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Digital Twins for Sustainable Local Governance and Heritage Protection: The HBIM Pilot in Sidi Fradj, **Kerkennah**

Policy Paper – 2026



11 SUSTAINABLE CITIES AND COMMUNITIES



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



16 PEACE, JUSTICE AND STRONG INSTITUTIONS

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Digital Twins for Sustainable Local Governance and Heritage Protection: the HBIM Pilot in Sidi Fradj, Kerkennah

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Published by the United Nations Human Settlements Programme (UN-Habitat).
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PREFACE

Achieving the 2030 Agenda requires more than translating global goals into national targets — it demands that sustainable development be rooted in the realities, needs, and capacities of local territories. Local and regional governments are indispensable actors in this process: they deliver essential services, address inequalities on the ground, and turn policy commitments into concrete actions. Yet this critical role is only fully effective when backed by strong evidence, meaningful knowledge exchange, and coherent governance across levels.

The Local2030 Knowledge and Scientific Network (KSN) was established within the UN Local2030 Coalition precisely to respond to this need. As a dynamic global platform, KSN connects young researchers, policymakers, community leaders, and practitioners around a shared mission: to harness science for sustainable development with local impact. It does so by aligning academic inquiry with the specific priorities of local development stakeholders, while amplifying research findings as inputs to SDG-related global processes.

Central to this approach is the understanding that research must not only be produced — it must be translated into policy and action. KSN promotes a more dynamic and responsive model of academia, one that co-creates scalable solutions rooted in scientific evidence and community priorities, and that empowers local actors with the skills, tools, and institutional support needed to engage in evidence-based decision-making and influence policy. Through its Country Pilots — sponsored by the Italian government and implemented by UN-Habitat and the Centro Studi di Politica Internazionale (CeSPI ETS) — and Innovation Labs, the network operationalizes this vision by connecting universities and students with local policymakers, enabling interdisciplinary collaboration and capacity-building in territories across Africa, Asia, and Latin America and the Caribbean.

Action-research is the methodological backbone of this work. Territories are engaged not as passive subjects of study, but as spaces for experimentation and learning, where sustained interaction between researchers, local governments, civil society, and communities drives learning, adaptation, and co-creation. By combining quantitative and qualitative methods — data analysis, spatial assessments, stakeholder engagement, and participatory approaches — this process generates a comprehensive and grounded understanding of local dynamics, inequalities, and

development opportunities.

This policy paper is the result of that process. It reflects the outcome of collaboration between academic research, territorial analysis, and multi-stakeholder dialogue, in the spirit of the KSN's core objective: translating research into policy and action. Its aim is to offer context-sensitive analysis and practical policy recommendations that can inform SDG localization at the local level – bridging the gap between global agendas and the communities that will ultimately determine their success.

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EXECUTIVE SUMMARY

This Policy Paper translates the scientific research “Digital Twins: HBIM Repositories as Drivers for Interdisciplinary Management of Sustainable Cities – The Case of Sidi Fradj, Kerkennah” into actionable policy directions. It sets the foundation for implementing digital twins, integrated within HBIM frameworks, to transform fragmented heritage and environmental data into centralized models that support sustainable territorial governance, risk management, and climate adaptation; through reality replication virtually for predictive simulation.

The Digital Twin of Sidi Fradj provided a real-time digital replica of the built environment, offering a platform where urban, environmental, and social layers converge. The proposed approach aligns essentially on SDG 11 (Sustainable Cities and Communities) but also on SDG9 Industry, innovation and infrastructure by its innovative digital methods and on SDG16 Peace, justice and strong institutions by democratizing the use of technologies and promoting inclusive institutions collaboration. This paper translates those findings into policy-relevant insights for local and national stakeholders. The document provides a framework for developing a Concept Note to attract national and international funding for the establishment of an interdisciplinary digital governance system in Tunisia.

Building on Tunisia’s digital transformation agenda and its national efforts toward the localization of the 2030 Agenda, this policy paper proposes HBIM-Digital Twins as a proposal for better municipal governance, positioning Kerkennah as a pilot territory for integrating technology, heritage, and sustainability. While Kerkennah serves as the initial testbed, the model is designed as a reference to be extended to other municipalities, particularly those facing similar pressures on heritage, climate resilience, and service management, allowing broader national deployment. It also opens opportunities for alignment with international networks such as UN-Habitat’s Local2030 Coalition, the UNESCO World Heritage Cities Program, and global Digital Twin initiatives, reinforcing Tunisia’s integration into wider innovation and knowledge-sharing platforms.

Keywords: HBIM, Digital Twin, SDG Localization, Climate Resilience, Heritage, Data Governance, Tunisia, Kerkennah, Island Sustainability

1. GENERAL CONTEXT

1.1. Problem Definition

The Kerkennah archipelago, located off the coast of Sfax, is one of Tunisia’s most climate-vulnerable regions, facing rising sea levels, rural depopulation, and fragmented institutional coordination. Despite ongoing local development plans, critical data on infrastructure, heritage, and the environment remain siloed, limiting the capacity for strategic and timely decision-making. Environmental and socio-economic pressures are accelerating the degradation of historic structures, while privately owned, deteriorating properties are increasingly demolished. This context, combined with the absence of digital infrastructure to support rapid and precise interventions, prompted the municipality to request a comprehensive documentation of the island’s endangered built heritage, laying the foundation for the Sidi Fradj Digital Twin project.

1.2. Proposed Solution

The Municipality requested documentation of endangered built heritage, leading to the development of the Sidi Fradj Heritage Building Information Modeling (HBIM) pilot project by PhD Architect Wiem Alimi within the KSN Framework. This Digital Twin repository serves as a single source of truth for spatial, architectural, and environmental data, fostering interdisciplinary collaboration across stakeholders from different sectors (architects, engineers, planners, and other policymakers). Developed through a participatory planning process, the project actively involved the Municipality of Kerkennah, whose continuous feedback validated local knowledge, refined modelling priorities, and ensured the model addressed real territorial needs. Onsite laser-scanning training empowered municipal teams to contribute to data collection, processing, and management. The project revealed that no architectural data existed for Sidi Fradj in municipal archives, as is the case for many historic buildings in Tunisia, prompting the creation of an HBIM-based Digital Twin integrating terrestrial laser scanning, parametric modelling, and semantic enrichment. The model enables predictive conservation, while incorporating traditional materials, assessing degradation, and highlighting the sustainability of

Kerkennah's vernacular construction techniques. Continuous collaboration with the municipality ensured contextual accuracy, validation, local ownership, and strengthened municipal technical capacity.

1.3. Multi-stakeholder and Participatory Approach

Fieldwork was closely coordinated with municipal staff, and continuous feedback loops were established during modelling and data integration to ensure accuracy and relevance. Regular consultations validated the model at each stage, while onsite laser-scanning training strengthened the technical capacities of municipal teams. The project also benefited from technical reviews by international researchers and UN-Habitat specialists, ensuring that the Digital Twin not only reflected local knowledge but also met rigorous scientific and operational standards. This collaborative approach reinforced local ownership and aligned the Digital Twin with both: real territorial planning needs, while contributing to global agendas such as SDG11 objective.

1.4. HBIM-Digital Twins Worldwide driving Conservation, Governance, and Immersive Engagement

Around the world, Digital Twins are proving to be revolutionary tools for heritage conservation, urban governance, and communication. A Digital Twin is a dynamic digital replica of a physical system that uses real-time data to simulate, analyse, and support decisions about the real world.

Virtual Singapore, one of the most advanced implementations, provides a comprehensive 3D model of the entire city-state that integrates geospatial and real-time data to support urban planning, infrastructure design, and scenario testing for everything from transport to environmental adaptation. The city's twin enables planners and researchers to visualise complex urban systems in ways that would be

impossible with traditional maps or isolated datasets.

In Kaunas, Lithuania, a Digital Twin is helping guide sustainable redevelopment in the historic Old Town by providing 3D visualisations that link building performance, energy use, and renovation scenarios, thus supporting holistic approaches to ageing infrastructure and heritage conservation.

Meanwhile, Matera, Italy uses its Digital Twin platform to integrate 3D city models with sensor data and participatory inputs, improving spatial planning, service delivery, and citizen engagement in the historic center.

At the scale of individual buildings, digital replicas are also proving invaluable. The creation of a highly detailed HBIM-based Digital Twin of Notre-Dame Cathedral in Paris capturing architectural and structural information at near-millimetre precision helped its immediate restoration after the fire, ensured its long-term preservation, and supported virtual exploration of this iconic heritage site.

Consequently, HBIM-based Digital Twins transform static heritage records into dynamic, interactive models that can be leveraged for conservation, urban governance, and immersive communication. These global examples show that HBIM-Digital Twins can become multi-purpose platforms that centralise complex data for evidence-based governance, enable predictive conservation strategies, and expand communication through interactive tools for planners, scholars, and the public alike.

Similarly, the Sidi Fradj HBIM-based Digital Twin in Kerkennah is helping safeguard endangered local heritage by centralising architectural, environmental, and historical data, enabling predictive conservation, and enhancing communication and stakeholder collaboration.

(How BIM is helping save Kerkennah's endangered heritage, Alimi, 2025, <https://www.mondopoli.it/2025/09/05/memoria-digitale-futuri-reali-come-il-bim-sta-aiutando-a-salvare-il-patrimonio-a-rischio-di-kerkennah/>)

1.5. Theory of Change (ToC)

The proposed HBIM-based Digital Twin model is founded on a clear causal logic that links digital innovation to enhanced territorial governance and SDG localization in Kerkennah. The project invests in cultural heritage and technology through the implementation of the HBIM process, resulting in the creation of a comprehensive Digital Twin. This model produces tangible outputs in documentation and conservation, including predictive restoration and the development of an inventory of sustainable local know-how, such as construction techniques and material mapping. It also supports communication and engagement by enabling the use of digital models in VR and AR, digital tourism, projection mapping, and the creation of artistic circuits. The anticipated impact unfolds across multiple timeframes, delivering better data and management in the short term, improved decision-making in the medium term, and ultimately contributing to climate-resilient and sustainable governance of the island in the long term.

2. TERRITORIAL PLANNING INSTRUMENTS

2.1. Integration Possibilities

The integration possibilities for the Sidi Fradj HBIM-based Digital Twin span national, territorial, and international levels.

At the national policy level, the project aligns with Tunisia's digital transformation agenda, which promotes digital governance, as well as with SNAT 2030 (Schéma National d'Aménagement du Territoire) to ensure interoperability and alignment. It also supports national heritage policy objectives through the Ministry of Culture and the Institut National du Patrimoine (INP), and contributes to national environmental policy goals under the Visa SNTE (Stratégie Nationale de Transition Ecologique). At the territorial and local level, the initiative integrates with urban planning instruments such as the Schéma Directeur d'Aménagement (SDA) and the Plan d'Aménagement Urbain (PAU) of Kerkennah 2016, currently under revision. The project further connects with global partnerships for SDG localization, including UN-Habitat's Local2030 framework and technical guidance, international cooperation programs such as GIZ (Agence de Coopération Internationale Allemande pour le Développement), and foresight initiatives like MED 2050 (La Méditerranée à l'horizon 2050).

At the international level, collaboration extends to the Asian Development Bank, which develops frameworks for using Digital Twins for sustainable infrastructure in developing countries, as well as the UNESCO World Heritage Cities Program, supporting heritage governance alignment and global best practices.

2.2. Partners/stakeholders and synergies

The successful implementation of the HBIM-Digital Twin model in Kerkennah relies on coordination with a broad range of national partners and stakeholders across public institutions, the private sector, and research and academic collaborators.

At the public level, this includes the Ministry of Equipment, Housing, and Territorial Development (for integration into urban and land-use planning), the Ministry of Communication Technologies (for interoperability and data management infrastructure), the Ministry of Culture and the Institut National du Patrimoine (INP) (for validation and conservation of heritage data), the Ministry of Environment (for climate and environmental data integration), and the Municipality of Kerkennah as the local data custodian and operational manager.

Private sector engagement involves local SMEs such as tourism and cultural startups (like DCX and Museum Lab Tunisie), responsible real estate agencies (for potential restoration), artisans specializing in traditional construction works as well as vendors of sustainable construction materials. Also, technology vendors, including FARO for laser-scanning equipment, can provide essential technical support.

Research and academic collaboration is central to methodology refinement and results validation, recommending connections with ENAU (Ecole Nationale d'Architecture et d'Urbanisme), LAAM (Laboratoire d'Archéologie et d'Architecture Maghrébines at Université de Manouba) and ISTEUB (Institut Supérieur des Technologies de l'Environnement de l'Urbanisme et de Bâtiment) for cultural heritage, architecture and urban planning). For interactive communication uses of the model, we recommend connections with ISAMM (Institut Supérieur des Arts Multimédia de la Manouba). To expand the initiative to a broader regional context, collaboration with other Mediterranean universities such as UNIPA (University of Palermo) is advised, alongside engagement with international researchers specialized in SDGs and cultural heritage.

This multi-level institutional framework ensures that the HBIM–Digital Twin model can become a national standard for local digital transformation, supporting SDG 11, SDG 9, and SDG 16.

3. POLICY OPTIONS & RECOMMENDATIONS

3.1. Immediate Actions

To embed the project within existing planning tools, a series of immediate, medium, and strategic actions are recommended. In the immediate term, the HBIM methodology should be replicated across heritage sites, laser scanners such as FARO models should be procured, and onsite staff training should continue to strengthen technical capacity. At the medium-term level, a municipal Digital Twin decision-support platform should be deployed, integrating HBIM outputs into municipal workflows to ensure local ownership and operational use. Strategically, datasets should be aligned with national spatial databases, the pilot project should be scaled to other regions, and open-data and interoperability standards should be developed to support long-term sustainability and integration into broader governance frameworks.

3.2 Implementation Roadmap

To operationalize the HBIM–Digital Twin approach beyond the Sidi Fradj pilot, a future initiative should be structured around a set of coordinated activities. These include: (i) the systematic identification and prioritization of vulnerable heritage and public assets at municipal level; (ii) the execution of standardized data acquisition campaigns (terrestrial laser scanning, photographic surveys, and material mapping); (iii) the development of HBIM models enriched with environmental, material, and sustainability-related data; (iv) the establishment of a municipal Digital Twin repository connected to GIS and shared within a Commun Data Environment; and (v) targeted capacity-building programs for municipal staff and local stakeholders. Complementary activities should also address participatory workshops, inter-institutional coordination mechanisms, and the definition of data governance protocols to ensure long-term maintenance, interoperability, and scalability of the system. Together, these activities form a replicable roadmap for deploying Digital Twins as decision-support tools for sustainable local governance and heritage protection.

3.3. Financing Resources

For reference about the price of Faro laser scanners please refer to <https://e-prisme.fr/product/scanner-laser-3d-faro-focus-m70/>). Also note that we cited in section 2.1. that ADB - Asian Development Bank develops frameworks for developing nations to use Digital Twins for sustainable infrastructure.

3.4. Monitoring & Evaluation (M&E) Framework

The Monitoring and Evaluation (M&E) framework for the HBIM–Digital Twin project relies on key performance indicators across technical, governance, capacity-building, and financial dimensions. Technical KPIs include the number of heritage assets digitally documented, the quality and completeness of HBIM datasets, and the adoption of standardized workflows. Governance KPIs measure the level of inter-institutional collaboration and the integration of HBIM outputs into municipal or national decision-making processes. Capacity-building KPIs track the number of trained professionals and the demonstrated use of HBIM tools by public stakeholders. Financial KPIs evaluate the efficiency of resource allocation and the cost reductions achieved through digital workflows, providing a comprehensive basis to assess project effectiveness and impact.

3.5. Preliminary Risk Assessment and Do No Harm Considerations

The project faces several potential risks: limited municipal digital capacity, fragmentation between institutions, risks of data loss or misuse, and possible resistance to new technologies. To mitigate these, it is needed to build early technical mastery and ensure human collaboration.

A Do No Harm approach is to be integrated throughout the process by ensuring open access for local actors, respecting community knowledge during documentation,

and handling cultural heritage data with transparency and sensitivity to avoid misinterpretation or exclusion.

4. CONCLUSION

The Kerkennah case exemplifies how digital tools can translate global sustainability targets into tangible territorial actions, fully aligning with the Local2030 Coalition and UN-Habitat's SDG Localization Programme. By advancing SDG 9 on industry, innovation, and infrastructure through innovative digital methods, supporting SDG 16 by fostering inclusive and accountable institutions, and contributing to SDG 11.3 and 11.4 through participatory planning and the protection of cultural and natural heritage, the initiative demonstrates a multi-dimensional impact. It further strengthens resilience to climate-related hazards in line with SDG 13.1 and promotes knowledge sharing and global partnerships under SDG 17.16–17.17. In this context, the Sidi Fradj Digital Twin and HBIM Repository stand as a pioneering example of data-driven, sustainable island governance in Tunisia, seamlessly integrating digital innovation, heritage conservation, and climate resilience to transform discrete technical interventions into a comprehensive, forward-looking territorial strategy that embodies the 2030 Agenda for Sustainable Development.

Acronym List

SDG – Sustainable Development Goals

HBIM – Heritage Building Information Modeling: Digital modeling methodology for documenting, managing, and conserving built heritage.

CDE – Common Data Environment: Centralized platform for storing, sharing, and managing digital data.

VR – Virtual Reality: Immersive digital simulation of physical environments.

AR – Augmented Reality: Overlay of digital information onto the physical world.

ToC – Theory of Change: Framework linking project activities to expected outcomes and impact.

M&E – Monitoring & Evaluation: System for tracking project performance and effectiveness.

SDA – Schéma Directeur d'Aménagement: Territorial masterplan in Tunisia.

PAU – Plan d'Aménagement Urbain: Urban development plan in Tunisia.

SNAT 2030 – Schéma National d'Aménagement du Territoire 2030: Tunisia's national spatial planning strategy.

SNTE – Stratégie Nationale de Transition Ecologique: Tunisia's national ecological transition strategy.

ADB – Asian Development Bank: International financial institution supporting sustainable infrastructure projects.

INP – Institut National du Patrimoine: Tunisia's National Heritage Institute.



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