From green transition to local sustainability: The role of locality and territorial embeddedness

A zöld átmenettől a helyi fenntarthatóságig: a lokalitás és a területi beágyazottság szerepe

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ABSTRACT: The green transition is increasingly framed through decarbonisation, technological innovation and regulatory change, yet these approaches do not by themselves explain why comparable sustainability policies generate different outcomes across territories. This paper develops locality as an analytical dimension of sustainability. Locality is defined here not simply as the local administrative scale, but as the territorial embeddedness of sustainability processes: the way place-specific environmental conditions, institutions, knowledge, social relations and actor capacities shape how sustainability objectives are interpreted, coordinated and implemented. The study asks two questions: through which mechanisms does locality affect sustainability transitions, and how are these mechanisms reflected in contemporary climate-adaptation governance and territorial evidence? The argument integrates regional science, institutional economics, social capital theory and the geography of sustainability transitions. It identifies local knowledge, stakeholder participation, social capital, transaction-cost reduction, territorial learning and adaptive capacity as the principal mechanisms linking territorial embeddedness to sustainability outcomes. Empirically, the paper uses a layered exploratory design. It first examines ISO 14092 as an institutional framework for local climate adaptation. It then codes 65 projects from the EU Mission on Adaptation to Climate Change using six locality-related dimensions and compares their territorial patterns. Finally, a Hungarian survey of 100 valid ICT-sector SME responses is used as a limited territorial illustration, focusing on regional differences in planned sustainability and climate innovation.

The evidence does not establish locality as a causal determinant; rather, it shows convergence across conceptual, institutional and empirical levels. Place-specific conditions systematically enter adaptation through knowledge, participation, learning and governance capacity, while European projects display differentiated territorial pathways rather than a uniform transition model. The Hungarian evidence similarly indicates regional variation, although the survey was not designed to measure locality directly. The paper therefore proposes locality as a complementary fifth dimension of sustainability: a relational and multi-scalar condition that connects universal

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sustainability goals with the territorial capacities through which they are realised. For international policy and research, the implication is not to privilege the local over higher scales, but to design multi-level sustainability governance that is sensitive to territorial diversity while enabling learning and coordination across places.

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KULCSSZAVAK: zöld átmenet; lokalitás; területi beágyazottság; fenntarthatóság; klímaadaptáció; regionális reziliencia; helyalapú fejlesztés

ABSZTRAKT: A zöld átmenetet egyre gyakrabban a dekarbonizáció, a technológiai innováció és a szabályozási változások keretében értelmezik, ezek azonban önmagukban nem magyarázzák, hogy hasonló fenntarthatósági szakpolitikák miért vezetnek eltérő eredményekhez különböző térségekben. A tanulmány a lokalitást a fenntarthatóság elemzési dimenziójaként értelmezi. A lokalitás itt nem egyszerűen a helyi közigazgatási szintet jelenti, hanem a fenntarthatósági folyamatok területi beágyazottságát: azt, ahogyan a helyspecifikus környezeti feltételek, intézmények, tudás, társadalmi kapcsolatok és szereplői kapacitások alakítják a fenntarthatósági célok értelmezését, koordinációját és megvalósítását. A tanulmány két kérdésre keresi a választ: milyen mechanizmusokon keresztül hat a lokalitás a fenntarthatósági átmenetekre, és miként jelennek meg ezek a mechanizmusok a kortárs klímaadaptációs kormányzásban és a területi tapasztalatokban? Az érvelés a regionális tudomány, az intézményi közgazdaságtan, a társadalmi tőke elmélete és a fenntarthatósági átmenetek földrajza eredményeit kapcsolja össze.

A területi beágyazottságot a fenntarthatósági eredményekkel összekötő fő mechanizmusok a helyi tudás, az érintettek részvétele, a társadalmi tőke, a tranzakciós költségek csökkentése, a területi tanulás és az adaptív kapacitás. Empirikusan a tanulmány rétegzett, feltáró kutatási elrendezést alkalmaz: először az ISO 14092 szabványt vizsgálja a helyi klímaadaptáció intézményi kereteként, majd az EU Klímaváltozáshoz való alkalmazkodás missziójának 65 projektjét kódolja hat, lokalitáshoz kapcsolódó dimenzió mentén, végül egy 100 érvényes válaszból álló magyar IKT-kkv-felmérés regionális különbségeit mutatja be a tervezett fenntarthatósági és klímainnovációk terén. A bizonyítékok nem igazolják a lokalitást önálló oksági tényezőként, de fogalmi, intézményi és empirikus szinten egyaránt konvergenciát jeleznek. A tanulmány ezért a lokalitást a fenntarthatóság kiegészítő, ötödik dimenziójaként javasolja: olyan relációs és többszintű feltételként, amely az általános fenntarthatósági célokat összekapcsolja azokkal a területi kapacitásokkal, amelyek révén e célok megvalósulnak. A szakpolitikai következtetés nem a helyi szint elsődlegessége, hanem a területi sokféleségre érzékeny, többszintű fenntarthatósági kormányzás szükségessége, amely egyúttal támogatja a térségek közötti tanulást és koordinációt.

Introduction

Climate change, biodiversity loss and socio-economic inequalities have intensified the search for sustainability transitions that are not only technologically feasible but also territorially effective. Comparable policies frequently produce different outcomes across places because environmental exposure, institutional capacity, knowledge, networks and development trajectories are unevenly distributed.

Regional science and place-based development research have long treated this spatial differentiation as fundamental (Barca 2009; McCann, Rodríguez-Pose 2011; Pike, Rodríguez-Pose, Tomaney 2017; Rodríguez-Pose 2018). The geography of sustainability transitions has reached a similar conclusion: transitions are institutionally embedded, multi-scalar and geographically uneven rather than spatially neutral (Coenen, Benneworth, Truffer 2012; Hansen, Coenen 2015). Recent climate-policy work likewise stresses that mitigation potential, vulnerability and adaptive capacity vary across territories (OECD 2023).

Against this background, the paper uses locality in a specific analytical sense. Locality does not denote a fixed administrative level, nor does it imply that local action is inherently superior to national or transnational governance. It refers to the territorial embeddedness of sustainability processes: the interaction of place-specific environmental conditions, institutions, knowledge, social relations and actor capacities through which sustainability objectives are interpreted and implemented. Locality is therefore relational and multi-scalar. A municipality, region or local business network is shaped by connections to actors, rules and resources operating at other scales, while retaining territorially specific capacities and constraints.

The study has two objectives. First, it develops a conceptual argument for treating locality as a complementary fifth dimension of sustainability alongside ecological, economic, social and temporal considerations. Second, it examines whether the mechanisms implied by this concept - local knowledge, stakeholder participation, social capital, lower coordination costs, territorial learning and adaptive capacity - are visible across different forms of climate and sustainability governance. Accordingly, the paper asks: (1) through which mechanisms can territorial embeddedness influence sustainability transitions; and (2) how are these mechanisms reflected in an international adaptation standard, European adaptation projects and a limited Hungarian territorial illustration?

The research follows a layered exploratory design rather than a single causal test. The conceptual framework is confronted with three types of evidence. ISO 14092 is examined as an institutional expression of local adaptation governance; 65 EU Mission Adaptation projects are coded using six locality-related dimensions to identify recurrent territorial patterns; and a 2022 Hungarian ICT-sector SME survey is used selectively to illustrate regional variation in sustainability and climate-innovation intentions. These sources differ in purpose and evidential strength, so convergence across them is interpreted as analytical support for the framework, not as proof that locality independently causes sustainability outcomes.

The paper proceeds from concept to mechanism and then to evidence. The second section defines locality and positions it within sustainability and transition research. The third section specifies the governance mechanisms linking territorial embeddedness to sustainability. The fourth section considers ISO 14092, the fifth section analyses the EU Mission Adaptation portfolio, and the

sixth section presents the Hungarian territorial illustration. The final section discusses the international relevance, limits and policy implications of the proposed framework.

Locality as the fifth dimension of sustainability

Classical sustainability conditions

Sustainability has traditionally been interpreted through ecological, economic and social dimensions (WCED 1987). Daly (1991) formulated ecological conditions concerning renewable resource regeneration, substitution for non-renewable resources and the assimilative capacity of ecosystems. Opschoor (2000) subsequently emphasised temporal compatibility and intergenerational responsibility. These dimensions specify important sustainability goals and constraints, but they say less about the territorial conditions under which such goals are translated into action. Table 1 summarises the extension proposed here.

Table 1: The fifth dimension of sustainability
A fenntarthatóság ötödik dimenziója

Sustainability Condition	*Main Dimension*	*Key Contributor*
Renewable resource regeneration	Ecological	Daly (1991)
Non-renewable resource substitution	Ecological	Daly (1991)
Assimilative capacity of ecosystems	Ecological	Daly (1991)
Intergenerational and temporal compatibility	Temporal	Opschoor (2000)
Locality and territorial embeddedness	Territorial / locality	Szalmáné Csete & Szlávik (2024)

Source: Authors' elaboration based on Daly (1991), Opschoor (2000) and Szalmáné Csete, Szlávik (2024)

The proposed extension is not intended to place geography alongside ecology as another substantive sustainability target. Rather, locality captures an implementation condition: ecological, economic, social and temporal objectives are pursued through territorially differentiated institutions, knowledge systems and actor relations.

From place-based development to the geography of sustainability transitions

Place-based development research rejects spatially neutral policy assumptions and argues that development trajectories depend on local assets, institutions, governance capacities and agency (Barca 2009; McCann, Rodríguez-Pose 2011; Pike, Rodríguez-Pose, Tomaney 2017; Rodríguez-Pose 2018). Sustainability-

transition research has increasingly incorporated the same concern. Coenen, Benneworth and Truffer (2012) identify territorial institutional embeddedness and multi-scalar relations as central to understanding why transitions unfold differently across space, while Hansen and Coenen (2015) show that place-specificity and inter-organisational geographies shape transition processes. This literature is important for the present argument because it moves beyond a simple local-versus-global distinction: local transition processes are embedded in wider networks, policies and flows.

This territorial perspective is also visible in climate governance. The OECD (2023) defines a territorial approach as integrating place-based perspectives into national and subnational climate policy and stresses that mitigation opportunities, climate impacts and vulnerabilities differ across territories. The implication is not that every sustainability challenge should be localised, but that universal objectives require context-sensitive combinations of scales, actors and instruments.

Defining locality and territorial embeddedness

In this paper, locality is defined as the territorial embeddedness of sustainability processes: the extent to which their design and implementation are shaped by place-specific environmental conditions, institutional arrangements, knowledge, social relations and actor capacities. Territorial embeddedness refers to the anchoring of actors and practices in these place-specific structures, while locality denotes the analytical dimension through which this embeddedness affects sustainability governance.

Three clarifications are essential. First, locality is not synonymous with administrative decentralisation: territorially embedded action may involve municipalities, regions, firms, civil-society organisations and higher-level institutions. Second, locality is relational and multi-scalar, because local actors depend on external knowledge, finance, regulation and networks. Third, locality is not normatively beneficial by definition. Local networks can reduce coordination costs and mobilise knowledge, but they may also reproduce exclusion, weak capacity or lock-in. The analytical question is therefore how territorial embeddedness changes the conditions for sustainability action, not whether the local scale is inherently preferable.

This definition connects regional science with research on social capital, adaptive governance and resilience. Local knowledge can improve contextual understanding; social networks and trust can support collective action; and territorially embedded institutions can facilitate learning and adaptation (Ostrom 1990; Putnam 1993; Folke 2006). Locality thus complements the ecological, economic, social and temporal dimensions by specifying where and through which territorial capacities sustainability objectives become operational. The next section develops these mechanisms more explicitly.

Local governance, social capital and transaction costs

Local governance and sustainability

The growing recognition of locality in sustainability research has directed increasing attention towards the role of local governance. Sustainability transitions and climate adaptation are implemented through interactions among public authorities, businesses, civil society organisations and local communities. Consequently, governance arrangements at the local level significantly influence the effectiveness of sustainability policies and adaptation strategies.

Local governance extends beyond formal governmental structures and encompasses networks of actors involved in collective decision-making and resource management. In this context, the capacity to coordinate diverse interests, mobilise local resources and facilitate cooperation becomes a critical determinant of sustainability outcomes. Research on adaptive governance further highlights the importance of flexibility, learning and stakeholder participation in addressing complex environmental challenges (Folke 2006).

The significance of local governance is particularly evident in climate adaptation, where place-specific vulnerabilities and capacities require context-sensitive responses. Effective adaptation therefore depends not only on technical solutions but also on the institutional arrangements through which collective action is organised.

Social capital and local adaptive capacity

Social capital represents one of the most important mechanisms linking locality and sustainability. Although definitions vary, social capital is generally understood as the networks, trust-based relationships and norms of cooperation that facilitate collective action (Bourdieu 1986; Coleman 1988; Putnam 1993; Woolcock 1998).

At the local level, social capital contributes to information exchange, cooperation and knowledge sharing among actors. These processes support collective learning and strengthen the capacity of communities to respond to environmental and socio-economic change. Putnam (1993) argues that trust and civic engagement improve institutional performance, while subsequent research has demonstrated the importance of social networks for resilience and adaptation. In the context of sustainability transitions, social capital facilitates the diffusion of innovations, the mobilisation of local resources and the implementation of collective responses to climate-related risks. Consequently, local social networks constitute an important component of adaptive capacity and regional resilience.

The relationship between social capital and adaptive capacity also has important regional implications. Adaptation is not solely a technical process but a social process of learning, cooperation and institutional change. Therefore,

local sustainability depends not only on environmental investments but also on the strength of local relationships and governance networks.

Table 2: Locality and sustainability governance mechanisms
A lokalitás és a fenntarthatósági kormányzás mechanizmusai

Governance element	Sustainability function
Local knowledge	Better information and contextual understanding
Participation	Enhanced legitimacy and stakeholder support
Social capital	Cooperation and collective action
Subsidiarity	Lower governance and coordination costs
Adaptive capacity	Improved resilience and flexibility
Territorial learning	Innovation and long-term adaptation

Source: Authors' elaboration

Table 2 demonstrates that locality can influence sustainability through multiple interconnected governance mechanisms. These mechanisms extend beyond environmental management and contribute to broader processes of territorial resilience and sustainable development.

Transaction costs and sustainability governance

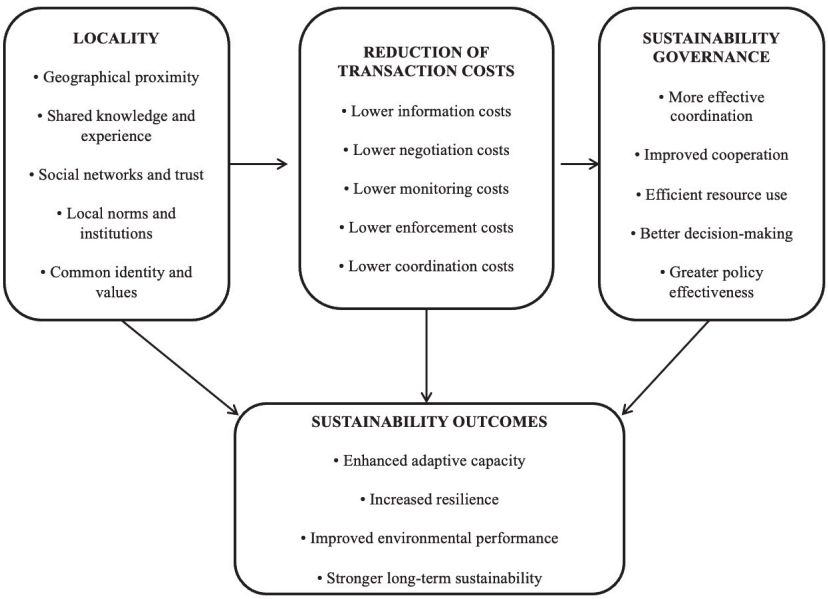
Institutional economics provides an additional perspective on the importance of locality. According to Coase (1937), economic and organisational activities are associated with transaction costs, including the costs of information acquisition, coordination, negotiation and monitoring. These costs influence the effectiveness of collective action and governance arrangements.

Locality may contribute to reducing transaction costs through proximity, shared knowledge and repeated interactions among actors. Local networks facilitate information exchange, while trust-based relationships reduce uncertainty and coordination costs. As a result, cooperation can be achieved more efficiently within territorially embedded communities and organisations.

The reduction of transaction costs is particularly relevant for sustainability governance, where successful outcomes depend on cooperation among multiple stakeholders. Climate adaptation, environmental management and sustainability planning all require information sharing, coordination and long-term collaboration. Local knowledge and established social relationships can therefore improve the effectiveness of governance processes and enhance adaptive capacity.

The relationship between locality, transaction costs and sustainability governance is summarised in Figure 1.

Figure 1: Locality and the reduction of transaction costs in sustainability governance
A lokalitás és a tranzakciós költségek csökkentése a fenntarthatósági kormányzásban



Source: Authors' elaboration based on Coase (1937), Ostrom (1990), Putnam (2000), Woolcock (1998), and Szalmáné Csete, Szlávik (2024)

Locality, social capital and regional resilience

Local governance, social capital and lower coordination costs can jointly strengthen adaptive capacity and regional resilience: the ability of territorial systems to respond to shocks while maintaining and adapting essential functions (Adger 2000; Boschma 2015; Martin, Sunley, 2015). Locality matters here through place-based resources, institutional capabilities and networks that support coordination, innovation and learning. These mechanisms provide the theoretical bridge from territorial embeddedness to the adaptation evidence examined below.

ISO 14092 and the institutionalisation of locality in climate adaptation

The increasing urgency of climate adaptation has stimulated the development of international standards supporting adaptation planning and implementation. Within the ISO 14090 family of standards, ISO 14092 represents a significant step towards the operationalisation of climate adaptation at the local and community levels. Published in 2026, the standard provides guidance for local governments

and communities in planning, implementing, monitoring and evaluating adaptation actions. Consequently, it offers an important institutional framework for translating climate adaptation objectives into place-based practices.

ISO 14092 within the ISO adaptation framework

ISO 14092 builds upon the broader adaptation framework established by ISO 14090 (Adaptation to Climate Change – Principles, Requirements and Guidelines) and ISO 14091 (Adaptation to Climate Change – Guidelines on Vulnerability, Impacts and Risk Assessment). While ISO 14090 establishes general adaptation principles and ISO 14091 focuses on climate risk and vulnerability assessment, ISO 14092 addresses the practical implementation of adaptation at the local level. The standard therefore acts as a bridge between climate risk assessment and adaptation action.

The evolution of the ISO adaptation standards reflects a growing recognition of the importance of local and territorial dimensions in climate governance (Table 3.). Whereas earlier standards primarily focused on principles and assessment methodologies, ISO 14092 places greater emphasis on local implementation, stakeholder engagement and adaptive capacity development.

Table 3: Evolution of ISO climate adaptation standards
Az ISO klímaadaptációs szabványok fejlődése

Standard	*Year*	*Main focus*	*Territorial relevance*
ISO 14090	2019/2021	Principles, requirements and guidelines for adaptation	General framework
ISO 14091	2021	Climate risk, vulnerability and impact assessment	Risk assessment support
ISO 14092	2026	Adaptation planning for local governments and communities	Direct focus on locality and territorial governance

Source: Authors' compilation based on ISO adaptation standards

From the perspective of the recent study, the significance of ISO 14092 lies in its contribution to the institutionalisation of locality within climate adaptation governance. The standard recognises that adaptation outcomes depend on local environmental conditions, socio-economic characteristics, governance arrangements and stakeholder capacities. Consequently, adaptation planning is framed as a place-based process rather than a uniform technical exercise.

Locality as a cross-cutting principle

A central characteristic of ISO 14092 is its recognition of territorial diversity. The standard emphasises context-specific assessment and decision-making, acknowledging that adaptation strategies must reflect local environmental risks, development conditions and institutional capacities. This approach is closely aligned with the place-based perspectives discussed in regional science and sustainability research.

Stakeholder engagement constitutes another important element of the framework. Effective adaptation requires cooperation among local governments, businesses, civil society organisations and citizens. Participation is therefore considered not merely a procedural requirement but a mechanism for integrating local knowledge, improving decision quality and strengthening collective ownership of adaptation strategies.

The principles embedded in ISO 14092 collectively demonstrate that locality functions as a cross-cutting element throughout the adaptation planning cycle. Place-specific risk and vulnerability assessments acknowledge territorial diversity, while stakeholder engagement and the integration of local knowledge strengthen the legitimacy and quality of decision-making. The standard further emphasises adaptive capacity development, continuous monitoring and institutional learning, thereby linking local governance processes with long-term resilience-building. Rather than treating locality as a separate component, ISO 14092 incorporates territorial embeddedness into all major stages of adaptation planning and implementation. This institutional logic provides further support for the proposition that locality constitutes a fundamental dimension of sustainability.

Adaptive capacity and institutional learning

ISO 14092 treats adaptation as an iterative process of assessment, implementation, monitoring and revision. Its emphasis on adaptive capacity shifts attention from infrastructure alone towards institutional capabilities, knowledge sharing and collaborative governance. This learning-oriented logic links place-specific implementation with longer-term resilience.

Implications for sustainability governance

ISO 14092 therefore provides institutional support for the paper's argument by embedding territorial diversity, local knowledge, participation and adaptive learning in adaptation planning. It does not establish locality as a separate sustainability dimension, but it demonstrates how territorial embeddedness can be operationalised within an international governance framework.

Evidence from EU Mission on Adaptation on Climate Change projects: Towards a territorial typology of climate resilience

The EU Mission on Adaptation to Climate Change project portfolio as an empirical evidence base

While ISO 14092 provides a normative framework for locality-based climate adaptation, the European Union Mission on Adaptation to Climate Change offers an opportunity to examine how these principles are implemented in practice across diverse territorial contexts. Through the Mission Adaptation Implementation Platform (MIP4Adapt), more than sixty projects address climate resilience, adaptive governance, stakeholder participation and territorial learning across Europe. Although projects differ in thematic focus and geographical setting, they share a common objective: strengthening climate resilience through locally embedded adaptation pathways.

From the perspective of this study, the Mission portfolio represents a unique empirical laboratory for examining the practical role of locality in sustainability transitions. Rather than focusing on individual projects, the analysis seeks to identify broader territorial patterns and adaptation logics emerging across the project portfolio. Such an approach aligns closely with regional science traditions, which emphasise territorial differentiation, place-based governance and spatially embedded development processes.

Methodological framework

To evaluate how Mission projects operationalise locality, the study applies a structured qualitative coding framework derived from the preceding sections. The unit of analysis is the individual project as described in the Mission Projects Catalogue (CINEA, 2026). Six dimensions are coded: territorial embeddedness, stakeholder participation, territorial learning, functional governance, spatial justice and transformative capacity (Table 4). These dimensions translate the conceptual framework into observable project characteristics rather than measuring project effectiveness.

For each dimension, the authors applied a three-point ordinal coding rule: 0 when the characteristic was not identifiable in the catalogue description, 1 when it was explicit but secondary or partial, and 2 when it was a central or recurrent feature of the project design. Scores were used for descriptive comparison only; they should not be interpreted as interval-scale measurements of performance.

Table 4:Locality-based assessment framework for projects under the EU Mission on Adaptation to Climate Change
Az EU klímaadaptációs missziójához kapcsolódó projektek lokalitásalapú értékelési kerete

Dimension	*Evaluation focus*	*Link to theoretical framework*
Territorial embeddedness	Degree of adaptation to local conditions	Locality
Stakeholder participation	Involvement of local actors	Social capital
Territorial learning	Knowledge generation and exchange	Adaptive capacity
Functional governance	Cooperation beyond administrative borders	Place-based development
Spatial justice	Inclusion of vulnerable groups	Sustainability
Transformative capacity	Long-term territorial change	Regional resilience

Source: Authors' elaboration

The assessment covers 65 projects listed in the Mission Projects Catalogue (CINEA, 2026). Coding was based on publicly available project descriptions and was aggregated to identify recurrent patterns across the portfolio. The exercise is exploratory: catalogue descriptions differ in detail, the coding involves interpretive judgement, and no causal relationship between locality dimensions and project outcomes is tested. These limitations are considered when interpreting the aggregate scores.

European adaptation macro-regions

The comparative review groups recurring combinations of climate risks and adaptation responses into six heuristic macro-regional types (Table 5). These categories are analytical clusters developed for this study, not official EU, NUTS or administrative regions; individual projects may contribute to more than one territorial type.

The typology highlights substantial territorial differentiation. Mediterranean settings are associated mainly with drought, water scarcity, heat and wildfire responses; coastal settings with sea-level rise and flooding; urban settings with heat and infrastructure resilience; river basins with integrated water governance; rural and peripheral areas with capacity building; and mountain or ecosystem settings with biodiversity and nature-based adaptation. The categories therefore describe recurring adaptation logics rather than mutually exclusive geographical zones.

Table 5: European adaptation macro-regions emerging from EU Mission projects
Európai alkalmazkodási makrorégiók az EU klímaadaptációs misszió projektjei alapján

Adaptation macro region	*Dominant climate risks*	*Adaptation focus*	*Representative Mission projects*
Mediterranean Europe	Drought, heat stress, water scarcity, wildfires	Water governance, ecosystem restoration, nature-based solutions	ARSINOE, DesirMED, TransformAr
Atlantic and Coastal Europe	Sea-level rise, coastal flooding, storms	Coastal resilience, integrated coastal management	ARSINOE, TransformAr
Continental Urban Europe	Urban heat islands, pluvial flooding	Urban resilience, climate-neutral infrastructure, governance innovation	SMARTER, RESIST
River Basin Europe	River flooding, water management challenges	Integrated watershed governance, adaptive water management	ARSINOE, IMPETUS
Rural and Peripheral Europe	Drought, demographic vulnerability, limited institutional capacity	Community resilience, capacity building, local adaptation planning	REHUBS, Pathways2Resilience
Mountain and Ecosystem Regions	Biodiversity loss, ecosystem transformation, natural hazards	Ecosystem resilience, nature-based adaptation	DesirMED, TransformAr

Source: Authors' compilation based on CINEA (2026)

Across these differentiated contexts, local knowledge, stakeholder engagement and adaptive governance recur as implementation mechanisms. This pattern is consistent with the paper's definition of locality as territorial embeddedness, while the cross-regional circulation of methods and knowledge also underlines its multi-scalar character.

Territorial learning, adaptive capacity and regional resilience

One of the most consistent characteristics observed across Mission projects is the importance of territorial learning. Numerous initiatives rely on Living Labs, co-creation processes, stakeholder experimentation and knowledge-sharing platforms. Adaptation is therefore increasingly understood not as a purely technical exercise but as a process of collective learning and institutional transformation.

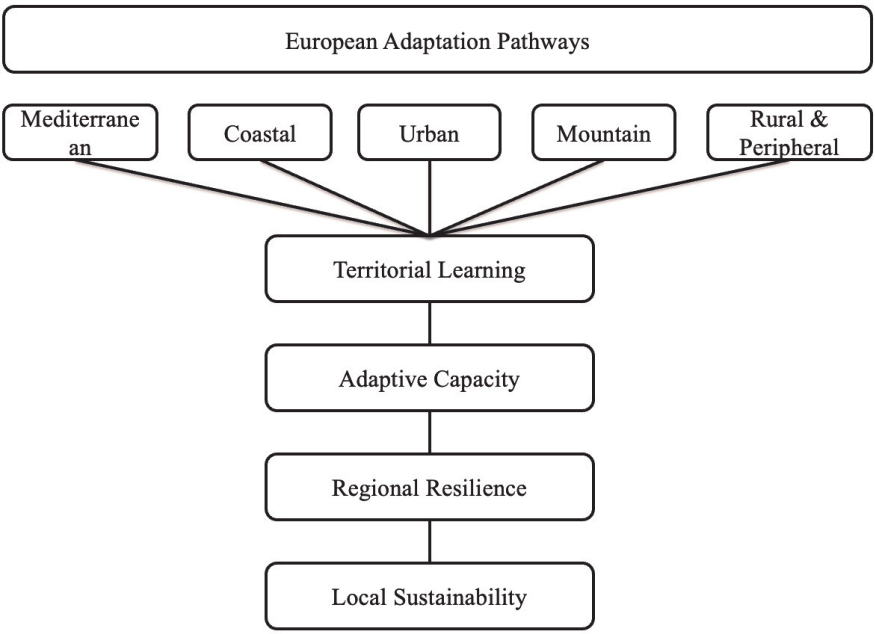
This finding closely corresponds to the theoretical framework developed in the paper's third section. Adaptive capacity emerges not only from technological innovation and financial resources but also from the ability of territories to generate,

exchange and apply knowledge. Local governments, businesses, researchers and civil society organisations jointly contribute to adaptation planning and implementation, reinforcing collaborative governance structures and strengthening resilience.

The analysis also highlights the growing importance of spatial justice and inclusive adaptation. Several projects increasingly address vulnerable communities, socially disadvantaged groups and peripheral territories, indicating a broader understanding of resilience that incorporates social cohesion and territorial equity. Although these considerations appear less frequently than territorial embeddedness or adaptive learning, their presence reflects an emerging recognition that successful adaptation must also address uneven vulnerabilities and access to resources.

The comparative assessment further reveals that European regions follow different resilience pathways. Some prioritise technological innovation and infrastructure investment, while others focus on ecosystem restoration, governance innovation or community capacity-building. These differences reflect varying environmental conditions, institutional capacities and development trajectories. Nevertheless, diverse territorial contexts converge towards a common adaptation logic based on learning, adaptive capacity and resilience-building.

Figure 2: Locality-based adaptation pathways across European macro-regions
Lokalitásalapú alkalmazkodási pályák az európai makrorégiókban



Source: Authors' elaboration

Figure 2 illustrates how different territorial adaptation contexts ultimately contribute to the development of adaptive capacity, regional resilience and local sustainability. Although environmental risks vary significantly across Europe, successful adaptation initiatives consistently rely on locality-based governance mechanisms and territorial learning processes.

Aggregated results

The qualitative–quantitative assessment of Mission Adaptation projects reveals a remarkably consistent pattern regarding the characteristics of successful adaptation initiatives. The assessment indicates that territorial embeddedness represents the most consistently observed feature across Mission Adaptation projects (Table 6). Virtually all initiatives are strongly rooted in specific environmental, social and economic contexts, reflecting the place-based character of climate adaptation governance. Territorial learning and transformative capacity also received particularly high scores, reflecting the widespread use of Living Labs, stakeholder co-creation processes and experimental governance approaches.

Table 6: Average scores of locality dimensions across mission adaptation projects
A lokalitás dimenzióinak átlagos pontszámai a missziós adaptációs projektekben

Dimension	*Average score (0–2)*
Territorial Embeddedness	2.00
Territorial Learning	1.87
Transformative Capacity	1.80
Stakeholder Participation	1.73
Functional Governance	1.60
Spatial Justice	1.27

Source: Authors' assessment based on the Mission Project Catalogue (CINEA 2026)

Stakeholder participation and functional governance similarly emerge as dominant project characteristics. Local authorities, businesses, community organisations and citizens frequently play active roles in adaptation planning and implementation, contributing to legitimacy, social acceptance and the mobilisation of local knowledge. Functional governance arrangements extending beyond conventional administrative boundaries are also increasingly common, particularly in river basins, metropolitan regions and ecological systems. Spatial justice received comparatively lower scores, although its importance has increased in more recent projects focusing on vulnerable communities and equitable adaptation. This suggests that while social inclusion is increasingly recognised, adaptation policy remains primarily organised around territorial and governance considerations.

The aggregate scores indicate that territorial embeddedness, learning and transformative capacity are the most visible dimensions in the catalogue descriptions. Because the coding captures project design rather than verified outcomes, these results should be read as evidence of how adaptation is framed and organised, not as a ranking of project success.

The geographical distribution of projects further demonstrates that climate adaptation pathways remain territorially differentiated across Europe. Rather than converging towards a single adaptation model, regions develop context-specific resilience strategies reflecting their environmental conditions, institutional capacities and socio-economic characteristics.

Taken together, the Mission portfolio provides empirical illustration of the mechanisms proposed in the conceptual framework: adaptation is territorially differentiated, but knowledge, participation, learning and governance capacity recur across contexts. The evidence supports the relevance of locality as an analytical lens without implying that local embeddedness alone determines adaptation outcomes.

Hungarian territorial illustration: SME innovation intentions

Data, scope and limitations

The Hungarian evidence is retained as a deliberately limited territorial illustration rather than a separate test of the locality framework. The underlying questionnaire survey was conducted in September 2022 within the Sustainable Development and Technologies National Programme of the Hungarian Academy of Sciences (MTA FFT NP FTA) among SMEs in ICT manufacturing and services. The dataset contains 101 responses; one incomplete case was excluded, leaving 100 valid observations for descriptive analysis.

The sampling procedure used nationwide random selection with regional quotas. In the analytical sample, 42 firms are located in Central Hungary, 16 in Transdanubia and 42 in Great Plain and North. These are the three Hungarian NUTS 1 major socio-economic regions under the NUTS 2021 classification applicable to the 2022 survey (Eurostat 2022). The survey was designed to study sustainability, digitalisation and climate innovation, not locality or territorial embeddedness directly. Accordingly, the analysis below uses only the regional innovation items that can be linked transparently to the paper's territorial argument. Results are descriptive; the small regional subsamples, especially Transdanubia, do not support causal inference or broad generalisation to Hungarian SMEs.

Regional variation in sustainability and climate innovation

Enterprises are territorially embedded in labour markets, business networks, knowledge systems and regulatory environments, but the present survey does not measure these mechanisms directly. Its contribution is narrower: it shows whether stated innovation intentions vary across broad territorial contexts (Table 7).

Table 7: Planned Sustainability and Climate Innovations by NUTS 1 Region
Tervezett fenntarthatósági és klímainnovációk NUTS 1 régiók szerinti bontásban

NUTS1 macro-region	*Sustainability innovation (%)*	*Climate innovation (%)*
Central Hungary (HU1)	52.4	38.1
Transdanubia (HU2)	50.0	56.3
Great Plain and North (HU3)	57.1	47.6

Source: Authors' calculations based on the DSDG 2022 survey. Regional classification: Eurostat (2022)

Sustainability-oriented innovation intentions vary only moderately across the three NUTS 1 regions (50.0-57.1%), whereas the reported shares for climate-related innovation show a wider range (38.1-56.3%). The pattern is descriptive and should not be attributed to regional vulnerability, institutional quality or local adaptive capacity because these factors were not measured in the survey. Its relevance for the paper is therefore limited but useful: even within one national regulatory setting, sustainability-related intentions are not spatially uniform.

The Hungarian case consequently serves as a boundary check on the broader argument. It is compatible with territorial differentiation, but it cannot demonstrate the mechanisms identified in the preceding sections. Removing the broader SME analysis avoids overstating what this dataset can establish and keeps the empirical contribution focused on the paper's central concept of locality.

Discussion, policy implications and conclusions

The paper's main contribution is to specify locality as a missing analytical condition between general sustainability objectives and territorially uneven outcomes. The concept is narrower than "place" in its broad cultural sense and broader than "local government" as an administrative scale. Defined as territorial embeddedness, locality directs attention to how environmental conditions, institutions, knowledge, networks and actor capacities jointly shape implementation. This formulation also qualifies the claim of a "fifth dimension": locality does not add another substantive sustainability goal, but identifies a cross-cutting territorial condition that affects how ecological, economic, social and temporal objectives can be realised.

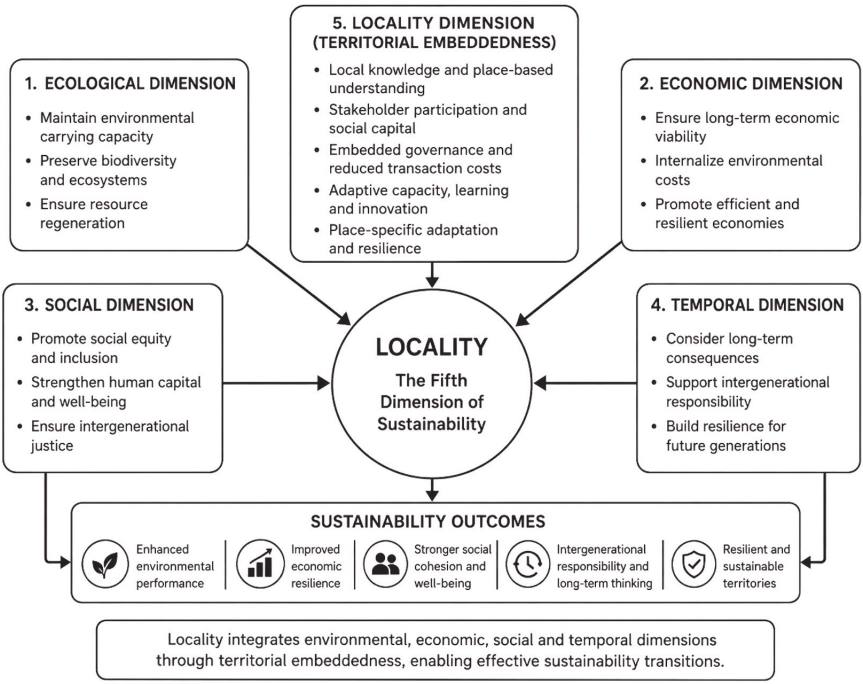
This distinction helps integrate strands of literature that are often treated separately. Place-based regional development explains why generic interventions encounter heterogeneous territorial capacities; institutional economics clarifies how proximity, repeated interaction and shared knowledge may alter information and coordination costs; social capital and adaptive-governance research identifies cooperation and learning mechanisms; and the geography of sustainability transitions shows that transition processes are institutionally embedded and multi-scalar (Coenen et al. 2012; Hansen, Coenen 2015). The proposed framework therefore does not claim that spatial sensitivity is absent from existing scholarship. Its contribution is to synthesise these insights around a compact set of mechanisms and connect them explicitly to sustainability conditions.

The empirical layers sharpen rather than prove this proposition. ISO 14092 shows how context sensitivity, participation and adaptive learning can be institutionalised in local adaptation planning. The Mission portfolio indicates that similar mechanisms recur across very different climate-risk contexts, while its heuristic macro-regional typology demonstrates that adaptation pathways remain territorially differentiated. The Hungarian survey adds only a modest observation: innovation intentions vary across NUTS 1 regions, but the data cannot identify why. Taken together, the evidence is strongest as triangulation across different forms of governance evidence, not as a causal test.

Figure 3 summarises this interpretation. Locality interacts with, rather than sits outside, the ecological, economic, social and temporal dimensions. The framework also implies an important caution: stronger territorial embeddedness is not automatically beneficial. Local systems may lack resources, exclude actors or become locked into established practices. Effective sustainability governance therefore requires a balance between place sensitivity and cross-scale capacity – local knowledge and participation combined with national regulation, external finance, scientific expertise and translocal learning.

For an international audience, the policy implication is consequently not "localise everything". It is to make multi-level climate and sustainability policy territorially responsive. National and EU-level objectives should be accompanied by mechanisms that diagnose place-specific risks and capacities, involve relevant territorial actors, support institutional learning and enable knowledge transfer across regions. This interpretation is consistent with the OECD's territorial approach to climate action, which combines place-based policy with coordination across scales (OECD 2023). It is especially relevant where uniform targets meet highly uneven exposure, administrative capacity and development conditions.

Figure 3: Locality as the fifth dimension of sustainability
A lokalitás mint a fenntarthatóság ötödik dimenziója



Source: Authors' elaboration

The study has several limitations. The Mission coding relies on project descriptions and interpretive ordinal scores rather than outcome evaluation; the macro-regions are heuristic analytical types; and the Hungarian survey was not designed to measure locality directly. Future research should therefore operationalise territorial embeddedness with measurable indicators, test the proposed mechanisms using comparative regional data, and examine when local embeddedness enhances adaptation and when it produces exclusion or lock-in. Multi-scalar designs are particularly important because local capacities are partly produced by extra-local institutions and networks.

Locality is thus best understood as a relational, multi-scalar condition of sustainability governance. Recognising it explicitly makes territorial variation analytically visible without treating the local scale as inherently superior. The broader conclusion is that sustainability transitions require not only appropriate goals and technologies but also institutional arrangements capable of translating them into diverse territorial contexts. This is the sense in which locality can usefully be treated as a complementary fifth dimension of sustainability.

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