

Developing City Information Modeling to Support Urban Circular Transitions

From Knowledge
to Competitiveness

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Program



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Space, Climate and Sustainable Systems - Sustainable Cities and Urban Systems

RESEARCH CONTEXT

Tackling climate change requires systemic, globally coordinated action. The circular economy (CE) offers a regenerative pathway to sustainable development, treating waste as a potential resource and keeping materials in use. As essential players in this transition, cities offer a platform for implementing and testing innovative solutions. Understanding cities as integrated wholes through urban metabolism, analyzing material flows, stocks, and metabolic processes is key to assessing environmental performance and “closing, slowing, and narrowing” material loops. Information technologies, such as City Information Modeling (CIM), can catalyze collaborative, holistic decision-making. This work investigates CIM’s potential to assess CE practices in cities.



Urban metabolism: the conceptual lens for tracking material flows and stocks across the city.

RESEARCH GAP

GIS and BIM are well-established tools in material flow (MFA) and stock (MSA) analysis. The literature has shown that many studies examine these tools separately, analyzing spatial patterns and modeling building characteristics. When combined, their integration often mirrors CIM logic, even when the term is not employed, suggesting a terminological and conceptual gap attributed to the novelty and lack of a standardized definition for CIM.

OBJECTIVES

Primary objective: develop a method to automate Material Flow and Stock Analysis using CIM to support Urban Circularity Assessments (UCA), tested in Guimarães.

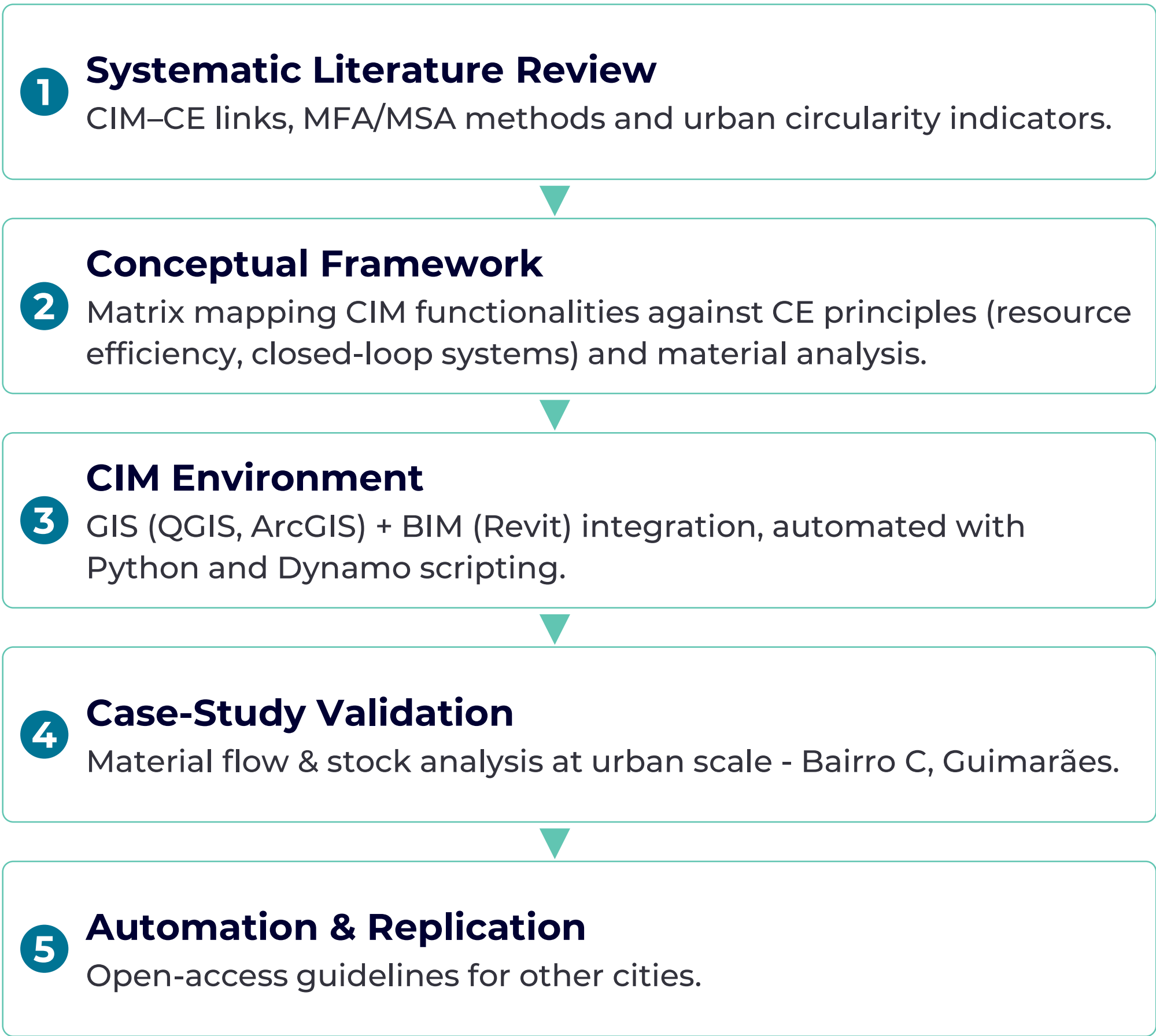
- Evaluate CIM’s potential to automate MFA, focusing on construction materials.
- Test the method in Bairro C (Guimarães).
- Develop open guidelines for replicating the method in other cities.

RESEARCH QUESTIONS

- RQ1.** How can CIM integrate and automate MFA/MSA at the urban scale?
- RQ2.** What technical and data-related barriers affect the integration of UCA into digital urban modeling?
- RQ3.** To what extent can CIM-based workflows improve accessibility, accuracy, and policy usability?
- RQ4.** What methodological adaptations are needed for replication in other cities?

METHODOLOGY

Applied research design combining conceptual development, digital modeling, and empirical testing.



CASE STUDY - BAIRRO C, GUIMARÃES

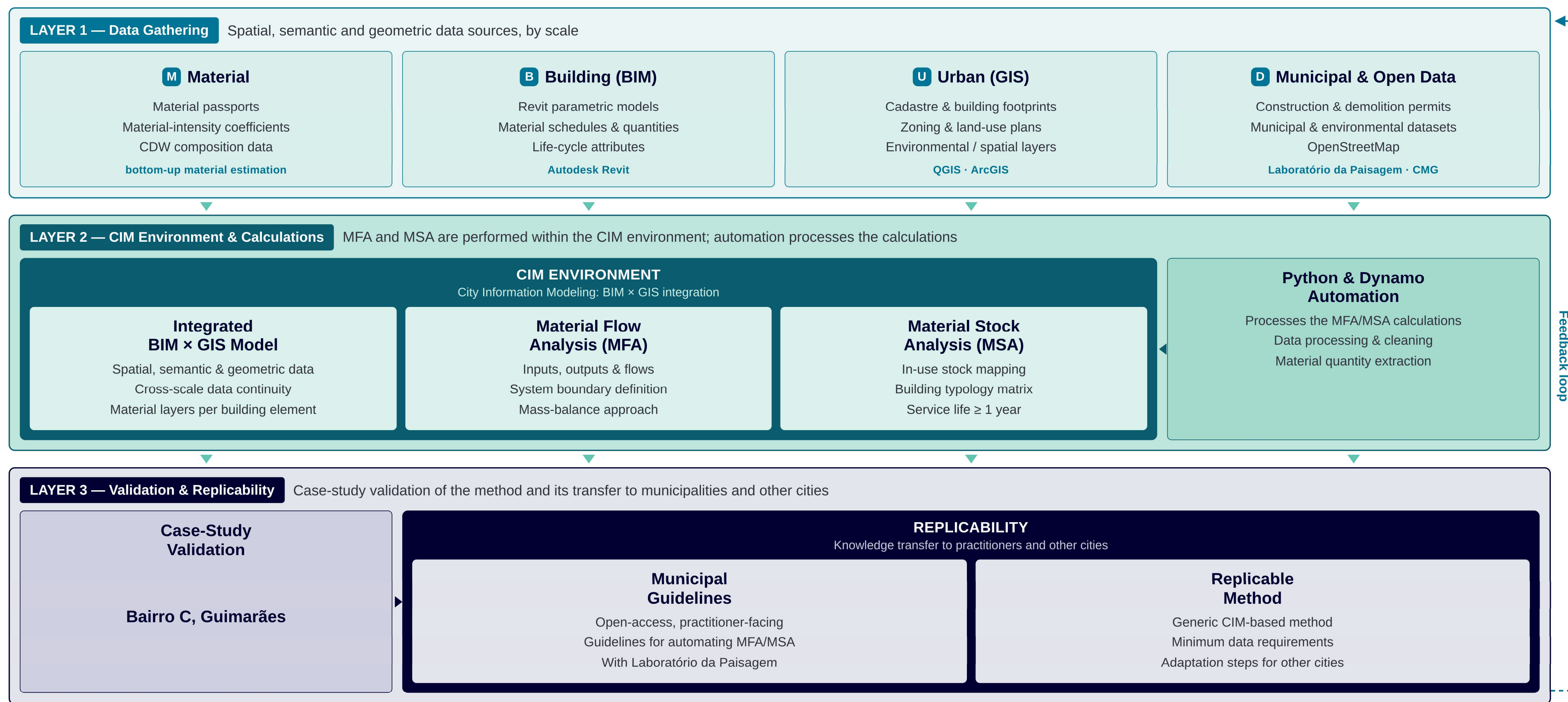


Bairro C study area, Guimarães, outlined within the UNESCO World Heritage zone

- Guimarães’s pilot net-zero district, within the UNESCO World Heritage buffer zone.
- First empirical test of the CIM-based MFA/MSA method at the urban scale.
- Aligned with the Climate City Contract 2030.
- Method assumptions: bottom-up estimation · stock convention = service life ≥ 1 year · boundary at building + urban-block level.

Multi-Layer CIM Framework for Material Analysis

Integrating BIM, GIS and Material Flow / Stock Analysis (MFA/MSA)



EXPECTED OUTCOMES

- Validated, replicable CIM-based method for automating MFA/MSA at urban scale.
- Identification of technical and data-related barriers to integrate circularity assessment into digital urban modeling.
- Open-access guidelines for replication in other cities; and enhanced collaboration between academia, municipalities, and innovation hubs.

SCIENTIFIC CONTRIBUTION & IMPACT

- A method to explicitly integrate CIM with MFA/MSA for urban circularity assessment, addressing an identified conceptual gap.
- Advances the twin digital–green transition for cities.
- Technology-transfer potential: an open, replicable workflow for municipalities beyond Guimarães.

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