Case Study Report

The role of digital twins for building resilient communities

Case of Dublin

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Abstract

'Resilience' is an overarching term subsuming capacity of any society to deal and adapt with new changes in existing systems. 'Digital' is rapidly becoming a new order of life, especially with urban solutions labelled more and more as 'smart', in rhetoric hopes of achieving a high quality of life. Digital twins are one such emerging technology, focussing to create virtual replicas of physical assets, and systems, with advanced data analytics and prediction capabilities in real-time. For cities, they can result in cost efficiencies, operational efficiencies, better urban management, and informed decision-making. However, for communities, they can aid in better participation, accessibility, and inclusive communication, which could result in localization of sustainable development goals, and improved levels of acceptance for a just and green transition, thus eventually building more resilience within communities. Realising their potential role in decision-making, Dublin City Council's smart cities unit has collaborated with the Science Foundation of Ireland's ADAPT Research Centre for AI-Driven Digital Content Technology on a two-year long targeted project for developing a digital twin framework. The project started in December 2022 with core objective to adopt a human-centric approach for future engagement frameworks. It is unique in terms of its collaborative and multi-stakeholder structure.

Keywords

City Digital Twins, Community Engagement, Stakeholder Collaboration, Smart City Use Cases, Resilient Communities

1. Project Motivation

Different departments of Dublin City Council (DCC) have been experimenting with state-of-the-art 3D modelling technologies such as drones, building information models and LIDAR scanners for surveying, mapping, and data collection. This data is further being used for planning across various thematic challenges such as energy consumption, urban planning, public engagement, environment, tourism, and infrastructure management to support its vision for a dynamic, sustainable city, that is future-ready, built on thriving, inclusive neighbourhoods, and communities, a strong economy, a vibrant cultural life, and compact, connected growth (Dublin City Council, 2020). Also, there is a noticeable growing interest towards the use of digital twins for modelling climate change (DestinE system and digital twin for oceans), sustainable freight management, policy making (DUET, PoliVisu, COMPAir projects) and skills for citizen engagement (the European Network of Living Labs – EnoLL) under the Europe's Digital Decade framework to ensure a smoother adoption of digital by its member states (Government of Ireland, 2018; European Commission, 2020, 2021; Digital Europe, 2021a, 2021b).

A local digital twin (LDT) is more than a digital representation of a city's physical assets, systems and processes targeting a bidirectional information exchange between them (European Commission, 2020;

Shahat, Hyun and Yeom, 2021). Ideally, they are supposed to be living models representing a system throughout its lifecycle (Sepasgozar, 2021; Botín-Sanabria *et al.*, 2022; Caprari *et al.*, 2022). This new emerging technology offers possibilities of advancement from traditional 3D city models towards AI-driven living city models to simulate urban system(s), improve city management and explore new user-interfaces between communities, public authorities, service providers and researchers (European Commission, 2020; Digital Europe, 2021b; Botín-Sanabria *et al.*, 2022). Realizing its potential for territorial planning, DCC's smart cities unit has partnered with the ADAPT SFI Research Centre for AI-Driven Digital Content Technology at Maynooth University, on a 2-year long targeted project, which started in December 2022, to explore its potential as a decision-support and engagement tool (ADAPT Centre, 2022). It aims to develop an ethical framework for using LDTs and trial proof of concept for stakeholder and community engagement.

1.1. Case of (Smart) Dublin

Smart Dublin is an initiative launched by the four local authorities in the Dublin region with an aim to future-proof the region by trialling, testing, and scaling innovative solutions to tackle issues ranging from climate change to increasing digital divide (Dublin City Council, 2017). The programme uses a district (testbed) approach for developing and deploying proof of concept solutions in strategically selected locations where innovation projects can be fast-tracked. Smart Docklands was the first smart district under the Smart Dublin umbrella, launched in 2018, further followed by the launch of Smart DCU, Smart Dun Laoghaire, Smart Balbriggan and Smart D8 (Smart Dublin: Homepage). Dublin city is also an active member of the EUROCITIES network, Bloomberg Philanthropies, Harvard Tech City Innovators Forum, Cities Today institute, the European Commission's Mission for 100 climate-neutral and smart cities, Lving-in.EU and UN's Cities Coalition for Digital Rights, and has been involved in various European Horizon 2020 Projects (Operandum, Senator), and INTERREG project (Building an ecosystem to generate opportunities in open data). **Figure 1** illustrates various smart districts under the Smart Dublin umbrella.

Figure 1: Smart Districts. Source: Smart Dublin.

Many cities around the world such as Singapore, Zürich, Utrecht, Wellington, and Helsinki are already building their digital twins using 3D environments for improving quality of life, city services, local governance, mobility, and environmental conditions (Schrotter and Hürzeler, 2020; Abdeen and Sepasgozar, 2022; Anshari and Hamdan, 2022). Smart Dublin also realises a massive opportunity to leverage LDT technology for improving communication with its key stakeholders and communities on

future projects and investments planned for the city. In 2019, it organized a 3D Hackathon event by releasing an open-source 3D model of the Docklands Strategic Development Zone and recently, in 2023, it launched Google AirView Hackathon by releasing over 50 million air quality measurements at 5 million locations across the city. It has also been exploring GIS-based platforms such as Cesium ion and ESRI's ArcGIS, gaming engines such as Epic's TwinMotion and the use of VR/AR for increasing the value of existing models.

1.3. Research Need and Objectives

Cities are complex 'human' systems, where multiple dimensions interweave at economic, social, environmental, institutional, and cultural levels. Although there are many definitions of 'resilience', but all of them have 'capacity' as a common element, which is a positive attribute that can be built and acquired by cities, communities, or organizations (Figueiredo, Honiden and Schumann, 2018). This capacity comprises of certain actions, such as adapt, resist, absorb, transform, change, recover and prepare, in the event of any shocks, stresses, hazards, or high-risk situations (Béné *et al.*, 2012). For European cities and citizens, this term also considers the changes brought about by digital innovation, demographic change, climate change, globalization, and migration (Manca, Benczur and Giovannini, 2017). With a global focus on just and green transition leaving-no-one-behind, a participatory governance is required at the core to build public acceptance and trust in new localised changes, to build their absorptive, adaptive, and transformative capacities (Béné *et al.*, 2012). OECD's resilience framework also identifies participation of communities and other stakeholders in urban planning initiatives as crucial to enhance urban resilience (Figueiredo, Honiden and Schumann, 2018).

While the concept of digital twins has existed for decades, it is recently becoming prominent in urban planning (European Commission, 2020). LDTs can visualize data from different stakeholders simultaneously in an integrated, interactive, and 3D ('real life') way. Because of this, they have the potential to include a wider range of citizens in decision-making processes for territorial planning, because they can make technical plans more 'visual', comprehensive, and interactive for different people, and organizations. The Digital Twin for Engagement (DT4E) project intends to explore use-cases to innovate, trial and test digital twin solutions for better engagement at urban scale while considering the learning and adaptive capacities of implementing agencies, technology providers and local communities. It is expected to support goals of participatory governance, inform decision-making and raise awareness about the possibilities that could arise when working in a virtual environment (World Economic Forum, 2022).

Some of the anticipated implementation challenges fall under the category of data governance (storage, sharing/open-data, management, acquisition, advanced processing capabilities), lack of trained staff, interoperability, ethical concerns (privacy, data protection, safe handling of data, equity, participatory democracy, transparency, accountability, non-discrimination of data, content/algorithms, impact on balance of power between government) and scaling solutions to city level (complex multi-domain data, financial constraints, lack of political support) (Cardullo, Di Feliciantonio and Kitchin, 2019; Botín-Sanabria *et al.*, 2022; Saeed *et al.*, 2022). DT4E will understand these challenges and underlying opportunities, develop, and evaluate interventions and propose roadmaps to progress the future digital twin ecosystem at DCC. The project has the following three goals -

1. To identify, evaluate and advance existing 3D modelling technology towards digital twin ecosystems for effective stakeholder and community engagement.
2. To engage with and encourage collaboration of all stakeholders in the development and deployment of LDTs across identified sectors and applications.
3. To evaluate and mitigate ethical challenges in deploying LDT technology.

2. Mapping Digital Twin Ecosystem at DCC

The first phase of this project analyses and compiles the ongoing digital twin projects at DCC. DCC is actively using drone-captured data for generating 3D models. Also, the Smart Tourism programme, supported by DCC and Fáilte Ireland is exploring immersive engagement solutions through its Dublin Discovery Trails app (**Figure 2**). From a more technical standpoint, DCC's climate action unit has developed a digital twin for assessing the full carbon impact and efficiency of renovation strategies, over three different time periods for one of its social housings (dashboard in **Figure 3**) (Integrated Environmental Solutions Ltd, 2022). Another interesting use-case is developed by Dublin Fire Brigade to test a digital twin for emergency response, shown in **Figure 4**, to collate and display risk-critical information about high-impact sites in Dublin. There are plans to explore cloud services, Internet of Things device feeds and Simultaneous Location and Mapping of internal details of buildings.

Figure 2: Smart Tourism's App using AR technology. Source: Dublin Discovery Trails App

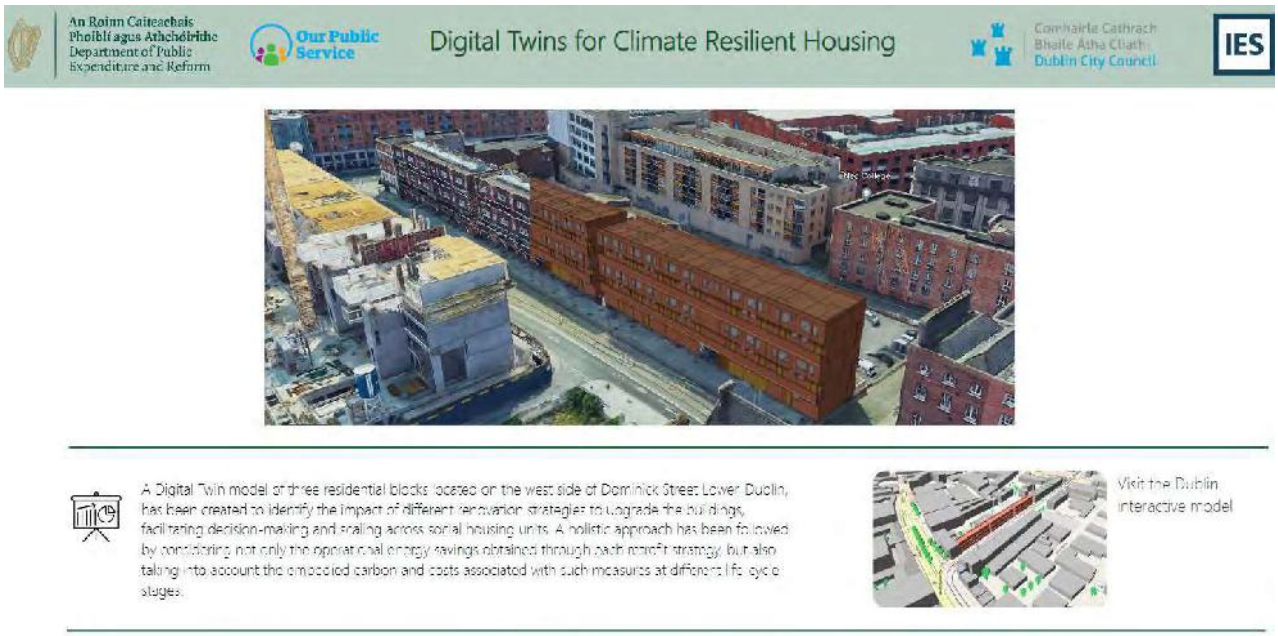

Figure 3: Digital Twin for Climate Resilient Housing. Source: IES Decarbonisation Roadmap Dashboard

Figure 4: Dublin Fire Brigade Digital Twin Model for BOC Gas. Source: Bentley OpenCities Planner Screenshot

Smart cities unit is also enabling the development of LDTs for enhanced visualization and data value for civic engagement through its smart districts' collaboration. The smart DCU district is building Ireland's first higher education digital campus, with the first phase of rapid prototyping of a 3D version of the university campus, both indoors and outdoors, overlaid with some light sensor data and 360-degree views, as illustrated in **Figure 5.** In its next phase, use-cases towards an adaptive campus environment using immersive technologies are expected. Smart Docklands is another district, which has procured a 3D block model with varying levels of detail, a VR model and a reality mesh captured using drone and LIDAR technology (White et al., 2021). **Figure 6** illustrates a proof of concept for Dockland's digital twin.

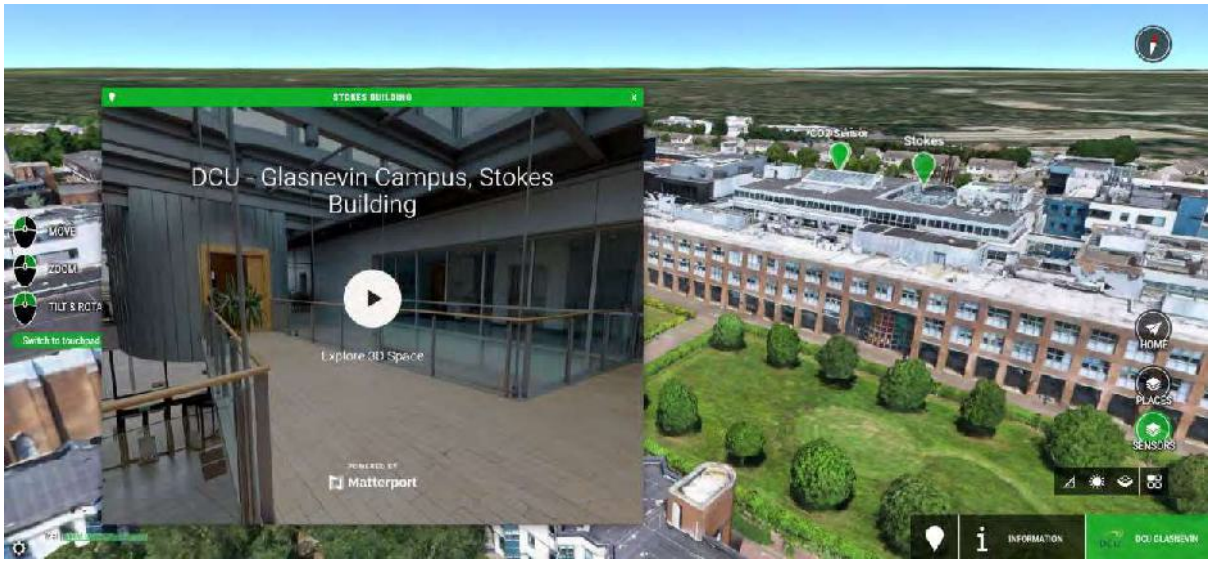

Figure 5: Smart DCU Digital Twin of Glasnevin Campus. Source: Bentley OpenCities Planner screenshot

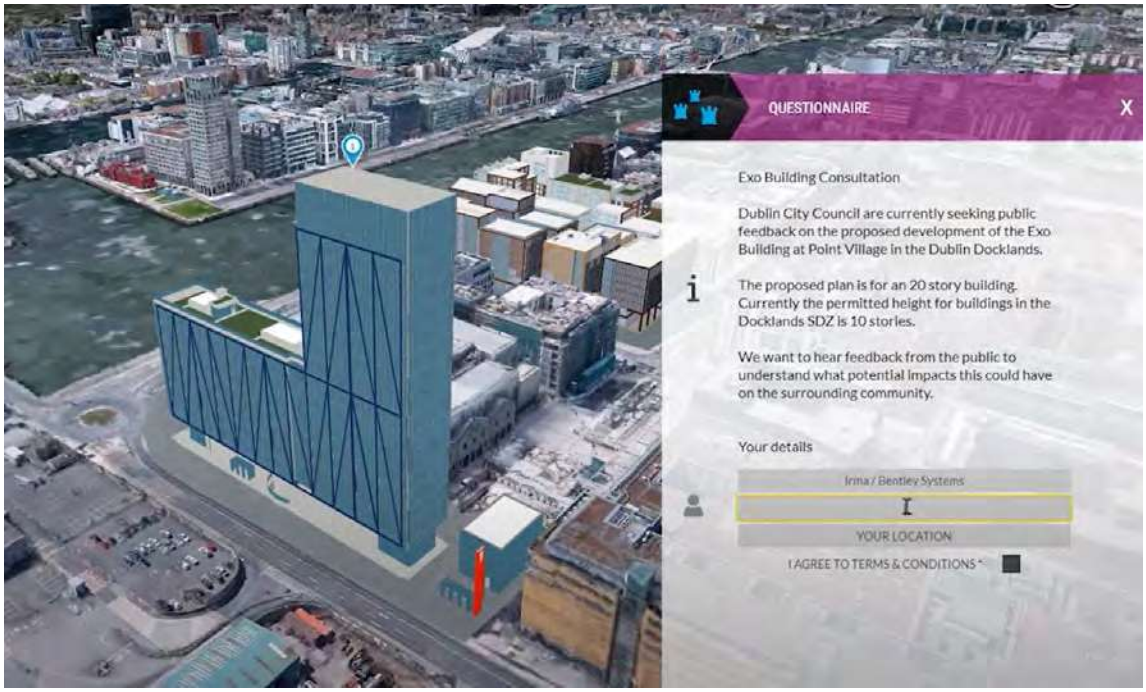

Figure 6: Pilot for Citizen Feedback for Docklands Model. Source: Bentley OpenCities Planner Screenshot

3. Proposed approach

As mentioned, there are some practical challenges in deploying LDTs. Therefore, a strategic approach is proposed for a phase-wise implementation towards insightful twins. Some foundational questions about data requirements, integration platforms, data governance, ethical concerns, and building essential collaborations for impactful use cases need to be answered. A possible implementation journey and work-streams are illustrated in **Figure 7** and **Figure 8** respectively.

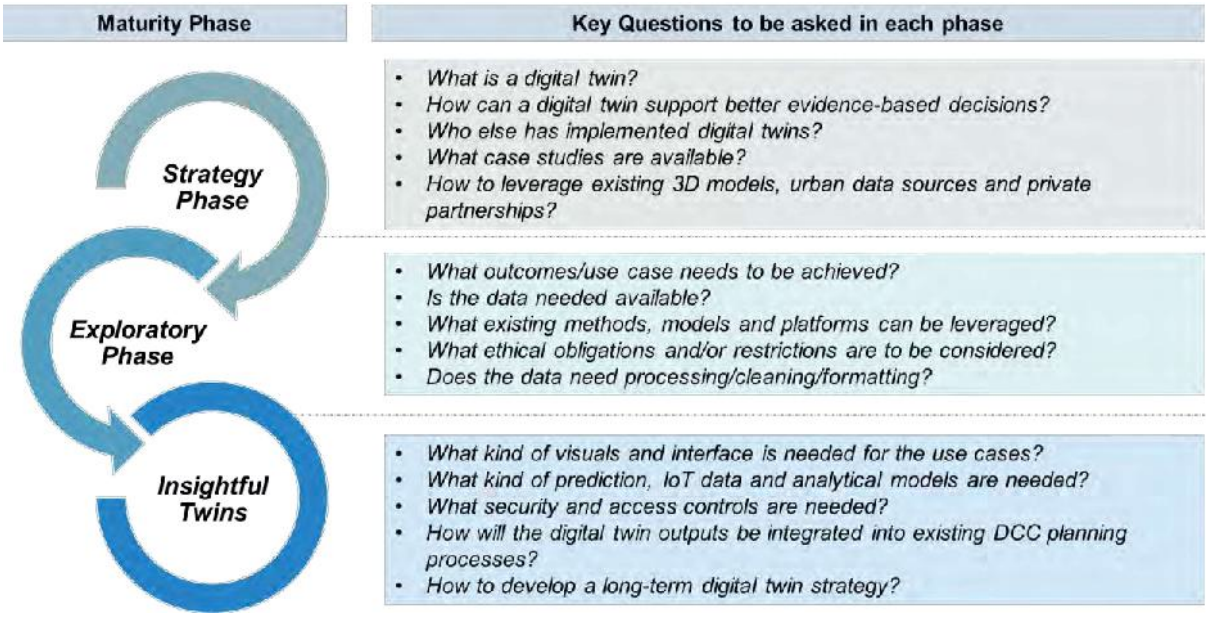

Figure 7: Suggestive Implementation Journey. Source: Authors

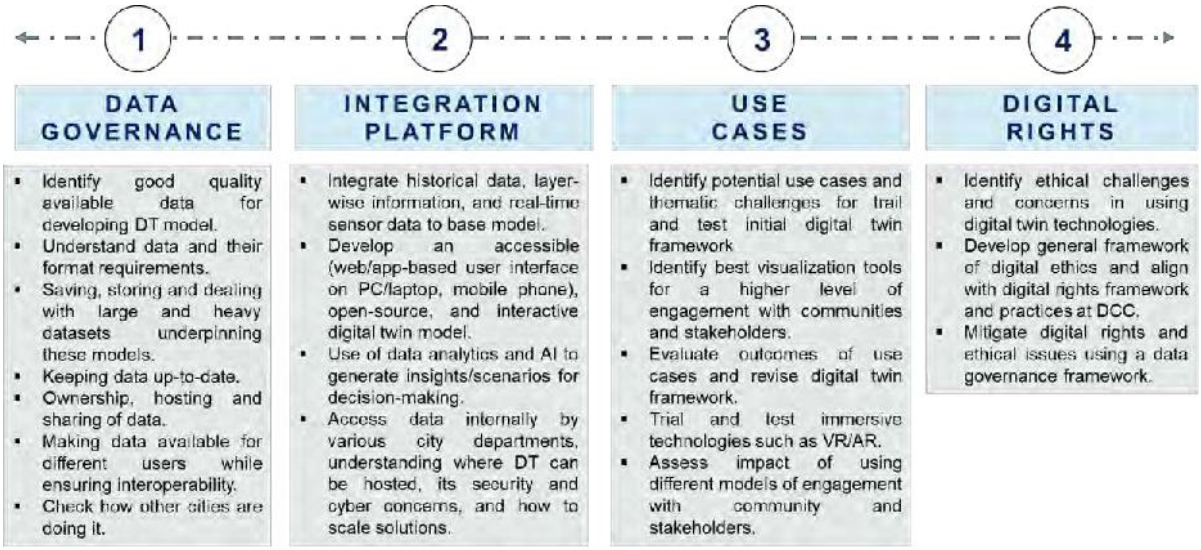

Figure 8: Proposed Work Streams. Source: Authors

The potential use-cases can be broadly classified as Type I and Type II. Type I use-cases are essentially visual and interactive twins, with a strong purpose to engage with non-technical target groups (Alessi *et al.*, 2020; Parker, Tomitsch and Fredericks, 2020; Abdeen and Sepasgozar, 2022). Examples of this include the extension of Smart DCU digital twin model into Unreal Engine for autism-friendly navigation, overlaying validated future flooding scenarios on the Docklands digital twin and complementing the process of public consultation for active travel project schemes in Dublin (claimed to be one of the largest investments in Europe). The emphasis will be to harness the potential of digital prototypes using 3D models, spatial layers, and design renderings for community engagement. Presently, the information shared with the public is very technical, insufficient, and difficult to understand the overall process and timelines, leading to final proposals. Also, many times, it is not designed to meet the needs of different age-groups, abilities, and genders.

Type II use cases target technical or semi-skilled stakeholders who need these models for informed planning decisions and situational awareness. Examples of this include using the proposed digital twin for emergency response by Dublin Fire Brigade for personnel training, and prospects of developing a multi-thematic planning use case for Smart D8 (a health and wellness district) by identifying planning relationships between different datasets such as air quality, parks and green area density, health and social services, active travel routes, housing, noise, community initiatives and other infrastructures. Key questions for identifying the type of digital twin depends on target audience, purpose and added engagement value desired from them. For instance, an immersive solution may work better for community engagement while an advanced analytical dashboard/platform is probably required by public departments. These use-cases are currently in the exploratory phase and use engaged research principles (Campus Engage, 2022). For evaluation of prototype models, stakeholder workshops, interviews and citizen think-ins will be explored.

4. Expected Outcome and Broader Impact

One of the key priorities for Ireland is to transition to a low-carbon and climate-resilient society by 2040, and projects such as Active Travel Network are of special relevance because of their explicit focus on the overall societal well-being. At city scale, building resilience within communities can be understood to make them adaptive to these new changes, which makes the role of local public authorities even more critical to foster policies towards positive socio-economic-environmental outcome of sustainability, cohesion and prosperity of a society (Wardekker, 2022). These long-term goals also depend on building innovative

communication channels between citizens and service providers (Digital Europe, 2021a; Anshari and Hamdan, 2022). DT4E expects to bridge this gap by employing evidence-based research, for developing inclusive planning solutions. For DCC, it expects to assist in creative and agile community engagements based on a robust governance and ethical framework for LDTs, while streamlining planning processes and induce effective stakeholder collaborations.

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