

Tourism Walkability Index: A Data-Driven Tool for Tourism Urban Planning

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Abstract: Walking plays a central role in how tourists experience cities, yet most walkability measures remain oriented toward residents and do not reflect the specific spatial behaviours, sensitivities, and motivations of visitors. Existing indices typically overlook the importance of cultural access, environmental comfort, and safety perceptions for tourist mobility. As a result, there is a need for tourism-specific approaches that can capture how walkability varies within cities and how it relates to tourist mobility patterns. This paper proposes the Tourism Walkability Index (TWI), a fully geospatial and street-level framework designed to quantify walkability from a tourist perspective. The TWI integrates three dimensions – accessibility to relevant points of interest, access to public and shared transport systems and comfort conditions shaped by infrastructure and environmental quality. These dimensions are operationalised using a pedestrian network with slope-adjusted travel times and geospatial datasets describing urban amenities, mobility services, and comfort-related variables such as lighting, pedestrianisation, heat exposure, air quality, noise and traffic safety. The TWI is applied to four cities in northern Portugal – Porto, Braga, Guimarães and Vila Real – representing contrasting data environments and urban morphologies. Across all cities, the TWI reveals a recurring spatial structure: historic centres emerge as the most walkable areas, while peripheral zones consistently score lower. The fine spatial resolution reveal micro-scale contrasts that broader neighbourhood metrics obscure, including highly accessible but low-comfort streets, and comfortable yet poorly connected areas. These patterns highlight opportunities for targeted interventions, improved tourist dispersal, and enhanced alignment between tourism mobility and urban liveability goals. The multi-city application further demonstrates that the TWI yields coherent results even when only open data are available, indicating that its conceptual structure is robust and transferable. By providing a replicable, open-source workflow and fine-grained urban diagnostics, the TWI offers a practical tool for integrating walkability into tourism planning and sustainable mobility management.

Keywords: Walkability Index; Data-driven Tourism; Tourist Experience; Urban Mobility

1. Introduction

Walking is a central mode of mobility for tourists in urban destinations, enabling access to cultural landmarks, leisure areas, and authentic local experiences. However, most existing walkability indicators have been designed for residents, reflecting everyday mobility needs rather than the distinct behaviours and sensitivities of visitors. Tourism-related walking is shaped by factors such as aesthetics, comfort, safety, and the potential for exploration and activity (Samarasekara, Fukahori and Kubota, 2011; Ujang and Muslim, 2015; Dihingia, Gjerde and Vale, 2022), which are only partially captured by traditional indicators. Although one study has proposed a tourism-specific walkability index for Sydney (Bassiri Abyaneh *et al.*, 2021), its reliance on subjective survey inputs and its narrow geographic scope limit broader applicability. As a result, a scalable, data-driven, street-level framework tailored for tourism remains lacking.

This paper addresses this gap by developing the Tourism Walkability Index (TWI) and applying it across four cities in northern Portugal – Porto, Braga, Guimarães and Vila Real. By integrating accessibility, mobility and comfort into a single, data-driven measure designed for tourists, the TWI provides a fine-grained understanding of walkability that reveals both expected spatial patterns and micro-scale disparities with strong planning relevance. The multi-city application demonstrates that the framework is adaptable and produces meaningful results even in data-scarce contexts, while richer datasets - such as those available in Porto - enable more detailed comfort and safety diagnostics. Crucially, the TWI is replicable, relying on an open-source analytic workflow, allowing other cities to adopt the approach in support of more evidence-based tourism mobility strategies.

2. Literature Review

Walkability can be understood as a multidimensional quality of the built environment that reflects how effectively urban spaces enable and encourage walking - by ensuring safety, comfort, connectivity, and visual appeal - while

recognizing it as a complex spatial capacity embedded in urban form rather than a direct measure of walking activity (Southworth, 2005; Dovey and Pafka, 2020).

Traditionally, walkability studies assess the built environment using urban form indicators such as density, land-use mix, and street connectivity, used as spatial proxies for accessibility and proximity (Hall and Ram, 2018; Rundle *et al.*, 2019; Frank *et al.*, 2021). More recent approaches expand this focus to include physical, social, and perceptual dimensions of walking, integrating objective and subjective elements like topography, safety, comfort, aesthetics, and individual motivations (Cerin *et al.*, 2013; Jardim, de Castro Neto and Barriguinha, 2023).

In the context of tourism, walking is a primary mode of mobility, providing visitors with opportunities for exploration and immersion in the urban landscape. Studies applying walkability metrics to tourism have emerged only recently. Hall and Ram (2019), for example, used Walk Score to examine links between walkability and tourism performance across English attractions, finding only weak, nonlinear relationships overall and concluding that tourism-specific walkability assessments are needed. In fact, most walkability indicators were developed for residents and focus on everyday mobility needs rather than tourist experiences.

Dias and Wijeweera (2021) can be seen as an early, tourism-relevant attempt: they operationalised a street-level walk score oriented to visitor activity by integrating proximity to amenities relevant for tourists: banks, restaurants, ATMs, shopping malls and transit stops, and used it to identify optimal walking routes between attractions. However, the approach relied on extensive field audits and covered a limited range of touristic features. Building on the need for tourism-specific metrics, Abyaneh (2021) developed one of the few walkability indices explicitly designed for tourist environments, combining perceptions and spatial attributes in ten tourism precincts in Sydney. While this study provided valuable insights into the role of aesthetics, safety, and accessibility, it remained constrained by its survey-based methodology and small geographic scope. Moreover, several of the meso-level factors it incorporates - such as land-use mix or population density - reflect residential dynamics that may not directly align with tourists' needs or preferences.

Empirical studies have identified a range of factors influencing tourist walking behaviour. These include street infrastructure conditions, the availability of wayfinding signage and accessibility infrastructure (Dias and Wijeweera, 2021; Das and Maitra, 2025). Perceptions of safety and comfort are equally decisive, as tourists tend to be more sensitive than residents to issues such as environmental appearance, personal security and traffic safety (Samarasekara, Fukahori and Kubota, 2011; Ujang and Muslim, 2015; Bassiri Abyaneh *et al.*, 2021; Dias and Wijeweera, 2021; Dihingia, Gjerde and Vale, 2022). Climatic and weather conditions also significantly affect tourist walking choices (Hall and Ram, 2021). Furthermore, connectivity between pedestrian networks and public transport is central to tourist mobility, as visitors often rely on seamless links between transit nodes and walkable areas to navigate unfamiliar cities efficiently (Liow, 2022). Importantly, tourists' primary motivation for walking lies in exploration and the potential for discovery, linking walkability not only to mobility but to the experiential and cultural dimensions of travel (Samarasekara, Fukahori and Kubota, 2011; Farkic *et al.*, 2015).

While reinforcing walkability can enhance tourist experiences and support sustainable mobility, it also requires attention to local community needs. As Clavé (2019) cautions, promoting pedestrian-friendly environments that attract tourists must go hand in hand with ensuring accessibility and quality of life for residents.

Despite growing interest, the literature on tourism walkability remains sparse and fragmented. Existing approaches often rely on aggregate neighbourhood indicators, overlooking the fine-grained variations that shape the tourist experience. This study addresses these gaps by proposing a tourism-specific walkability index based entirely on geospatial data. Overall, the TWI builds on resident-oriented walkability indices that conceptualise walkability as a composite of accessibility and granular street-level urban qualities, but reorients these ingredients toward visitor-relevant destinations and conditions. Whereas resident indices typically proxy everyday needs, the TWI foregrounds dimensions that have been shown to be especially salient for tourists. In doing so, it complements tourism-specific walkability measures that rely heavily on subjective surveys or single-city case studies, and provides a tool capable of capturing micro-scale discrepancies.

3. Methodology

3.1 Conceptual Framework

Building on the literature, the TWI translates key factors influencing the tourist walking experience into quantifiable, spatially explicit indicators. The methodology draws from the recurrent dimensions identified in previous research - such as accessibility, safety, comfort, aesthetics and connectivity - and focuses on those that

can be operationalised through objective geospatial data. This approach provides a scalable, data-driven way to operationalise subjective dimensions of walkability. The proposed indicator is structured around three core dimensions:

- Accessibility to Points of Interest (POI), capturing how easily tourists reach attractions and places of cultural and practical relevance;
- Transportation Accessibility, reflecting access to available public or shared transport modes;
- Comfort, encompassing environmental and infrastructural conditions that influence the pleasantness and perceived safety and security of walking.

Together, these dimensions capture the key factors of tourist walking. The framework operationalises the literature’s multidimensional understanding of walkability within a geospatial analytical structure implemented in Python with open-source data, ensuring scalability and reproducibility.

3.2 Analytical Framework

3.2.1 Network Construction

All analyses were conducted on a pedestrian network extracted from OpenStreetMap (OSM) (OpenStreetMap contributors, 2025). To maintain street-level precision, long network edges were divided into shorter segments. The network was enriched with elevation data from the ALOS PRISM Digital Elevation Model (DEM) (JAXA, 2025; Gonçalves, Pinhal and Bio, 2026). The derived slopes were used to estimate travel times according to Tobler’s hiking function (Tobler, 1993). This weighted network forms the basis for all accessibility and comfort calculations.

3.2.2 Accessibility to POI and Transportation

The accessibility components measure how easily tourists can reach relevant destinations within a 30-minute walking range. The analysis considers two complementary sets:

- Tourism-related POI: cultural and heritage attractions, natural and scenic spaces, food and beverage establishments, areas of authentic local character, tourist information points, ATMs and money services, and accommodation facilities.
- Transportation facilities: metro, tram, and bus stations, ferry terminals, taxi ranks, shared mobility services such as bicycles and scooters and tourist-oriented transport services.

Accessibility was computed through a network-based gravity measure using walking travel time (Equations 1 and 2), assigning maximum scores to destinations reachable within 5 minutes, with diminishing values for longer travel times. A_i represents the accessibility at the node i for a certain category of amenities, n is the number of destinations for the specific category in the area of study. $f(t_{ij})$ is the Gaussian decay function, where t_{ij} represents the travel time between origin node i and amenity destination j , in seconds.

$$A_i = \sum_{j=1}^{100} f(t_{ij}) \quad (1)$$

$$f(t_{ij}) = \begin{cases} \frac{e^{-\frac{(t_{ij}-300)^2}{129842.6}}}{1} & \text{if } t_{ij} > 300 \\ 1 & \text{if } t_{ij} < 300 \end{cases} \quad (2)$$

For each network node, the model identified up to 100 nearest amenities at less than 30 minutes. To ensure spatial consistency, polygonal and linear features (such as parks or large attractions) were converted into regularly spaced representative points along their extent, so that the closest point to the node could be considered. Accessibility scores were then normalised on a 0–1 scale for each POI or transport category, then aggregated into composite sub-indexes for overall POI accessibility and transport accessibility.

3.2.3 Comfort Dimension

The comfort dimension evaluates the environmental and infrastructural conditions that influence the pleasantness, safety, and perceived effort of walking. This dimension includes the following variables:

- Public lighting: Street segments intersecting street lamps or lit features received a binary score representing perceived evening security.

- Urban furniture: Accessibility to benches and drinking water points was computed using distance- and time-based thresholds (100 m for benches, 10 minutes for water points), with values decreasing with travel time.
- Pedestrianised streets: Segments tagged as pedestrian or pedestrian-priority were assigned the highest comfort value.
- Urban heat: This indicator accounts for the thermal conditions that affect tourists' willingness to walk, particularly in summer. Surface temperatures were sampled at network nodes and normalised so that cooler areas received higher comfort values.
- Air quality: Air quality was assessed using either sensor-based or raster data, with pollutant levels compared against WHO guideline thresholds and normalised accordingly.
- Noise exposure: Average day–evening–night sound levels were sampled across the street nodes. Areas located in quieter zones obtained higher comfort values.
- Traffic safety: Traffic accidents from Waze were spatially clustered and linked to close street segments, with higher accident densities resulting in lower comfort scores.

Each comfort indicator was normalised to a 0–1 scale, with higher values representing more favourable walking conditions.

3.2.4 Aggregation and Composite Index

Edge-level indicators (e.g., lighting, pedestrianisation) were combined with node-based scores (e.g., accessibility, air quality) by averaging start and end node values for each edge. Then, all variables were normalised and aggregated by dimension to obtain 3 sub-indices: POI accessibility, transport accessibility and comfort. These dimension-level scores were finally combined with equal weighting to produce the TWI, ranging from 0 (least walkable) to 1 (most walkable). This choice reflects a deliberate baseline assumption that the three dimensions contribute equally to the overall tourist walking experience, providing a neutral reference scenario.

The final output includes:

1. A walkability map representing the TWI at the street-segment level;
2. Sub-index layers for each dimension (POI, transport, comfort);
3. An analytical dataset including all indicator and dimensions data, allowing reweighting of dimensions.

This flexibility follows Blečić et al. (2015), who emphasised that walkability varies across user types - tourists, parents, or cultural visitors – and motivations. Similarly, the TWI allows the weighting of its dimensions to be fine-tuned, supporting differentiated evaluations of walkability for distinct tourist profiles or trip purposes.

3.3 Study Area and Data

This study focuses on four northern Portuguese cities - Porto, Braga, Guimarães, and Vila Real (Figure 1). These cities represent different scales of urbanisation, data availability, and tourism maturity, offering a basis for testing the flexibility and transferability of the TWI.



Figure 1: Location of the 4 case study municipalities in northern Portugal (Porto, Braga, Guimarães and Vila Real)

The most complete implementation of the TWI was developed for Porto, where a rich dataset, supported by the city's extensive open data infrastructure, enables a comprehensive analysis (Table 1). For reproducibility, the full codebase is openly available at <https://github.com/novacidade-org/turismo-porto-walkability>. To test adaptability in data-scarce contexts, the TWI was also applied to Braga, Guimarães, and Vila Real (<https://github.com/novacidade-org/turismo-norte-walkability>) using only open data (Table 1). These cities are typical examples of smaller Portuguese destinations, relevant for cultural and heritage tourism but with less developed spatial data infrastructures.

Table 1: Data sources. Municipal Master Plan (Câmara Municipal do Porto, 2022), ECMWF (Lauwaet *et al.*, 2024), Waze App, no date, Porto Digital, no date

Amenity/Dimension		Porto	Braga	Guimarães	Vila Real
POI	Heritage	Porto Digital (monuments, heritage streets and squares, fountains, statues)	OSM (monasteries, cathedrals, castles, historic sites, cultural and historical heritage protected sites)		
	Culture	Porto Digital (art galleries, cinemas, museums, concert halls, theatres)	OSM (museums, art galleries, arts centres, exhibition centres, music venues, nightclubs, planetariums, cinemas, theatres, aquariums, theme parks)		
	Authentic character	Porto Digital (viewpoints, marketplaces, fado houses)	OSM (marketplaces and viewpoints)		
	Nature	Porto Digital (green areas, beaches, river)	OSM (gardens, parks, nature reserves, forests, meadows, orchards, vineyards, coastal and water bodies, river and canals)		
	Lodging	Turismo de Portugal			
	Information point	Porto Digital	OSM		
	ATM	OSM (ATM and money transfer services)			
	Bars and restaurants	OSM (restaurants, cafés, bars, pubs, beer gardens, ice cream shops, food courts)			
Transport	Bus stops	Porto Digital	OSM		
	Subway station	Porto Digital	-	-	-
	Taxi ranks	Porto Digital	OSM		
	Bike and scooter docks	Porto Digital	OSM	-	-
	Touristic vehicles	Porto Digital	-	-	-
	Tram stops	OSM	-	-	OSM
	Train station	OSM	OSM		
	Ferry	OSM	-	-	-
Comfort	Benches	OSM			
	Drinking water fountains	OSM			
	Public lighting	OSM (lit streets and street lamps)			
	Traffic safety	Waze (accidents)	-	-	-
	Urban heat	ECMWF	-	-	-
	Air quality	Porto Digital (PM _{2.5} , PM ₁₀ , NO ₂ , O ₃ , CO)	EEA (PM _{2.5} , PM ₁₀ , NO ₂ , O ₃)		
	Pedestrianised streets	OSM			
	Noise	Municipal Master Plan	-	-	-

4. Results

4.1 Interrelations between Dimensions and Indicators

To explore the internal structure of the TWI, a Spearman rank correlation analysis was conducted using normalised dimension scores and sub-indicators (Figure 2). This method helps identify whether accessibility and comfort vary together or express distinct spatial logics.

The results show that POI accessibility and transport accessibility are strongly aligned, indicating that areas rich in tourist amenities tend to be well connected to public transport. In contrast, the comfort dimension displays weak correlations with both accessibility dimensions, revealing that environmental and infrastructural comfort is not inherently associated with proximity to POIs or transit nodes. This relationship suggests that high-accessibility streets often coincide with lower comfort, pinpointing critical segments where targeted interventions could enhance the tourist walking experience. Environmental variables contribute to this divergence: air quality and heat tend to worsen in highly accessible areas, reflecting central mobility pressures.

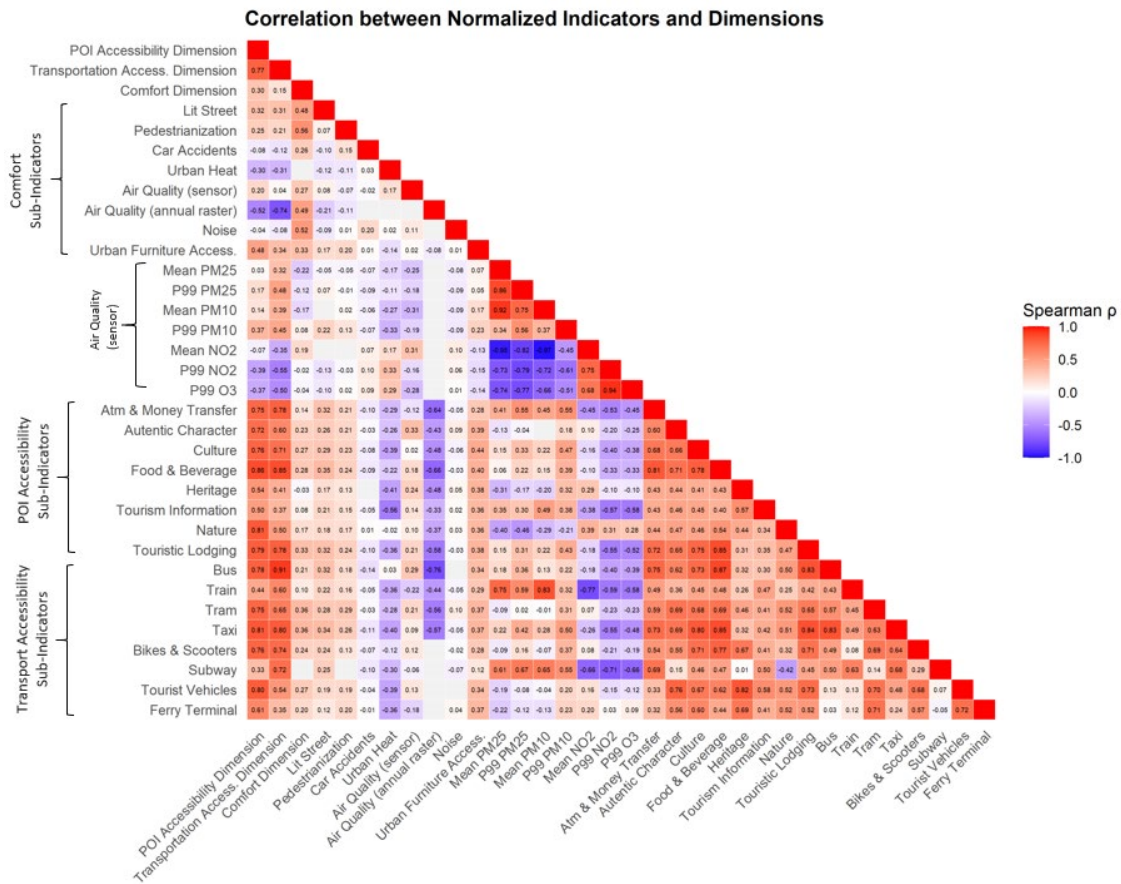


Figure 2: Spearman correlation matrix showing relationships between the TWI dimensions and their underlying sub-indicators, based on normalised street-level scores.

4.1.1 Mapping Walkability Patterns

Figure 3 maps the street-level TWI for the four cities, while Figure 4 shows parish averages based on TWI per metre of street. In all cases, the highest values concentrate in and around historic cores, where tourism POIs, pedestrian-priority streets and public transport converge. Outside these cores, walkability declines rapidly, with large portions of each municipality dominated by low-scoring streets. Differences between parishes are marked: central or university areas show the highest averages, while peripheral, residential or industrial parishes consistently score lower. At the micro scale, some secondary corridors emerge as local hotspots – typically around train and metro stations or along comfortable streets with moderate POI access.

The maps also reveal several “blind spots” in the tourist walking network. In each city there are parishes where important attractions or natural areas are only connected by low-walkability streets (e.g.: Parque de Serralves in Porto or Bom Jesus in Braga), forcing visitors to cross low-comfort, traffic-dominated segments.

4.2 Tourism Walkability Typologies

Lastly, street segments were classified into walkability typologies by computing quartiles for each dimension and assigning each segment to a category based on whether its scores fell in the top or bottom 25% of each dimension (Figure 5). Segments with high scores across all three dimensions cluster around historic centres (green), contrasting with peripheral zones with uniformly low walkability (red) (Figure 3).

The analysis also identifies imbalanced areas where high accessibility coincides with low comfort (purple). These patterns mostly reflect safety and security-related factors – such as non-pedestrianised or unlit streets, higher car accident densities, or lack of benches and drinking water points – which helps explain the discrepancy with nearby highly walkable streets. Such areas represent prime candidates for targeted, small-scale interventions that could help redistribute tourist flows across a broader set of routes.

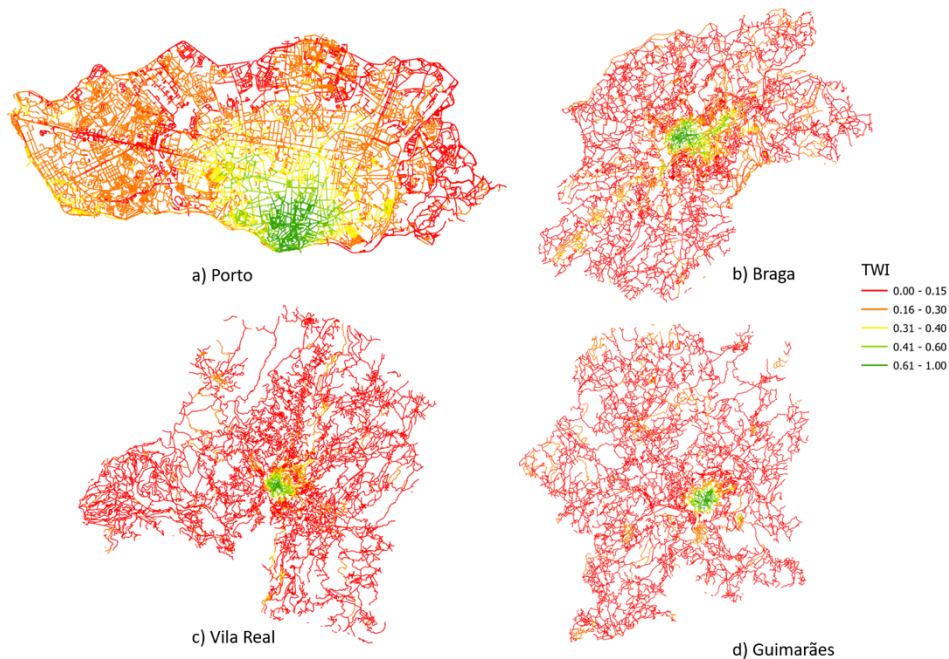


Figure 3: Street-level TWI for the 4 study cities, highlighting highly walkable streets (green) and lower scored ones (red).

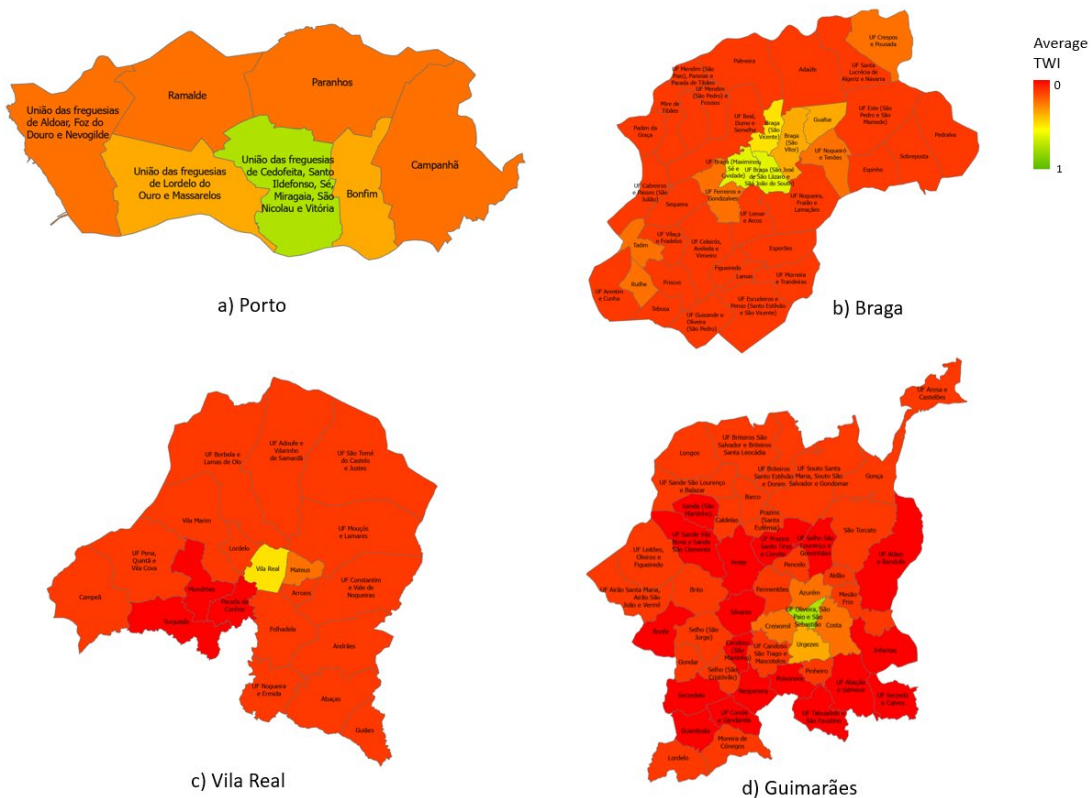


Figure 4: Average parish-level TWI for the 4 study cities, illustrating pronounced contrasts between central and peripheral parishes.

Conversely, segments with high comfort but low accessibility (pink) appear primarily in quieter residential districts or green areas (e.g., Parque da Cidade in Porto). Enhancing connectivity or interpretative infrastructure in these zones could support greater tourism dispersal while maintaining high environmental quality, while a better redistribution of services or cultural activities could unlock latent walkability potential in these otherwise pleasant but poorly connected areas.

Areas with high POI density but limited transport accessibility (blue and light blue) also warrant attention, as improved mobility connections could increase their attractiveness and reduce visitor reliance on private vehicles (e.g., Parque da Penha – Guimarães). In Porto, this is particularly relevant on the western side of the city, where natural areas offer high comfort but remain poorly connected compared with the city centre.

In the less dense municipalities (Vila Real, Guimarães and Braga), clusters of high transport accessibility but low POI accessibility (yellow) were also identified, typically corresponding to train stations or transport nodes located far from major tourist attractions.

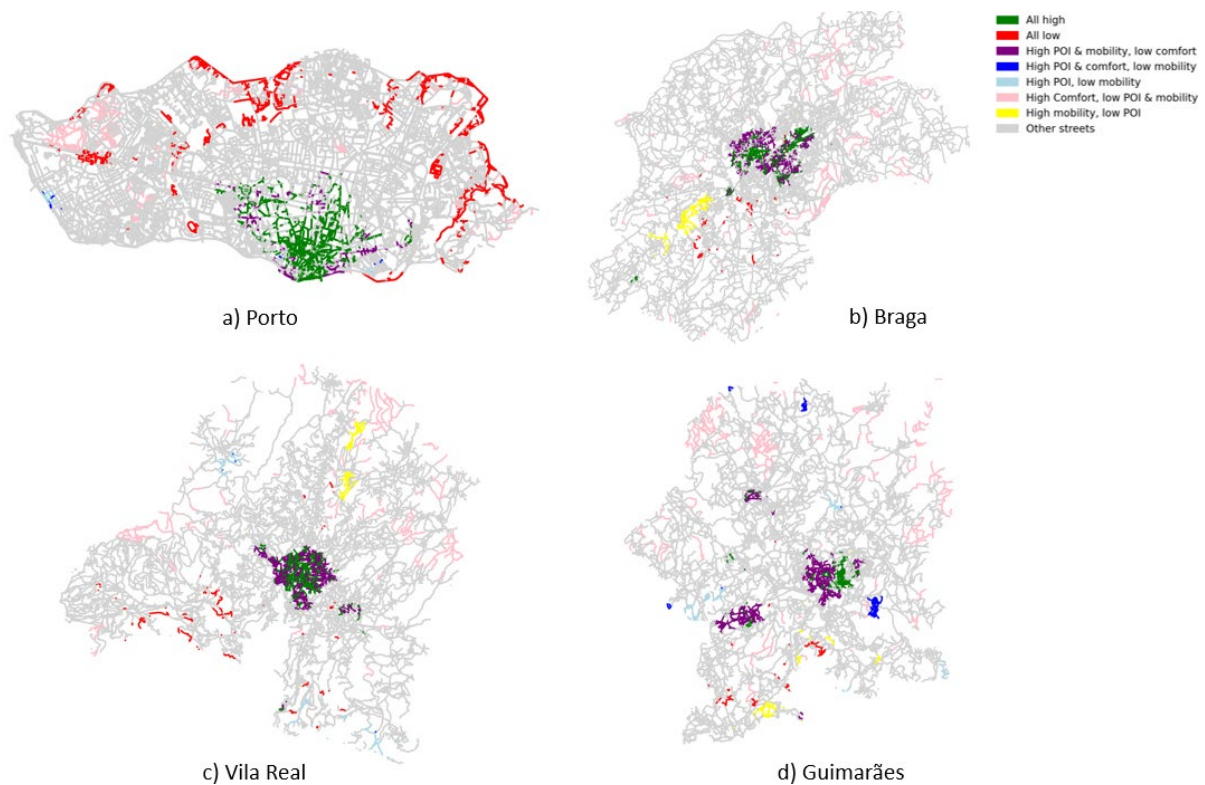


Figure 5: Walkability typologies across the 4 study cities, derived from quartile-based classification of the TWI dimensions.

Together, these patterns highlight where improvements in pedestrian infrastructure, environmental quality or public transport integration could most effectively extend walkable conditions beyond the traditional heritage core and redistribute tourist flows more evenly across the urban fabric.

4.3 Sensitivity Analysis

Sensitivity testing indicates that the spatial structure of the TWI is largely robust to alternative weighting schemes. Across all tested scenarios, including accessibility- and transport-oriented profiles, the overall spatial pattern remains consistent. Notable changes emerge only under scenarios that strongly prioritise the comfort dimension. In these cases, the contrast between central and peripheral areas becomes less pronounced, and walkability scores exhibit a more decentralised spatial distribution. This reflects the higher relative performance of quieter residential streets and green areas in terms of environmental comfort, which gain importance when accessibility to points of interest and transport is down-weighted.

5. Discussion

The TWI proposed in this study demonstrates that a fully geospatial and street-level approach can meaningfully represent the spatial structure of tourism walkability. Across the four case-study cities, the TWI consistently identifies the same tendency: historic centres concentrate the highest walkability, while peripheral areas remain predominantly low-scoring. This reflects the spatial logic of European heritage-driven tourism and aligns with findings from previous work linking cultural clusters, multimodal access and pedestrian comfort to higher walkability (Farkic *et al.*, 2015; Liow, 2022; Ujang and Muslim, 2015).

Beyond confirming expected patterns, the TWI reveals subtle intra-neighbourhood contrasts. By operating at the street-segment scale, the index exposes micro-level variations – for example, highly walkable corridors adjacent to streets with very low comfort, or quiet residential segments with high comfort but limited accessibility. This granularity represents a methodological advantage over indicators that operate at larger spatial scales or rely on subjective survey data. It supports the idea that tourist experiences are also shaped by highly localised conditions of infrastructure, safety, and environmental exposure. This level of detail allows planners to identify specific streets where small-scale interventions – such as benches, shading, improved lighting or traffic calming – could substantially enhance the walking experience for visitors and residents.

The TWI's structure aligns with factors identified in the literature as relevant to tourist walking - accessibility to cultural and leisure-oriented POIs, connectivity to transport, and environmental comfort - yet it operationalises them using objective geospatial data. While this enables reproducibility and scalability, it also introduces limitations: OSM data is not always systematically validated, and comfort indicators might rely on data of uneven precision or coverage (e.g., Waze reports, noise maps). Implementations should therefore incorporate verified local data where possible, and pursue validation through passive mobility sources (e.g., mobile network records, GPS traces).

The multi-city application demonstrates the adaptability and robustness of the index. Porto's richer dataset allowed a more complete implementation, yet using only open data, in Braga, Guimarães, and Vila Real still produced coherent spatial patterns and meaningful typologies. This suggests that the TWI can support tourism walkability assessments in both data-rich and data-scarce contexts, with input layers expanding as more datasets become available. Importantly, the use of city-specific standardisation means the index captures relative variation within each city rather than enabling absolute comparability across cities; interpretations should therefore remain context-sensitive.

While the sensitivity analysis confirms the robustness of the TWI under alternative weighting schemes, further work could extend this approach by defining explicit tourism profiles and systematically exploring weighting configurations tailored to different visitor preferences, following approaches such as Blečić *et al.* (2015)..

Finally, the discussion of walkability must consider its broader implications. As noted by Clavé (2019), improving walkability for tourism can generate opposing dynamics: it may relieve pressure by dispersing visitors to less frequented areas, but it can also increase visitor flows to levels that exceed local tolerance, exacerbating tensions between tourists and residents. For this reason, the TWI should be understood as a diagnostic tool, and its outputs can inform planners about where walkability improvements may benefit tourists and residents, but decisions should prioritise community well-being and avoid tourism-induced imbalance.

6. Conclusion

This paper introduced the TWI, a geospatial framework that integrates accessibility, mobility, and comfort into a single, data-driven measure tailored to tourists. By relying primarily on geographic data, the TWI is scalable, replicable, and suitable for monitoring walkability over time and across different urban contexts. Its fine spatial granularity captures micro-level disparities that neighbourhood indicators cannot, making the index actionable: targeted improvements on low-scoring streets can help redistribute tourist flows and benefit both visitors and local communities. Although grounded in objective indicators, the index also reflects key subjective factors highlighted in previous research – such as security and safety – through consistent and transparent spatial proxies.

The TWI provides a practical bridge between tourism studies, urban analytics and planning practice. It operationalises the idea that tourism walkability is not simply the ability to move between attractions, but the experience of doing so in environments that are safe, secure, and environmentally acceptable. The application across four Portuguese cities demonstrates the framework's adaptability and potential to support more equitable, evidence-based integration of walkability into tourism and mobility strategies.

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AI Declaration

This paper was partially developed with the assistance of the AI tool ChatGPT (OpenAI, GPT-5). The tool assisted with drafting tasks, such as grammar checking, rephrasing, and improving structure. All ideas, analyses, and interpretations are the author’s own, and AI-generated content was reviewed and validated before inclusion.

Ethics Declaration

Ethical clearance was not required for the development of this study.

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