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Breaking the silos: integrated approaches to foster sustainable development and climate action

Oliver Lah[1,2,3*]

Abstract

A number of critical disconnects across sectors, actors continue to affect implementation action on sustainable development and climate action. Even when technical solutions, political commitments, and funding streams are avaiable, implementation often remains siloed and fragmented. This debate piece does not present definitive solutions or conclusive evidence; rather, it aims to foster critical reflection on how co-design, participatory approaches, Living Labs, and epistemically connected actor coalitions may help break down institutional and conceptual barriers. It proposes the SCALE framework [Shared epistemic foundations, Cross-sectoral integration, Adaptive co-design, Local enabling environments, and Evaluation & expansion) as way of operationalising the Safe Systems for Sustainable Development concept presented in Lah 2024, exploring how knowledge integration, iterative experimentation, and locally grounded solutuions can help creating implementation partnerships that last. This approach highlights questions concerning resource intensity, longevity, and scalability that must be addressed. By facilitating co-design, testing and validation of concrete solutions at the local level, the approach presented in this paper invites policymakers, researchers, practitioners, and civil society actors to engage in a more nuanced and constructive debate on whether, how, and under what conditions sustainable development solutions are considered to be viable and hence can endure even in politically volatile environments.

Keywords Sustainable development, Co-design, Living labs, Cross-sectoral collaboration, Participatory planning

Introduction

Despite significant international commitments, advanced technologies, and available funding dedicated to sustainable development and climate action, tangible on-the-ground progress frequently lags behind aspirations [1–3]. Multiple systemic disconnects—between sectors, among actors, and along the research–implementation continuum—often prevent interventions from delivering their full potential.

This paper is conceived as a debate piece, reflecting on experiences from innovation and implementation projects and the relevant literature. It builds on the Safe Systems for Sustainable Development concept presented earlier in this journal [4], and aims to provide some practical steps to integrate participatory methodologies in research and development cooperation projects to help bridging persistent gaps. The core argument suggests that participatory co-design in Living Labs can help creating epistemically connected coalitions of actors, offering pathways to reconcile differing policy objectives, integrate knowledge across disciplines, and enhance local

*Correspondence:
Oliver Lah
oliver.lah@un.org
[1]Urban Living Lab Center, UN-Habitat Collaborating Center, Wuppertal Institute, Chausseestr. 86, 10115 Berlin, Germany
[2]Technische Universitaet Berlin, Str. des 17. Juni 135, 10623 Berlin, Germany
[3]Urban Electric Mobility Initiative (UEMI), Kopenhagener Straße 31E 10437 Berlin, Germany

ownership. The SCALE concept—Shared epistemic foundations, Cross-sectoral integration, Adaptive co-design, Local enabling environments, and Evaluation & expansion—organizes these ideas into a coherent framework.

This paper also acknowledges uncertainties and debates surrounding these approaches. Critics have questioned the resource-intensity, feasibility of scaling, and the longevity of co-created solutions once external funding ceases [5, 6]. The intention here is not to claim a universal solution but to encourage dialogue, nuance, and foster bolder approaches when designing implementation-oriented projects. While this paper focuses mostly on the operating context of innovation and implementation projects in developing and emerging economies, the main points of a need to connect sectors and actors are applicable everywhere.

Identifying critical disconnects in sustainable development

Sustainable development and climate action are frequently hampered by structural disconnects. This paper argues that the **disconnects among actors and sectors** are the key factors that lead to siloed policy development, fragmented institutional arrangements, misaligned priorities, duplication of work and inefficient implementation.

Sustainable development initiatives and climate action efforts are often hindered by deeply rooted disconnects. These disconnects—particularly between sectors and actors—manifest as fragmented planning, misaligned priorities, and inefficient resource allocation. This chapter examines the main features of these disconnects and their resulting challenges, providing the foundation for discussing strategies to address them.

Two critical dimensions of these barriers—sectoral disconnects and actor disconnects—significantly hinder the ability of policies and initiatives to achieve intended outcomes. These disconnects represent more than operational inefficiencies; they are structural issues deeply embedded in the governance, planning, and implementation processes of sustainable development [7–9].

Sectoral disconnects: fragmentation of interdependent systems

Sectoral disconnects originate from the fragmented approach to planning and decision-making across key domains such as mobility, energy, water, housing, and urban development. Although these sectors are inherently interdependent, decision-making processes often occur in isolation, resulting in a lack of policy coherence and missed opportunities for synergy [10, 11]. Rather than forging integrated strategies, many initiatives remain siloed within sector-specific mandates, a pattern that is at odds with the multi-scalar, cross-cutting nature of sustainability challenges.

For instance, urban development projects that fail to incorporate considerations of energy efficiency or integrated mobility solutions often produce sprawling, resource-intensive cities [12–14]. Likewise, energy policies developed without acknowledging land-use planning or public transportation integration lead to suboptimal outcomes, such as reliance on carbon-intensive energy sources that entrench unsustainable patterns [3, 15]. Similarly, the water-energy-food nexus literature highlights how disconnected governance across these critical resources can create vulnerabilities and inefficiencies, underscoring the need for systemic thinking [16, 17].

Key features of sectoral disconnects

Independent planning processes

Sector-specific frameworks operate independently, leading to disjointed timelines, objectives, and resource allocations [18, 19].

Fragmented policies and objectives

Policies developed in isolation fail to consider cross-sectoral linkages, hindering holistic approaches [20, 21].

Overlooking cross-sectoral co-benefits

Potential synergies, such as integrating electric mobility with decentralized renewable energy systems, remain underexploited [3, 22].

Results of sectoral disconnects

Inefficient resource use

Suboptimal deployment of financial, human, and natural resources results from missed integration opportunities [14, 23].

Unsustainable trajectories

Disconnected planning locks in unsustainable infrastructures, making transitions to low-carbon, resilient pathways more costly and complex [24, 25].

Policy contradictions

Diverging sectoral goals yield contradictory policies—for example, promoting renewable energy while simultaneously subsidizing fossil fuel-based transport [21, 26].

The persistence of sectoral disconnects highlights the urgent need for integrative frameworks that account for the interconnected nature of sustainable development. Approaches such as multi-level governance, collaborative planning, and polycentric management systems can help align sectoral strategies, ensuring that policies reinforce rather than undermine each other [27–29].

Actor disconnects: challenges in stakeholder collaboration

Actor disconnects occur when diverse stakeholders—including governments at multiple levels, international

organizations, the private sector, civil society, and local communities—struggle to collaborate effectively. Sustainable development goals require engagement across political, social, and economic spheres, yet institutional silos, power imbalances, and limited participatory mechanisms inhibit cohesive action [30–32].

Governance structures that prioritize short-term gains or operate within narrowly defined mandates fail to accommodate the complexity of sustainability challenges [33, 34]. Moreover, limited involvement of local actors and communities often results in interventions that lack local legitimacy and effectiveness [35–37]. Efforts to enhance participatory governance and collaborative decision-making hold promise for bridging actor disconnects [38].

Key features of actor disconnects

Weak collaboration across stakeholder groups

Narrow mandates and limited cross-sectoral dialogue hinder collective action [30, 39].

Misaligned goals and fragmented governance structures

Short-term pressures and institutional fragmentation undermine long-term strategic thinking [34, 40].

Insufficient engagement of local actors

Excluding communities and civil society reduces the relevance, acceptance, and sustainability of implemented solutions [35, 36].

Results of actor disconnects

Policy misalignment

Without comprehensive stakeholder input, policies fail to reflect local conditions and priorities [31, 41].

Fragmentation and governance inefficiencies

Overlapping, conflicting mandates create confusion and hamper policy implementation [7, 38].

Wasted resources

Duplication of efforts and inadequate coordination result in inefficient use of financial and human capital [32, 42].

Implementation delays

Lack of a shared vision prolongs decision-making and impedes timely action [43].

Actor disconnects reinforce the importance of fostering robust mechanisms that facilitate collaboration, trust-building, and knowledge-sharing among diverse actors. Polycentric governance arrangements, co-production processes, and multi-level stakeholder platforms have emerged as potential pathways to align interests and resources, thereby enhancing the legitimacy and effectiveness of sustainability initiatives [27, 28, 44].

The interplay between sectoral and actor disconnects underscores the systemic complexity of sustainable development challenges. Fragmentation across sectors and stakeholders not only perpetuates inefficiencies and contradictions but also undermines long-term policy coherence and resilience. Overcoming these challenges necessitates integrative planning, transdisciplinary research, and capacity-building that link sectoral agendas with diverse actor networks [22, 45]. These challenges are summarized in the matrix below:

Key Disconnect	Main Features	Results
Sectoral Disconnects	- Lack of integration between critical sectors such as mobility, energy, and urban development. - Independent planning and decision-making processes. - Fragmentation of sector-specific policies and goals.	- Inefficient resource use and missed opportunities for synergy. - Lock-in of unsustainable trajectories (e.g., car dependency, fossil fuel reliance). - Policy contradictions and reduced effectiveness.
Actor Disconnects	- Weak collaboration among diverse stakeholders (governments, private sector, civil society, academia, and communities). - Siloed institutional structures and misaligned priorities.- Limited engagement and participation of local actors.	- Policy misalignment and fragmented governance structures.- Lack of local ownership and relevance.- Duplicated efforts and wasted resources. - Implementation delays and inefficiencies.

The disconnects outlined above create systemic barriers to achieving sustainable development goals. Policy misalignment, implementation gaps, and resource inefficiencies are not isolated problems but are deeply intertwined with the sectoral and actor disconnects. Addressing these foundational challenges requires strategic levers that bridge the gaps between sectors and actors.

This paper introduces an approach grounded in co-design processes and coalition building to tackle these disconnects. The proposed framework builds epistemically connected coalitions of stakeholders and promotes integration across sectors. Later chapters detail how these strategies can unlock synergies, enhance governance, and accelerate progress toward sustainability goals.

By establishing a clear understanding of the key disconnects, their features, and their consequences, the following chapters disnetangle the key features of the disconnects and identify practical levers to overcome them. The focus now shifts to how innovative approaches, which will be introduced in this paper and which may help overcoming these barriers to initiate systemic change.

This paper's subsequent chapters propose a strategic framework aimed at bridging these disconnects. By emphasizing co-design, coalition-building, and knowledge co-production, the framework seeks to create more inclusive and adaptive governance structures that enable sustainable transitions. Drawing on practical examples, it demonstrates how transformative, integrated approaches can lead to meaningful, enduring change.

Connecting sectors: overcoming silo approaches

Sustainable development is complex requires an integrated and coordinated approach, yet many minitries, city departments but also research communities often have a sectoral focus. However, sectors such as mobility, energy, and urban development are intrinsically interconnected, and addressing them in isolation leads to inefficiencies, conflicting policies, and missed opportunities for synergy. This fragmentation hinders progress toward sustainable development goals, particularly in developing and emerging economies where rapid urbanization and infrastructure development are taking place at unprecedented rates.

A siloed approach in the mobility sector often results in transportation systems that are inefficient, environmentally detrimental, and socially inequitable. Investments in road infrastructure without consideration for public transportation or non-motorized transport options can increase reliance on private vehicles, exacerbating traffic congestion and air pollution. Without integrating mobility planning with energy policies and urban development strategies, efforts to reduce emissions and improve mobility remain insufficient. This becomes particularly pronounced in the area of electric mobility, where mobility and energy systems are critically interdependent. Electric vehicles (EVs) not only act as energy consumers but also hold significant potential as energy storage units through vehicle-to-grid (V2G) technologies. Proper integration of EVs into energy systems can support grid stability, enhance renewable energy integration, and create opportunities for decentralized energy solutions [46, 47]. However, this potential can only be realized if mobility planning and energy infrastructure development are coordinated to enable V2G systems to thrive.

Similarly, when the energy sector operates in isolation, it may fail to account for the energy demands of urban development and transportation systems and is likely to underutilize potential. Continued reliance on fossil fuels for energy generation not only contributes to climate change but also overlooks the potential for renewable energy integration into urban and transport infrastructure. As of 2020, fossil fuels still accounted for over 80% of global energy consumption [48]. In many developing economies, the lack of coordination between energy planning and urban development leads to inadequate energy access in rapidly expanding urban areas. The United Nations estimates that approximately 759 million people globally lack access to electricity, with the majority residing in sub-Saharan Africa [49].

Urban development pursued without integrating mobility and energy considerations can result in urban sprawl, inefficient land use, and increased resource consumption. Unplanned or poorly planned urban expansion often leads to the proliferation of informal settlements lacking basic services and infrastructure. Over one billion people live in slums worldwide, primarily in developing countries [50]. These settlements are frequently disconnected from employment centers and public services, exacerbating socioeconomic inequalities and environmental degradation.

The pitfalls of a siloed approach are evident in the way infrastructure investments are made without considering cross-sectoral impacts. Investing heavily in road infrastructure without parallel investments in public transportation and non-motorized transport can lock cities into car-dependent mobility patterns. This not only increases greenhouse gas emissions but also leads to congestion and reduced urban livability. The World Health Organization [51] estimates that outdoor air pollution causes 4.2 million premature deaths annually, with transportation being a significant contributor.

Key synergies can be harnessed by connecting the mobility, energy, and urban development sectors. Integrated urban planning that combines land use with transportation planning promotes compact, transit-oriented development (TOD). TOD encourages higher-density, mixed-use developments centered around high-quality public transportation systems, reducing the need for private vehicle use and lowering emissions. Studies have shown that TOD can reduce vehicle kilometers traveled by up to 30%, significantly decreasing energy consumption and emissions [13].

Integrating renewable energy solutions into urban and transport infrastructure can further enhance sustainability outcomes. The deployment of electric vehicles (EVs), when coupled with renewable energy sources, can substantially reduce emissions from the transport sector. The global stock of electric passenger cars surpassed 10 million in 2020, a 43% increase from 2019 [48]. However, the environmental benefits of EVs are maximized when the electricity used is generated from renewable sources, necessitating coordinated planning between the energy and mobility sectors.

In developing and emerging economies, the challenges of connecting sectors are compounded by institutional fragmentation at the government level but also among development cooperation actors. Weak governance structures often lack mechanisms for cross-sectoral approaches and coordination of key actors inside and

outside the government. Ministries and agencies may operate independently, leading to policy incoherence and conflicting priorities. For instance, a transportation ministry might prioritize road expansion to stimulate economic growth, while an development cooperation agency seeks to reduce emissions, resulting in contradictory approaches.

Financial constraints limit the ability of developing countries to invest in integrated infrastructure projects. Scarce resources are often allocated to immediate needs rather than long-term planning. Dependence on external aid can further complicate matters, as donor priorities may not align with holistic local needs. Infrastructure financing needs in developing countries are estimated to exceed $1.5 trillion annually, with current investment levels falling significantly short [52].

Capacity gaps, including shortages of skilled professionals in integrated planning and sustainable technologies, hinder the implementation of cross-sectoral initiatives. The lack of reliable data and analytical tools impedes evidence-based decision-making. Rapid urbanization exacerbates these challenges. By 2050, nearly 70% of the global population is projected to live in urban areas, with 90% of this increase occurring in Asia and Africa [53]. This unprecedented urban growth places immense pressure on existing infrastructure and services.

Investment flows into mobility, energy, and urban infrastructure without a cross-sectoral perspective risk creating negative lock-in effects. Infrastructure investments are long-term commitments; once built, they shape patterns of behavior and development for decades. For example, investing in coal-fired power plants locks in high carbon emissions and deters investment in renewable energy. The 17,warns that planned investments in coal power could result in over $600 billion in stranded assets globally by 2030.

In the mobility sector, constructing highways without investing in public transportation infrastructure can lock cities into car dependency. This not only contributes to increased emissions but also undermines efforts to promote sustainable urban development. Transportation emissions have increased by 71% since 1990, largely due to increased private vehicle use in developing countries [54]. Without a shift toward integrated, sustainable mobility solutions, these trends are likely to continue.

To avoid these negative lock-in effects, investment programs must adopt a cross-sectoral perspective. Integrated planning and investment can optimize resource allocation, maximize synergies, and enhance the sustainability of infrastructure projects. Integrating renewable energy generation with urban development can provide reliable, clean energy to urban residents while reducing emissions. Distributed renewable energy systems, such as rooftop solar panels, can enhance energy access in urban areas and reduce reliance on centralized, fossil fuel-based power generation. In India, for example, the government's rooftop solar program aims to install 40 GW of rooftop solar capacity by 2022, contributing to energy access and sustainability [55].

The adoption of integrated mobility solutions, such as Bus Rapid Transit (BRT) systems and non-motorized transport infrastructure, can improve urban mobility while reducing emissions. The introduction of BRT in cities like Bogotá, Colombia, has resulted in a 40% reduction in travel times and significant decreases in CO_2 emissions [56]. Integrating these systems with urban development plans ensures accessibility and promotes equitable urban growth.

Living Labs offer a practical approach to connecting sectors and actors to address these challenges. By facilitating the co-creation, testing, and implementation of innovative solutions in real-world settings, Living Labs bridge the gaps between research and practice. They promote stakeholder engagement, enhance coordination among sectors, and support the development of context-specific solutions. The SOLUTIONSplus project exemplifies how Living Labs can be used to integrate mobility, energy, and urban development sectors in developing countries.

In Kigali, Rwanda, SOLUTIONSplus implemented an electric motorcycle project that integrates mobility and energy sectors. Collaborating with local stakeholders, including government agencies, private companies, and academic institutions, the project developed electric motorcycles suited to local needs and established a battery-swapping infrastructure powered by renewable energy. This initiative not only reduces emissions but also addresses urban mobility challenges and supports local economic development. The project has the potential to reduce CO_2 emissions by 12,000 tons annually if scaled to replace 20% of the existing motorcycle fleet [57].

In Quito, Ecuador, the project focused on integrating e-mobility solutions with urban logistics. Introducing electric cargo bikes and vans for last-mile deliveries reduces congestion and emissions in the city center. Collaborations with local businesses, government agencies, and community organizations ensure that solutions are tailored to local contexts. Initial results indicate a 60% reduction in delivery times and a significant decrease in operational costs due to lower energy and maintenance expenses [57].

The success of these initiatives highlights the importance of connecting sectors and adopting integrated approaches. Scaling up such solutions requires addressing underlying challenges in developing and emerging economies. Institutional reforms are needed to establish coordinating bodies that facilitate cross-sectoral planning. Strengthening governance structures and

enhancing policy coherence are essential steps. For instance, creating inter-ministerial committees or agencies dedicated to sustainable urban development can promote collaboration and policy alignment.

Capacity building is critical to developing the technical expertise required for integrated planning and implementing sustainable technologies. Investing in education and training programs equips professionals with necessary skills. Enhancing data collection and management systems supports evidence-based decision-making and cross-sectoral analysis. Partnerships with international organizations and knowledge institutions can facilitate capacity development. The World Bank's Global Platform for Sustainable Cities (GPSC) supports cities in developing integrated urban planning frameworks and building local capacity [58].

Innovative financial mechanisms are needed to mobilize resources for integrated projects. Blended finance, which combines public and private funds, can leverage additional resources. Public-private partnerships can bring together strengths of different sectors. International financial institutions and development agencies can support integrated projects by aligning funding criteria with sustainability goals. The Green Climate Fund (GCF) provides financing for projects that contribute to low-emission and climate-resilient development, supporting cross-sectoral initiatives [59].

Community engagement is vital to ensure that projects meet the needs of local populations and gain public support. Participatory planning processes involve communities in decision-making, enhancing the relevance and acceptability of interventions. Knowledge-sharing platforms can facilitate the exchange of best practices and lessons learned among cities and regions. The C40 Cities network enables cities to collaborate on climate action, sharing experiences and solutions [60].

Addressing the challenges of silo approaches in mobility, energy, and urban development is essential for achieving sustainable development goals. Connecting sectors unlocks synergies that enhance sustainability outcomes, improve resource efficiency, and promote social equity. In developing and emerging economies, addressing institutional fragmentation, capacity gaps, and financial constraints is crucial. Adopting integrated planning and investment strategies, supported by innovative approaches like Living Labs, can help avoid negative lock-in effects and pave the way toward sustainable, resilient, and inclusive development.

Key takeaways—connecting sectors

- Breaking down silos in mobility, energy, and urban development unlocks significant efficiency, equity, and sustainability gains.
- Integrated planning can prevent negative lock-ins and yield co-benefits, from reducing emissions to improving urban livability.
- Capacity building, financial innovation, and institutional reforms, coupled with participatory approaches like Living Labs, are vital for scaling integrated solutions in developing and emerging economies.

Connecting actors: overcoming fragmentation in development cooperation

The effective implementation of sustainable development initiatives relies heavily on the coordination and collaboration among various actors across different levels of governance. However, institutional fragmentation and the lack of coordination between sector-oriented ministries and city departments present significant challenges. This fragmentation is further compounded in the context of development cooperation, where an additional layer of international actors, including donor agencies, non-governmental organizations (NGOs), and private sector entities, operate alongside domestic governments and civil society. This chapter examines the complexities arising from the lack of collaboration and coordination among these actors, particularly focusing on sustainable energy, mobility, and urban development sectors. It highlights how these shortcomings hinder the delivery of effective outcomes and underscores the importance of cross-sectoral approaches, co-design methodologies, and coalition building.

Institutional fragmentation occurs when responsibilities and authority are dispersed among multiple organizations and levels of government without adequate coordination mechanisms [61]. In many countries, sector-oriented ministries operate in silos, focusing narrowly on their specific mandates without considering the interdependencies with other sectors. For example, the energy ministry may develop policies independently of the transportation or urban development ministries, leading to conflicting strategies and inefficiencies [62]. At the subnational level, city departments often mirror this fragmentation, with limited collaboration between departments responsible for transportation, housing, environment, and economic development [18].

The lack of coordination is not only horizontal (across sectors) but also vertical (across levels of government). Multilevel governance involves interactions among institutions at local, regional, national, and international levels [63]. However, without effective mechanisms for coordination, policies and actions at different levels may be misaligned. Local governments may struggle to implement national policies if they are not adapted to local contexts or if there is insufficient support [64]. Conversely, national governments may overlook local needs

and priorities, leading to policies that are ineffective or even counterproductive at the local level [65].

In the context of development cooperation, these challenges are exacerbated by the involvement of international actors. Donor agencies, international NGOs, and multinational corporations bring additional agendas, priorities, and procedures that may not align with those of domestic governments and local communities [66]. The proliferation of actors can lead to duplication of efforts, competition for resources, and policy incoherence [67]. Bourguignon and Sundberg [68] note that aid fragmentation increases transaction costs and strains the administrative capacities of recipient governments, which may already be limited.

Coordination among development cooperation actors is often insufficient. Donors may focus on their own projects without adequate collaboration with other donors or alignment with national development strategies [42]. This lack of coordination can result in overlapping projects, inconsistent approaches, and missed opportunities for synergy. Furthermore, development projects may fail to engage effectively with government actors, particularly at the local level. Local governments are crucial for implementing policies and programs, but they are frequently bypassed in favor of working directly with national governments or non-state actors [34].

The private sector and civil society are also essential actors in sustainable development but are often inadequately integrated into development cooperation efforts. Private sector involvement can bring innovation, investment, and expertise, yet mechanisms for engaging businesses in development initiatives are sometimes lacking or underdeveloped [69]. Civil society organizations (CSOs) can contribute local knowledge, mobilize communities, and advocate for marginalized groups, but they may be excluded from planning and decision-making processes [30].

These coordination challenges have significant implications for delivering effective outcomes, especially in the sectors of sustainable energy, mobility, and urban development. In the energy sector, for instance, the lack of collaboration between ministries responsible for energy, environment, and finance can hinder the development and implementation of comprehensive renewable energy strategies [70]. Similarly, in mobility, uncoordinated efforts between transportation departments and urban planners can lead to infrastructure that does not adequately address congestion, emissions, or accessibility [71]. Urban development projects that fail to integrate considerations from energy and mobility sectors may result in unsustainable urban sprawl, increased emissions, and reduced quality of life [14].

The design of sector-oriented implementation activities without cross-sectoral approaches perpetuates these issues. Projects focused narrowly on one sector may not consider the broader system in which they operate, leading to unintended consequences or limited impact. For example, introducing electric vehicles without addressing the energy source can simply shift emissions from the transportation sector to the energy sector if the electricity is generated from fossil fuels [6]. Therefore, cross-sectoral approaches that integrate policies and actions across sectors are essential for achieving sustainable outcomes.

Furthermore, the lack of co-design approaches and coalition building in development cooperation limits the effectiveness and sustainability of interventions. Co-design involves stakeholders in the planning and implementation of projects, ensuring that solutions are tailored to local contexts and needs [72]. Without genuine engagement with local actors, projects may lack relevance, face resistance, or fail to build local capacity [73]. Coalition building brings together diverse actors to pool resources, share knowledge, and align efforts toward common goals [74]. In its absence, fragmentation and competition among actors can undermine collective action.

The SOLUTIONSplus project provides valuable insights into how these challenges can be addressed through collaborative and integrated approaches. SOLUTIONSplus is an international initiative aimed at developing innovative e-mobility solutions in urban areas, involving a wide range of stakeholders, including local and national governments, private sector companies, research institutions, and international organizations [75]. The project adopts a Living Lab approach, creating environments where stakeholders co-create, test, and implement solutions in real-world settings.

In Kigali, Rwanda, SOLUTIONSplus facilitated collaboration between the city government, local universities, private companies, and civil society organizations to develop and deploy electric motorcycles with battery-swapping services. This approach ensured that the solutions were adapted to local needs, leveraging local knowledge and building local capacity. It also integrated considerations from the energy sector by establishing renewable energy-powered charging infrastructure, thus addressing cross-sectoral linkages [57].

In Quito, Ecuador, the project brought together actors from urban planning, transportation, and environmental sectors to develop electric cargo bikes and vans for urban deliveries. By coordinating efforts across these sectors, the project addressed issues of urban congestion, emissions, and logistics efficiency. The involvement of local businesses and community organizations in the co-design process ensured that the solutions were economically viable and socially acceptable [57].

These examples illustrate how co-design approaches and coalition building can enhance coordination among

actors, integrate cross-sectoral considerations, and lead to more effective and sustainable outcomes. They also demonstrate the importance of involving local governments, private sector, and civil society in development initiatives. By engaging these actors, projects can tap into local expertise, resources, and networks, increasing their relevance and impact.

To overcome the challenges of institutional fragmentation and lack of coordination, several strategies can be employed. Establishing formal coordination mechanisms, such as inter-ministerial committees or working groups, can facilitate communication and collaboration among sector-oriented ministries and departments [61]. Developing integrated policy frameworks that align objectives and actions across sectors and levels of government can enhance policy coherence [76].

In the context of development cooperation, harmonizing donor efforts through mechanisms like joint programming, pooled funding, or sector-wide approaches can reduce fragmentation and enhance alignment with national development strategies [42]. Engaging local governments and other local actors in the planning and implementation of development projects ensures that interventions are responsive to local needs and contexts [35]. Building partnerships with the private sector and civil society can leverage additional resources, innovation, and capacities [69].

Co-design approaches are particularly effective in fostering collaboration and ownership among stakeholders. By involving actors in the design phase, projects can build consensus, align expectations, and ensure that solutions are feasible and acceptable [72]. This approach also enhances the sustainability of interventions by building local capacity and embedding knowledge within communities [77].

Coalition building is essential for mobilizing collective action and resources. Coalitions can bring together actors with complementary strengths and resources, creating synergies and amplifying impact [74]. In the energy sector, for example, public-private partnerships can facilitate the deployment of renewable energy technologies by combining public sector support with private sector innovation and investment [6].

Connecting actors is crucial for overcoming institutional fragmentation and enhancing the effectiveness of sustainable development initiatives. The lack of collaboration between sector-oriented ministries and city departments, insufficient coordination across levels of government, and the complexities introduced by development cooperation actors pose significant challenges. By adopting cross-sectoral approaches, co-design methodologies, and coalition building, these challenges can be addressed. The SOLUTIONSplus project demonstrates the potential of such approaches to deliver effective outcomes in sustainable energy, mobility, and urban development. Engaging local governments, private sector, and civil society in meaningful ways enhances relevance, ownership, and sustainability of development interventions. As the global community strives to achieve the Sustainable Development Goals, fostering collaboration and coordination among actors across sectors and levels remains a critical imperative.

Key takeaways—connecting actors

- Overcoming institutional fragmentation and lack of coordination is essential for effective sustainable development cooperation.
- Co-design and coalition building ensure that local knowledge, capabilities, and priorities shape interventions, enhancing legitimacy and sustainability.
- Engaging diverse actors—governments, private sector, civil society—creates synergies, reduces duplication, and improves overall impact.

Connecting sectors and actors: co-design in urban living labs as tool for transformative change

The persistent shortfall between the availability of innovative technologies, political commitments, and funding on the one hand, and the limited on-the-ground implementation of low-carbon and sustainable development solutions on the other, reveals deep structural and operational disconnects. Despite decades of incremental progress and a growing body of international frameworks, policies, and incentive structures, significant challenges remain in translating well-intentioned plans and research findings into tangible, contextually relevant actions. These gaps are not merely technical but fundamentally institutional and relational, reflecting how sectors and actors fail to collaborate effectively, how policy objectives become misaligned, and how research rarely reaches practical application at scale.

The complexity and interconnectedness of sustainable development challenges—including decarbonization, resource management, social equity, and climate adaptation—demand integrated, multi-level, and multi-sectoral approaches. Rather than focusing narrowly on isolated goals, addressing today's grand challenges requires forging cross-sectoral coalitions, integrating policies to unlock co-benefits, and ensuring that a broad array of stakeholders—governments, NGOs, businesses, local communities, and academia—work together in pursuit of common interests. Traditional governance structures and development cooperation models, however, often struggle to achieve these conditions. Fragmentation, misalignment, and lack of coordination remain pervasive.

Co-design processes and participatory methodologies emerge as crucial instruments. They promise to enhance relevance, accelerate learning, and build ownership by involving all key actors early and continuously in decision-making and problem-solving. Rather than imposing top-down solutions or relying solely on external expertise, co-design embraces the complexity of local realities, contextualizing innovations so they fit the conditions on the ground. Participatory planning and design thinking approaches provide structured methods for iterative improvement, dialogue, and capacity-building, ensuring that solutions address multiple objectives and are resilient to changing circumstances.

In turn, Living Labs operationalize co-design principles in real-world settings. Acting as open innovation ecosystems, Living Labs encourage user-centric experimentation, iterative feedback, and collaborative refinement of new solutions. They bring the concepts of integrated policy-making and stakeholder engagement down to earth, allowing policies, technologies, and strategies to be tested, validated, and adapted before broader implementation. Living Labs help bridge the gap between research and implementation by situating innovation processes within communities, aligning global best practices with local priorities, and involving a wide range of actors who can champion successful outcomes.

This chapter synthesizes the findings from previous analyses of sectoral fragmentation, policy misalignment, stakeholder coordination failures, and the research-implementation divide. It also incorporates insights from extensive literature reviews on co-design, participatory methods, design thinking, and Living Labs approaches. From these discussions, a clear message emerges: connecting actors and sectors through participatory co-design processes and embedding these efforts in Living Labs can help break down policy silos, harness co-benefits, nurture coalitions, and translate potential into practice. The following sections unfold this logic, moving from the challenge of connecting diverse actors, to integrating siloed sectors, to applying participatory design and Living Labs as a route toward effective, equitable, and sustainable transformative change.

Connecting actors: building collaborative foundations

At the heart of the disconnects hindering climate action and sustainable development is the challenge of coordinating a wide array of actors. Governments, NGOs, private companies, local communities, and academic institutions each bring unique resources, interests, and capacities. Yet without mechanisms to forge alignment, these stakeholders often work at cross-purposes, pursuing narrow mandates without recognizing the bigger picture. Research [18, 78, 79] shows that participatory governance structures, collaborative planning, and inclusive decision-making processes can overcome these divides. By involving multiple stakeholders in planning and policy formation, it is possible to identify shared priorities and reduce duplication of efforts. Co-creation ensures that interventions resonate with local realities, enhancing the legitimacy and durability of outcomes [73, 80].

In development cooperation contexts, this is especially critical. Traditional models often rely heavily on international consultants and external expertise, potentially overshadowing local capacities and ignoring indigenous knowledge. Strengthening local research institutions and ensuring balanced funding allocations between international advisors and local entities fosters local ownership and empowerment. This leads to interventions that are more sustainable, as capacity remains in the region after projects end. Literature [81, 82] confirms that building local capabilities and focusing on local value creation reduce dependency on external actors, improving the long-term relevance and impact of development programs.

To connect actors effectively, therefore, funders and implementers must create structured forums, collaborative platforms, and working groups. Government agencies can support such arrangements by adjusting policies and incentive structures to encourage partnerships and knowledge-sharing. Civil society and community-based organizations can serve as conduits of local insight, ensuring that solutions are culturally appropriate and socially equitable. The private sector can bring innovation, investment, and scaling potential, while academia provides rigor, research, and methodological guidance. Co-design enables these diverse actors to find common ground and learn from each other's constraints and opportunities.

Connecting sectors: overcoming fragmentation and harnessing co-benefits

Even when actors are aligned, siloed governance and sectoral fragmentation pose another formidable barrier. Energy, transportation, urban development, agriculture, and other sectors often develop policies independently, leading to misaligned incentives and contradictory outcomes. For example, transportation policies that focus solely on road infrastructure expansion may conflict with carbon reduction targets or urban livability goals if they induce more car usage. Similarly, energy strategies that fail to consider land-use planning or resource management may miss opportunities to integrate renewables effectively or reduce urban heat islands.

Holistic strategies recognize that these goals are not competing but complementary. Properly integrating sectors can reveal co-benefits—where environmental, economic, and social objectives reinforce one another. The

literature on environmental policy integration and sustainable urban development [15, 31, 83] shows that creating cross-sectoral synergies amplifies impact. Policies that align, for instance, the deployment of electric public transport with renewable energy supply and equitable urban planning can simultaneously reduce emissions, improve air quality, advance mobility access for disadvantaged communities, and support local economic activity.

To achieve such coherence, decision-makers must adopt integrated policy frameworks and encourage inter-agency cooperation. This involves forming cross-sectoral committees or joint task forces, promoting interdisciplinary research, and investing in capacity-building that helps sectoral experts understand and appreciate other domains. Funding agencies can reward proposals that demonstrate cross-sectoral thinking and stakeholder engagement, thereby incentivizing integrated approaches. Policymakers can enact guidelines that require consultation and coordination across ministries and departments, reducing the likelihood that sectoral strategies work at cross-purposes.

In essence, connecting sectors relies on a shift from linear, siloed policy-making to adaptive, networked governance. This involves rethinking planning processes so that each sector's plans acknowledge and build upon the goals of others. By doing so, governments and their partners can identify co-benefits rather than navigate trade-offs, delivering more holistic outcomes that better serve communities and ecosystems.

Connecting sectors and actors: co-design and participatory planning as integrative vehicles

Connecting actors and connecting sectors are complementary tasks. Co-design and participatory planning methodologies offer a unifying framework that tackles both dimensions simultaneously. These approaches provide structured methods for involving stakeholders from multiple sectors and different levels of governance, ensuring that their voices are heard and integrated into solution development. Design thinking principles and iterative learning cycles encourage participants to empathize with user needs, redefine problems collectively, ideate joint solutions, prototype interventions, and refine them based on feedback [84, 85].

Co-design elevates these processes from mere consultation to genuine collaboration. Rather than presenting a finished plan for rubber-stamping, co-design sessions allow stakeholders to shape priorities, identify barriers, and uncover synergies. By harnessing diverse perspectives, co-design reduces the likelihood of unintended consequences and increases the chance that solutions are well-grounded, acceptable, and implementable.

This approach is particularly valuable when bridging the research-implementation gap. Academics and researchers, often isolated in their own spheres, can engage directly with practitioners, policymakers, local entrepreneurs, and residents. Doing so ensures that academic findings are translated into practical interventions. Simultaneously, practitioners and policymakers gain access to cutting-edge research to guide their decision-making. As a result, co-design reduces friction between theory and practice, fostering translational research that anticipates and overcomes real-world challenges.

Living labs: institutionalizing co-design and creating spaces for coalition-building

Living Labs operationalize co-design by establishing inclusive, user-driven environments for experimentation and learning. They embody the principles of participatory planning, design thinking, and iterative refinement. By situating innovation in real-life contexts—urban neighborhoods, mobility corridors, local marketplaces—Living Labs make abstract policy concepts and technological solutions tangible.

Participants in Living Labs test prototypes, monitor impacts, and provide feedback. They can witness how well integrated solutions work before committing to large-scale investments. This reduces risks and allows for early course corrections. Critically, Living Labs also function as coalition-building arenas. By enabling stakeholders to collaborate on pilot projects, trust is built, and stakeholders see first-hand the benefits of integrated strategies. As these collaborations mature, they can scale up successes, adapt lessons learned, and form longer-term networks or coalitions that endure beyond the initial projects.

Key takeaways—connecting actors and sectors through co-design and living labs

- Participatory co-design and Living Labs facilitate genuine collaboration, breaking down both actor-level and sectoral silos.
- These approaches ensure that research informs practice and that local contexts guide the adaptation of global solutions, reducing the risk of unintended consequences.
- Living Labs can serve as coalition-building platforms that foster trust, enhance local capacity, and enable scaling of successful interventions.

Bringing together actors and sectors requires methodologies that support deep collaboration. Co-design and Living Labs have gained prominence as means to develop context-specific, user-centered solutions [5, 84, 85]. Living Labs embed innovation in real-world contexts, enabling iterative feedback, rapid prototyping, and capacity building [12, 86]. By situating projects locally,

these approaches help bridge the research-implementation gap, ensuring that academic insights inform practical solutions, and that local experiences influence research agendas [82, 87]. However, these methodologies demand resources and political will. Ensuring that co-design is genuinely inclusive and not merely a box-ticking exercise remains a challenge [73, 77]. This paper encourages debate on whether and how these strategies can enhance integrated planning, local relevance, and adaptive learning where previous approaches have failed.

The SCALE concept: an integrated approach

To provide a conceptual scaffold, this paper introduces SCALE as a practical approach for the Safe Systems concept [4]:

- **S (Shared Epistemic Foundations)**: Establish common understandings among stakeholders via joint vision building, data sharing, scenario development, and active dialogue [27].
- **C (Cross-Sectoral Integration)**: Align policies and investments across sectors, reducing contradictions and ensuring synergies [15].
- **A (Adaptive Co-Design)**: Employ iterative and participatory co-creation of solutions in Living Labs, refined by user feedback [5, 85].
- **L (Local Enabling Environments)**: Build local capacities, engage communities, and support local research institutions to ensure cultural relevance and ownership [18, 35].
- **E (Evaluation & Expansion)**: Continuously monitor, evaluate, and learn, guiding iterative improvements and informed scaling [31, 88].

SCALE emphasizes epistemic alignment, sectoral integration, adaptive design, local empowerment, and continuous learning.

Operationalizing SCALE

Consider a city seeking to decarbonize its transport system while ensuring equitable access to mobility and reliable energy supply.

- **S (Shared Epistemic Foundations)**: Municipal officials, transport engineers, energy utilities, community groups, and academics develop a common understanding of current conditions through scenario modeling [13].
- **C (Cross-Sectoral Integration)**: Interdepartmental committees align urban planning with renewable energy targets, deploying EV charging powered by solar microgrids near affordable housing [89].
- **A (Adaptive Co-Design)**: A Living Lab tests e-buses and cargo bikes, refining technology and operations based on stakeholder feedback [5].
- **L (Local Enabling Environments)**: Training programs build local technical expertise and empower community-based entrepreneurs in EV servicing [35].
- **E (Evaluation & Expansion)**: Continuous monitoring of emissions, service reliability, and user satisfaction informs iterative improvements and the replication of success elsewhere [31].

Integrating the 5 I's with the SCALE concept: the SOLUTIONSplus experience

The SOLUTIONSplus project, funded by the European Union's Horizon 2020 program, provides a real-world example of applying integrated, participatory approaches to sustainable urban mobility. SOLUTIONSplus aims at developing and testing innovative e-mobility solutions in cities worldwide, involving actors from local governments, private sector companies, research institutions, and international organizations [57].

SOLUTIONSplus adopted a Five I's Framework—**Inform, Inspire, Initiate, Implement, and Impact**—to guide engagement and capacity-building activities:

1. **Inform:** Capacity-building workshops and seminars enhance stakeholder knowledge, providing them with the necessary background, data, and tools. This stage aligns with the **S (Shared Epistemic Foundations)** in SCALE. By informing stakeholders, SOLUTIONSplus fosters a common understanding and a knowledge-rich environment for decision-making.
2. **Inspire:** Successful case studies and best practices motivate stakeholders to consider integrated solutions. Inspiration resonates with **C (Cross-Sectoral Integration)** in SCALE, as exposure to holistic examples encourages actors to appreciate connections between sectors. This motivational step ensures that participants see the value of linking mobility with energy and urban planning.
3. **Initiate:** Stakeholders co-create demonstration concepts in Living Labs, reflecting the **A (Adaptive Co-Design)** dimension of SCALE. By initiating pilots, SOLUTIONSplus enables experimentation, prototyping, and iterative learning. The launch of Living Labs directly incorporates user feedback and local conditions, ensuring continuous adaptation.
4. **Implement:** Practical application of co-created solutions in real-world conditions represents a tangible manifestation of **L (Local Enabling Environments)** in SCALE. Implementation relies on building local capabilities, ensuring that

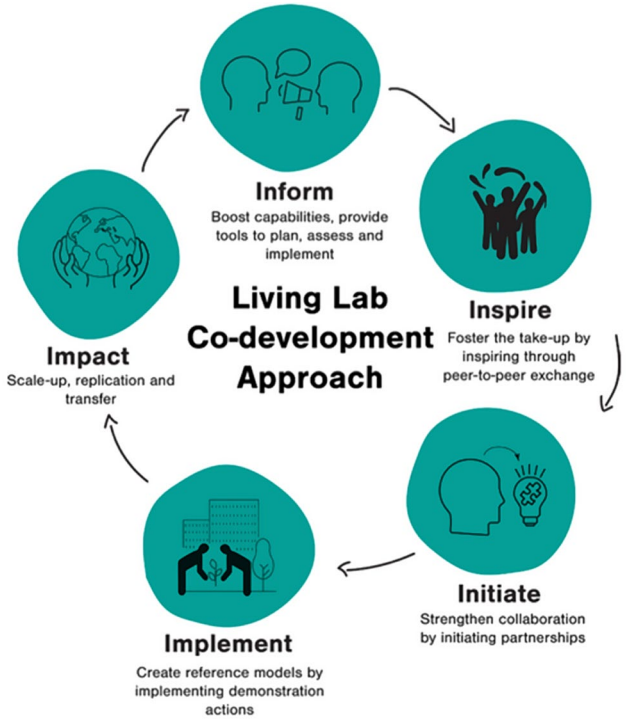

Fig. 1 SOLUTIONSplus 5Is approach (based on [86])

communities, local entrepreneurs, and municipal officials have the skills and structures to support sustainable mobility solutions.

5. **Impact:** Rigorous evaluation and dissemination of results link to **E (Evaluation & Expansion)** in SCALE. By documenting outcomes, assessing performance, and sharing lessons, SOLUTIONSplus sets the stage for scaling successful interventions and informing broader policy adjustments.

The operational steps of the 5 I's approach provide a practical structure of innovation and implementation projects to apply the SCALE framework, e.g. SOLUTIONSplus moves from information-sharing and inspiration (S and C) through adaptive co-design (A) to local enabling implementation (L) and finally to measurable impact and replication (E). These operational and conceptual frameworks provides a structured pathway: from building shared understanding and cross-sectoral recognition, to testing solutions iteratively, empowering local stakeholders, and evaluating outcomes for potential scaling.

For example, in Kigali, Rwanda, SOLUTIONSplus facilitated the co-development of electric motorcycles with battery-swapping services, powered by renewable energy [57, 86]. At the **Inform** stage, stakeholders learned about e-mobility technologies and their environmental benefits (S). **Inspiration** came from similar examples in other contexts, highlighting integrated approaches combining renewable energy and transport (C). **Initiation** occurred as Living Labs brought together local businesses, transport operators, and urban planners to prototype battery-swapping infrastructure (A). Implementation was supported by capacity-building efforts, training technicians, and adapting the technology to local conditions (L). The resulting **Impact** was assessed through monitoring frameworks that measured emissions reductions, service reliability, and user satisfaction, guiding further refinements and future expansions (E) (see Fig. 1 below).

By weaving the 5 I's into the SCALE concept, the SOLUTIONSplus project demonstrates how structured engagement sequences support integrated, adaptive, and locally resonant solutions. This combined approach moves beyond theoretical constructs, illustrating how actual projects can operationalize these principles to connect actors and sectors effectively.

Addressing challenges: scaling, longevity, and resource intensiveness

Adopting SCALE and the 5 I's integrated approach does not eliminate challenges. Co-design and Living Labs demand time, funding, and skilled facilitation [5, 84]. Sustaining efforts beyond project timelines remains critical. SOLUTIONSplus, for example, considers how local institutions can maintain and expand e-mobility solutions after the project ends, ensuring that learned capabilities persist [75].

Scaling solutions to different contexts requires adaptation rather than replication [35]. Cultural differences, institutional arrangements, and resource availability influence how interventions play out. The continuous evaluation and learning process (E) in SCALE aids this translation, as demonstrated by SOLUTIONSplus's approach of sharing lessons among partner cities to inspire adaptation rather than imposing uniform models.

Ensuring inclusivity in co-design processes is also crucial. If marginalized groups are not adequately represented, participatory approaches risk reinforcing existing power imbalances [73, 77]. Projects must design engagement strategies that specifically invite and empower underrepresented actors, a concern addressed in both the 5 I's (Inform and Inspire stages to broaden participation) and SCALE (L, building local capacity and inclusivity).

Implications for policymakers, funding agencies, implementers, and academia

Policymakers

Policymakers can institutionalize frameworks that encourage multi-stakeholder engagement, cross-sectoral planning, and iterative learning. Mandating that projects align with SCALE principles and adhere to the 5 I's approach can help embed integrated thinking in routine governance [31, 90].

Funding agencies

Donors and development banks can prioritize proposals that demonstrate both SCALE and the 5 I's steps, ensuring projects invest in capacity building, shared knowledge creation, and adaptive co-design before large-scale implementation [42, 59].

Implementers (governments, NGOs, private sector)

Project managers and practitioners can adopt the 5 I's sequence to gradually build trust, knowledge, and adaptive capacity. By using Living Labs and co-design, implementers can deliver outcomes that reflect local realities and align with SCALE principles [5, 86].

Academia

Researchers can work with practitioners to ensure translational research supports problem-solving. Interdisciplinary teams can produce decision-support tools and indicators that guide integrated approaches. Academic institutions can also assist in training and curriculum development to embed participatory methods and systems thinking into professional education [82, 87].

Institutionalizing change and multiplying impact

The ultimate goal is to move from isolated successes to mainstreaming integrated, adaptive, and locally grounded strategies. Demonstration effects—such as those from SOLUTIONSplus Living Labs—can inspire other cities and funders to adopt similar approaches [91, 92].

Over time, as stakeholders witness tangible improvements—lower emissions, better mobility access, robust local economies—the political and social capital supporting integrated strategies grows [1, 3]. The combination of SCALE principles and the 5 I's engagement sequence offers a structured method for ongoing evolution rather than a static model.

This paper emphasizes that SCALE and the 5 I's are not endpoints. They are simple approaches to operationalise complex transformation processes in action-oriented innovation and implementation projects. The SOLUTIONSplus example provides a glimpse into how these concepts work, but further debate is encouraged to refine these frameworks for wider applicability.

Conclusion

Persistent disconnects—sectoral fragmentation, policy misalignment, stakeholder coordination failures, and research-practice divides—continue to constrain sustainable development and climate action. Recognizing these issues is a start, but addressing them requires innovative frameworks and methodologies.

This debate piece suggests that participatory co-design, Living Labs, and epistemically connected actor coalitions provide potential pathways to integrate sectors, engage actors, and ensure local relevance. By introducing the SCALE framework and linking it with the 5 I's approach as demonstrated in SOLUTIONSplus, this paper offers a conceptual guide to structuring engagement, knowledge integration, and iterative learning. However, uncertainties remain. Resource constraints, scaling challenges, and equity concerns persist. Rather than presenting a universal formula, this paper encourages stakeholders to engage in further debate, test these ideas, and adapt them to their contexts.

The complexity of sustainable development and climate action demands flexible, context-sensitive, and evolving approaches. By critically examining these frameworks and refining them, the global community can move closer to achieving the holistic, equitable, and enduring progress envisioned in international sustainability goals and climate commitments.

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Author contributions

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This research project did not require ethics approval and consent to participate as it did not involve human subjects or sensitive data.

Consent for publication

This research project did not contain any individual person's data in any form.

Competing interests

The authors declare no competing interests.

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Publisher's Note

Oliver Lah coordinates the Urban Urban Living Lab Center, a UN-Habitat Collaborating Center co-hosted by Technical University Berlin, Wuppertal Institute for Climate Environment and Energy and Massachusetts Institute of Technology. He is the director of the Urban Electric Mobility Initiative and an Adjunct Professor at the Blekinge Institute of Technology (BTH). Prior to that Oliver worked with UN-Habitat, UN Environment, UNDP, OECD/ITF and GIZ on urban mobility and climate change issues. He was a lead author for the Fifth IPCC Assessment Report, was a member of the Habitat III Policy Unit on Urban Services and Technology and worked at the Ministry of Transport of New Zealand and the Minister of State to the German Federal Chancellor. Oliver holds a Bachelor of Art in History from Humboldt University, a Bachelor of Arts with Honours in Political Science and a Master of Environmental Studies from Victoria University of Wellington and a PhD in Urban Ecology from Technical University Berlin.