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Restorative Transitions at the Crossroads: Multi-Actor Experiences of Leveraging Living Labs



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Abstract. The research deepens on the notion of transformative governance as a means to enhance individual and collective responsibility towards positive climate change. It is rooted on two main frameworks: a) the triple transition – green, digital and social – with its multidimensional perspective to address the intricacies of evolving environmental and socio-economic and geopolitical challenges; b) the Anthropocene epoch that reflects and triggers the capacity of humans to imprint a deep impact on the planet. More holistic, multi-player and cross-level co-design strategies are proving to ease the upheaval of new forms of living labs and the readiness of regional innovation ecosystems for addressing triple transition interconnected challenges. The study examines solutions that generate negotiated visions and more proactive participatory multi-actor engagement. It argues that climate neutrality and regeneration require active quadruple helix community involvement and citizen-led action. This study uniquely positions individual and collective responsibility as the central drivers of sustainable change. The research deepens on more synergetic strategies for aligning transformative governance around ecosystem-based visions and layered, interactive and multi-helix participatory participation. The research reveals that harnessing and maximizing a systemic triple transition approach – (digital, social and green and) and multi-actor collaborative approaches, novel forms of living labs can be developed for achieving higher levels of sustainability, positive and even regenerative impacts able to shift towards more resilient future urban, peri-urban and rural settings.

Key words: triple transition, peri-urban transition, synergetic collaboration, co-creation, adaptive transformative governance, common good.

“Maximizing synergies and managing trade-offs depend on specific practices, scale of implementation, governance, capacity building, integration with existing land use and the involvement of local communities and Indigenous peoples and through benefit-sharing, supported by frameworks such as Land Degradation Neutrality within the UNCCD”

(Shukla et al., 2022)

Despite the proliferation of living labs in research and policy (Schuurman et al., 2016; Leminen et al., 2017), existing approaches often address digital, green and social transitions in silos. This paper responds to that gap by proposing an integrated composition of living lab tools that enables a more systemic, impact-oriented transition strategy (Voytenko et al., 2016; McCormick, Hartmann, 2017).

The question is how we position ourselves to work together to create more aligned collective efforts to reverse the effect of our Anthropocene damage.

Regardless of human inherent reactance to change, we are incessantly confronted with change at all levels from individual to community to global level. Current events such as the COVID-19 pandemic, severe droughts, drastic floods, wildfires and social inequities exemplify the “heavy storms”

Introduction

Humanity is in a state of transition, driven by anthropogenic changes, which reflects the deep changes affecting our planet in an epoch known as the Anthropocene era. This is featured by the vast impact imposed by humans on the planet. All living beings in the different ecosystems in the world are and will be affected by climate transition.

that disrupt our socio-economic, political and environmental status quo. Among the most pressing of these global challenges are the need to mitigate and adapt to climate change (Smith et al., 2020).

These disruptions highlight the need for a courageous acknowledgment of our role as predators or exploiters without measure or control, or as positive agents of change with the Anthropocene epoch presenting unique governance challenges and opportunities. Humanity has reached this critical juncture by prioritizing individual interests, leaving only a few to shoulder the responsibility for the common good. To address this imbalance, we must promote a global and personal awakening that inspires transformative positive changes across societies, artificial systems and natural ecosystems. This requires embracing our collective role as agents of change and committing to a shared vision of the common good.

This study aims to explore how collaborative transformative governance can drive systemic environmental transitions by fostering climate responsibility and equipping emerging innovators through co-creation and novel tools. Objectives of the research are as follows:

- 1) to define collaborative transformative governance in the context of environmental and climate transitions;
- 2) to assess the role of co-creation methodologies in fostering climate responsibility;
- 3) to examine how novel tools and services support new generations of environmental and social innovators;
- 4) to evaluate the impact of multi-actor governance approaches on systemic sustainability outcomes.

Therefore, the following hypotheses are formulated and tested:

H1: Collaborative transformative governance fosters individual and collective responsibility for climate and environmental action, enabling broader and deeper sustainability transitions. This can be achieved through systemic, forward-looking thinking combined with multi-actor and multi-level co-creation methodologies (e.g., community-based environmental initiatives, participatory planning for climate resilience).

H2: Transformative governance grounded in collaborative principles and supported by novel methodologies, tools and services (Caro-González, 2023) can be effectively established by nurturing new generations of change-makers and enabling the emergence of innovators across environmental, digital and social domains—thus accelerating the shift toward climate-neutral, inclusive and sustainable futures.

Literature review

Urban areas play a critical role in mitigating climate change due to their significant greenhouse gas (GHG) emissions, growing urban populations, expanding urban land and infrastructure and the long lifespans of buildings and transport systems (Seto et al., 2021). Systemic approaches to governance are crucial for a) promoting and accelerating regenerative climate change in urban, peri-urban and urban-rural settlements; b) ensuring long-term stability; and c) supporting transformative actions that drive more rapid positive environmental changes in these communities.

The Triple Transition framework (Caro-González et al., 2023) envisions a comprehensive transformation – social, green and digital – under the motto “One for All, All for One.” It advocates just, human-centered and environmentally-friendly transitions guided by negotiated win-win approaches, addressing global challenges such as warfare, environmental

degradation and social alienation. The framework emphasizes regenerative practices like the circular economy and sustainable, equitable growth¹. It promotes transformative governance, multi-agent collaboration for climate targets and a systemic approach integrating digital, energy and environmental concerns.

Cities and peri-urban areas are envisioned as vast “co-laboratories” (new generation of LLs and ecosystems) with capacity to drive radical changes through experimentation, learning and multi-actor engagement, promoting systemic innovation and collaboration across various dimensions (Scholl et al., 2022; Bhatta et al., 2023; Serra et al. 2024).

To effectively address climate change in urban and peri-urban areas, it is essential to involve multiple levels of governance, including government and non-state entities and secure substantial funding beyond sector-specific strategies (Costero Bolaños, 2024). Concurrently, multi-level governance, as discussed by various authors (Fuhr et al., 2018, Di Gregorio et al., 2019; Gonzales-Iwanciw et al., 2020;), has evolved into a complex polycentric system spanning global, national and sub-national levels, relying on formal and informal networks. It coordinates policies across these levels to ensure coherent responses to climate challenges. While climate change mitigation is global in scope, its local impacts and adaptation needs create challenges for policy integration. Cross-level interactions between mitigation and adaptation remain underexplored, but social learning – convergent changes in stakeholders’ perspectives – plays a crucial role by fostering integrated solutions through collective action.

¹ <https://eohforgood.com/eoh-lution-podcast/>

As (Heinen et al., 2022) affirm, polycentric climate governance and multi-level governance operate across five dimensions: governance issues, decision-makers, interactions, rules-in-use and dependency degrees. Polycentric governance emphasizes local self-regulation, while multi-level governance focuses on formally interdependent actors collaborating across government levels.

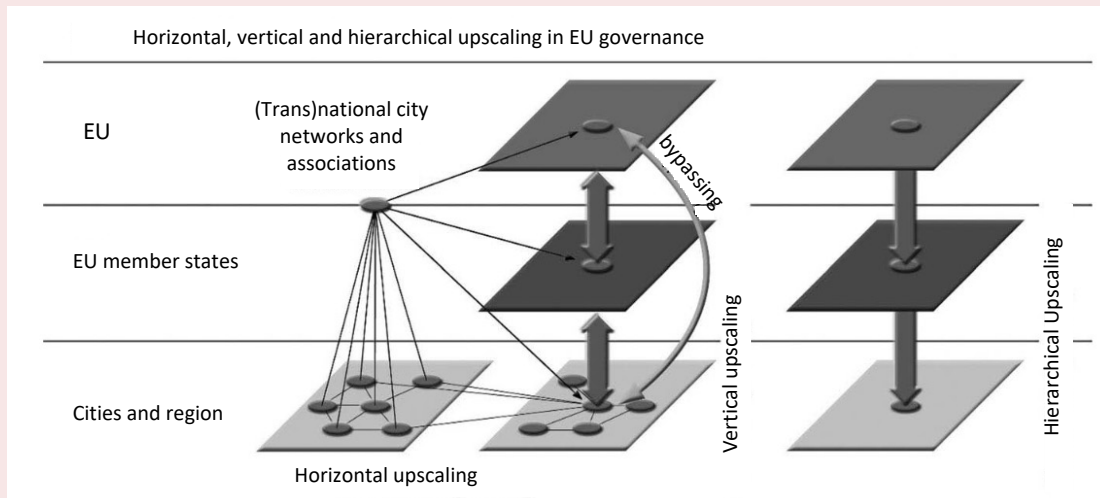
In transnational municipal networks, cities operate under different rules based on national legal frameworks. Some cities engage in self-regulated climate actions, while others integrate efforts across government levels with substantial funding.

These differences lead researchers to varying conclusions on factors like leadership, trust and self-regulation. Many small to medium-sized ones lack appropriate strategies (although cities like Copenhagen and Sydney take effective climate actions), highlighting the urgent need for proactive sub-national policies to limit global temperature rise to 1.5°C.

(Kern, 2019) explored EU multilevel climate governance, highlighting dynamics among leaders, followers and laggards (Fig. 1). She noted that local climate action has gained prominence, with authority shifting both upwards to the EU and downwards to subnational authorities. Many Europeans now live in cities with ambitious climate goals, such as Girona, Limerick, Reggio Emilia or Fyli Municipality, among others². However, Kern cautioned that local action alone is not a complete solution.

² Network of ambitious cities on climate neutrality grows to 184 on EU Cities Mission peer-learning programme. NetZeroCities. Available at: <https://netzerocities.eu/2025/01/22/network-of-ambitious-cities-on-climate-neutrality-grows-to-184-on-eu-cities-mission-peer-learning-programme/> (accessed: January 28, 2025).

Figure 1. Horizontal, vertical and hierarchical upscaling in EU governance



Source: (Kern, 2019).

(Fuhr et al., 2018) emphasized the benefits of bottom-up climate approaches, highlighting urban experimentation within polycentric governance. They introduced “embedded upscaling”, a governance model integrating horizontal, vertical and hierarchical arrangements while addressing multi-actor dynamics.

Transformative governance refers to the process of how societies are managed to achieve sustainable and equitable outcomes. It involves moving beyond traditional governance models to embrace more holistic, inclusive and adaptive approaches for the common good (Caro-González, 2023). Key elements of transformative governance include:

- a) eco-systemic thinking to understand and manage urban contexts in an integrated, holistic and planet friendly manner;
- b) community-based and citizen engagement to actively involve local communities and individuals in decision-making processes and have the responsibility to “add our drop in the ocean”;

c) multi-actor engagement to ensure that diverse perspectives and interests are represented and considered;

d) systems transformation to promote comprehensive changes across social, economic and environmental systems with a long-term common good vision.

Transformative governance offers a pathway to navigate complex transitions and build a just, sustainable and inclusive future. The primary challenge lies in effectively implementing regenerative policies and practices and this requires social innovators to design frameworks involving political and religious leaders, entrepreneurs and purpose-driven community members. These social infrastructures sustain, refine and evolve the process to ensure long-term success.

Environmental challenges in urban, peri-urban and rural settlements progress slowly without coordinated, multi-faceted action, risking insufficient pace, impact and efficiency. This study

highlights the potential of the T-Shaped concept (Shabnam et al., 2016) as a framework for enhancing multi-level transformative governance. This model, characterized by the ability to collaborate across disciplines (the horizontal bar) and the deep navigation in specific areas (the vertical bar of the “T”), is particularly effective in accelerating positive climate transitions. This model fosters comprehensive and coordinated efforts essential for addressing complex climate challenges by integrating cross-sectoral collaboration with specialized knowledge.

Research methodology

In the theoretical component of the study, we conducted a comprehensive literature review to synthesize existing frameworks on co-creation, innovation ecosystems and climate adaptation. This informed the conceptual foundation of the proposed T-Shaped Living Labs. Furthermore, the development of the Living Labs involved a mixed-methods approach that integrated stakeholder mapping, system dynamics modeling and iterative design workshops. These methods supported the translation of theoretical insights into practical design elements, ensuring that the proposed labs are both evidence-based and context-sensitive.

A rigorous qualitative methodology has been employed to examine opportunities and challenges in accelerating climate-positive change across urban, peri-urban and rural-urban settlements in different world contexts. Through qualitative methods, the research captures nuanced perspectives and contextual factors shaping transformative governance.

The sample design prioritizes diversity and representativeness, drawing on initiatives from Europe, America, Asia and Africa (via expert

cooperation). Purposeful and snowball sampling identified participants aligned with research objectives, focusing on governance innovation, societal co-responsibility and climate-positive transitions within the “triple transition” framework.

This strategy enabled the collection of insights from initiatives at varying stages of maturity, across multiple geographic regions, thematic areas, and levels of stakeholder involvement. As a result, the analysis encompasses a spectrum of DSI initiatives – from emerging projects to established ventures – providing a nuanced understanding of how DSI manifests in different contexts and sectors.

This study is part of a broader ongoing research project where 17 semi-structured interviews were conducted with diverse stakeholders of various sectors (*Fig. 2*). The sample balanced geography, themes, maturity levels of initiatives and gender (55.6% male, 44.4% female), highlighting regenerative practices and co-responsibility. Desk research complemented the interviews and thematic analysis using Atlas.ti identified key patterns and insights into transformative governance.

For this research, representatives from 14 countries were selected to examine context-driven urban and peri-urban climate change initiatives. These initiatives vary in scope:

- LLs on circular economy (e.g. Tokoro Lab, Japan);
- long-term institutional transformative plans (e.g. Danish Institute for Fire and Security Technologies; Estonian National Museum; i2Cat Foundation; Norwegian University of Science and Technology);
- community-based projects (Equipo Europa; Global Shapers to promote the engagement of young people);

- European education, research and innovation projects (FORTH in Philippines; INTEGER in three European regions);
- social movements (e.g. Xquenda_Lab in Mexico for Zapoteca indigenous people; Mujeres Conectadas in Perú to enhance women participation in Trujillo);
- local, regional or national development strategies (e.g. Alliance of Municipalities Alto Tajo, Spain; Catalan regional strategy; Chilean national strategy for Social Sustainability);
- European networks and Associations (e.g. ENoLL - Working Group Energy & Environment; European Network of Cultural Centres; Education for an Interdependent World).

The *Table* entitled “List of semi-structured in-depth interviews conducted with key stakeholders” presents information regarding the country of origin for each primary initiative. It should be noted, however, that the interviews also encompass additional initiatives – both past and ongoing – situated in various other locations.

Research results

To strengthen the credibility of the findings, feedback and evaluations were solicited from peers and external experts. This process of external validation helped identify potential blind spots and biases, thereby enhancing the study’s overall rigor. Experts consulted included professionals from innovation ecosystems beyond those directly examined in the chapter, such as Denmark, Norway, the Netherlands and Canada.

This section spells out the results of the analysis, stressing the role of co-creation as a key driver of innovation and sustainability. The findings reveal that co-creation fosters both individual and collective responsibility, enabling more inclusive and adaptive approaches to climate action. In particular,

it emerges as a critical mechanism for advancing urban and peri-urban transformations, supporting the development of locally grounded, collaborative solutions to complex environmental challenges.

Agenda 2030 highlights multi-level adaptation governance, promoting mitigation practices with co-benefits that do not compete for land. These practices reduce land conversion, aiding climate mitigation, land restoration, food security and SDG achievement (Smith et al., 2020). Inclusive, multi-sectoral planning with flexible, low-regret pathways ensures cross-sectoral benefits, preserves future options and defines the solution space for long-term climate adaptation (Shukla et al., 2022).

Several experts, in line with the ideas of the Anthropocene, suggest that innovation processes have the potential to transform individuals and societies:

“Subjects in one form can transform, or we can transform ourselves through these innovation processes” (I8-ES, 2024; 00:08:48).

One interviewee (I8-ES, 2024; 00:26:11) underscores cultural innovation as a human-driven process, highlighting the active role of humans in shaping the world. The expert notes a lack of awareness about this role and its impact on natural evolution, cultural innovation theories are needed to hold us accountable and responsible for changes instigated in natural systems.

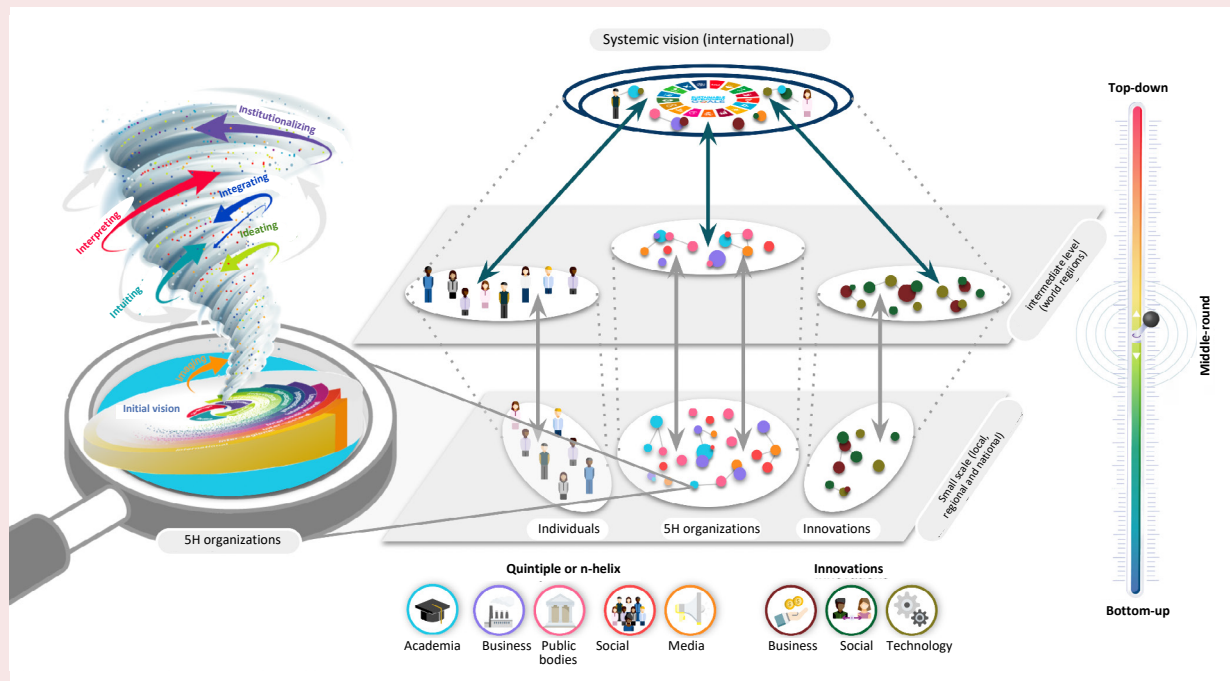
Figure 2 presents a holistic multi-level and multi-i model approach where bottom-up, top-down and middle-round perspectives converge. (Busquets, 2010) proposed the concept of Orchestrating Smart Business Networks (SBN), which complements the idea of the Eoh-for-Good tornado (on the left of the figure) (Caro-González, 2023). This model results from a longitudinal research in action, experimentation and learning

List of semi-structured in-depth interviews conducted with key stakeholders

Location (country/ region)	Code	Gender	Scope	Fields	Target groups
Belgium (Europe)	I4-BE	F	International	Education, inclusion, integrity, common language, social movements	Youth, academia
Chile (Latin America)	I2-CL	M	National	Technology education, social sustainability	Society, academia, public policy makers
Denmark (Europe)	I11-DK	M	National	Techno-anthropology, fire and security technologies, information and communication technologies (ICT), policy development	Society, public administration
Estonia (Europe)	I3-EE	F	National	Cultural and creative industries (CCI), museums, development, intergenerational use of media, digitalization	Society, public administration and local culture preservation
Hamburg, Germany (Europe)	I6-GER	M	Regional European	Economy, innovation, startups, advanced technology, health, civic engagement	Public administration, ministry, civil society
Japan (Asia)	I17-JPN	F	National	Economy cooperation, public administration	Public administration, OECD, academia
Mexico (America)	I5-MX	M	National	Digitalization, AI, technology, culture, language inclusion, innovation and indigenous practices	Indigenous communities, civil society
Netherlands (Europe)	I10-NL	M	International	Ecosystem redesign, blockchain technology	Business, academia, technology
Norway (Europe)	I9-NO	F	International	Sustainable innovation, engineering, education, tech transfer, gender, health technology	Academia, women, society
Peru (Latin America)	I1-PE	F	National	Gender intersectional approach, entrustment of women	Women, society
Philippines (Asia)	I16-PHL	F	National	Education, youth engagement and volunteer work: Society Helix	Non-profit organizations, education
Poland (Europe)	I7-PL	M	European	Territorial development-rural/urban, civic participation and participatory practices, CCIs	Culture institution, civil society
Spain, Catalonia (Europe)	I8-ES	M	Regional International	Helix participation, innovation universal systems, research and innovators, governance	Innovation ecosystems, connection and elaboration helixes
Spain (Europe)	I12-ES	F	Regional	Integration, diversity, education	Civil society, territory balance, public administration
Spain (Europe)	I13-ES	M	National	Politics, re-urbanization of rural areas, territorial and social innovation	Civil society, public sector, government, policy makers
Spain (Europe)	I15-ES	M	International	Youth, civic and non-political organizations dedicated to improving society: society helix	Young activists and civic organizations
Switzerland (Europe)	I14-CH	M	International	Sustainable energy, electrification of transport, energy policy, urban regeneration, knowledge & technology transfer	Researchers, policymakers, energy sector, sustainable technology experts

Source: <https://eehforgood.com/>

Figure 2. Eoh-for-Good Multi-level vertical and horizontal interconnected perspectives



Source: <https://eohforgood.com/>

process in different settings to systematically analyze and frame a new cultural innovation theory to accelerate innovation processes by absorbing the innovation from the edges.

The lower level comprises individuals, disconnected helices and organizations, often functioning as isolated nodes without integration. The top-down level refers to policies and strategies that support the implementation of plans, programs and tools across different levels of governance by ensuring vertical coordination. According to the 2022 IPCC report, integrated, cross-sectoral, inclusive and systems-based approaches – when combined with supportive public policies – enhance long-term resilience with high confidence (Shukla et al., 2022, p. 90). EU-level climate policy frameworks (e.g. soil mission) increasingly promotes LLs as spaces for enhancing multi-level

collaboration, linking people, innovations and helices to support transformative governance neutral or regenerative climate transitions.

The multi-i model unfolds combinations of collaborative dynamics with a number of dimensions that start with ‘i’: interpersonal, intersectional, interdisciplinary, interhelix, intersectoral, inter-generational, intercultural, inter-institutional, inter-regional and international (Caro-González, 2023, pp. 59–73). These interactions promote innovative co-creation and collaboration processes within and across institutions, sectors and contexts, ensuring that solutions are context-specific, socially inclusive and can become more broadly supported.

The multi-i transformative governance for innovation, involves active engagement and alignment of relevant parties, including internal and external partners, securing collaboration and

shared ownership of the change process. These operate alongside interdisciplinary action-research collaboration, rooted in a human-centered approach (Vrontis et al., 2020; Iandolo et al., 2024) and prioritizes experimentation over mechanistic processes.

The transboundary nature of many climate risks and species responses requires multi-national or regional governance solutions for land (Shukla et al., 2022, p. 111). By bringing together diverse actors and stakeholders, co-creative multi-i tornado (as portrayed in the left-hand side of Figure 2) have the potential to boost hubs of innovation, generating transformative solutions to complex problems faced by entrepreneurs, teams, organizations and ecosystems (Caro-González, 2023, p. 73). The interview results analyzed the contexts network's centripetal and centrifugal collaborative forces shaping the structural dynamics of innovation. This approach shows promise in creating an efficient pathway to innovation by successfully coordinating interactions across multiple actors and levels, managing network boundaries and integrating digital platforms.

Living Labs are positioning as spaces at base of the vortex for the inception of ideas, intra- and entrepreneurial activities, stakeholder engagement and continuous learning and adaptation. They are becoming the rotating bezel accelerating the needed process of change, fostering knowledge exchange, experimentation and the collective development of innovative solutions.

This rotation ensures alignment, collaboration, shared ownership, continuous improvement and resilience amidst change. The funnel expands rapidly by drawing in innovation from its edges, including interdisciplinary collaborations, local or international intersectoral projects and community-based urban and peri-urban environmentally friendly initiatives.

Transnational organizations, networks, LLs and other initiatives act as intermediaries to connect different spaces and levels. Therefore, interdisciplinary and intersectoral collaboration is crucial, as integrating diverse knowledge and involving citizens in decision-making enhances governance's responsiveness and effectiveness in addressing climate change challenges (Degroot et al., 2021). As highlighted by the expert operating in Denmark:

“And when do we understand? What is the knot for? Well, suddenly, the one who has more experience in a subject can contribute and we all come to that agreement and we build in an interdisciplinary way [...] when we talk about transdisciplinary it is no longer the discipline. For example, it is one thing to have engineers and sociologists and another thing to have a discussion with a citizen as the citizen will bring a completely different approach” (I11-DK, 2024, 00:07:35).

New disciplines like techno-anthropology and techno-sociology merge social sciences and design (Matus et al., 2018) to create inclusive solutions, crossing traditional disciplinary boundaries. Having change agents trained in this hybrid subdiscipline of engineering and social sciences facilitates processes that provide mediators who do not belong to a single discipline but can cross their boundaries.

Environmental changes in cities and peri-urban settlements are moving typically slowly. One of the urgent needs is to accelerate regenerative urban and peri-urban climate action to enhance both individual and collective responsibility. For this, different experts and practitioners are advocating and implementing novel flexible, adaptable, collaborative and co-creative methodologies with capacity to promote resilient and regenerative urban environments (e.g. use of blockchain for transformative change, with the aim to create inclusive ecosystems; I10-NL 2024; development of artificial intelligence tool capable of recognizing

patterns of Zapotec culture, fostering the democratization of innovation of the indigenous culture; I5-MX 2024). As stated by one of the experts:

“The type of acceleration that climate change mitigation and adaptation will require from cities, requires as a jump in the capacity of cities of moving fast and transform around the few sectoral issues like rooftops, electric mobility and urban forest and the quality of mobility” (I14-CH, 2024, 01:16:28).

Employing co-creation is crucial for fostering innovation and sustainability, as it facilitates discussions and decision-making processes and also broadens collaboration, engagement and entrustment of society. This approach helps in reaching strategic goals and making citizen engagement a goal in itself. The critical point here, which makes companies like Eoh-for-Good and professionals such as techno-anthropologists and well-trained change agents imperative, is that poorly guided co-creation does not work, is not sustainable or leads to short-lived agreements.

The flexible, formal and informal configurations of co-creation within urban, peri-urban and urban-rural living labs (LLs) enable diverse participation, fostering dynamic environments where both long-term and short-term objectives can be addressed concurrently. This approach promotes an inclusive and innovative culture of urban development (Puerari et al., 2018). One of the experts interviewed recognizes the importance of these interrelatedness:

“Here, you have an ally in anyone who wishes to contribute to the common good, particularly in the context of the numerous rural communities across Spain. These villages are the foundation upon which our cities have been built, reflecting the hard work and dedication of previous generations [...]. Just as these rural areas once served as vital engines of development, they now have the potential to benefit

us all. The key takeaway is that by focusing on and supporting rural areas, we can address many of the pressing issues currently faced by urban centers, such as housing affordability, transportation challenges and pollution” (I13-ES, 2024, 00:43:00).

As many problems are intrinsically linked, addressing rural depopulation is crucial for managing urban overpopulation.

Collaborative methodologies and co-creation engage diverse actors in the design, implementation and evaluation of initiatives, enabling motivated individuals, as what we have identified as “early adopters”. They become change agents with the support of proper capacity programs, which aligns the needs and innovations of individuals and institutions within co-creative transformative governance networks. Socio-digital innovation designs transform challenges into solutions via collaboration with two-way feedback mechanisms for social-digital innovators finding effective solutions and integrating all participants through collaboration into the ecosystem:

“The next step is how can you, when you are a community working together, collective action, you create value for somebody and it is offered to the whole community” (I10-NL, 2024, 0:27:00) and “everybody who is participating, whether as a developer, or as a user, or as a founder... they can all become part of the whole ecosystem” (I10-NL, 2024; 00:16:50).

Such inclusivity ensures solutions that are both technologically sound, socially acceptable and environmentally neutral or regenerative, fostering a community-centric approach and adaptable collective action. This is connected to the principle of “no one left behind” and is particularly important for women, indigenous people and minorities. Integrated, multi-sectoral solutions that address social inequities, tailor responses to climate risks and working across systems can enhance the

feasibility and effectiveness of adaptation in various sectors (Shukla et al., 2022, p. 21).

While structure and specific requirements are necessary, templates should remain flexible to foster creativity and innovation, creating a balance that encourages diverse, pioneering proposals aligned with the triple transition's goals (Rodríguez Müller et al., 2024):

"It is, in some way, excluding people who have not been privileged within this system due to social structures that have been imposed for centuries" (I5-MX, 00:08:40).

The design and implementation of innovative spaces, tools and dynamics adapted to context is central to creating purpose-driven, future-ready resilient and regenerative urban and peri-urban settlements.

"In connecting the dots, it's crucial to understand what works but more important is what didn't work across different contexts" (I9-NO, 2024; 00:07:24).

Accelerating climate change mitigation and adaptation in cities requires strengthening their capacity to transform key sectors such as rooftop photovoltaics, energy supply, urban forestry and mobility. The challenge of using space for renewable energy deployment is often approached quantitatively, neglecting its urban and territorial context (Delgado-Jiménez, 2024). Energy policies frequently overlook local dynamics and community-driven actions, while bottom-up initiatives play a key role in ensuring a fair and environmentally responsible transition. To enable individuals to work together effectively, it is essential to implement spaces, mechanisms and dynamics such as LLs, community platforms and collaborative initiatives that exchange knowledge, raise awareness and influence policies by engaging a coalition of like-minded individuals (I17- PHL, 2024).

The last decades have witnessed the proliferation of living labs (LLs), fab labs, collaboratories, superlabs, policy labs and more that are trying to change the innovation ecosystems as an important part of our social fabric. The "Lab" could symbolize all these dispersed and unconnected pieces of a new social structure, which can be classified by:

a) focus area with Urban LLs addressing urban mobility and sustainable development; Rural LLs for agricultural innovation and rural development; Health and Wellbeing LLs focused on digital health and elderly care; Environmental LLs working on climate change mitigation and water management; Energy LLs for renewable energy and efficiency; ICT and Digital Innovation LLs advancing technologies like IoT and cybersecurity; Social Innovation LLs for inclusion and community development; Cultural and Creative LLs supporting digital culture; Educational LLs to foster EdTech and lifelong learning; Transport LLs for innovate smart transportation; Manufacturing LLs advancing Industry 4.0; and Food and Agriculture LLs to ensure food security and sustainable farming;

b) geographic scope with Local LLs focusing on city or community levels; Regional LLs covering multiple localities; National LLs to engage actors at the country level; and International LLs operating across borders, involving multiple nations;

c) operational models which vary from University-based LLs, Corporate LLs, Government-led LLs, Community LLs to Public-private partnerships.

In addition to those identified in (Kern, 2019), various instruments and dynamics support collaboration in polycentric and multi-level climate governance. Urban LLs, for instance, promote collaboration among diverse actors and contribute to long-term sustainability transitions through

experimental co-creation processes involving multiple stakeholders. These labs, along with test beds, adopt experimental approaches to innovation policy, testing and advancing new sociotechnical arrangements and governance modes under real-world conditions (Puerari et al., 2018; Engels et al., 2019). Public-private partnerships also play a critical role by enhancing the efficiency and scope of public investment through integrated project phases (Prats, 2019). Additionally, multi-stakeholder platforms and networks connect agents to facilitate dialogue and implement joint climate initiatives (Betsill, Bulkeley, 2021), such as energy sustainability interventions within urban buildings (e.g. Sunthalpy efficiency solutions).

The multi-helix model (e.g., quadruple or n-helix) fosters innovation and systemic transformation by integrating government, industry, academia and civil society into governance processes. LLs, operating within these models, enable real-time co-creation, experimentation and scaling of urban and peri-urban environmental solutions.

Most interviews highlight inadequate collaborative spaces as a major barrier to problem identification, shared responsibility and coordinated solution development (I9-NO, I6-GER, I7-PL, I8-ES). As one interviewee pointed out:

“In the realm of environmental sustainability, it’s evident that many initiatives struggle to engage the right audience because the necessary platforms or venues for effective outreach are lacking. The issue isn’t that the message doesn’t reach anyone, but rather that it fails to reach the specific audience that needs to make impactful decisions” (I2-CL, 2024; 00:05:16).

Organizations like LLs facilitate multi-level, multi-helix collaboration by fostering knowledge exchange and partnerships and promoting shared

responsibility, innovative climate solutions and societal engagement.

Transnational networks and alliances are also crucial for the success of climate initiatives, offering opportunities for international cooperation and open, disruptive or user-driven innovation:

“So this vision of forming transnational alliances and networks is crucial for the success of these kinds of initiatives. We hope that we can effectively manage these opportunities in a positive way” (I5-MX, 2024; 00:16:34).

“Let’s say to innovate as a society by creating spaces that democratize innovation and creativity, allowing everyone to redesign their own lives and their cities” (I5-MX, 2024; 00:08:36).

Similarly, LLs provide multi-sectoral, multipurpose platforms that underline altruism and the common good, building value for cities, the environment and the achievement of SDGs.

“Multi sectoral, multipurpose tools like the LLs allow to select people doing the right things and be a crucial aspect for the common good, not immediate being a stakeholder with stake specifically for their own existence and self-interest. Is the altruistic aspect of LLs that need to be emphasized in order to build value for the city, environment and SDGs” (I14-CH, 2024, 01:16:06).

These collaborative spaces engage diverse stakeholders (e.g., vocational training, social services, small businesses, public sports centers) to identify challenges and co-develop strategies. A notable case illustrates this by aligning vocational training for individuals with intellectual disabilities with their empowerment, workforce integration, sustainable urban mobility, healthy lifestyles and environmental care. This holistic approach addresses interconnected needs, highlighting a novel initiative often overlooked by municipalities.

A good example is inclusive bicycles for children and youth with special needs:

“Something that no one had thought of was making inclusive bicycles for kids who can’t get on regular bikes due to special needs; they need more stability and hence a tricycle. While municipalities have implemented electric bicycles to decongest traffic and promote healthy transportation, they haven’t considered those who can’t use them” (I7-ES, 2024, 01:06:34).

Engaging diverse perspectives enhances understanding, fosters collective ownership and improves solution quality. These spaces also address ecological disasters and promote social innovation through private initiatives, as highlighted by an interviewee:

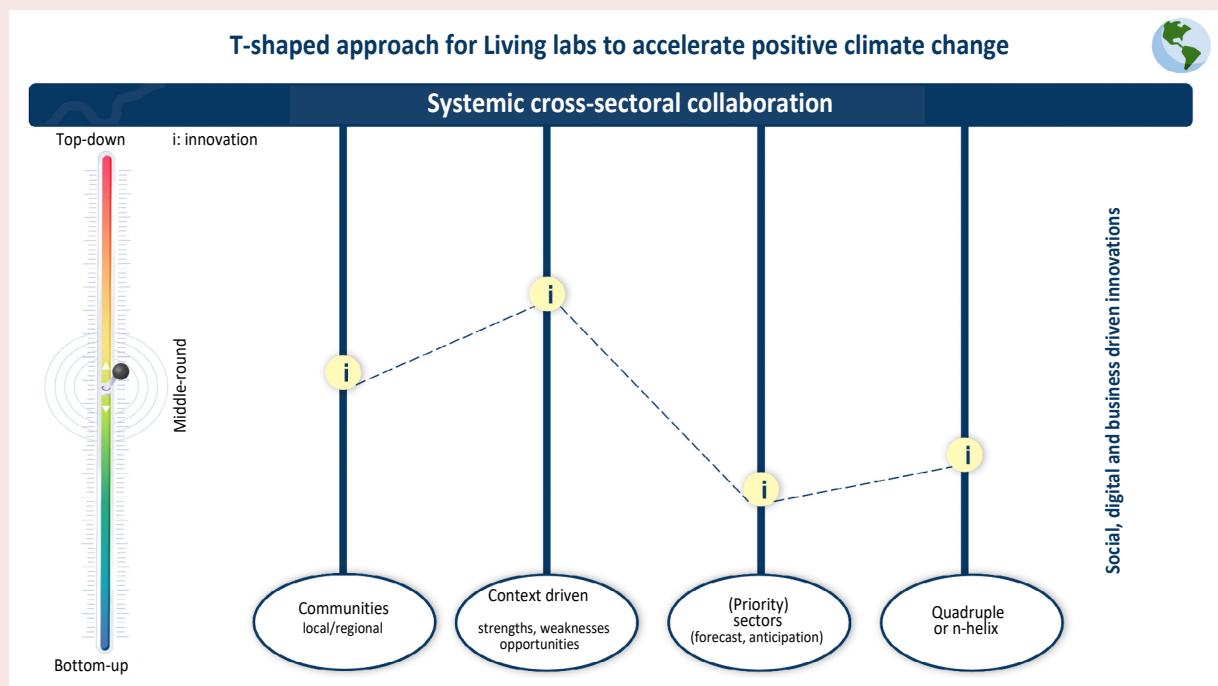
“Specifically here, for example, near Riverside, there are cases of terrible ecological disasters that have affected many indigenous populations, so we need to decide who to work with and why and how, without

participating in any form of greenwashing. However, there are many companies, like Microsoft, that are trying to generate programs promoting social innovation within their companies, enabling ecosystems for business. Microsoft, for instance, is enabling its labs and courses like TEALS or TechSpark and a variety of programs that facilitate access to technologies” (I12-MX, 2024, 00:28:40).

These initiatives stress the important role of the private sector in advancing regenerative climate solutions and catalyzing social and environmental innovation.

To enhance responsiveness, accountability and adaptability in climate governance, this study proposes the development of a new generation of T-Shaped living labs (LLs) (Fig. 3), which are neutral and inclusive environments for co-creation and experimentation, encompassing quadruple, quintuple or n-helix models. T-shaped LLs are

Figure 3. New generation of T-Shaped living labs



Source: <https://eohforgood.com/>

collaborative spaces designed to integrate systemic, interdisciplinary collaboration (the horizontal axis) with deep expertise in specific areas (the vertical axis). These labs foster innovation (i) by bringing together diverse stakeholders to co-create solutions for complex challenges through a balanced approach combining specialized knowledge with cross-sectoral engagement. Addressing and mitigating the impacts of climate change requires collaboration across multiple disciplines, including climate science, environmental engineering, urban planning, public health, economics, sociology, political science, agriculture, energy systems and information technology.

T-Shaped LLs ensure that solutions are contextually relevant and meet real-world needs by offering mechanisms for evaluating the impacts of policies and initiatives, ensuring that governance structures remain adaptable and impactful. These labs, as cooperative instruments, underscores a peer-to-peer approach between business, social and technology-driven innovations (Caro-González, 2023).

The systemic perspective represented by the horizontal line of the T is crucial for analyzing and understanding contextual factors within these settings through a holistic approach. This approach considers long-term visions, identified needs, immediate responses and shared or negotiated agendas, leading to inclusive, win-win collaborative dynamics that yield mutually beneficial outcomes.

The sample ensures a comprehensive perspective on strategies and practices across urban and rural contexts, with the T-Model deepening vertically along several climate change lines of actions, such as:

- 1) communities engaging diverse individuals and organizations to respond to identified climate challenges;
- 2) local and global connected agendas in a hyper-globalized world, paying special attention to the strengths, opportunities and weaknesses of each context;
- 3) fields or related sectors addressing the acceleration of climate transition focusing on priority areas;
- 4) helices integrating multiple stakeholders in the innovation process.

Conclusions

The emergence of T-Shaped LLs represents a new generation of transformative governance models that could serve as critical bridging spaces for co-creating negotiated solutions. These models enhance multi-level and multi-actor engagement by integrating quadruple/multi-helix dynamics to promote initiatives for the common good, shifting from destructive patterns towards regenerative ones.

There is a need for more coordinated co-creation efforts and international exchange of radical actions. Developing policies with broader political acceptance is essential, along with active citizen and actor engagement for transformative governance. Policymakers should prioritize inclusive participation mechanisms like public consultations and collaborative platforms to foster ownership and drive collective action. Each city or location's unique conditions must be considered when implementing initiatives. Local context, culture and challenges vary, making tailored decision-making essential, as strategies effective in one area may not work in another. Involving all relevant stakeholders ensures co-responsibility and practical outcomes, aligning with the quintuple helix model that engages diverse actors, from citizens to businesses, in planning and implementation.

In conclusion, addressing and accelerating regenerative climate change in urban, peri-urban and rural areas needs a multifaceted strategy that

integrates innovative transformative governance, individual and collective responsibility among societal actors and the design and implementation of new frameworks for innovation, such as the new generation of T-Shaped LLs.

This study highlights the importance of integrating expert perspectives to validate the benefits of this new generation of LLs that must

promote principles of interdisciplinarity and rigor to specialize knowledge and develop effective, inclusive and sustainable solutions. We can create impactful strategies to mitigate the anthropogenic effects of climate change and drive positive environmental outcomes by fostering well-trained agents of change, interdisciplinary collaboration, engaging all stakeholders and leveraging these advanced LLs.

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