

Community-funded environmental innovation as a new university governance trend

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Abstract

Community-funded environmental innovation (CFEI) represents an emerging governance model in which universities and local communities co-finance, co-design, and co-implement sustainability projects, shifting communities from passive beneficiaries to active co-investors. This paper defines CFEI, situates it within the broader rise of university-community partnerships, and examines its potential to integrate teaching, research, operations, and civic engagement. A systematic Scopus search was conducted, requiring the simultaneous presence of “community-university partnerships,” “community-based research,” and “community-based participatory research” in titles, abstracts, or keywords, yielding 648 peer-reviewed articles spanning 2000–2025. The analysis identified five core characteristics of CFEI—shared funding mechanisms, participatory governance, co-creation of solutions, embedded learning environments, and local sustainability impact, and mapped its evolution through a sharp increase in relevant publications after 2010. Empirical evidence shows that CFEI enhances student leadership, provides experiential “living-lab” settings, and generates context-specific innovations that strengthen regional resilience. However, persistent barriers include fragmented institutional efforts, limited senior-management support, and insufficient resources for sustained partnership work. The study highlights ongoing debates over power-sharing, trust-building, and the measurement of partnership success. Findings suggest that whole-institution alignment, integrated planning, and supportive governance structures are essential to scale CFEI and advance Sustainable Development Goals through equitable, community-driven environmental innovation.

Keywords: University governance, Institutional Transformation, Sustainability Innovation, Smart City Governance, Environmental Innovation.

1. Introduction

Universities stand at a critical juncture in their relationship with society. Facing escalating environmental challenges, calls for greater civic accountability, and demands to address the Sustainable Development Goals, higher education institutions are increasingly expected to move beyond traditional teaching and research roles to become active agents of sustainability transformation [1, 2, 3, 4]. Yet conventional top-down university governance structures, wherein institutional leaders set priorities and communities implement recommendations, have proven insufficient for catalyzing systemic environmental change [5]. An emerging alternative is reshaping how universities engage with local stakeholders: community-funded environmental innovation (CFEI), a governance model wherein universities and communities jointly finance, design, and implement sustainability projects, positioning communities not as passive beneficiaries but as co-investors in environmental solutions [6, 7].

Community-funded environmental innovation is embedded within the broader framework of university-community partnerships, which have become recognized as essential

mechanisms for fostering social innovation, building community capacity, and advancing sustainable development [5]. Within this ecosystem, CBPR and community-based research approaches have emerged as methodological foundations that prioritize co-production of knowledge, shared decision-making, and integration of academic expertise with lived community experience [5]. These partnerships promise to enhance social capital, overcome social exclusion, and empower marginalized groups by creating platforms for joint problem-solving and knowledge creation [5]. However, a comprehensive understanding of how CFEI specifically operates as a governance trend—and how it differs from related collaborative approaches—remains limited in the scholarly literature.

The importance of clarifying CFEI lies in its distinctive characteristics. Unlike traditional university-community partnerships that may be unidirectional or episodic, CFEI is defined by distributed leadership, shared resource mobilization, and active community participation in sustainability-oriented innovation processes. Funding mechanisms span community micro-grants, volunteer labor, in-kind contributions, and co-financing initiatives that enable genuine co-ownership [8, 9]. Furthermore, CFEI integrates teaching, research, operations, and civic engagement—functioning as a whole-institution approach that embeds community priorities into curricula, transforms universities into hubs for experiential learning, and positions students as key agents of local sustainability transitions [8, 9].

Recent research highlights the growing importance of university-community partnerships in driving sustainability transitions and reshaping contemporary governance [1]. Yet significant gaps remain. How prevalent is CFEI in contemporary university practice? What are the enabling conditions and barriers to successful implementation? How do universities measure the success and sustainability of these partnerships? And what institutional competencies and structures are required to move from isolated initiatives to systemic, whole-institution alignment?

To address these questions, this paper pursues three primary objectives: first, to provide a clear conceptualization of community-funded environmental innovation and differentiate it from related collaborative frameworks; second, to map the scholarly landscape of community-university partnerships through a systematic Scopus-based literature review, examining trends, debates, and research directions; and third, to synthesize empirical evidence on the enablers, barriers, and impacts of CFEI as a governance trend, with implications for universities, communities, and policymakers. By grounding our analysis in a rigorous examination of 648 peer-reviewed articles on community-based participatory research and university-community partnerships, we seek to establish CFEI as a distinct and increasingly vital governance approach for achieving equitable, locally rooted environmental innovation.

2. Defining community-funded environmental innovation

A clear and consistent conceptualization of community-funded environmental innovation is essential for interpreting its significance within contemporary university governance and sustainability transitions. Grounded in recent research on university–community

partnerships, social innovation, and participatory governance, this term captures an emerging form of collaborative environmental action that is reshaping how universities engage with society [1, 6, 7].

Community-funded environmental innovation refers to a governance model in which universities and local communities jointly finance, design, and implement environmental projects aimed at addressing shared ecological and socio-economic challenges. Unlike traditional top-down university governance structures, this model is defined by distributed leadership, shared resource mobilization, and active community participation in sustainability-oriented innovation processes. Funding mechanisms may include community micro-grants, volunteer labor, in-kind contributions, philanthropic engagement, or co-financing initiatives that enable communities to act not merely as beneficiaries but as co-investors in environmental transformation.

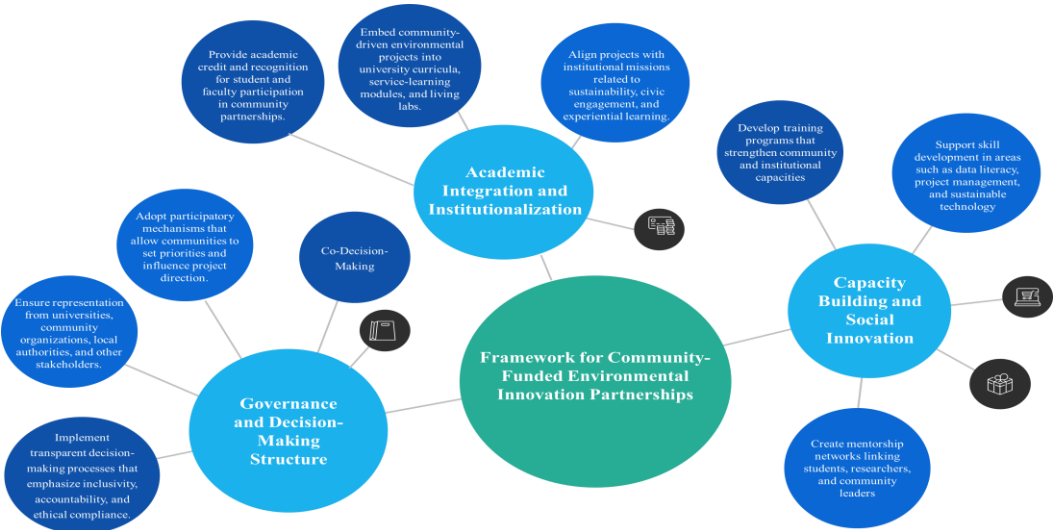


Fig. 1. Key characteristics of community funded environmental innovation partnership
Source: Own

This governance trend is embedded within the broader framework of university–community partnerships, which are collaborative efforts that mobilize academic resources, expertise, and knowledge to foster social innovation, strengthen community capacity, and promote sustainable development. Such partnerships help overcome social exclusion, enhance social capital, and empower marginalized groups by creating platforms for co-production of knowledge and joint problem-solving. Through initiatives such as Community Research Awards (CRA) and community-based research (CBR), universities support community-inspired research agendas, while students and researchers develop transferable competencies—including leadership, ethics, communication, and public engagement [5].

Within this ecosystem, community-funded environmental innovation serves as a practical manifestation of whole-institution sustainability approaches, integrating teaching,

research, operations, and civic engagement. It embeds community priorities into curricula, transforms universities into hubs for experiential learning, and positions students as key agents of local sustainability transitions. These collaborations bridge the gap between academic knowledge and real-world environmental challenges, fostering context-specific solutions grounded in both scientific evidence and lived community experience.

Table 1. Key features of community-funded environmental innovation

Feature	Description
Shared funding mechanisms	Communities contribute financial or material resources to university-linked environmental projects, enhancing co-ownership and legitimacy.
Participatory governance	Decision-making authority is distributed among universities and community stakeholders rather than centralized within academic hierarchies.
Co-creation of solutions	Environmental challenges are jointly defined and addressed, integrating scientific knowledge with local expertise and lived experience.
Embedded learning environments	Projects often function as sustainability living labs, enabling student participation and experiential education.
Local sustainability impact	Initiatives target context-specific environmental issues, strengthening regional resilience and community engagement and also integrating local cultural aspects.
Innovation orientation	Emphasis on novel practices, technologies, or social arrangements that enhance environmental and social outcomes.

3. Recent advances in university–community partnerships for contemporary university governance and sustainability transitions

Recent research highlights the growing importance and complexity of university–community partnerships in driving sustainability transitions and shaping contemporary university governance. These partnerships are increasingly recognized as essential for achieving the Sustainable Development Goals (SDGs), fostering social innovation, and embedding sustainability within higher education institutions (HEIs). University–community partnerships are pivotal in advancing sustainability initiatives, supporting SDG implementation, and catalyzing regional and societal transformation. Effective partnerships enable universities to act as engines of change, connecting research, teaching, and community engagement to address complex sustainability challenges [2, 3, 4, 7]. Case studies from diverse contexts demonstrate that such collaborations can empower both academic and non-academic actors, expand human capabilities, and co-produce transdisciplinary knowledge for just and sustainable transitions.

Table 2. Conceptual comparison table

Aspect	Community-Funded Environmental Innovation	University–Community Partnerships	Community-Based Research	Social Innovation in Higher Education	Sustainability Governance
Community financial participation	Yes	No/Yes	No	No	No
Co-production of knowledge	Yes	Yes	Yes	Yes	Yes/No
Shared decision-making	High	Medium/High	Medium	Medium	Medium
Focus on local sustainability challenges	High	Medium	Medium	Medium	Medium/High
Integration into curricula	Yes/No	Yes	Yes	Yes	Yes
Student leadership and agency	High	Medium	Medium	Medium	Medium
Emphasis on innovation	High	Medium	Medium	High	Medium
Whole-institution alignment	Medium	Low/Medium	Low	Low	High

3.1. Emerging trends associated with university–community partnerships for contemporary university governance and sustainability transitions

To further explore emerging trends associated with university–community partnerships for contemporary university governance and sustainability transitions and related concepts, an advanced literature search was conducted using the Scopus database. The search strategy included titles, abstracts, and keywords. The database query was constructed to identify peer-reviewed journal articles that explicitly examine community–university partnerships through the lens of community-based research and community-based participatory research (CBPR). To ensure conceptual precision and thematic relevance, the search string required that all retrieved publications include references to community–university partnerships, community-based research, and community-based participatory research within the title, abstract, or keywords fields. This triple-condition requirement ensured that only studies integrating these three core concepts appeared in the final dataset. Community–university partnerships constitute the structural and relational context within which CBPR is implemented. Including this term ensured that studies explicitly address collaborative arrangements and governance dynamics between academic institutions and community stakeholders. Community-based research is a foundational methodological framework underlying CBPR. Applying this filter, we identified studies where communities played an active role in research design, implementation, or decision-making—consistent with PRISMA’s requirement to align search terms with the review’s core concepts. CBPR represents a specific participatory methodology central to the review’s aims. Restricting results to literature referencing

CBPR ensures that included studies align with the principles of co-production, shared governance, and participatory knowledge creation.

To further refine the search, the query was limited to journal sources, thereby excluding conference papers, books, editorials, notes, and other non-peer-reviewed formats. This restriction ensured that all results were grounded in scholarly research subject to rigorous academic review. Journals typically subject submissions to peer review, increasing the reliability and validity of included studies.

In addition to the mandatory title/abstract/keyword conditions, the query incorporated a series of controlled vocabulary filters (EXACTKEYWORD) intended to capture publications explicitly aligned with participatory and community-engaged research traditions. These included established descriptors such as Community-based participatory research, Participatory research, Participatory action research, Community participation, Community engagement, Community-based research, Community-institutional relations, and Participatory approach. The inclusion of broader terms such as Community and Community care helped ensure that relevant participatory or partnership studies using alternative terminology were not overlooked.

Taken together, the query reflects a highly targeted and methodologically rigorous search strategy. By simultaneously requiring references to community–university partnerships, community-based research, and CBPR—and by applying layered keyword, source-type, and document-type filters—the search isolates a body of literature that directly engages with participatory, collaborative research models situated within university–community relationships. This approach ensures that resulting studies are deeply relevant to examining the mechanisms, processes, and outcomes of participatory governance, co-production of knowledge, and socially engaged scholarship within higher education contexts.

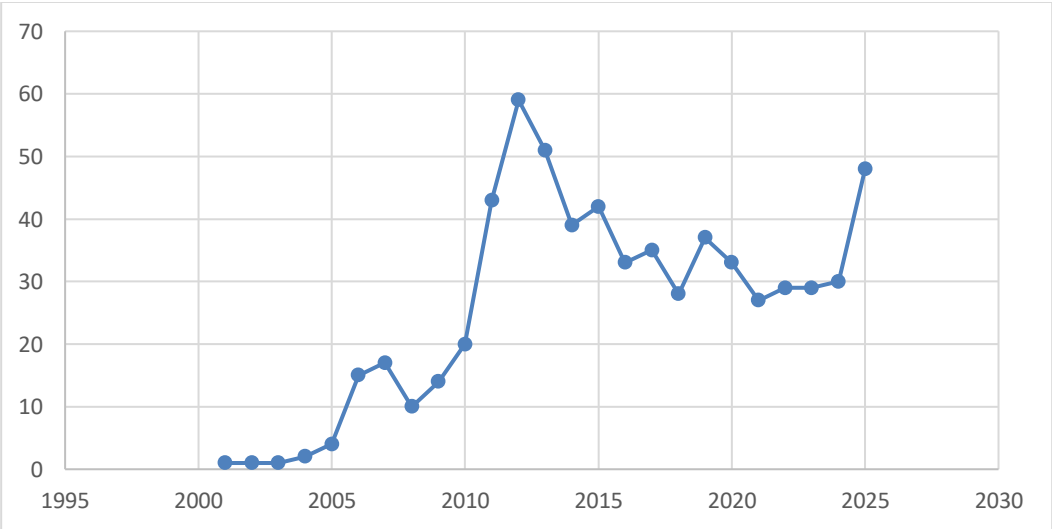


Fig. 2. Documents (by year) written on the subject of community-based participatory research.
Source: Scopus Analyze tool according to own query search (n=648)

If we looked only at community-based participatory research limited to environmental science, we observed in Figure 3 how the 715 peer-reviewed documents retrieved from Scopus from 2000 to 2025 are spread across academic subject areas.

This figure reveals that even within an “Environmental Science” limited search, the literature spans more than 13 distinct subject areas. This disciplinary breadth is not incidental but rather, it provides empirical evidence that community-funded environmental innovation and CBPR demand genuinely transdisciplinary approaches.

As we observe that Environmental Science (47%) is the foundational anchor and comprises nearly half the literature, confirming that ecological knowledge and sustainability science form the core of CBPR-based environmental initiatives. However, the presence of 53% of articles from other disciplines demonstrates that environmental challenges cannot be resolved through ecological expertise alone.

Medicine (23%) and the health-environment nexus are substantially represented and reflect that environmental problems are simultaneously health problems. Pollution, water contamination, and climate impacts directly affect public health outcomes. Within co-creation frameworks, environmental scientists and health professionals have to jointly define environmental challenges. For example, a contaminated watershed becomes an ecological degradation issue and a public health crisis simultaneously. This co-definition ensures that solutions address both ecosystem restoration and community health protection. [10], [11].

Social Sciences (12%) and the governance-equity dimension presence signals that understanding community behavior, governance structures, power dynamics, and socioeconomic inequities is essential for environmental innovation. Co-creation mechanisms require that social scientists contribute to problem-framing from the outset, ensuring that solutions address not only biophysical environmental concerns but also questions of justice, participation, and equitable benefit distribution. There is increasing emphasis on developing core competencies for equitable partnerships, such as democratic leadership, inclusive decision-making, and capacity to address identity and inequities [12], [13], [14], [8].

Agricultural and Biological Sciences (4%), Energy (3%), and Earth Sciences (3%) clusters reflect specific environmental domains like food systems and land use (agriculture), energy transitions (energy), and geoscientific processes (Earth sciences). Their collective presence demonstrates that co-creation extends across multiple environmental problem-spaces. A community-funded project addressing urban-rural sustainability [15, 16, 17, 18], for example, simultaneously engages agricultural scientists (crop systems) [19, 20], energy experts (renewable transitions) [21, 22], and earth scientists (soil and water resources) [23, 24]. Co-creation ensures these perspectives are integrated rather than siloed.

Economics (1%), Engineering (1%), and Computer Science (2%) signal emerging frontiers in CBPR-based environmental innovation: economic valuation of ecosystem services and community benefits, technical design and implementation of solutions, and

digital tools for participatory engagement. Their minimal representation may indicate that integration of these areas into CBPR remains underdeveloped—a gap consistent with the identified barrier of fragmented efforts within universities. Overcoming barriers requires integrated planning and cross-sectoral cooperation.

The interdisciplinary composition of Figure 3 becomes meaningful only through understanding how the co-creation of solutions operationalizes transdisciplinary integration. Rather than environmental scientists defining the problem and other disciplines offering ancillary insights, co-creation requires that communities and all relevant disciplines jointly frame environmental challenges from the outset. A water quality issue becomes simultaneously environmental, medical, social, agricultural, and economic.

Multi-stakeholder knowledge synthesis that CBPR and related approaches challenge traditional notions of knowledge production by emphasizing co-creation, mutual learning, and the integration of diverse knowledge systems. Environmental scientists, hydrological data, physicians, health impact assessments, social scientists, equity analyses, and community members' lived experience all contribute equally to understanding and solving the problem. Community-funded environmental innovation serves as a practical manifestation of whole-institution sustainability approaches, integrating teaching, research, operations, and civic engagement. When universities embed co-creation into their structures, rather than treating it as an isolated initiative, disciplines are forced to work in concert. Students from environmental science, medicine, engineering, and social sciences engage simultaneously in shared problem-spaces, enabling cross-disciplinary competency development.

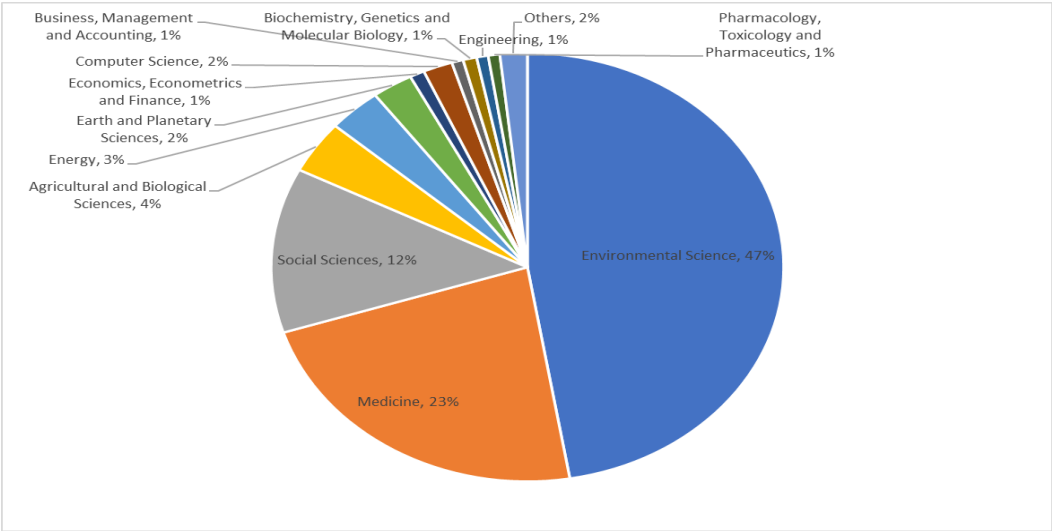


Fig. 3 Documents by subject area (n=715)
Source: Scopus Analyze tool according to own query search

Integrating 47% environmental science with 53% from other disciplines requires mechanisms for bridging epistemological differences. Trust-building is repeatedly

identified as essential for partnership sustainability. Environmental scientists must trust social scientists' understanding of equity, engineers must trust community members and contextual knowledge, and economists must recognize the value of qualitative social data. Core competencies such as democratic leadership and inclusive decision-making enable practitioners across disciplines to navigate these differences. Anyway, it is mandatory to find a solution to overcome the disciplinary fragmentation. Because a persistent challenge in university-based environmental innovation we have to acknowledge is fragmented efforts, when departments pursue sustainability in isolation. Common barriers include a lack of senior management support, fragmented efforts, and insufficient resources. Overcoming these requires integrated planning and cross-sectoral cooperation. Figure 3 interdisciplinary composition suggests that successful CBPR and CFEI initiatives demand structural mechanisms that force integration of shared funding, participatory governance structures, and co-created solutions that no single discipline can achieve alone. Because contemporary environmental innovation is fundamentally interdisciplinary, with Environmental Science complemented by Medicine, Social Sciences, Engineering and numerous other fields. However, this disciplinary diversity only becomes productive through co-creation mechanisms embedded in CBPR and community-funded environmental innovation frameworks. Co-creation transforms disciplinary differences from potential sources of fragmentation into integrative strengths, ensuring that environmental solutions are ecologically sound, health-promoting, socially equitable, economically viable, and culturally meaningful—simultaneously.

4. Research methodology

The empirical foundation of this paper rests on a systematic literature search conducted in the Scopus database. The search strategy required the simultaneous presence of “community-university partnerships,” “community-based research,” and “community-based participatory research” in titles, abstracts, or keywords, filtered to peer-reviewed journal articles published between 2000 and 2025, yielding a final corpus of 648 articles. A second search restricted to the Environmental Science subject area retrieved 715 documents for the bibliometric subject-area analysis. Controlled vocabulary filters (EXACTKEYWORD) were applied to capture publications aligned with participatory and community-engaged research traditions, including descriptors such as community-based participatory research, participatory action research, community participation, and community-based research. This triple-condition requirement ensured that only studies explicitly integrating all three core concepts were included, consistent with PRISMA guidelines for systematic reviews. Figures 3 and 4 present the resulting bibliometric outputs, including annual publication trends and disciplinary distribution across the corpus.

5. Theoretical linkages

Recent research on CBPR, participatory action research, and community–university partnerships highlights both significant progress and ongoing debates, especially regarding sustainability, environmental innovation, and institutional transformation.

A central debate concerns how to achieve genuine power sharing and equitable participation between academic and community partners. Trust-building is repeatedly

identified as essential for partnership sustainability and systemic transformation, but research also notes the need to study why and how trust sometimes fails, leading to partnership breakdowns and community mistrust [12] [13], [14], [8], [9]. There is increasing emphasis on developing core competencies for equitable partnerships, such as democratic leadership, inclusive decision-making, and the capacity to address identity and inequities [13], [14].

There is no consensus on how to define or measure the success and sustainability of CBPR partnerships. Sustainability is seen as both the continuation of partnership work and the maintenance of relationships, with capacity building at multiple levels being crucial [8], [9], [10], [11]. The field is moving toward developing validated instruments and frameworks to assess partnership outcomes, but challenges remain in capturing long-term and systemic impacts [9], [11].

Academic institutions increasingly recognize the value of CBPR and community-engaged research, but institutional support, resources, and incentives often lag behind. While leadership may support these approaches in principle, practical barriers such as lack of funding, insufficient training, and limited integration into university governance persist [14], [25], [26]. There is a call for transforming institutional structures to better support community leadership and sustained engagement [14], [25], [26].

CBPR and related approaches challenge traditional notions of knowledge production by emphasizing co-creation, mutual learning, and the integration of diverse knowledge systems. This shift raises questions about whose knowledge is valued, how research agendas are set, and how findings are disseminated and used for social change [27], [28], [29], [30]. The debate extends to the role of technology and participatory tools in facilitating engagement and action, especially in sustainability and climate initiatives [31].

Table 3. Table summarizing current research directions and debates in CBPR and related fields.

Research direction	Description	Citations
Core competencies for equitable partnerships	Focus on skills like democratic leadership, inclusivity, and capacity building	[13], [14], [26]
Institutional transformation for sustainability	Developing tools and policies to embed CBPR in university governance and practice	[14], [25], [26]
Measuring long-term impact and sustainability	Creating validated frameworks and instruments for partnership evaluation	[8], [9], [10], [11]
Technology-enabled participatory methodologies	Using digital tools to enhance engagement in climate action and sustainability	[31]
Addressing diversity, equity, and inclusion	Adapting CBPR for marginalized groups and diverse contexts, including disability justice	[13], [821]
Financial and resource management in partnerships	Understanding how funding and resource allocation affect partnership dynamics and outcomes	[32]

The field is moving toward greater clarity on competencies, sustainability, and institutional change, but debates about power, equity, and the democratization of knowledge remain central. Future research is likely to focus on developing robust evaluation tools, transforming institutional cultures, and leveraging technology for participatory sustainability initiatives.

6. Interdisciplinary perspectives and empirical foundations for environmental innovation as a university governance trend

Environmental innovation is increasingly recognized as a key trend in university governance, driven by interdisciplinary collaboration and empirical research. Universities are central actors in fostering sustainable development, with innovation emerging through integrated approaches across disciplines, collaborative governance, and institutional leadership.

Interdisciplinary perspectives offer important insights into the ways universities can foster effective environmental innovation. Effective environmental innovation in universities relies on collaborative governance models that integrate diverse disciplines (e.g., economics, engineering, social sciences) and stakeholders (academia, industry, government, community). These models emphasize knowledge sharing, leadership, and institutional design as critical for generating innovative solutions [33], [34], [35].

In parallel, interdisciplinary work on learning and social-ecological networks underscores the central role of collective learning processes and the co-production of knowledge in advancing sustainability transitions. By integrating learning theories with transition studies, researchers have demonstrated how innovative practices emerge, circulate, and become embedded within complex university systems. Such perspectives draw attention to the dynamic interactions between actors, institutions, and ecological contexts that shape the trajectory of environmental change [35], [36].

Furthermore, universities are increasingly positioned within open innovation ecosystems that extend beyond traditional academic boundaries. Through collaboration with industry, governmental bodies, and civil society, universities contribute to digital transformation, regional development, and the advancement of sustainable practices. The “quintuple helix” framework has become particularly influential in this regard, as it conceptualizes innovation as an outcome of synergies among academia, industry, government, community actors, and the natural environment. This model supports more inclusive, responsible, and ecologically attuned innovation cycles, reinforcing the university’s role as a key agent in broader socio-environmental change [34].

Table 4. Table summarizing interdisciplinary and empirical insights on environmental innovation in university governance

Empirical focus	Key findings	Citations
Global university practices	Successful cases show that leadership, whole-institution approaches, and transdisciplinary initiatives are vital for sustainability innovation.	[37], [38], [39]
Barriers and enablers	Common barriers include a lack of senior management support, fragmented efforts, and insufficient resources. Overcoming these requires integrated planning and cross-sectoral cooperation. Environmental regulation, green finance, and supportive institutional environments significantly stimulate green innovation.	[38], [39], [40], [41], [15], [42], [834], [44], [45]
Social and governance dimensions	Inclusive leadership, gender equity, and stakeholder engagement are increasingly recognized as essential for sustainable university governance.	[46]

7. Community-Funded Environmental Innovation (CFEI) as a smart city governance mechanism

7.1. CFEI as a smart city governance mechanism

Community-Funded Environmental Innovation (CFEI) can be conceptualized as a concrete governance mechanism within contemporary smart city agendas, as it operationalizes three fundamental principles of smart governance: citizen participation, data-informed decision-making, and collaborative, cross-sectoral implementation. Within smart city initiatives (e.g., India, Germany, Switzerland), public authorities are increasingly expected to transition from traditional top-down infrastructure provision towards participatory and digitally supported governance models that directly embed citizens in planning and implementation processes [47, 48, 49].

Smart city strategies in Europe and beyond explicitly emphasize: (1) the establishment of dedicated smart city teams and cross-departmental coordination structures, (2) the definition and monitoring of clear objectives through key performance indicators (KPIs), and (3) the systematic involvement of citizens and businesses to ensure social legitimacy [47]. Within this framework, CFEI aligns closely with these institutional requirements by creating structured processes through which citizens and local organizations co-design, co-finance, and co-implement environmental solutions—such as green infrastructure, low-carbon mobility systems, and circular economy initiatives—while municipal authorities provide regulatory, technical, and digital support.

Smart city initiatives further emphasize that citizen participation is not merely an optional component but a fundamental precondition for effective and legitimate urban transformation [49]. Active public involvement contributes to conflict reduction, enhances accountability, and ensures alignment between projects and actual societal needs, particularly when supported by information and communication technologies (ICT) and e-governance tools [49]. In this context, CFEI operationalizes participatory governance by transforming citizens into co-investors and co-owners of environmental innovation, thereby moving beyond symbolic or “ceremonial participation” towards substantive and

decision-relevant engagement [49]. The six root cause clusters identified in the Problem Tree (Annex A) – spanning governance deficits, financial constraints, capacity gaps, digital barriers, territorial inequalities, and cultural factors – confirm that ceremonial participation is not merely an attitudinal problem but a structural one, requiring the systemic intervention that CFEI is designed to provide.

Concurrently, smart city strategies increasingly rely on experimental and iterative formats—such as living labs, pilot districts, climate quarters, and innovation hubs—to test solutions under real-world conditions. These initiatives function as platforms for experimentation and collective learning, as well as intermediaries for knowledge exchange and funding allocation [50]. CFEI projects can be structured as localized living labs, in which neighborhoods or rural communities implement and test interventions—such as urban greening, nature-based stormwater management, energy-efficient retrofits, or 15-minute city solutions—through iterative processes informed by citizen feedback [51].

Within this framework, co-creation emerges as a central organizing principle of CFEI. Citizens, public administrations, private actors, academic institutions, and non-governmental organizations collaboratively define problems, design solutions, mobilize financial resources, and evaluate outcomes. This approach responds directly to calls within the smart city literature to move beyond technocentric paradigms and incorporate social transformation, participation, and sustainability as integral dimensions of “smartness” [47, 50].

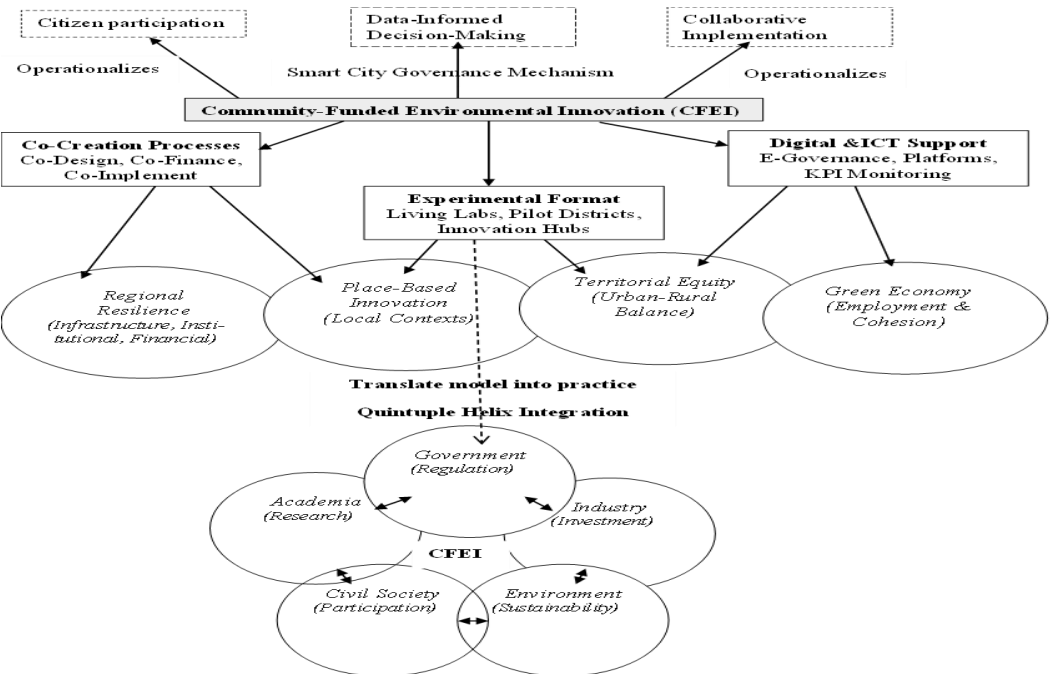


Fig. 4. The CFEI governance mechanism within the smart city framework
Source: Own

The CFEI Governance Mechanism (Figure 4) visualizes how CFEI operationalizes the three core smart city governance principles: citizen participation, data-informed decision-making, and collaborative implementation. The upper tier shows CFEI as the central mechanism flanked by Co-Creation Processes (co-design, co-finance, co-implement) and Digital and ICT Support (e-governance, platforms, KPI monitoring), implemented through Experimental Formats such as living labs, pilot districts, and innovation hubs. These mechanisms produce four regional development outcomes: Regional Resilience, Place-Based Innovation, Territorial Equity, and Green Economy. At the base, the Quintuple Helix diagram maps CFEI as the operational core linking Government, Academia, Industry, Civil Society, and Environment. This figure should be read alongside the Problem Tree (Annex A) and Objective Tree (Annex B), which map the root cause clusters that CFEI addresses and the measurable outcomes it targets.

7.2. CFEI's contribution to regional development

7.2.1. Strengthening regional resilience

Smart and sustainable urban concepts—such as 15-minute cities, smart villages, and green city initiatives—highlight the importance of decentralized and locally embedded solutions in enhancing resilience to systemic shocks, including pandemics, climate change impacts, and infrastructure disruptions [51, 50].

CFEI contributes to regional resilience through multiple mechanisms. First, it enhances infrastructure resilience by supporting community-funded green infrastructure—such as urban trees, permeable surfaces, and small-scale water retention systems—which can complement or partially substitute conventional grey infrastructure for climate regulation, runoff management, and flood mitigation, often at lower cost [52].

Second, it strengthens institutional resilience by embedding collaborative funding mechanisms and participatory decision-making processes, thereby fostering trust, civic capacity, and long-term cooperation among stakeholders [47, 49].

Third, it improves financial resilience by combining community contributions with municipal, regional, or European funding sources, thus diversifying financial structures and reducing dependence on single funding streams or political cycles [48, 50].

7.2.2. Supporting Place-Based Innovation and Territorial Innovation Systems

Contemporary smart city and smart region frameworks emphasize the need for place-based strategies that adapt digital and environmental solutions to specific local socio-economic and ecological contexts [48, 50]. For example, in Moldova, adapting smart initiatives to smaller urban and rural areas is essential for bridging the rural–urban divide [50].

CFEI is inherently place-based, as project agendas emerge from the priorities of local stakeholders—such as dust mitigation, riverbank protection, neighborhood green spaces, or local cycling infrastructure [52]. This bottom-up approach, combined with co-funding mechanisms, facilitates the development of territorial innovation systems in which

municipalities, citizens, SMEs, and knowledge institutions collaboratively generate and disseminate context-specific solutions [16, 50].

By linking multiple localized initiatives within broader territorial frameworks, municipalities can transform fragmented projects into coherent regional strategies aligned with smart city roadmaps and sustainability objectives [47, 48, 50].

7.2.3. Reducing Urban–Rural Disparities

Smart city programs may inadvertently reinforce urban–rural disparities when innovations are concentrated in major urban centers [50]. In response, smart village frameworks emphasize scalable, affordable technologies and strong community engagement adapted to rural contexts [50].

CFEI provides a practical mechanism to extend environmental innovation beyond metropolitan areas. In rural contexts, it can support climate-smart agriculture, decentralized renewable energy, and community-based natural resource management. In intermediate urban areas, it can facilitate green mobility, circular economy initiatives, and climate-resilient public spaces [50].

By enabling communities of different sizes to engage in participatory innovation and co-funding mechanisms, CFEI contributes to reducing territorial inequalities in access to sustainable and smart solutions [50].

7.3. *Expanding the development dimension of CFEI*

7.3.1. *Economic development and green employment*

Localized, low-carbon urban models—such as 15-minute cities—demonstrate that sustainable urban development can generate employment opportunities while strengthening local economies [51].

CFEI produces comparable economic effects by generating employment in environmental services, construction, maintenance, and digital support through investments in green infrastructure and circular economy initiatives [52, 51]. Furthermore, improvements in urban attractiveness and quality of life contribute to increased economic activity and property values [51].

Additionally, as smart cities increasingly rely on highly skilled professionals, CFEI generates demand for environmental engineers, data analysts, and social innovation practitioners, reinforcing the role of cities and regions as hubs of knowledge-based innovation [53].

7.3.2. *Social cohesion and responsible urban consumption*

Inclusive governance and participatory urban development are widely recognized as key drivers of social cohesion and trust [47, 49, 51].

CFEI contributes to these outcomes by bringing together diverse stakeholders—residents, SMEs, civil society organizations, and educational institutions—to collaboratively design

and manage projects [47, 49]. It also enables marginalized groups to influence environmental priorities when inclusion mechanisms are effectively implemented [49].

Moreover, literature on urban sustainability highlights the importance of promoting responsible consumption behaviors [54]. By supporting community-led initiatives that reduce pollution and promote circular practices, CFEI transforms citizens into active participants in sustainable development processes [54].

7.4. CFEI within the quintuple helix model

The quintuple helix model conceptualizes innovation as emerging from interactions among academia, government, industry, civil society, and the natural environment. CFEI can be interpreted as an operational mechanism that integrates these dimensions through co-funded environmental initiatives.

Universities contribute through research, evaluation, and capacity building; governments provide institutional frameworks and regulatory support; private sector actors contribute innovation and investment; civil society ensures participatory governance; and environmental considerations guide project design and evaluation [53, 47, 48, 49, 50].

By structuring governance processes and funding mechanisms to involve all five subsystems, CFEI translates the quintuple helix model into practical implementation at the urban and regional levels [48, 50].

7.5. Policy implications for smart cities and regions

Municipalities seeking to adopt CFEI should integrate it into existing smart city strategies, establish dedicated governance structures, implement transparent participatory processes, and develop blended financing mechanisms combining public, private, and community resources [47, 48, 49, 50]. The six objective clusters of the CFEI Objective Tree (Annex B) – governance, financial, knowledge and capacity, technological, territorial, and cultural – provide a structured framework for translating these recommendations into measurable institutional actions, directly addressing each root cause cluster identified in Annex A. Monitoring and evaluation should be supported through KPIs and data-driven approaches capturing environmental, social, and economic outcomes [47, 48]. Local governments play a central coordinating role, while regional agencies and European policy frameworks can provide additional support through funding, standardization, and inter-municipal cooperation [47, 48, 50].

7.6. Digital and smart technologies in CFEI

To ensure alignment with smart city and smart region agendas, digital tools and data-driven governance mechanisms must be integrated into CFEI. Digital platforms can support idea generation, project management, transparency, and performance monitoring, while citizen engagement tools enhance inclusivity and responsiveness [47, 48, 49].

Data-driven decision-making, supported by KPIs and monitoring systems, enables evidence-based evaluation and continuous learning, transforming CFEI into an adaptive governance mechanism consistent with smart city principles [47, 48].

By embedding digital infrastructure, participatory tools, and performance evaluation systems, CFEI strengthens the operationalization of smart governance and links participatory innovation with measurable sustainability outcomes [47, 48, 49].

8. Conclusions and future research directions

Community-funded environmental innovation represents a critical governance trend in contemporary higher education, fundamentally reshaping how universities engage with society to address sustainability challenges. The evidence from the peer-reviewed articles in the Scopus database confirms that university–community partnerships centered on participatory governance, shared resource mobilization, and co-created solutions are increasingly recognized as essential for achieving sustainable development and driving institutional transformation.

A central finding is that successful environmental innovation requires genuine interdisciplinary and transdisciplinary integration. The subject-area distribution across Environmental Science (47%), Medicine (23%), Social Sciences (12%), and other disciplines demonstrates that environmental challenges demand simultaneous input from multiple knowledge systems. However, disciplinary diversity alone does not guarantee effective innovation but rather, co-creation mechanisms must explicitly integrate these perspectives through joint problem definition, shared decision-making, and equitable knowledge synthesis.

The research also identifies a critical paradox: while academic institutions increasingly recognize the theoretical value of community-based participatory research and community-engaged scholarship, practical barriers persist. Fragmented institutional efforts, insufficient funding, limited training, and inadequate integration into university governance structures undermine even well-intentioned initiatives.

Overcoming these barriers requires whole-institution alignment—ensuring that community-funded environmental innovation is embedded across teaching, research, operations, and civic engagement rather than remaining isolated within specific programs or departments.

Trust-building between academic and community partners emerges as foundational yet fragile. While trust is repeatedly identified as essential for partnership sustainability and systemic transformation, research also reveals that trust sometimes fails, leading to partnership breakdowns and justified community skepticism of extractive academic engagement. Future success depends on moving beyond trust-building rhetoric toward concrete institutional mechanisms that distribute power, resources, and decision-making authority to communities.

Research in community-funded environmental innovation should prioritize the following emerging areas:

1. Developing validated frameworks for measuring partnership outcomes and sustainability

There is currently no consensus on how to define or measure the success and sustainability of CBPR or CFEI partnerships. Future research must develop and validate instruments that capture not only immediate project outputs but long-term systemic impacts, including changes in institutional policy, community capacity, and environmental outcomes. Research should employ longitudinal designs to understand how partnerships sustain themselves beyond initial funding cycles and how institutional learning persists.

2. Understanding power dynamics and equity in co-creation processes

While co-creation is increasingly championed, limited evidence exists on how power imbalances between academics and communities are actually negotiated, resolved, or perpetuated within participatory processes. Research should examine whose knowledge is ultimately valued in decision-making, how conflicts between scientific and community expertise are resolved, and whether procedural participation translates into meaningful influence over project outcomes. Future studies should interrogate the conditions under which genuine power-sharing occurs and the institutional barriers that prevent it.

3. Integrating technology and digital tools into participatory environmental governance

There is growing recognition that digital tools and participatory technologies can enhance engagement, particularly for climate action and sustainability initiatives. However, research on how to ensure equitable access to these tools, prevent digital exclusion of marginalized groups, and design technology that serves community priorities (rather than imposing academic preferences) remains underdeveloped.

4. Embedding CFEI within institutional governance and reward structures

Current research identifies that institutional barriers limit CFEI uptake, but future work must develop practical strategies for transforming university policies, funding mechanisms, promotion criteria, and accountability systems to genuinely reward and sustain community-engaged research. This includes examining how to align CFEI with accreditation standards, performance metrics, and disciplinary reward systems that currently privilege traditional research outputs.

5. Expanding CFEI to marginalized and underrepresented communities

Future research should examine how CFEI principles can be adapted for historically excluded groups, including disabled communities, indigenous populations, and economically disadvantaged neighborhoods. This requires culturally responsive methodologies and understanding how intersecting inequities (race, class, disability, immigration status) shape both environmental challenges and partnership dynamics.

6. Understanding the role of financial mechanisms in partnership equity

Understanding how funding and resource allocation affect partnership dynamics and outcomes remains underdeveloped. Research should examine whether community co-funding mechanisms genuinely enhance equity or reproduce existing resource inequalities, and how to design financing structures that support community leadership rather than reproducing academic or welfare communities' dominance.

7. Bridging disciplinary silos through co-creation

Future research should document and analyze how successful co-creation processes integrate diverse disciplines (as evidenced by Figure 3 interdisciplinary composition) and identify institutional innovations that facilitate cross-disciplinary collaboration within universities. This includes examining whether disciplinary structures and incentives inhibit the collaborative governance models essential for environmental innovation.

Our recommendations for academics and researchers

1. Establish partnerships through extended dialogue with communities before defining research questions. Allow community priorities to shape research agendas rather than seeking community participation in predetermined academic agendas.
2. Invest in developing and demonstrating competencies in democratic leadership, inclusive decision-making, conflict resolution across epistemologies, and the capacity to address identity-based inequities. Recognize these skills as essential research competencies, equivalent to technical expertise.
3. Contribute to the field's understanding by openly examining when and why partnerships break down, rather than only publishing success stories. This transparency advances collective learning and prevents communities from experiencing repeated patterns of failed engagement.
4. We need to design curricula and research projects that require simultaneous engagement across disciplinary boundaries. Position students as agents of systems change who can navigate and synthesize diverse knowledge systems.

Recommendations for Public Institutions and Universities

1. Establish whole-institution alignment for community-engaged sustainability by moving beyond isolated programs, integrating community-funded environmental innovation into institutional governance, policy, operations, and accountability systems. This will ensure alignment across teaching, research, community engagement, and campus operations.
2. Create dedicated funding streams for community-partnered research and modify promotion, tenure, and evaluation criteria to reward community-engaged scholarship equally with traditional research outputs. Remove institutional barriers that currently penalize academics investing time in genuine partnership-building and co-creation.
3. Provide mandatory training in participatory methodologies, community engagement ethics, and equitable partnership practices for all faculty and students engaged in community-partnered work. Develop policies to ensure that communities hold decision-making authority (not merely advisory roles) in university-community initiatives. Create accountability mechanisms ensuring that the community voice shapes institutional priorities. Finally, establish institutional structures and funding mechanisms that deliberately require interdisciplinary and cross-sectoral collaboration, explicitly designed to overcome fragmented efforts.

Community-funded environmental innovation, grounded in principles of participatory governance and co-creation, represents a necessary evolution in how universities contribute to sustainability transitions. The growing interdisciplinary and international scholarship documenting these approaches confirms their relevance. However, translating this scholarly consensus into institutional practice requires deliberate, sustained commitment to restructuring power, resources, and incentive systems. The gap between rhetorical endorsement of community engagement and institutional transformation remains significant. Closing this gap demands that academics, researchers, and public institutions move beyond incremental adaptations toward fundamental reconfiguration of how universities understand their role in society and how they organize knowledge production, learning, and change-making for sustainable and equitable futures.

Annex A: Problem Tree – Root Causes and Effects of Top-Down, Fragmented Governance

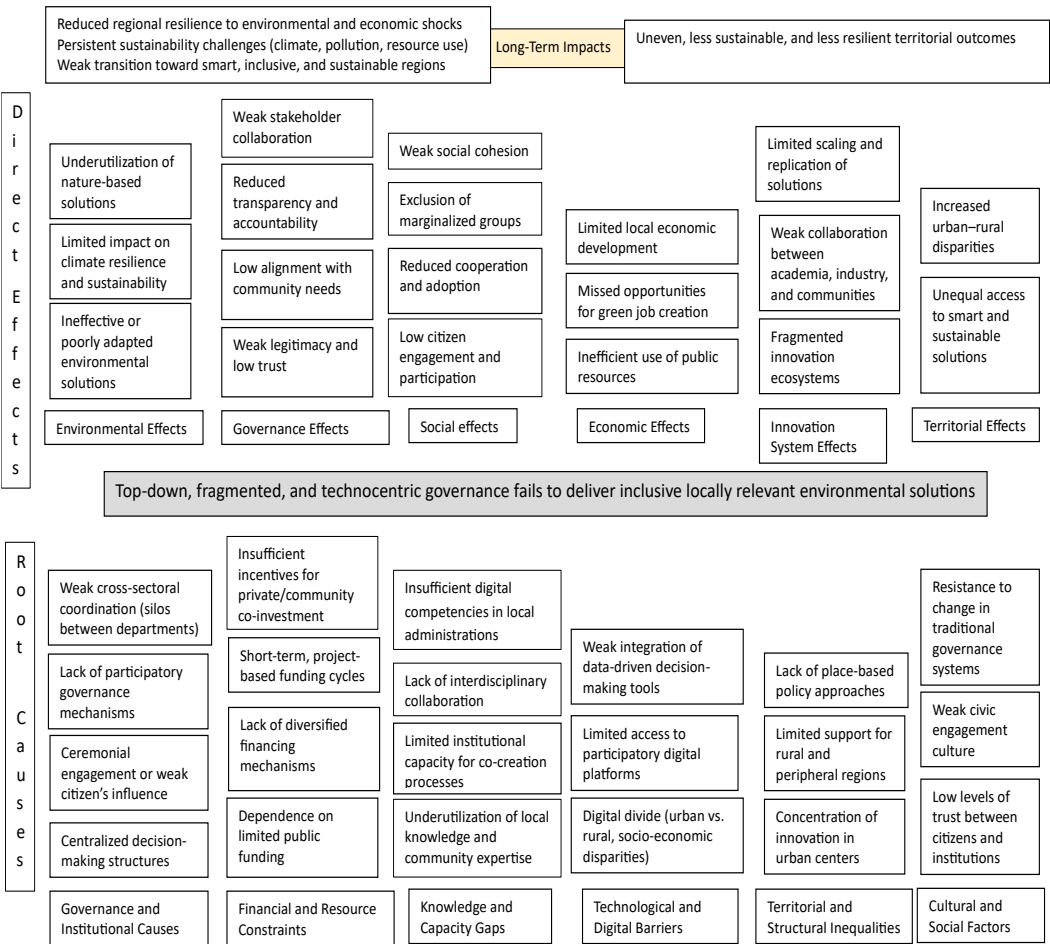


Fig. A1. Problem Tree: Root Causes and Effects of Top-Down, Fragmented Governance (Source: Own)

The Problem Tree (Figure A1) presents a structured diagnostic of why top-down, fragmented, and technocentric governance fails to deliver inclusive, locally relevant environmental solutions. Six root cause clusters are identified: (1) Governance and Institutional Causes – including lack of participatory mechanisms, ceremonial engagement, and centralized decision-making; (2) Financial and Resource Constraints – including short-term project-based funding cycles and insufficient incentives for community co-investment; (3) Knowledge and Capacity Gaps – including underutilization of local expertise and lack of interdisciplinary collaboration; (4) Technological and Digital Barriers – including the digital divide and weak data-driven decision-making integration; (5) Territorial and Structural Inequalities – including concentration of innovation in urban centers and absence of place-based policy; (6) Cultural and Social Factors – including low citizen–institution trust and resistance to governance change. These root causes generate six direct effect clusters (environmental, governance, social, economic, innovation system, and territorial) and three long-term impact categories: reduced regional resilience, persistent sustainability challenges, and entrenched social and territorial inequalities.

Annex B: Objective Tree – CFEI Goals, Results, and Means

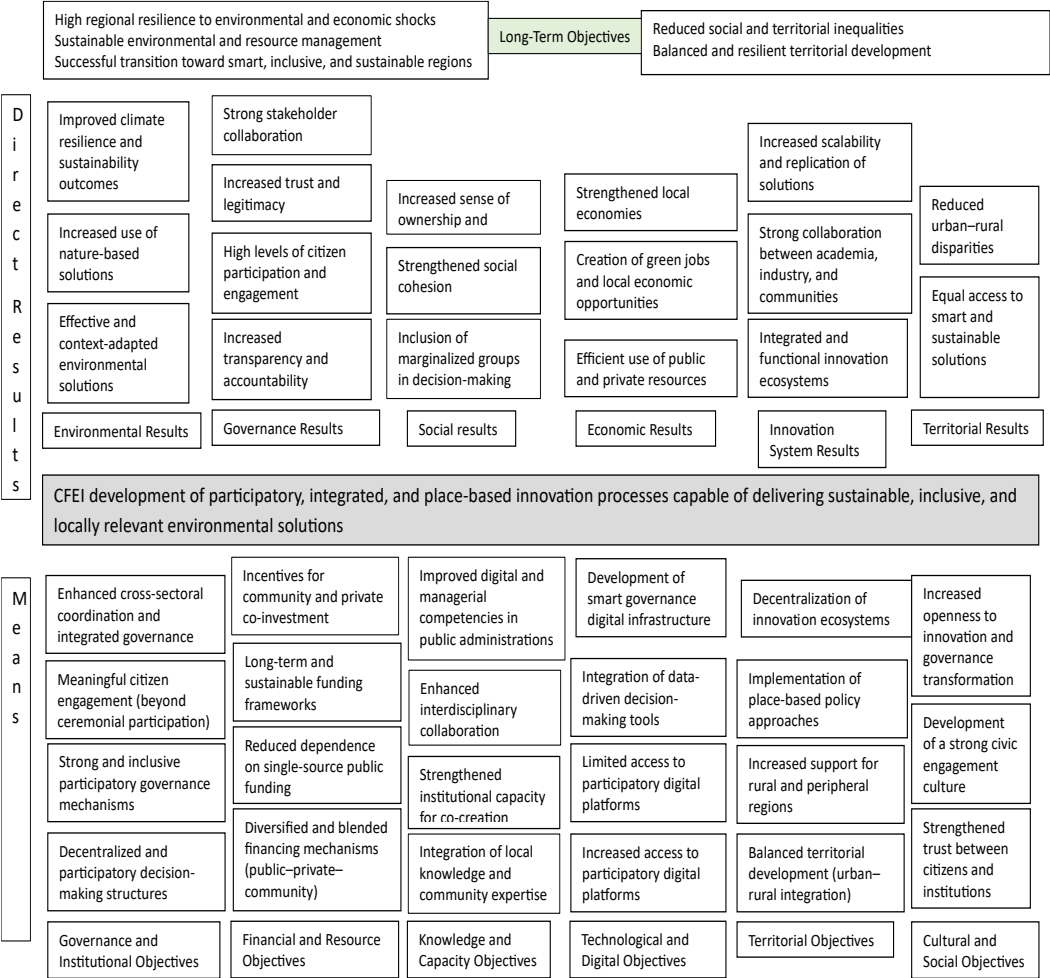


Fig. A2. Objective Tree: CFEI Operational Goals, Results, and Means
(Source: Own)

The Objective Tree (Figure A2) presents the positive transformation of each element from the Problem Tree into the corresponding CFEI goals, direct results, and means of implementation. The central objective is the development of participatory, integrated, and place-based innovation processes capable of delivering sustainable, inclusive, and locally relevant environmental solutions. Six clusters of means are defined (Governance and Institutional Objectives; Financial and Resource Objectives; Knowledge and Capacity Objectives; Technological and Digital Objectives; Territorial Objectives; Cultural and Social Objectives), each corresponding directly to a root cause cluster in Annex A. Direct results include improved climate resilience, increased trust and legitimacy, high citizen participation, strengthened local economies, integrated innovation ecosystems, and equal access to smart solutions. Long-term objectives include high regional resilience,

sustainable resource management, and a successful transition toward smart, inclusive, and sustainable regions

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