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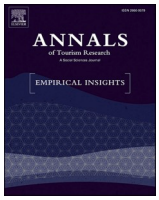

Evaluating tourism scenarios within the limit of acceptable change framework in Barcelona

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ABSTRACT

This article introduces an expanded Limit of Acceptable Change model, enhancing the traditional approach by incorporating various tourism scenarios and a broader range of indicators. This approach allows to gain a more comprehensive understanding and foresee the effects of diverse tourist profiles and intensities of use in Barcelona. It considers factors like motivation, origin, and accommodation type, and evaluates their effects on key sustainability indicators. The study reveals that significant shifts in tourism patterns are required to impact these indicators noticeably, emphasizing the need to consider both tourist numbers and typologies in sustainable tourism management. This approach equips destination planners with a valuable tool for strategic decision-making and long-term planning.

1. Introduction

The escalating influx of tourists into urban areas is reaching critical proportions, necessitating urgent attention and action from local governments. This phenomenon, often termed 'overtourism', poses significant challenges to the sustainability of cities and has become a paramount concern on the policy agendas of municipal administrations (Bertocchi, Camatti, Giove, & van der Borg, 2020; Koens, Postma, & Papp, 2018). Central to addressing these challenges are questions like, "What constitutes an excessive number of tourists?" and "Is there a limit to the number of tourists that can be sustainably accommodated?" Historically, these questions have been explored through the lens of the 'Tourism Carrying Capacity' concept. The Tourism Carrying Capacity is a critical measure, articulated by the UNWTO in 1981, which defines it as "the maximum number of people that may visit a tourist destination simultaneously, without causing irreversible damage to the physical, economic, and socio-cultural environment, while also ensuring an acceptable quality of experience for visitors." This concept plays a vital role in helping cities navigate the complexities of tourism management, balancing the economic benefits of tourism with the need to preserve the integrity and sustainability of urban environments.

Two developments have given rise to interest in Tourism Carrying Capacity (Bertocchi et al., 2020; Garola, López-Dóriga, & Jiménez, 2022; Muler, Coromina, & Galí, 2018). The first is the progressive incorporation of sustainability in the tourism debate, as sustainable development means having limits (Saarinen, 2006). The UNWTO has been proposing a shift towards a more sustainable approach in the tourism sector for several years, and this has intensified since the adoption of the Sustainable Development Goals and the acknowledgement of environmental problems in the context of the climate emergency. The second development is the emergence of a social movement decrying the effects of tourism on the economy, society, and the environment. In major European cities, initiatives have sprung up from citizens protesting against the impact of tourism on local communities, and proposals to limit the number of visitors (Wall, 2020).

However, there is no single and universal method to determine the maximum number of visitors, and there isn't a unique method to calculate the tourism carrying capacity (Bertocchi et al., 2020; Saarinen, 2006). While the concept of carrying capacity remains widely used to understand the adverse impacts of tourism, the usefulness of its perspective has been questioned (Koens et al., 2018, p. 2). As a complement of Tourism Carrying Capacity, alternative models have been suggested, such as the Limit of Acceptable Change (Diedrich, Huguet, & Subirana, 2011; Jordão, Breda, Veríssimo, Stevic, & Costa, 2021; Koens et al., 2018; McCool, 2009, 2012). The Limit of Acceptable Change model focuses on the changes a destination is willing to tolerate due to

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tourism pressure, rather than focusing on the maximum number of tourists a destination can host.

The aim of this article is to introduce and evaluate a novel approach within the framework of Limit of Acceptable Change models, focusing on enhancing stakeholder engagement in determining the sustainable threshold of tourist numbers at a destination. The method involves a dynamic projection system that models the responses of key indicators to various tourist scenarios, ranging from fluctuations in visitor numbers to changes in tourist demographics. This approach allows stakeholders to better understand and anticipate the impacts of different tourist profiles, considering factors such as motivation, origin, and duration of stay. We have applied this method in Barcelona, offering insights into the acceptable level of tourism-induced change, thereby illustrating its practical application and value. This approach represents a significant advancement in Limit of Acceptable Change models, moving beyond simple visitor count to a more comprehensive understanding of the multifaceted impacts of tourism. Barcelona has been one of the European cities in which the process of overtourism has manifested itself. With 17 million tourists in 2019, of which 86% are international, the city has experienced a tourism boom since the 90s (Mansilla & Milano, 2022).

2. Literature review

2.1. Overtourism

The term "overtourism," broadly referring to the excessive influx of tourists at a specific destination and its adverse impacts (Koens et al., 2018), is defined by the UNWTO (2018) as "the impact of tourism on a destination, or parts thereof, that excessively influences perceived quality of life of citizens and/or quality of visitors experices in a negative way" (UNWTO, 2018, p. 4). While there's no unified criteria to define overtourism, it has evolved from being solely about tourist numbers to encompassing spatial and temporal concentration, the rate of growth, and the interaction between tourism and other urban activities.

Overtourism results from a convergence of structural tourism elements (like spatial/temporal concentration and the growth in national/international tourism) with recent factors such as demographic and social changes, technological advances, intensified destination promotion, and the increasing significance of tourism as an economic driver (Dodds & Butler, 2019). Contributing factors are diverse, including reduced travel costs, the rise of digital accommodation platforms, globalization of tourism (UNWTO, 2018), and the use of technology and social networks (Gretzel, 2019), leading to travel patterns that favor well-known destinations, thus causing their saturation.

Although overtourism impacts a range of destinations, its effects are primarily seen in urban areas, exacerbated by the growth of urban/metropolitan tourism and inherent city issues like gentrification, housing access, and congestion (Koens et al., 2018; Wall, 2020). It's linked to perceived social density and shifting resident attitudes towards tourists (Gössling, McCabe, & Chen, 2020). The tourism pressure can trigger a negative local response, often termed "tourismphobia," a controversial label that sometimes obscures social/neighborhood movements against tourism's negative impacts (Milano, 2018). Mihalic (2020) associates overtourism with changing socio-psychological capacities of residents and their views on tourism growth, visitor satisfaction levels, and the socio-political environment, including aspects like ethics, legislation, planning, and collaboration for responsible tourism.

Various strategies to mitigate tourism pressure include deseasonalization, decongestion, decentralization, diversification, and deluxe tourism (Milano, 2018; Romera, Lama, & Tabales, 2023). Although these strategies can be effective, Milano suggests they may not provide a structural solution. Thus, overtourism is conceptually linked to carrying capacity: Both concepts imply a threshold, a maximum number of tourists beyond which negative impacts on the destination occur. Mihalic (2020) proposes establishing indicators and values to define these thresholds, positioning carrying capacity and acceptable limit as strategies to address overtourism's challenges.

2.2. Tourism carrying capacity

The UNWTO concept of Tourism Carrying Capacity is a critical aspect of sustainable tourism management. Tourism Carrying Capacity is defined as the maximum number of visitors that a destination can accommodate without causing adverse effects on the local environment, community well-being, and overall visitor experience. The assessment of Tourism Carrying Capacity is multifaceted, incorporating physical, environmental, economic, and social dimensions. This comprehensive approach reflects a growing recognition of the intricate balance required to sustain tourism destinations in the long term.

Physical carrying capacity, often applied in natural environments, assesses the impact of tourism on both the natural landscape and the local community. It encompasses the capacity of an area to withstand tourist activities without environmental degradation or undue strain on local resources. Environmental carrying capacity extends this analysis to consider the limits of resource consumption (such as water and energy) and waste management, as well as the impact on landscape aesthetics and biodiversity. This perspective is underpinned by empirical research that elucidates the relationship between resource use and tourism intensity (Kallis & Coccossis, 2017; Sharma, 2016; Zhang, Liu, Wu, & Wang, 2018).

Economic factors in Tourism Carrying Capacity, though critical, have been less emphasized due to the complexities involved in quantifying the negative externalities of tourism. Nevertheless, the economic dimension is integral in understanding the broader implications of tourism on local economies and infrastructure.

The social dimension of Tourism Carrying Capacity has gained prominence in contemporary research, focusing on the perceptions and experiences of both visitors and local residents regarding the effects of tourism. This approach considers the subjective nature of overcrowding and the threshold at which tourism becomes a detriment to the quality of life and the visitor experience (Muler et al., 2018; Saveriades, 2000).

Despite the established utility of Tourism Carrying Capacity in guiding sustainable tourism practices, its application has been subject to debate. Critics argue that an overemphasis on numerical thresholds of tourist numbers may overlook the nuanced impacts of tourism on destinations (Lindberg, McCool, & Stankey, 1997; Manning, Wang, Valliere, Lawson, & Newman, 2002). In response, alternative models such as the Limits of Acceptable Change have been proposed, offering a more flexible framework for managing tourism growth (Koens et al., 2018; McCool, 2009, 2012).

In recent years, a consensus has emerged advocating for the integration of sustainability principles into tourism management. This paradigm shift, in alignment with the Sustainable Development Goals, seeks to harmonize economic growth with environmental stewardship and social responsibility. Concurrently, social movements have highlighted the adverse impacts of tourism on local economies, societies, and environments, leading to increased awareness of the phenomenon of overtourism and its detrimental effects (Koens et al., 2018; Mihalic, 2020; Romero-Padilla, Cerezo-Medina, Navarro-Jurado, & y Romero Martínez, J. M., 2019; Wall, 2020). This evolving discourse underscores the importance of a multidimensional approach to Tourism Carrying Capacity, one that embraces both the quantitative and qualitative aspects of tourism impacts to ensure the sustainability of destinations worldwide.

2.3. Limits of acceptable change

The Limits of Acceptable Change, conceptualized in the 1970s and 1980s, emerged as a progressive framework for managing the impacts of tourism on destinations. Distinct from the traditional Tourism Carrying Capacity, Limit of Acceptable Change shifts the focus from quantifying

visitor numbers to assessing the extent of environmental, social, and ecological changes that a destination can sustainably accommodate (Stankey, 1973; Stankey, Cole, Lucas, Petersen, & Frissell, 1985). This approach prioritizes the quality of the environment and visitor experience over numerical thresholds, aiming to maintain the integrity of destinations amidst increasing tourism pressures (Diedrich et al., 2011; Frauman & Banks, 2011).

Limit of Acceptable Change represents a strategic planning methodology that facilitates informed decision-making. It encourages an adaptable management approach, where acceptable conditions are defined based on the specific objectives of each destination (Ahn, Lee, & Shafer, 2002; Dragovich & Bajpai, 2022). This dynamic criterion contrasts with the static nature of traditional Tourism Carrying Capacity models, offering a more nuanced and goal-oriented perspective (Cole & Stankey, 1997; McCool, 2009, 2012). According to McCool (2012), the central query of Limit of Acceptable Change revolves around the conditions deemed appropriate and acceptable for an area, shifting the dialogue from a simplistic count of visitors to a more complex consideration of the desired state of the destination.

One of the challenges in implementing the Limit of Acceptable Change framework lies in distinguishing between preferable and acceptable conditions. The standards established by Limit of Acceptable Change are aimed at being tolerable, not necessarily ideal. This distinction raises the critical question of tolerability for whom, recognizing the diverse and sometimes conflicting interests of various stakeholders in urban tourism planning (McCool, 2012). Effective destination planning thus involves collaboration and negotiation among local governments, visitors, and other actors in spatial management, striving to harmonize differing interests (McCool, 2009).

The implementation of Limit of Acceptable Change involves a series of methodical steps. These have been synthesized by scholars into three primary stages: (1) defining the objectives of the destination; (2) identifying measurable indicators for social, economic, and environmental conditions; and (3) setting standards to maintain these conditions (Ahn et al., 2002; Dragovich & Bajpai, 2022; Frauman & Banks, 2011; Jordão et al., 2021). The governance of the destination, involving various stakeholders, plays a pivotal role in determining these limits and, consequently, the optimal number of visitors the destination can sustainably support. The complexity of this process arises from the challenge of integrating a broad spectrum of variables, often with limited availability, and the intricate nature of decision-making regarding acceptable limits (Ahn et al., 2002; Diedrich et al., 2011). As a result, Limit of Acceptable Change, while theoretically robust, presents practical application challenges that require careful consideration and adaptive management strategies.

3. Method

3.1. Tourism in Barcelona

Since the 1992 Olympic Games, Barcelona has transitioned from tourism obscurity to being ranked among the top European cities for visitors. 2019 saw a record number of tourist arrivals, before the city was hit by the COVID-19 pandemic, which left a profound impact (Donaire, Galí, & Camprubí, 2021). Barcelona's strategic tourism plan 2020, and particularly the Special Urban Plan for Tourist Accommodation (PEUAT), was designed to curb tourism pressure on the city, against a backdrop of growing criticism from residents (Zerva, Palou, Blasco, & Donaire, 2019).

Barcelona recorded 17 million tourist arrival in 2019. Of these, 86% were international visitors, and 70% were mainly motivated by leisure. Barcelona has tourism characteristics similar to other European cities: short stays, a strong international component and arrivals by air. However, international tourism in Barcelona is particularly high, and business tourism is lower than in other similar cities. Data on the concentration of tourist activity reveal that supply and demand centre around two of Barcelona's ten districts: the medieval district (Ciutat Vella) and the 19th-century Eixample district. The study commenced with an estimation of the actual number of tourists, taking into account unobserved tourists (De Cantis, Parroco, Ferrante, & Vaccina, 2015), those who do not appear in official statistics but nonetheless have a significant impact on the city. To estimate the number of tourists staying overnight, we utilized mobile phone data recorded in the city, combined with platform data and official statistics. This approach enabled us to determine the number of tourists staying in unofficial tourist accommodations and private homes, revealing that in 2019, the city hosted 17 million tourists, 24% more than the official figure (See Fig. 1).

Furthermore, following UNWTO guidelines, we have estimated the number of day-trippers (visitors who do not stay overnight in the city). A portion of these day-trippers are individuals who are accommodated in the Barcelona Metropolitan Area and visit the city during the day, staying overnight in neighboring cities. Their aim is to visit Barcelona, but they prefer to spend the night in its environs due to pricing considerations. Russo (2002) refers to them as 'false day-trippers'. Again, the results significantly exceed official estimates, indicating that the impact of tourism and visitors on the city is much greater than anticipated by the city's Statistical Office. De Cantis et al. (2015) has emphasized the importance of identifying this gap between official data and actual figures.

3.2. Indicators

The concept of Limit of Acceptable Change integrates indicators derived from the literature on carrying capacity, focusing specifically on density, physical capacity, environmental and economic criteria. These criteria are detailed in the following subsections. In this study, we identified a complete set of 20 indicators.

The notion of social carrying capacity has been widely explored in various contexts, including the perspectives of residents and tourists (Bertocchi et al., 2020; Muler et al., 2018; Saveriades, 2000). This framework has been successfully applied to various environments, such as protected natural areas (Klanjšček, Geček, Marn, Legović, & Klanjšček, 2018), coastal and beach destinations (Gonson, Pelletier, & Alban, 2018; Jurado, Damian, & Fernandez-Morales, 2013), theme parks (Zhang, Li, Su, & Hu, 2017) and cruises (Jacobsen, Iversen, & Hem, 2019). In our analysis, we opted not to include indicators based on social perceptions, as we couldn't identify a statistically significant correlation between the volume of tourists and their perception by either locals or visitors in Barcelona. Our examination of the time series data for both tourist numbers and the sentiments of residents or tourists revealed no discernible relationship. For instance, although a peak in residents' evaluations was observed in 2017 (Ajuntament de Barcelona, 2023), this was followed by a period during which, despite an increase in tourist numbers, the level of negative evaluations diminished. This "disconnect" between evaluations and the number of tourists means that we are unable to predict how the opinions of tourists or residents might change in scenarios of growth or decline. This represents a notable limitation of our model: it can only integrate indicators that exhibit predictable behaviors in response to scenario variations, such as density, and environmental or economic factors. Consequently, important variables such as evaluations, access to housing, or noise levels are not accounted for.

To illustrate the methodology, see Fig. 2. The first step involves selecting density, environmental, and economic indicators, as well as specifying data sources for each category of indicators. Various scenarios are subsequently presented. Each scenario encompasses different permutations of these indicators, allowing decision makers to choose the scenario that best aligns with their strategic objectives and priorities in tourism development. (See Table 1.)

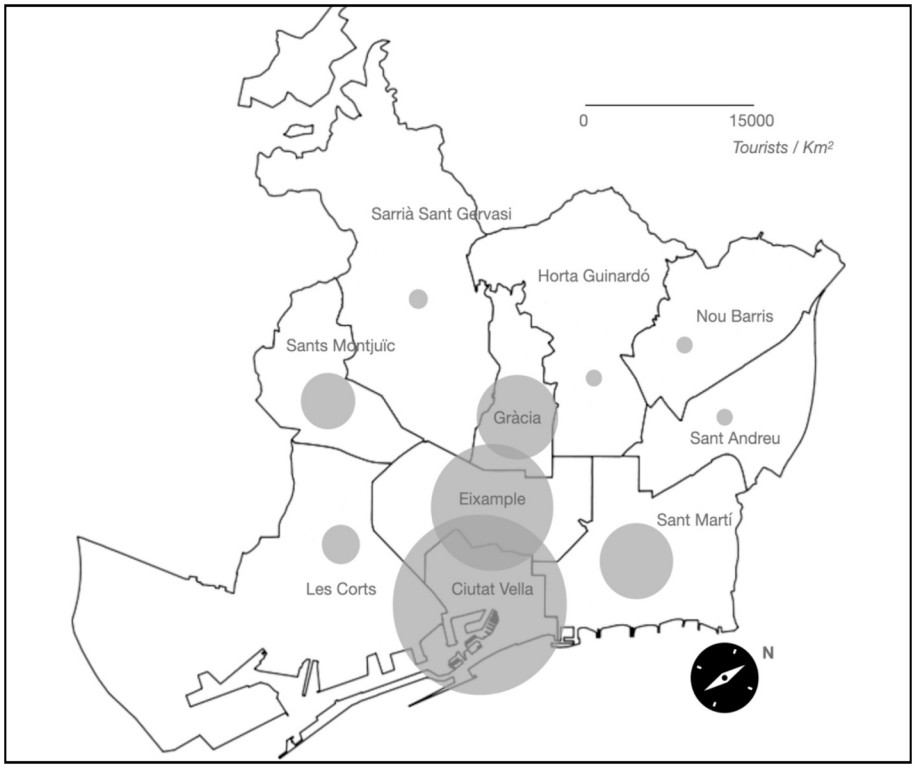

Fig. 1. Map of tourism density.

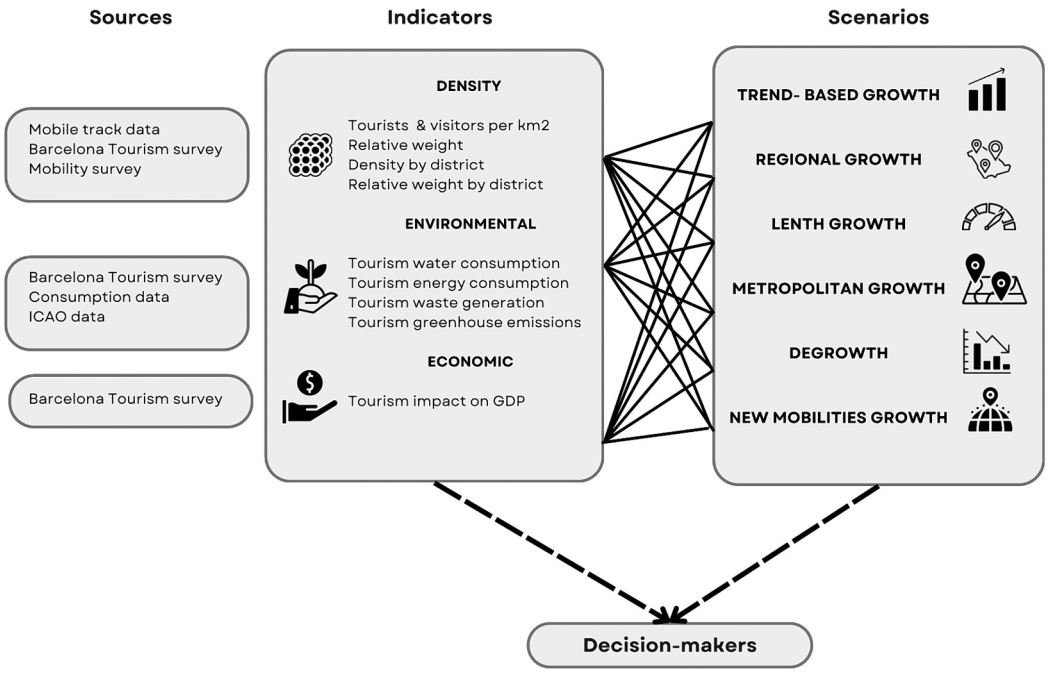

Fig. 2. Methodology framework.

3.3. Density indicators

In the field of physical carrying capacity, density indicators have been a pivotal component, particularly in environments with well-defined spatial characteristics and visitor behaviour, such as natural areas or beaches (Basterretxea-Iribar, Sotés, & Maruri, 2019; Collins-Kreiner, Malkinson, Labinger, & Shtainvarz, 2013; Jurado et al., 2013). A landmark study in this domain was conducted by Cifuentes (1992), who devised a framework for assessing carrying capacity based on physical dimensions, accounting for the maximum permissible number of individuals in relation to density, area size, and operational hours. Density, as a primary measure of carrying capacity, signifies the undue burden on a space caused by the simultaneous presence of an excessive number of visitors (Gonson et al., 2018; Mateusz, 2021; Shen et al., 2022; Visentin & Bertocchi, 2019; Wang et al., 2021; Wu, 2022).

For determining tourist density indicators in Barcelona, we analyzed

Table 1
Visitors/day to Barcelona city (2019).

Type of visitors	Arrivals	Days	Visitors/day
Tourists	17,355,003	62,370,802	170,877
False day-trippers	10,497,443	10,497,443	28,760
Day-trippers	28,899,970	28,899,970	79,178
Total	56,752,416	101,768,215	278.815

Source: Own elaboration.

data sourced from mobile phone signals of individuals entering the city. An algorithm automatically categorized each mobile device into one of four groups: (1) Barcelona residents, (2) commuters working in Barcelona but residing elsewhere, (3) Spanish non-commuters from other municipalities, and (4) international visitors using phones registered abroad. This methodology provided an hourly breakdown of user counts in each category throughout the year.

Since 2019, the Spanish National Statistics Institute has been releasing detailed monthly statistics on international mobile phone usage by nationality for each municipality in Spain. This enabled a thorough cross-verification of our municipal data with national statistics, bolstering the reliability of our findings. Additionally, national statistics offers data on inter-provincial people movement at the municipal level. We also utilized experimental data from the Spanish National Statistics Institute, consolidating information from major accommodation booking platforms (e.g., Airbnb, Booking, Expedia, TripAdvisor), and data from various surveys assessing tourist behaviour and perceptions in Barcelona (Observatori Turístic de Barcelona, 2020), coupled with the annual Barcelona mobility survey (Autoridad del Transporte Metropolitano- ATM, 2020). Leveraging multiple datasets concurrently allowed us to refine the classifications of city users originally based on mobile phone records.

Table 2 (density indicators) distinguish between tourists and visitors (tourists, false day-trippers and day-trippers). We also examined specific districts: Ciutat Vella, experiencing the highest tourism pressure, and Gràcia, noted for the most significant growth in tourism-related congestion (Mansilla & Milano, 2022). Additionally, the use of the 80th percentile in our analysis helped mitigate the influence of extreme data points.

Table 2
Density indicators.

Code	Indicator	Definition	Unit	Value
I1	Tourist density.	80th percentile of tourists and false day-trippers over the total area of the municipality.	Tourists / km^2	2397
I2	Visitor density.	80th percentile of visitors over the total area of the municipality.	Tourists / km^2	3194
I3	Relative share of tourism.	80th percentile of the ratio between the number of tourists and false day-trip tourists over the total number of users of the city.	%	9.05
I4	Relative share of visitors.	80th percentile of the ratio of the number of visitors to the total number of users in the city.	%	12.07
I5	Tourist density - Ciutat Vella.	Indicator variant 1 in Ciutat Vella.	Tourists / km^2	22,539
I6	Tourist density – Gràcia.	Indicator variant 1 in Gràcia.	Tourists / km^2	3777
I7	Relative share of tourists in Ciutat Vella.	Indicator variant 3 Ciutat Vella.	%	34.7
I8	Relative share of visitors in Ciutat Vella.	Indicator variant 4 in Ciutat Vella.	%	37.2
I9	Relative share of tourists in Gràcia.	Indicator variant 3 in Gràcia.	%	10.73
I10	Relative share of visitors in Gràcia.	Indicator variant 4 in Gràcia.	%	13.11

Source: Own elaboration.

3.4. Environmental indicators

In recent years, environmental considerations have increasingly influenced discussions about the sustainable limits of tourism growth. This shift is particularly evident since the widespread adoption of the 'carbon footprint' concept. This notion posits that a tourism destination's sustainable threshold is breached when tourists' resource consumption surpasses the local environment's capacity to replenish these resources. The environmental impact of tourism manifests in two primary ways. First, the ecological cost of tourist travel significantly exceeds that of resident mobility. Second, tourists typically consume more resources than residents, evident in their higher energy consumption, greater generation of solid and liquid waste, more extensive water use, and substantially larger carbon footprint (Cole & Sinclair, 2002). In densely populated urban areas, the demand for resources (such as food, energy, water, and waste management) often outstrips the area's capacity to produce them, prompting a need to establish environmental limits for tourism.

Numerous studies have focused on the tourism sector's carbon footprint (e.g. Gössling, Hansson, Hörstmeier, & Saggel, 2002; Lenzen et al., 2018; McKercher, Prideaux, Cheung, & Law, 2010; Rico et al., 2019). The UNWTO and ITF (2019) report that the average tourist trip generates approximately 0.25 t of CO_2 equivalent. However, this figure masks a wide range of scenarios. For instance, Dwyer, Forsyth, Spurr, and Hoque (2010) estimated that tourism contributes to 3.9% to 5.3% of Australia's total emissions. In Barcelona, Rico et al. (2019) found that the average carbon footprint per tourist is 111.6 kg CO_2 per day, compared to 43 kg CO_2 for day-trippers. Research into the footprint of other resources like energy, water, and waste generation is less common, and studies that link these footprints to a destination's carrying capacity are particularly rare. However, environmental indicators have been utilized in various studies (Bertocchi et al., 2020; Chen, Ye, Jing, Wu, & Ma, 2017; Geng, Maimaituerxun, & Zhang, 2020; Kallis & Coccossis, 2017; Leka, Lagarias, Panagiotopoulou, & Stratigea, 2022; Ren, Zhao, & Fu, 2019; Sharma, 2016; Zhang et al., 2018; Zhou, He, Wu, & Li, 2022).

Indicators for water usage, waste generation, and energy consumption are derived from projections of average consumption per establishment, combined with the total number of visitors for each tourist category. The methodology for calculating the carbon footprint in this study is based on Rico et al. (2019) approach, which includes a detailed assessment of the air travel footprint (using the International Civil Aviation Organization's consumption metrics per flight). Additionally, the carbon footprint associated with cruise ship travel is incorporated (Rico et al., 2019; Simonsen, Walnum, & Gössling, 2018).

Table 3 presents eights environmental indicators for Barcelona, detailing the measurement units (percentages for water, energy consumption, and solid waste generation; metric tonnes and kilograms of CO_2 equivalent for greenhouse gas emissions) and the corresponding scores for each indicator.

3.5. Economic indicators

Contemporary research on carrying capacity in tourism has predominantly emphasized biophysical and environmental dimensions, often overlooking the economic aspects. However, a holistic understanding of sustainability necessitates the integration of three interconnected pillars: environmental, economic, and socio-cultural.

A body of scholarly work has begun to explore the concept of economic carrying capacity. Pioneering contributions in this field include the studies by Canestrelli and Costa (1988), who were among the first to conceptualize economic carrying capacity in tourism settings. More

Table 3
Environmental indicators.

Code	Indicator	Explanation	Unit	Initial value
I11	Relative share of visitors' water consumption.	Ratio of visitors' direct water consumption to water consumption of the city as a whole.	%	15.5
I12	Relative share of tourists' energy consumption.	Ratio of tourists' and false day-trippers' energy consumption in accommodation, catering, internal transport and high traffic areas to total energy consumption of the city.	%	6.79
I13	Relative share of visitors' energy consumption.	Ratio of visitor energy consumption in accommodation, catering, internal transport and high traffic areas to the total energy consumption of the city.	%	7.39
I14	Relative share of municipal solid waste generated.	Ratio of the amount of municipal solid waste (MSW) generated by visitors to the amount of MSW generated by visitors.	%	10.11
I15	Greenhouse Gas (GHG) emissions from tourism.	Level of total emissions attributed to tourism activity including all variables: access transport, cruises, emissions from accommodation, internal transport, trade, high traffic areas and waste.	M Tn CO_2e	12.16
I16	Greenhouse Gas (GHG) emissions per tourist.	Ratio of overall tourism emissions to total number of tourists.	Kg CO_2e	434.48
I17	Greenhouse Gas (GHG) emissions per tourist/day.	Ratio of overall emissions from tourism to total number of stays (tourists per day).	Kg CO_2e	166.07
I18	Greenhouse Gas (GHG) emissions per visitor.	Ratio of global emissions to total number of visitors.	Kg CO_2e	214.24

Source: Own elaboration.

recent studies, such as those by Wang, Huang, Gong, and Cao (2020) and Garola et al. (2022), have furthered this discourse by examining the economic implications of tourism in various geographical contexts.

Our methodology involves analyzing the expenditure patterns associated with different types of accommodation. By examining reported expenditure data from various accommodation categories and estimating the total number of tourists within each category, we aim to quantify the economic impact of tourism in Barcelona. As seen in Table 4, this approach allows for a nuanced analysis of how tourism revenue contributes to the city's economy while also considering the potential economic thresholds that could signal over-tourism and its associated negative impacts.

Table 4
Economic indicators.

Code	Indicator	Explanation	Unit	Initial value
I19	Share of visitor spending in GDP.	Ratio of direct tourism spending (not including indirect and induced tourism spending) of tourists and false day-trippers to the total GDP of the city.	%	8.75
I20	Share of visitor spending in GDP.	Ratio of direct visitor spending by all visitors to the total GDP of the city.	%	10.36

Source: Own elaboration.

4. Results: projection of scenarios

The findings are obtained from the scenarios, which are projections based on hypotheses regarding the indicators' behaviour. Although the main purpose of a scenario is to anticipate future situations, in Limit of Acceptable Change, the scenario has another function: it enables the indicators' behaviour to be analyzed with simulations of the control variables. The objective is not so much to predict the future (foresee what will happen), but to anticipate the effects certain criteria will have on the future (foresee what would happen if …). To address the most common possible situations, six scenarios and 23 variants are proposed (Table 5). These are explained by both their degree of intensity and possible indirect effects. Variant behaviour patterns were estimated for each indicator.

4.1. Trend-based growth

This scenario is based on a projection of previous behaviour on location and habit patterns. At the highest level, tourist density is close to 5000 tourists per km^2, which is the population density of European cities such as Amsterdam or Prague. This impact would be particularly significant in districts with the highest tourism activity (Ciutat Vella), which could reach a density of over 44,000 tourists per km^2 in the highest growth scenario, and over 30,000 tourists with a growth of 40%. The proportion of tourists compared to the total number of people occupying the area would increase significantly. In all the projections, the 80th percentile of the share of tourists over the local population would reach 10%, and in the maximum growth scenario, this would be 16%, rising to 21% if all visitors are considered. In districts with maximum tourist occupation (Ciutat Vella), half of the city's users would be tourists, while in districts with less tourist pressure (Gràcia), this could be as high as a quarter.

Tourism pressure is also likely to affect environmental indicators. Under the maximum growth scenario, visitors would account for 14% of the city's total energy consumption and 18% of the city's solid urban waste. In a 40% growth scenario, emissions would rise to 24 million tonnes of CO_2, and in a maximum growth scenario this would reach 17 million tonnes. Average consumption would not be affected as the increase would be proportional across all typologies.

4.2. Regional growth

The regional growth scenario is based on increased tourism activity stemming from an increase in short-haul visits and a decrease in long-haul visits, i.e. it evaluates the effects of an increase in distance friction due to a steady increase in the price of transport. This means that the effect of the reduction in distance and increase in average length of stay can be studied separately, although these two processes generally tend to occur simultaneously.

Most indicators perform fairly similarly to the trend-based growth scenario. Longer distance visitors are more likely to use high-end hotels, but the difference is minor. There is also a somewhat lower tendency towards congestion among short-distance visitors, however, the difference is not significant in comparison with the rest. This also affects consumption, which is mainly explained by differentials in accommodation usage. Thus, in a scenario of moderate overall growth, substituting long distances for short distances reduces the number of tourists in places under more pressure (Ciutat Vella) and also reduces average energy and water consumption and waste generation, but its effect on overall values is minor.

Two indicators do have a major impact. The most evident is greenhouse gas emissions, which shows that an increase in the number of local tourists means that each new visitor contributes a lower emissions load than the average of the previous load (E21 and E22 in Table 5). The second effect is the share of tourism spending in the city's GDP, where the extreme projection shows that an increase in visitors would not be

Table 5
Variations in the indicators for the different scenarios.

Code	Trend-based growth				Regional growth				Length growth			
	E11	E12	E13	E14	E21	E22	E23	E24	E31	E32	E33	E34
I1	2628	2858	3320	4704	2685	2675	2648	2576	2536	2743	3088	3774
I2	3504	3815	4437	6301	3473	3463	3438	3369	3326	3523	3868	4571
I3	9.81	10.55	11.99	15.96	10.03	10	9.91	9.66	9.53	10.23	11.39	13.6
I4	13.09	14.09	16.02	21.31	13.05	13.02	12.93	12.68	12.55	13.25	14.36	16.45
I5	24,717	26,894	31,250	44,316	25,256	25,162	24,900	24,224	22,995	24,529	26,318	30,124
I6	4140	4503	5230	7409	4230	4214	4179	4067	5017	4616	5456	7157
I7	36.74	38.63	42.06	50.17	37.33	37.15	36.94	36.31	35.37	36.72	38.58	41.67
I8	39.41	41.44	45.13	53.85	39.74	39.45	39.23	38.71	38.04	39.13	40.88	43.81
I9	11.62	12.48	14.14	18.68	11.86	11.83	11.79	11.47	11.39	12.33	13.99	16.78
I10	14.2	15.27	17.31	22.9	14.22	14.18	14.18	13.85	13.86	14.65	15.92	18.78
I11	16.96	17.95	21.34	26.37	16.92	16.91	16.78	16.42	16.65	18.23	20.88	25.58
I12	7.35	7.99	9.3	13.4	7.51	7.45	7.38	7.21	7.34	8.28	9.88	13.22
I13	8.03	8.68	10	14.16	8.19	8.14	8.07	7.89	8.02	8.97	10.59	13.98
I14	10.98	11.82	13.46	18.03	11.19	11.13	11.02	10.79	10.98	12.24	14.26	18.03
I15	13.37	14.61	17.04	24.33	13.22	13	12.53	11.41	12.19	12.23	12.3	12.45
I16	436.55	437.15	437.11	436.76	421.85	416.52	405.55	380.02	437.63	439.11	441.68	446.84
I17	167.44	168.16	168.92	170.2	161.93	159.87	155.6	145.66	158.11	146.6	130.89	108.13
I18	214.25	214.54	214.52	214.35	219.43	216.26	209.51	193.62	214.78	215.5	216.76	219.3
I19	9.49	10.23	12.34	15.61	9.59	9.49	9.27	8.75	9.31	10.16	11.57	13.99
I20	11.25	12.12	14.65	18.55	11.18	11.11	10.91	10.43	10.91	11.73	13.14	15.52

Source: Own elaboration.
E11. Tourism grows by 10%, i.e. 50% of the UNWTO's projection for Europe as a whole.
E12. Tourism grows by 20%: movement predicted by the UNWTO.
E13. Tourism grows by 40%, through the combined action of growth in international tourism and Barcelona's international image.
E14. Tourism in the city doubles again, following the pattern of previous decades.
E21. Growth in tourism from all distances, but higher among tourists from nearby (+20%) than those from mid- (+10%) or long-distance origins (+5%).
E22. Growth in tourism from nearby origins only, with a greater intensity in tourism in closest origins (+25%) than in mid-distance origins (+5%).
E23. Drop in number of tourists from long-distance origins (−10%) offset by a rise in tourists from nearby origins (+33%), and a levelling off those from mid-distance origins.
E24. Sharp fall in tourists from long-distance origins (−33%) and a slight decrease in those from mid-distance origins (−10%) offset by those from the increased numbers of those from closest destinations (+50%).
E31. 10% increase in average length of stay for all tourist profiles.
E32. 25% increase in the average length of stay of all tourist profiles.
E33. 50% increase in the average length of stay for all tourist profiles.
E34. 100% increase in the average length of stay of all tourist profiles.

matched by an increase in overall spending. The cost for short distance travel would therefore be a drop in average spending, meaning that the economic impact of the new tourists would be smaller. (See Table 5.)

4.3. Length growth

One of the characteristics of urban tourism is the relatively low number of overnight stays per visitor, given the prevalence of business tourism and the short-duration city break model (Dunne, Flanagan, & Buckley, 2010). However, the growing professional-leisure profile, rising travel costs and the gradual adoption of new travel patterns may change this trend. Therefore, this scenario is based on increased average stays with a stable number of tourists.

Increased length of stay creates pressure on the city similar to trend-based growth. As the average length of stay increases, the relative pressure on the most popular districts decreases, and the pressure on secondary districts increases (such as Sant Andreu, Les Corts and Gràcia). Therefore, the effects of increased tourist numbers are much more evident in districts with less pressure (Gràcia) than in districts with more tourist pressure (Ciutat Vella).

The environmental impact stemming from the increased number of stays is very similar to the trend-based growth scenario. Stays affect the consumption of accommodation, transport, the commercial sector and catering in the same way as tourist arrivals, so the impact on water consumption, energy consumption and waste generation is therefore considerable. However, emissions are practically the same despite a significant increase in the number of stays. As in the previous case, lower emissions accompany lower tourism spending. This is explained by the fact that an increase in the average length of stay directly affects average daily spending. However, this impact is smaller than the differences in distances.

4.4. Metropolitan growth

Barcelona's Urban Plan for Tourist Accommodation limits the growth of the city's accommodation supply. Given that the occupancy rate is very high, increased tourism pressure may shift part of the demand to metropolitan municipalities that have good public transport links to the capital. This would lead to an apparent stagnation in the number of tourists, but an increase in the number of day-trip tourists, as a consequence of shifting the tourism model from the local to metropolitan level.

The first effect is a lower density of tourism, as part of the stay is in metropolitan areas. However, pressure on the areas of greatest concentration (Ciutat Vella) is higher as metropolitan tourists and day-trip tourists tend to visit these areas more. In contrast, tourism pressure in the secondary districts (Gràcia) is slightly reduced. This means that the decentralization of the accommodation supply is conducive to lowering tourist density in the city, but tends to reinforce the centrality of the higher density areas. The second effect is lower visitor spending, as metropolitan tourists are not spending money on the city's accommodation offer. Thus, there is considerable pressure from tourism in Ciutat Vella and in the city as a whole, but the share of spending in the city's GDP would decrease in comparison to 2019.

4.5. Degrowth

Internationally, tourism is projected to grow, and at a local level,

Table 5
(cont.). Variations in the indicators for the different scenarios.

Code	Metropolitan growth				Degrowth				New mobilities growth		
	E41	E42	E43	E44	E51	E52	E53	E54	E61	E62	E63
I1	2613	2521	2476	2440	2166	1936	1877	1705	2512	2628	2857
I2	3401	3312	3270	3236	2958	2736	2677	2262	3303	3415	3635
I3	9.79	9.48	9.33	9.2	8.25	7.44	7.23	6.67	9.44	9.84	10.62
I4	12.81	12.5	12.34	12.22	11.3	10.49	10.3	8.87	12.46	12.86	13.62
I5	24,658	23,999	24,466	26,737	20,362	18,184	17,950	16,006	23,498	24,457	26,375
I6	4120	3976	3909	3864	3414	3051	2949	2687	3959	4142	4506
I7	36.8	36.17	36.65	38.73	32.45	30.01	26.67	27.64	35.67	36.62	38.38
I8	39.23	38.63	39.09	41.09	35.05	32.72	32.43	29.61	38.15	39.05	40.76
I9	11.6	11.24	11.07	10.95	9.8	8.85	8.58	7.94	11.2	11.66	12.58
I10	13.95	13.61	13.44	13.33	12.21	11.31	11.04	9.67	13.57	14.01	14.88
I11	16.66	16.1	15.57	14.53	14.3	13.05	12.45	11.5	16	16.56	17.32
I12	7.35	7.04	6.72	6.1	6.1	5.48	5.17	4.87	6.88	6.97	7.29
I13	8.03	7.71	7.39	6.76	6.76	6.13	5.82	5.52	7.56	7.72	7.9
I14	10.98	10.55	10.12	9.24	9.24	8.35	7.9	7.44	10.51	10.94	11.71
I15	13.37	12.45	12.16	12.06	10.67	9.48	7.96	6.56	12.45	12.69	13.25
I16	442.92	429.3	401.52	360.78	425.55	425.55	354.5	336.48	434.06	430.07	425.07
I17	168.37	165.35	161.49	162.45	161.97	161.12	139.9	126.54	163.02	158.91	152.53
I18	266.32	216	205.46	193.46	197.66	185.26	155.04	165.13	216.21	217.3	220.6
I19	9.47	9.15	8.95	8.67	7.97	7.18	6.92	6.41	8.84	8.99	9.4
I20	11.07	10.76	10.56	10.28	9.59	8.81	8.56	7.57	10.45	10.55	11.03

Source: Own elaboration.
E41. 10% increase in Barcelona tourism and 25% increase in the number of metropolitan tourists.
E42. 5% increase in Barcelona tourism and 33% increase in the number of metropolitan tourists.
E43. Stable number of tourists in Barcelona and 100% increase in the number of metropolitan tourists.
E44. 10% drop in Barcelona tourism, but 200% rise in metropolitan tourism.
E51. 5% drop in number of tourists and false day-trippers, and steady number of day-trippers and passengers from cruise ships.
E52. 10% drop in number of tourists and false day-trippers, and steady number of day-trippers and passengers from cruise ships.
E53. 25% drop in number of tourists, 10% drop in number of false day-trippers, and 40% drop in passengers from cruise ships.
E53. 30% drop in all types of tourists.
E61. 25% increase in personal motivation and private home use.
E62. 50% increase in personal motivation and private home use.
E63. 100% increase in personal motivation and private home use.

Barcelona's tourism image has strengthened in recent years. However, Butler's life cycle theory (Butler, 1980) proposes that destinations go through different phases until maturity, when the destination stagnates. This is a critical period that can trigger decline, stagnation or renewal. Cities have a tourist limit, either because of how the urban destination evolves, or how the tourism space is managed. Hence, a scenario of degrowth is envisaged, which foresees a decrease in tourist numbers across all indicators.

Although predictions suggest very significant decreases, this has a moderate impact on the indicators. With significant decreases in demand, tourist density remains at extreme values and the impact on the two control districts is clear, particularly in the areas with the highest concentration of tourists (Ciutat Vella). If the number of tourists drops by a third compared to the current value, tourist density in Ciutat Vella is expected to be 16,000. This scenario indicates that the city would not change significantly even with a substantial drop in the number of tourists. This is also evident in the impact on consumption. A decrease in the number of tourists would logically reduce the pressure on the indicators, yet they remain relatively high. For example, with a 30% fall in all types of tourists (including day-trippers), the share of water consumption from tourism would be around 10%, and energy consumption would be just over 5%.

4.6. New mobilities growth

One of the most significant changes in contemporary tourism is the consolidation of new typologies that lie on the border between tourism and non-tourism (Domínguez & Russo, 2010), owing to three concurrent processes that have changed the traditional structure of tourism: (1) labour mobility, which enables new ways of working to emerge in spaces outside the conventional office (Chevtaeva & Denizci-Guillet, 2021; Reichenberger, 2018); (2) the considerable increase in personal motivation driving mobility in spheres such as education, health or social relations (Casado-Diaz, 2009; Choudaha & Chang, 2012); (3) the growing importance of quality-of-life migration and mobility related to personal fulfilment (Benson & O'Reilly, 2016).

One of the main issues with this type of tourist is invisibility. Many of these tourists stay in places not classified as tourist accommodation and are therefore very difficult to detect. This type of tourism is characterised by a significantly longer stay, a marked decline in average tourist spending and low-grade hotels. This new mobility growth scenario is based on increased personal motivation and the availability of para-hotel accommodation. Overall, the impact of new mobilities on the indicators is fairly modest. For example, this type of tourist has much less impact on the economic structure of the city, because of the effect of staying in private homes, and the fact that their average expenditure is significantly lower. Lower hotel use and higher use of private homes also explain the very low impact on the environmental indicators.

These new mobilities growth represent another way of travelling,and travelling accounts for the bulk of emissions. This suggests that if the criterion for limiting carrying capacity is environmental and entails restricting access by air, this strategy would have to be linked to a global overview of mobility within the city. The second area affected by this typology is density; although many of the visitors would not be considered tourists by local residents, they have an undeniable impact on urban density: these new types of mobility also take up space and affect perceptions of overcrowding, especially in areas with the highest concentration of visitors.

5. Conclusions

The Limit of Acceptable Change serves as a complementary tool to the Tourism Carrying Capacity. Unlike the Tourism Carrying Capacity, where the visitor threshold is determined by technical criteria, the Limit

of Acceptable Change framework allows decision-makers to set this threshold based on their willingness to accommodate changes arising from tourism pressure. The traditional Limit of Acceptable Change model relies on indicator results from existing data, leaving decision-makers without insights into potential changes under scenarios of increased growth. This article introduces an expanded Limit of Acceptable Change model that includes a range of hypothetical scenarios and variations in indicators for each scenario. This approach allows stakeholders to better understand and anticipate the impacts of different tourist profiles, considering factors such as motivation, origin, and duration of stay. By analyzing how these indicators respond to diverse tourism intensities and characteristics, our method provides a more nuanced understanding of the relationship between tourism and destination sustainability.

The six scenarios presented in this study focus on possible alternative tourism development options for Barcelona. These scenarios have 23 variations and 20 indicators and cover a wide range of typologies such as the proportional growth of tourism demand (Trend-based growth), an increase in local tourists (Regional Growth), an increase in day trip tourists (Metropolitan growth), a fall in the number of tourists (Degrowth), an increase in the number of days of stay (Length growth) or an increase in personal motivations combined with parahotel accommodation (New mobilities growth). The purpose of these scenarios is to assess the effects on key indicators arising from diverse changes in both the volume and characteristics of tourist influx. This evaluation aims to enhance the effectiveness of the decision-making process within the Limit of Acceptable Change framework.

The research findings indicate that substantial shifts in the indicators, either upward or downward, are required to produce significant changes. Minor or moderate alterations in tourist numbers generally have only a limited effect on the key variables. Given the entrenched nature of tourism in Barcelona, it's improbable that small or moderate fluctuations will lead to substantial transformations. Nonetheless, marked increases or decreases can profoundly influence the city's tourism structure. However, responses to these variations are not uniform across all indicators. For example, the density parameter shows minimal sensitivity to changes in visitor numbers, whereas environmental indicators, particularly those concerning water, energy, and waste management, demonstrate a more pronounced response. Consequently, a destination pursuing an environmental strategy might observe tangible outcomes even with relatively minor adjustments in tourist volumes.

As mentioned above, the objective of this extended version of Limit of Acceptable Change is not only to assess the impact of change in tourist numbers, but also the typology of tourists. Some indicators vary if visitor characteristics change (i.e., origin, location, accommodation and/or motivation) even if the overall number of tourists remains the same. For example, with regard to environmental indicators, there would be a clear difference in CO_2 emissions if tourists came from the metropolitan area (Regional growth) or from more distant origins (New mobilities growth), even if the number of tourists remained the same. Therefore, when establishing which changes are acceptable, both the number of tourists and their make-up must be considered.

Utilizing the Limit of Acceptable Change model equips city tourism managers with a crucial instrument for predicting and comprehending the dynamics in various scenarios. This has practical significance, enabling destination managers to formulate well-informed decisions and establish strategies that align with their objectives and priorities. With insights into the potential evolution of future scenarios, these managers can adeptly modify and steer the city's tourism policy. This includes adapting to emerging conditions through strategic initiatives and planning targeted actions for specific tourist demographics, or even mitigating the adverse impacts of tourism. Implementing this tool will enhance decision-making processes and facilitate long-term strategic planning in tourism, fostering sustainable development and maintaining a balanced approach to tourism in the city.

For example, if the destination's tourism decision-makers are interested in reducing the pressure on overcrowded sites, strategies for Regional Growth, Length growth or Degrowth scenarios may be appropriate, as they foresee reducing overcrowding. While Regional Growth leads to a drop in tourism spending, Length growth leads to an increase in water or energy consumption, and Degrowth leads to lower consumption. A further example would be destination managers interested in promoting the Meeting Incentives Congresses Exhibitions tourist typology. This would lead to a drop in the number of tourists in the most pressured areas (Ciutat Vella) moving them to more outlying areas with less tourist pressure; however, this would lead to higher CO_2 emissions.

There are several limitations to this study, as well as scope for further research. Firstly, based on the literature review, tourism density, economic and environmental indicators are used, although other indicators could also be considered. Therefore, outcomes may be conditioned by the choice of indicators, which is an integral part of the governance process of any tourism destination. Social indicators, which have been used in a number of previous studies, were not included in this article as no significant relationship could be established between the variation in the number of tourists and their impact on the indicators. This stands as a significant limitation of our model, which only accommodates indicators demonstrating predictable responses to scenario changes, such as density, environmental, or economic factors. Consequently, variables like evaluations, housing accessibility, or noise levels remain unaddressed.

Regarding applying the scenarios, the indicators are considered to be *cateris paribus*, as the values depend on the situation in which they are collected. Therefore, a periodical revision of the indicators would be required for the destination to be able to use up-to-date information.

CRediT authorship contribution statement

José A. Donaire: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Núria Galí:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Lluís Coromina:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation.

Declaration of competing interest

The authors declare no conflict of interest.

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