Tourism Through the 15-Minute Lens: Porto Case Study

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Abstract: The 15-minute city concept has become a cornerstone of modern urban planning. Despite its worldwide application, research has mostly focused on accessibility to essential services, while accessibility to tourism remains less explored. Tourism, key to urban identity, livability, and visitor management, needs to be considered within proximity planning. In this context, analysing travel times and accessibility to tourist locations across different travel modes represents a key opportunity to gain insight into how these shape cities. This study applies the 15-minute city framework to tourism, characterizing accessibility from a visitor's perspective. Porto, Portugal, a city facing the impacts of massive tourism, is used as a pilot area to measure access to touristic amenities. Using the Porto open data portal, we compiled 290 points of interest across eight tourism categories. For every Base Reference Geographical Information (BGRI) cell, the Portuguese census tracts, we computed the centroid and generated network-based travel times to each amenity for walking, cycling, and driving. From the origin-destination matrices, we derived a set of 15-minute city indicators, namely minimum travel time required to reach the amenities and counts and percentage of amenities reachable within 5/10/15 minutes. Results show how accessibility patterns vary by parishes and travel mode and offer a reproducible base for urban planning and destination management. The outcomes reveal that accessibility to tourism is strongly centre-weighted: the historic centre offers short walking times and high amenity variety, while the eastern and northern edges face slower access and fewer choices. Trips starting from two central parishes reach 43% of amenities within a 15-minute walk, while trips originating in peripheral parishes typically reach only 5% to 9%. Cycling enhances accessibility by making accessible a variety of amenities across most parishes within 10 minutes and nearly citywide by 15 minutes. This work reframes 15-minute accessibility around tourism, providing a multimodal transportation assessment, translating analytics into actionable indicators. The framework supports policymaker in diversifying attraction availability in underserved areas, distributing visitor flows, and aligning cultural-access goals with livability agendas, promoting smart cities' development.

Keywords: 15-minute City, Tourism, Multimodal Transportation, Urban Planning, Smart Cities, Sustainable Tourism

1. Introduction

Cities are attractive not only because they are places to live, but also because they are places to experience, and accessibility is central to both. Within the tourism context, accessibility was defined by Ghose & Johann (2018) as the ease with which desired destinations can be reached through the availability, affordability, and convenience of transport and information, or the geographic distribution of activities and destinations. As a key attribute of destination image, accessibility directly influences tourist satisfaction (Rajesh, 2013; Handayani, 2016). Castro et al. (2017) emphasised the crucial role of tourist accessibility in trip planning, as tourists require accurate and timely information about activities and sites. Taken together, these perspectives underscore the need for a proximity-oriented lens that links ease of reach, information, and network design to the tourists' experience of cities.

The 15-minute city (FMC) offers a guiding framework for urban planning, proposing that essential amenities should be reachable within a 15-minute walk or cycle, complemented by public transport for longer trips (Moreno *et al.*, 2021a). The FMC emphasises proximity, mixed use, and decentralised networks of daily-life amenities, showing through the experiences from Barcelona, Paris, and Milan, that proximity-oriented strategies can measurably improve livability and environmental performance (Moreno *et al.*, 2021b; Pozoukidou and Chatziyiannaki, 2021). Touristic sites are pivotal to urban identity and local quality of life, yet in high-demand contexts they can also produce congestion and uneven burdens on neighbourhoods. Thus, assessing accessibility in tourism through the FMC lens provides a basis for improved environmental policies and for evaluating how the city welcomes visitors to its touristic sites. Assessing tourism through the FMC framework can help planners assessing proximity patterns, identifying where targeted interventions could enhance tourist access while mitigating negative externalities. Even though the FMC framework presents strong potential for the tourism domain, only a limited number of studies have applied FMC-based analyses to assess tourism accessibility. While

some research has explored how this accessibility is conceptualised and measured, multimodal, time-dependent approaches remain underdeveloped (Moreno *et al.*, 2025).

To address this gap, this paper reframes the FMC for tourism, using Porto Municipality, Portugal, as a case study. This region is the second-largest urban centre in Portugal. It has an area of 41.42 km², comprising seven parishes and a total of 1,659 census tracts, with a total population of 248,769 inhabitants (estimate 2023) (*Portal do INE*, no date). Almost 30 years after being declared a World Heritage Site by UNESCO (1996), and positioned as a major European capital, the city suffers the impacts of massive tourism, with 1,137,756 yearly overstays in the Metropolitan Area of Porto during 2024 (*Portal do INE*, no date). In this context, the FMC framework offers a timely and relevant analytical lens. Its principles align with Porto's compact morphology, historic street fabric, and existing mixed-use patterns, especially in its central and intermediate neighbourhoods. This makes it particularly suited to inform more integrated mobility and land-use strategies that position accessibility as a key objective of tourism planning.

The study presents multimodal accessibility indicators to tourism amenities at the BGRI scale, allowing fine-grained analysis of how touristic opportunities are distributed in urban areas. By analysing tourism accessibility within the FMC framework, this study aims to demonstrate how this approach can generate valuable insights for the tourism domain. Specifically, it seeks to (1) propose a replicable set of FMC-based indicators to characterize urban accessibility to touristic amenities, (2) quantify the spatial distribution of accessibility across different areas of Porto Municipality, and (3) evaluate how accessibility varies by amenity type and travel mode, using location-based measures to compare outcomes across walking, cycling, and public transport. Altogether, this approach can turn into a dynamic tool for urban planners and policymakers to simulate the visitor experience through the FMC lens and to identify challenges and opportunities in areas of the city with varying levels of accessibility.

2. Related Work

How cities distribute opportunities and how networks stitch these together determines how far, how often, and by which modes people travel (Crane, 2000). This premise has shifted urban research and practice to an accessibility-first lens. The FMC, formalised by Moreno et al. (2021b), translates this paradigm into a planning framework, promoting compact, mixed-use neighbourhoods where essential services, such as work, education, healthcare, commerce, culture, and leisure are reachable within a short walk or cycle, complemented by public transport for longer trips (Moreno *et al.*, 2021a; Pozoukidou and Chatziyiannaki, 2021). Centred on proximity, diversity, and decentralisation, the FMC framework seeks to reduce car dependence and encourage active modes, linking accessibility to sustainability, social equity, and public health (Allam *et al.*, 2024; Moreno, 2024).

During the last years, a solid corpus of literature has explored how the FMC framework can assess and improve accessibility inequalities across a diverse set of use cases and urban context. In the local context of Porto, a set of studies have already operationalised the FMC principles, demonstrating its suitability for identifying accessibility patterns and inequalities for different types of amenities, transportation modes and population groups. Alves et al. (2021) developed a walkability index for the elderly within Porto historic centre, incorporating distance, steepness, safety, and land use. Guerreiro et al. (2026) expanded this analysis for Porto Municipality extension, focusing on a network-distance based approach. Using the same approach, Silva et al. (2023) analysed accessibility to general interest amenities in ten categories for Porto Metropolitan Area, categorizing the territory in different classes according to their walking accessibility. Fonseca et al. (2022) complemented these works by addressing walkability perception, developing a comparative study between Porto and Bologna through citizens questionnaires. Collectively, these studies demonstrate the suitability of the FMC framework for assessing equity and service accessibility in the geographic context of Porto. However, they remain narrowly focused on residential and daily-life functions, such as healthcare, commerce, and education, while overlooking tourism-related opportunities and experience, a key driver shaping the urban experience and mobility patterns in the city.

Within the tourism domain, accessibility has been mainly addressed in relation to transport efficiency or destination attractiveness, rather than proximity planning. Li et al. (2022) analysed accessibility of tourism attractions using real-time travel data and a modified gravity model, exploring the impact of transport infrastructure and destination attractiveness. Zhang et al. (2020) introduced a route-optimisation model considering travel time, inter-destination distance, and departure time. From a behavioural perspective, Kim et al. (2023) highlighted how tourists' valuation of time can lead to a Time-Use Rebound Effect, with new travel technologies inducing additional trips and activities. Although these approaches integrate multimodal and

temporal factors within tourism analysis, they fall short of developing frameworks for embedding accessibility within broader urban proximity approaches such as the FMC, where tourism is examined as part of a wider urban system.

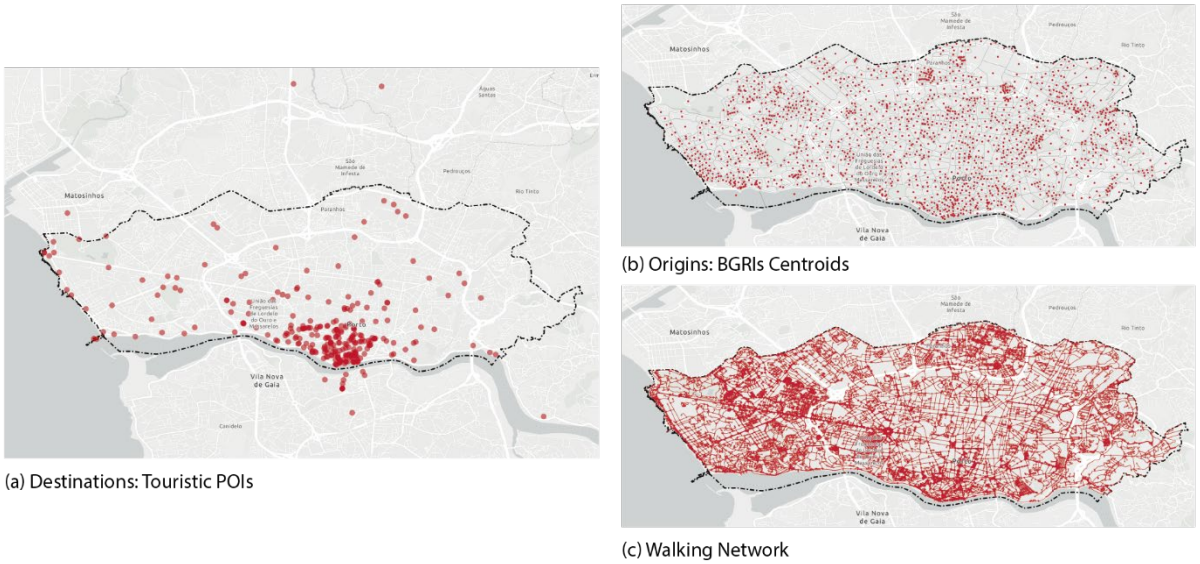
Scholars studying historic centres have stressed the increasing pressure of tourism on cultural assets and residential areas, underscoring the need to integrate tourism accessibility analysis into proximity planning (García-Hernández, De la Calle-Vaquero and Yubero, 2017). In the context of tourism, transport and accessibility are means to broader goals, such as equity, inclusion, sustainability, rather than ends in themselves (Allam *et al.*, 2022). Yet, existing FMC research rarely addresses tourism explicitly, and existing tourism accessibility studies scarcely adopt an accessibility–equity lens rooted in proximity planning. This need is further supported by recent work from Moreno et al. (2025), who calls for methods that make accessibility to tourism sites visible within proximity planning, rather than treating it as a by-product of general service accessibility.

Responding to this gap, the present study operationalises the FMC framework in the context of tourism accessibility, using Porto as a case study. It presents multimodal accessibility indicators to tourism amenities at the BGRI scale, allowing fine-grained analysis of how touristic opportunities are distributed in urban areas. By combining multimodal network analysis with spatial accessibility metrics, it examines how this distribution aligns, or conflicts, with FMC principles. This integration offers a methodological contribution towards bridging proximity-based urban planning and tourism studies, providing a replicable framework for assessing equitable and sustainable access to cultural and touristic amenities in historic urban settings.

3. Methodology

3.1 Origin and Destination Data

Running an accessibility analysis requires a set of origin points and destination points. For this project, the analysis was carried out at the spatial resolution of census tracts. Accordingly, the set of origins was defined by calculating the centroid for all census tracts within the Municipality of Porto, obtained from the official 2021 census geographical base provided by INE (*Portal do INE*, no date), comprising a total of 1659 origins.



(a) Destinations: Touristic POIs

(b) Origins: BGRIs Centroids

(c) Walking Network

Figure 1: Spatial datasets used for the travel distance and times calculation

The set of destination points was defined based on touristic attractions located in the Municipality of Porto and its surroundings. The data was retrieved from the Porto Open Data Portal (Município do Porto, no date) by selecting eight geospatial datasets containing information relevant to the tourism sector. Specifically, these datasets included information on cinemas, statues and sculptures, water fountains, art galleries, viewpoints, museums and thematic centres, concert halls, and theatres.

The selected datasets were merged, resulting in a dataset with 290 destinations. Pre-processing was then applied using Python to ensure that each amenity contained standardized attributes. Additionally, using a geospatial administrative dataset of Portugal, each point of interest (POI) was enriched with its corresponding

census tract (BGRI), Parish, Municipality, and District. Touristic destinations located outside the administrative limits of the Municipality of Porto were also retained in the dataset to minimize boundary effects (Griffith, 1983) (Figure 1).

3.2 Accessibility Modelling

For this work, we modelled multi-modal distance and time-based accessibility to cultural touristic Points of Interest (POIs) in eight categories, using census tracts centroids as origin points.

To retrieve routing information for the different transportation modes, namely walk, bike and drive, data from OpenStreetMaps was used. One network covering the analysis area was downloaded for each transportation mode, using the Python library OSMnx (Boeing, 2017). The library makes uses of the OSM tags to determine suitable segments for each mode, including directional restrictions attributes among others.

Based on this network, travel impedance was operationalized by inputting travel speed for each travel modality and network edge. For the driving network, the OSM native edge travel speeds were considered. In the case of the two other networks, a constant speed of 4 km/h for walking and 15 km/h for biking was manually input, following conservative average values considered in previous related studies (Schleinitz *et al.*, 2017; Hosford, Beairsto and Winters, 2022; Willberg, Fink and Toivonen, 2023). For each transportation mode, the shortest path in the network between each origin and destination point was retrieved using Python NetworkX library (Hagberg, Schult and Swart, 2008). Based on the length and speed attributes of the edges, the total trip distance and time was calculated.

The final results were appended to a single table containing, for each origin-destination pair, the distance, and travel time for each travel mode, in addition to the destination category.

3.3 15-Minute City Indicators

To implement the FMC lens for tourism, we computed three complementary, accessibility indicators from the results table described above. These indicators follow standard location-based approaches used to assess FMC compliance and related neighbourhood-scale accessibility (Kelobonye *et al.*, 2020), and they are reported for walking, cycling and driving, both across all amenities and by amenity category.

a. **Minimum travel time to the nearest amenity**: for each BGRI origin o and mode m, we take the minimum network travel time, min t, to any touristic amenity destination *d*:

$$T_m^{min}(o) = \min_{d \in D} t_m(o, d)$$

b. **Cumulative opportunities within time thresholds (5, 10, 15 min)**: for each BGRI origin o, mode m, and threshold $\tau \in \{5, 10, 15\}$ minutes, we count how many amenities are reachable within τ:

$$A_{m,\tau}(o) = \sum_{d \in D} 1\{t_m(o, d) \leq \tau\}$$

c. **Percentage of amenities reachable within time thresholds (5, 10, 15 min)**: for each parish p, mode m, and threshold τ, we calculate the proportion of touristic amenities that a trip originating in that parish can reach within τ:

$$P_{p,m,\tau}^{c} = \frac{\sum_{o \in O_p} A_{m,\tau}^{c}(o)}{D}$$

4. Results and Discussion

The accessibility results obtained through the operationalization of three defined 15-Minutes City indicators were visualized using choropleth maps, allowing a clear identification of unequal spatial accessibility patterns to touristic POIs in different areas of Porto municipality.

A mode-by-mode accessibility analysis exposes clear differences to the closest amenity between the three studied transportation means (Figure 2). When analysing the minimum time to reach the closest touristic POI by walking, it is possible to identify areas with poor accessibility at the east side of the city, on the periphery, especially in Campanhã parish. Contrary, the area with higher accessibility in tourism corresponds to the historic centre and along the Douro riverfront, reflecting a dense network of accessible touristic sites. When analysing

cycling accessibility, trips duration is reduced, with the average travel time to a touristic POI falling from 32 to 18 minutes, a reduction of 43% of the time. With this transportation mean, most of the city becomes a 10-minute city for at least one touristic option, and a 15 or 20-minute city for at least one touristic option for each category. By car, the average time to reach any touristic amenity is within a 5-minute ride.

Figure 2: Travel time (minutes) to the nearest touristic amenity by walking (left), cycling (centre), and driving (right). Red indicates lower accessibility; green indicates higher accessibility.

If focusing specifically on walking accessibility, the 5-minute walking map shows that only the inner-city parish achieves several amenities (10), with north and east parishes reaching very few to none (Figure 3). A 15-minute walking trip, the accessible belt widens and becomes continuous from the river upwards thı traditional central neighbourhoods. Yet, trips starting from outer belts remain achieving few touristic a This analysis highlights that, when studied from a touristic pedestrian-friendly perspective, the city clear inequalities, falling away from the FMC objectives mainly at peripherical areas.

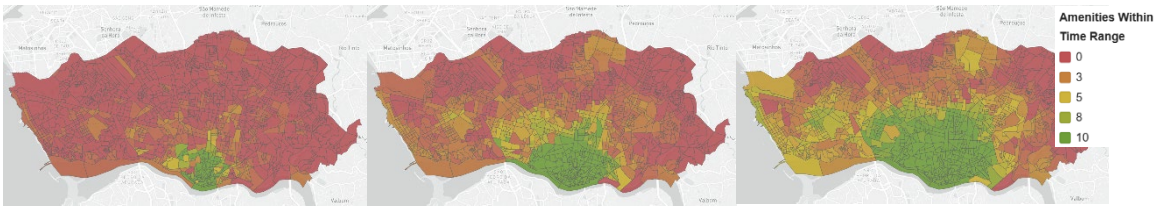


Figure 3: Number of touristic amenities reachable by a 5-minute (left), 10-minute (centre), and 15-minute (right) walk. Red indicates lower accessibility; green indicates higher accessibility.

Cycling reduces these gaps. The 5-minute biking map (Figure 4) reaches ≈94% (273) of amenities, similar to the results for a 15-minute walk trip, and 10 and 15 minutes by bike raise coverage to ≈96% (279) and ≈98% (284), respectively, with most areas attaining high choice. Driving, as expected, yields near-universal coverage even at 5 minutes (≈83–88% per parish) and becomes effectively complete by 10 minutes (100%, 290 amenities). By car, at least one touristic site of each category is accessible within a 5-minute trip.

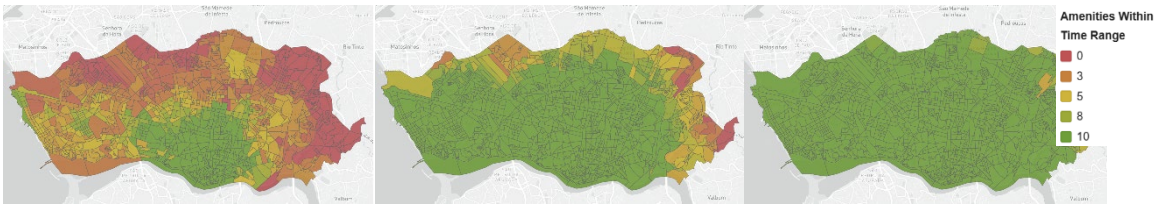


Figure 4: Number of touristic amenities reachable by a 5-minute (left), 10-minute (centre), and 15-minute (right) bike ride. Red indicates lower accessibility; green indicates higher accessibility.

The parish versus category matrices highlights origin-destination accessibility patterns. As expected, the walking trips that start from parishes in the historic centre, União de Freguesias (UF) de Cedofeita, Santo Ildefonso, Sé, Miragaia, São Nicolau e Vitória, are the ones having a higher percentage of amenities covered, followed by UF de Lordelo do Ouro e Massarelos. Peripheral parishes such as Campanhã, Ramalde, and Paranhos have only 5% to 9% of accessible touristic amenities for every amenity category, corroborating the maps' evidence of a persistent outer ring of low walking accessible tourist options. The statue or fountain, monument, museum and art gallery categories show a high walking accessibility rate for trips that start in the historic centre parish, which is expected since most of these touristic amenities are located in that parish. For all the other parishes and categories, the pedestrian accessibility to touristic amenities is low. These scarcities imply that beyond the historic core, many residents and visitors will not find touristic POIs within a walking distance.

Table 1: Percentage of accessible touristic amenities by a 15-minute walk, by parish and category.

Amenity Category	Bonfim	Campanhã	Paranhos	Ramalde	UF de Aldoar, Foz do Douro e Nevogilde	UF de Cedofeita, Santo Ildefonso, Sé, Miragaia, São Nicolau e Vitória	UF de Lordelo do Ouro e Massarelos	Total
Art Gallery	4%	1%	2%	2%	1%	13%	10%	**16%**
Cinema	1%	0%	0%	1%	0%	1%	1%	**2%**
Concert Venue	1%	0%	0%	0%	0%	2%	1%	**2%**
Monument	3%	1%	1%	2%	2%	17%	7%	**20%**
Museum	3%	2%	3%	2%	2%	12%	8%	**19%**
Statue or Fountain	8%	0%	1%	1%	3%	20%	9%	**23%**
Theatre	2%	0%	0%	0%	0%	3%	1%	**4%**
Viewpoint	1%	0%	0%	0%	1%	6%	3%	**8%**
Total	**22%**	**5%**	**8%**	**8%**	**9%**	**76%**	**38%**	**95%**

Cycling closes the accessibility gap showed on foot. Within a 10-minute bike ride, trips starting in outer parishes reach between 13% to 45% of city's touristic amenities, while trips starting in central parishes reach more than 80% of all touristic amenities. When increasing the maximum bike ride to 15-minutes, trips from every parish surpass 66% of covered touristic amenities, and trips from central parishes reach around 90% coverage. The only exception is UF de Aldoar, Foz do Douro e Nevogilde parish, who is isolated and whose accessibility do not increase as much as the others with the increase in maximum trip duration. Although accessibility increases in general for bike trips, accessibility to amenity categories with low density remains scarce.

Table 2: Percentage of accessible touristic amenities by a 10-minute bike ride, by parish and category.

Amenity Category	Bonfim	Campanhã	Paranhos	Ramalde	UF de Aldoar, Foz do Douro e Nevogilde	UF de Cedofeita, Santo Ildefonso, Sé, Miragaia, São Nicolau e Vitória	UF de Lordelo do Ouro e Massarelos	Total
Art Gallery	8%	4%	11%	10%	2%	15%	14%	**16%**
Cinema	1%	1%	2%	1%	1%	2%	2%	**2%**
Concert Venue	1%	1%	1%	1%	0%	2%	2%	**2%**
Monument	14%	4%	6%	4%	2%	18%	18%	**20%**
Museum	12%	5%	9%	7%	4%	18%	13%	**22%**
Statue or Fountain	19%	8%	13%	4%	2%	21%	20%	**22%**
Theatre	3%	2%	2%	1%	0%	4%	4%	**4%**
Viewpoint	4%	2%	1%	2%	1%	7%	7%	**8%**
Total	**62%**	**27%**	**45%**	**29%**	**13%**	**86%**	**79%**	**96%**

Table 3: Percentage of accessible touristic amenities by a 15-minute bike ride, by parish and category.

Amenity Category	Bonfim	Campanhã	Paranhos	Ramalde	UF de Aldoar, Foz do Douro e Nevogilde	UF de Cedofeita, Santo Ildefonso, Sé, Miragaia, São Nicolau e Vitória	UF de Lordelo do Ouro e Massarelos	Total
Art Gallery	14%	8%	15%	14%	5%	15%	15%	**16%**
Cinema	1%	1%	2%	1%	1%	2%	2%	**2%**
Concert Venue	2%	2%	2%	1%	0%	2%	2%	**2%**
Monument	17%	14%	17%	17%	4%	19%	19%	**20%**
Museum	18%	16%	17%	15%	6%	21%	19%	**23%**
Statue or Fountain	20%	19%	21%	19%	3%	22%	22%	**23%**
Theatre	3%	3%	4%	3%	1%	4%	4%	**4%**
Viewpoint	6%	4%	7%	6%	3%	7%	8%	**8%**
Total	**82%**	**67%**	**84%**	**77%**	**23%**	**91%**	**91%**	**98%**

The results suggest that cycling notably improves the accessibility to tourism POIs, with the capacity to convert Porto into a 15-minute tourism city. These findings highlight the need to bring attention to this active mode and increase the efforts to promote it, particularly for the tourism sector. A special attention is needed regarding UF de Aldoar, Foz do Douro e Nevogilde, which is segregated from the rest of the city in terms of tourism accessibility. Promoting cycling within Porto is crucial, according to Rocha & Ferreira (2025), only 2% of city trips are made by bike. This arises from Porto's challenging topography, characterized by hilly and narrow streets that complicate cycling infrastructure development (Silva, Altieri and Teixeira, 2023), and the absence of a cohesive active-mobility strategy. Metropolitan growth led mainly by private actors, without long-term mobility planning, has produced fragmented infrastructure that discourages active travel, particularly cycling (Serra, Gil and Pinho, 2017).

The fact that higher accessibility results are found at the historic centre, while areas with low accessibility are found on the outskirts is in line with findings from recent literature in other cities, even when analysing other type of amenities. A previous study by Guerreiro et al. (2026) in Porto showed similar spatial patters regarding general urban services concentration. The work findings highlighted the highest accessibility in the historic centre and lower in the periphery of the city, with particularly bad accessibility in the eastern parishes of the municipality. For Barcelona case, Ferrer-Ortiz et al (2022) found out that parcels with the best access cluster in the oldest areas, notably the historic centre and its surroundings, while periphery shows weaker accessibility. These outer zones suffer from low service coverage due to non-residential, mono-functional land uses that disrupt continuity and limit access.

The findings from this study are also in line with the previous analysis on Porto tourism concentration conducted by Municipio do Porto (2024), which identified the historic centre as an area of high tourist concentration, with uneven distribution of visitors across the municipality parishes. Building upon the re-distribution proposals made by the authors and considering that some categories will remain scarce by design in Porto, itinerant programmable cultural offers in the eastern and northern regions could raise the effective touristic POIs choice. This would help to redistribute visitors throughout the city without diluting the historic centre.

In summary, Porto functions as a 15-minute city for tourism on foot, in the historic centre, and by bicycle across almost the entire municipality. Prioritizing a connected cycling network and last-mile walking quality conditions would close the remaining accessibility gaps, particularly in Campanhã, Ramalde, and Paranhos. These efforts would turn today's uneven access into a richer set of choices for visitors.

5. Conclusions, Limitations and Future Work

This study analysed accessibility to tourism POIs in Porto, Portugal, through the FMC lens. It presents multimodal accessibility indicators to tourism amenities at the BGRI scale, allowing fine-grained analysis of how touristic opportunities are distributed in urban areas. By using proximity-based indicators at census tract scale, we show how these patterns vary by regions and travel mode, offering a reproducible base for urban planning and destination management. The results revealed unequal accessibility patterns, highlighting key challenges and opportunities to enhance sustainable tourism. The study concluded that accessibility to tourism is high on the historic centre, in part explained by the high density of touristic POIs and the city's compact morphology, exposing the periphery where tourism walking accessibility is much lower. The results show that shifting from walk to bike overcomes these gaps, having a high impact on accessibility to tourism and turning the periphery more connected.

Despite the insights regarding accessibility to tourism in Porto, it is important to acknowledge certain limitations inherent to the study's methodological framework. Specifically, the analysis focused exclusively on quantitative dimensions of distance-based travel time, excluding qualitative aspects such as perceived safety or user satisfaction. Furthermore, it lacked consideration of land-use characteristics at trip origins and destinations, and paths characteristics such as steepness and road type, factors that could influence travel duration and mode choice.

Regarding POIs, the analysis was focused solely on cultural amenities existing in Porto Open Data Portal. Future work could include other destinations of interest for tourists, such as bars and restaurants or public spaces, for better modelling tourism accessibility. The location of tourism accommodation, such as hotels and 'local accommodation' (AL) points, could also be added as a new analysis layer. In this sense, a foreseen research direction is to correlate accessibility results with tourism accommodation locations, to analyse the potential existence of spatial patterns. Adding a time dimension to the analysis, by incorporating POIs opening hours and schedules and fine-scale data regarding visitors' displacements, would also help deepen the understanding of these complex interactions, enhancing the development of tourism management decision support tools.

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Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

This paper was partially developed with the assistance of ChatGPT (OpenAI, GPT-5 model). The tool was used to support the drafting and refinement of text, including grammar checking, rephrasing for clarity, and generating structure suggestions. All ideas, analyses, and final interpretations are the author's own, and all outputs generated by AI were reviewed, edited, and validated by the author before inclusion.

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