LOCATIONAL VARIABLES IN MASS APPRAISAL: CONCEPTUAL CLASSIFICATION GROUNDED IN SYSTEMATIC REVIEW AND INTEGRATED INTO THE LADM VALUATION MODEL

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INTRODUCTION

Property Valuation is inherently complex, requiring the consideration of **multiple factors**.

Locational variables play a decisive role in explaining real estate market heterogeneity and strongly influence property prices.

Mass Appraisal (MA) is **strategic** for **municipal financial sustainability** (e.g., IPTU/ITBI in Brazil) and for promoting **fiscal justice**.

The use of **locational variables in mass appraisal models still lacks conceptual standardization**.

Standardization is essential for initiatives like the **Multipurpose Terrestrial Cadastre (CTM)** and for promoting **interoperability**.

Goal: To propose a **conceptual classification** of locational variables based on a systematic review and **integrate these seven categories into the Valuation Package of ISO 19152-4 (LADM)** in the traditional urban 2D context.

METHODOLOGY

Study Design: Qualitative, exploratory study conducted through a systematic literature review, following the PRISMA 2020 protocol.

Information Sources: Search conducted in SciSpace, covering topics like Property Appraisal, Locational Variables, and Spatial Econometrics.

Corpus: Analysis of **55 articles** from the initial 491 studies published between 2015 and 2025.

Processing: Employed Natural Language Processing (NLP) techniques and semantic clustering (K-means, Word2Vec/BERT) to identify, normalize, and categorize variables.

Outcome: More than 120 distinct locational variables were identified and normalized.

FINDINGS

Based on semantic clustering and analysis, the research organized all identified variables into **seven main categories**:

1. **Geographic Coordinates:** Absolute location defined by x, y coordinates.

2. **Spatial Units:** Categorical indicators for zones, districts, submarkets, etc.

3. **Central Accessibility:** Distance to a Central Business District (CBD) or city center.

4. **Public Transportation:** Accessibility to metro/train stations and bus stops.

5. **Urban Services and Amenities:** Proximity to schools, healthcare facilities, commercial centers, and leisure areas.

6. **Environmental Characteristics:** Factors such as views, topography, and environmental quality (e.g., green areas).

7. **Neighborhood Socioeconomic Context:** Indicators like average income, crime rates, and population density.

FINDINGS

Overall Relevance: Location was classified as a **highly relevant factor** in explaining property values in **64%** of the studies analyzed.

- **Most Frequent Categories**:

    - **Urban Services and Amenities:** 54.5% of studies.

    - **Public Transportation:** 43.6% of studies.

    - **Spatial Units (Zone/District):** 36.4% of studies.

    - **Central Accessibility:** 27.3% of studies.

- **Most Recurring Specific Variables**:

    - Proximity to Schools (36%).

    - Proximity to Hospitals (33%).

    - Distance to the City Center (31%).

    - Proximity to Commercial Centers (27%).

    - Public Transportation (Metro/Train Stations: 24%; Bus stops: 16%).

Insight: Factors linked directly to urban infrastructure and access to services are crucial in urban valuation contexts.

INTEGRATION WITH LADM

Category	LADM_VM Correspondent Class	Validation
Urban Services and Amenities	VM_SpatialUnit and VM_ValuationUnitGroup	Distances to points of interest (schools, healthcare, commerce) modelled in VM_SpatialUnit as spatial relationship attributes; grouping in VM_ValuationUnitGroup by service provision zones.
Public Transportation	VM_SpatialUnit and VM_ValuationUnitGroup	Proximity/access to stations/lines are stored in VM_SpatialUnit; accessibility zones are configured in VM_ValuationUnitGroup.
Special Units (Zone/District)	VM_ValuationUnitGroup	The definition of administrative or market zones directly uses instances of VM_ValuationUnitGroup.
Central Business District (CBD)	VM_SpatialUnit	Distance to the Central Business District (CBD) stored as an attribute of VM_SpatialUnit.
Socioeconomic Context Neighbourhood	VM_ValuationUnitGroup	Grouping by socioeconomic characteristics is supported through instances of VM_ValuationUnitGroup, linked to external data.
Geographical coordinates (lat/long)	VM_SpatialUnit	Geometry (point) of each unit registered in VM_SpatialUnit.
Environmental Characteristics	VM_SpatialUnit and VM_ValuationUnitGroup	Basic environmental attributes (topography, land use) in VM_SpatialUnit; grouping by environmental zones in VM_ValuationUnitGroup.

CONCLUSION

Locational variables are **central** and a **structuring element** in property price formation, strongly associated with urban infrastructure and transportation.

Contribution: The conceptual structuring into seven categories enhances the **transparency, comparability, and applicability** of mass appraisal models, aligning empirical practices with international standards.

Practical Contribution: Adopting this standardized framework favors the integration of terrestrial cadastres, property records, and tax systems, strengthening public policies related to taxation and urban planning.

Future Directions:

1. **Expansion:** Extend the analysis and classification to **3D and 4D contexts**.
2. **Validation:** Test the practical application and effectiveness of the classification in mass appraisals and tax systems, particularly within Brazil.

ACKNOWLEDGEMENTS

Federal University of Santa Catarina (UFSC).
Postgraduate Programme in Territorial Management (PPGTG).
Municipality of Brusque
GeoBrusque, Municipality of Brusque
Brusque Institute of Planning