted expert panel, the study ensured that the resulting policy model is grounded in both cross-sectoral consensus and specialized practical knowledge.

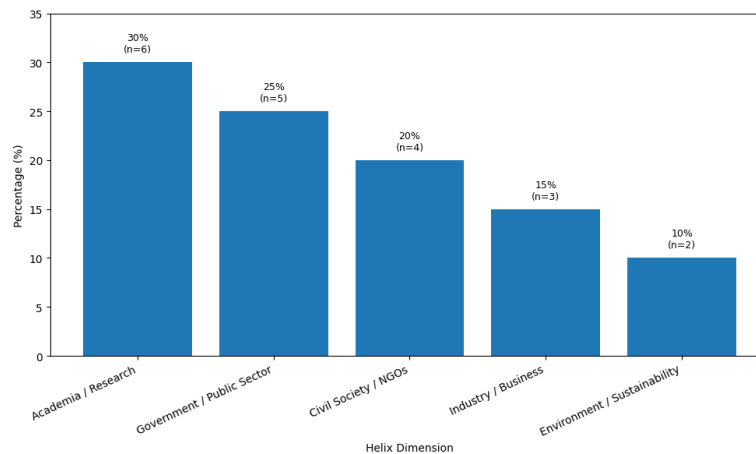


Figure 1. Distribution of Delphi experts

4.2 Fuzzy Delphi Screening Outcomes

The Fuzzy Delphi screening stage was conducted to evaluate the initial set of 40 policy options and identify those that demonstrated sufficient expert convergence for inclusion in the final policy framework. Based on the updated results from the 20-expert panel, 34 policy options were retained and 6 were excluded, resulting in an overall acceptance rate of 85.0% and a rejection rate of 15.0%. This indicates a high overall level of expert convergence, with more than four out of every five proposed policy options satisfying the predefined thresholds for retention. At the level of the five Quintuple Helix dimensions, the distribution of retained items shows a differentiated but still broadly positive pattern. The Academia/Research (ACA) and Civil Society/NGOs (CIV) dimensions emerged as the strongest-performing categories, each achieving a 100% acceptance rate with 8 out of 8 policy options

retained. The Government (GOV), Industry (IND), and Natural Environment (ENV) dimensions each followed with a 75.0% acceptance rate (6 of 8 items retained)

These results indicate generally strong expert agreement across all dimensions. The highest level of convergence was observed in the Academia and Civil Society dimensions, where all policy options were retained. By contrast, the Government, Industry, and Environment dimensions each retained six of the eight proposed policies (75%). Although these dimensions recorded comparatively lower retention rates, the acceptance of three-quarters of the proposed items still reflects substantial expert agreement. The 25% difference between the highest and lowest retention levels remains analytically relevant, as it indicates that convergence was not entirely uniform across stakeholder domains. As illustrated in Figure 2, the distribution of accepted and rejected policy options across the five dimensions confirms both the overall strength of consensus and the moderate variation in support among the stakeholder categories.

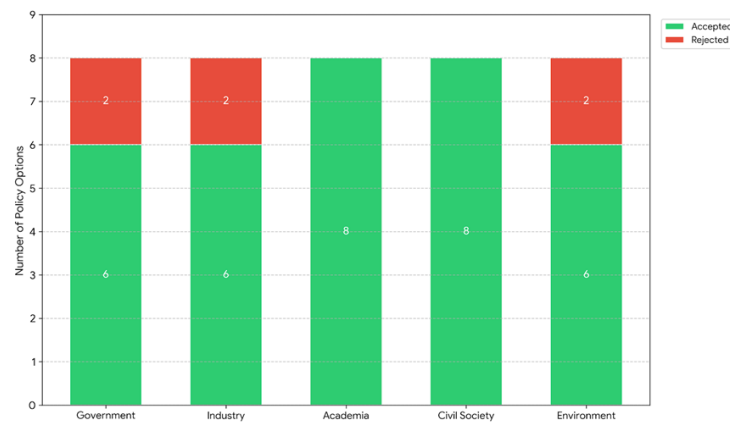


Figure 2. Distribution of Accepted and Rejected Policy Options Across Quintuple Helix Dimensions

4.3 Comparative Results Across Quintuple Helix Dimensions

4.3.1 Government/Public Sector dimension (GOV)

The Government/Public Sector dimension recorded a robust level of convergence in the updated Fuzzy Delphi analysis, with 6 of the 8 proposed policy options retained and 2 excluded, producing an acceptance rate of 75.0% and a rejection rate of 25.0%. In proportional terms, the 6 retained government policies account for 17.6% of the total 34 policies accepted across the entire Quintuple Helix framework. While this indicates a slightly more selective screening compared to the Academia and Civil Society dimensions, the results confirm a strong expert consensus that centralized state coordination and regulatory modernization are the primary enabling conditions for transitioning from pilot-scale experiments to national-scale innovation systems in Egypt. Figure 3 illustrates the average suitability scores for this dimension, highlighting the specific prioritization of the proposed measures.

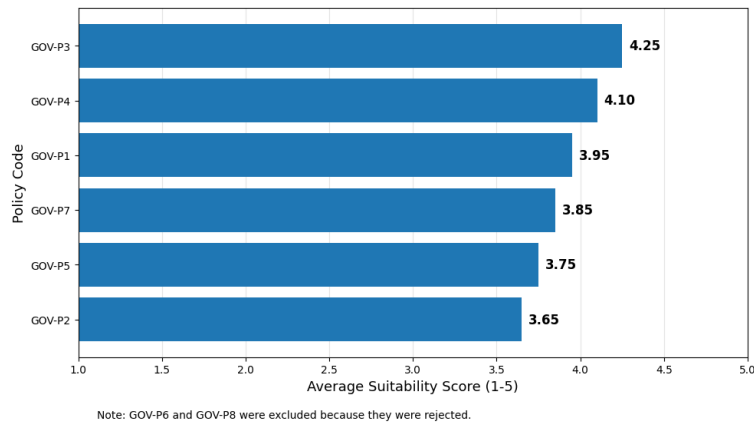


Figure 3. Average Suitability Ratings for Government/Public Sector Policies

Source: Delphi Survey

Within this dimension, the highest-ranked policy option was the establishment of a multi-year Living Lab scale-up fund (GOV-P3), which secured support from 18 of the 20 experts (90.0%) and achieved the highest defuzzification score in the dimension ($A = 0.85$). This was followed closely by the proposal for regulatory sandboxes for priority sectors (GOV-P4), which received endorsement from 17 experts (85.0%) with a suitability score of 4.10. These scores reflect a clear shift in priority toward "de-risking" the scaling process through both direct financial support and "regulatory agility." The high scores for these measures suggest that experts view the government's role not merely as a regulator, but as an active risk-sharer that provides the necessary infrastructure for startups and researchers to test urban solutions without the immediate burden of standard bureaucratic barriers. A second cluster of retained items emphasizes the necessity of formal institutional architecture and market-creation mechanisms. The development of a National Living Lab policy framework (GOV-P1) and standardized legal templates (GOV-P7) both achieved an 80.0% consensus level, with suitability scores of 3.95 and 3.85, respectively. Furthermore, the inclusion of public procurement pathways (GOV-P5) and a national registry/accreditation system (GOV-P2) both supported by 75.0% of the panel emphasizes a strategic intent to link Living Lab results to state purchasing power. Across the six retained government items, suitability ratings ranged from 3.65 to 4.25 on the five-point Likert scale, with an average suitability score of 3.91. This distribution suggests that the expert panel views these measures as an interdependent "governance package" where accreditation (GOV-P2) and standard MoUs (GOV-P7) provide the trust-base required to activate the more impactful scale-up funds and procurement routes.

Two policies were excluded in this dimension: the cross-ministerial coordination unit (GOV-P6) and mandatory monitoring and evaluation (GOV-P8). These items failed to meet the required 75.0% consensus threshold, receiving support from only 65.0% and 60.0% of the experts, respectively. The qualitative feedback associated with these rejections suggests a concern over "administrative inflation"; experts indicated that creating new specialized units or adding mandatory reporting layers might exacerbate existing bureaucratic bottlenecks in Egypt's public sector. Consequently, the consensus focused on streamlining existing processes rather than adding new ones. The Government/Public Sector results indicate that the most actionable pathway for scaling is one anchored in financial de-risking, regulatory sandboxes, and procurement-based uptake, rather than the creation of new administrative bodies (see Table 2).

Table 2. Fuzzy Delphi results for Government/Public Sector dimension (GOV)

Code	Policy option	Consensus (of 20)	Defuzzified score (A)	Supporting reference	Decision	Most-cited instrument
GOV-P3	Launch a multi-year Living Lab scale-up fund dedicated to replication and diffusion of proven pilots.	18/20 (90%)	0.85	(Von Wirth et al., 2018)	Accept	Dedicated budget line; Competitive grants with milestone payments.

Code	Policy option	Consensus (of 20)	Defuzzified score (A)	Supporting reference	Decision	Most-cited instrument
GOV-P4	Introduce regulatory sandboxes/experimental permits for priority sectors to enable safe, legally supported real-world testing.	17/20 (85%)	0.82	(Ranchordás, 2021)	Accept	Sandbox permits; Time-bound approvals with regulatory oversight.
GOV-P1	Establish a national Living Lab policy framework defining roles, governance, and minimum operating requirements.	16/20 (80%)	0.79	(Westerlund et al., 2018)	Accept	Ministerial decree; National operating standards and compliance guidelines.
GOV-P7	Develop flexible legal guidance and model templates (MoU, liability, IP/data clauses) for partnerships.	16/20 (80%)	0.77	(Voorwinden et al., 2023)	Accept	Standard legal templates; Voluntary guidance for inter-sectoral MoUs.
GOV-P5	Institutionalize an innovation procurement pathway (PPI) using Living Lab evidence for adoption decisions.	15/20 (75%)	0.75	(Van Winden & Carvalho, 2019)	Accept	Procurement reform; PPI rules integrating LL evidence into tenders.
GOV-P2	Establish a national Living Lab registry/accreditation framework with periodic review and transparency.	15/20 (75%)	0.73	(Toso et al., 2023)	Accept	National registry; Accreditation criteria and periodic digital audits.
GOV-P6	Establish a cross-ministerial coordination unit to streamline approvals and remove scaling bottlenecks.	13/20 (65%)	0.68	(Christensen et al., 2007)	Reject	Concerns over administrative inflation and new bureaucratic layers.
GOV-P8	Require mandatory monitoring & evaluation (M&E) and public reporting for publicly funded Living Labs.	12/20 (60%)	0.65	(Dekker et al., 2021)	Reject	Perceived as high administrative burden for early-stage pilots.

Source: Delphi Survey

4.3.2 Industry/Business Dimension (IND)

The Industry/Business dimension demonstrated a solid level of convergence in the updated Fuzzy Delphi analysis, with 6 of the 8 proposed policy options retained and 2 excluded, resulting in an acceptance rate of 75.0% and a rejection rate of 25.0%. In proportional terms, the six retained industry policies represent 17.6% of the total 34 policy options accepted across the entire Quintuple Helix framework. Although this places the industry dimension slightly below the Academia and Civil Society categories in terms of total retention, it indicates substantial expert support for business-oriented measures as a vital engine for the scaling process. The overall pattern suggests that experts view private-sector engagement as essential for sustainability, but they favor instruments that reduce immediate operational barriers and generate clearer near-term commercialization pathways over complex fiscal reforms. Within this dimension, the strongest support was recorded for SME Living Lab vouchers (IND-P2), which received agreement from 18 of the 20 experts (90.0%) and achieved the highest suitability score in the category (4.20). This was followed by industry-led challenge calls and prizes (IND-P6), supported by 17 experts (85.0%) with a suitability score of 3.95 (0.79), and co-investment matching grants (IND-P1), supported by 16 experts (80.0%) with a score of 3.80 (0.76). This concentration of support indicates that experts place the greatest emphasis on measures that lower entry costs for firms, share scaling risks, and provide competitive incentives for market-ready solutions. By prioritizing vouchers and grants, the panel signals that direct, accessible liquidity is more critical for the Egyptian private sector than indirect supports.

A second group of retained policy options reflects a focus on institutional ease and market readiness. Standard model contracts for IP and data sharing (IND-P4), tax incentives for LL-validated R&D (IND-P3), and commercialization mentorship hubs (IND-P7) each received support from 15 of the 20 experts, corresponding to 75.0% consensus. Their suitability scores ranged from 3.55 to 3.75 (0.71 to 0.75). Substantively, this cluster points to a preference for mechanisms that reduce "negotiation friction" and prepare homegrown innovations for

the rigors of the marketplace. Figure 4 visualizes these ratings, highlighting the clear preference for SME-centric and competition-based instruments.

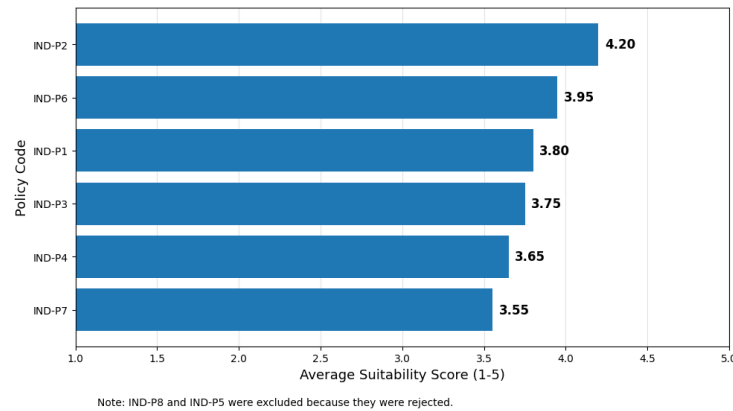


Figure 4. Average Suitability Ratings for Industry/Business Policies

Source: Delphi Survey

The two rejected policy options failed to meet the required 75% consensus threshold defined in the Fuzzy Delphi screening procedure, indicating that expert agreement was insufficient for their inclusion in the final policy framework. The proposal for sector-focused Living Lab consortia (IND-P5) and blended finance/PPP mechanisms (IND-P8) failed to meet the 75.0% consensus threshold, receiving support from only 60.0% and 65.0% of the experts, respectively. The qualitative feedback suggests that while experts recognize the theoretical value of these complex financial and organizational models, they are less confident in their governance design or feasibility in the current Egyptian context. Specifically, PPPs were noted as being potentially too "heavy" for the agile nature of Living Lab pilots. Overall, the Industry/Business results indicate that consensus is strongest around near-term, operationally feasible measures particularly vouchers and challenge prizes while more complex structural mechanisms require further refinement (see Table 3).

Table 3. Fuzzy Delphi Results for Industry/Business Dimension (IND)

Code	Policy Option	Consensus (of 20)	Defuzzified Score (A)	Supporting Reference	Decision	Most-Cited Instrument
IND-P2	Provide SME Living Lab vouchers for prototyping, testing, and certification support.	18/20 (90%)	0.84	(Sala et al., 2015)	Accept	Voucher scheme redeemable for LL services (testing, certification).
IND-P6	Launch challenge calls/prizes aligned with national priorities and buyer commitments.	17/20 (85%)	0.79	(Georghiou et al., 2013)	Accept	Innovation prizes; Competitions with guaranteed pilot contracts.
IND-P1	Implement co-investment/matching grants for firms scaling LL-validated solutions.	16/20 (80%)	0.76	(Owen & Mason, 2016)	Accept	Matching grants; Co-financing tied to specific scale milestones.
IND-P3	Introduce tax incentives or fee reductions for R&D and pilot-to-scale investments.	15/20 (75%)	0.75	(Ballon et al., 2018)	Accept	R&D tax credits; Reduced licensing fees for LL-validated startups.
IND-P4	Provide standard model contracts for IP, data, and liability to reduce negotiation friction.	15/20 (75%)	0.73	(Gilbert et al., 2025)	Accept	Model contract pack with default IP and liability clauses.
IND-P7	Create a commercialization and market-access program (investor matchmaking, export readiness).	15/20 (75%)	0.71	(Selviaridis & Spring, 2024)	Accept	Matchmaking platforms; Export readiness training and roadshows.

Code	Policy Option	Consensus (of 20)	Defuzzified Score (A)	Supporting Reference	Decision	Most-Cited Instrument
IND-P8	Support blended finance/PPP mechanisms for solutions with high public value but slow payback.	13/20 (65%)	0.67	(Bolton et al., 2020)	Reject	Perceived as too complex for current implementation frameworks.
IND-P5	Establish sector-focused Living Lab consortia/clusters to support scaling partnerships.	12/20 (60%)	0.65	(McPhee et al., 2021)	Reject	Concerns over silo creation and organizational overhead.

Source: Delphi Survey

4.3.3 Academia/Research dimension (ACA)

The Academia/Research dimension recorded the highest level of convergence in the updated Fuzzy Delphi analysis, with 8 of the 8 proposed policy options retained, resulting in a perfect acceptance rate of 100.0%. In the updated sample of 20 experts, this dimension emerged as the undisputed leader in institutional readiness. Proportionally, these eight academic policies represent 23.5% of the total 34 policies accepted across the Quintuple Helix. This pattern suggests a unanimous expert agreement that scaling Living Labs in Egypt is fundamentally dependent on methodological rigor, institutional learning, and the formalization of research-based implementation systems. Within this dimension, the highest-ranked policy option was the market-linked collaborative research fund (ACA-P6), which achieved a suitability score of 4.35. This was followed closely by the "impact" metrics for researcher promotion (ACA-P2), which secured a score of 4.15 (0.83). These results indicate a significant shift in the Egyptian academic landscape: experts are calling for a move away from purely theoretical publications toward "engaged scholarship." By prioritizing impact metrics and market-linked funding, the panel suggests that universities should be incentivized to act as the "R&D departments" for urban innovation, providing the evidence base required for scaling (see Figure 5).

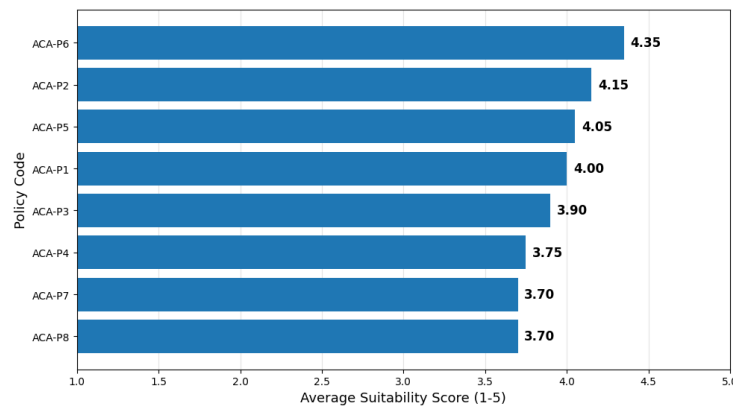


Figure 5. Average Suitability Ratings for Academia/Research Dimension

Source: Delphi Survey

A second cluster of retained policy options further reinforces this pattern. Knowledge translation units (ACA-P4), joint industry–academia applied research programs (ACA-P5), embedded researcher and student placements (ACA-P7), and specialized ethics and data governance boards (ACA-P8) each received support from 15 of the 20 experts, corresponding to 75.0% consensus. Their suitability scores ranged from 3.70 to 3.75, indicating stable and internally consistent support across this second tier of academic measures. Across the eight retained academic items, the total number of positive judgments reached 131 out of a possible 160, producing an aggregate endorsement rate of 81.9%. At the same time, the retained items recorded suitability scores ranging from 3.70 to 4.35, with an average score of 4.11. The relatively narrow spread in both consensus and defuzzified values suggests that support was not concentrated in a single item but rather distributed across a coherent package of academic policies focused on evaluation, training, infrastructure, translation, and responsible governance of

experimentation. Overall, the Academia/Research results indicate that expert consensus is strongest around three numerically clear priorities: market-linked research funding (ACA-P6), incentive reform for engaged scholarship (ACA-P2), and institutional policies for experimental testing (ACA-P5). Collectively, these results position academia not merely as a supporting actor, but as a central institutional driver of methodological coherence, evidence generation, and learning-based scaling in the Egyptian Living Lab ecosystem (see Table 4).

Table 4. Fuzzy Delphi results for Academia/Research dimension (ACA)

Code	Policy Option	Consensus (of 20)	Defuzzified Score (A)	Supporting Reference	Decision	Most-Cited Instrument
ACA-P6	Create market-linked research funds aligned with Living Lab scaling priorities.	19/20 (95%)	0.87	(Van Geenhuizen, 2016)	Accept	Co-funded calls: industry cost-share - applied deliverables
ACA-P2	Reform university incentives to recognize engaged scholarship and real-world impact.	18/20 (90%)	0.83	(Lhoest et al., 2024)	Accept	Promotion/tenure reform: impact-based KPIs for faculty
ACA-P5	Establish university policies for experimental testing and real-world experimentation.	17/20 (85%)	0.81	(Van Engelenhoven et al., 2023)	Accept	Institutional bylaws allowing for campus-based testing
ACA-P1	Develop a national Living Lab evaluation protocol (KPIs, impact measurement) for Egypt.	16/20 (80%)	0.80	(Van Geenhuizen, 2018)	Accept	National evaluation standard: KPIs - replication criteria - templates
ACA-P3	Fund shared research infrastructure (data platforms, repositories, evidence toolkits).	16/20 (80%)	0.78	(Ruijter, 2021)	Accept	Infrastructure grants for platforms, repositories, consent tools
ACA-P4	Establish knowledge translation units to convert LL findings into policy briefs.	15/20 (75%)	0.75	(Evans & Scarbrough, 2014)	Accept	University unit mandate - staffing - policy brief outputs
ACA-P7	Support embedded researcher/student placements inside Living Labs.	15/20 (75%)	0.74	(Van Engelenhoven et al., 2023)	Accept	Funded placements/internships linked to LL projects and evaluation
ACA-P8	Establish specialized ethics and data governance boards for real-world testing.	15/20 (75%)	0.74	(Racine et al., 2023)	Accept	Ethics/data board with fast review timeline - audit role

Source: Delphi Survey

4.3.4 Civil Society/NGOs dimension (CIV)

The Civil Society/NGOs dimension demonstrated absolute convergence in the updated Fuzzy Delphi analysis, with 8 of the 8 proposed policy options retained, resulting in a perfect acceptance rate of 100.0%. In the updated sample of 20 experts, this dimension joined Academia as a top-performing category, reflecting a powerful consensus that social legitimacy is not a "secondary" concern but a fundamental prerequisite for scaling innovation in the Egyptian context. Proportionally, these eight policies represent 23.5% of the total 34 validated measures, indicating that experts view human-centric governance as a pillar of the overall framework. Within this dimension, the highest-ranked policy option was the requirement for mandatory ethics, informed consent, and grievance mechanisms (CIV-P3), which achieved a suitability score of 4.25. This was followed closely by the establishment of digital engagement and co-creation platforms (CIV-P1), securing a score of 4.15 (0.83). These results underscore a shift toward "procedural trust"; experts argue that for Living Labs to move from isolated pilots to urban-scale systems, there must be a rigorous, legally backed protection framework for participants. By prioritizing digital platforms alongside ethics, the panel suggests that scaling requires both high-tech accessibility and high-touch transparency (see Figure 6).

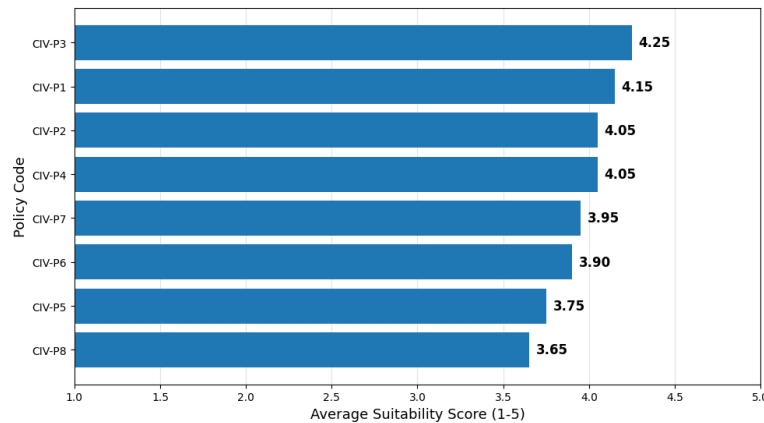


Figure 6. Average Suitability Ratings for Civil Society/ NGOs Dimension
Source: Delphi Survey

A second cluster of retained items reinforces the operational role of inclusive participation. The funding of community intermediaries and NGOs (CIV-P2) and the implementation of open data/transparency dashboards (CIV-P7) both received support from 17 of the 20 experts, corresponding to 85.0% consensus. Their suitability scores ranged from 3.95 to 4.05, indicating stable support for the role of "trusted brokers" who can bridge the gap between technical labs and local neighborhoods. Experts highlighted that in the Egyptian context, NGOs often possess the local social capital that government or industry actors lack, making them essential for the long-term sustainability of real-world trials. Furthermore, the retention of inclusion-by-design toolkits (CIV-P6) and community-led innovation grants (CIV-P4) reflects a commitment to "Data Democracy." Across the eight retained civil society items, the total number of positive judgments reached 132 out of a possible 160, producing an aggregate endorsement rate of 82.5%. Suitability scores ranged from 3.65 to 4.25, with an average of 4.08. This narrow spread suggests that the expert panel views these measures not as a menu of options, but as a coherent "Social License Package." Collectively, these findings suggest that the most feasible pathway for scaling Living Labs in Egypt lies in strengthening trust and procedural legitimacy through standardized inclusion and transparent communication (see Table 5).

Table 5. Fuzzy Delphi Results for Civil Society/ NGOs Dimension (CIV)

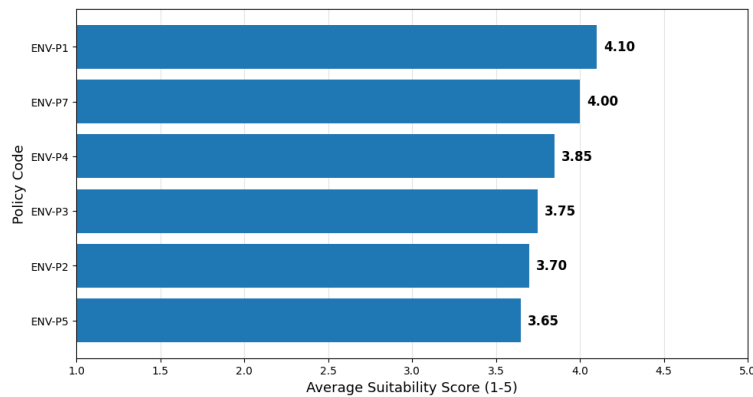
Code	Policy Option	Consensus (of 20)	Defuzzified Score (A)	Supporting Reference	Decision	Most-Cited Instrument
CIV-P3	Require ethics, informed consent, transparency, and grievance mechanisms for all trials.	18/20 (90%)	0.85	(Mollen, 2024)	Accept	Binding ethics protocol; consent forms; grievance channel
CIV-P1	Adopt digital engagement and co-creation platforms to enable hybrid (online/offline) participation.	18/20 (90%)	0.83	(Mačiulienė & Skaržauskienė, 2020)	Accept	National digital portal; co-creation toolkits; reporting dashboards
CIV-P2	Fund community intermediaries (NGOs) to recruit participants and sustain engagement.	17/20 (85%)	0.81	(Hernberg & Hyysalo, 2024)	Accept	NGO grants/contracts for facilitation and trust-building
CIV-P4	Implement community-led innovation grants for user-driven solutions and micro-pilots.	17/20 (85%)	0.81	(Sudoj et al., 2021)	Accept	Micro-grant scheme; participatory budgeting for community labs
CIV-P7	Launch open data/transparency dashboards to share LL results and environmental impacts.	16/20 (80%)	0.79	(Van Geenhuizen, 2018)	Accept	Public dashboards; open-results publishing; media partnerships
CIV-P6	Implement inclusion-by-design toolkits (accessibility, low-literacy methods) to broaden participation.	16/20 (80%)	0.78	(Loignon et al., 2021)	Accept	Standardized toolkits; training for inclusive co-creation methods

Code	Policy Option	Consensus (of 20)	Defuzzified Score (A)	Supporting Reference	Decision	Most-Cited Instrument
CIV-P5	Integrate citizen science approaches to support data collection and policy evidence.	15/20 (75%)	0.75	(Heigl et al., 2020)	Accept	Guidelines and pilot programs for citizen science data quality
CIV-P8	Adopt a Citizen Participation Charter specifying minimum requirements for representation.	15/20 (75%)	0.73	(Haug & Mergel, 2021)	Accept	Official charter; minimum inclusion and feedback standards

Source: Delphi Survey

4.3.5 Environment/Sustainability dimension (ENV)

The Environment/Sustainability dimension demonstrated substantial convergence in the updated Fuzzy Delphi analysis, with 6 of the 8 proposed policy options retained and 2 excluded, resulting in an acceptance rate of 75.0% and a rejection rate of 25.0%. In proportional terms, the six retained environmental policies represent 17.6% of the total 34 policy options accepted across the Quintuple Helix. While this aligns the ENV dimension with the Government and Industry categories, it emphasizes a clear expert consensus that sustainability must be an "embedded" feature of the scaling process rather than an afterthought. The pattern suggest that experts favor measures integrated through practical rules and planning requirements over highly technical monitoring systems. Within this dimension, the strongest support was recorded for defining Green Living Lab criteria (ENV-P1), which received endorsement from 17 of the 20 experts (85.0%) and achieved the highest suitability score in the category (4.10). This was followed by the inclusion of green public procurement criteria (ENV-P7), supported by 16 experts (80.0%) with a suitability score of 4.00 (0.80). These results reflect a strategic preference for market-pull mechanisms; by linking Living Lab validation to "Green Procurement," experts believe Egypt can create a powerful incentive for firms to prioritize sustainable urban solutions (see Figure 7).



Note: ENV-P6 and ENV-P8 were excluded because they were rejected.

Figure 7. Average Suitability Ratings for Environment/Sustainability Dimension

Source: Delphi Survey

A second tier of four retained policies reflects a focus on resilience and thematic prioritization. Nature-based solutions (ENV-P4), Circular economy calls (ENV-P3), Environmental gating (ENV-P2), and Climate risk assessments (ENV-P5) each received support from 15 of the 20 experts (75.0%), with suitability scores ranging from 3.65 to 3.85. Substantively, this indicates that experts support environmental mainstreaming when it is built into existing approval and funding processes. For example, making scale-up funding conditional on verified performance (ENV-P2) is seen as a more practical lever than mandating separate, costly technical audits. The two excluded policy options help clarify the boundaries of current technical readiness in Egypt. The proposals for integrated environmental monitoring systems (ENV-P6) and mandatory Life-Cycle Assessments (LCA) or carbon accounting (ENV-P8) failed to meet the 75.0% consensus threshold, receiving support from only 65.0% and 60.0% of the experts, respectively. Qualitative feedback indicated that while these measures are strategically valuable, the capacity and cost burden for LCA and real-time data maintenance are currently too high for most

Egyptian startups and municipal labs. Overall, the ENV results suggest that the most feasible environmental pathway for scaling lies in operational sustainability rules and incentive alignment, while more technical accounting systems remain a long-term goal (see Table 6).

Table 6. Fuzzy Delphi Results for Environment/Sustainability Dimension (ENV)

Code	Policy Option	Consensus (of 20)	Defuzzified Score (A)	Supporting Reference	Decision	Most-Cited Instrument
ENV-P1	Define Green Living Lab criteria (baseline targets for energy, water, waste) for scaling.	17/20 (85%)	0.82	(Cuomo, 2022)	Accept	Green standard/checklist: baseline and measurable targets
ENV-P7	Introduce green public procurement criteria favoring LL-validated sustainable solutions.	16/20 (80%)	0.80	(Braulio-Gonzalo & Bovea, 2019)	Accept	Procurement rules adding sustainability and LL validation
ENV-P4	Prioritize Living Labs testing nature-based solutions (urban cooling, flood control) via grants.	15/20 (75%)	0.77	(Ascione et al., 2021)	Accept	Thematic grant calls for nature-based solution pilots
ENV-P3	Prioritize Living Labs testing circular economy solutions (reuse, recycling) via grants.	15/20 (75%)	0.75	(Engez et al., 2021)	Accept	Thematic grant calls prioritizing circularity outcomes
ENV-P2	Apply environmental gating, making scale-up funding conditional on verified performance.	15/20 (75%)	0.74	(De Miranda Ribeiro & Kruglianskas, 2012)	Accept	Funding conditionality tied to verified green indicators
ENV-P5	Require climate risk/resilience assessment in scale-up proposals to mainstream adaptation.	15/20 (75%)	0.73	(Zebisch et al., 2022)	Accept	Planning requirement: resilience section in approval stage
ENV-P6	Integrate Living Labs with environmental monitoring/open data systems for governance.	13/20 (65%)	0.68	(Ruijter & Meijer, 2019)	Reject	Data governance concerns: ownership and maintenance capacity
ENV-P8	Require life-cycle assessment (LCA) / carbon accounting for solutions transitioning to scale.	12/20 (60%)	0.65	(Finkbeiner, 2014)	Reject	High capacity and cost burden for carbon accounting audits

Source: Delphi Survey

4.4 Empirical Validation of the Quintuple Helix-Based Policy Model

The final stage of the analysis provides strong empirical support for the proposed Quintuple Helix-based policy model for scaling Living Labs in Egypt. From the initial pool of 40 policy options, 34 were retained and 6 were excluded following the updated Fuzzy Delphi screening process, producing an overall validation rate of 85.0% and a rejection rate of 15.0%. In practical terms, this means that nearly 9 out of every 10 proposed policy measures satisfied the rigorous validation thresholds. Given the equal structure across five dimensions, the retention of 34 items indicates that the model remained substantively intact, with only a limited degree of refinement. This high level of retention suggests that the overall architecture was regarded by the expert panel as highly relevant and broadly applicable to the Egyptian context. The internal balance of the model is reflected in the dimensional distribution of accepted policies. The Academia/Research and Civil Society dimensions demonstrated the highest level of expert alignment, each retaining 100.0% of their proposed policies (8 of 8). The Government, Industry, and Environment dimensions each retained 75.0% of their options (6 of 8). Consequently, the difference between the highest and lowest dimensional acceptance rates was only 25.0 percentage points, indicating a robust spread of agreement across the five helices. In share terms, Academia and Civil Society each contributed 23.5% of the validated portfolio, while the remaining three dimensions contributed 17.6% each. These proportions indicate that no single helix was disproportionately weakened, and the model remains structurally balanced rather than concentrated in one institutional domain.

A detailed numerical reading reinforces the robustness of the model. Across the 34 retained policy options, the aggregate level of positive expert support reached 549 endorsements out of a possible 680 expert-item responses, producing an aggregate endorsement rate of 80.7%. By contrast, the 6 excluded items generated 75 positive endorsements out of 120 possible responses (62.5%). This indicates that rejected items were not viewed as irrelevant but rather fell below the required 75.0% consensus threshold. This indicates that the exclusion process functioned as a mechanism of selective refinement rather than fundamental rejection, filtering out measures perceived as having higher administrative complexity or lower immediate feasibility (see Table 7).

Table 7. Summary of Retained and Rejected Policies by Dimension

Dimension	Policies Proposed	Accepted	Rejected	Acceptance Rate (%)
Academia / Research (ACA)	8	8	0	100.0%
Civil Society / NGOs (CIV)	8	8	0	100.0%
Government / Public Sector (GOV)	8	6	2	75.0%
Industry / Business (IND)	8	6	2	75.0%
Environment / Sustainability (ENV)	8	6	2	75.0%
Total	40	34	6	85.0%

Ultimately, these results confirm that the Quintuple Helix-based policy model is empirically validated as a multidimensional and robust framework. Its strength lies in the high overall validation rate and the balanced retention pattern. The final validated model captures a coherent set of priorities that are both cross-sectoral and practically grounded. The model functions as an integrated policy architecture where institutional coordination, business engagement, academic capacity, social legitimacy, and sustainability requirements are all retained as essential and mutually reinforcing pillars for scaling Living Labs in Egypt.

5. Conclusion

This study addresses a central policy challenge in Egypt's innovation landscape: how Living Labs can move from fragmented, short-term pilot initiatives into a scalable and institutionally embedded instrument of national innovation governance. Anchored in the Quintuple Helix framework, the analysis extends beyond conventional triple-helix accounts by explicitly incorporating civil society and the natural environment as constitutive, interdependent domains shaping innovation processes. In doing so, the study aligns the logic of experimentation and co-creation with the priorities of Egypt Vision 2030, positioning Living Labs as mechanisms not only for technological upgrading and competitiveness, but also for social legitimacy and ecological resilience. Empirically, the policy model was developed and validated using the Fuzzy Delphi Method, yielding strong overall convergence: 34 of 40 proposed policy options were retained, corresponding to an aggregate validation rate of 85.0%. This high retention level indicates that the proposed policy architecture is widely perceived by experts as coherent, contextually relevant, and feasible. Notably, full retention in the Academia/Research and Civil Society/NGO dimensions signals these domains as primary engines of co-creation capacity, institutional learning, and societal trust. By contrast, the comparatively lower retention observed across the Government, Industry, and Environment dimensions (75.0%) suggests that despite substantial support scaling in these domains requires more finely calibrated instruments to address regulatory fragmentation, financial risk aversion, market adoption constraints, and the practical challenges of environmental mainstreaming.

The results reinforce that scaling Living Labs in Egypt is not a purely technical or project-level matter; it is a systemic governance task that depends on coordinated policy interventions across helix domains. Synthesizing the retained options, the study identifies three interlocking pillars for institutionalization. First, governance and standardization are required to provide definitional clarity, differentiate Living Labs from adjacent formats (e.g., incubators and innovation hubs), and establish formal evaluation standards that enable comparability, accountability, and learning across sites. Second, financial and commercial sustainability must shift the model away from ad-hoc grants toward predictable public financing and credible commercialization pathways that reduce uncertainty and incentivize private-sector participation. Third, socio-ecological integration is necessary to

ensure that “user-centricity” is operationalized through inclusive citizen participation while simultaneously accounting for Egypt’s ecological constraints through explicit sustainability requirements embedded in funding, procurement, and ethics frameworks. Conceptually, the paper advances Living Lab scholarship by moving beyond general advocacy for co-creation toward an operational, policy-oriented account of scale-up and institutional embedding. The Quintuple Helix is deployed not only as an explanatory lens, but as a practical structure for designing cross-sectoral policy mixes linking state coordination, academic capability building, industry engagement, social legitimacy, and environmental rules capable of converting localized experimentation into systemic impact.

The study’s limitations are also clear. The findings derive from expert judgement based on a purposive panel (n = 20), and the resulting model constitutes a validated policy framework rather than an assessment of implementation effectiveness. Future research should therefore examine how the retained policy options perform in practice across sectors and governorates, using longitudinal monitoring and comparative implementation analysis to test real-world efficacy under varying institutional and socio-ecological conditions. Nonetheless, the validated set of 34 prioritized policy options provides a robust roadmap for policymakers, universities, firms, civil society organizations, and sustainability stakeholders seeking to position Living Labs as a durable, scalable component of Egypt’s evolving innovation ecosystem one that is technologically progressive, socially inclusive, and environmentally responsive.

References

- Almeida, F., & Deutsch, N. (2025). Urban living labs as catalysts for innovation: Advancing urban ecosystems within the quintuple helix model. *Urban Governance*, 5(2), 133-141. <https://doi.org/10.1016/j.ugj.2025.05.005>
- Arioz, U., Bratina, B., Mlakar, I., Plohl, N., Uran, S., Roj, I. R., Šafarič, R., & Šafran, V. (2024). Unlocking the power of socially assistive robotic nurses in hospitals through innovative living lab methodology. *Health Informatics Journal*, 30(4), 14604582241291380. <https://doi.org/10.1177/14604582241291380>
- Ascione, G. S., Cuomo, F., Mariotti, N., & Corazza, L. (2021). Urban Living Labs, Circular Economy and Nature-Based Solutions: Ideation and testing of a new soil in the city of Turin using a multi-stakeholder perspective. *Circular Economy and Sustainability*, 1(2), 545-562. <https://doi.org/10.1007/s43615-021-00011-6>
- AUC. (2014, February 4). AUC launches new Research Institute for a Sustainable Environment | The American University in Cairo. Retrieved January 15, 2026, from <https://www.aucegypt.edu/media/media-releases/auc-launches-new-research-institute-sustainable-environment>
- Ballon, P., Pierson, J., & Delaere, S. (2005). Test and Experimentation Platforms for broadband innovation: Examining European practice. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.1331557>
- Ballon, P., Van Hoed, M., & Schuurman, D. (2018). The effectiveness of involving users in digital innovation: Measuring the impact of living labs. *Telematics and Informatics*, 35(5), 1201-1214. <https://doi.org/10.1016/j.tele.2018.02.003>
- Beaudoin, C., Joncoux, S., Jasmin, J., Berberi, A., McPhee, C., Schillo, R. S., & Nguyen, V. M. (2022). A research agenda for evaluating living labs as an open innovation model for environmental and agricultural sustainability. *Environmental Challenges*, 7, 100505. <https://doi.org/10.1016/j.envc.2022.100505>
- Bhatta, A., Vreugdenhil, H. S., Ellen, G. J., Schuurman, D., & Slinger, J. H. (2025). Influence of living labs in the policy landscape. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.5534753>
- Bhatta, A., Vreugdenhil, H., & Slinger, J. (2023). Characterizing nature-based living labs from their seeds in the past. *Environmental Development*, 49, 100959. <https://doi.org/10.1016/j.envdev.2023.100959>
- Blezer, S., & Abujidi, N. (2021). Urban Living Labs and Transformative Changes: A qualitative study to the triadic relationship between financing, stakeholder roles and outcomes of Urban Living Labs on their impact creation in the city of Groningen, the Netherlands. *Technology Innovation Management Review*, 11(9/10), 73-87. <https://doi.org/10.22215/timreview/1466>

- Bolton, P., Musca, X., & Samama, F. (2020). Global Public-Private Investment Partnerships: A Financing Innovation with Positive Social Impact. *Journal of Applied Corporate Finance*, 32(2), 31–41. <https://doi.org/10.1111/jacf.12403>
- Braulio-Gonzalo, M., & Bovea, M. D. (2019). Relationship between green public procurement criteria and sustainability assessment tools applied to office buildings. *Environmental Impact Assessment Review*, 81, 106310. <https://doi.org/10.1016/j.eiar.2019.106310>
- Bui, T. D., Tsai, F. M., Tseng, M., & Ali, M. H. (2019). Identifying sustainable solid waste management barriers in practice using the fuzzy Delphi method. *Resources Conservation and Recycling*, 154, 104625. <https://doi.org/10.1016/j.resconrec.2019.104625>
- Ceseracciu, C., Branca, G., Deriu, R., & Roggero, P. P. (2023). Using the right words or using the words right? Re-conceptualising living labs for systemic innovation in socio-ecological systems. *Journal of Rural Studies*, 104, 103154. <https://doi.org/10.1016/j.jrurstud.2023.103154>
- Choe, Y., & Kim, N. (2024). From the classroom to the Living Lab for developing competencies in tourism higher education. *Journal of Hospitality Leisure Sport & Tourism Education*, 35, 100511. <https://doi.org/10.1016/j.jhlste.2024.100511>
- Christensen, T., Fimreite, A. L., & Lægrend, P. (2007). Reform of the employment and welfare administrations – the challenges of co-ordinating diverse public organizations. *International Review of Administrative Sciences*, 73(3), 389–408. <https://doi.org/10.1177/0020852307081149>
- Criado, J. I., Dias, T. F., Sano, H., Rojas-Martín, F., Silvan, A., & Filho, A. I. (2020). Public Innovation and Living Labs in Action: A Comparative Analysis in Post-New Public Management Contexts. *International Journal of Public Administration*, 44(6), 451-464. <https://doi.org/10.1080/01900692.2020.1729181>
- Cuomo, F. (2022). Urban Living Lab: An experimental Co-Production tool to foster the circular economy. *Social Sciences*, 11(6), 260. <https://doi.org/10.3390/socsci11060260>
- Dabaieh, M., Mahdy, D. E., & Maguid, D. (2018). Living labs as a pedagogical teaching tool for green building design and construction in hot arid regions. *International Journal of Architectural Research Archnet-IJAR*, 12(1), 338. <https://doi.org/10.26687/archnet-ijar.v12i1.1285>
- De Miranda Ribeiro, F., & Kruglianskas, I. (2012). Improving environmental permitting through performance-based regulation: a case study of Sao Paulo State, Brazil. *Journal of Cleaner Production*, 46, 15-26. <https://doi.org/10.1016/j.jclepro.2012.09.017>
- Dekker, R., Contreras, J. F., & Meijer, A. (2019). The Living Lab as a Methodology for Public Administration Research: a Systematic Literature Review of its Applications in the Social Sciences. *International Journal of Public Administration*, 43(14), 1207-1217. <https://doi.org/10.1080/01900692.2019.1668410>
- Dekker, R., Geuijen, K., & Oliver, C. (2021). Tensions of evaluating innovation in a living lab: Moving beyond actionable knowledge production. *Evaluation*, 27(3), 347-363. <https://doi.org/10.1177/1356389021997848>
- Dewika, M., Markandan, K., Ruwaida, J. N., Sara, Y., Deb, A., Irfan, N. A., & Khalid, M. (2024). Integrating the quintuple helix approach into atmospheric microplastics management policies for planetary health preservation. *The Science of the Total Environment*, 954, 176063. <https://doi.org/10.1016/j.scitotenv.2024.176063>
- Egypt Vision 2030. (2016). Sdsegyp2030. Retrieved January 2, 2026, from <http://sdsegyp2030.com/>
- Engel, A., Leminen, S., & Aarikka-Stenroos, L. (2021). Urban Living Lab as a Circular Economy Ecosystem: Advancing Environmental Sustainability through Economic Value, Material, and Knowledge Flows. *Sustainability*, 13(5), 2811. <https://doi.org/10.3390/su13052811>
- Evans, S., & Scarbrough, H. (2014). Supporting knowledge translation through collaborative translational research initiatives: ‘Bridging’ versus ‘blurring’ boundary-spanning approaches in the UK CLAHRC initiative. *Social Science & Medicine*, 106, 119-127. <https://doi.org/10.1016/j.socscimed.2014.01.025>
- Fan, X., Wargocki, P., Silvestri, A., Borkowski, E., & Schlueter, A. (2025). Mediating effects of ventilation on the impacts of temperature on human comfort, health and cognitive performance: A living lab study. *Building and Environment*, 285, 113587. <https://doi.org/10.1016/j.buildenv.2025.113587>

- Finkbeiner, M. (2014). The International Standards as the Constitution of Life Cycle Assessment: The ISO 14040 Series and its Offspring. In *LCA compendium* (pp. 85–106). https://doi.org/10.1007/978-94-017-8697-3_3
- Fuglsang, L., & Hansen, A. V. (2021). Framing improvements of public innovation in a living lab context: Processual learning, restrained space and democratic engagement. *Research Policy*, 51(1), 104390. <https://doi.org/10.1016/j.respol.2021.104390>
- Gascó, M. (2016). Living labs: Implementing open innovation in the public sector. *Government Information Quarterly*, 34(1), 90-98. <https://doi.org/10.1016/j.giq.2016.09.003>
- Georghiou, L., Edler, J., Uyerra, E., & Yeow, J. (2013). Policy instruments for public procurement of innovation: Choice, design and assessment. *Technological Forecasting and Social Change*, 86, 1-12. <https://doi.org/10.1016/j.techfore.2013.09.018>
- Gilbert, S., Mathias, R., Schönfelder, A., Wekenborg, M., Steinigen-Fuchs, J., Dillenseger, A., & Ziemssen, T. (2025). A roadmap for safe, regulation-compliant Living Labs for AI and digital health development. *Science Advances*, 11(20). <https://doi.org/10.1126/sciadv.adv7719>
- Haug, N., & Mergel, I. (2021). Public Value Co-Creation in Living Labs Results from Three Case Studies. *Administrative Sciences*, 11(3), 74. <https://doi.org/10.3390/admsci11030074>
- He, D., Deng, H., Niu, Y., Li, J., Zainol, R., & Azali, N. S. (2025). Governing sustainable urban brownfield redevelopment in China: Applying the Quintuple Helix model in Chengdu. *Ain Shams Engineering Journal*, 17(1), 103855. <https://doi.org/10.1016/j.asej.2025.103855>
- Heigl, F., Kieslinger, B., Paul, K. T., Uhlik, J., Frigerio, D., & Dörler, D. (2020). Co-Creating and implementing quality criteria for citizen science. *Citizen Science Theory and Practice*, 5(1). <https://doi.org/10.5334/cstp.294>
- Hernberg, H., & Hyysalo, S. (2024). Modes of intermediation: How intermediaries engage in advancing local bottom-up experimentation. *Environmental Innovation and Societal Transitions*, 51, 100849. <https://doi.org/10.1016/j.eist.2024.100849>
- Herth, A., Verburg, R., & Blok, K. (2024). How can campus living labs thrive to reach sustainable solutions? *Cleaner Production Letters*, 8, 100078. <https://doi.org/10.1016/j.clpl.2024.100078>
- Hossain, M., Leminen, S., & Westerlund, M. (2018). A systematic review of living lab literature. *Journal of Cleaner Production*, 213, 976-988. <https://doi.org/10.1016/j.jclepro.2018.12.257>
- James, P., McWherter, B., & Westwood, A. R. (2025). Exploring co-production through engagement between scientists and producers in an agricultural living lab: A case study in Canada. *Journal of Rural Studies*, 119, 103777. <https://doi.org/10.1016/j.jrurstud.2025.103777>
- Leminen, S., Rajahonka, M., Westerlund, M., & Hossain, M. (2021). Collaborative innovation for sustainability in Nordic cities. *Journal of Cleaner Production*, 328, 129549. <https://doi.org/10.1016/j.jclepro.2021.129549>
- Leminen, S., Westerlund, M., & Nyström, A. (2012). Living Labs as Open-Innovation Networks. *Technology Innovation Management Review*, 2(9), 6-11. <https://doi.org/10.22215/timreview/602>
- Lhoest, S., Kelman, C. C., Barton, C. J., Beaudette, J., & Gerber, L. R. (2024). The impact factor of engaged research: Metrics for conservation outcomes. *Biological Conservation*, 292, 110534. <https://doi.org/10.1016/j.biocon.2024.110534>
- Lin, Y., Lin, Y., Lin, Y., Lin, Y., Liu, J., Tan, Z., & Han, W. (2025). Triple Helix Synergy Model in China's new technology diplomacy: Perspectives from AI startups. *Telecommunications Policy*, 50(1), 103079. <https://doi.org/10.1016/j.telpol.2025.103079>
- Loignon, C., Dupéré, S., Leblanc, C., Truchon, K., Bouchard, A., Arsenault, J., Carvalho, J. P., Boudreault-Fournier, A., & Marcotte, S. A. (2021). Equity and inclusivity in research: co-creation of a digital platform with representatives of marginalized populations to enhance the involvement in research of people with limited literacy skills. *Research Involvement and Engagement*, 7(1), 70. <https://doi.org/10.1186/s40900-021-00313-x>
- López-De-Alba, P. L., Rodríguez-Carvajal, R. A., Isiordia-Lachica, P. C., Segoviano, F. J. V., Hidalgo, J. a. R., & Puente, O. T. (2026). The five-blade propeller: An evolutionary model of innovation with sustainability as the rotor (SPIRAL). *Journal of Open Innovation Technology Market and Complexity*, 12(1), 100738. <https://doi.org/10.1016/j.oiotmc.2026.100738>
- Mačiulienė, M., & Skaržauskienė, A. (2020). Sustainable urban innovations: digital co-creation in European living labs. *Kybernetes*, 49(7), 1969-1986. <https://doi.org/10.1108/k-07-2019-0514>

- Maruccia, Y., Solazzo, G., Del Vecchio, P., & Passiante, G. (2020). Evidence from Network Analysis application to Innovation Systems and Quintuple Helix. *Technological Forecasting and Social Change*, 161, 120306. <https://doi.org/10.1016/j.techfore.2020.120306>
- Masseck, T. (2017). Living Labs in Architecture as Innovation Arenas within Higher Education Institutions. *Energy Procedia*, 115, 383-389. <https://doi.org/10.1016/j.egypro.2017.05.035>
- McPhee, C., Bancierz, M., Mambrini-Doudet, M., Chrétien, F., Huyghe, C., & Gracia-Garza, J. (2021). The defining characteristics of agroecosystem living labs. *Sustainability*, 13(4), 1718. <https://doi.org/10.3390/su13041718>
- Mollen, J. (2024). Towards a research ethics of real-world experimentation with emerging technology. *Journal of Responsible Technology*, 20, 100098. <https://doi.org/10.1016/j.jrt.2024.100098>
- Mukherjee, A. S., Sahay, S., Kumar, R., Banta, R., & Joshi, N. (2023). “A living lab within a lab”: approaches and challenges for scaling digital public health in resource-constrained settings. *Frontiers in Public Health*, 11, 1187069. <https://doi.org/10.3389/fpubh.2023.1187069>
- NATAE. (2025, October). Launch of Luxor Living Lab, in Egypt. Natae. <https://www.natae-agroecology.eu/launch-of-luxor-living-lab-in-egypt/>
- Owen, R., & Mason, C. (2016). The role of government co-investment funds in the supply of entrepreneurial finance: An assessment of the early operation of the UK Angel Co-investment Fund. *Environment and Planning C Politics and Space*, 35(3), 434-456. <https://doi.org/10.1177/0263774x16667072>
- Paskaleva, K., & Cooper, I. (2021). Are living labs effective? Exploring the evidence. *Technovation*, 106, 102311. <https://doi.org/10.1016/j.technovation.2021.102311>
- Pisello, A. L., Amer, T. M., & Pioppi, B. (2025). Ten questions concerning living laboratories (LL) for multi-domain comfort investigations. *Building and Environment*, 276, 112750. <https://doi.org/10.1016/j.buildenv.2025.112750>
- Racine, E., D’Anjou, B., Dallaire, C., Dumez, V., Favron-Godbout, C., Hudon, A., Montreuil, M., Olivier, C., Quintal, A., & Chenel, V. (2023). Developing a living lab in ethics: Initial issues and observations. *Bioethics*, 38(2), 153-163. <https://doi.org/10.1111/bioe.13246>
- Rageh, R. (2024). Civic university model as living lab: potential and challenges. *Multidisciplinary Adaptive Climate Insights*, 1(1), 11. <https://doi.org/10.21622/maci.2024.01.1.832>
- Rahman, N. H., & Kamauzaman, T. H. T. (2022). Developing Key performance Indicators for Emergency Department of Teaching Hospitals: a mixed fuzzy Delphi and nominal group technique approach. *Malaysian Journal of Medical Sciences*, 29(2), 114-125. <https://doi.org/10.21315/mjms2022.29.2.11>
- Ranchordás, S. (2021). Experimental regulations and regulatory sandboxes – law without order? *Law And Method*. <https://doi.org/10.5553/rem/.000064>
- Riaño-Herrera, D. A., Romero-Perdomo, F., Quintero-Castro, J., García-Sánchez, A., & Rodríguez-Urrego, L. (2025). Exploring the design and contributions of urban agroecosystem living labs for sustainable city development. *Sustainable Futures*, 10, 100976. <https://doi.org/10.1016/j.sftr.2025.100976>
- Ruijter, E. (2021). Designing and implementing data collaboratives: A governance perspective. *Government Information Quarterly*, 38(4), 101612. <https://doi.org/10.1016/j.giq.2021.101612>
- Ruijter, E., & Meijer, A. (2019). Open Government Data as an Innovation Process: Lessons from a Living Lab Experiment. *Public Performance & Management Review*, 43(3), 613-635. <https://doi.org/10.1080/15309576.2019.1568884>
- Sala, A., Landoni, P., & Verganti, R. (2015). Small and Medium Enterprises collaborations with knowledge intensive services: an explorative analysis of the impact of innovation vouchers. *R & D Management*, 46(S1), 291-302. <https://doi.org/10.1111/radm.12196>
- Santos, J. C. D. (2026). Regular orders for triangular fuzzy numbers and the weak law of trichotomy. *Fuzzy Sets and Systems*, 532, 109790. <https://doi.org/10.1016/j.fss.2026.109790>

Sarkki, S., Pihlajamäki, M., Soini, K., Ojala, A., Kluvankova, T., Spacek, M., Mishra, H., & Hiedanpää, J. (2025). Integrative literature review on co-concepts in connection with nature-based solutions. *Environmental Science & Policy*, 169, 104073. <https://doi.org/10.1016/j.envsci.2025.104073>

SEEDS Project (Ed.). (2025). Living Lab launched in Egypt to strengthen grain supply chain resilience. Seeds. <https://seeds-prima.eu/living-lab-launched-in-egypt-to-strengthen-grain-supply-chain-resilience/>

Sekem. (2025). SUS-SOIL Project: Sustainable soil and subsoil Management. <https://www.sus-soil.eu/>

Selviaridis, K., & Spring, M. (2024). Innovation intermediation in supply networks: Addressing shortfalls in buyer and supplier capabilities for collaborative innovation. *Journal of Operations Management*, 71(1), 40-80. <https://doi.org/10.1002/joom.1345>

Shin, J., Lee, J. Y., Cho, E., Kang, B., & Choi, J. Y. (2025). Implications of a collaborative production process based on the living lab approach for older adults' health: An integrative review. *Geriatric Nursing*, 66(Pt C), 103639. <https://doi.org/10.1016/j.gerinurse.2025.103639>

Stuckrath, C., Rosales-Carreón, J., & Worrell, E. (2025). Conceptualisation of Campus Living Labs for the sustainability transition: An integrative literature review. *Environmental Development*, 54, 101143. <https://doi.org/10.1016/j.envdev.2025.101143>

Sudo, A., De Vries, J., & Kamuya, D. (2021). A scoping review of considerations and practices for benefit sharing in biobanking. *BMC Medical Ethics*, 22(1), 102. <https://doi.org/10.1186/s12910-021-00671-x>

Toso, F., Brankaert, R., Hendriks, N., Lenaerts, L., & Wilkinson, A. (2023). Reflecting on Living Labs as Multi-Stakeholder Collaborative Networks to Evaluate Technological Products for People Living with Dementia. *International Journal of Environmental Research and Public Health*, 20(3), 1673. <https://doi.org/10.3390/ijerph20031673>

Tuni, A., Ijomah, W. L., Gutteridge, F., Mirpourian, M., Pfeifer, S., & Copani, G. (2023). Risk assessment for circular business models: A fuzzy Delphi study application for composite materials. *Journal of Cleaner Production*, 389, 135722. <https://doi.org/10.1016/j.jclepro.2022.135722>

Van Engelenhoven, A. M., Geiger, J. L., Ünal, A. B., Spinder, R., & Van Der Zande, I. S. (2023). Student perceptions of Living Lab research internships in the COVID-19 pandemic – a Dutch case study. *Education + Training*, 65(10), 65-80. <https://doi.org/10.1108/et-06-2022-0236>

Van Geenhuizen, M. (2016). Living Labs as boundary-spanners between Triple Helix actors. *Journal of Contemporary Eastern Asia*, 15(1), 78-97. <https://doi.org/10.17477/jcea.2016.15.1.078>

Van Geenhuizen, M. (2018). A framework for the evaluation of living labs as boundary spanners in innovation. *Environment and Planning C Politics and Space*, 36(7), 1280-1298. <https://doi.org/10.1177/2399654417753623>

Van Winden, W., & Carvalho, L. (2019). Intermediation in public procurement of innovation: How Amsterdam's startup-in-residence programme connects startups to urban challenges. *Research Policy*, 48(9), 103789. <https://doi.org/10.1016/j.respol.2019.04.013>

Von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., & Coenen, L. (2018). Impacts of urban living labs on sustainability transitions: mechanisms and strategies for systemic change through experimentation. *European Planning Studies*, 27(2), 229-257. <https://doi.org/10.1080/09654313.2018.1504895>

Voorwinden, A., Van Bueren, E., & Verhoef, L. (2023). Experimenting with collaboration in the Smart City: Legal and governance structures of Urban Living Labs. *Government Information Quarterly*, 40(4), 101875. <https://doi.org/10.1016/j.giq.2023.101875>

Westerlund, M., Leminen, S., & Habib, C. (2018). Key constructs and a definition of living labs as innovation platforms. *Technology Innovation Management Review*, 8(12), 51-62. <https://doi.org/10.22215/timreview/1205>

Yang, B., & Park, S. (2025). Evolving Innovation Ecosystems: Longitudinal Insights into the Triple Helix Model and Enterprise Innovation in China. *SAGE Open*, 15(4). <https://doi.org/10.1177/21582440251393200>

Zebisch, M., Terzi, S., Pittore, M., Renner, K., & Schneiderbauer, S. (2022). Climate Impact Chains A conceptual modelling approach for climate risk assessment in the context of adaptation planning. In Springer climate (pp. 217–224). https://doi.org/10.1007/978-3-030-86211-4_25

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