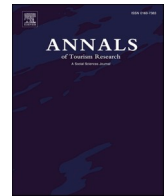




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A proposal for an overtourism index

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ABSTRACT

The rise of mass tourism has led to overtourism, where visitor numbers surpass a destination's sustainable capacity, causing environmental degradation, resource overuse, and social tensions. This study introduces a novel tourism intensity index tailored for small littoral towns, using the Cinque Terre (Italy) as a case study. Employing the Peña Distance method (DP2), the research quantifies tourism pressure and provides a framework for assessing overtourism risks. The resulting index aids in identifying policy interventions and strategies to mitigate overtourism, fostering long-term sustainability for vulnerable destinations. This approach offers a quantitative tool to address the critical challenges posed by overtourism, with implications for sustainable tourism management in similar contexts globally.

Introduction

The evolution of mass tourism has had a significant impact on society, the environment and the economics of destinations (Bang & Jang, 2025). In recent decades, as the global economy has grown and the availability of affordable transportation has increased, more and more people can travel to distant places and experience different cultures (Indovino, 2019).

The implications of mass tourism are numerous and complex. On the one hand, it has helped stimulate the economy of many tourist destinations, encouraging the creation of jobs and infrastructure. Tourism has become a vital sector for many countries. For example, in the case of Italy it represents 13 % of Italy's gross domestic product (GDP) (ISTAT, 2023). However, mass tourism can also lead to overexploitation of destinations' natural and cultural resources. Increased visitor numbers can put a strain on the environment, causing problems such as pollution, soil erosion and excessive water consumption. Furthermore, the influx of tourists can lead to a commercialization and standardization of destinations, with the homogenization of tourist attractions and the loss of cultural authenticity. Furthermore, this phenomenon can also have a negative social impact on local communities. The increase in tourism can lead to real estate speculation and an increase in housing prices, making it difficult for residents to continue living in their communities. In addition, labor exploitation, discrimination and the loss of local cultural traditions may occur (Gupta & Chomplay, 2021; Santos-Rojo et al., 2023; Séraphin & Chaney, 2023; Verissimo et al., 2020; Wattanacharoensil & Weber, 2020).

When mass tourism produces the negative impacts listed above, we speak of "overtourism". This phenomenon occurs when a tourist destination is overloaded with visitors: this results in the overexploitation of the destination's natural resources, the adverse impact on cultural attractions, and the negative effects on the environment and society (Gössling et al., 2020; Mihalic, 2020). In the field of

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literature, the phenomenon of overtourism has been the subject of recent studies from various perspectives, including its evolution, its causes, tourism phobia (Duignan et al., 2022), and its occurrence in large urban contexts such as Barcelona, Budapest, Venice, Prague, Amsterdam, and others.

However, a notable gap in these studies is the absence of an identified threshold beyond which the phenomenon of overtourism occurs. Existing measures tend to rely on large-scale aggregate data, such as provincial or national tourism density, which often obscures localized pressures, particularly in small or environmentally fragile destinations. Furthermore, many of these tools employ compensatory aggregation methods that serve to dilute the effect of critical indicators, thus failing to capture the complex and multidimensional nature of tourism overflow. This discrepancy is of particular concern in the context of the rapid growth of tourism that has accompanied the post-pandemic era, as destinations find themselves under pressure to balance the revitalization of the economy with considerations of long-term sustainability. This article aims to address this gap in the literature by developing a specific indicator which allows for the evaluation of the intensity of the phenomenon in a given destination (unfortunately not for a given time due to lack of data temporal disaggregation). Quantitative knowledge of the problem and the creation of appropriate indicators is the basis for correct policy guidelines.

The present study concentrated on the analysis of small areas, which have been identified as being more vulnerable to overtourism than large urban centers. This phenomenon can be attributed to a number of factors, including the absence of adequate tourist reception infrastructure, the limited physical space available in tourist centers, and the very small populations in which overtourism exerts a particularly significant impact. Destinations such as Santorini (Greece), Boracay (Philippines), and Easter Island (Chile) have all suffered the consequences of this phenomenon (Palombi, 2021; Sabandal & Gumban, 2024; Sarantakou & Terkenli, 2021), having to deal with excessive tourist flows and responding through closed numbers, cruise ship restrictions, and temporary closures. These cases illustrate how small-scale destinations, though numerically receiving fewer tourists than major cities, can nevertheless exceed their social and environmental carrying capacities. Consequently, the utilization of tools that are tailored to the scale and sensitivities of these contexts is imperative for the governance of tourism in an informed manner.

To this end, the present work focuses on the case study of the Cinque Terre, a world-known group of five littoral villages in Liguria Region (Italy) and compares their performances with other 4495 small Italian administrative units. To achieve this goal, we employed the Distance-Peña (DP2) method, a non-compensatory technique for the construction of aggregate indices, capable of offering substantial benefits in the examination of overtourism in tourist destinations, due to its non-compensatory structure and capacity to address multidimensional complexity (Ciacci et al., 2021; Ivaldi et al., 2020).

The work is divided into five sections. In the introductory section, the phenomenon of overtourism is defined, and the importance of analyzing tourist flows to address critical issues and identify valid solutions is emphasized. Section 2 (“Background research”) presents a literature review, a national and international benchmarking analysis, and the main motivation to consider the measurement of overtourism. In Section 3 (“Materials and Methods”) the data available and the methodology used to construct a first proposal for a tourism intensity index that can be used for the evaluation of the risk of overtourism in small municipalities, by taking as an example the case of the Cinque Terre. The findings of the study are presented in Section 4 (“Results”) and discussed in Section 5 (“Discussion and Conclusions”), where also limitations and suggestions for a possible research agenda are exposed.

Background research

Literature review

The United Nations World Tourism Organization (UNWTO) defines “overtourism” as the negative effect that tourism, in a destination or part of it, has on the quality of life perceived by residents and/or on the visitor experience (Koens et al., 2018). This phenomenon affects both residents and visitors, as they compete for limited resources. It is caused by tourist flows exceeding six different capacities that a destination should enforce to avoid the negative impacts of overtourism. (a) The physical capacity of a space is defined as the maximum number of people it can contain; (b) ecological capacity refers to the efficient management of tourist flows without damaging the environment; (c) social capacity is the limit on the number of tourists to avoid tensions with residents; (d) economic capacity is the balance between economic benefits and disadvantages of tourism; (e) psychological capacity is the maximum number of tourists who can be present without causing psychological distress and (f) policy capacity is the effective administrative management of the number of visitors (Indovino, 2019; Peeters et al., 2021). Academic research has been studying this issue in recent years: the term “Trexist” (a contraction of “tourist” and “exit”) has been coined to describe the strategies implemented by local planners to limit the tourist flow (Séraphin et al., 2018).

The United Nations' definition allows for both qualitative and quantitative measurements of the phenomenon, which, however, do not appear to follow a clearly defined methodological framework. Literature, however, has usefully focused on the causes of tourism pressure and its consequences.

About causes, although the challenges associated with overtourism are context-specific, the literature has identified several common factors. These include the expansion of emerging tourism markets (e.g., China, India, Brazil), the prevalence of day visitors who contribute minimally to local economies, reduced travel costs due to the proliferation of low-cost airlines, the rise of the sharing economy through platforms such as Airbnb, increased media exposure of destinations featured in popular media, the effectiveness of destination marketing strategies, and the fragmentation of local stakeholders, which often results in a lack of coordinated governance and shared objectives in tourism management (Atzori, 2020; Dodds & Butler, 2019; Goodwin, 2017; Gowreesunkar & Vo Thanh, 2020; Séraphin et al., 2023).

The consequences of overtourism for the lives of residents are far from trivial. As Milano (2017) notes, the adverse effects of

overtourism on a destination include an increase in property prices, congestion and privatization of public spaces, a decline in the purchasing power of residents, an imbalance in the number of visitors and residents, seasonal and precarious work in the tourism sector and a transformation of the commercial fabric. Ghidini (2019) emphasizes that the concept of overtourism is relatively new, and it can give rise to economic, environmental, and socio-cultural imbalances and negative consequences.

Bourliataux-Lajoinie et al. (2019) examine the city of Barcelona (Spain), with a particular focus on the impact of digital technologies in exacerbating overtourism. The authors utilize Doxey's model (Doxey, 1975) to describe the five stages through which residents react to increased tourism: elation, apathy, irritation, antagonism, and replanning. As tourism increases, residents initially experience a sense of excitement and optimism regarding the economic and infrastructure benefits. However, as the negative aspects of tourism, such as noise, waste, and stress, become more pronounced, residents begin to express frustration and seek solutions to address these challenges. In the phase of antagonism, tourists are perceived as a source of disruption to daily life, and residents request that local authorities implement more sustainable management of tourism.

In recent years, various studies have addressed the topic of tourism-phobia as an inevitable consequence of the phenomenon of overtourism (Table 1).

We must be careful not to confuse tourism-phobia with touristification. Although these terms are sometimes used interchangeably in literature, it is essential to recognize the conceptual difference between them. Tourism-phobia, defined as an aversion to the presence of tourists or tourism itself (Sánchez-Bayón & Daumann, 2025), is regarded as a threat to the quality of local life. Conversely, the concept of 'touristification' signifies a more extensive and systemic process, encompassing the profound transformation of territories under the influence of tourism-oriented logics (e.g. the conversion of residential spaces into tourist accommodation, the diminution of proximity services). This phenomenon can lead to sentiments of frustration, anger and dispossession among residents (Cocola-Gant, 2023). Moreover, the extant literature indicates that the term "tourism-phobia" was coined to discredit the political opposition to the touristification process (Blanco-Romero et al., 2019), which is also understood as "the socio-spatial transformation derived from the capitalist nature of tourism commodification processes" (Cañada et al., 2023). In this sense, the extant literature clearly highlights how tourism-phobia can be considered a corollary of the touristification of a destination. Academic research and public policies must adopt analytical approaches capable of distinguishing between the two dimensions to propose truly effective and contextualized strategies.

As can be seen from what has been reported so far, both the United Nations and the literature show concern for the cause and consequences of tourism pressure, and from these consequences derives the very concept of overtourism. However, a method for measuring this pressure on the tourist destination seems to be lacking. To propose effective strategies, it becomes essential to have a litmus test that measures critical issues in relation to different local contexts and their specific vulnerabilities. By quantifying tourism pressure and introducing a novel tourism intensity index specifically designed for small littoral towns in Italy, this work aims to provide an innovative tool for the management of sustainable tourism.

Benchmarking analysis

This section of the manuscript presents the main case studies identified in literature both at national and international level.

In Italy, the Dolomiti Bellunesi have established a platform that provides data on traffic, arrivals, and attendance, as well as air quality monitoring (Tzatzadaki, 2021) while in Alto Adige a maximum number of beds on a provincial scale (set at 34 million overnight stays per year) has been imposed. The access to Braies Lake (Alto Adige Region) is now subject to a mandatory reservation system, with a limited number of tourists allowed per day. In the fragile Montecristo Island environment (Tuscany), the authorities have imposed an annual visitor limit of 2000 people (ticket price of €130 per person including return motorboat and guided tour of the island). In addition, the island can only be visited between March and October for a total of 22 days.

In the city of Perugia, there is an ordinance prohibiting tourist buses from entering the historic center and a monitoring system to identify the types of buses passing through. Since 2024 in Venice there is a system of random checks to guarantee a limited number of tourists, not exceeding 40,000 per day. Tickets cost between €3 and €10, depending on how crowded the city is. In addition, since August 1st, 2021, the government banned big cruise ships from entering the canals and basins of the historical city (Anzoise & Benetti, 2023; Dal Bianco, 2019; González, 2018).

The international case studies that have been most extensively examined in the literature are presented in Table 2.

The main strategies employed to mitigate the impacts of overtourism were categorised into two main groups: flow regulation and pricing policies. With regard to flow regulation, the most frequently employed solution on a global scale is the implementation of a maximum daily limit for tourists. This measure has been implemented in the majority of observed contexts (Dhiraj & Kumar, 2021; Hugo, 2020; Pathak, 2024). However, this was only possible through the collection of data on tourist flows, which are essential for

Table 1

A review of the literature on residents' aversion to tourism.

Author/s	Context	Purpose
Almeida-García et al. (2019)	Malaga city center	Identifying the reasons behind residents' aversion to tourism in historic city center.
Zerva et al. (2019)	Barcelona	Understanding of tourism perceptions by residents and local administration.
Rejón-Guardia et al. (2020)	Majorca	Proposing a scale to quantify tourism-phobia in Balearic Islands.
Shchuka (2020)	Berehove (Transcarpathia)	Identifying the key factors underlying the phenomenon of tourism-phobia among residents.
Almeida-García et al. (2021)	Malaga and Gdansk	Analyzing the impacts of overtourism and gentrification of historic city centers

Table 2
International benchmarking.

Context	Solution adopted/proposed
Barcelona	Approval of the plan "Barcelona Tourism 2020: a collective strategy for sustainable tourism".
Dubrovnik	By organizing the arrival times of the ships, both on a daily and annual basis, the objective of achieving a better tourism flow has been achieved. In addition, the number of simultaneous cruise calls has been limited to two and the number of cruise passengers to 4000.
Prague	Imposition of a maximum number of annual rentals on Airbnb, considered to be the cause of uncontrolled and irregular tourism.
Japan	"Sayonara tax" (tax on leaving the country) application to all residents and tourists leaving the country by plane or ship, with few exemptions.
Boracay Island (Philippines)	There is a limit of 6405 visitors per day and activities such as smoking, drinking, beach dining and beach parties are prohibited. In addition, ships carrying more than 2000 passengers are banned during the high season to avoid overloading the island's infrastructure and resources.
Machu Picchu (Peru)	The number of tickets to enter the area has been limited to 4550 per day and can only be purchased on the official website of the Ministry of Culture. Tickets can be purchased based on 8 different schedules, from 6 a.m. to 2 p.m., the maximum time allowed is two hours and it is forbidden to re-enter the area once you have left.
Maya Bay (Thailand)	Tourists can only visit the island for 1 h a day between 10 am and 4 pm, with a maximum of 375 tourists per hour.
Taj Mahal (India)	A daily limit of 40,000 visitors, ticket prices quadrupled compared to 2018, a maximum of three hours inside the mausoleum, installation of 7 gates with turnstiles and possibility of carrying out visits 5 nights a month to ease the daytime flow.

Source: own elaboration based on (Ballester Vicens, 2020; Bourliataux-Lajoinie et al., 2019; Camatti et al., 2020; Indovino, 2019; Koh & Fakfare, 2020; McKirdy, 2018; Timbrook, 2019).

determining the maximum capacity of a given area (for example, a square, main street, museum, etc.) and, consequently, for the optimal management of mass tourism (Mashkov et al., 2025).

Further regulatory policies identified in the literature concern the reduction of the number of means of transport reaching a specific destination (e.g. Amsterdam and Venice) (Kwai, 2023; Schemmer, 2022), as well as the implementation of restrictions on tourist visits. Following the advent of online booking (Honey & Frenkiel, 2021), the introduction of restrictions on the number of short-term rentals (e.g. Prague) and beds (Jason, 2022) has been observed, as well as a maximum duration of visits for tourists. Furthermore, the extension of visiting hours has been identified in the literature as a potential strategy for reducing the pressure of tourist flows and achieving a more balanced distribution of visitors throughout the day (Rafael et al., 2023).

In terms of pricing policies, there is the possibility of adaptation to different contexts. One such example is the implementation of a ticket system for access to specific tourist areas, including historic centres and museums. The ticket is based on a model that considers the timing of user entry, both on a daily and seasonal basis. Consequently, higher rates are applied during peak hours or seasons, while lower rates are applied during off-peak hours or seasons (Nepal & Nepal, 2021). Further potential solutions to the issue of overtourism include the introduction of taxes on hotel stays, cruises, or day visits. Examples of such policies include the Venice Lagoon Tax, the Montecristo Island Tax, and the Sayonara Tax in Japan. It is of the utmost importance that the revenue generated from these policies is then reinvested to enhance the accommodation facilities in the area and guarantee that tourist experiences do not negatively impact the quality of life of residents (Séraphin & Ivanov, 2020).

However, a critical reflection on the contradictions inherent in the pricing policies adopted to regulate tourist flows also deserves attention. In certain instances, these strategies are intended to enhance the tourist offer through a high-end positioning, with the objective of attracting visitors with greater spending capacity. This approach has been shown to favor elitism processes, with the implicit exclusion of less well-off social segments, and contribute to the so-called "fake degrowth", or an apparent reduction in tourist pressure, which does not address the structural issues of the development model but relocates them on other socioeconomic bases (Blanco-Romero et al., 2023; Fletcher et al., 2020). These dynamics give rise to questions regarding the true sustainability and inclusivity of such policies.

Why and how to measure overtourism

The negative externalities associated with overtourism have led in recent years to an openness toward the development of statistical tools that can measure and monitor the phenomenon, although to date there are still limited application examples in the literature. At the European level, significant importance can be attributed to the European Parliament's research for the Transport and Tourism (TRAN) Committee "Overtourism: impact and possible policy responses" (Peeters et al., 2018), which advocates the need to provide policy makers with tools to support urban tourism planning. In a first attempt to formalize an index, Peeters et al. (2018) propose the development of a composite indicator for measuring regional (NUTS-2) overtourism, identifying possible dimensions like tourism density and intensity, the impact of sharing economy in the accommodation offer, the presence of significant transport nodes (e.g. airports, cruise ports), and the role played by World Heritage Sites (WHS).

A different approach in the choice of indicators was adopted by Amore et al. (2020). The authors in fact emphasized the potential ambiguities associated with intensity of tourism, since the variables related to the number of arrivals and overnight stays do not allow the distinction between the share of visitors who travel for tourism and those who travel for other reasons (e.g., work, study, etc.), besides excluding one-day visitors from counting. Another example reported by Amore et al. (2020) and Costa and Martinotti (2003) is related to the use of tourist density, which is considered misleading by the authors because of the short average length of stay and the concentration of tourists around the city center area, in proximity to the main attractions. This would make the use of the overall resident population as a reference value incorrect.

An additional element to consider is related to the spatial dimension in the application of the index. Most proposals tend to

approach the study of the phenomenon at the regional or provincial level (Demoskopika, 2024; Peeters et al., 2018) or limit the study to comparable contexts, as in the case of capital cities and large urban centers that attract major tourist flows (Amore et al., 2020).

Demoskopika (2024) proposes a preliminary index for the national monitoring of the distribution of overtourism in Italy, through the construction of a tourism pressure index applied at the provincial level (NUTS-2). In addition to the indicators traditionally used in the literature, the proposal takes into account the contribution of tourism flows to municipal waste generation, identifying the pressure on waste management generated by the tourism sector as an additional negative externality.

Macroscopic analyzes often overlook small areas and islands, which are highly vulnerable to overtourism due to limited space and fragile orography (Amore et al., 2020). This creates a lack of a standardized, spatially sensitive, and non-compensatory framework specifically designed to assess overtourism at the municipal level. Literature shows also that existing indicators often rely on compensatory methods or aggregated data, risk being distorted by the strong correlations among the variables. To fill this gap, the study develops an ad hoc index based on the Peña Distance method (DP2), which corrects for multicollinearity and preserves interpretability, offering a robust way to measure overtourism intensity (detailed in Section 3.2). The index is applied to small Italian coastal municipalities, with a focus on the Cinque Terre.

This UNESCO site, composed of five littoral towns, is particularly exposed to overtourism due to its geography, limited accommodation capacity, and intense flows, which could generate environmental stress, congestion, and negative perceptions among residents.

Materials and methods

Application area and selection of data

The aim of the article is to provide a useful tool for spatial and temporal monitoring of overtourism within small administrative units. For this reason, by using the geospatial classification of the Italian Institute of Statistics (ISTAT), 4.495 medium municipalities with a territorial extension equal or less than 25km² (2.500 Ha) were selected, out of a total of 7.904. The adoption of smaller geographical units makes it possible to limit the distortive effects mentioned regarding the use of overly large area and global resident population as a reference variable (Blázquez-Salom et al., 2023; Peeters et al., 2018). Moreover, according to the main data collected by ISTAT, it appears that in large urban centres the extent of the historic centre is generally between 15 and 20 km². In view of the findings of the literature review, where it was observed that tourist flows are more concentrated in the historic centres, limiting the classification to medium-sized municipalities could prove to be an approach to assessing the risks of overtourism in large urban centres (Celata & Romano, 2022; Città di Venezia, 2022).

The selection of the indicators to be considered, which is repeated in the literature, is still an issue that has not been fully clarified, allowing in several cases the construction of datasets with internally high levels of correlation between variables.

The identification of the dimensions of overtourism was carried out by combining a review of the theoretical framework and an analysis of previous experiences at national and international level, and by adopting a reflective approach. The selection of indicators was guided by their established use in the literature on overtourism, the availability of reliable data across all municipalities, and the need to ensure comparability and consistency across a large territorial sample.

Five key indicators were selected (Table 3), which were previously used by Demoskopika (2024) for the development of an overall index of overtourism, carried out on an experimental basis for the evaluation of tourism at NUTS-3 level.

The dataset was successively rebuilt and harmonized to ensure comprehensive coverage of indicators at the spatial level. This process included the exclusion of municipalities without accommodation facilities, which ultimately refined the sample to 1245 medium-sized municipalities. The sample of municipalities was then further filtered by restricting the study to littoral municipalities, i. e. those whose location on the coastline means that they have direct access to the coast. Given the peninsular and insular nature of Italy, this choice seems significant in view of the potential socio-environmental vulnerabilities that small maritime municipalities represent.

Table 3

Definition of indicators of overtourism selected.

Indicator	Cod.	Description	Source ¹
Tourist Density	<i>TD</i>	Measures the concentration of tourists per unit area, calculated as the ratio of annual tourist attendance to the spatial scale of the area (km ²).	ISTAT
Accommodation Density	<i>AD</i>	Number of beds available per unit area (km ²). Data on alternative forms of overnight accommodation (e.g. AirBnB or owner-occupied holiday homes) are not available for the calculation of beds.	ISTAT
Tourist Intensity	<i>TI</i>	Ratio of tourist arrivals to the resident population providing a measure of the relative impact of tourism on residents' daily lives.	ISTAT
Utilization Rate	<i>UR</i>	Percentage of actual utilization of available beds, offering a measure of the intensity with which accommodation facilities are being used.	ISTAT
Share of Urban Waste per Tourist	<i>SUWT</i>	Assessment of the impact of tourism to municipal waste production, calculated as the difference of waste production per capita (resident population) and the waste production of the equivalent population (resident population plus tourist arrival) spread over 365 days (Eurostat, 2006).	ISPRA ISTAT

¹ Indicators calculated for the year 2022 and collected using the Italian National Statistics Institute (ISTAT) and Italian Institute for Environmental Protection and Research (ISPRA) databases.

Aggregation methodology

Recent studies increasingly employ synthetic indicators to measure overtourism. In Italy, Demoskopika (2024) proposed the AMPI ± index (Mazziotta & Pareto, 2018), but the high correlation among variables often reduces interpretative value. Our correlation matrix confirmed strong links, e.g. between Tourism Density and Accommodation Density (0.90), suggesting redundancy and risks of misinterpretation (Fig. 1). To overcome these limits, we adopt the Peña Distance method (DP2), which sequentially incorporates variables based on their unique contribution, avoiding multicollinearity (Nayak & Mishra, 2012; Somarriba & Pena, 2009; Traversa & Ivaldi, 2024).

Unlike PCA or DEA, DP2 preserves interpretability and provides absolute measures suitable for small municipalities (Fernandez & Martos, 2020).

The method works by calculating distances from a worst-case benchmark, normalising with the Fréchet distance, and assigning weights that reflect each variable's unique contribution after correcting for redundancy (Peña, 1977; Domínguez & Martos, 2012; Ciacci et al., 2021). This ensures balance between correlated dimensions and avoids dominance of a single indicator. Key properties such as monotonicity, invariance, transitivity and neutrality guarantee logical consistency and comparability across contexts. This methodology aligns with the principles recommended by the OECD for developing synthetic indices (OECD, 2008, Diamantopoulos et al., 2008).

Despite these strengths, DP2 is sensitive to outliers, so careful data screening is essential. To test reliability, we conducted an Influence Analysis (IA), repeatedly recalculating the index while excluding one variable at a time (Maggino, 2017). Results confirmed that the overall ranking of municipalities remains stable, supporting the robustness of the DP2 index for overtourism assessment.

Results

Elaboration of basic indicators

After completion of the selection process, the final sample used to calculate the index consists of 206 littoral municipalities, distributed across 12 Regions at NUTS-2 level, as shown in Table 4. In addition to the regional distribution, a number of descriptive statistics are provided for the sample, giving a detailed overview of its main characteristics (Table 5).

Results of overtourism synthetic index

The final index was calculated using the R package p2distance (Pérez-Luque et al., 2012). Table 6 shows the value of the (1-R²) correction factor, together with the order in which the elementary indicators were included. This order was determined based on the correlation coefficient between the values of each variable and the DP2 index, reflecting their relative contribution to the overall index.

Tourism Density (TD) was the first variable included, with the highest linear correlation coefficient (1.45) and a correction factor of

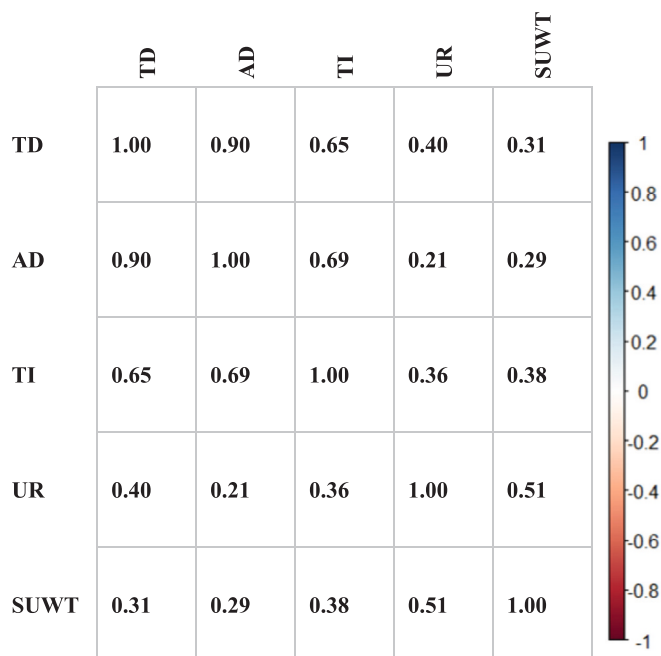


Fig. 1. Correlation matrix of Overtourism dimensions.

Table 4
Regional distribution of medium (<25 km²) littoral municipalities of Italy.

Region (NUTS-2)	Number of litoraneal municipalities (<25 km ²) ¹
Abruzzo	9
Calabria	28
Campania	35
Emilia-Romagna	7
Friuli-Venezia Giulia	4
Lazio	3
Liguria	44
Marche	13
Puglia	15
Sardinia	3
Sicily	39
Tuscany	6

¹ Number of total observations 206.

Table 5
Interquartile distribution of individual variables and basic indicators of overtourism for medium littoral municipality of Italy.

	Mean	Min	1st Quartile	2nd Quartile	3rd Quartile	Max	Source ¹
Individual Variables							
Total Area (km ²)	12.95	0,12	8,04	13,18	17,98	24,85	ISTAT
Resident Population	7.957	369	2.343	5.055	10.085	63.330	ISTAT
Number of hotel beds	2.757	63	434,8	1.165	2635,5	68.017	ISTAT
Number of annual arrivals	409.304	1.015	23.057	111.430	457.867	7.344.440	ISTAT
Basic Indicators							
Tourist Density	40.459	46,31	2.285,12	12.202,96	42.282,76	517.891,88	ISTAT
Accommodation Density	268	3,61	36,10	106,95	283,99	4.329,73	ISTAT
Tourist Intensity	65	0,11	6,02	26,11	83,68	1.074,84	ISTAT
Utilization Rate	33	0,95	14,47	28,95	45,48	102,35	ISTAT
Share of Urban Waste per Tourist	-21	-150,29	-26,95	-6,74	-2,28	1,59	ISTAT/ISPRA

¹ Indicators selected for the year 2022 and collected through the use of the Italian National Statistics Institute (ISTAT) and Italian Institute for Environmental Protection and Research (ISPRA) databases. Number of total observations 206.

Table 6
Order of variables entrance in the DP2 and correction factor values.

Sort	Variable Cod.	Linear Correlation Coefficient	Correction Factor (1 - R ²)
1	TD	1.45	1
2	AD	1.33	0.18
3	TI	1.30	0.52
4	SUWT	0.75	0.85
5	UR	1.33	0.50

1. This indicates that TD has the strongest relationship with the DP2 index and serves as the most influential variable in its construction.

Accommodation Density (AD) and Tourism Intensity (TI) follow with similar correlation coefficients of 1.33 and 1.30 respectively. However, their correction factors are different. AD has a low correction factor (0.18), suggesting that much of its variability is already accounted for by TD. In contrast, TI, with a higher correction factor (0.52), introduces additional, unique information into the index.

The Share of Urban Waste per Tourist (SUWT) was included next. Although it has a lower correlation coefficient (0.75), its relatively high correction factor (0.85) indicates that it provides unique information not captured by the other variables, despite its weaker overall association with the index.

Finally, the Utilization Rate of Structures (UR) was included with a correlation coefficient of 1.33 and a correction factor of 0.50. This suggests that while the UR is strongly correlated with the DP2 index, its contribution overlaps to some extent with the previously included variables.

The interquartile and geographical distribution of DP2 index scores of tourism intensity is shown in [Table 7](#).

Table 7
Interquartile and geographical distribution of DP2 index scores of tourism intensity.

Region (NUTS-2)	N. of observations	Mean	Min	1st Quartile	2nd Quartile	3rd Quartile	Max
Total sample	206	5.31	0.05	4.02	5.18	6.37	17.78
Regional distribution							
Abruzzo	9	5.36	2.63	4.98	5.20	6.22	6.99
Calabria	28	4.50	2.10	3.51	4.42	5.14	7.70
Campania	35	6.04	0.23	4.64	5.59	7.20	14.95
Emilia-Romagna	7	8.66	5.33	6.09	7.46	10.89	13.85
Friuli-Venezia Giulia	4	7.68	2.90	4.01	5.03	8.70	17.78
Lazio	3	4.95	4.23	4.57	4.91	5.31	5.70
Liguria	44	5.88	0.05	5.20	5.87	6.93	11.37
Marche	13	5.75	2.77	5.06	5.46	6.02	9.68
Puglia	15	3.71	1.22	1.99	3.69	4.76	6.54
Sardinia	3	4.33	3.83	3.87	3.91	4.58	5.24
Sicily	39	4.24	0.59	3.12	4.26	5.20	9.39
Tuscany	6	5.62	3.90	4.71	6.15	6.24	6.98

Discussion and conclusions

The indicator of tourism intensity

The primary objective of this paper was to devise a tourism intensity index with the capacity to identify and quantify the risk of overtourism. The index developed was particularly focused on small littoral municipalities, providing a foundation for the implementation of policies aimed at promoting tourism sustainability. This necessity emerged from the paucity of literature identifying a threshold for the certification of overtourism in a given territory. The index was constructed using data from 4495 Italian municipalities with a median area of less than 25 km², including only those with littoral characteristics and accommodation facilities, yielding a sample of 206 municipalities. Five key indicators were selected to represent the size of the phenomenon: tourist density, accommodation density, tourist intensity, utilization rate and waste impact per tourist.

The construction of the index is based on the Peña Distance method (DP2), which uses a parametric distance model to create an aggregate indicator. This method facilitates the management of correlations between variables, thereby avoiding redundancies, and enables the ordering of indicators according to their relative importance for the final result. The development of this index has enabled the creation of a novel metric for the measurement of overtourism, thereby empowering administrative bodies to utilize scientific methods for the precise determination of the presence or absence of this phenomenon within their respective municipalities. Consequently, this facilitates the prioritization of targeted interventions, including visitor flow regulation, infrastructure enhancement, and spatial redistribution strategies. For instance, globally, a variety of strategies have been adopted for the purpose of regulating tourist flows: the imposition of a daily cap on the number of tourists permitted is undoubtedly the most widespread practice (e.g. Lake Braies, the island of Montecristo and Venice in Italy, Dubrovnik in Croatia, Machu Picchu in Peru, and the Taj Mahal in India). Other measures most adopted were the limitation of the number of incoming transport vehicles (e.g. Venice, Dubrovnik and Maya Bay) and the reorganization of entry ticket prices (e.g. Venice, Machu Picchu, Taj Mahal).

Furthermore, when combined with qualitative data – such as resident perceptions or stakeholder input – the index has the capacity to inform participatory planning processes aimed at balancing tourism development with local well-being. In consideration of its adaptability, the index may also be integrated into monitoring dashboards or early warning systems, thus providing a valuable tool for longitudinal tracking and adaptive management of tourism dynamics at the local and regional levels.

However, the development of the model encountered several challenges, including the scarcity of data with temporal units less than a year, which restricts the capacity for seasonal analysis. Additionally, the absence of data on daily visits can potentially lead to an underestimation of the phenomenon, and the lack of data concerning non-hotel accommodation facilities and overnight stays in holiday homes also complicates the analysis.

The identified method and the measurement index constructed were applied to the Cinque Terre area, an Italian littoral location that is a UNESCO heritage site, characterized by a particular vulnerability due to limited infrastructural and environmental capacity.

The selection of this area for analysis is consistent with the ongoing local debate, in which both public and private entities are actively engaged in efforts to comprehend the potential drivers of overtourism. The objective is to develop policies that can effectively mitigate the negative externalities associated with tourism, thereby ensuring a more sustainable management of the region's activity. By focusing on the case of Cinque Terre, a globally renowned and highly visited destination, the study offers timely insights into the complexities of overtourism and provides a relevant case study for addressing the challenges faced by similar sites worldwide. It is therefore important to examine the context of Cinque Terre, tracing the results obtained in relation to the individual variables and then to the elementary indicators with which the DP2 index of overtourism was constructed.

It is noteworthy that in the case of all three Cinque Terre municipalities – Monterosso al Mare, Riomaggiore and Vernazza – the number of tourist beds exceeds the local resident population. This ratio is not discounted when considering that, of the 206 littoral municipalities included in the analysis, only 25 have a ratio of beds to resident population greater than 1. Additionally, the number of recorded visits to Monterosso al Mare and Riomaggiore in 2022 is notable, with figures of 511,824 and 474,506, respectively. These

exceed the national average for that year (409,304), particularly when one considers the absence of data regarding daily visitors and visits attributed to holiday homeowners.

A focus on the tourism pressure indicators, calculated for the construction of the overtourism index (Table 3) reveals that the greatest criticalities are found in the case of the Tourist Density, Tourist Intensity and the Index of Utilization of Tourist Facilities. With regard to tourist density, it is notable that Vernazza, which exhibits average values, is an exception. In contrast, both Monterosso al Mare and Riomaggiore display more pronounced levels of criticality, with results in 2022 exceeding the national average and positioning them within the lowest quartile of the distribution of small municipalities. It is noteworthy that for all three municipalities the indicator of tourism intensity TI exhibits values that are four to five times higher than the national average. Furthermore, while at the national level the occupancy rate of accommodation facilities in small Italian littoral municipalities is approximately 33 %, in the case of the Cinque Terre the annual estimate (in 2022) is higher than 70 % for all municipalities, reaching 90 % in the case of Monterosso al Mare.

The accommodation density indicator and the share of municipal waste per tourist are of less significance in all three municipalities. It is important to reiterate that the current methodology for calculating the impact of daily tourists and holiday homeowners on waste management does not include them in the calculation of the “equivalent population” (Table 3). This is a limitation of the current approach at the European and Italian national levels.

An analysis of the results for the three municipalities of the Cinque Terre based on the DP2 index reveals that they all fall within the highest quartile (Q3-MAX), which reflects the highest values of the index (Fig. 2). This suggests that these municipalities experience a considerably elevated level of tourism, underscoring the considerable impact of tourism in the area.

Vernazza is classified as being at high risk of overtourism with a DP2 score of 7.46., The municipalities of Riomaggiore and Monterosso al Mare demonstrate an even greater vulnerability, with DP2 scores of 8.49 and 8.73, respectively. These results are consistent with those obtained from the individual dimensions analysed, thus further underscoring the varying degrees of tourism pressure faced by these municipalities. Moreover, when all 206 small littoral municipalities are considered, Vernazza, Riomaggiore and Monterosso al Mare are ranked 24th, 15th and 9th, respectively. The lack of a complete dataset spanning a period of less than one year (e.g., bimonthly, monthly) precludes an investigation into the seasonality of the phenomenon. One potential solution would be to utilize data from telephone cells in order to supplement the data on arrivals and presences that are not detectable through official statistics.

A greater awareness of the temporal concentration of flows, in conjunction with an understanding of their distribution across the territory derived from the application of the index, would facilitate the implementation of redistribution policies with regard to tourist flows, encompassing both temporal and spatial considerations. With regard to the geographic aspect, it is observed that the region of Liguria, which hosts the Cinque Terre, has the highest concentration of small littoral municipalities, amounting to 44 out of 206. Of these, 29 exhibit a moderate to very high level of risk of overtourism. The awareness gained from the application of the index allows for the activation of tourism promotion policies affecting areas with a lower risk of overtourism. This can be achieved by promoting a portion of the territory capable of accommodating flows and reducing the pressure on areas that are already saturated.

This is of particular importance since the environmental consequences of overtourism in small littoral villages (e.g. Cinque Terre) affect not only the ecosystems but also the cultural and economic fabric that defines the areas' identity. The direct environmental impact is considerable. The surge in tourist numbers presents a significant challenge to waste management, as municipal systems are

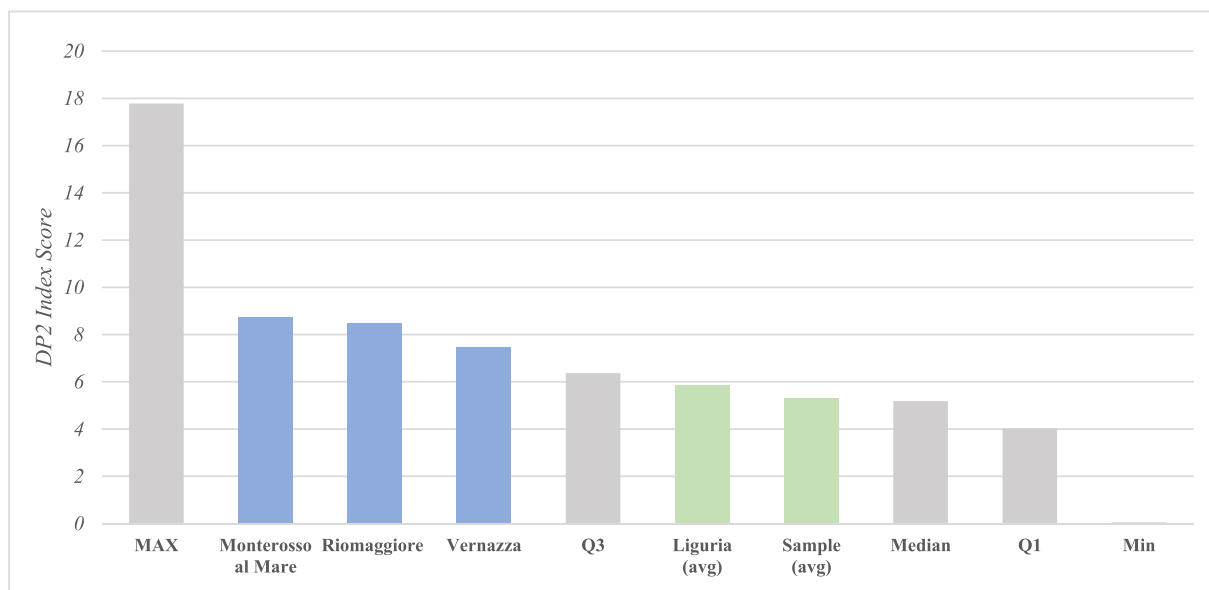


Fig. 2. DP2 Index Score Comparison: Monterosso al Mare, Riomaggiore, and Vernazza vs Regional and Statistical Benchmarks.

unable to cope with the considerable quantities of litter, plastic and organic waste generated by tourists. Furthermore, vehicular pollution, particularly in narrow and fragile areas, serves to exacerbate existing air quality issues and contribute to the erosion of the natural landscape. Congestion on local roads and paths intensifies soil erosion and inflicts damage upon native vegetation, which is vital for local biodiversity.

In addition to the more obvious effects, the phenomenon of overtourism has a more insidious impact on the local population in ways that are less visible but just as profound. As a result of the growing importance of tourism as an economic activity, property prices have risen significantly, and local services have had to adapt to meet the demands of tourists. This has led many residents to move away. This migration has resulted in the abandonment of traditional agricultural practices, particularly those associated with the cultivation and maintenance of vineyards on the iconic terraced hillsides. Built over centuries and supported by intricate dry-stone walls, the terraces require constant maintenance to prevent degradation. Despite the absence of empirical studies on the environmental consequences of the depopulation of tourist destinations due to overtourism, this phenomenon has been previously identified and examined in the context of rural abandonment driven by factors such as migration for work and study (Basile & Cavallo, 2020; Pavanini, 2023). The phenomenon of depopulation, regardless of its underlying cause, is associated with the neglect of cultivated fields. This can result in hydrogeological instability and an increased risk of landslides over the medium to long term (Acierno, 2015). The decline of agricultural practices also affects the production of local goods such as Sciacchetrà wine, a product inextricably linked to the heritage of the Cinque Terre. As local artisans and producers abandon these trades, the loss of traditional knowledge not only diminishes cultural diversity but also weakens the sustainable practices that have long preserved the region. The result is a landscape transformed - not only visually, as the terraced hills fall into disrepair, but also ecologically, as a once-diverse environment becomes susceptible to the homogenising pressures of mass tourism, eroding the environmental and cultural richness that makes places like the Cinque Terre unique.

These transformations underscore the need for a broader and more integrated analytical approach to touristification and overtourism, one that not only captures the quantitative pressure of visitors but also reflects the deep social and economic disruptions experienced by host communities. In this regard, future research would benefit from incorporating additional dimensions into the analysis, such as working conditions (e.g., wage levels, employment stability), housing affordability, and local income inequality. These variables are particularly relevant in contexts like the Cinque Terre, where the increasing reliance on tourism has coincided with rising living costs, labour precarity, and the gradual exclusion of long-term residents from the housing market. In line with this perspective, Martínez-Caldentey and Murray (2019) emphasize how tourism-related variables, such as employment in the tourism sector and overnight stays per inhabitant, can be key indicators of uneven geographical development, especially in regions that adopted tourism as a post-crisis economic strategy within the broader framework of European austerity policies.

Such factors help to reveal how overtourism contributes to processes of socio-spatial displacement and economic stratification, intensifying the erosion of local identity and resilience. This multidimensional approach would not only provide a more holistic understanding of overtourism but also strengthen the utility of the index as a policy tool. It would allow decision-makers to monitor early signs of tourism-driven inequality and housing stress, design more inclusive regulatory frameworks, and implement targeted interventions aimed at balancing tourism development with local quality of life. Furthermore, the integration of these variables aligns with international recommendations. The OECD (2024) emphasizes the importance of developing robust evidence bases for sustainable tourism policies, advocating for indicators that encompass economic, social, and environmental dimensions to inform policy decisions. Similarly, UNWTO's Statistical Framework for Measuring the Sustainability of Tourism (MST) provides an internationally agreed structure for assessing tourism's economic, social, and environmental aspects, facilitating more informed and holistic policy-making (Dwyer, 2024). In doing so, the analytical framework would not only become more robust, but also more attuned to the complexities of protecting cultural heritage, social equity, and environmental integrity in areas facing overtourism pressures.

It must be acknowledged that this work is not without limitations. The primary constraints associated with the conducted work pertain to the dearth of data regarding daily visits, the lack of data concerning non-hotel accommodation and the absence of comprehensive data disaggregated over a timescale of less than one year (i.e., two months or a month). A temporal segmentation would permit the implementation of differentiated instruments in accordance with the flow period, and, where feasible, the dispersion of flows by alleviating peak situations.

In view of the dearth of data on tourist flows in Cinque Terre, it would be advantageous to introduce a free entry permit issued by a single authority, which would facilitate the monitoring of tourist arrivals and presence in the area. Tourists would be required to provide the relevant authorities with information regarding the expected duration of their visit and the principal destinations they intend to visit. Such data would enable the authorities to collect information on tourist flows, thus facilitating the implementation of appropriate measures. It is also important to highlight that even with complete and temporally segmented data, it is not possible to separate knowledge of the context from a qualitative analysis that identifies the critical issues perceived by the resident population, stakeholders and public decision-makers.

As reported by Dong et al. (2024), one of the best ways to overcome the limitations associated with the lack of abovementioned data is the use of cellular data. By leveraging the geolocation capabilities offered by smartphones, it is now possible not only to provide a new definition of cities by delineating their dynamic boundaries, but also to address overtourism by monitoring flows in real time and gaining full awareness of the phenomenon. With this kind of data, the indicator and methodology proposed in this paper can also be expanded and replicated in other contexts and with other entities (e.g., other UNESCO-protected towns or islands).

Proper management of flows can involve decisions that involve pricing and regulation, so public decision-makers must start with quantitative and qualitative expertise to apply the best strategy to their territory. From a quantitative perspective, indicators that measure the extent of the problem, such as the one developed in this research, become essential.

In light of the findings of the literature analysis, it would be beneficial to consider incorporating a qualitative dimension of analysis

in future insights on the application of the index. While this does not represent the goal of the current study, it will contribute to a more contextualized understanding of the phenomenon at the territorial level by assessing the perceptions of both residents and tourists. In this regard, the proposed index may not be appropriate for regional, remote, or rural contexts, where even a small number of tourists can be perceived as overtourism. It is therefore suggested that future research tests the index's applicability in these contexts, possibly including qualitative measures or thresholds tailored to local communities' perceptions, to make the tool more equitable and sensitive to territorial differences.

CRedit authorship contribution statement

Claudia Burlando: Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Investigation, Funding acquisition, Conceptualization. **Enrico Musso:** Writing – review & editing, Supervision, Conceptualization. **Tiziano Pavanini:** Writing – review & editing, Writing – original draft, Resources, Investigation, Conceptualization. **Susanna Traversa:** Writing – review & editing, Writing – original draft, Methodology, Data curation.

Declaration of competing interest

We, the undersigned authors of the manuscript titled “A Proposal for an Overtourism Index”, confirm that we have no financial or personal relationships with other people or organizations that could inappropriately influence or bias our work.

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Data availability

Data will be made available on request.

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