

Framework and Strategy for Growth and Sustainability

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Disclaimer

This document is based on the deliverable 2.3 Framework and Strategy for Growth and Sustainability 1, which is currently under review by the European Commission and should be considered as tentative. This document has been revised to remove references to project deliverables and link to related documents made available externally, to guide the pilots and other stakeholders. This document has also been slightly edited to make it more reader friendly.

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Executive summary

Despite significant European investment in data spaces, local digital twins (LDTs) and smart communities overall, the current digital landscape remains fragmented and lacks sustainable operational and governance models. Interoperability across systems is not yet fully realised, and many LDT solutions remain isolated, hindering not only replication and opening up network effects, but also limiting the potential for collaboration across communities ([European Commission, 2023](#); [Garske et al., 2024](#)). This is particularly challenging as several issues local communities face (e.g. climate adaptation, mobility, energy optimisation, environmental resilience) are not confined to municipal borders and increasingly require interoperable and cooperative approaches across sectors and territories ([European Commission, 2022](#); [European Commission, 2024](#)).

This document titled "Framework and Strategy for Growth and Sustainability" presents the first edition of the LDT4SSC project's strategic plan for growing and sustaining the emerging European LDT ecosystem, defined as an *open and interoperable collaboration framework for LDT initiatives used and sustained by multi-stakeholder communities to address common local and regional challenges*.

It serves three purposes - guiding pilots in designing sustainable LDT implementations and fostering the sharing and replication of the assets and services created throughout, aligning LDT4SSC activities and assets towards long-term ecosystem development; and informing external stakeholders and policymakers on the conditions required for a sustainable European LDT ecosystem. As a whole, this document operationalises these purposes by moving from strategic context and ecosystem diagnosis toward practical sustainability conditions, implementation capabilities and actionable recommendations for pilots, policymakers and ecosystem stakeholders. The recommendations are clustered around the following strategic themes:

1. Coordinating toward interoperability and multi-stakeholder collaboration;
2. Advancing local digitalisation at scale with replicable and open services driven by shared local needs;
3. Demonstrating LDTs' business and public value for stakeholders across the value chain;
4. Systematically engaging and growing the communities of practice around LDTs in local communities; and
5. Continuous strengthening of technical and non-technical capabilities across the three levels (individual LDT, LDT ecosystem and LDT4SSC shared assets and services).

As of May 2026, this document represents a capability-oriented framework and strategy, which will be validated and iterated into a second edition by November 2028. The strategy will be refined based on pilot implementation evidence as well as expanded stakeholder engagement. In addition, long-term federation responsibilities are expected to be clarified in coordination with the Networked Local Digital Twins towards the CitiVERSE European Digital Infrastructure Consortium (LDT CitiVERSE EDIC), to explore governance and federation mechanisms that could support ecosystem continuity beyond the project lifetime.

1. Introduction and purpose of the strategy

This first chapter outlines the project's overall context and objectives and summarises key insights from the project's *Impact Assessment Framework* to drive intended outcomes and long-term impact. It clarifies the scope of the framework and describes the used methodology. Building on this context, this document aims to establish the strategic conditions, capabilities and pathways required to transition from pilot-based experimentation toward a more sustainable, interoperable and scalable European LDT ecosystem.

1.1 Vision, mission and objectives of the LDT4SSC project

The Local Digital Twins for Smart and Sustainable Communities (LDT4SSC) project¹ is set out to build a robust, scalable network of LDTs and stimulate the use of innovative, AI-driven LDT services across European local communities. As a Digital Europe Programme (DEP) funded project, it contributes to two main goals/directives from the EC:

1. **Improving the digitalisation of Europe as a whole, and**
2. **Improving citizens' lives through sustainability and projects to better preserve and protect the environment.**

This project builds on and integrates outputs from related European Union (EU) funded projects and initiatives, such as [the deployment project for the European data space for smart communities](#) (DS4SSCC-DEP)², the [EU LDT Toolbox](#)³, [Living-in.EU](#)⁴, [CitCom.ai](#)⁵, and the [Smart Middleware Platform](#) (SIMPL)⁶ leveraging existing knowledge, tools and stakeholder networks. In doing so, LDT4SSC operates not as a standalone initiative, but as a strategic liaison within a broader European ecosystem of digital infrastructure, data spaces and governance frameworks. [Figure 1](#) below shows how LDT4SSC is positioned in the wider network of initiatives.

¹ The LDT4SSC project is implemented by 9 partners, seen at <https://ldt4ssc.eu/about/>. Furthermore, it aims to establish 15 - 20 pilot projects through three rounds of open calls, onboarding a community of practitioners from European local communities to reach envisioned objectives and build an open and collaborative LDT ecosystem.

²The European data space for smart communities is an EU-wide action creating a cross-sectorial data space for governments on all levels and their providers to deliver the best possible services to their citizens by enabling interoperability to reach critical goals.

³ The EU Local Digital Twin Toolbox is a flagship initiative of the European Commission that provides a modular, standards-based suite of tools designed to help cities and communities across Europe simulate, analyse, and plan urban environments more effectively.

⁴ Living-in.EU is an EU initiative for local and regional leaders who believe that technology can help them make their town, city, or region a better place to live.

⁵ Testing AI in Smart Cities and Communities.

⁶ Simpl is an open source, secure middleware that supports data access and interoperability in European data initiatives.

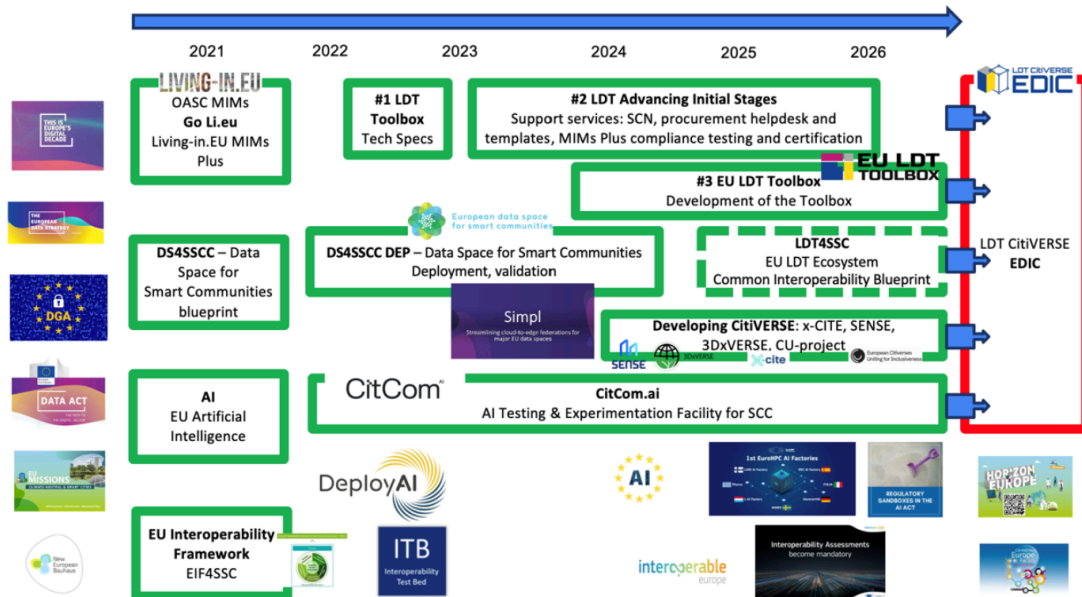


Figure 1: From DS4SSCC to LDT4SSC: LDT4SSC Smart Communities Ecosystem

This project contributes directly to DEP objectives of enhancing technological sovereignty, promoting ethical AI, and fostering an inclusive digital market, while integrating ongoing initiatives including the [Networked Local Digital Twins towards the CitiVERSE European Digital Infrastructure Consortium](#) (LDT CitiVERSE EDIC), as well as supporting policy goals like the [New European Bauhaus](#), the [European Green Deal](#) and the [Digital Decade](#). In particular, through close alignment with the LDT CitiVERSE EDIC, the project accelerates the deployment of interoperable digital infrastructures across Member States, fostering cross-border collaboration. In doing so, it contributes to the DEP's vision of a resilient, unified digital landscape. The project also addresses broader barriers to AI adoption in Europe, which include limited investment, regulatory complexity and gaps in expertise. By pooling public sector demand and ensuring a fair, competitive environment for innovators, it supports the development of advanced AI-driven digital twin solutions. This approach benefits both the public and private sectors, aligns with the EU's priorities for ethical AI and open standards and reduces dependence on foreign technologies.

The LDT4SSC project is implemented by 9 partners, outlined in Table 1. Furthermore, it aims to establish 15 - 20 pilot projects through [three rounds of open calls](#), onboarding a community of practitioners from European local communities to reach envisioned objectives and build an open and collaborative LDT ecosystem.

Mission

We build a scalable and interoperable ecosystem of Local Digital Twins (LDT) to empower European local communities with opportunities to share and reuse (real-time) data, advanced AI capabilities, simulation and federated services. These assets and services will foster data-driven decision-making, improved public value creation and

resilient, equitable urban and community development.

Vision

The LDT4SSC aims to foster a resilient, inclusive and interconnected European LDT ecosystem, where:

- LDTs can operate as core public digital infrastructure;
- Stakeholders from local communities are able to share data, services, and other assets seamlessly;
- Integration with the LDT Toolbox fosters replication of LDT4SSC assets and services and support their scalability;
- SIMPL and the LDT CitiVERSE EDIC can offer opportunities for long-term federation and sustainability;
- AI-powered LDT services support the EU's green & digital transition, and
- Europe's competitiveness and digital sovereignty are strengthened.

Objectives

The LDT4SSC project pursues three main objectives:

1. **Connecting existing data platforms and LDTs from cities and communities** to create a federation of LDTs across the EU. Reinforced interoperability through the aggregation of LDTs at a larger scale (cross sectors, cross cities, and cross borders) will help to scale up the EU common data sets and open-source solutions. It will also facilitate less advanced cities and communities joining the existing EU LDT ecosystem.
2. **Expanding existing local data platforms and LDTs with new open-source LDT services based on the shared needs of cities and communities.** These services should aim to improve decision-making processes and citizen/residents interaction, reduce risks, costs, and downtime, enhance resilience and sustainability of LDT platforms and enable new value creation.
3. **Complementing the EU LDT Toolbox launched under WP2021-22 with additional AI-based and innovative services** (e.g. for adaptable multi-sector considerations, advanced simulation and modelling approaches, including bottom-up self-organised models). Through the pilots, AI services will be developed and tested within existing cities/communities and be replicable in other contexts.

1.2 Scope and intended use of the strategy

This document presents a framework and strategy for growth and sustainability of the LDT ecosystem and its resources, including opportunities to use Testing and Experimentation Facilities (TEFs) and other methodologies to validate services and support their certification through competent bodies. It does this by exploring strategies of LDT exploitation and replicability for pilot results targeting smart cities and

communities, and engaging with all possible stakeholders across the value chain (cities, AI innovators, technology providers, research organisations, etc.). In particular, the strategy is intended to serve three main purposes:

1. To guide pilots in designing sustainable and scalable LDT implementations;
2. To support the LDT4SSC consortium in aligning activities and assets towards long-term ecosystem development; and
3. To inform external stakeholders and policymakers on the conditions required for a sustainable European LDT ecosystem.

The document contributes in particular to the project's specific objective to *"create a sustainable European Market for LDT components and solutions by demonstrating LDTs economic and social value"*. To reach that goal, the LDT4SSC project is set out to explore viable business models and value creation, which will inform the consolidated interoperability blueprint and the LDT ecosystem to ensure local, regional, national, and European LDTs' economic and social viability.

In order to foster the intended outcomes, this document takes a step back to first ask:

- *How is sustainability understood?*
- *How is an LDT-ecosystem understood?*
- *What does "achieving a fully sustainable ecosystem" mean?*

Furthermore, this framework is grounded in the understanding that sustainability is not a fixed, achievable end-state, but should be considered as a continuous, multi-dimensional capability that is influenced by a number of factors. As such, this framework and strategy is anchored around two core questions:

1. *What capabilities, conditions for value creation and value capture, as well as validation mechanisms must exist for LDTs to remain viable, trusted and reusable beyond project funding?*
2. *What conditions for stakeholder engagement, as well as technical and non-technical enablers, must exist for fostering and sustaining a thriving LDT ecosystem?*

As of May 2026, this framework and strategy should be seen as a **capability-oriented sustainability framework**, and **reference guidelines** for both the LDT4SSC project consortium as well as its pilots to validate and strengthen its capabilities to sustain its activities, its upcoming assets and services, and most importantly, the LDT ecosystem built throughout the project implementation. By the end of the project in November 2028, a second version of the strategy will be delivered, providing a validated viewpoint on the local communities' capabilities to develop, adopt, replicate and scale LDTs and deliver policy-aligned outcomes through ecosystem-wide collaboration.

1.3 Insights from the Impact Assessment Framework

The LDT4SSC's *Impact Assessment Framework* (IAF) provided a structured approach for assessing the performance and expected impact of LDT4SSC pilots by also setting key indicators for LDT4SSC's pilots to follow. The IAF serves a dual purpose. Firstly, to monitor and evaluate the implementations and results of pilot activities in alignment

with project objectives and requirements. Secondly, it aims to consolidate evidence across pilots to assess scalability, replication potential and long-term sustainability of LDTs. At its core, the IAF is grounded in a Theory of Change (ToC) approach. This establishes a causal logic linking **context, inputs, activities, outputs, outcomes and impact**, allowing stakeholders to understand how and why pilot interventions contribute to broader change (see [Figure 2](#)).

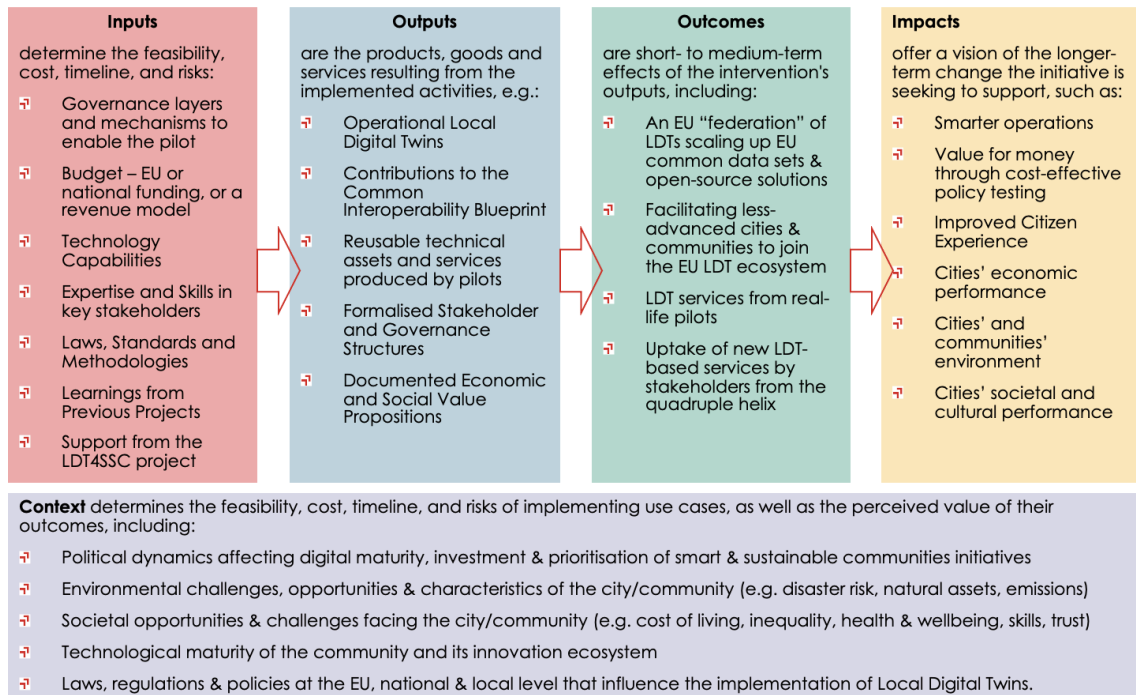


Figure 2: An intervention logic illustrating the Theory of Change for LDT4SSC pilots

This document looks at the IAF through the lens of sustainability, considering the various sustainability dimensions described in [chapter 4](#), providing guidance for increasing the probability of sustainability across the document and defining key recommendations in [chapter 7](#).

The foundational understanding of sustainability is that it is not an end-state, but should be considered as a continuous, multi-dimensional capability that:

- is shaped by **contextual (local) conditions** (political, economic, social, technological, legal and environmental). These influence pilot performance, e.g., the feasibility and cost of implementation, risks and enabling factors for adoption, relevance and perceived value of individual LDT services by the local stakeholders, and the likelihood that outputs could be translated into outcomes and long-term impacts;
- is **built through input and activities** (e.g., governance structures, funding models, interoperability, legal frameworks, and stakeholder engagement);
- is **expressed through outputs, outcomes and impacts** as different forms of public value;
- evolves over time through **monitoring, learning and adaptation**.

The LDT4SSC project and its pilots' success, including its feasibility for sustainability and growth, will be measured against the delivered outputs and outcomes. The five

categories of outputs and four expected outcomes can be understood as tangible building blocks of sustainability. If successfully delivered, these can increase the potential for sustainability in the following ways:

- **Operational LDTs and interoperable assets (OP1-OP3⁷)** are positioned to strengthen LDTs' and LDT-ecosystems' technological and data sustainability;
- **Governance and stakeholder structures (OP4)** could support political, legal and social sustainability;
- **Documented economic and social value propositions (OP5)** underpin the possibility for economic, social and environmental sustainability;
- **Federation and interoperability of LDTs (OC1)** is both driven by, as well as influence technological, political and economic sustainability;
- **Inclusion of less advanced communities (OC2)** indicates the extent of social and economic sustainability;
- **Implementation of LDT services from real-life pilots (OC3)** indicates the feasibility of technological and economic sustainability; and
- **Uptake of new LDT-based services and stakeholder engagement (OC4)** may speak especially about economic and social sustainability.

Finally, the IAF defines **impacts as longer-term change, the LDT4SSC project is seeking to support, and its expected benefits and beneficiaries**. Impacts can be positive, negative, primary and secondary long-term effects produced by an intervention, directly or indirectly, unintended or intended.⁸

This reframing of the IAF highlights that local context, inputs and activities, outputs and outcomes are not only indicators for short- and long-term impact, but enabling factors that may determine whether LDTs can be sustained, scaled and embedded into real-world contexts. The IAF therefore serves as the empirical backbone of this strategy, ensuring that strategic recommendations are grounded in measurable outcomes and aligned with demonstrated pilot performance and expected long-term impacts.

1.4 Methodological approach

The development of the Framework and Strategy of Growth and Sustainability follows a progressive, two-phase and evidence-based methodological approach, aligned with practices that emphasise results, accountability and continuous learning. This first version focuses on establishing a robust conceptual and strategic operational baseline for the LDT ecosystem. The methodology follows a structured progression from analysis to synthesis, ensuring that strategic recommendations are grounded in both theory and stakeholder-informed insights. It combines multiple complementary methods:

1. **Desk research and policy analysis**, consisting of a review of EU policy documents, academic literature, project deliverables, interoperability frameworks and ecosystem-related reports. This provides the basis for defining the LDT ecosystem in [chapter 2](#), describing the strategic, regulatory and

⁷ The numbering refers to the outcomes and outputs as per IAF.

⁸ Simister, N, 2015, Outputs, Outcomes and Impact, INTRAC

economic context of LDTs in [chapter 3](#), structuring sustainability dimensions (based on the [PESTLE](#) framework in [chapter 4](#), and understanding value creation and capture mechanisms in [chapter 5](#).

2. **Stakeholder co-creation:** Although more limited in this phase, inputs from the **joint LDT4SSC & DS4SSCC-DEP Stakeholder Forum meeting**⁹ (February 2026, attendance: 70) were used to validate and prioritise sustainability dimensions. Participants assessed key sustainability dimensions and related criteria via the [Mentimeter](#), and provided qualitative feedback, offering an initial indication of perceived drivers of sustainability. It should be noted that stakeholder input (number of responses provided) at this stage remained limited (N = up to 18), and therefore [chapter 4](#) provides a preliminary indication of priorities. This limitation will be addressed in the final version of the strategy through broader validation based on pilot implementation and expanded stakeholder engagement.
3. **Internal workshops with LDT4SSC consortium:** Two targeted workshops were organised to validate assumptions and support analytical development.
 - **SWOT analysis workshop** (March 2026): 11 representatives from the LDT4SSC consortium mapped strengths, weaknesses, opportunities and threats (SWOT) at both the LDT ecosystem level and the level of LDT4SSC's assets and services. The results of the first workshop informed the ecosystem diagnostics ([Chapter 3.2](#)), and both workshops supported identifying strategic gaps and risks;
 - **Scenario planning workshop** (April 2026): 11 representatives from the LDT4SSC consortium explored future sustainability scenarios, identifying key drivers and assessing them based on impact and uncertainty. As a result, four distinct scenarios were constructed. The method and sustainability scenarios are elaborated in [chapter 4.2](#).

This baseline framework will be tested and refined throughout the LDT4SSC implementation, particularly through the analysis of pilots' progress and results, leading to the final version of the Framework and Strategy for Growth and Sustainability by November 2028. Pilots' implementation will provide the evidence for assessing how LDTs and developed assets and services function in practice, how value is created, and how sustainability conditions materialise across different contexts. However, given that LDT4SSC aims to build a scalable and interoperable ecosystem of LDTs across Europe, the final version will also examine how the developed LDT solutions could perform beyond individual pilots. As such, the evaluation will combine pilot results, Key Performance Indicators (KPI), technical feedback, stakeholder engagement, and capacity insights. This methodological approach ensures that the final strategy is both evidence-informed and adaptable, allowing it to evolve as real-world implementation data becomes available and the ecosystem matures.

⁹ For more information on the SF, participants overview, and topics covered can be found in *Community Collaboration and Engagement Report 1*.

2. Local Digital Twins ecosystem - definitions and scope

This chapter explores the various layers of what constitutes a LDT ecosystem, i.e., the individual LDT implementations, the related stakeholders, as well as assets and services created and shared across the ecosystem. It then provides an overview of the main strengths, weaknesses, opportunities and threats for the LDT ecosystem as of early 2026 to build situational awareness for setting strategic priorities and recommendations in order to **foster growth and sustainability**.

2.1 Understanding Local Digital Twins and their ecosystem

To better understand the scope of the LDT ecosystem, it is worthwhile to contextualise first how an LDT itself is understood. The [LDT4SSC project has set](#) a working definition¹⁰ for a LDT as the following:

A Local Digital Twin is a digital representation of physical assets, systems, or processes, in a defined local context (e.g., city, district, building, industry, port, airport). It leverages either historical data, near real-time data, or real-time data, and it enables visualisation, analysis, simulation, and reasoning services that support decision-making.

While this definition captures the technical essence, it is important to recognise that LDTs are not merely technical artefacts, but socio-technical systems embedded in governance, organisational processes and stakeholder relations.

From a business and organisational perspective, LDTs may be designed and offered in various ways. The [DUET project \(2021\)](#) explored various types for Urban Digital Twins (which resonate closely with LDTs) based on two characteristics - **usage and control** (see [Figure 3](#)). The former distinguishes primary LDT users and beneficiaries in a closed model (with the local government being the sole user) towards an open one in which a LDT (and the value created) is open to other stakeholders, such as residents and companies. Control parameters denote owners of data and technical infrastructure, ranging from centralised (regulated by the government) to decentralised (regulated by the ecosystem) settings. In the latter case, different stakeholders may serve as data sources/providers, and remain in control of the information they hold and can set conditions for data sharing and access. Combining the parameters, four types of LDTs were identified:

¹⁰ Note that the working definition differentiates between the functional scope and specific capabilities, see further details in [the Knowledge Hub](#).

- **Closed LDTs** are centrally managed and used internally by the local government, relying on public-sector data to support decision-making and urban planning. Access, funding, and control are fully held by the local authority;
- **Network-oriented LDTs** are government-led but open to external stakeholders, enabling businesses, researchers, and residents to use shared data and insights to create new services and drive innovation;
- **Network-owned LDTs** are collaborative, ecosystem-driven digital twins where multiple stakeholders (public, private, academia, civil society) jointly fund, govern, and develop the system, based on open and interoperable data sharing, and;
- **Network-enabled LDTs** refer to a model where data and infrastructure can come from a broader ecosystem, but the LDT itself is used exclusively by the government for policy-making and internal decision support.

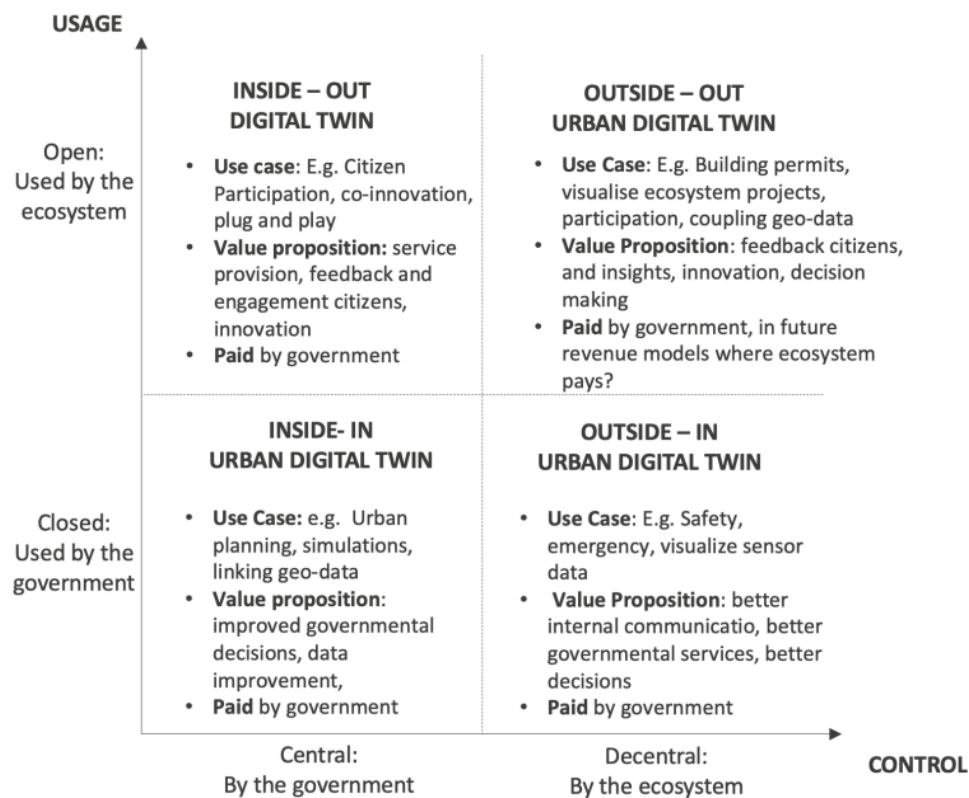


Figure 3: Use cases, value proposition and revenue models of Urban Digital Twins.

Source: [DUET project \(2021\) Cloud-based business model analysis](#)

Understanding these different types is important because the design, governance, and business model of a LDT depend on the chosen approach (one of the four types) and how effectively local communities can establish collaborations with other stakeholders. From a strategic perspective, these typologies may also reflect different maturity levels and sustainability pathways, ranging from isolated, internally-focused systems to fully collaborative, ecosystem-driven infrastructures.

In the context of LDT4SSC, network-enabled and -owned types take priority, recalling these broadly **as ecosystem-based LDTs**. This is due to the necessity of multi-stakeholder (data) cooperation to enrich LDT services, improve the accuracy of services, and strive towards replicating various services across single local communities.

This preference also partly stems from the EU's strategic goal to move from isolated solutions to a coordinated LDT ecosystem. Many local communities lack the capacity (e.g., time, expertise) and resources to develop such technologies on their own. At the same time, the landscape for digital solutions is fragmented, access to data, technology and services is frequently restricted, all of which reduce real choice, transparency, and stakeholder participation. To overcome these challenges, and support the EU's strategic agenda, the LDT4SSC aims to create a robust, interconnected ecosystem of LDTs that scales across sectors, regions, and borders, driving the development, adoption and replication of LDTs and advanced AI-driven services.

In this context, the **LDT ecosystem** is defined as ...

...an open and interoperable collaboration framework for Local Digital Twins initiatives used and sustained by multi-stakeholder communities to address common local and regional challenges.

Rather than a specific platform or marketplace, the ecosystem is defined **by the contributions, reuse, and collaboration across the LDT initiatives**, linking diverse sets of stakeholders across sectors, domains and borders.

The interconnected LDTs ecosystem can be further looked at from three interdependent layers ([Figure 4](#)):

1. The **LDT level** (individual implementations), where LDTs deliver value in specific local contexts through data-driven services.
2. The **LDT ecosystem level**, seen as a collaboration framework for connecting LDTs, stakeholders and infrastructures into an interoperable system, is driven by reuse and cooperation across sectors and borders.
3. **LDT4SSC assets and services level**, focusing on the reusable resources and services for local communities to exploit existing LDT services, supporting interoperability, scalability and ecosystem development (initial list of potential assets and services provided in [chapter 2.3](#)).

These layers are mutually reinforcing and reflect LDT4SSC's ambition to build a federated and interoperable LDT ecosystem across Europe.

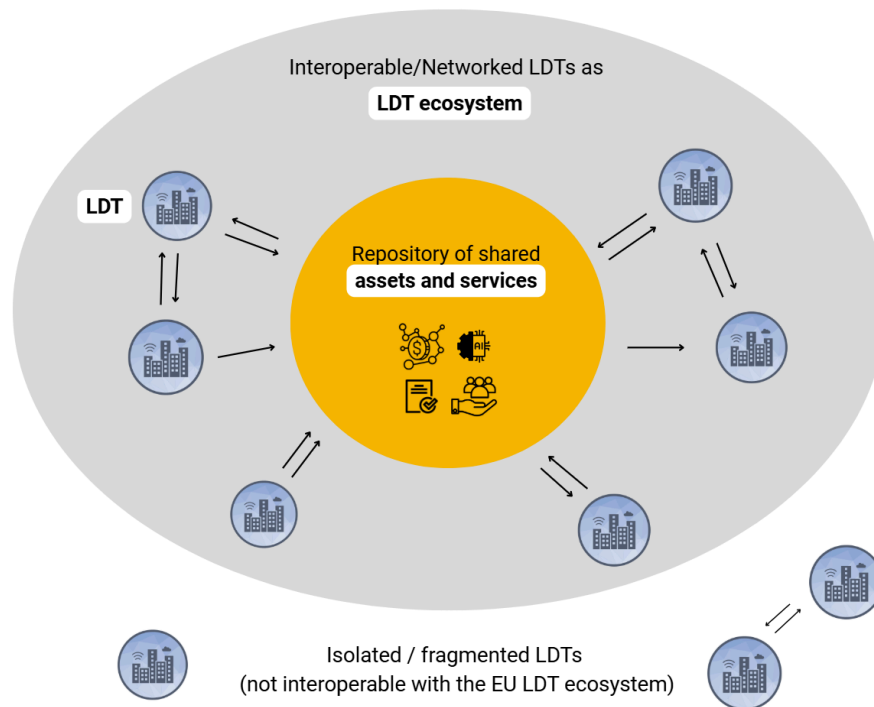


Figure 4: Overview of the LDTs landscape and the interconnections between individual LDTs, the LDT ecosystem and LDT4SSC's assets and services

During the implementation of the LDT4SSC project, an emphasis is given to the LDTs and other resources developed through the 15-20 pilots across [three Work Strands](#), and the broader community of stakeholders (see the objectives in [chapter 1.1](#)). The LDT ecosystem will grow gradually by requiring the LDT4SSC pilots to build interoperable and replicable services. This growth can be understood as a transition from fragmented local implementations towards a federated European ecosystem of LDTs, where interoperability, shared standards, and governance alignment act as key scaling mechanisms, helping smaller and still fragmented LDT ecosystems (built between a few local communities engaged in single pilots) to interconnect (see [Figure 5](#)).

LDT4SSC's broader goal is to provide a framework and tangible assets to also extend the ecosystem to more communities and their solutions beyond the project's lifetime, and as such, advance Europe's sovereign digital transformation and competitiveness. It starts with an overall engagement framework introduced in *Community Collaboration and Engagement Report 1*, clarifying the engagement and collaboration mechanisms as well as initial targets per stakeholder groups. The project recognises the importance of making its resources widely available and hence will support deployment on interoperable LDTs with capacity building resources and dissemination with a dedicated communication strategy.

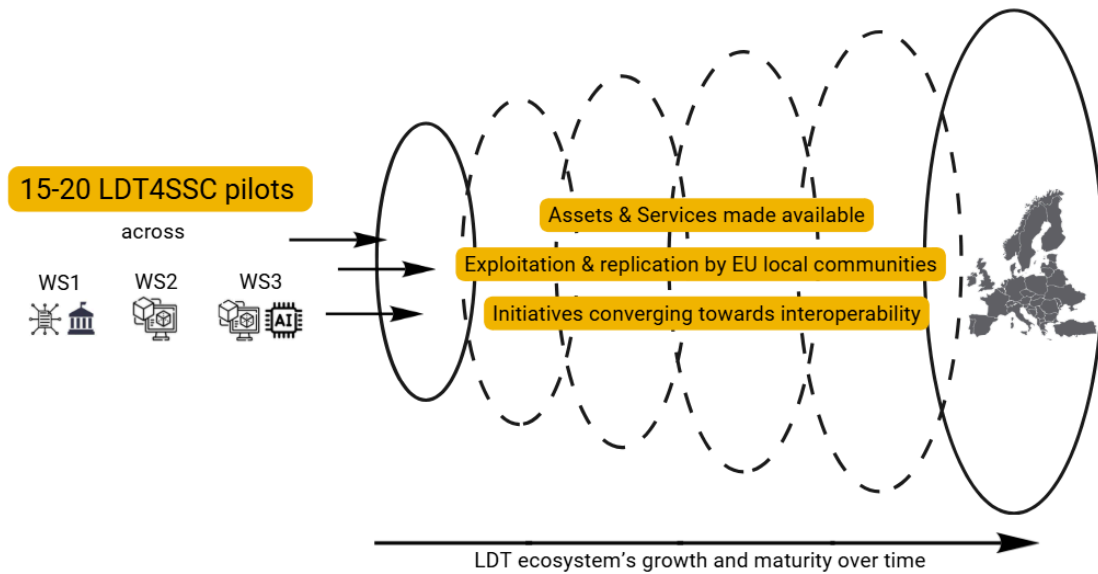


Figure 5: Vision for growing and maturing towards an EU-wide LDT ecosystem

2.2 Key stakeholder groups and roles

This subchapter will look more closely at the specific stakeholder groups and their roles within an ecosystem of LDTs, describing their needs and primary foreseen role in the LDT ecosystem (see [Table 1](#)). Note that this mapping is not exhaustive or restrictive, as other roles and ways to interact with LDTs and their ecosystem may occur. Importantly, stakeholder roles are dynamic and may evolve over time as the ecosystem matures, technologies evolve, and new governance or business models emerge. Further mapping will be conducted based on specific use cases by analysing the division of roles within each pilot project, as well as through engagement with the LDT4SSC Stakeholder Forum and other smart communities initiatives.

Table 1. Relevant stakeholders to the LDT ecosystem per specific need, interaction modality, and roles

Stakeholder group	Needs	Interaction with LDTs and its ecosystem	General role	Likely roles to carry in the context of data sharing and governance (one or more roles)
Local and regional authorities (LRA) (i.e., City municipalities and local governments as per D6.4)	Addressing local challenges, seeking sustainable and digital solutions to foster local wellbeing and resilience, and efficient operations. LRAs are likely to want to: a) be (more) transparent and trustworthy among their constituents, and b) build a thriving business ecosystem to ensure a prosperous and sustainable community.	LRAs are key implementers and beneficiaries of LDTs, engaging in the design, development as well as actual use of the LDT. LRAs may be actively seeking collaboration opportunities with other cities and communities to meet common needs, as well as explore possibilities to cooperate with the private sector, academia, and civil society.	(Likely) Owner and/or Governance Authority of the LDT	1. Governance Authority 2. Orchestrator/ coordinating entity 3. Use case orchestrators, 4. Community support bodies 5. Data Holder 6. Data Provider 7. Data User 8. End-User (of services)
SMEs and Industry as Service Providers (utilities and others)	Efficiency gains and new business opportunities. Implement innovative LDT and AI-driven solutions in real-world applications, see their applications come to life through concrete challenges.	(May) engage in the design, development, deployment and further replication of the LDT.	Users and partners of LDTs	1. Orchestrator/ coordinating entity 2. Use case orchestrators 3. Data Holder 4. Data Provider 5. Data User 6. Intermediaries 7. End-User (of services)
Tech providers and other enabling services	Demonstrate and deploy their technology and/or services in a real (urban or community) setting, create value, earn income and grow their business. Position themselves as trustworthy vendors towards cities and communities.	(May) engage in the design, development, deployment and further replication of the LDT.	Developers	1. Orchestrator/ coordinating entity 2. Use case orchestrators 3. Community support bodies 4. Data Holder 5. Data Provider 6. Data User 7. Intermediaries

Academia and research	Implement their research, seek funding, e.g. for future research and collaboration.	(May) engage in the design, development, deployment and further replication of the LDT. These stakeholders provide expertise, methodologies, (technical) support, and frameworks for implementation. Also, they contribute to innovation ecosystems and capacity-building.	Supporters and potential developers	1. Orchestrator/ coordinating entity 2. Use case orchestrators 3. Community support bodies 4. Data holder 5. Data provider 6. Data user 7. End-user (of services)
Civil society organisations (CSOs)	Ensuring that city challenges are tackled fairly and that community needs are properly addressed. Find opportunities for pilot projects in which they can implement this approach.	When made available to the public, CSOs can participate both in the design and use of the LDT. CSOs may use it for data-based advocacy, monitor policy impacts (e.g., on the environment, social equity, accessibility), raise issues early, and work jointly on solutions.	Users and partners, especially in providing oversight	1. Orchestrator/ coordinating entity 2. Use case orchestrators 3. Community support bodies 4. Data holder 5. Data provider 6. Data user 7. End-user (of services)
(Local) Residents	Generally, a good living and working environment. Trust in the management and service delivery of cities and various utilities.	Depending on the LDT's purpose and implementation, residents may participate in the design of the LDT through facilitated co-creation as well as use the LDT to better understand current urban conditions and future plans (e.g., a new park or transit system) and to actively engage with these to provide feedback.	Users and beneficiaries of the LDT-based services	1. Data Provider 2. Data User, 3. End-User (of services)

From a strategic perspective, this initial stakeholder mapping highlights that the LDT ecosystem is inherently multi-sided, requiring alignment of incentives, roles and value propositions across actors with different objectives and capabilities. A key challenge for the ecosystem is therefore **sustained alignment across stakeholders** to ensure that actors perceive sufficient value to participate over time. It is therefore important for pilots to explore the needs of stakeholder groups in more detail, specifying the exact profile and their objectives, ranging from different domains, levels of hierarchy, as well as specific roles. The LDT4SSC project aims to validate (and if needed, iterate) the needs, interaction modalities, roles and value propositions for the second version of the framework and strategy for growth and sustainability.

2.3 Key expected assets and services from LDT4SSC

The LDT4SSC project delivers a set of key assets and services to support the development, adoption, and scaling of LDTs across cities and communities. These assets collectively form the “enabling infrastructure” of the LDT ecosystem, supporting interoperability, reuse and capacity-building across local communities.

[Common Interoperability Blueprint](#) brings together existing guidance and tools into one clear structure that supports interoperability across technical, organisational, legal, and business dimensions. In practice, it helps stakeholders align data, systems, governance approaches, and compliance requirements so that LDT solutions can be more easily adopted, replicated, and scaled across different cities and contexts. The blueprint is designed as an operational resource for implementation and will be further refined through feedback from pilot activities. Strategically, this blueprint acts as a guide for supporting convergence, reducing fragmentation and enabling scalable deployment across heterogeneous environments.

The Repository of Assets and Services (upcoming) serves as the curated and discoverable home for the mature, shareable outputs generated through LDT4SSC. Complementing the pilot repositories, which document each pilot’s journey and ongoing developments, it provides the formal space where reusable results can be made accessible to the wider LDT4SSC community and beyond. The repository is designed to host both technical and non-technical assets, including tools, datasets where legally shareable, data models, software components, services, governance frameworks, legal or contractual templates, stakeholder engagement artefacts, and operational methodologies.

To support effective uptake and reuse, each asset is accompanied, where relevant, by clear documentation, metadata, implementation guidance, and contextual information such as ownership, licensing, provenance, dependencies, and practical use cases. Rather than functioning as a general storage space, the repository acts as a structured mechanism for identifying, curating, and promoting assets that have clear value beyond the original pilot context. By linking with existing marketplaces and wider ecosystem channels, it also strengthens the visibility, accessibility, transferability, and long-term sustainability of project results. In this sense, the repository is a key instrument for value scaling, enabling solutions developed and validated in pilot settings to be discovered, adapted, reused, and replicated across different LDT initiatives and contexts.

Capacity-Building resources and activities (upcoming) are designed to equip end-users, particularly public authorities, with the skills and knowledge needed to effectively use and valorise LDT services and assets in urban decision-making. These include online and in-person training, practical use cases, and hands-on activities with the LDT playground, alongside sector-specific materials such as slides, videos, and factsheets. The programme supports the integration of LDT tools into policy and decision-making processes across domains such as energy, mobility, and safety, while evolving over time through needs assessment and community feedback. Capacity building plays a critical role in addressing one of the main systemic barriers to LDT adoption, namely the lack of technical, organisational, and governance capabilities within local authorities and beyond.

3. Context and diagnostics

To establish the situational awareness for setting strategic recommendations for LDTs and their ecosystems growth and sustainability, this chapter provides an overview of the European Commission's (EC) strategic policy agenda in relation to digitalisation, European Green Deal and competitiveness as well as explores the overall strengths, weaknesses, opportunities and threats for the ecosystem.

3.1 Europe's strategic agenda

The LDT4SSC project has been called upon by the EC to contribute to its strategic agenda on strengthening strategic autonomy, driving the green transition and reinforcing democratic values. It contributes to the strengthening of the single market, boosting innovation in AI and technology, and ensuring sustainable economic growth, as well as accelerating the EU's commitment to climate neutrality and biodiversity protection.

The LDT4SSC project is inspired and guided by a number of European strategies and policies, as follows:

- [EU Data Strategy](#) and the [EU Data Union Strategy](#), including their regulatory instruments such as the Data Governance Act, Data Act, AI Act, Interoperable Europe Act and others. LDT4SSC contributes to a single digital market by promoting secure, interoperable data spaces that enable cross-border collaboration and innovation;
- [Apply AI Strategy](#), which aims to accelerate the large-scale adoption and integration of AI across Europe to boost competitiveness, productivity, and technological sovereignty, with direct relevance to local communities through improved public services, and economic opportunities (especially for SMEs);
- [EU Missions on Climate-Neutral and Smart Cities](#), [Soil Deal Mission](#), and the [Restore Our Ocean and Waters Mission](#), by providing data-driven decision-making tools that enhance resilience, biodiversity, and circular economy practices;
- [Twin Transition](#), recognising Europe's approach to pursue the green and digital transformations together, identifying synergies and minimising environmental impacts of digitalisation while maximising its contribution to climate and sustainability goals;
- [Digital Decade 2030](#), a policy programme that guides Europe's digital transformation. LDT4SSC aligns with it and aims to foster digital sovereignty, interoperability, and AI-driven public services;
- [European Green Deal](#), a set of EU policy initiatives with the overarching aim of making the EU climate neutral by 2050. LDT4SSC helps to facilitate progress towards climate neutrality, sustainable urban development, and resource efficiency, in particular through alignment with the EU's [Destination Earth](#) initiative;

- [New European Bauhaus](#), a policy and funding initiative that focuses on making green transition in built environments and beyond enjoyable, attractive and convenient for all. This project embraces its principles to create inclusive, aesthetic, and sustainable urban environments, and emphasises multi-stakeholder collaboration across the quadruple helix, especially by engaging citizens and communities into urban actions;
- [The Future of European Competitiveness – A Competitiveness Strategy for Europe](#) (the so-called Draghi report) by empowering cities and communities with innovation capacities;
- [The Green Deal Industrial Plan](#), contributing with ambitions to model, optimise, and scale eco-friendly and net-zero urban digital systems at place-based level;
- [European Declaration on Digital Rights and Principles](#), by supporting cities and communities to embed human-centric, rights-based, inclusive and participatory principles into data-driven urban models and decision-making systems.

Taken together, these frameworks create both an enabling environment and a set of potential challenges for LDT deployment. On one hand, they generate strong demand for interoperable, data-driven solutions aligned with sustainability and digital transformation goals. On the other hand, they introduce regulatory complexity, compliance requirements and coordination challenges across governance levels. LDT4SSC operates at this intersection, translating policy ambition into operational, scalable and reusable solutions.

The next section provides a multidimensional diagnostic of the LDT ecosystem as of early 2026, drawing on further desk research, the LDT4SSC consortium's internal SWOT workshop, as well as insights from the joint LDT4SSC–DS4SSCC–DEP Stakeholder Forum meetings.

3.2 Ecosystem diagnostics

The primary underserved need in Europe seems to be the lack of open, interoperable, AI-capable, and replicable LDT services accessible to resource-constrained municipalities. LDT4SSC aims to address a distinctive niche by combining institutional legitimacy, an evidence-generating piloting programme and interoperability by design approach that focuses on enabling collaboration and reuse of LDTs across stakeholders. However, its relative weaknesses may include lower short-term usability than commercial tools, limited brand recognition and dependence on sustained ecosystem participation and long-term maintenance contributions, which may limit the speed of feature development and maintenance compared to large commercial vendors.

By early 2026, tangible institutional infrastructure initiatives include the [EU LDT Toolbox](#), the [Smart Middleware Platform \(SIMPL\)](#), the [LDT CitiVERSE EDIC](#), and the [LDT4SSC project](#) itself, with the expected 15–20 pilots to be launched in 2026 across three work strands and a targeted community of at least 100 stakeholders. The broader

communities of practice span not only the aforementioned initiatives but also representatives from local communities, SMEs, academia and beyond, all engaged in smart city initiatives which help reduce cold-start barriers. Despite this momentum, the ecosystem remains characterised by project dependency.

Several LDTs developed in EU communities exist as grant-funded pilots with limited transition to sustained public infrastructure ([Directorate-General for Communications Networks, Content and Technology, 2023](#); [EC, 2022 Eurocities, 2022](#)). However, as [Sorri et al \(2021\)](#) remind us, isolated pilot projects (and initiatives alike) may lead to a fragmented structure and poor general awareness. *“The ecosystem actors may not even know that they are critical actors for the ecosystem to succeed. Better clarity regarding the actors’ roles may increase the experienced value capture and future value potential.”* (ibid, p. 9) This indicates a structural transition gap, as while technological and conceptual foundations exist, mechanisms for long-term operation, governance and financing remain underdeveloped.

From the business perspective, the European digital twin market was estimated at around USD 7.1 billion (approx. **6.1 billion €**, [exchange rate of 25.05.2026](#)) in 2025, with projections of USD 42.8 - 49.3 billion (approx. **36.8 - 42.3 billion €**, [exchange rate of 25.05.2026](#)) by 2030 (Compound Annual Growth Rate (CAGR) of 34 - 47%). The smart infrastructure and smart cities segment, a proxy to the LDT domain, represented an estimated USD 0.7–0.8 billion (approx. **0.6 - 0.7 billion €**, [exchange rate of 25.05.2026](#)) in Europe in 2024 ([Markets and Markets, 2026](#), [WorkNomads, 2025](#)). These aggregate figures overstate the immediately addressable LDT4SSC market, yet signal strong directional momentum and growing demand for LDT solutions, particularly in the public sector driven by EU regulatory obligations (see previous chapter), cost pressures in public administration, and rising expectations for data-informed governance.

In addition, literature suggests three structural shifts that warrant strategic attention:

1. **AI integration is elevating expectations from visualisation to predictive modelling and scenario simulation** (e.g. [Alam, 2025](#); [Bibri et al., 2024](#));
2. **Federated data infrastructures** ([GAIA-X](#), [SIMPL](#), among others) are moving from concept to **operational phase**, directly enabling the LDT4SSC interoperability model;
3. **Growing public procurer preference for open-source and vendor-independent platforms** reduces structural barriers that previously favoured proprietary incumbents. For example, [the Interoperable Europe Act](#) embeds open standards compliance as a baseline requirement in public digital service delivery across member states, while the [Interoperable Europe Centre’s official Guideline on Public Procurement of Open Source Software](#) explicitly obliges public authorities to prefer open standards-based solutions in procurement decisions. Recently, the European Commission opened a formal [call for evidence in January 2026 for a dedicated European Open Digital Ecosystem Strategy](#), further cementing open source as a pillar of EU technological sovereignty policy.

Finally, the LDT ecosystem operates within a complex landscape, where actors compete for resources, attention and adoption, while also contributing to shared infrastructures. This requires examining the competition landscape, especially across the following three actor categories:

1. **Commercial platform vendors** (e.g., [Microsoft Azure Digital Twins](#), [Siemens Xcelerator](#), [Bentley iTwin](#), [ESRI](#), [IBM Intelligent Operations](#)) offer feature-rich, often well-resourced platforms with strong usability, but carry vendor lock-in, high licensing costs, and limited alignment with public-sector sovereignty and open-standards requirements. While certain commercial vendors offer a wide range of use-cases on their digital twin platforms, those addressing municipal markets are mostly weak on the cross-sector, interoperable federation model LDT4SSC targets. These actors represent strong short-term competitors in terms of usability and deployment speed, but weaker alignment with public-sector values such as openness, interoperability and sovereignty;
2. **Competing EU-funded initiatives** (e.g., [Destination Earth](#), [GAIA-X](#)) are not direct competitors for LDTs *per se*, but compete for political attention, expert bandwidth, and stakeholder engagement. City officials, ministries, and researchers are simultaneously engaged across DS4SSCC-DEP, LDT4SSC, Living-in.EU, LDT CitiVERSE EDIC, CitCom.ai, and SIMPL. Depending on the ability of strategic liaising, this may either support alignment or instead create a risk of fragmentation and duplication, as well as stakeholder fatigue due to overlapping initiatives and engagement demands;
3. **National digital twin programmes** (e.g. [Dutch Digital Delta](#)) represent mature, policy-coherent comparators and potential benchmarks or future partners.

Given their relevance and influence on the LDT ecosystem's growth, these stakeholder groups should be considered also in the relation of LDT4SSC's engagement framework.

3.2.1 SWOT Analysis

The following SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis (see a summary in [Table 2](#)) provides a structured strategic appraisal of the LDT ecosystem and the LDT4SSC assets and services at their current stage of development. It was developed through a dedicated consortium workshop in March 2026 and grounded in the desk research and competitive landscape analysis presented in the preceding section. The analysis operates at two interdependent levels - the broader LDT ecosystem and the specific LDT4SSC assets and services (elaborated in [chapter 2.3](#)), which are treated in an integrated manner under each dimension to reflect their mutual conditioning.

Table 2: SWOT Summary - LDT ecosystem and assets and services

Strengths (Internal)	Weaknesses (Internal)
LDT ecosystem • EU Policy alignment • Institutional credibility • Open-source foundations • Technical maturity • Growing pilot portfolio • Community infrastructure and facilitation capacity LDT4SSC assets and services • Institutional trust, legitimacy and EU ecosystem anchoring • Technical openness, standards alignment and EU sovereignty • Centralised asset management and discoverability	LDT ecosystem • Digital maturity disparities and onboarding gaps • Technical fragmentation and interoperability readiness • Underdeveloped business models • Uneven funding access • Missing internal value proposition • Documentation and communication • Internal leadership and network-building capacity • Cross-disciplinary skills deficit • Data quality and provenance standards • Environmental footprint of LDT infrastructure • Citizen co-production deficit LDT4SSC assets and services: • Technological robustness and relevance • Adoption, perception and ethical limitations • Positioning and differentiation • Structural ecosystem readiness gaps
Opportunities (External)	Threats (External)
LDT ecosystem • New regulatory instruments creating structural demand • EU institutional co-investment and adjacent ecosystem resources • Growing urban challenges creating market pull • Sectoral expansion into energy, mobility and environment • Independent convening power of European city networks • EU LDT model as global norm-setting platform LDT4SSC assets and services • Compatibility with LDT CitiVERSE EDIC as a pathway for sustainability • Open to external developers and service provisioning as well as to external contributions	LDT ecosystem • EU funding cycle discontinuity and public financing contraction • Proprietary platform competition and Big Tech dominance • Technical standards fragmentation across the broader EU landscape • Stakeholder resistance, ecosystem fatigue and perception risks • Geopolitical, climate and force majeure disruptions • Cybersecurity threat landscape and federation attack surface • AI Act compliance obligations and legal uncertainty LDT4SSC assets and services • Fragmentation and choice overload • EU funding dependency and long-term viability • Security risks from networked LDTs

Strengths

The LDT ecosystem and the LDT4SSC asset portfolio derive institutional credibility from mutually reinforcing properties: **EU programme funding, community co-production, and structural integration with prior and ongoing EU initiatives** such as SIMPL, LDT Toolbox, DS4SSCC and Living-in.EU. This anchoring, validated through concrete pilot demonstrators, reduces regulatory and political barriers to adoption among public administrations and cannot be readily replicated by competing solutions in the short term. **Technical openness** constitutes a second core strength shared across both the ecosystem and its asset portfolio. Open-source foundations prevent vendor lock-in; grounding in [MIMs Plus](#), [NGSI-LD](#), and [FAIR principles](#) ensures interoperability and data quality; and alignment with principles such as digital sovereignty makes the assets compatible with GAIA-X, SIMPL, and the [EU Data Strategy](#), properties that proprietary non-European alternatives do not match so far. **Centralised publication through a neutral repository** with rich metadata may reduce onboarding friction and enable consistent asset lifecycle governance independent of the original contributing teams in the future. **Community facilitation by the LDT4SSC consortium** reinforces these technical foundations further by providing onboarding support, training, and peer exchange.

Weaknesses

Local communities face significant structural **disparities in digital maturity**, as also reflected in [LORDIMAS maturity assessments](#) and broader smart city implementation experience across Europe (e.g., see [ESPON, 2026](#); [Caragliu & Del Bo, 2023](#)). Current resources and onboarding pathways are oriented toward technically advanced frontrunner municipalities, creating a participation ceiling that limits equitable access. Business models for ecosystem-based LDTs remain underdeveloped and uneven post-project funding access leaves long-term operational continuity uncertain. A cross-disciplinary skills deficit may sustain dependency on external consultancy, limiting communities' potential for growth. Current **technical fragmentation within the LDT ecosystem** also challenges its federation promise. Legacy infrastructure and proprietary inertia create internal heterogeneity that may misalign aspirational interoperability frameworks with actual cross-community data exchange. At the LDT4SSC assets and services level, data quality and semantic labelling **may not be validated** at the point of contribution, meaning interoperability claims **may lack embedded quality assurance support** (see also [chapter 6](#)). Several asset specifications also risk being outpaced by AI and platform innovation before achieving scaled adoption. The portfolio additionally **still lacks governance frameworks or stewardship templates clarifying post-project maintenance responsibilities**, and services have not been designed with progressive capability tiers accessible to municipalities with limited (technical) staff.

The LDT ecosystem and its assets also share a **communication and differentiation deficit**. The portfolio still lacks a sufficiently clear distinction from assets produced by adjacent EU programmes and proprietary smart city platforms, making it difficult for potential adopters to assess specific added value at procurement. Internally, **operational realities have not yet been translated into compelling evidence-based narratives or replicable playbooks**. The **absence of an environmental footprint assessment** for LDT infrastructure creates a credibility risk with Green Deal-aligned

policymakers, and **insufficient mechanisms for genuine citizen co-production** may expose the ecosystem to technocratic capture and reduced political durability.

Opportunities

Regulatory developments create a structural demand for the capabilities the LDT ecosystem aims to offer (see sections 3.1 and 3.2). The **EC's financial and political commitment** to urban digital infrastructure, combined with reusable assets from adjacent EU initiatives, provides an external co-development and co-financing environment that substantially reduces build costs. **Compatibility with LDT CitiVERSE EDIC ambitions** further **opens a pathway** to transitioning the asset portfolio from project artefacts to publicly governed EU digital infrastructure. In addition, growing urban challenges in climate adaptation, mobility, and energy create an independent **market pull** that reduces communication overhead. Established **European city networks extend the ecosystem's convening reach** far beyond the consortium, which may be drawing in municipalities, policymakers, and private actors without requiring direct project outreach. Standardised, open APIs may **attract external developers** to build compatible services, generating ecosystem growth through contributions that require no direct consortium investment. At the global level, the EU's sovereignty-respecting, open-standards approach may position the LDT ecosystem model as a **competitive norm-setting** reference point, offering both market expansion and geopolitical credibility.

Threats

Dependence on EU grant cycles constitutes an existential financial risk. Without diversified funding models or formal cost-sharing arrangements, both ecosystem functions and individual assets may face discontinuity at each project transition. Shifts in EU or national policy priorities could redirect investment away from fostering open ecosystems, removing the primary financial basis for coordination and asset maintenance. Commercial platforms backed by large-scale marketing infrastructure may create **competitive pressure that open-source ecosystems structurally struggle** to match in near-term usability and market positioning. Also, the proliferation of competing public and proprietary solutions may increase choice overload for municipalities, while the absence of clear comparative documentation may obscure LDT4SSC assets' specific added value at the point of selection, until this shortcoming is overcome. In addition, as LDTs interconnect (e.g., through SIMPL) and interface with critical urban infrastructure, the **federation's collective attack surface expands** with each new node, and a propagating breach would damage ecosystem-wide trust in the interconnection model itself. Geopolitical instability, climate-related events, and other force majeure disruptions are threats to digital infrastructures and global supply chains which the LDT ecosystem and the underlying critical public services depend on. **Stakeholder fatigue, incumbent resistance, and persistent digital divides** in the broader workforce may further constrain adoption momentum independently of technical quality.

These strengths, weaknesses, opportunities and threats provide the basis for setting strategic priorities and recommendations in [chapter 7](#).

4. What sustainability means for LDTs

Depending on whether LDTs are considered as simply *one of the technical services communities may deploy* or as a *strategic digital infrastructure for various uses*, perceptions and motivations for sustaining them vary. As of today, many LDTs across Europe are fragmented and limited with only a few use cases and user groups, although policy and ecosystem initiatives are increasingly positioning them as core infrastructure for data-driven governance and sustainability transitions. Thus, their potential for growth and sustainability is hindered.

It's worthwhile to emphasise that in data-intensive and multi-stakeholder community systems, sustainability goes beyond technical and financial upkeep. It includes the conditions that foster value creation for all stakeholders, and meaningful integration into urban, peri-urban and/or rural governance and service delivery within communities. Furthermore, sustainability is tied with societal acceptance, alignment with public values and legal frameworks. As such, sustainability should be assessed in a context of ongoing institutional, technical and regulatory development ([Garske et al, 2024](#)), and be better understood by examining its key dimensions and how they operate across different layers of implementation and coordination.

4.1 Dimensions of sustainability in the LDT context

Inspired by the [PESTLE framework](#), the following subchapters (4.1.1–4.1.6) outline six key dimensions – Political, Economic, Social and Civic, Technological and Data, Legal, and Environmental – to set the foundations for the conditions that support the long-term sustainability of individual LDT services, as well as the broader ecosystem, and the shared assets and services within it. The following sustainability dimensions and their associated drivers are derived from desk research and supported with initial rankings collected during the Stakeholder Forum (SF) meeting in February 2026 (attendance 70, responses from 9-18), providing a preliminary indication of their relative relevance. An overview of the responses provided by the stakeholders is available in Figures 6-12. It should be noted that, at this stage, the adapted PESTLE framework offers an initial overview of key sustainability considerations. These will be further refined and systematised through the analysis of LDT4SSC pilots as part of the final version of the Framework and Strategy for Growth and Sustainability.

4.1.1 Political sustainability

Political sustainability refers to the *ability of political and governance systems at local, national and EU levels to provide stable support, coherent policies, and enabling frameworks for the long-term implementation and scaling of LDTs within a coordinated European ecosystem*. It relies on sustained political commitment, policy alignment, institutional stability, and adaptive multi-level governance.

Sustainability drivers:

- **Political leadership in fostering LDTs through resource allocation and enabling frameworks:** Leadership shapes how strategic priorities are translated into regulatory development, institutional arrangements and

investment decisions, but moreover, how partnerships are formed and negotiated. Capacity gaps can limit engagement in LDT initiatives, reinforcing the need for leadership in both setting strategic goals and capacity-building. Current EU initiatives (e.g. the [LDT Toolbox](#) and [LDT CitiVERSE EDIC](#)) therefore facilitate active participation from local level authorities, enabling them to both contribute to and benefit from the wider ecosystem.

- **Sustained political buy-in and multi-level support:** Effective implementation and scaling of LDTs require continuous political commitment and a supportive policy environment across local, national, and EU levels. This commitment is key to securing initial funding, and enabling institutional support for long-term development and upkeep. Successful deployment of LDTs also depends on strong cross-departmental coordination and governance structures that support data sharing and joint decision-making ([DUET, 2022](#); [Schneider, 2024](#); [OASC, 2026](#)). This aligns with the EU's push for coordinated digital governance (e.g., the [Interoperable Europe Act](#)), although communities vary in their capacity to engage with these frameworks.
- **Policy coherence for continuity across political cycles:** Public sector innovation and policy implementation may take several years, which requires systematic maintenance of institutional memory and rooting policies into strategic documents (such as mandates, development plans). [Policy coherence](#) (including alignment with EU priorities such as [Green Deal](#), [Digital Decade](#) or SDGs) can help ensure that actions across governments and policy areas are mutually reinforcing, reducing fragmentation, and supporting integrated implementation. Aligning LDTs with strategic public policy agendas and embedding them into statutory planning and multi-annual funding frameworks are useful ways to increase initiative's durability and reduce vulnerability to political turnover.

Across these drivers, political leadership was ranked as the main driver of **political sustainability** by 60% of respondents during the SF meeting ([Figure 6](#)). Respondents also separately highlighted the importance of clearly communicating the benefits for all stakeholder groups to maintain direction and alignment.

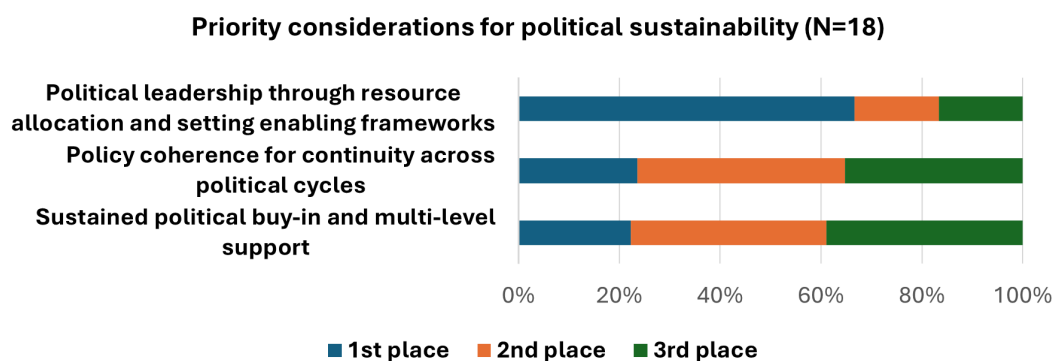


Figure 6: Ranking results for political sustainability drivers

4.1.2 Economic sustainability

Economic sustainability refers to the *financial viability, resource mobilisation, logic for value creation and value capture, and organisational capacity that enable LDTs to operate, adapt and scale over time*. It involves matching investments and operational costs to demonstrated and evolving demand, while ensuring sustainable financing pathways and the capacity to generate and maintain value across the full lifecycle.

Sustainability drivers:

- Clear value propositions with measurable public and economic outcomes:** LDTs should be grounded in clearly defined public/social and economic value (e.g. public good, cost savings, service optimisation, risk reduction), rather than abstract “innovation goals” (see also [chapter 5](#)). To ensure sustainability, value must be measurable and adaptable over time, allowing it to reflect evolving needs and justify continued investment. This is particularly important at the LDT level, where demonstrated value drives local adoption and sustained use, while at the ecosystem level, value is created through network effects and scale.
- Strong market intelligence (future-looking “fit to the market”) and engagement with ecosystem stakeholders:** A forward-looking perspective on the demand, supply dynamics and stakeholder needs can support identifying value creation opportunities and marketing towards potential users. Engagement with ecosystem actors (including vendors, partners and public stakeholders) enables alignment, creates potential for data cooperation and long-term use (in line with the [European Data Strategy](#)’s emphasis on data-sharing ecosystems and cross-sector value creation). However, as market structures for LDT services are still emerging, sustained stakeholder engagement is essential not only for coordination but also for shaping viable use cases and service models ([Garske et al., 2024](#)).
- Internal capacity and integration into organisational workflows:** Economic sustainability also depends on building internal technical and managerial capacity ([Rashed et al. 2025](#)), to reduce dependency on external providers or consultants, lower lifecycle costs, and strengthen the ability to mobilise resources (e.g. fundraising and partnerships) over time. While several capabilities and skills can be outsourced and/or acquired through procurements, critical competencies should be maintained in-house to drive innovation actions as well as ensure strong positioning in collaborative funding and innovation networks. Furthermore, economic sustainability is connected with the capability to integrate LDTs into core organisational workflows and decision-making processes (e.g. planning, service delivery, operational coordination) to improve efficiency and enable more cost-effective operations.
- Cost-benefit planning over the full LDT lifecycle:** Quite often, initial LDT deployments are supported through grants or project-based funding, while long-term operational costs are frequently underestimated ([de Matos et al., 2024](#)). Economic sustainability, however, requires planning beyond pilot phases by accounting for full lifecycle costs, including infrastructure, data management,

computing resources, maintenance, compliance, and staff capacity, among others. This approach enables more informed and cost-effective decision-making by considering total costs and benefits over time (see e.g., [EU guidance on life-cycle costing](#)).

- **Funding continuity through diversified and credible financing mechanisms:** Overreliance on short-term grants or investments creates uncertainty, therefore in many public and digital infrastructure domains, governments seek public-private partnerships (PPPs) and blended financing approaches (see also [chapter 5.2](#)) to mobilise additional (private) resources and distribute risk, particularly where public funding alone is insufficient to meet investment needs ([Kumar et al., 2025](#)). Diversified funding models, however, require a good understanding how costs and benefits are distributed across stakeholders, in order to address misaligned incentives and support fair distribution of benefits and costs.

Across these **economic sustainability drivers**, more than half (58%) of SF meeting respondents identified clear value propositions with measurable public and economic outcomes as the main driver of economic sustainability ([Figure 7](#)). This was followed by strong market intelligence and stakeholder engagement (25%) and internal capacity and organisational integration (17%). One respondent specifically highlighted the importance of resilience to external shocks, particularly the ability to sustain operations during a financial downturn.

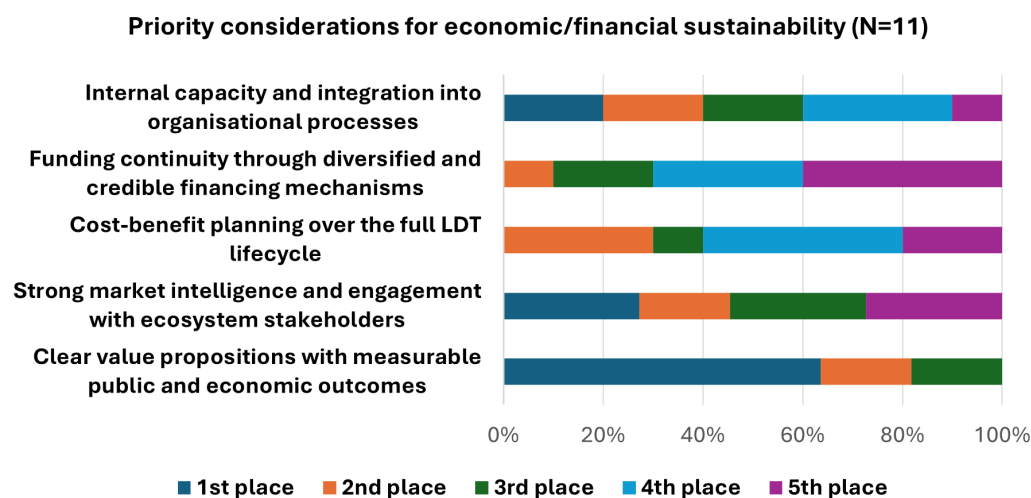


Figure 7: Ranking results for economic sustainability drivers

4.1.3 Social & civic sustainability

Social and civic sustainability refers to *how effectively LDTs reflect and support community needs, inclusion, legitimacy, trust and equitable participation*. It focuses on fostering societal acceptance, overall social well-being and cohesion, and inclusive engagement, ensuring that LDTs do not reinforce socio-economic or socio-technical divides. It is also noteworthy that most SF meeting respondents (78%) identified social and civic sustainability as the most important dimension (see [Figure 12](#)).

Sustainability drivers:

- Demonstrating community benefits and insight-driven governance:**
 Literature shows that LDT applications in urban planning and infrastructure are associated with higher public acceptance when benefits are tangible (i.e., visible and measurable) and locally relevant, as interactive visualisation, user-friendly design and real-world use cases enhance citizen engagement, understanding and trust in decision-making processes ([DUET, 2022](#); [Luo et al., 2025](#)). Hence, communicating how insights from data analytics and LDT services inform local decisions can drive social sustainability by strengthening transparency and legitimacy of using advanced digital technologies in local communities. See more about public/social value in [chapter 5.1](#);
- Fostering trust through transparent social data governance and ethical practices:** *Social data governance* refers to inclusive and accountable practices for how data about people and communities is collected, used, managed and shared, while considering ethical and social impacts – essential for building trust and legitimacy. Although several EU regulatory frameworks (e.g. GDPR, AI Act, see also [section 4.1.5](#)) help foster trust through regulation, the practical implementation of transparent governance in data sharing (especially cross-border and cross-sectors) remains challenging ([Eke & Stahl, 2024](#));
- Inclusive co-design and participatory engagement mechanisms:**
 Meaningful engagement of diverse communities, including digitally underserved and less advanced groups, in co-design and decision-making can also strengthen legitimacy and ensure alignment with the real needs of local communities in their entirety. European initiatives increasingly emphasise citizen-centric approaches, as seen, for example, in the case of Bologna’s civic digital twin, where co-design is used to align the system with both administrative needs and citizen expectations ([Luca et al., 2024](#); [Interoperable Europe, 2024](#)). At the LDT ecosystem level, the co-design of shared solutions and assets needs to consider the involvement of stakeholders across regions and contexts;
- Human-centric and inclusive design choices to support adoption:**
 Accessible, intuitive and interpretable tools support usability across diverse user groups and help address digital divides. This aligns with [EU digital rights principles](#), which emphasise that digital technologies should be accessible, inclusive and centred on people, ensuring that LDT tools are not overly complex or limited to expert users but usable by a wide range of stakeholders.

Across these drivers, nearly half (45.5%) of respondents identified demonstrating community benefits and insight-driven governance as the main driver of social sustainability, ranking it first (see [Figure 8](#)). This was followed by fostering trust through transparent social data governance and ethical practices (27%). One respondent specifically emphasised the importance of broader societal understanding of LDTs, including both their purpose and potential implications.

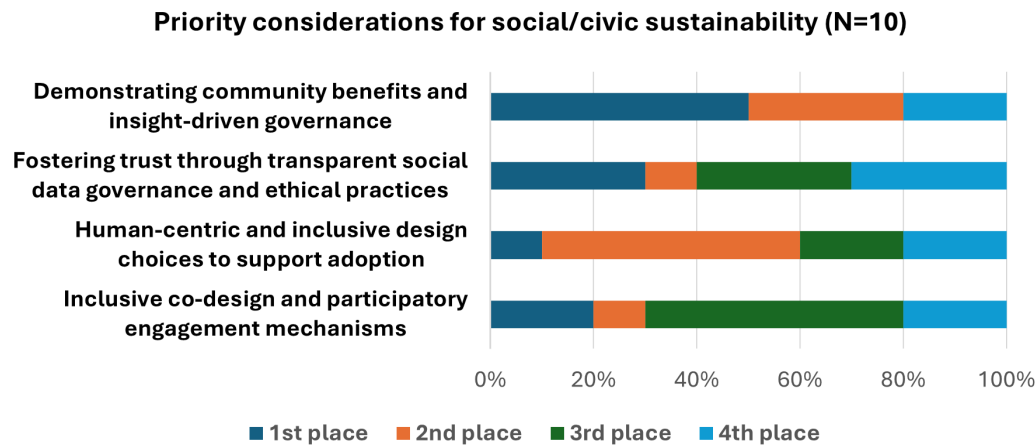


Figure 8: Ranking results for social & civic sustainability drivers

4.1.4 Technological & data sustainability

Technological and data sustainability refers to *the extent to which LDT architectures, infrastructure choices, standards and operational practices support long-term usability, adaptability, resilience and ecosystem compatibility as technologies and use cases evolve*. It emphasises avoiding fragmented or bespoke solutions that limit reuse, interoperability and long-term value. *Interoperability* (understood as the ability of systems to exchange data and services seamlessly) is central to ensuring that complex socio-technical systems function as integrated ecosystems.

Sustainability drivers:

- Using modular, interoperable architectures and open standards:** Designing LDTs with modular components and open standards enables them to be adopted, updated, replaced or extended without vendor lock-in, supporting integration across platforms and fostering interoperability. Today, many cities still rely on fragmented or monolithic legacy systems, hindering interoperability and cross-domain integration ([de Matos et al., 2024](#)), and constraining the practical realisation of connected LDT ecosystems. Using frameworks and standards such as [ISO](#), [MIMs Plus](#) and [NGSI-LD](#) can help address these challenges by enabling data exchange across heterogeneous systems and supporting federated infrastructures. For further information on the technical landscape and guidance for interoperability, refer to [Technical Landscape Report for Pilots](#) and [Preliminary Consolidated Blueprint: Comprehensive guidelines for sustainable LDT interoperability](#).
- Ensuring systematic data governance, quality and lineage:** Embedding robust data governance practices (including provenance, lineage tracking, versioning, and quality assurance) supports reliable and interpretable outputs over time, while helping to maintain data quality, transparency, and trust in data-driven processes ([Guittou et al., 2024](#)). In the context of LDTs, it is needed for decision-making accuracy, while at the ecosystem level, systematic

governance enables interoperable data sharing and the reliable reuse of models, datasets, and digital components across actors.

- Proactive management of technical debt and maintenance planning:** Over time, LDTs may accumulate technical debt through iterative prototyping, legacy integrations or deferred updates, reducing maintainability and negatively affecting the reliability and performance of systems ([Ernst et al., 2026](#)). This can increase future maintenance costs, system complexity and operational risks if left unmanaged ([Nielsen et al., 2020](#)). However, technical debt can be addressed through proactive maintenance planning, including code audits, security updates, model retraining, clear ownership of system components (e.g. pipelines, APIs, models), and dedicated resources for upkeep. For LDTs, in particular for those originating from pilots or research projects, this is critical to ensuring operational continuity and adaptability to evolving technologies.
- Embedded cybersecurity and operational resilience:** Security and resilience features, such as encryption, authentication, access controls, and incident response planning, are particularly critical for LDTs, which often interface with sensitive or critical infrastructure (e.g. transport, energy, water) and therefore require robust protection against cyber threats. EU cybersecurity policy and regulations (e.g., [NIS2 Directive](#) and the [Cyber Resilience Act](#)) emphasise coordinated risk management, incident reporting, and cross-border cooperation as key elements of resilience. However, implementation remains complex, as organisations must align technical, organisational, and governance practices across sectors, often resulting in fragmented cybersecurity capabilities across the EU ([ENISA 2025](#)).

Across the beforementioned drivers, 73% of the survey respondents identified “using modular, interoperable architectures and open standards” as the primary driver of **technological and data sustainability** ([Figure 9](#)). One respondent also specifically highlighted the importance of building organisational capacity, noting that vendor lock-in remains a significant challenge for long-term sustainability.

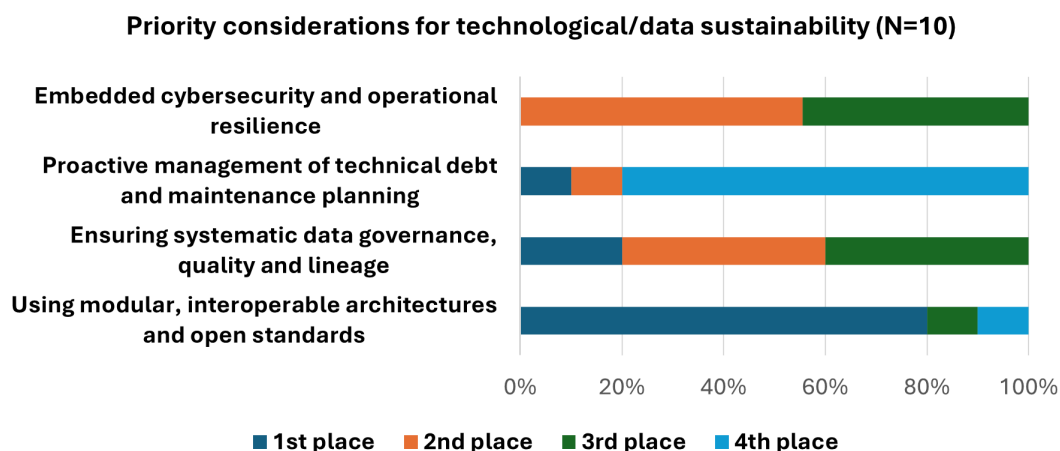


Figure 9: Ranking results for technological & data sustainability drivers

4.1.5 Legal sustainability

Legal sustainability reflects *how well an LDT's design, data governance, and operational models align with evolving legal and regulatory frameworks on one hand, and how well legal instruments such as contractual obligations help ensure compliance, accountability, and protection of rights across the lifecycle on the other.*

Sustainability drivers:

- Ensuring regulatory compliance by design:** In the EU context, LDTs intersect multiple EU regulatory frameworks, including data protection (special focus on GDPR), data governance (including [Data Governance Act](#), [Data Act](#)), cybersecurity obligations ([NIS2](#), [Cyber Resilience Act](#)) and AI-specific rules under the [AI Act](#). These require compliance mechanisms embedded directly into governance, architecture and operational processes. In addition, domain-specific regulations (e.g., [Intelligent Transport Systems \(ITS\) Directive](#), [Energy Efficiency Directive](#), [European Climate Law](#)) influence how LDTs are applied in areas such as mobility, energy and climate action. Regulatory compliance by design relates to how LDTs can embed requirements into the design and governance of the systems, rather than treating compliance as an afterthought. Aligning with different regulatory frameworks also supports cross-border collaboration across the EU, where shared assets need to meet requirements across multiple jurisdictions and domains;
- Leveraging legal enablers for safe experimentation and scaling:** Legal sustainability is strengthened when regulatory approaches actively support innovation and scaling through instruments such as regulatory sandboxes and pilot-specific legal arrangements. These can enable experimentation under controlled conditions while maintaining regulatory oversight. Regulatory sandboxes, in particular, provide supervised environments where technologies can be tested, validated, and refined before deployment, helping to balance innovation with risk mitigation ([Madiega & Van De Pol, 2022](#), [AI Act](#)). However, challenges related to coordination, capacity, and fragmentation across national implementations of sandboxes remain, which may limit their effectiveness for scaling innovations across the EU ([Ahern, 2025](#)), especially relevant for the legal sustainability of the LDT ecosystem;
- Deploying clear legal instruments to agree on rights, responsibilities and liabilities:** Establishing clear legal instruments, such as data-sharing agreements, licences, and codes of conduct, etc, helps to translate governance agreements into enforceable legal arrangements concerning the design and use of LDTs. This includes clarifying data rights, intellectual property, liability (e.g. in cases where LDT-informed decisions lead to harm or loss), audit rights, conditions for exit or switching, adaptation clauses and compliance obligations. At the LDT ecosystem level, this is particularly important, as actors operate across jurisdictions and shared assets require clear and enforceable governance mechanisms. For example, as part of the [Data Act's](#) implementation, the EC released recommendations for non-binding Model Contractual Terms for data access and use, with the hopes of facilitating faster

negotiation of terms, especially for cross-border and cross-sectoral data sharing;

- **Forward-looking strategies anticipating regulatory evolution:** As regulatory frameworks evolve rapidly, LDT stakeholders need to adopt proactive strategies, including monitoring legal developments and conducting compliance risk assessments. The EU digital regulatory landscape remains complex and dynamic, where multiple overlapping instruments (e.g. GDPR, Data Act, AI Act) often interact and create layered obligations ([Nannini et al., 2026](#)). Recent initiatives such as the [EU Digital Omnibus](#) aim to streamline and simplify regulatory frameworks by aligning and updating existing rules across data, cybersecurity, and AI domains. This ongoing evolution reinforces the need for continuous adaptation rather than one-time compliance approaches.

Across these drivers, more than half of the SF meeting respondents (67%) identified “ensuring regulatory compliance by design” as the main driver of **legal sustainability** (see [Figure 10](#)). Overall, legal sustainability was perceived as less critical, with half of the respondents ranking it as the least important dimension (see [Figure 12](#)).

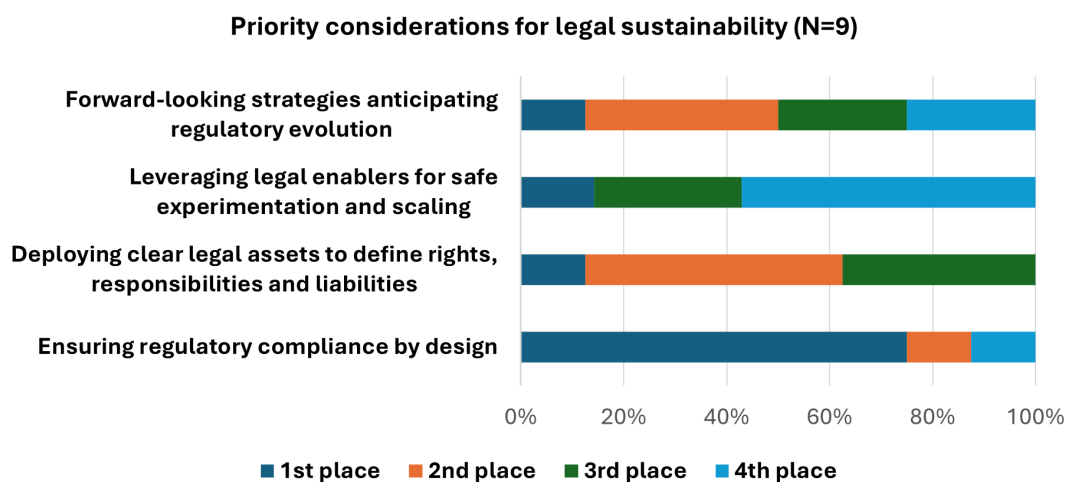


Figure 10: Ranking results for legal sustainability drivers

4.1.6 Environmental sustainability

The **environmental sustainability** dimension explores both LDTs’ direct and indirect ecological impacts (e.g. resource use, carbon footprint) and their role in enabling environmental outcomes (e.g. emissions reduction, climate adaptation, resource optimisation).

Sustainability drivers:

- **Fostering sustainability through dynamic and targeted environmental assessment:** LDTs can support environmental monitoring, scenario testing and analysis, and evidence-based decision-making by combining data from multiple sources and enabling predictive modelling. This is particularly impactful at the LDT level, where insights on e.g., emissions reduction, energy efficiency, and

resource use can inform local planning and decision-making, while at the ecosystem level, aggregated and comparable data and shared analytical tools support coordinated monitoring and reporting. In the EU context, initiatives such as [Destination Earth \(DestinE\)](#) demonstrate this approach by developing a highly accurate digital twin of the Earth to monitor, simulate and predict environmental change, supporting evidence-based policy and climate action ([Hoffmann et al., 2023](#));

- **Minimising LDT’s environmental footprint:** Environmental sustainability also encompasses the reduction of the digital system’s environmental impact, as its energy use and emissions are significant and increasing globally, driven in part by data centres and AI workloads ([He et al., 2025](#)). This includes optimising computing processes (e.g. efficient algorithms, edge processing where appropriate), using low-carbon or “green” cloud infrastructure and integrating digital emissions into broader sustainability strategies. AI systems can be highly energy-intensive across their lifecycle, with substantial carbon and resource footprints, particularly during training and large-scale deployment ([Ding et al., 2025](#)).

Across these drivers, most respondents (89%) from the SF meeting identified “fostering sustainability through dynamic and targeted environmental assessment” as more important than reducing an LDT’s footprint (see [Figure 11](#)). However, respondents emphasised the need to better define environmental thresholds – such as when the resource use of an LDT (e.g. AI-related energy consumption) may outweigh its benefits and justify limiting or discontinuing its use.

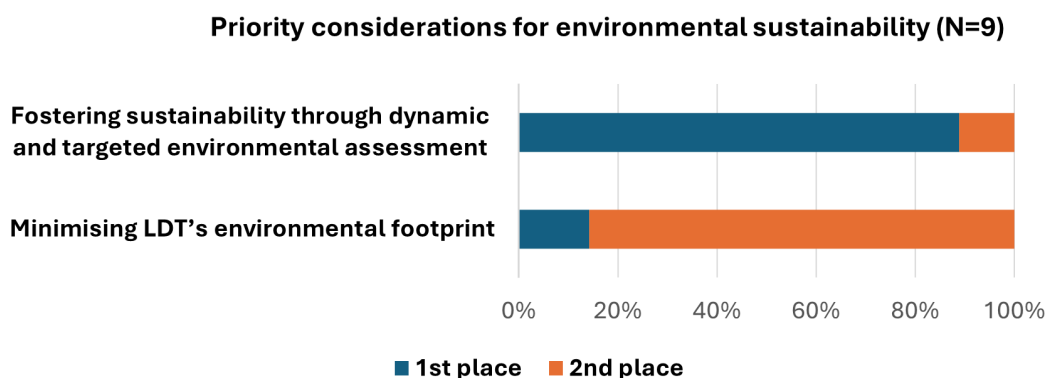


Figure 11: Ranking results for environmental sustainability drivers

The six dimensions and drivers outlined above highlight essential considerations for influencing the long-term sustainability of LDTs and their ecosystem. However, while these dimensions define what is needed, they do not explain how sustainability unfolds in practice. To address this, the next section shifts to a scenario-based perspective, exploring how key uncertainties may shape different future pathways for sustainability in the EU LDT ecosystem.

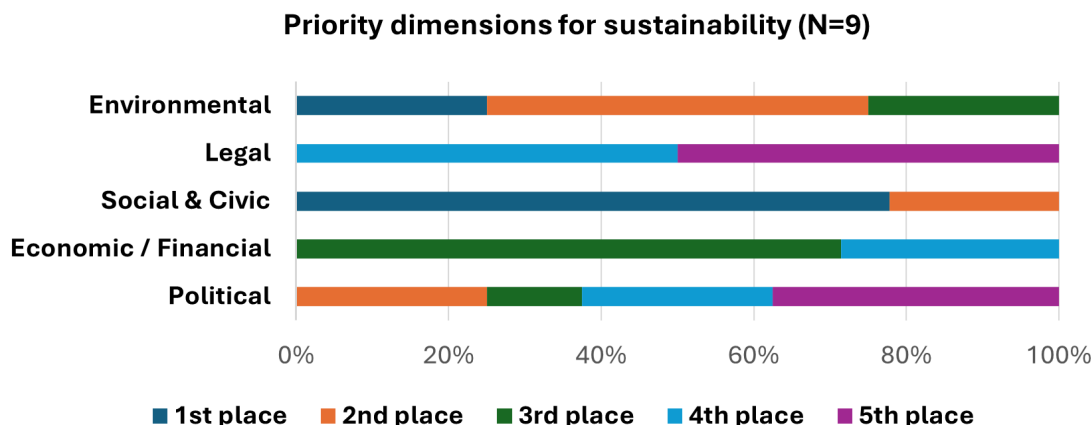


Figure 12: Ranking results for the sustainability dimensions¹¹

4.2 Identifying sustainability scenarios

To contextualise sustainability dimensions for LDT4SSC's strategy, the project deployed scenario planning as a strategic foresight method. *Scenario planning* is used to explore multiple plausible futures under uncertainty, helping organisations build more robust and adaptable strategies rather than relying on a single prediction. This widely used method (e.g., see [UNDP](#)) supports structured exploration of alternative development pathways and trade-offs in complex, multi-stakeholder environments.

The process began with prioritising and selecting the most relevant sustainability drivers (see [section 4.1](#)) based on their degree of uncertainty and expected impact on long-term sustainability. The initial mapping and discussion highlighted drivers such as funding model (public-private), centralised vs decentralised governance, degree of openness vs proprietary control of technological systems (e.g. vendor lock-in, autonomy and dependency), political and regulatory landscape (e.g. changing priorities), as well as privacy questions and environmental effects (e.g. force majeure). After ranking these, finally, two key drivers were selected to form the scenario axes:

1. **Funding model** (public-driven vs private-driven);
2. **Technological choices** (open vs closed/proprietary systems).

These two drivers were identified as decisive in shaping the future of LDTs and the LDT ecosystem in the EU, as they directly influence ownership, value creation and capture, scalability and ecosystem dynamics. As a result, these drivers became the two axes for identifying four distinct scenarios representing alternative future development pathways. The resulting scenarios (see also [Figure 13](#)) describe plausible states of the LDT ecosystem approximately five years after the project (around 2033-2034). While this approach simplifies reality by focusing solely on two drivers, it enables the construction of clear and contrasting scenarios that support strategic reflection and decision-making.

¹¹ Note that technological dimension was left out by mistake from the survey, and therefore, these results can be only used indicatively.

4.2.1 Scenario 1: “Digital Public Infrastructure”

Drivers: Open systems & Public funding

In this scenario, LDTs evolve into shared digital public infrastructure, governed and financed primarily by the public sector. The main advantage of this model lies in its strong alignment with public values and European policy objectives, enabling coordinated development of interoperable digital services across cities and regions. Open standards support cross-border collaboration and reuse, addressing fragmentation challenges and allowing LDTs to function as part of a broader “network of networks” of public digital systems, as promoted by EU interoperability frameworks. Interoperability across technical (data exchange and APIs), semantic (common data models), organisational (process alignment) and legal (data governance and agreements) layers ensure that these benefits can be shared and scaled across contexts, reinforcing ecosystem-level value creation. In this context, LDTs can be understood as part of a broader Digital Public Infrastructure (DPI), i.e. foundational digital systems that support the delivery of services and data exchange across sectors and levels of governance ([ITU, 2025](#)).

However, this scenario faces important limitations. Its reliance on public funding creates vulnerability to political prioritisation and heavy demand on public budgets (where opportunity costs, i.e., something else will be funded less, must be accounted for). This requires long-term political commitment, including funding continuity for widely used components to avoid the “project → funding ends → ecosystem declines” trap. Coordination across governance levels also introduces additional complexity, requiring sustained alignment between local, national, and EU actors. Without such commitment, there is a risk that interconnected (and especially federated) LDT systems remain underdeveloped or fail to scale effectively.

For LDT4SSC, this scenario represents one of the preferred long-term directions, as it aligns with the vision of LDTs as shared digital infrastructure supporting public value and European digital sovereignty. At the same time, it should be understood as a target state, requiring strong governance, sustained funding, and active ecosystem participation to be realised.

4.2.2 Scenario 2: “Open Innovation Marketplace”

Drivers: Open systems & Private funding

This scenario describes an ecosystem where private actors sustain open and interoperable infrastructures to increase access to LDT assets and services, scale service delivery and enable network effects. Its main advantage lies in its ability to combine openness with dynamic innovation. Open standards reduce entry barriers and enable interoperability, allowing a diverse set of actors, including SMEs, startups and research organisations to contribute to the ecosystem.

At the same time, this scenario introduces governance and incentive challenges. Because multiple independent actors must jointly invest and collaborate, there is a need for a robust governance framework that clearly defines roles, cost-sharing mechanisms, and value distribution. Without these, dominant participants may steer the ecosystem in their favor, undermining genuine openness. At the same time, early-stage development is constrained by a “chicken-and-egg” dynamic as actors are reluctant to commit resources without visible returns, yet those returns depend on sufficient collective adoption and investment, making initial scaling particularly difficult.

For LDT4SSC, this scenario represents another preferred pathway in the long run to support European competitiveness and economic growth while ensuring openness through governance mechanisms.

4.2.3 Scenario 3: “Underexploited Silos”

Drivers: Closed systems & Public funding

In this scenario, LDTs are publicly funded and developed within closed environments influenced by proprietary solutions, legacy systems or insufficient interoperability requirements. When systems are procured from private providers without strong interoperability requirements, they may remain partially closed, leading to fragmentation. Interoperability may still exist, but it is often uneven, constrained by vendor-specific implementations or limited by inconsistent standards. This results in systems that are technically functional but difficult to integrate across cities or sectors.

This scenario reflects a common situation in many EU communities today, where local authorities procure solutions to deliver value for individual use cases but which remain confined to fragmented, partially interoperable setups, ultimately constraining long-term ecosystem development and broader value creation. As such, cities and regions may also develop parallel solutions that are only partially compatible, restricting reuse and cross-border collaboration. From a value perspective, this scenario limits scalability and ecosystem-wide benefits, as value creation remains localised and duplication of effort increases costs.

In the context of LDT4SSC, this scenario represents an undesirable but plausible outcome, particularly if interoperability and openness are not actively enforced. It highlights the importance of embedding interoperability-by-design, open standards, and coordinated governance into funding, procurement and implementation frameworks.

4.2.4 Scenario 4: “Vendor-Controlled Platforms”

Drivers: Closed systems & Private funding

This scenario reflects an ecosystem where LDT solutions are primarily delivered and shaped by private vendors through proprietary platforms and services. The main advantage of this model lies in its efficiency and rapid deployment, as private providers can offer advanced, integrated solutions with strong usability and performance.

In this setting, interoperability may still be present, but it is typically controlled by vendors and limited to their ecosystems. Systems may exchange data through APIs or

interfaces, but such interactions are often conditional, depending on licensing terms, technical constraints or commercial agreements. As a result, interoperability may exist, but remain limited in openness, portability and scalability across vendors (and vendor related ecosystems). Such vendor lock-in can increase long-term costs, reduce flexibility and limit the ability of public authorities to build or integrate systems across providers.

Communities and public authorities remain the primary users and procurers of LDT solutions, and, therefore, play a central role in defining interoperability requirements through procurement rules and contractual obligations. This means that the institutional and technical capacity of public actors is a strong factor of the extent to which vendor lock-in may emerge in the procurement and development of LDTs, or their components, within local communities. However, communities may need to compromise for suboptimal solutions when no viable alternatives, or only those of lower quality, exist. Furthermore, in this scenario, the LDT ecosystem is primarily funded by private actors, who may constrain access to actors who do not align with their business strategies.

For LDT4SSC, this scenario represents a realistic risk that must be actively managed. While private-sector participation is essential for innovation, it should be balanced with safeguards such as open standards, fostering data sharing and designing procurement approaches that prevent long-term dependency on individual vendors.

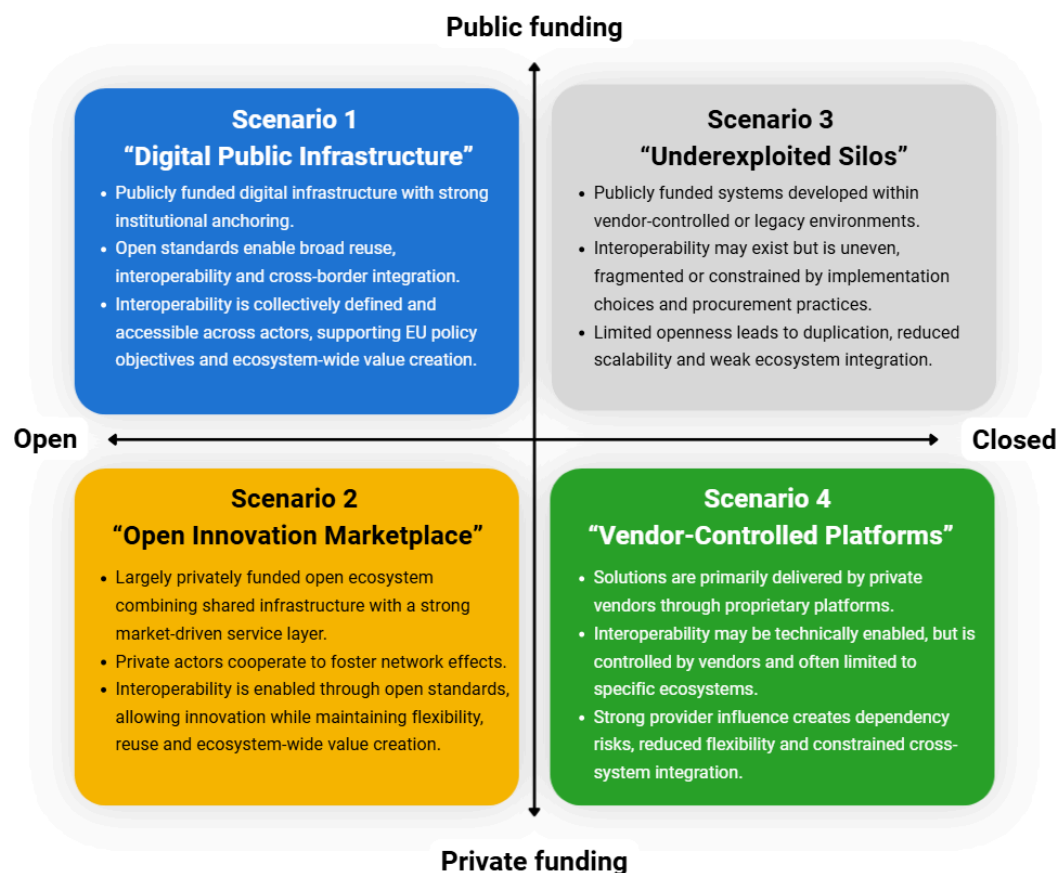


Figure 13: Sustainability Scenarios for Local Digital Twins (LDTs): Funding model vs Openness of technological systems

These scenarios indicate distinct and extreme scenarios, derived from the interaction of public vs private funding models and differing levels of technological openness. Real-world situations are more likely to reflect hybrid combinations of these scenarios rather than any single scenario in isolation. For LDT4SSC, this means actively steering the ecosystem toward configurations that combine the strengths of public infrastructure and market-driven innovation, while mitigating risks associated with fragmentation and vendor dependency. In short, several cross-cutting insights emerge from the scenario planning exercise:

- **Openness of technological systems** consistently enables greater interoperability, reuse and scalability, making it a foundational condition for long-term sustainability;
- **Diversified funding models** increase resilience by reducing dependency on a single source, whether public or private;
- **Governance and ownership structures** play a critical role in shaping trust, stakeholder incentives and value capture across the ecosystem; and
- **Public-private collaboration** is essential for innovation and scaling, but must be carefully balanced to avoid fragmentation, dependency or misaligned incentives.

5. Understanding value creation and value capture in smart communities

This chapter examines how LDT initiatives create and capture value within smart community ecosystems, which is inherently tied with LDTs business model designed and deployed either explicitly or implicitly ([Perätalo et al 2022](#), see also the business model building block description in [Preliminary Consolidated Blueprint: Comprehensive guidelines for sustainable LDT interoperability](#)). However, particularly in private-public contexts, value creation and capture seems to stay opaque as different stakeholders tend to approach it from various perspectives. Hence, this chapter aims to provide a conceptual foundation for understanding the various dimensions of value creation as well as how involved stakeholders can capture value in a fair manner.

5.1 Dimensions of value creation and value capture

Smart communities are commonly understood as communities that strategically combine human resources, technology, data and stakeholder collaboration to improve quality of life, sustainability, resilience and local competitiveness (e.g. [Caragliu et al., 2011](#); [UN-Habitat, 2025](#), [ITU, 2026](#)). LDT initiatives are part of this broader movement, and similarly, depend on the continuous engagement and collaboration of stakeholders, including the sharing of data and services¹². This, in turn, requires careful consideration of what constitutes valuable for various stakeholders in the local community, and how one creates and captures that value.

Smart communities and smart city literature consistently conceptualise value creation as **multi-dimensional** and **ecosystem-based**, involving economic, social, environmental and governance outcomes rather than single sector or actor gains. This aligns with broader sustainability frameworks such as the “triple bottom line” ([Miller, 2020](#))¹³, which emphasises the simultaneous creation of economic, social and environmental value rather than focusing solely on financial performance. In this context, value seems to include several complementary layers (if strategically aligned) and can be looked at from multiple different angles.

One of the key distinctions concerns **business vs public value**. *Business (or private) value* refers to market creation, innovation, efficiency gains, and revenue capture, often enabled by digital platforms, (open) data, and new service models. Furthermore, it emphasises commercial gains through tangible returns for firms or investors (e.g., profits, reduced costs, new products or services). For example, service providers (tech

¹² The Multi-Stakeholder Governance Scheme for the European data space for smart communities ([Gangneux, 2023](#)) indicates several opportunities and challenges for data cooperations between local authorities, the private sector, academia, citizens and others. It emphasises the importance of identifying mutual interests and building strategic alignment between partners to ensure the success of data sharing (using tools like the [Data Cooperation Canvas](#)). Essentially, this refers to how stakeholders aim to create value through cooperation.

¹³ Triple bottom line refers to a sustainability accounting framework measuring performance across three dimensions - People (social equity), Planet (environmental impact), and Profit (economic viability) - coined by John Elkington and popularised by Miller (2020). It challenges traditional profit-only metrics and promotes integrated reporting for holistic organisational success.

providers, utilities, among others) can monetise data and/or specific services and create innovative business opportunities through participating in data ecosystems (D'Hauwers et al 2022, Toorajipour et al 2024). In contrast, *public or social value* is rooted in public administration theory (e.g., [Moore's public value](#)), focusing on collective benefits such as quality of life, equity, sustainability, democratic participation, and legitimacy of governance (Neuroni et al 2019). However, both value streams are interrelated as public value encompasses economic prosperity as experienced by the community, plus outcomes like social cohesion, improved services or reduced social problems (Cosgrave et al 2014). For instance, a smart street-lighting network may yield citywide energy savings (business value for utilities and cost efficiency for municipalities) and also reduce crime and increase perceived safety (social value).

A second layer to explore value creation is through the lens of **direct vs indirect value**. In smart communities, direct value refers to immediate, attributable outcomes generated by specific interventions, such as cost savings from energy-efficient infrastructure, or revenues from digital services. These are typically measurable (e.g., through KPIs), short feedback-loop effects that are often prioritised in business-oriented evaluations and policy related initiatives. In contrast, indirect value emerges through systemic effects, such as improved innovation capacity, knowledge creation, increased trust in institutions, or enhanced data ecosystems. These are particularly relevant in early phases of ecosystem-based initiatives, which focus on generating social, epistemic (knowledge-related), and functional value before monetary returns start to materialise (Sorri et al 2024¹⁴). Indirect value accumulates over time and becomes critical for resilience and long-term competitiveness, especially in initiatives driven by local communities. This insight reinforces that early-stage ecosystems (such as LDT4SSC) are firstly driven by non-financial value (knowledge, collaboration, trust), with direct financial value emerging later as the ecosystem matures.

The third layer of value creation dimensions exists between **short-term value**, which focuses on immediate outputs and performance gains (e.g., pilot results, efficiency improvements, quick wins for political or commercial validation), and **long-term value**, which relates to sustained societal transformation, including institutional capacity, environmental sustainability, and inclusive economic development. Smart community research consistently finds that early stages of initiatives tend to prioritise visible short-term gains to justify investment, while long-term value depends on governance continuity, ecosystem maturity, and cumulative learning effects (Anthopoulos et al 2016; UN-Habitat 2021).

However, it's important to identify and manage potential tensions between objectives related to short- and long-term value creation. For example, optimisation for short-term efficiency (e.g., high-quality but proprietary solutions) may undermine long-term public value (e.g., interoperability, data sovereignty). LDT strategies should therefore explicitly balance short-term performance with long-term capability building – a principle widely recognised in growth strategies (see e.g., organisational ambidexterity) (Hamblin et al., 2024) or dynamic capabilities frameworks (Kattel et al., 2025), where organisations must simultaneously manage current operations and future innovation pathways.

¹⁴ Sorri et al introduces an Ecosystem Value Balance Framework that emphasises the core value types identified in the literature – financial, functional, social, emotional, and epistemic value dimensions.

Figure 14 highlights that stakeholders operate across multiple value dimensions simultaneously, and calls stakeholders to align these dimensions rather than optimising for a single outcome.

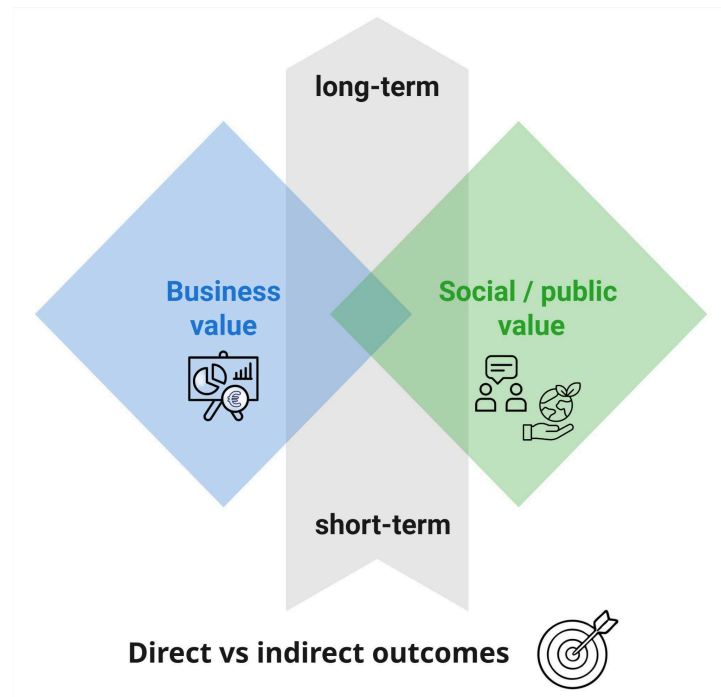


Figure 14: Summary of the value dimensions that stakeholders must consider when setting their objectives

Beyond value creation, smart communities need to also reflect on how their stakeholders can capture the generated value, especially in ecosystem-based initiatives. **Value capture** is described as “as the process of securing financial or nonfinancial return[s] from value creation” (Chesbrough et al., 2018, Toroslu et al., 2023), addressing questions such as how benefits are recognised and who benefits. In *business value* contexts, this can mean who is able to monetise and through which mechanisms, while *public value capture* looks at how societal benefits can be articulated through justifiable metrics and reinvested into broader policy goals.

However, business and public valorisation are not necessarily contradictory - local communities need to **consider the cost-benefit ratio** of deploying smart city solutions, and how business value could be captured in the community in order to reinvest this into local development. It opens up questions around **how smart city developments are funded** (often involving mixed financing combining city budgets, EU funds, and private investments, see also [chapter 5.2](#)), **how value is captured and distributed** as well as their **interplay with governance** (i.e., ultimately about who is in control and has the power to influence the implementation and outcomes of the initiatives). For example, local and regional authorities may set up contracts with tech firms to include performance-based clauses (e.g., investment in exchange for service delivery guarantees) or establish shared governance boards and joint living labs to co-design solutions with public agencies, businesses and citizens.

For LDT ecosystems, value capture is particularly complex, as the benefits created and costs incurred are not always equally distributed, especially when different time scales

or value dimensions are considered. This imbalance creates key sustainability challenges, as without appropriate value capture mechanisms, stakeholders may lack incentives to continue contributing to the ecosystem. A successful ecosystem is capable of aligning individual incentives with collective outcomes, balancing cooperation (i.e., value creation) and competition (i.e., value capture) ([Dai et al 2024](#)). This is aligned with the guidance by the Data Spaces Support Centre (DSSC), emphasising important collective benefits created by data spaces as specific ecosystem-based collaboration models ([DSSC 2026](#)):

- **Efficiency gains** by reducing economic transaction costs through standardising interfaces and lowering integration efforts, especially across sectors and ecosystems.
- **Improved collaboration** by facilitating collaboration between data providers and consumers, which can improve interoperability.
- **Sovereignty & control** by ensuring (data) owners maintain control over access and usage conditions, enhancing trust. This includes avoiding lock-in.

Furthermore, according to the [DSSC Starter Kit \(2024\)](#), specific data sharing use cases may provide opportunities for:

- **Cost sharing**, e.g., by participants sharing their data to meet shared requirements (e.g., compliance, process efficiency, transparency). Every member saves money and time by sharing the burden;
- **Joint innovation**, where customer (or local) innovation can only be realised by ecosystem members working together. No single ecosystem member would have all the necessary data (or resources) to do it alone;
- **Combined forces**, where ecosystem members team up to prevent a limited number of dominant market players from emerging. No single ecosystem member has the necessary resources and commitment to do this alone;
- **Shared marketplace**, where ecosystem members team up to provide quality-assured, easy access to data of a domain of common interest (open data, business partner data, etc.). Transaction costs go down for all ecosystem members;
- **Greater common good**, by public and private sector entities sharing data for a greater common, societal goal (e.g., climate protection).

These models and mechanisms can also be leveraged for the LDT ecosystems, articulating that value is often realised through reduced transaction costs and enabled network effects. On the other hand, specific applications and use cases built on top of the shared assets have distinct business models, aimed at creating business and public value for the stakeholders and communities involved.

However, one must account for changes in the ecosystem, described by [Sorri et al 2024](#): *“One may value something in the present that will become invaluable in the future, therefore understanding the future expectations for the ecosystem is essential. It is important to realize, however, that expectations will change when the ecosystem evolves, and the world outside the ecosystem transforms due to cultural or technological changes.”* This underscores that value creation in the LDT ecosystem is dynamic and path-dependent, meaning that early design decisions (e.g. openness, governance, standards) have long-term consequences for ecosystem evolution.

5.2 Funding models for open-source initiatives

Growing and sustaining LDT initiatives requires appropriate funding models, which depend on the requirements set for LDTs. In the context of LDT4SSC, initiatives are recommended to deploy open-source software (OSS) and models, as these can foster the integration of heterogeneous data sources, interoperable platforms, and continuous collaboration across stakeholders. This is particularly relevant in the context of establishing an open LDT ecosystem, as with OSS, municipalities are more likely to avoid vendor lock-in, ensure adaptability of digital twin components, and foster collaborative ecosystems where models, data pipelines, and analytical tools are continuously improved and reused (see e.g., [Open Source in Cities and Regions](#)). Therefore, this section explores insights from other OSS initiatives, focusing primarily on alternative funding models for sustaining their activities.

[Table 3](#) provides a snapshot of the common OSS funding and business models relevant to cities, derived from the [EC guidance](#) (accessed in April 2026) as well as other literature ([The Linux Foundation 2023](#), [Osborne 2024](#)). These models illustrate that there is no single optimal approach to OSS sustainability, and successful strategies typically combine multiple funding mechanisms (i.e., **blended funding**, such as public-private partnerships or research grants plus sponsorship) and governance arrangements. In practice, this means that cities share development costs with peers or foundations, hire or contract developers for maintenance, and set procurement rules that favor open code. The key is to match the model to the local context. For example, large metropolitan areas may seek funding from dedicated OSS funds (à la Germany's [Sovereign Tech Fund](#)), while smaller towns could join larger consortia or co-ops to pool expertise and resources.

Overall, local communities should treat OSS as digital infrastructure, budgeting for its maintenance like any public good, while fostering a community around it. This requires long-term investment, clear governance, and an ecosystem approach that balances public oversight with community participation, ensuring that LDT solutions remain interoperable, adaptable, and aligned with public value objectives ([Devenyi et al 2020](#)).

While this chapter has focused on OSS and its relationship to sustainability primarily from an economic and financial perspective, as learned in the [previous chapter](#), OSS sustainability should also be understood within a broader framework that encompasses economic viability, social collaboration, and environmental efficiency as key organisational dimensions ([Vargas-Hernández. 2021](#)). For example, sustaining OSS initiatives includes several challenges, such as outdated procurement laws, unclear license rules, and staff skill gaps, which require public managers to use legal enablers such as embedding open-license requirements into tenders, and to invest in capacity-building (i.e., building internal talent).

Table 3. Common Open-Source Software (OSS) funding models relevant to communities

Model	Key Features	Pros	Cons	Typical Funding Sources	Applicability to Cities
Government-led Public Funding	OSS developed or maintained by government grants or budgets	Stable, large-scale funding; aligns with public interest; no license fees	Subject to political cycles; budget cuts; may underfund community-building	Tax revenue; national / EU grants	Ideal for core “digital infrastructure” (e.g. city platforms). Best for large cities or consortiums that can tap national/EU funds
Municipal Consortium / Co-funding	Multiple cities pool resources (via consortia or inter-municipal agreements)	Cost-sharing; economies of scale; peer support	Coordination overhead; possible slow consensus-finding; risk of free-riders	Member contributions (proportional to size/use); shared contracts.	Works when cities face similar needs and preconditions (e.g. shared budgeting, service portals). Examples: Signalen (Dutch schools), eVaka (Finland)
Service Contracts / Paid Support	City or users hire companies/consultants to develop or maintain OSS	Professional support ensures reliability; suppliers assume some cost	Can introduce lock-in to service provider	Fees for development, hosting; Service Level Agreements (SLAs); training; consulting	Common for governments lacking in-house dev staff. E.g. contract dev of an open ERP or GIS platform. Must ensure the contract requires code release (procurement clauses)
Nonprofit Foundations / Trusts	An independent entity (foundation or trust) hosts the project	Neutral governance; stable brand; can receive donations/grants	Foundation overhead; needs ongoing funding and engagement	Donations; membership fees; grants (public or philanthropic)	Suitable for large cross-jurisdiction projects (e.g. Linux Foundation Europe). For cities, this could mean sponsoring a local foundation for shared tools

Platform Cooperatives (Co-ops)	Multi-stakeholder co-op owns the project; users as members	Democratic governance; aligns incentives of users and maintainers	Organisational complexity; relies on members' willing; still nascent form	Membership/ subscription fees (like voluntary council subscriptions); co-op reinvests revenue	E.g., UK's Open Digital Cooperative (LocalGov Drupal) founded as council-supplier co-op with voluntary subscriptions. Good for communities of practice
Volunteer / Community-driven	Relies on unpaid contributions (devs, citizens)	Low direct cost; fosters civic engagement and innovation	High risk of burnout; uneven support; sustainability issues	Donations or ad-hoc sponsorships. No guaranteed revenue	Works for small-scale or experimental projects. Alone, it's fragile – should be augmented by other funding (guidance suggests hiring devs when possible)
Hybrid Models	Any mix of above (e.g. free core + paid services, foundation + contracts)	Diversified risk; can combine community trust with funding	More complex to manage; potential conflicts of interest	Combines revenue streams above (e.g. public grants + foundation + donations)	Often most realistic for large initiatives (e.g. commercial support + foundation). Allows scaling projects while retaining openness

6. Framework for LDT service validation and certification

Validation, certification and standardisation are interconnected enablers of trust, procurement readiness and scalable uptake of LDT services. *Standards* provide the criteria against which services are validated; *validation* produces the evidence on which certification rests; *certification*, in its various forms, signals to procurers and regulators that the service meets recognised expectations. Together they should be seen as a **valorisation strategy**: an investment that strengthens the market position of the services, the credibility of the private partners developing them, and the procurement confidence of the public authorities deploying them. This chapter maps the practical landscape across all three, introduces the certification and assessment instruments available to pilots, and proposes a framework through which LDT4SSC pilots can progressively assemble a set of conformity assessments as they move through the project methodology phases.

6.1 Scope and maturity

Validation should be proportional to both the maturity and risk profile of an LDT service. Not all components or stages require the same level of rigour. The [LDT4SSC Methodology](#) provides a four-step implementation framework that guides pilots from initial ideation through to full deployment:

1. **EXPLORE** (Ideation) generates user-centred use cases and initiates the assessment of costs, benefits and impacts. Here, validation is lighter: feasibility checks and architectural assumptions;
2. **VALIDATE** (Specifications) translates those use cases into technical and functional requirements, addressing data governance, interoperability and legal constraints;
3. **DEFINE** (Prototyping) tests concrete solutions using real data and representative users, confirming technical feasibility and refining design choices;
4. **IMPLEMENT** (Deployment) stabilises the prototype into a long-term operational tool, finalising the technical infrastructure, economic model, legal framework and stakeholder onboarding. Here, governance robustness, explainability and regulatory compliance come to the foreground.

The recently published [ISO/IEC 30186:2025](#) Digital Twin maturity model reinforces this staged logic with internationally recognised assessment indicators, allowing teams to determine appropriate validation depth at each step.

6.2 The standardisation landscape

LDT services sit at the intersection of multiple standardisation streams. [ISO/IEC JTC 1/SC 41](#) ("Internet of Things and Digital Twin") provides the core digital-twin standards

(terminology, maturity, reference architecture, interoperability), while ETSI ISG CIM maintains [NGSI-LD](#) and, together with the [Smart Data Models](#) initiative (FIWARE, OASC, TM Forum), forms the semantic interoperability base. [OGC](#) and [ISO/TC 211](#) cover the geospatial and 3D-modelling layers ([CityGML](#), [SensorThings API](#), [3D Tiles](#)), with [buildingSMART's IFC 4.3](#) bridging Building Information Modelling (BIM). International Data Spaces Association's (IDSA) Reference Architecture Model and the Eclipse-maintained Dataspace Protocol ([2025-1](#)) govern trusted data exchange in federated deployments and underpin the [Gaia-X](#) Trust Framework.

At the European level, [CEN-CENELEC Joint Technical Committee 21](#) (JTC 21) is producing harmonised standards to confer a presumption of conformity with the AI Act, while [CEN/TC 465](#) ("Sustainable and Smart Cities and Communities") is the most plausible home for elevating LDT4SSC outputs into European standardisation. The obligatory regulatory regime – the AI Act, Data Act, Cyber Resilience Act, NIS2 Directive and eIDAS 2.0 – applies to all in-scope LDT components, though the valorisation strategy proposed here treats alignment with these frameworks as a market-access asset rather than mere compliance.

6.3 Testing and Experimentation Facilities

Under the Digital Europe Programme, Testing & Experimentation Facilities (TEFs) are being established as large-scale, specialised reference environments where technology providers can test and experiment with AI-enabled technologies (including LDT components) in realistic, controlled settings. TEFs support full integration, scenario experimentation and performance testing, including governance and compliance signals, in ways that mirror operational contexts ([European Commission - Sectorial AI Testing Experimentation Facilities](#)). The added value of a TEF is to identify research or near-market opportunities relevant for practical challenges, and bring them together in a testing loop with final users for releasing and scaling up practical solutions while guaranteeing them to be replicable, interoperable and compliant with the AI regulatory framework. TEFs help generate structured validation artefacts, such as performance benchmarks, interoperability logs and scenario evaluations, that can be reused in certification submissions and procurement evaluations. By operating at scale and engaging with real-world conditions, TEFs also contribute to regulatory sandboxes linked to the AI Act, offering supervised testing environments that help bridge validation with conformity assessment.

CitCom.ai

Among the four sectoral TEFs, AgrifoodTEF, TEF-Health, AI-MATTERS and [CitCom.ai](#), the latter focuses on trustworthy AI services for cities, communities, and citizens. It supports technical testing, real-life validation and scaling, as well as compliance to standards and regulation to successfully address concrete needs and ensure sustainability. Co-funded by the Digital Europe Programme and Member States (€40 million, 2023–2027), and coordinated by imec, CitCom.ai consists of 15 experimentation sites across 10 European countries, organised into three thematic super-nodes:

- **POWER** (energy – Denmark, Sweden, Finland);
- **MOVE** (mobility – Belgium, the Netherlands, France, Luxembourg);
- **CONNECT** (cross-sector citizen-facing infrastructure – Spain, Italy, Poland).

[CitCom.ai services](#) fall in one of six families: 1) **application creation & validation services** (for data collection, storage, preprocessing, machine learning frameworks, model training, evaluation, hyperparameter tuning, deployment, scalability, and monitoring); 2) **community engagement services** (ecosystem management, matchmaking, market access); 3) **compliance & ethics assistance** (adherence to laws, regulations, and ethical standards); 4) **physical facility access** (test in city infrastructure with guidance, street closure, and installation support, reducing deployment time); 5) **scope definition / opportunity assessment** (understanding target audiences, assessing organisational viability, evaluating technical feasibility); and 6) **virtual facility access** (access to computing resources, supporting remote experiments and real-time data analysis).

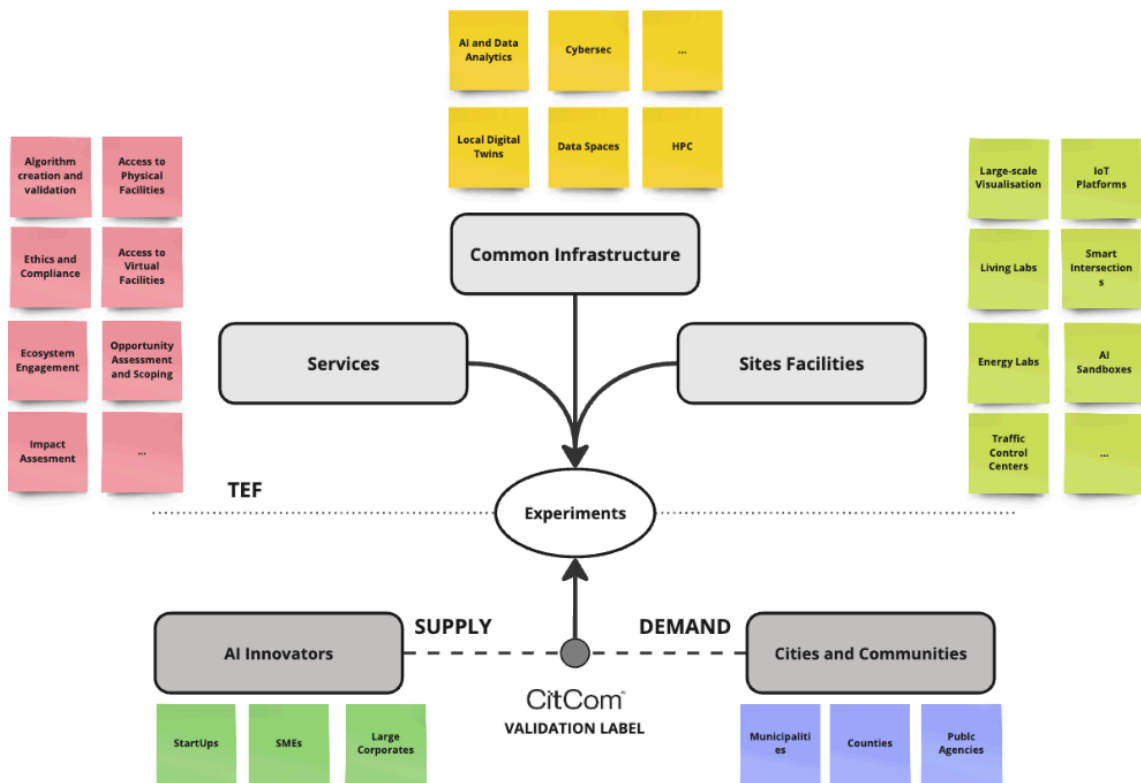


Figure 15: Initial mapping of the supply and demand, connecting AI industry with Citizen's needs¹⁵

CitCom.ai also operates a [Responsible AI Label](#) programme, through which TEF site partners conduct independent expert assessments of AI systems deployed in smart-city contexts. The programme produces up to three badges, each independently awarded: **Technical Testing** (performance, robustness, fairness, safety, explainability and failure-mode analysis), **Processes** (governance, oversight, accountability, monitoring and incident response) and **Impact** (effects on affected populations, differential impact, transparency, recourse, community participation and environmental

¹⁵ Note that the visual represents an initial mapping of the potential services, and since then, the services families above have evolved.

footprint). The Label is an expert judgement, grounded in evidence, about whether a system has been seriously and independently scrutinised on each dimension. Badges awarded on partial evidence say so explicitly, and the absence of evidence is treated as a finding rather than a reason to defer judgement.

6.4 Certification mechanisms

A certification mechanism is a structured system that defines what is being evaluated (a product, a service, an organisation or a process), against which criteria (standards, regulations or rules), by whom (the provider itself, an independent body or an automated system), what evidence is required, what the outcome looks like (a certificate, a label, a badge, a mark or a declaration of conformity) and how long it remains valid. Different schemes differ on all of these dimensions: some are self-declared, others require third-party auditing; some certify the organisation, others certify a specific service offering; some are legally mandated, others are voluntary market signals. As of today, and to the authors' knowledge, there is no single certification scheme that covers an LDT service end to end. What exists is a patchwork of mechanisms that an LDT provider can assemble, and understanding this patchwork and its gaps is part of the valorisation strategy.

The AI Act's default route for most high-risk categories is self-declaration of conformity (**CE marking**) under [Article 43](#), where the provider carries legal liability and alignment with [JTC 21](#) harmonised standards triggers presumption of conformity. At the organisational level, [ISO/IEC 42001:2023](#) is the first certifiable AI Management System standard - particularly relevant for WS3 pilots because it provides evidence that AI Act governance obligations are systematically managed. For data-space participation, two voluntary schemes apply: [Gaia-X Labels](#) (ranging from self-declared Level 1 to CAB-attested Level 3 for fully sovereign, EU-headquartered providers) and the [IDSA Certification Scheme](#) for data-space connectors built on the Dataspace Protocol. [ISO/IEC 27001:2022](#) and [ISO/IEC 27701:2025](#) remain the de facto security and privacy baseline for providers handling public-authority data.

On the interoperability side, LDT4SSC's own [Interoperability Self-Assessment Questionnaire \(ISAQ\)](#) provides a structured, comparable record of interoperability commitments across pilots, though it currently carries no badge or third-party review. The [Minimal Interoperability Mechanisms \(MIMs Plus\)](#) framework complements this by defining what a system must be able to do, not which technology it must use, to achieve interoperability. The foundational MIMs cover the data journey: accessing data (MIM0), representing data (MIM2), interlinking data (MIM1), securing data (MIM6), and sharing data (MIM3). Application-based MIMs address personal data (MIM4), geospatial data (MIM7), interoperable AI (MIM5), and Local Digital Twins (MIM8). The **CitCom.ai Responsible AI Label**, with its three badges (Technical Testing, Processes and Impact), occupies a distinctive space: more rigorous than self-attestation, more contextual than generic standards, and purpose-built for AI in smart-city contexts.

What is missing is a unified scheme that attests, in a single act, that an LDT service is architecturally mature, interoperable, [eco-designed](#), secure and AI-ready. Looking ahead, the **LDT4SSC Interoperability Blueprint** – currently under development, while

aligned with both MIMs Plus, especially the MIM8, and the EU LDT Toolbox – could, in conjunction with the **ISAQ** and **CitCom.ai**'s infrastructure, inform a full-stack interoperability normalisation operated either by **CitCom.ai** or the **LDT CiTiVERSE EDIC**. Such an effort could combine interoperability attestation with responsible-AI assessment in a single instrument purpose-built for LDT services. This remains a possibility to be explored rather than a commitment, but the building blocks are being assembled.

6.5 Validation framework

The instruments described in the preceding sections – standards, TEF validation, certification mechanisms and the [Responsible AI Label](#) – are most useful when assembled into a coherent progression rather than pursued in isolation. The framework proposed here maps them onto the four phases of the LDT4SSC methodology, producing a growing set of conformity assessments that pilots carry with them from ideation to deployment. Participation in the framework is not required of any pilot (nor participant to the LDT ecosystem), but using it helps to foster a stronger market position for the developed services, making a more compelling procurement case for the communities deploying them, and signal clearer credibility for the private partners developing them.

The pilots could deploy the proposed validation framework as follows:

- EXPLORE (Ideation).** The pilot defines its use case, identifies the applicable alignments (NGSI-LD, MIMs Plus, Smart Data Models, CityGML or IFC where applicable) and, for AI components, classifies the use case under the AI Act risk framework. The ISAQ template is populated for the first time as a pilot deliverable, but also as a planning instrument. The conformity set at this stage contains a risk classification memo and a first-pass ISAQ.
- VALIDATE (Specifications).** The pilot translates use cases into technical and functional requirements, addressing data governance, interoperability constraints and legal frameworks. CitCom.ai can be engaged at this stage through its [scope definition and opportunity assessment services](#) to evaluate technical feasibility and organisational viability. Provider organisations may begin pursuing management-system certification where applicable ([ISO/IEC 27001](#), and for WS3 [ISO/IEC 42001](#)). WS1 pilots, or, overall, pilots envisioning a data space connection, may begin preparation for [Gaia-X Label](#) and [IDSA Certification](#); all pilots map their existing or envisioned architecture against the Interoperability Blueprint and the LDT Toolbox components.
- DEFINE (Prototyping).** The pilot determines technical requirements and gaps, finds or creates data models for semantic interoperability, and builds and tests a prototype using real data and representative users. They could extend the engagement with CitCom.ai through its [application creation and validation services](#) (model training, evaluation, monitoring and scalability testing), [physical facility access](#) (testing on city infrastructure with guidance and installation support) and [virtual facility access](#) (computing resources for remote experiments and real-time data analysis). For WS3 pilots' AI components in

scope of the AI Act, CitCom.ai's [compliance and ethics assistance services](#) could help produce the evidence that conformity assessment will later require. This is also the stage at which engagement with the [Responsible AI Label](#) becomes productive for WS3 pilots: the Technical Testing badge draws on the same evidence base the testing facilities are already producing. All pilots may complete the Interoperability Blueprint alignment and refine ISAQ scores. The set is enriched with reports arising from CitCom.ai services, performance benchmarks and, where pursued, the first Responsible AI Label badges.

- IMPLEMENT (Deployment).** The pilot stabilises its prototype into an operational tool and consolidates its regulatory and certification position. For WS3 high-risk AI components, the evidence produced during earlier phases – including any reports from CitCom.ai technical and [Responsible AI Label](#) badges – can support entry into a national AI regulatory sandbox under [Article 57](#); the sandbox exit report under Article 57(7) then becomes part of the conformity set. Technical documentation under AI Act Article 11 / Annex IV is finalised; the EU Declaration of Conformity is signed; CE marking is affixed where applicable. The full set of CitCom.AI [Responsible AI Label](#) badges – Technical Testing, Processes and Impact – becomes relevant for WS3 as part of the market-facing evidence. Pilots connecting to a data space may finalise [IDSA Certification](#) and [Gaia-X Label](#); all pilots may complete [ISAQ](#) finalisation and Blueprint conformity. Management-system certifications, when pursued, are issued by accredited bodies. The set of conformity assessments is now complete and accompanies the service into the project's Assets and Services Repository, the [EU LDT Toolbox Marketplace](#), [DOME](#), and the [LDT CiTiVERSE EDIC](#) federation.

Beyond validating individual services, the proposed framework can help generate both operational and strategic value across the wider European digital ecosystem. As an example, the dossier assembled through this framework has concrete **downstream value**, as it provides evidence (benchmarks, attestations, badges, certifications) to communities and public authorities to support audit-defensible selection and help shorten tendering cycles. For the services themselves, standards-aligned assets compound in value across the federation, e.g., a service built to NGSI-LD, SAREF and Smart Data Models specifications can be discovered, combined with other services and reused across cities without reintegration. At the same time, evidence generated across the pilot portfolio also can be fed upstream. For example, [ISO/IEC JTC 1/SC 41 Working Group 6](#) is actively developing the digital-twin reference architecture ([ISO/IEC 30188](#)) and further deliverables. [CEN/TC 465](#) has opened the door to a revised business plan emphasising LDTs. [CEN-CENELEC JTC 21](#) needs operational evidence to refine the AI Act harmonised standards. OASC maintains MIMs Plus through iterative community input and, specifically for LDTs, the MIM8. Feeding pilot lessons into these forums – via CEN Workshop Agreements, liaison contributions or new work item proposals – converts LDT4SSC from a consumer of European standards into a contributor to them. For the communities and companies in the federation, this is strategic leverage visible in the EU standards regime itself.

7. Strategic priorities and recommendations for growth and sustainability

7.1 Capabilities that foster sustainability and growth

The underlying principle in this document has been that sustainability is not a fixed stage of maturity, but rather a dynamic set of conditions that must be sufficiently in place for LDTs to function, generate value, and continue evolving over time. This calls on looking at capability assessment from three interdependent levels:

1. At the **individual LDT level**, the focus is on ensuring that each LDT is operationally viable within its local context and that communities are capable of continuing its operations beyond the pilot phase. This includes embedding the LDT into governance and organisational structures and processes, and ensuring that it delivers value to stakeholders. It also involves establishing the minimum conditions for long-term operation, including minimum technical and non-technical interoperability mechanisms, as well as an appropriate legal framework. Sustainability is also closely linked to the ability to create tangible value (e.g. improved decision-making, efficiency gains, or environmental insights) and to capture that in a way that opens up opportunities for continuation and reinvestments.
2. At the **LDT ecosystem level**, the focus shifts from individual LDTs to coordination, interoperability and collective value creation across multiple actors and locations. Here, sustainability depends on the ability to connect LDTs into a broader system, where value is not only created locally but also shared, scaled and reinforced across the ecosystem. This includes enabling reuse, replication, and collaboration as well as aligning governance, funding and technical approaches across (smart) communities (where appropriate). The sustainability of an LDT ecosystem is defined by the way in which individual actors are able to contribute to the ecosystem with their assets, services, and other resources (knowledge, time, financial) and how they can capture value in return.
3. At the third level of **LDT4SSC assets and services**, the strategic focus is on the shared assets that local communities need to build or advance their LDTs and concrete use cases. It focuses on sustaining the tools (e.g., the repository of assets and services, including some of the assets themselves), guidelines (e.g., interoperability blueprint), capacity-building programmes and interaction modalities developed within LDT4SSC, requiring clear governance of the produced outputs, shared understanding of their long-term maintenance, and support for adoption through training and capacity-building.

To remain practical and avoid overly complex expectations towards the pilots, the previously mentioned considerations have been mapped against the pilot requirements and recommendations defined in various [call texts](#) ([Table 4](#)). It focuses on common aspects across Work Strands and links them to the various sustainability dimensions.

Table 4: Sustainability and growth-supporting capabilities in relation to the open calls requirements (Rq) and recommendations (Rc) for pilots

Capabilities (Ch 7.1 in D2.3)		Applicable			Dimensions	WS1	WS2	WS3
		Individual LDT	LDT-ecosystem	Assets & services				
Value & Impact	1. Ability to define and continuously validate a shared value proposition (social, economic, environmental) that resonates across multiple communities and user groups.	x	x	x	Political, Economic		Rq5 Rq22	Rq5 Rq22
	2. Capacity to align local initiatives with EU policy priorities and planning frameworks, ensuring relevance and access to broader support mechanisms.	x	x	x	Political, Economic	Rq3	Rq6 Rq3	Rq6 Rq3
	3. Capability of designing and implementing sustainable funding models, including cost-sharing and coordinated investment across stakeholders.				Economic	Rq8	Rq12	Rq12
	4. Ability to iteratively refine business models based on ongoing evaluation of costs, benefits, revenues, and lifecycle considerations.	x	x	x	Economic	Rq8	Rq12	Rq12
Business Models	5. Integration of sustainability principles into core business strategy, ensuring long-term operational viability.	x	x	x	Economic		Rq25	Rq25
	6. Capacity to scale solutions efficiently by leveraging shared infrastructure and economies of scale.	x	x	x	All		Rq10 Rq30 Rc2	Rq10 Rq30 Rc2
	7. Capability to engage stakeholders continuously across sectors (quadruple helix), ensuring transparency, trust, and legitimacy.	x	x	x	Political, Social	Rq4 Rq6	Rq9 Rq8	Rq9 Rq8
	8. Ability to establish clear ownership, leadership, and governance structures, embedding solutions into organisational processes for continuity beyond pilot phases.	x	x	x	Political	Rq5	Rq7	Rq7
Governance, Ownership & Stakeholder Engagement	9. Capacity to integrate responsible digital practices, including eco-design and ongoing monitoring, into solution development and operations.	x		x	Economic, Environmental	Rc6 Rq8	Rc10 Rc9 Rq12	Rc10 Rc9 Rq12

Legal & Ethical Readiness	10. Capability to apply legal frameworks that enable data access and sharing, including cross-jurisdictional interoperability.	x	x	x	Legal	Rq7	Rq24	Rq24
						Rc8	Rc6	Rc6
	11. Ability to anticipate and adapt to regulatory changes, and embed compliance and ethics-by-design into all development and operational processes.	x		x	Social, Legal	Rq8	Rq12	Rq12
							Rq21	Rq21
Digital Maturity & Data Governance	12. Capacity to build and execute a strategic roadmap for digital maturity, including skills development and organisational capacity building.	x	x	x	Economic, Tech	Rq1	Rc1	Rc1
	13. Capability to implement robust data governance practices, ensuring data quality, traceability, access control, and clearly defined responsibilities across systems.	x			Social, Tech	Rq8	Rq12	Rq12
						Rq9	Rq19	Rq19
	14. Ability to operationalise interoperability across technical, organisational, legal, and semantic layers.	x	x	x	Tech	R14	Rq18	Rq18
						Rq10	Rq17	Rq17
Technical Infrastructure & Interoperability	15. Capability to adopt and implement shared standards and common smart middleware, enabling seamless data exchange across systems and governance levels.	x	x	x	Tech	Rc9	Rc7	Rc7
						Rq12	Rc4	Rc4
	16. Capacity to build and leverage open-source solutions, promoting transparency, reducing costs, and enabling collaborative innovation.	x	x	x	Tech	Rc7	Rc5	Rc5
							Rq11	Rq11
	17. Ability to align with European digital initiatives (e.g., DSSC, Gaia-X, SIMPL, LDT Toolbox, ...) and frameworks (e.g., NGSI-LD, MIMs), contributing to ecosystem convergence and multi-level coordination.		x	x	Political, Tech	Rc10	Rc3	Rc3
	18. Commitment and capacity to share resources through open licences, enabling reuse and scaling of interoperable assets and services.		x	x	Economic, Tech	Rq13	Rq27	Rq27
						Rq11	Rq28	Rq28

7.2 Strategic priorities and recommendations

This final section of this Strategy defines the key strategic priorities to achieve the LDT ecosystem's growth and sustainability. These priorities have emerged from the exploration of the LDT4SSC's main objectives (see [chapter 1](#)) in relation to sustainability and growth, as well as key insights articulated in this document (i.e., the importance of considering communities' capabilities, and understanding the ecosystem's growth through the contributions, reuse, and collaboration across the quadruple helix). These priorities are translated into concrete recommendations towards the project's pilots, LDT4SSC consortium and further stakeholders across local communities, and other EU initiatives relevant to smart communities, including policymakers.

1. Coordinating efforts towards interoperability and multi-stakeholder collaboration

The foundation of a scalable European LDT ecosystem lies in the ability to connect heterogeneous systems across communities, sectors and borders. While interoperability frameworks and tools already exist, their consistent adoption and operationalisation remain limited. This calls for strong leadership and coordination of efforts across initiatives, fostering alignment and convergence in approaches. This directly contributes to the objective of connecting existing LDTs and data platforms into a European federation and supports the sustainability dimensions outlined in chapter 3, including technological, economic and political sustainability.

Recommendations to pilots:

1. Establish clear governance and strategic leadership for LDT development and long-term operation (beyond pilot implementation) and describe it in respective project deliverables;
2. Stay proactive in identifying opportunities for replication and collaboration through LDT4SSC-wide activities, and beyond.

Recommendation to LDT4SSC:

1. Provide practical guidance and tools for implementing the interoperability blueprint as part of the project's activities, especially *Training for awarded pilots* and *Capacity Building for end-users to valorize and use the LDT services and assets*;
2. Build governance and coordination mechanisms to support federation of LDTs beyond pilots;
3. Facilitate collaboration and replication across pilots (working groups, exchanges, joint activities) and other relevant initiatives such as Simpl, the LDT CitiVERSE EDIC and the EU LDT Toolbox Marketplace.

Recommendation to other stakeholders:

(Rc to pilots also relevant here)

1. Get prepared to participate in the LDT ecosystem by aligning with the Interoperability Blueprint;

2. Where possible, contribute to standardisation and interoperability efforts, including policy interoperability, delivery and adoption of legal enablers, etc.

2. Advancing local digitalisation at scale with replicable and open services driven by shared local needs

Many LDT services remain siloed and non-replicable, limiting reuse and scalability across communities. Hence, LDT4SSC focuses on ensuring the pilots' LDTs are designed as reusable, modular and replicable solutions addressing shared challenges across communities. This helps other cities and communities to expand existing solutions rather than developing them from scratch, supporting assets' replication as well as their sustainability.

Recommendation to pilots:

1. Design advanced LDT services with the principle of "replicability by design", including open licensing, providing clear documentation, use cases and guidance for reuse, as well as defining how those services will be maintained over time.
2. Reuse resources and leverage activities provided by the LDT4SSC project, other pilots, the LDT CitiVERSE EDIC, DS4SSCC-DEP, Simpl and the EU LDT Toolbox.

Recommendation to LDT4SSC:

1. Identify shared needs between communities and match them with existing or new solutions contributed to the repository of assets and services as part of the project's activities, especially *Strategy and Sustainability, Community engagement and collaboration, Monitoring of services and assets in pilots WS1, WS2, WS3, and evaluate the efficiency of methodologies, and Capacity Building for end-users to valorize and use the LDT services and assets*;
2. Support visibility of services through LDT Toolbox and other marketing channels as part of the project's *Dissemination & Communication*;
3. Define clear responsibilities for sustaining the assets and services, and providing support to replicators as part of the project's activities, especially *Quality Management and Project Impact Monitoring and Assets and Services Repository*;
4. Encourage decentralised maintenance of assets and services (e.g., by their initial developers) wherever feasible, supporting ecosystem participants in identifying and aligning their own incentives for sustained contribution. In the short term, the project should assume responsibility for maintaining pilot assets and services only where there is clear evidence of their continued relevance and future need. Clarifying long-term maintenance should be explored in discussion with the LDT CitiVerse EDIC.

Recommendation to other stakeholders:

1. Reuse and adapt existing solutions instead of developing new ones from scratch;
2. Participate in collaboration opportunities provided by LDT4SSC;

3. Provide feedback on usability and applicability.

3. Demonstrating LDTs' business and public value for stakeholders across the value chain (cities, AI innovators, technology providers, research organisations, etc.).

A critical barrier to LDT ecosystems' sustainability is the limited articulation and assessment of business and public value generated by LDTs. Without clear value propositions and value capture mechanisms across stakeholders, the assets' and ecosystems' long-term sustainability remains uncertain. As such, LDT4SSC focuses on establishing evidence-based value frameworks, alignment with the *Impact Assessment Framework*, and demonstrating both public and business value across the ecosystem. By linking value creation with value capture, this priority area underpins economic sustainability and supports the emergence of a structured LDT market.

Recommendation to pilots:

1. Promote LDT services by assessing and demonstrating tangible value propositions across stakeholders (cities, providers, citizens, etc.), supporting adoption and replicability. This should be documented in respective deliverables and presented in LDT4SSC activities, such as peer-learning sessions and Stakeholder Forum meetings;
2. Contribute to the evolution of business and governance models (e.g. cost-sharing, PPPs) by testing viable alternatives and documenting learnings clearly in respective deliverables;
3. Valorise their services by following the validation framework, converging alignment with the Interoperability Blueprint, the ISAQ assessment, the Responsible AI Label badges, MIM8, and the LDT Toolbox adoption.

Recommendation to LDT4SSC:

1. Engage extended stakeholders across the value chain into LDT4SSC activities to better understand their (business) needs and support pilots in addressing these through project's activities, especially *Strategy and Sustainability*, *Community engagement and collaboration* and *Capacity Building for end-users to valorize and use the LDT services and assets*;
2. Collaborate with other smart communities initiatives to assess market dynamics across the value chain and identify gaps as part of *Community engagement and collaboration*.
3. Co-create with pilot representatives a framework for assessing value creation and negotiating value capture across initiatives, helping pilots to balance value capture across the ecosystem;
4. Collaborate with other initiatives (such as CitCom.ai, the LDT CiTiVERSE EDIC, MIM8, the EU LDT Toolbox) towards a full-stack validation service for LDTs.

Recommendation to other stakeholders:

1. Test and validate LDT4SSC assets and services' fit to the market and provide feedback;
2. Support development of market enablers (funding, procurement, partnerships).

4. Systematically engaging and growing the communities of practice around LDTs in local communities.

The LDT ecosystem is inherently a multi-stakeholder environment, requiring sustained and growing collaboration across public authorities, private sector actors, academia and civil society. The LDT4SSC's aim is to gradually grow the LDT ecosystem from initially pilot-driven ecosystems to a more mature EU-wide LDT ecosystem. This requires strengthening ecosystem coordination, stakeholder engagement and community building, ensuring that actors are aligned around shared goals, value propositions and collaboration mechanisms. It emphasises the role of LDT4SSC as a facilitator and orchestrator, enabling peer learning, co-creation and cross-sector collaboration, especially among stakeholders with differing levels of maturity.

Recommendation to pilots:

1. Engage stakeholders (public, private, academia, civil society) to identify additional use cases and opportunities for collaboration and describe the potential for replication and scaling in respective deliverables;
2. Define KPIs for a) ecosystem growth around local implementations, and b) collaborations fostered through the EU-wide LDT ecosystem.

Recommendation to LDT4SSC:

1. Establish a clear engagement funnel (e.g., identifying actors → contact-building → fostering participation → achieving stakeholders' contributions to the ecosystem → replication by other communities) as part of the project's activities, especially *Strategy and Sustainability*, *Community engagement and collaboration* and *Engagement campaign*;
2. Investing in marketing of the LDT ecosystem and the repository through, e.g., events, matchmaking and capacity-building activities, through the project's *Community engagement and collaboration*, *Dissemination & Communication*, and *Engagement campaign*.

Recommendation to other stakeholders:

1. Participate in communities of practice and knowledge exchange across communities and smart communities initiatives.

5. Continuous strengthening of technical and non-technical capabilities across the three levels (individual LDT level, LDT ecosystem level and LDT4SSC shared assets and services level).

As articulated throughout this framework and strategy, sustainability depends on the LDT stakeholders' ability to develop and mobilise the necessary technical, organisational and governance capabilities. Hence, this priority area emphasises strengthening capabilities across all three levels of the ecosystem (single LDTs, ecosystem, shared assets and services), including organisational integration and governance, technical capacity and interoperability, business and funding models, skills

development and knowledge exchange.

Recommendation to pilots:

1. Assess and monitor internal capabilities as per [chapter 7.1](#).
2. Participate in the capacity-building activities provided by LDT4SSC to strengthen capabilities, where needed.

Recommendation to LDT4SSC:

1. Ensure that the assets and services provided by the LDT4SSC, such as the Interoperability Blueprint and capacity-building activities, are fit for purpose to support LDT sustainability and growth through the project's *Capacity Building for end-users to valorize and use the LDT services and assets*.

Recommendation to other stakeholders:

1. Disseminate and re-use LDT4SSC capacity-building activities in your respective communities;
2. Contribute back to the LDT ecosystem by referencing additional capacity-building activities;
3. Provide long-term support mechanisms (financial, institutional);
4. Align research, education and innovation with needs for capacity-building and strengthening capabilities.

Annex A: Abbreviations and acronyms

Abbr.	Description	Abbr.	Description
AI	Artificial Intelligence	EU	European Union
API	Application Programming Interface	FAIR	Findable, Accessible, Interoperable, Reusable
CAGR	Compound Annual Growth Rate	GDPR	General Data Protection Regulation
CSOs	Civil society organisations	GIS	Geographic Information System
D + number	Deliverable + number	i.e.	Id est; that is / in other words
DCAT	Data Catalog Vocabulary	IAF	Impact Assessment Framework
DEP	Digital Europe Programme	IAM	Identity and Authorisation Mechanisms
DS4SSCC	Data Space for Smart and Sustainable Cities and Communities project	ICT	Information and Communications Technology
DS4SSCC-DEP	the deployment project for the European data space for smart communities	ISO	International Organisation for Standardisation
DSSC	Data Space Support Centre	KPI	Key Performance Indicator
DUET	Digital Urban European Twins project	LDT	Local Digital Twin
e.g.	Exempli gratia; for example	LDT CitiVERSE EDIC	Networked Local Digital Twins towards the CitiVERSE European Digital Infrastructure Consortium
EC	European Commission	LDT4SSC	Local Digital Twins for Smart and Sustainable Communities project
EDIC	European Digital Infrastructure Consortium	LRA	Local and Regional Authorities
EIU	Economist Intelligence Unit	MIMs	Minimal Interoperability Mechanisms
NGSI-LD	Next Generation Service Interfaces - Linked Data	SWOT	Strengths, Weaknesses, Opportunities, Threats

NUTS	Nomenclature of Territorial Units for Statistics	T + number	Task in the project's workplan
OASC	Open & Agile Smart Cities & Communities	TEFs	Testing and Experimentation Facilities
OC	Outcome indicator (as per IAF)	ToC	Theory of Change
OP	Output indicator (as per IAF)	UN	United Nations
OSS	Open-Source Software	URL	Uniform Resource Locator
PD	Project Deliverable	USD	United States Dollar
PESTLE	Political, Economic, Sociological, Technological, Legal and Environmental	WP	Work Package
PPP	Public-Private Partnerships	WS	Work Strand
R&D	Research and Development	XR	Extended Reality
Rc	Recommendation		
RDF	Resource Description Framework		
Rq	Requirement		
SAAS	Software As A Service		
SDGs	the United Nations Sustainable Development Goals		
SF	Stakeholder Forum		
SIMPL	Smart Middleware Platform		
SME	Small Medium Enterprise		

Annex B: Glossary

Term	Explanation
Capacity Building	Process of enhancing skills, knowledge, resources, and institutional capabilities within individuals, organisations, or communities to address challenges and achieve long-term goals. It involves e.g. targeted training, infrastructure development, and knowledge transfer to foster self-reliance. In practice, it bridges capacity gaps through sustained investment rather than one-off interventions. (European Parliamentary Research Service Briefing on Capacity Building (2017))
Data Platform	Software for collecting, processing and rendering data in the form of a graphical interface or other control tools. Depending on needs, this software can be configured to send commands or the results of its analyses to other entities, connected objects and business software in particular. Based on this definition, many types of software can be data platforms, and an Information Technology (IT) infrastructure can potentially have several data platforms (software for visualising connected objects, data dashboards, digital twins, etc.).
Data Space	Interoperable framework, based on common governance principles, standards, practices and enabling services, that enables trusted data transactions between participants. (DSSC 2026)
Ecosystem Value Balance Framework (EVB)	Model by Sorri et al. (2021) , Sorri et al. (2024) assessing platform ecosystem sustainability across five dimensions: financial (monetary returns), functional (utility), social (relationships), emotional (experience), and epistemic (knowledge growth). It diagnoses imbalances threatening collaboration. Ensures all actors perceive fair exchange to prevent defection.
End-User	Any individual, group or organisation that directly uses or benefits from the Local Digital Twin services. It is the person who actually uses the service and not the developer or maintainer.
Interoperability	Ability of different systems, applications, or components to communicate, exchange data, and use the information effectively despite different technical architectures or vendors. (European Commission 2017)
Local Digital Twin	a digital representation of physical assets, systems, or processes, in a defined local context (e.g., city, district, building, industry, port, airport). It leverages either historical data, near real-time data, or real-time data, and it enables visualisation, analysis, simulation, and reasoning services that support decision-making. See the working definition here: https://knowledgehub.ldt4ssc.eu/resources_content/tech_resources/#what-is-a-local-digital-twin

Local Digital Twin Ecosystem	An open and interoperable collaboration framework for Local Digital Twins initiatives used and sustained by multi-stakeholder communities to address common local and regional challenges.
Local Digital Twin Assets and Services	The interoperable open-source components, such as datasets, AI models, algorithms, and software tools, that form the technical foundation for creating and federating digital replicas of cities and communities. These assets enable scalable services like AI-driven simulations for climate adaptation, energy optimisation, and urban planning, linking local LDT platforms into a pan-European network.
Operational Resilience	Organisation's ability to prevent, adapt to, respond to, and recover from disruptions while maintaining delivery of critical services and operations. In digital ecosystems like LDT4SSC, it encompasses robust ICT infrastructure, data governance, and contingency planning to ensure LDT platforms remain functional during cyberattacks, outages, or extreme weather events affecting smart city services. Key elements include impact tolerance thresholds, scenario testing, third-party risk management, and continuous improvement through lessons learned from incidents.
Platform Cooperatives	Cooperatives that own and democratically govern digital platforms (websites, apps, protocols) to facilitate goods and services exchange, owned by users, workers, and stakeholders rather than venture capital investors. They emphasise broad-based ownership, co-design, open source principles, and equitable value distribution as alternatives to extractive gig economy models. In smart city contexts, they enable community-controlled data platforms and shared urban services while preventing data monopolisation by proprietary actors. (OECD 2023)
Service	In this context is a means for a public administration to support public activities and/or help the decision-making processes. It should not be confused with the technical definition of a service.
Stakeholder	A stakeholder is any individual, organisation or group that has an interest in, is affected by, is concerned by, or can influence a pilot's use-case or service. They are not necessarily pilot members. Some examples of stakeholder roles are: participating in shaping pilot projects, data providers, end-users of the service or the people impacted by it, experts, decision-makers, etc.
Use case	A use case is a concrete, user-centred scenario in which an LDT (or federation of LDTs) delivers one or more services to tackle a real local challenge. It specifies the actors (who, for who), the data and systems involved (what), the expected service or outcome (why), and the technical and governance arrangements required to deliver, measure and sustain that service.

Value Creation	Generation of new benefits, utility, or economic worth through products, services, or processes for stakeholders. It focuses on customer-perceived value beyond cost, driving loyalty and growth. In ecosystems, it emerges from collaborative exchanges rather than isolated activities. (Lepak, D.P. et al. 2007)
Value Capture	Process by which participants, e.g. municipalities, developers, and service providers, appropriate sustainable returns from the collective value generated by e.g. shared LDT assets and services. (Lepak, D.P. et al. 2007)
Vendor Lock-in	Situation where a customer becomes so dependent on a vendor's proprietary products, services, or ecosystem that switching to alternatives incurs too high costs, efforts, or risks. This arises from e.g. incompatible data formats, specialised APIs, customised integrations, or long-term contracts, limiting flexibility and bargaining power. (Free Software Foundation Europe (FSFE) 2019)

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