A BI Tool to Support Decision-Making Processes for Public Heritage Assets in CIM Systems

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Abstract

Today, numerous studies explore the concepts of Smart City and City Information Modeling (CIM), highlighting the need to develop methods for systematizing, analyzing, and representing data typically managed by different information systems. The shared vision is to integrate BIM outputs with those from GIS, as well as with data from various other sources (historical documents, technical reports, IoT sensors, etc.), within a single working environment, thus building a true digital twin of extensive territorial areas. The goal is to optimize decision-making processes at both building and urban scales, and a potential solution lies in the combined use of Business Intelligence (BI) tools, which allow for the reading, integration, and querying of data stored across the different information systems mentioned. In this context, the present contribution aims to frame the issue of data integration and to test a digital solution integrating BIM, GIS, and BI, developed through a collaboration between the research group at the University of Naples Federico II and the company ACCA Software, and applied to publicly owned building assets.

1. Introduction

The multidimensional articulation of data involved, in a direct or indirect way, in the management of the built heritage and the territory, highlights the urgency of having coordinated and interoperable digital systems, capable of aggregating, analyzing and returning heterogeneous information in a structured form.
The funded project BIM_BI-AI developed by the company ACCA software, which involves several departments from various Italian universities, among which the DiARC and DiCEA research groups of the University of Naples Federico II, pursues the objective of creating and making operational software solutions that integrate different types of information, enabling multiscale queries and the delivery of new data through a single and intuitive visualization.
Through a data-driven approach based on the Common Data Environment (CDE), the project aims to integrate BIM (Building Information Modeling) data with GIS (Geographic Information System) data and Artificial Intelligence (AI) in order to provide a geospatial working environment for the management of digital twins of buildings and infrastructures, supported by advanced tools for data analysis, organization, and prediction.
The research group represented by the authors specifically focuses on the management and integration of data related to the built heritage in the operational phase, analyzing its potential applications at both the architectural and territorial scale, with the aim of generating valuable and synthetic information. (Scandurra et al. 2025).
The work, whose initial results are presented in this contribution, uses as its main tool the SaaS platform usBIM.geotwin, developed from the integration of ACCA’s usBIM and ESRI’s ArcGIS. At the same time, it involves the adoption of typical Business Intelligence (BI) tools, enabling the querying of complex datasets through dynamic dashboards and Key Performance Indicators (KPIs). The case study focuses on the use of the system in service of public entities managing complex real estate assets distributed across extensive territorial networks. The operational experimentation involves the building heritage of the University of Naples Federico II (Italy), which includes over 150 properties located in urban and peri-urban contexts.
In this context, the system was employed to analyze the functional distribution of high-risk spaces, assessing their compatibility with the territorial vulnerability framework. A multiparametric evaluation was thus conducted regarding the placement of sensitive premises in relation to environmental risk scenarios (seismicity, volcanism, hydrogeology), with the aim of supporting more informed planning. Furthermore, the system is being structured to also support the planning of interventions that utilize publicly owned buildings to mitigate the urban heat island effect.

2. State of art

The integration between BIM and GIS has been extensively explored in recent years, but no uniquely satisfactory solutions have yet been identified. Indeed, technical and semantic limitations persist, as highlighted in the literature, primarily concerning the lack of shared interoperable standards, the difficulty in storing and dynamically updating large volumes of data, and the limited accessibility of tools for non-expert users. As is well known, the BIM standard focuses on object-oriented logics at the architectural scale, while GIS operates on cartographic and topological layers of significantly larger scope. Both systems have proven essential for intelligently addressing the design and management of constructions at the building and urban scale, but the increasing complexity of territorial governance services suggests the need for coordinated, flexible, and sustainable solutions capable of coherently querying increasingly diverse data sources, in an effort to support more effective strategic and operational decisions.
In this perspective, the concept of CIM (Souza and Bueno, 2022) (Figure 1) and, even more so, that of the geospatial twin (Döllner, 2020) are framed as digital solutions capable of integrating data from entire territories at multiple scales, including BIM and GIS but also technical documentation, digital surveys, Internet of Things (IoT) data, cost lists, statistical information, etc. A replica of the physical built environment that can combine geometric and analytical data. In this context, numerous research projects and applied experiments, both in academia and industry, are exploring the adoption of integrated geospatial platforms oriented towards different types of uses and based on diverse software technologies.

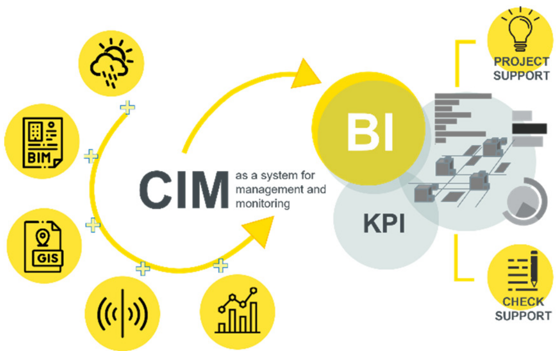

Figure 1. "Schema of the CIM-BI management and analysis system that integrates and queries heterogeneous data (BIM, GIS, sensor data, etc.) based on defined KPIs.

Specifically, the analysis of scientific literature highlights a plurality of approaches, many focused on the integration of BIM and GIS systems with a view to constructing CIM environments based on integration methods ranging from data exchange between distinct systems, to the creation of hybrid models, to the development of third-party systems for data fusion.
The software tools employed for integration involve the use of existing commercial platforms or are derived from customized data conversion algorithms (Zhu and Wu, 2022). Indeed, the definition of shared standards and data formats, as well as their mutual translation to enable communication within shared management platforms, remains a central and unresolved issue (Jetlund, 2021; Janečka, 2019a). For example, some studies propose direct conversions from BIM to GIS through translating data from Industry Foundation Classes (IFC) to City Geography Markup Language (CityGML) (Stouffs et al., 2018a; D'Agostino and Antuono, 2023), while others prefer to extend one model onto the other, giving rise to hybrid solutions that combine characteristics of both (El-Mekawy et al., 2012). At the same time, approaches based on semantic web technologies and the use of specific ontologies are being developed with the aim of improving data integration and management (Hor et al., 2016a; González et al., 2022). Therefore, although the correlation between BIM and GIS data is still immature (Zhu and Peng, 2022a), the first CIM applications are currently under development, some oriented towards 3D/4D visualization of complex urban scenarios and aimed at multi-scalar urban and energy analyses (Stouffs et al., 2018b; Hor et al., 2016b); others based on platforms such as Esri CityEngine, to integrate three-dimensional and socioeconomic data with the goal of supporting efficient urban planning (Jetlund, 2021).
Alongside this, the idea of integrating IoT data and monitoring sensors into the system is steering CIM systems towards mimicking physical reality as closely as possible, to understand it and evaluate its transformations in real time, for example by monitoring construction sites (Zhu and Peng, 2022b) or essential urban services (González et al., 2022). Some global projects have been designed to create dynamic and interoperable geospatial digital twins, with the aim of improving sustainability, resilience, and real-time urban governance (Janečka, 2019b).
The application purposes of CIM systems are still continuously expanding, reflecting the multidimensional and interdisciplinary nature of a tool that is equipping itself with sophisticated functionalities. Among the most recently explored possibilities is the integration of typical Business Intelligence (BI) tools. Although BI tools are well established in numerous applications dedicated to business process management (Willen, 2002), they remain underutilized in the construction sector for monitoring activities and processes.
The most recent scientific literature identifies three main areas where the integration of CIM and BI tools can provide significant contributions: management of environmental criticalities; urban safety and maintenance management; and planning and management of interventions for environmental sustainability. For instance, studies (Zhang et al., 2020) orient the CIM-BI system towards monitoring the effects of urban heat island phenomena, aiming to identify the most critical areas and plan mitigation measures. Other studies (Szeligova et al., 2023) suggest integrating BIM building models with GIS data related to flood risk to facilitate, through BI tools, the identification of vulnerable zones and to estimate costs and timelines for flood risk reduction interventions.
In the field of urban safety and maintenance, the CIM-BI approach extends traditional Urban Facility Management (UFM) models to the urban scale, combining building information with data related to infrastructure networks, traffic flows, the location of utilities, and critical city elements (Atta and Talamo, 2020). The objective is to enable more efficient predictive planning, process standardization, and continuous updating of plant networks (Chapman et al., 2020).
Moreover, from a sustainability and resilience perspective, CIM-BI integration has proven useful for optimizing building energy performance by enabling the simulation of alternative scenarios to control consumption and emissions (Omrany et al., 2024). Finally, CIM is emerging as an enabling tool for Life Cycle Assessment (LCA) analysis at the urban scale, thanks to its capacity to collect and organize data on buildings, infrastructure, furniture, and vegetation. CIM can be enhanced to manage and predict complex variables and data related to local climatic conditions, shading, or impacts in terms of emissions generated by infrastructure (Loiseau et al., 2018; Mielniczek et al., 2022).
The state-of-the-art analysis highlights the current absence of a definitive solution for the structuring of geospatial and multi-scalar digital twins, as well as their potential to support managers of complex building and urban systems, particularly public administrations (Di Giuda, et al., 2022). Despite the mandatory use of GIS by territorial management entities and BIM for construction contracts, industry statistics still reveal difficulties in the systematic adoption of information systems by entities involved in the AEC (Architecture, Engineering, and Construction) sector. In Italy, institutions such as the Superintendencies and local technical offices continue to rely on traditional workflows, often due to a lack of resources and internal expertise (Bevilacqua, 2020), or because of the absence of standardized and shared operational workflows among data managers. This situation shows that mere awareness of the benefits is insufficient without adequate organizational and technological support, which is essential to overcome current barriers and enable effective digital management of the built environment.

3. Methodology and case study

Public assets, characterized by many years of history and high complexity, face issues related to fragmented information, lack of systematic updates, and often disconnected decision-making processes, which make their management challenging and inefficient. This is also true for much of the building system of Italian universities, where assets are distributed across the territory and difficult to manage, especially because they are still heavily reliant on traditional, paper-based documentation flows. This hinders optimized resource management, resulting in

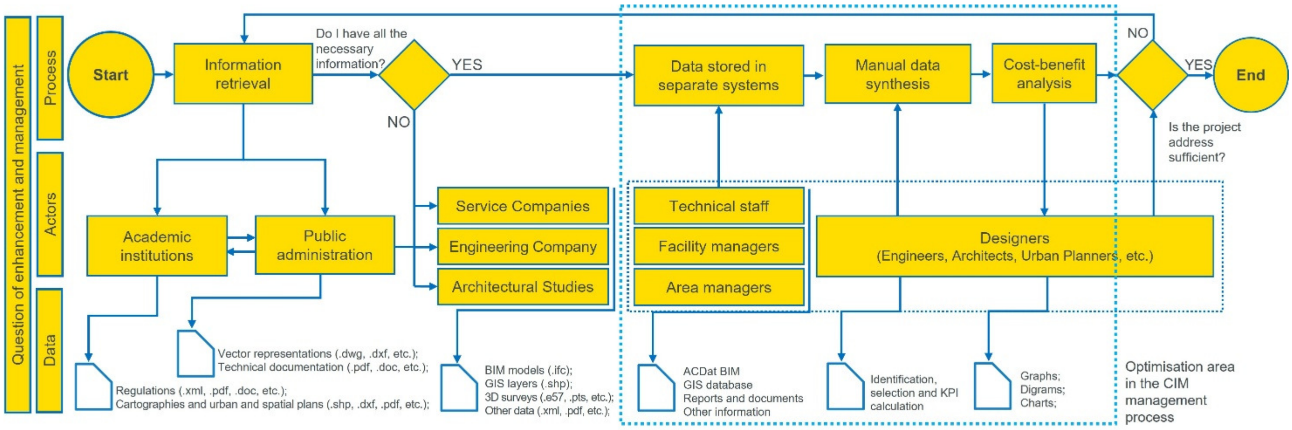

Figure 3. Diagram showing the traditional process and how the CIM paradigm optimizes data exchange among actors and stakeholders, generating information to guide decisions on space monitoring, energy efficiency, and sustainable impact in university buildings.

difficulties in systematizing the impacts that any change to a single structure may have on the surrounding territory and vice versa. In this regard, the research work presented here aims to support this transition by proposing and testing the development of a CIM system applied to university assets, extendable to the broader real estate heritage and integrated with BI to become both a data sharing platform and a tool for analysis and decision support.

Following discussions and consultations with the individuals responsible for managing the university assets at Federico II University of Naples, the work has focused on defining a series of small analytical scenarios in which the integration of building data and territorial data within a geospatial digital twin could effectively improve - in terms of time efficiency, combined data interpretation, and/or prediction/design of future scenarios - the traditional processes currently in use (Figure 2)

To this end, particular attention was given to aspects related to the intrinsic and extrinsic risk and vulnerability of university buildings, as well as to the reciprocal influence that the buildings and the surrounding urban area may have in terms of energy and environmental sustainability.

Clearly, the intended applications of the tool can - and are hoped to - be expanded soon; however, to test the workflow, it was deemed necessary to narrow the scope of use to better define the data required to achieve the initial results.

Specifically, following the definition of the objectives, the workflow was divided into three preparatory phases:

- Data acquisition and organization of the data repository;
- Data normalization and repository updating
- Data integration into a single platform;

Finally, data querying was introduced and tested using BI systems to generate new information through dashboards.

3.1 Data acquisition and organization of the data repository

The first phase of the work involved building the heterogeneous database necessary to structure the subsequent work (Figure 3).

For the Federico II university campuses - approximately 150 across the regional territory and categorized by municipality, function (gyms, classrooms, offices, cafeterias, conference rooms, etc.), and type (recently constructed buildings, historic buildings, green areas, industrial areas, etc.) - drawings and technical documents stored in the offices were first collected, and the current organizational structures were mapped. These structures group locations differently based on management themes as well as the territorial area of each site. With the aim of moving toward a digital geotwin, it was considered appropriate to carry out 3D surveys where documentation was outdated, as well as to obtain point cloud models that can represent the physical world of the city in the digital domain with real-world dimensions and a level of detail sufficient to capture the current state of the sites (for example, surface degradation). These models can be updated with further future acquisitions. These data were also used for building BIM models, useful for defining a digital representation composed of intelligent semantic components, enriched with functional and stratigraphic information, and capable of replicating the entire lifecycle of the buildings, the transformations they have undergone, the materials used for construction, and the physical and mechanical characteristics of each constituent part.

For the BIM models, sample buildings were selected, differing in type and function, some of which were developed as part of previous research. The software solutions adopted were of two types depending on the case, namely Autodesk Revit and Edificius, both used for architectural and structural modeling.

For larger-scale data, namely satellite data and thematic territorial maps, ArcGIS Pro by ESRI was chosen. Operating within the Italian regulatory and administrative framework, priority was given to recognized institutional sources to ensure semantic consistency, legal validity, and continuous updating of the datasets. In particular, for the representation of risk and hazard factors at the urban scale, cartographic datasets published by territorial planning authorities were used: the Municipality of Naples, the Campania Region, the cadastral office, and the Civil Protection Department. These sources provided, among other things, the basis for the

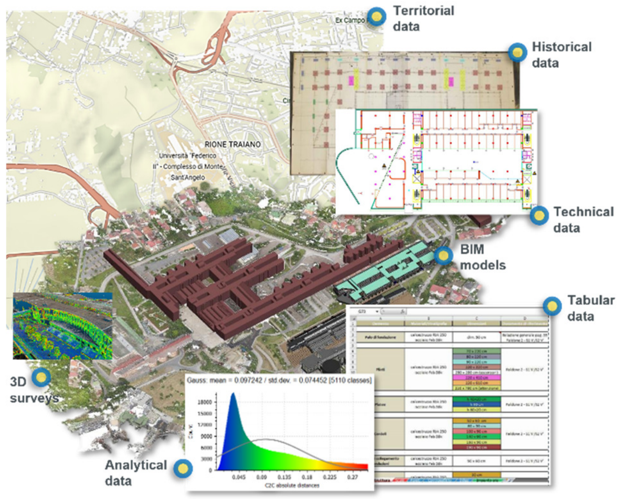

Figure 3. Types of heterogeneous data acquired related to the university buildings of Federico II of Naples for populating the CIM platform.

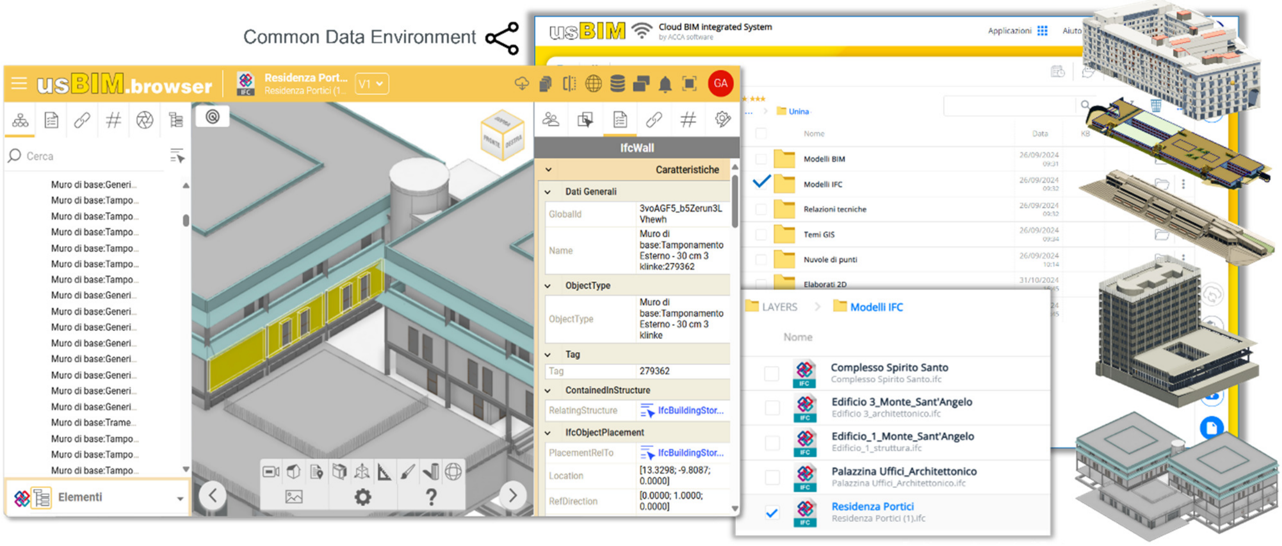

Figure 4. usBIM platform for the collection, management, and sharing of heterogeneous data. In particular, the folder organization is highlighted, gathering GIS data and IFC models of the university building heritage, which can be viewed in the shared digital space.

extraction and georeferencing of thematic maps related to seismic hazard, volcanic risk, and hydrogeological criticalities, derived from Municipal Urban Plans (PUC), General Regulatory Plans (PRG), and civil protection plans. Additionally, information from remote sensing data services (Copernicus, Landsat) generating spatial representations of surface temperatures was acquired.

Other data deemed useful for achieving the objectives are, finally, textual or tabular in nature and include occupancy indices within university spaces, monitoring data of internal and external environmental conditions acquired from sensors measuring temperature, humidity, and irradiation, information collected from databases such as ENEA, CNR, and ISTAT, as well as building and urban regulations and legal constraints.

The data repository and organization platform chosen was usBIM by ACCA software (Figure 4), CDE compliant with UNI 11337 (2017) and ISO 19650 (2018) standards, which enables centralized, traceable, and collaborative management of information flows throughout the lifecycle of the assets. usBIM allows controlled access to documents, models, and data, supporting the management of digital content revisions, tracking changes, and their progressive validation, up to orderly archiving in accordance with the authorization levels predefined by the working group. Within usBIM, the work folder tree was organized by prioritizing at the first level the typological division of the various information sources, namely BIM data, GIS layers, photographs, 3D surveys, diagnostic investigations, technical drawings, technical reports, IoT data, satellite data, ISTAT data, etc. Each of these folders was then further subdivided into sub-levels considering the specific quality, level of development, and working phase of each loaded information product.

3.2 Data normalization and loading into the repository

To ensure consistency among the data, each originally produced for purposes different from the current ones, it was decided to proceed, where possible, with their normalization, subjecting them to a process of structural and semantic harmonization. Specifically, the normalization involved geometric-topological aspects (spatial coordinates, reference systems, object representation) and informational aspects (codes, nomenclatures, classifications, and levels of detail).

This need proved particularly significant, on one hand because the work aims to orient itself as much as possible toward the use of open formats, and on the other because the data involved come from heterogeneous sources and operate at different scales, each typically associated with specific regulatory protocols and reference standards. In particular, while the openBIM representation of the building requires the adoption of the IFC format, the description of the urban and territorial context is based on geospatial information schemas such as CityGML, INSPIRE, and GIS formats. The coexistence and interoperability of these standards is - as anticipated in the state of the art - still complex and unresolved, making it essential to carry out careful syntactic harmonization to build information models capable of interacting coherently and functionally within a shared CIM environment. Therefore, the uniform coding of the BIM models was implemented according to the IFC standard to ensure a unique identification of architectural and functional components. Indeed, membership to standardized IFC classes allows, as is well known, to avoid interpretative ambiguities in automatic querying processes and semantic data linking. For each individual architectural component (walls, slabs, beams, columns, etc.), a naming rule was also adopted, associating with each an alphanumeric code divided into multiple blocks of three characters, structured to quickly identify the building to which the component belongs, its material-dimensional characteristics, and the level. For example, for internal functional spaces (laboratories, offices, libraries, classrooms, and common areas), the IfcSpace entity was used, adopting a systematic nomenclature for the modeled instances according to the scheme XXX_YYY_ZZZ, where XXX represents a unique building code, YYY the function of the space, and ZZZ the level/floor to which it belongs. This convention effectively facilitated the immediate identification of the location and intended use of the environments, efficiently supporting spatial and functional querying within the CIM environment.

The originally available territorial layers in raster formats (e.g., JPEG, GeoTIFF) were first imported into the ArcGIS Pro environment and subjected to a vectorization and georeferencing process - mostly manual - to ensure their compatibility with other geospatial datasets. Specifically, these data were converted into shapefile (SHP) format, aligning both formally and semantically

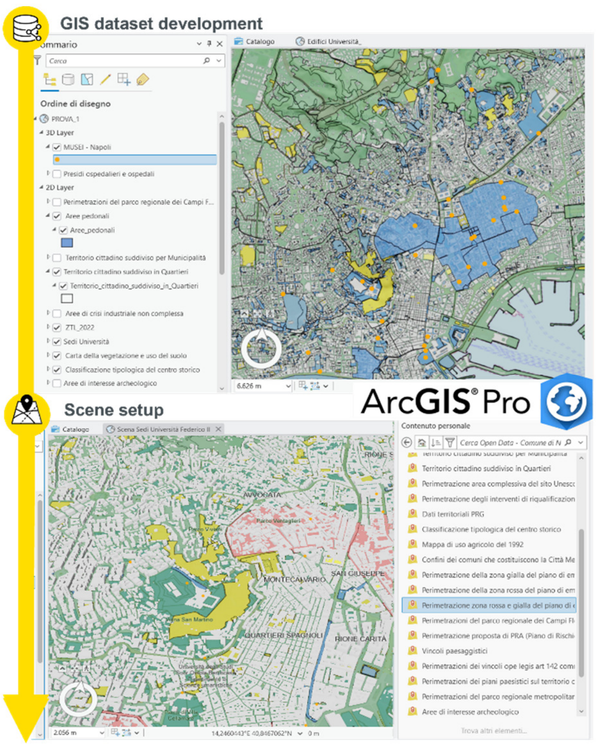

Figure 5. From the structuring of the GIS database, through the normalization and organization of heterogeneous geospatial data, to the generation of corresponding scenes for visualization and spatial analysis of the content.

Figure 6. Preliminary results of data integration in the usBIM.geotwin platform, involving the integration of data managed in collaboration with the Esri GIS platform and through an organized collection of information via usBIM.

with the layers already provided by territorial governance bodies, which were natively available in vector format.
The organization of SHP data was carried out using the ESRI ArcGIS Online platform (Figure 5), configuring specific multilayer Web Scenes - interactive 3D environments that enable visualization, thematic analysis, and sharing of georeferenced content, both publicly and with restricted access for selected users. The Scene application infrastructure allowed for the projection and thematization of two-dimensional GIS layers within three-dimensional environments that schematically replicate the urban context, supporting a more effective and intuitive representation of the spatial and functional relationships among elements. This maintained the coherence of attributes associated with each GIS entity and adapted their representation to the terrain’s orography. This operation enabled the unification of the territorial information base, making the layers fully interoperable and directly integrated into the geospatial information system.

For all other tabular data derived from institutional sources, censuses, and monitoring activities, the work to date has focused on identifying relevant territorial parameters aimed at the indirect geolocation of the data and their spatial association with specific areas of territory or individual building units, that is, contextualizing the values.

The data thus processed have been uploaded into the usBIM repository.

3.3 Data integration into a single platform

The systematization of data was managed within the usBIM.geotwin platform by ACCA software.
Within the research project, the platform - partly already available online - is increasingly acquiring innovative functionalities updated according to the needs emerging from ongoing operational experiments. In general, the usBIM.geotwin platform has been conceived as an integrated environment for multi-scale visualization, management, and querying of built assets digitally immersed in their territorial context. It is primarily configured as an environment for constructing geospatial digital twins, accessible online, capable of hosting and relating informational models at different scales and of various types.
Among its pioneering features is the ability to integrate openBIM models and GIS data within a single three-dimensional operational space, fully preserving both the original semantic structures and the provenance of the information sources (Figure 6). Unlike many solutions that require data duplication or conversion, the platform adopts a non-redundant logic, where each IFC content uploaded into the usBIM cloud repository is simply referenced in geotwin through dynamic links. This management mode preserves data uniqueness and ensures continuous synchronization: every update made to the original file in the repository is reflected in real time within the integrated geospatial environment, preventing version conflicts, overwrites, or proliferation of inconsistent copies.
The GIS data remains that of the ArcGIS Scene, in this case acquired through the online sharing link provided by ESRI on its platform. Thanks to the collaboration between ESRI and ACCA, the GIS interface of usBIM.geotwin perfectly adheres to that of ArcGIS Online, optimizing the user training required. The semantic overlay between datasets is guided by geographic coordinates that enable topological alignment between BIM models, GIS data, and other project datasets. Having uploaded the university campus models and the GIS Scene, we were therefore able to read everything in perfect overlay within usBIM.geotwin, gaining a comprehensive understanding of their mutual relationships.

4. Application of BI systems and dashboard construction

One of the central methodological nodes of the project lies in the production of strategic knowledge aimed at supporting decision-making. The complexity of the currently available information assets requires the adoption of advanced management architectures

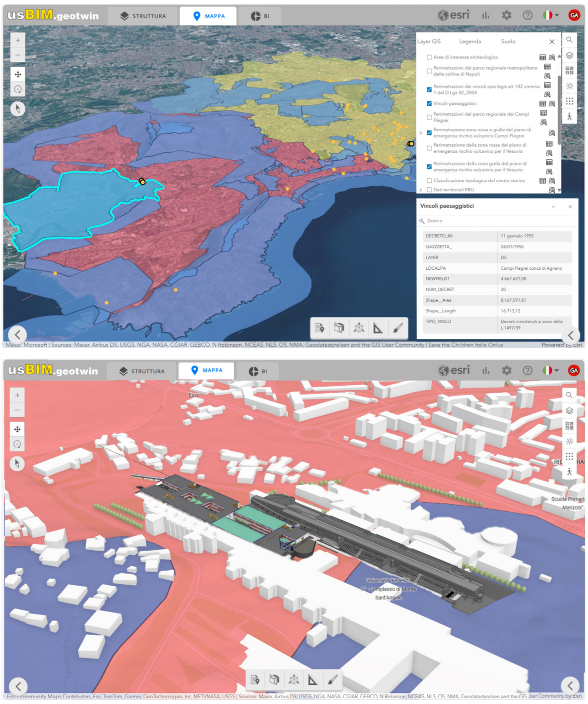

Figure 7. Integrated visualizations of BIM models and GIS layers in usBIM.geotwin: views show how the university building data can be overlaid on the description of the restricted areas.

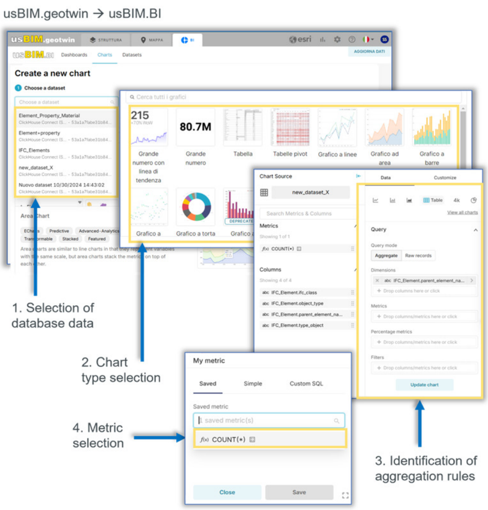

Figure 8. BI querying process scheme: from data selection to the definition of analysis metrics and aggregation rules, to generate new information viewable through dashboards.

oriented toward the development of derived knowledge models- namely, namely new and high value-added information obtained by inference and correlation across different domains.

Once processed, this information can be synthesized and communicated effectively through interactive visualization tools, such as dynamic infographics and multidimensional dashboards, designed for different types of users, from technical operators to public decision-makers. This approach is based on the typical logic of Business Intelligence (BI), which involves organizing data through a structured Extraction, Transformation, and Loading (ETL) flow into a central data warehouse - in our case, identified as usBIM.geotwin. This archive, optimized through thematic sub-collections (data marts represented by individual sources such as GIS, BIM, etc.), has been used for analyzing the first strategic scenarios proposed by the research, in order to test the system beyond simple 3D visualization of the territory and the asset. It was thus used to analyze the functional distribution of high-risk spaces - such as chemistry laboratories - by evaluating their coherence with the broader territorial vulnerability framework, and to assess improvement strategies in terms of environmental sustainability, energy efficiency, and urban heat island mitigation.

Central to this process was the definition of KPIs, that is, synthetic sets of numerical or qualitative parameters capable of describing the analyzed phenomena. Their visual representation in the form of dashboards was designed to make analytical results more accessible, allowing non-technical users to easily access strategic information. From this perspective, the case study related to the University of Naples Federico II constitutes a prototype experiment aimed at building a dynamic decision-support system. The BI system was enabled to directly retrieve information contained in the BIM models: the hierarchical structure of the IFC models was systematically explored according to the logical and semantic relationships defined by the openBIM standard, with the aim of accessing relevant information parameters directly from within the BI environment. In parallel, GIS data was made queryable through attribute tables associated with vector layers, making the corresponding metadata available. Integration between the two information domains was achieved through the definition of a unique matching key, specifically the building's numerical identifier structured in a way that made it present in both the BIM models and the GIS layers (Figure 7). This solution enabled the logical union of the datasets within the BI tools (Figure 8).

4.1 Use Cases and Information Flows

Particular importance, within the context of this study, is given to two key application areas, namely:

- the mitigation of the Urban Heat Island (UHI) effect, with particular attention to design strategies for building rooftops.
- emergency and safety planning, specifically through strategic planning for the management of sensitive university laboratories in high environmental risk scenarios.

Urban Heat Island (UHI): To develop interventions aimed at mitigating the UHI effect, the system queries various data sources, extracting KPIs. From the BIM, it takes data on materials and the stratigraphy of surfaces, structural resistance (to allocate photovoltaic panels or to convert them into green roofs), roof type (flat, pitched), percentage of free surface (e.g., presence of technical rooms), height of parapets, and reflectance (capacity to reduce heat absorption).

From GIS data, it acquires UHI mappings (thermal gap), green areas in the zone (NDVI vegetation index).

Other relevant datasets include legal constraints from overarching urban plans, and indices provided by ENEA and CNR regarding solar exposure and temperatures. These information layers are traditionally those that provide decision-makers with useful tools to identify critical areas for intervention, to choose how to proceed with future retrofit or greening operations (Zhang et al., 2020).

The difference, through the system proposed in usBIM.geotwin with BI, lies in integrating everything into a single system, making queries semi-automatic and fully digital. Drawing from the parameter values assigned to the characteristics of each IFC element involved in the analysis (the roofs) and from the attribute tables of the GIS, the BI system further processes this information to generate infographic summaries in the form of dashboards, graphically customizable with layouts deemed most appropriate for the type of information and the user's role. For example, in our case, the platform identifies the areas most subject to heat accumulation and supports the evaluation of

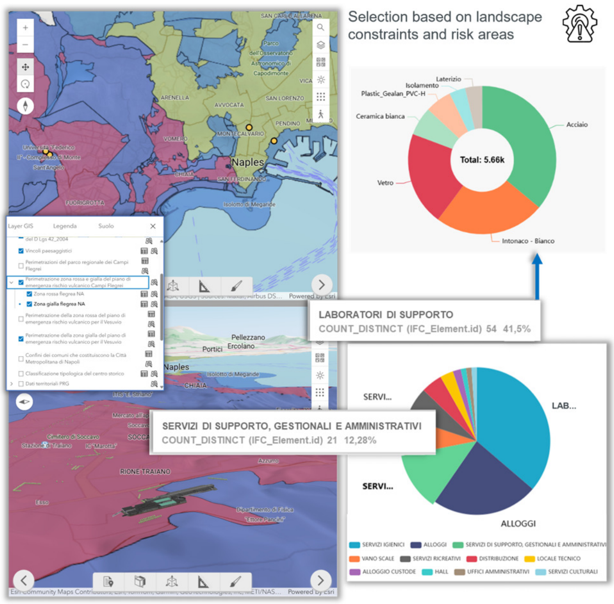

Figure 9. Querying BIM and GIS data and generating dashboards on materials and spaces of university buildings located in high-risk areas.

alternative strategies (reflective materials, green roofs) by estimating their impact through the potential variation of absorption and temperature indices (KPIs). Each indicator supports a different decision-making level: from spatial evaluations (where overheating occurs) to strategic choices (where to invest in greening). Ultimately, this approach contributes to strategic action by integrating building-scale and urban-scale data to identify the most critical areas requiring intervention and to simulate potentially effective design scenarios (RezaeiRad and Afzali, 2024).

Emergency Planning for Sensitive Facilities: Within the building stock of the University of Federico II, emergency and safety planning is particularly oriented toward managing risks related to seismic activity, hydrogeological instability, and the broader range of hazards resulting from climate change. The CIM-BI system developed facilitates this approach. From BIM models, it acquires data on spatial configurations, functions, and emergency routes. From sensor monitoring, it queries flows and occupancy percentages, as well as environmental conditions. From technical documentation and inspection reports, it gathers structural vulnerability indices. From GIS, it acquires the level of risk and hazard for each area where buildings are located and, consequently, for individual functional spaces. The result is a synthesis of the degree of exposure and the fragility index for each space (KPIs) (Figure 9).
This data infrastructure is particularly valuable for the strategic management of sensitive university laboratories, which often host critical or hazardous materials and require specialized emergency protocols. Through dashboards customized according to user roles -such as safety officers, facility managers, and emergency planners - the platform enables multi-parameter evaluations based on data, scenarios, and monitoring, for the development of targeted evacuation strategies. It also supports consideration of possible strategic relocations. It does not suggest direct solutions but supports decision-makers with visualizations that are both concise and comprehensive, encompassing everything that must be included in the decision-making process (Table 1).

5. Conclusion

The construction of a unique geospatial system that integrates BI with BIM data at the building scale and with urban and environmental GIS datasets significantly enhances digital processes for multi-scale and multidisciplinary analysis, supporting informed decision-making in line with contemporary approaches to resilient infrastructure management. Simplified dashboards - based on maps, risk codes, and ranking systems - ensure that even users without expertise in data management or BI systems can easily read and interpret results, participating directly in the decision-making process. This is especially advantageous in contexts of collaborative emergency planning: the effects of climate change, the cyclical nature of certain natural disasters, and the consequences of environmental transformation and exploitation policies increasingly require the rapid correlation of large volumes of data. However, significant challenges remain in the widespread and systematic adoption of these tools by public institutions and industry professionals - particularly in contexts like Italy, where traditional processes and fragmented data still prevail.
The software structure that ACCA is developing, along with the procedural processes currently being tested, aims to contribute to a proactive, evidence-based strategy.
The initial tests that the DiCEA and DiARC teams have chosen to conduct on the built heritage of the University of Naples Federico II represent a promising framework aimed not only at streamlining management practices but also at enabling new uses focused on the sustainability and safety of public urban infrastructure.

Key Data	GIS Data	BIM Data (IFC)	Other Data	Application	Dashboard
Surface Temperature Differential/ Roof Reflectance	Land surface temperature from satellite imagery	Roof material and stratigraphy	Temperature trends (ISPRA data, etc.)	Identifying local heat accumulation zones	Heat maps on built surfaces; comparative bar charts
Vegetation Index (NDVI)	Land use classification; Satellite-derived NDVI layers	Material stratigraphy and surfaces area	Aero photogrammetric data, ENEA/CNR indexes	Quantifying presence and density of vegetation	Pie charts of adaptable surfaces
Laboratory Sensitivity Index	Risk zoning maps;	Typology and material data. functional data on lab use and equipment layout	Civil protection classifications, Census and Uses data;	Identifying buildings and spaces most exposed to risk	Risk laboratory classification charts

Table 1. Data synthesis and dashboard for some queries

6. Future works

The BIM_BI-AI project aims to continue toward the implementation of AI systems that further facilitate use by both expert and non-expert users, while also simplifying the BI process interface. A particularly relevant potential application of the system is its use in supporting municipal administration in the processes of building verification and authorization. In Italy, historically, the concept of the *fascicolo del fabbricato* (Dejaco et al., 2017) has never been fully implemented in practice. Today, thanks to the adoption of BIM, its concrete digital realization can be envisioned. If every building intervention - new construction, renovation, expansion - were accompanied by the submission of the corresponding BIM model to the municipality, the public authority could progressively build an up-to-date geospatial digital twin of its territory, integrated with geographic and planning data (such as PUC, PGR, ZTO, landscape plans, etc.), within a system like the one proposed by the project. This would enable dynamic and geo-referenced querying of the urban planning conditions in which an architectural structure is inserted into the physical environment. Moreover, the structuring of building and urban planning regulations (height limits, floor area ratios, land use, legal constraints) into code-checking systems interoperable with the geo-twin model, and enhanced by BI tools, would allow for automatic verification of building permit applications. In such a scenario, a citizen submitting a request for building modification or intervention, by providing the project in BIM format, would - upon uploading it to the municipal geospatial platform - trigger a system capable of automatically assessing the compliance of the intervention with current regulations, thanks to codified rules and an integrated data infrastructure. This would accelerate response times, reduce human error, and increase procedural transparency.

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References

Atta, M., Talamo, C. 2020: Urban Facility Management: extending building management systems to urban scale. *Journal of Urban Management*, 9(3), 299-310.

Bevilacqua, C., Calabrò, F., Della Spina, L. (eds) (2020). *New Metropolitan Perspectives. Knowledge Dynamics, Innovation-driven Policies Towards the Territories’ Attractiveness*, Vol. 1. Springer Nature, Cham.

Chapman, D., Providakis, S. Rogers, C., 2020. BIM for the Underground - An enabler of trenchless construction. *Underground Space*, 5(4), 354-361.

Cognos Corporation. (2008). *The Right Architecture for Business Intelligence: The Foundation of Effective Enterprise BI.* White paper, https://public.dhe.ibm.com (20 April 2025).

Dejaco, M. C., Maltese, S., Re Cecconi, F., 2017: *Il fascicolo del fabbricato*. Maggioli Editore, Santarcangelo di Romagna.

Di Giuda, G. M., Accardo, D., Meschini, S.., Tagliabue, L. C., 2022. Digitalization and management of diffused university assets through BIM-GIS data integration. In *International Conference 2030 a.d. Future Projections for Sustainable Design.* Messsina, 17-19 nov 2022.

Döllner, J., 2020. Geospatial artificial intelligence: Potentials of machine learning for 3D point clouds and geospatial digital twins. *PFG - J. Photogramm. Remote Sens. Geoinf. Sci.*, 88(1), 15-24.

D’Agostino, P., Antuono, G., 2023: Dal modello edilizio alla gestione informativa su scala urbana: Un’applicazione di integrazione IFC-CityGML. *DN*, 12, 19-29.

El-Mekawy, M., Östman, A., Hijazi, I., 2012: A unified building model for 3D urban GIS. *SPRS Int. J. Geo-Inf.,* 1(2), 120-145.

González, E., Piñeiro, J.D., Toledo, J., Arnay, R., Acosta, L., 2021: An approach based on the ifcOWL ontology to support indoor navigation. *Egypt. Inform. J.*, 22, 1-13.

Hor, A.-H., Jadidi, A., Sohn, G., 2016a: BIM-GIS integrated geospatial information model using semantic web and RDF graphs. *ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci.*, III-4, 73-79.

Hor, A., Rezgui, Y., Zieba, K., 2016b: Semantic web technologies for BIM-GIS integration: A review. *Automation in Construction*, 66, 105-124.

Janečka, K., 2019a: Standardization supporting future smart cities – a case of BIM/GIS and 3D cadastre. *GeoScape*, 13(2), 106-113.

Janečka, K., 2019b: Challenges in BIM and GIS data integration. *Journal of Spatial Science*, 64(2), 251-266.

Jetlund, A., 2021: Data standards for BIM and GIS interoperability. *Int. J. Digit. Earth,* 14(7), 895-914.

Loiseau, E., Aissani, L., Le Féon, S., Laurent, F., Cerceau, J., Sala, S. Roux, P., 2018: Territorial Life Cycle Assessment (LCA): what exactly is it about A proposal towards a common terminology and a research agenda. *Journal of Cleaner Production*, 176, pp. 474-485.

Mielniczek, A., Roux, C., Jacquinod, F., 2022. City Information Modelling for lifecycle assessment. LCIC 2022: collaborate, innovate, co-create. FSLCI e.V., Jun 2022, Berlin, Germany.

Omrany, H., Ghaffarianhoseini, A., Ghaffarianhoseini, A., Dhawan, K., Almhafdy, A., Oteng, D., 2024. *The Use of City Information Modelling (CIM) for Realizing Zero Energy Community: A Path Towards Carbon Neutrality.* In Cheshmehzangi, A., Batty, M., Allam, Z., Jones, D. (eds), City Information Modelling, Springer, Singapore, pp. 111-138.

Scandurra, S., Antuono, G., Galluccio, G., Bonafiglia, A., 2025. *Integrare e interrogare dati GIS e BIM attraverso CIM e BI.* In Convegno ESRI 2025.

Souza, L., Bueno, C., 2022: City Information Modelling as a support decision tool for planning and management of cities: A systematic literature review and bibliometric analysis. *Building and Environment*, 207, 108403.

Stouffs, R., Tauscher, H., Biljecki, F., 2018a: Achieving complete and near-lossless conversion from IFC to CityGML. *ISPRS International Journal of Geo-Information*, 7(9), 355.

Stouffs, R., van Berlo, L., Kremers, E., 2018b. BIM to GIS data translation for urban modeling. Computers. *Environment and Urban Systems,* 70, 1-10.

Szeligova, J., Klen, R., Moravcikova, L., 2023: Integrating GIS and building data for flood risk assessment and mitigation planning. *Natural Hazards,* 117(2), 1539-1557.

Willen, C. (2002). Airborne Opportunities. *Intelligent Enterprise*, 5(2), 11-12.

Zhang, Y., Li, X., Wang, F. (2020). Urban heat island mitigation strategies based on BIM and GIS data integration. *Sustainable Cities and Society*, 62, 102367.

Zhu, J., Wu, P., 2022: BIM/GIS data integration from the perspective of information flow. *Automation in Construction*, 136, 104166.

Zhu, J., Peng, Y., 2022: Integrating BIM and GIS for smart city applications: A review and future directions. *Automation in Construction*, 139, 104337.