Integration of BIM/GIS/IoT data through a Digital Twin for multi-risk analysis

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Research context & objectives

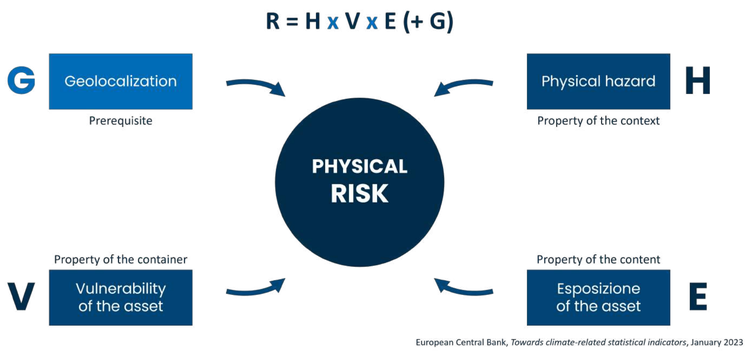
Context

Definition of a **Digital Twin for multi-risk analysis** of urban and suburban areas through the integration of advanced BIM-GIS-IoT modelling and management tools for knowledge, maintenance and forecasting purposes.

Objectives

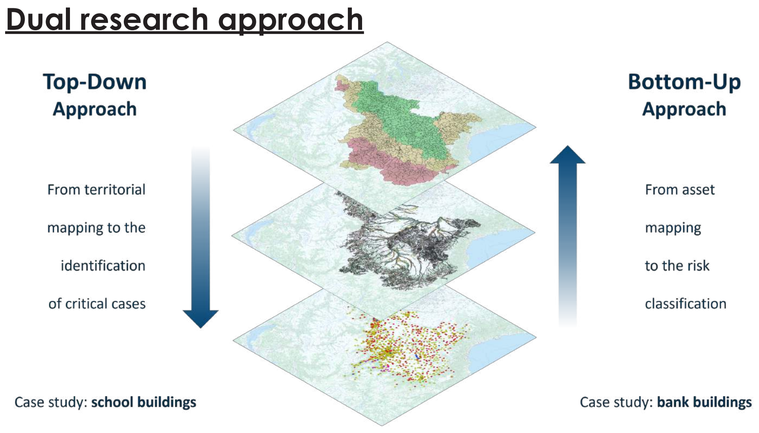
The research focuses on the development of a Digital Twin methodology to collect and manage data about risk management on existing assets. **GIS** and **BIM** tools are used in an interoperable and scalable way from the general (territorial area) to the particular (work of art) and vice versa. Starting from a real and replicable case study, a queryable GIS-based **geodatabase** of the territory was used to evaluate and visualize geolocalised **risk indicators** concerning flood hazard, seismic hazard and potentially other **natural hazards**. At the same time, BIM models of critical assets were developed to be used in an interoperable way with the GIS system for detailed analysis. Data from **IoT systems** will be collected and integrated, from which **analysis algorithms** will be developed.

Risk score evaluation

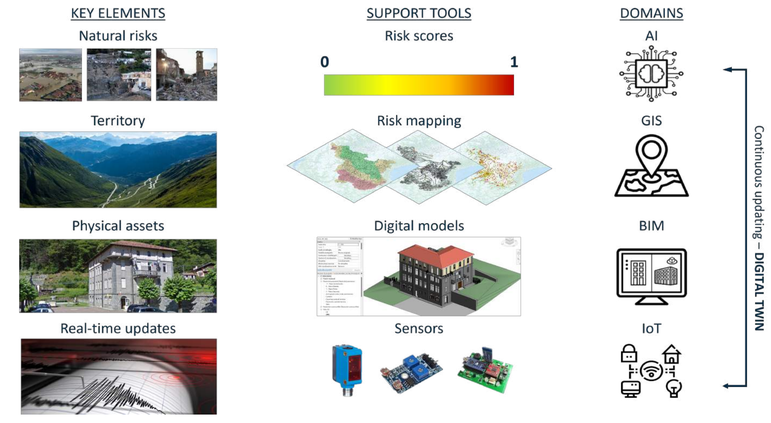


European Central Bank, *Towards climate-related statistical indicators*, January 2023

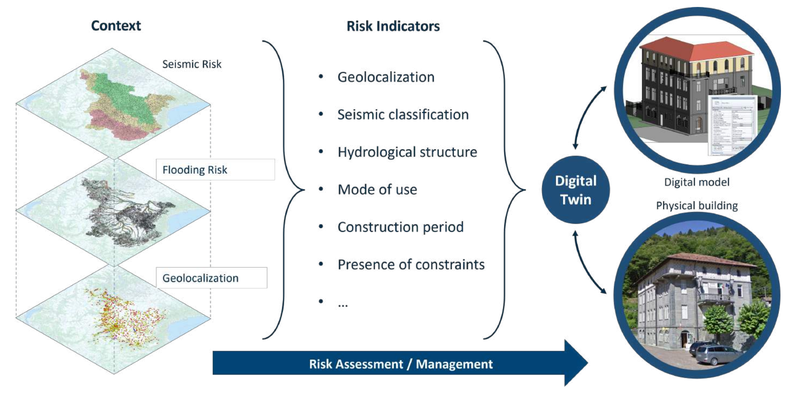
Dual research approach



Data domains



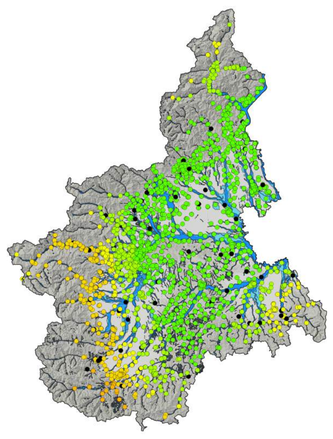
Information levels



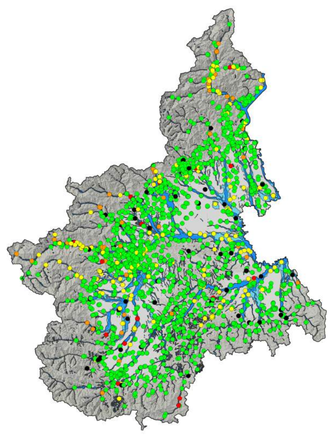
GIS - Risk Score Assessment

Case study A: school buildings

Data source: public Ministry of Education datasets



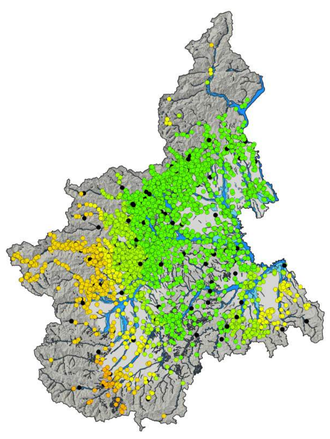
School buildings: seismic hazard normalized score



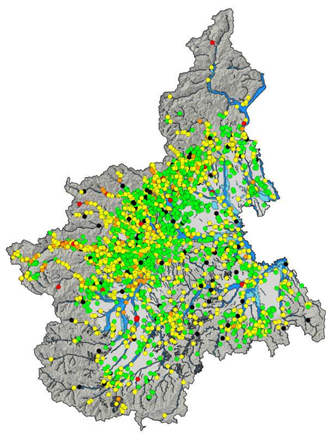
School buildings: flooding hazard normalized score

Case study B: bank buildings

Data source: private data exchange with Banca Sella



Bank buildings: seismic hazard normalized score



Bank buildings: flooding hazard normalized score

Methodology

- Data collection
- Gecoding
- Geospatial analysis with hazard maps
- Score calculation
- Score normalization (0.00-1.00)

The seismic hazard was calculated comparing the assets positions against the National Peak Ground Acceleration (PGA) grid.
The flooding hazard was calculated comparing the assets positions against the ISPRA flooding hazard National mosaic.
The effectiveness of such methodology is that it can be standardized and replicated for many other different mapped hazards.

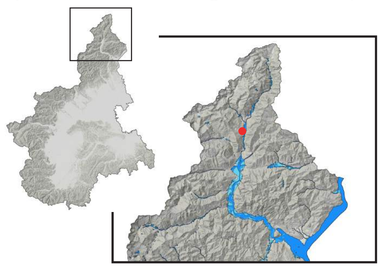
Legend

- 1.00 - Maximum hazard
- 0.75
- 0.50
- 0.25
- 0.00 - Minimum hazard
- Verified wrong geocoding

BIM - Digital Model production

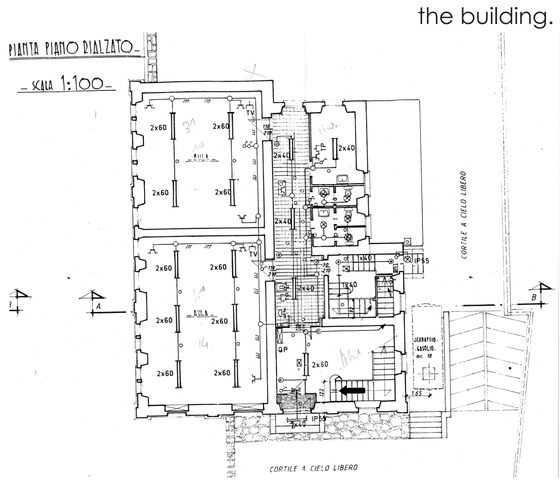
Case study for BIM model development

Primary school building in Crodo (VB)



Site inspection:
context and exterior (above);
interior 360° photographic survey (below).

Historical and documental research:
archive research and recent survey and project documents were fundamental to understand the building.

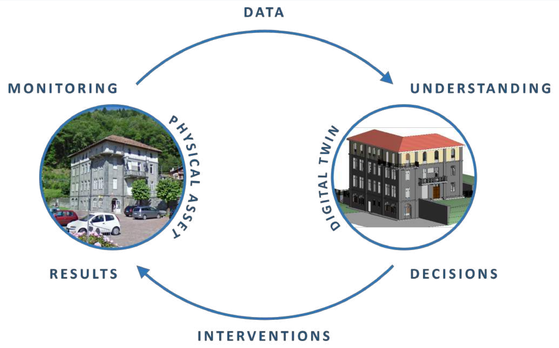


Structural and Architectural BIM model production

Further developments

Work in progress:

- **Vulnerability** and **exposure** scores implementation
- **Digital Twin** development
- 2D/3D **spatial interface** for analysis and data visualization
- Modularization and **automatization** of all the steps of the methodology through coding/scripting
- **IoT** integration for continuous updating
- **ML/AI** integration for predictive assessments and improvements



Learning activities

Hard Skills (Total hrs. attended: **190h**):

- 01TRCRS Advanced geospatial data management
- 01TTIRS BiM and interoperability for SMART Cities processes and Tools
- 01HPERW Design and Optimization of Shells and Spatial Structures: Computational Modelling and Generative Design
- 01UJVRS IoT platforms for spatial analytics in smart energy systems
- 01QKGRW Monitoraggio strutturale con la tecnica delle emissioni acustiche
- 01TRERS Open geospatial data
- 01GMERL Rischio sismico dei beni culturali
- 01UIVRW Some basics of the analysis and mitigation of landslides risk
- 01TSXRW Tecniche geomatiche innovative per il monitoraggio di strutture, infrastrutture e territorio
- 01SZZRW Tecniche di consolidamento e miglioramento sismico per il patrimonio storico-architettonico

Soft Skills (Total hrs. attended: **39h**):

- 01DMJRW Design Thinking, Processes and Methods
- 01RISRW Public speaking
- 01SWPRW Time management
- 01SWQRW Responsible research and innovation, the impact on social challenges
- 01SYBRW Research integrity
- 01UNVRW Navigating the hiring process: CV, tests, interview
- 01UNXRW Thinking out of the box
- 01UNYRW Personal branding
- 02LWHRW Communication
- 02RHORW The new Internet Society: entering the black-box of digital innovations
- 08IXTRW Project management

Publications

Colucci, E., Iacono, E., Matrone, F., Ventura, G.M., "The development of a 2D/3D BIM-GIS web platform for planned maintenance of built and cultural heritage: the Main10ance project", in *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, n. XLVIII-M-2-2023, 2023, pp. 433-439.

Iacono, E., Ventura, G.M., "Logiche progettuali per una piattaforma orientata alla conservazione programmata", in Fasana, S., Zerbinatti, M. (editors), *La conservazione programmata e la gestione sostenibile per complessi culturali ambientali resilienti. Metodi e strumenti per la conoscenza e il progetto*, 2023, ISBN: 978-88-85745-84-1, Torino (print).

Iacono, E., Ventura, G.M., "Dal modello di conoscenza alla piattaforma MAIN10ANCE", in Fasana, S., Zerbinatti, M. (editors), *La conservazione programmata e la gestione sostenibile per complessi culturali ambientali resilienti. Metodi e strumenti per la conoscenza e il progetto*, 2023, ISBN: 978-88-85745-84-1, Torino (print).

Matrone, F., Colucci, E., Iacono, E., Ventura, G.M., "The multiscale HBIM-GIS Main10ance platform for the planned maintenance of built heritage", in *Advanced 3D Mapping and Diagnostic Technologies for Constructions and Built Heritage* (Special Issue), Sensors, MDPI, 2023. https://doi.org/10.3390/s23198112.

Colucci, E., Iacono, E., Lingua, A., Matrone, F., Ventura, G.M., Zerbinatti, M. "Una piattaforma web HBIM-GIS per la manutenzione programmata del patrimonio architettonico: il progetto MAIN10ANCE", poster presented in the context of *Geomatica 2023: intersezioni disciplinari. 65° convegno nazionale SIFET*, Arezzo 27-29 September 2023.

Additional activities