3.2.2– Sets of threshold values

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INDEX

1. Introduction

Coordinated by AVT and with the support of FSMLRH, the system of indicators developed in the framework of the HERIT-DATA project has been conceived as a set of information that allows us to observe the sustainability of different heritage sites under the pressure of tourism. It is important to point out that the partnership has taken special care to develop a system that is flexible to the different types of locations (historic centres, natural spaces, archaeological sites or cities) and has also taken into account mass tourism in general, and cruise tourism in particular, since in several scenarios of the project pilots present this characteristic. Finally, it has been considered necessary that the work be replicable to other destinations of equivalent conditions in the European space.

The document describes the set of limits, their organization and the organization chart that make up the HERIT-DATA indicator system.

2. Levels of system characterization and operation

The system of indicators is based on a four-level hierarchical organization. The initial level is that of the indicators components, it is the base on which the rest of the levels are based, it delimits the limit states of the monitoring and statistical data. The next level is that of the indicators, and their generation is produced by the interaction of the indicators components. The third level is made up of the indicators set, there are only six of them. Finally, at the top of the structure is the overall sustainability benchmark, this index represents the general state of the system.

3. Thresholds by indicator components

3.1. Data to collect by indicator components

(E1) I.1.1	Environmental levels Sites
THRESHOLD	

(E1) I.1.2	Cost Investment - Maintenance sites
THRESHOLD	

(E1) I.2.1	Real saturation levels of people / spaces
THRESHOLD	

(E1) I.2.2	Expected saturation levels of people / spaces
THRESHOLD	

(E1) I.3.1	**Overnights/(number of beds in un-official accommodation*30)**
THRESHOLD	
93%	
(E1) I.3.2	**Cost Investment - Maintenance sites**
THRESHOLD	
93%	
(E1) I.3.3	**Tourists overnights in official accommodations / number of residents (monthly) (georeferred)**
THRESHOLD	
> 1	
(E1) I.3.4	**Tourists overnights in un-official accommodations / number of residents (monthly) (georeferred)**
THRESHOLD	
> 1	

(E1) I.3.5	Tourists overnights in all types of accommodations / number of residents (monthly) (georeferred)
THRESHOLD	
> 1	
(E1) I.3.6	**Ratio between the number of tourists overnights and the number of residents within a significant neighbourhood (to be defined according to the characteristics of the place or building, for example the UNESCO center)**
THRESHOLD	
to be defined according to the studied site	

(E2) I.4.1	Detection real transit of nº people / area / time
THRESHOLD	
fluid crowd = 1 person /m2 dense crowd = 2,5 person /m2 very dense crowd = 4,3 person /m2	
(E2) I.4.2	**Analytics anticipated reserves management: prediction of critical values agglomerations**
THRESHOLD	

(E3) I.5.1	Real time percepción overcrowded: Social net
THRESHOLD	
Monitoring of the trend and cycle of a series over time. Identification of an unusual increasing change of the negative reviews with respect a specific analysed topic	

(E3) I.5.2	Index perception post-experience overcrowded (sample)
THRESHOLD	

(E3) I.6.1 Real time perception overcrowded: Social net

THRESHOLD

Monitoring of the trend and cycle of a series over time. Identification of an unusual increasing change of the negative reviews with respect a specific analysed topic

(E3) I.7.1	Real time perception Security: Social net
THRESHOLD	
Monitoring of the trend and cycle of a series over time. Identification of an unusual increasing change of the negative reviews with respect a specific analysed topic	

(E3) I.7.2	Index perception post-experience Security (sample)
THRESHOLD	

(E3) I.8.1	Real time perception about hygiene, sanitation and cleaning conditions: Social net
THRESHOLD	
Monitoring of the trend and cycle of a series over time. Identification of an unusual increasing change of the negative reviews with respect a specific analysed topic	
(E3) I.8.2	**Index perception post-experience about hygiene, sanitation and cleaning conditions (sample)**
THRESHOLD	

(E3) I.9.1	Index perception post-experience cultural heritage preservation (sample)
THRESHOLD	

(E4) I.10.1	Ratio people / baskets / containers (ratio de contenerización)
THRESHOLD	

(E4) I.10.2	Volume of solid waste collection
THRESHOLD	
Defined as the max waste collection capacity (daily) from the company in charge	

(E4) I.10.3	Intervention ratio hygiene service by area
THRESHOLD	

(E4) I.11.1	Crime rate (tourism and general) in target area (EUROSTAT indicators)
THRESHOLD	

(E4) I.12.1	Air pollution ranges in heritage environment stations
THRESHOLD	

(E4) I.12.2	Range of noise pollution in heritage sites
THRESHOLD	

(E4) I.13.1 Waiting times in main transport public
THRESHOLD
> 10/15 minutes

(E4) I.14.1	% of free parking spaces in parking areas around the UNESCO center (daily).
THRESHOLD	
< 5%	

(E5) I.15.1	Residential / tourist housing ratio
THRESHOLD	

(E5) I.15.2	Housing value (m2): rent / buy
THRESHOLD	

(E5) I.15.3	Population movement flow analysis: historic center - other areas
THRESHOLD	
Negative change of residents number (annual), related to the middle term time series	

(E5) I.16.1	Rate and quality employment in target areas
THRESHOLD	

(E5) I.17.1	Analysis of the commercial offer in the target area
THRESHOLD	

(E5) I.18.1 Local price index
THRESHOLD

(E5) I.19.1	Employees' number of traditional activities (historical shops, handicraft shops, etc.) / total number of employees within the UNESCO area
THRESHOLD	
Negative change of the employees (referred to a specific ATECO), related to the middle term time series	

(E0) 0.20.1	**Delimitation and basic characteristics of sites subject to saturation : sites / spaces / heritage areas**
THRESHOLD	
(E0) 0.20.2	**Characterisation and types of routes - Tourist shops**
THRESHOLD	
(E0) 0.20.3	**Characterization of tourist profile visiting heritage areas/sites**
THRESHOLD	
(E0) 0.20.4	**Characterization of tourist profile visiting heritage areas/sites**
THRESHOLD	
(E0) 0.20.5	**Historical data tourism heritage areas**
THRESHOLD	

(E0) 0.20.6 Economic data tourism
THRESHOLD

(E0) 0.21.1	**maximum number of passengers disembarkation day / hour**
THRESHOLD	
(E0) 0.21.2	**Historical disembarkation of passengers**
THRESHOLD	
(E0) 0.21.3	**Disembarkation forecast nº of passengers / itineraries x day / hour**
THRESHOLD	

(E0) 0.22.1	Capacity of saturation sites
THRESHOLD	

(E0) 0.22.2	Accommodation by Type
THRESHOLD	

(E0) 0.22.2	Public transport by type
THRESHOLD	

(E0) 0.22.2	Tourist services by type in heritage areas
THRESHOLD	

(E0) 0.22.2	Restoration by type in heritage areas
THRESHOLD	

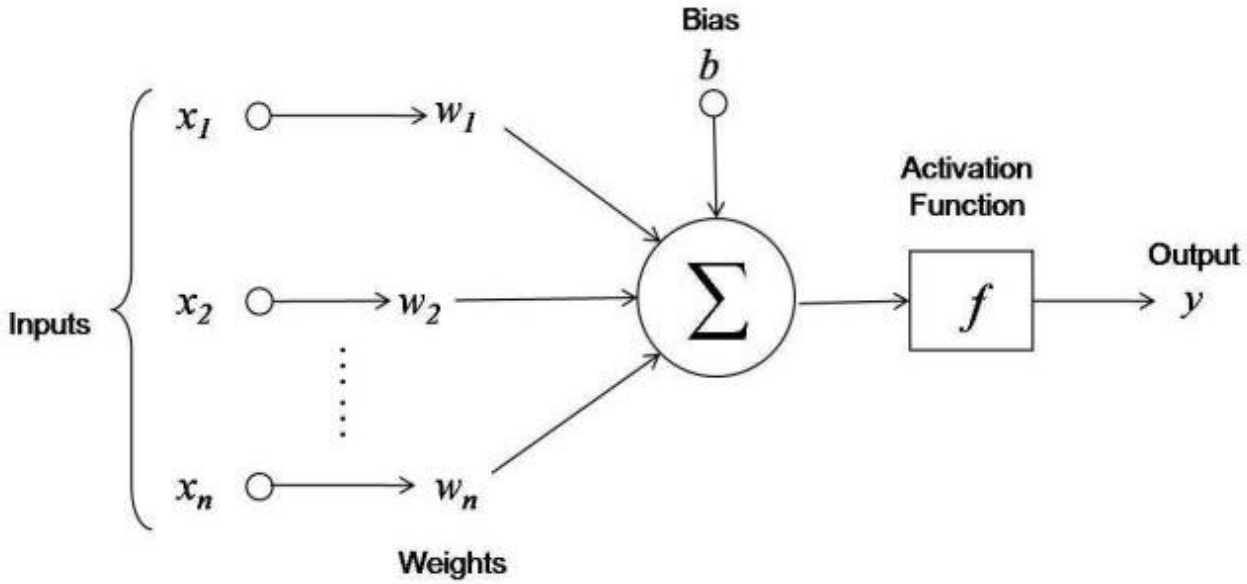
(E0) 0.22.2 Parking spaces in heritage areas
THRESHOLD

4. Thresholds by indicator

4.1. How it works

Indicators are obtained by formulating the indicator components and assigning a weight to each of them depending on the characteristics of the indicator (pilot scenario, relevance and quality).

The calculation process is based on two basic calculation models. The first one is the one that gives the function its structure, and it is the artificial neuron or perceptron, only in this case the activation function is not necessary, nor are the learning capacities required for the neuron, which will be implemented in future versions.



The other component of the process is an adjustment of the value of the weights depending on the number of indicator components involved in the calculus. This system allows you not to import the number of indicator components to obtain a valid indicator value, placing the result always between 1 and 3, the value 0 equals indicator without result.

Therefore, the following sequence is followed for the calculation of each indicator:

- Validation of elements with a value between 1 and 3 in the indicator components.
- Summation of the values of the weights of validated indicator components.
- Product of each indicator, by the weight of the indicator components, divided by the sum of the values of the weights.
- Sum of all product values.

The attached formula summarizes this process:

$$I = [(IC_1 x WC_1/\Sigma WC_s)+(IC_2 x WC_2/\Sigma WC_s)+...+(IC_n x WC_n/\Sigma WC_s)]$$

I = Indicator (value between 1 and 3)

ICn = Indicator component n

WCn = Weight of Indicator component n

ΣWCs = Sum of validated indicators weights

The weights of the indicator components are attached hereto. The weights vary between 1 and 3, with the value of 1 low, 2 medium, 3 high.

The representation of the result corresponds to a colour scale, the value 1 corresponds to GREEN, the value 2 corresponds to YELLOW, and the value 3 corresponds to ORANGE. As it is a colour scale, the intermediate values will have a colour representation dependent on the gradient, as shown in the attached image.

4.1. Weights of indicators components

(E1) I.1.1	Environmental parameters: temperature, relative humidity, degree of humidity, luminosity, xylophagous detection, gases (CO2, CO, NO2, NO, O3, SO2).	**3**
	Material used in construction	**1**
	Characteristics of the area to be monitored: movable property; air-conditioned/unheated space; covered/uncovered outdoor space, etc.	**2**
(E1) I.1.2	Annual investment in maintenance of sites of cultural interest (€)	**1**
	Technical study of annual maintenance requirements (with estimated cost data in euros)	**2**
(E1) I.2.1	Number of people per square meter at critical monitoring points	**-**
(E1) I.2.2	Number of people with reservations for tourist itineraries in places of cultural value	**3**
	Tourist Itinerary: sites included in the itineraries and visiting hours of each of them	**2**

(E1) I.3.1	N. of beds in official accommodation facilities (georeferenced), N. of overnights in official accommodation facilities	-
(E1) I.3.2	N. of beds in un-official accommodation facilities (AirBnB) (georeferenced), N. of overnights in un-official accommodation facilities ovenights	-
(E1) I.3.3	N. of overnights in official accommodation facilities, N. of residents	-
(E1) I.3.4	N. of overnights in un-official accommodation facilities, N. of residents	-
(E1) I.3.5	N. of overnights in official + un-official accommodation facilities, N. of residents	-
(E1) I.3.6	N. of overnights in official + un-official accommodation facilities, N. of residents, squared mile/meters around a spefic site or building	-
(E2) I.4.1	Number of persons in transit between two tourist points in a given time. Real time transit map - flows	-
(E2) I.4.2	Number of persons with anticipated reverva for each tourist itinerary X (tourist package or predefined tour)	**2**
	Tourist Itinerary X (predefined tour): sites included in the itineraries and visiting hours of each of them	**3**
(E3) I.5.1	Number and type of words-comments in social networks related to the concept of "massification", identified as a negative aspect in the tourist visit.	-
(E3) I.5.2	Answers to questions of questionnaires made to real tourists to the perception of "overcrowding" or "tourist saturation" of the visited site.	-
(E3) I.6.1	Number and type of words-comments in social networks related to the concept of "massification", identified as a negative aspect for the residents.	-
(E3) I.7.1	Number and type of words-comments in social networks related to the concept of "insecurity" identified as a negative aspect during the tourist visit.	-
(E3) I.7.2	Answers to questions of questionnaires made to real tourists to the perception of "insecurity" during the tourist visit made.	-
(E3) I.8.1	Number and type of words-comments in social networks related to the concept of "hygiene, sanitary conditions and cleanliness", in the tourist visit made.	-
(E3) I.8.2	Answers to questions of questionnaires made to real tourists to the perception of "hygiene, sanitary conditions and cleanliness", in the tourist visit made.	-

(E3) I.9.1	Number and type of words-comments in social networks related to the concept of "conservation of cultural heritage", in the tourist visit carried out.	**-**
(E4) I.10.1	Number of litter bins/containers installed in cultural heritage areas	**1**
	Total number of people at critical monitoring points.	**3**
(E4) I.10.2	Kilograms of solid urban waste collected per day in cultural heritage areas	**2**
	Number of times per day that waste is collected from bins or containers installed in cultural heritage areas	**1**
(E4) I.10.3	Number of times per day that cleaning/hygiene services are performed in public spaces in cultural heritage areas	**-**
(E4) I.11.1	Crime rate per 1,000 inhabitants: (total known criminal offences/total population) x1,000	**2**
	Number of robberies with violence or intimidation	**3**
	Number of criminal offences and misdemeanours of all types of theft	**2**
(E4) I.12.1	Levels of key pollutants that are harmful to human health and the environment: particulate matter (PM2,5 and PM10), tropospheric ozone (O3), nitrogen dioxide (NO2) and sulphur dioxide (SO2) - data from measuring stations located in heritage areas.	**-**
(E4) I.12.2	Acoustic indices: noise index day, noise index evening, noise index night.	**3**
	Type of acoustic area to which the cultural heritage to be monitored belongs (defined according to the predominant use of the land, for example residential use, sanitary use, educational and cultural use, etc.).	**2**
(E4) I.13.1	Average waiting time at public transport stops located in cultural heritage areas (by time zone and days of the week): by type of transport (bus, metro, etc.).	**-**

(E4) I.14.1	Number of parking spaces in parking areas around the UNESCO Center.	**2**
	Number of free parking spaces in parking areas around the UNESCO Center (daily/Hour).	**3**
(E5) I.15.1	Total number of dwellings in cultural heritage areas.	**2**
	Number of dwellings in cultural heritage areas dedicated to rental for tourists (tourist apartments).	**3**
(E5) I.15.2	Average price per square metre of housing in cultural heritage areas: sale and rent (€).	**-**
(E5) I.15.3	Number of residents in cultural heritage areas.	**-**
(E5) I.16.1	Direct tourism employment as percentage of total employment Total number of residents directly employed by tourism Total size of destination labour force	**2**
	Temporary rate in the tourist industry (percentage of employees with temporary contracts as compared with the total number of employees).	**3**
	Percentage of full-time/part-time contracts in tourism industry activities	**1**
(E5) I.17.1	Number of retail stores by type of products on sale: food and beverages; household items; cultural and recreational items; other items.	**-**
(E5) I.18.1	Consumer Price Index (CPI) in each of the 12 groups according to the international classification of consumption in the European Union (EU): ECOICOP (EuropeanClassification of Consumption by Purpose).	**-**
(E5) I.19.1	Demographics of economic activities by ATECO (Economic Activities Classification by ISTAT) sector in the Unesco area	**-**
(E0) 0.20.1	List of Tourist Areas (Hinterland + City) - heritage and historical areas	**2**
	List of main tourist attractions per area (geo referenciación)	**3**
	Area (km2) of each heritage area/historical centre	**2**
	List of Cultural Heritage buldings per area (geo referenciados)	**3**
(E0) 0.20.2	List of points of visit (tourist attraction) that are included in the itineraries / tours that are offered to tourists.	**2**
	Top five most popular tourist attractions (heritage and cultural attractions) included in tours.	**3**
(E0) 0.20.3	Number of tourists per country of origin	**2**
	Number of tourists per age	**2**
	Number of tourists travelling alone / with children	**2**
	Number of turists by means of transport used to reach the turist destination	**1**

(E0) 0.20.4	Number of tourist packages sold (total)	**3**
	Number of pre-sale tourist packages	**2**
(E0) 0.20.5	Number of visitors per Turistic Areas/ year	**3**
	Number of touristis in the peak month and number of tourists in the least crowded month in the Turistic Areas (historical and heritage areas)	**2**
(E0) 0.20.6	Expenditure made by turists (historical and hertigae areas) - average daily spending per tourist	**2**
	Expenditure made by cruiseship tourists (on land)- average daily spending per tourist	**3**
	Cultural heritage site attraction promotion (€/year)	**1**
(E0) 0.21.1	Maximum number of cruise passagers per every day of the week	**-**
(E0) 0.21.2	Number of passengers disembarked by month and year	**-**
(E0) 0.21.3	Maximum number of passengers that will disembark per day of the week and hours	**-**
(E0) 0.22.1	Maximum number of tourists allowed in the historical center and in Cultural Heritage buldings	**3**
	Average time (tourists) spent in historical center and in Cultural Heritage buldings	**2**
(E0) 0.22.2	Number of accommodations/beds in historical center	**3**
	Number of accommodations/beds in historical center- official accommodation: hotel, hostel, villas.	**2**
	Number of accommodations/beds in historical center - unofficial accommodation (tourist apartaments)	**2**
	Number of public bus stops in the historical center	**2**
	Number of metro stops (underground) in the historial center	**2**
	Number of train/tram stops in the historial center	**1**
	Number of…..... Stops in the historical center	**1**
	List of companies dedicated to cruise ships that arrive at ports linked to historical and heritage sites/zones	**3**
	Number of registered (officially certified) tourism enterprises operating the historic centre	**2**
	Number of unregistered (without official certification) tourism managers operating in the historic centre	**3**
	Number of Offical tourism information in the historical center	**2**
	Number of restaurants - historical center	**2**
	Number of bars (nigthclubs, pubs, etc.)	**1**
	Number of parking spaces in parking around areas the historical center	**2**
	Number of free parking spaces in parking areas around the historical center	**3**

5. Thresholds by indicator set

5.1. How it works

Indicators set are obtained by formulating the indicators and assigning a weight to each of them depending on the characteristics of the indicator set (pilot scenario, relevance and quality).

The calculation process is based on the same basic principles as the indicator calculation.

Therefore, the following sequence is followed for the calculation of each indicator set:

- Validation of indicators with a value between 1 and 3 in the indicator.
- Product of each indicator squared and multiplied by the weight of the indicator.
- Sum of the multiplication of the indicators by the weight of the indicators.
- Division of previous operations.

The attached formula summarizes this process:

$$ISET = \frac{\sum_{i=1}^{n}(In^2 * Wn)}{\sum(In * Wn)}$$

ISET = Indicator set (value between 1 and 3)

In = Indicator n

Wn = Weight of Indicator n

The weights of the indicator components are attached hereto. The weights vary between 1 and 4, with the value of 1 low, 2 medium, 3 high, 4 very high.

The representation of the result corresponds to a colour scale, the value 1 corresponds to GREEN, the value 2 corresponds to YELLOW, and the value 3 corresponds to ORANGE. As it is a colour scale, the intermediate values will have a colour representation dependent on the gradient, as shown in the attached image.

5.1. Weights of indicators

3	(E1) I.1 Preservation Level in optimal conditions (environmental and architectural) of sites of cultural value
4	(E1) I.2 Optimal levels of overcrowding of sites of cultural value
2	(E1) I.3 Optimal levels of Tourists overnights
-	(E2) I.4 Optimal levels of overcrowding of people transit
3	(E3) I.5 Tourists perception about adequacy of Overcrowded site experience
3	(E3) I.6 Residents perception about adequacy of Overcrowded site experience
1	(E3) I.7 Personal perception about adequacy of Security site experience
2	(E3) I.8 Personal perception about hygiene, sanitation and cleaning conditions site experience
4	(E3) I.9 Personal perception about cultural heritage preservation site experience

1	(E4) I.10 Optimal capacity of the urban cleaning service and decorum
2	(E4) I.11 Capacity to maintain optimal citizen security
2	(E4) I.12 Capacity to ensure permitted ranges of contamination - basic environmental conditions in heritage areas
4	(E4) I.13 Fluid access to public transport in heritage areas
3	(E4) I.14 Fluid access to parking spaces around heritage areas
2	(E5) I.15 Optimal levels of access to housing in tourist areas by local population
2	(E5) I.16 Optimal levels of access to Employment quality in tourist areas by local population
3	(E5) I.17 Optimal levels of access to local stores and products in tourist areas by residential population
4	(E5) I.18 Higher prices in target areas
1	(E5) I.19 Lack of identity of the traditional activities within the UNESCO area
3	(E0) 0.20 Characterization areas / sites of tourist value and tourism profiles
4	(E0) 0.21 Access capacity charge (heritage area from port)
2	(E0) 0.22 Capacity charge heritage area

6. Threshold by the overall sustainability benchmark

6.1. How it works

The overall sustainability benchmark is obtained by formulating the indicators set and assigning a weight to each of them depending on the characteristics of the indicator set (pilot scenario, relevance and quality).

The calculation process is based on the same basic principles as the indicator, and the indicator set calculation.

Therefore, the following sequence is followed for the calculation of each indicator set:

- Validation of indicators with a value between 1 and 3 in the indicator set.
- Product of each indicator set squared and multiplied by the weight of the indicator set.
- Sum of the multiplication of the indicators set by the weight of the indicators set.
- Division of previous operations.

The attached formula summarizes this process:

$$OSB = \frac{\sum_{i=1}^{n}(ISn^3 * WSn)}{\sum(ISn * WSn)}$$

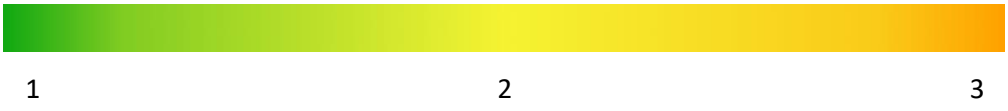
OSB = Overall sustainability benchmark (value between 1 and 3)

ISn = Indicator set n

WSn = Weight of Indicator set n

The weights of the indicator set components are attached here. The weights vary between 1 and 4, with the value of 1 low, 2 medium, 3 high, 4 very high.

The representation of the result corresponds to a colour scale, the value 1 corresponds to GREEN, the value 2 corresponds to YELLOW, and the value 3 corresponds to ORANGE. As it is a colour scale, the intermediate values will have a colour representation dependent on the gradient, as shown in the attached image.



6.1. Weights of indicators set

3	E.1 Building / Site Capacity Overcrowded
4	E.2 Tourist City Flows
3	E.3 People perception of overcrowded places
2	E.4 Capacity and quality to services access (heritage area)
1	E.5 Residential quality site
2	E.0 Characterization of areas of heritage value

7. Annexes

7.1. The concept of carrying capacity: theoretical aspects and its most consolidated formalization models

Definition of carrying capacity and related concepts

Since the 1960s, academic literature has produced several studies around the concept of carrying capacity, both from a theoretical and an empirical perspective (see e.g., Wagar, 1964; Fisher and Krutilla, 1972; Hovinen, 1982; Mathieson and Wall, 1982; O Reilly, 1986; Canestrelli and Costa, 1991; Butler, 1996; MAP Coastal Area Management Program "Fuka-Matrouh" Project, 1999; Cocossis et al., 2001; Bimonte and Punzo, 2004; Jovicicic and Ivanovicic, 2007; Navarro et al., 2012; Navarro et al., 2013; Salerno et al., 2013; Prokopiou et al., 20014 ; Chen and Teng, 2016; Feliziani, 2016; Carboni et al., 2017; Makhadmeh et al., 2018; Muler et al., 2018; López-Dóriga et al., 2019).
At any rate, carrying capacity can be generically defined as the *greatest number of tourists that a destination can bear (maximum use level), beyond which their impact becomes physically, economically and socially damaging, causing a net loss* (Costa and Manente, 2000).
More specifically, the World Tourism Organization defines the carrying capacity as the maximum number of people who can visit a given destination during the same period without compromising its environmental, physical, economic and socio-cultural characteristics and without reducing individual tourist satisfaction at the same time (WTO, 1999). Hence, carrying capacity is a set of capacities, including the ecosystem one, and can be represented in terms of (Satta, 2003; Bimonte and Punzo, 2005):

- Availability vis-à-vis use of a destination's natural resources;
- The aesthetical and experiential capacity connected to tourist satisfaction;
- And the socio-economic capacity referred to the satisfaction of the host community.

The concept of carrying capacity is closely related to that of the impact. There are three types of positive/negative impacts produced by tourism: economic, physical and social. The *economic impact* of tourism is *expressed as the monetary costs and benefits resulting from the development and use of tourist goods and services. The physical impact* consists in the *changes caused to the physical environment (with regard to both nature and culture)*. The *social impact* concerns *the changes caused to the destination's social and economic functions, which are representative of the host*

community's quality of life (Costa and Manente, 2000). While the economic impact is a market effect, the physical and social impacts do not manifest directly in monetary terms and therefore they qualify as externalities. In all three cases, the size and extent of the changes, whether positive or negative, depend on the level of use of a tourist destination and its resources endowment. Therefore, when investigating carrying capacity and maximum level of use, it is essential to identify the limit beyond which negative impacts exceed positive impacts, which often causes irreversible damage to a destination.

The existence of three types of impact, implies three possible sub-definitions of carrying capacity as described below (Costa and Manente, 2000):

- Economic carrying capacity: the limit beyond which the quality of tourist experience is drastically reduced, up to causing a decrease in the demand and thus in its corresponding supply or production. This concept reflects the point of view of those who consume the tourism product, that are, tourists and visitors;
- Physical carrying capacity: the limit beyond which a destination's environmental and/or cultural resources are damaged; this concept applies to any and all natural, historical and/or artistic resources that cannot be replicated and have been assigned to recreational uses;
- Social carrying capacity: the limit beyond which an area's social and/or economic functions are damaged and/or hindered, with the consequential degradation of the host population's quality of life.

In all three cases the effective limit is related to the number of visitors. The crowding-out effect of tourism over other businesses, is one of the most serious phenomena connected to social carrying capacity; this occurs with greater frequency, causing damage to the economic and social fabric. When the crowding out effect begins to appear, the maximum level of use, in terms of social carrying capacity, is supposed to be reached (Costa and Manente, 2000).

All three dimensions of the carrying capacity concept need to be assessed in terms of costs and benefits, as follows (Costa and Manente, 2000):

- The economic carrying capacity shall correspond to the limit beyond which the economic benefits reach their maximum value, i.e. the maximum demand level;
- The physical carrying capacity shall correspond to the limit beyond which the resource is irreversibly degraded or may only be recovered at costs so high that they may be considered infinite;

- The social carrying capacity shall correspond to the limit beyond which costs exceed benefits when it comes to the impact made by tourism.

We can conclude that, whereas economic carrying capacity is prevalently associated with market effects, mostly in terms of benefits, physical and social carrying capacities are linked to non-market effects, namely externalities, which assume relevance most of all in terms of costs. We are not referring to private production costs (intermediate and value-added costs, which, by definition, are equal to the primary labour costs, capital, etc.) but rather to the costs that the business of tourism causes to actors not directly involved. These costs may be attributed to three basic categories (Costa and Manente, 2000):

- **Public costs for infrastructure, superstructures and services not directly intended for tourists** (but for the host community ahead of everyone else) of which visitors make extensive use without contributing in an adequate manner;
- **Costs resulting from excessive tourism pressure, for example, congestion and/or pollution**, making a destination's services less accessible to residents and tourists. Impairment the physical integrity and safety of local attractions, thus making necessary to incur in costs to support or recover such resources;
- **Costs associated with long-term effects** related to the social and economic functions of a destination (as in the case of the crowding out effect).

The three dimensions (and their limits) of carrying capacity described above, contribute to determine the total carrying capacity of a destination. On this account, we introduce the concept of *maximum reception capacity of a destination*, which is identified as the strictest between the economic, physical and social constraints. However, this is not an absolute limit but an indicator of the critical thresholds that should be considered during the planning of a destination's tourism development.

We highlight that, for all the three carrying capacity cases, most of the time, the constraints cannot be precisely defined even when taking into account measurable variables. This situation can be effectively exemplified using the fuzzy set mathematical concept, by which there are constraints and thresholds that are not perfectly defined but may fall within a relatively broad range, within which an irreversible damage can occur (Costa and Manente, 2001).

Fisher and Krutilla's maximum reception capacity formalization model

As shown previously, when we consider the three dimensions of carrying capacity (economic, physical and social) and therefore three different limits, maximum reception capacity is understood to be the strictest constraint, namely the one that "Manifests itself" first out of the three.
The maximum reception capacity concept may be formalized by applying the Fisher and Krutilla model (1972) to the optimum use conditions of an outdoor recreational resource. In this case, the optimum tourism use of a destination is given by the maximization of:

$$\pi (q) = B(q) - C(q)$$

where:
π = net benefits
B = benefits (net of congestion disutilities)
$C(q) = C_c (q) + C_k (q) + C_d (q)$
C = costs
q = use level of the recreational attraction
C_c = current expenditures
C_k = capital expenditures
C_d = cost of damage to ecological environment

The net benefits π are given by the benefits of net costs, which the model breaks down as follows:

- current expenditures (operating expenses aimed at reducing, modifying or eliminating the adverse effects of congestion);
- capital costs to expand capacity, for example, reducing visit hours;
- costs caused by environmental damage, due to too many consumers concentrating in the same place, which generally causes irreversible damage to a resource.

The maximization is obtained by differentiating the function with respect to q and setting it equal to zero. The solution of the equation (q^o) represents the point of optimum use, that is, the value at which marginal costs equal marginal benefits. This value is associated with the optimum reception capacity level (C^o). However, this optimum point is not necessarily a point of balance; it does not mean that a condition such as moving away from it would bring no social convenience. As previously seen, the use of a resource entails that those who bear the costs of its upkeep (i.e. the host community) are not necessarily those who receive its benefits (visitors and all those whose business is in some way related to tourism and the tourism industry). In other words, a host community would tend to limit the use of a resource to the level beyond which the costs begin to rise, while tourists would tend to expand such use to the point of maximum total benefits. Hence, this shows that very

often the constraints on a destination's tourism development and therefore the maximum reception threshold will come into play before the maximum physical and/or economic threshold is reached and regardless of the optimum use level. Given a certain optimum level of reception capacity (C^o), the various interests involved can therefore set a balanced use level other than the optimum level. Consequently, the maximum reception capacity level will depend on the sustainable development goals set for a destination and the balance of power between the different sets of actors involved. This level will be included between a minimum threshold (C^*), to the left of the optimum point, corresponding to the point where the total costs begin to increase significantly (and therefore this threshold will be indicated as the maximum reception capacity level that the host community can accept), and the extreme physical limit (C^f) where costs become infinite. Given the aforementioned goals, the optimum point can become a point of balance only if there is a public entity with the strength and ability to distribute the resulting advantages to all the social groups involved in an equal manner and obtain consensus on this decision (Costa and Manente, 2000).

Canestrelli and Costa's model (1991) for the maximum reception capacity of a city rich in art heritage

Canestrelli and Costa (1991) came up with this model to determine the maximum reception capacity of an art heritage city (specifically, the historic centre of Venice) based on the Fisher and Krutilla recreational resource model, with the addition of three hypotheses. This model considers that there are several levels of balance associated with a tourist destination related to (i) market and non-market goods and services, (ii) tourist demand and public and private tourism offer and (iii) the host community, which is affected both positively and negatively by tourism. Hence, this model calculates in a very efficient manner tourist reception capacity in an art heritage city and the optimum use level.

The first hypothesis refers to the possibility of separating the benefits and costs into two mutually exclusive subgroups of a population, it is possible to distinguish a resident population group that makes no real profit from the tourism business ("non-tourism-dependent" population), from another group that is indeed connected to such business ("tourist-dependent population"). In other words, according to the community economic base theory (Tiebout 1956), tourism does not represent the overall economic base of a city, but only one of its components and therefore a city carries out other fundamental functions.

The second hypothesis maintains that it is possible to attribute a share of expenses to the two population subgroups. Whereas current and investment costs are borne by the entire local

community, only the population subgroup that does not depend on tourism bear C_d, namely the cost of damage to the ecological environment in the model of Fisher and Krutilla, which in this case can be viewed as costs due to tourism expanding to the detriment of alternative businesses (crowding-out effect).

The third hypothesis concerns the effects of growing demand. Usually, in the case of a recreational resource, the more are the visitors, the fewer are the individual user benefits, because of the deteriorating quality of the experience. Consequently, when the frequency rate increases, marginal users are less willing to pay. However, this doesn't happen in destinations of consistent tourist flows, where, as the number of tourists increases, the prices of complementary goods and services grow and in spite of that the tourists' willingness to pay remain stable or even increase.

The Canestrelli and Costa model was applied to the city of Venice based on the hypothesis that the city wants to maximize its tourism income while avoiding unwanted costs. The model proposes to determine the maximum reception capacity of the city and its historic centre, starting from the evaluation of the carrying capacity of a set of physical and functional subsystems used by tourists, who are broken down into different categories, namely: hotel tourists, non-hotel tourists and one day travellers. This model can thus determine the intensity of use for each category of visitors and identify the optimum reception capacity allocation between tourists and one day travellers, under the constraints of the different carrying capacities.

Hence, this model consists in identifying the subsystems used by the visitors (tourists and one day travellers) in a destination, defining the intensity levels of use of each subsystem by each category of visitors and estimating the levels of use allowed by each subsystem. The reception capacity calculation problem is thus resolved through a linear programming problem.

With regard to the constraints, for the specific case of Venice city were considered the constraints related to six supporting facilities:

1. HB: number of hotel beds available;
2. NHB: number of non-hotel beds;
3. L: number of meals provided by restaurants;
4. P: number of parking spaces;
5. T: number of local public transport seats/trips available;
6. WD: solid urban waste collection and disposal capacity.

Obviously, the model had to consider also the constraints related to the use of non-reproducible resources, such as tourist attractions. The Venice Basilica's daily carrying capacity was assumed as the most representative monument and a must-see destination for all visitors. Thus, the model defined the following as the seventh constraint:

7. The maximum number allowed of daily visits inside the Basilica. This constraint represents the "extreme" reception capacity limit

The problem is therefore maximizing the daily turnover of the local tourism industry, considering the constraints (which may be treated as fuzzy, defining for each one not a single capacity value but a minimum and a maximum value) represented by the carrying capacity of the individual subsystems and the behavioural differences of the three categories of visitors (hotel tourists, non-hotel tourists and one day travellers) using the afore-mentioned subsystems. Formally, the objective function is the following:

$$\text{Max } z = c_1TH + c_2TNH + c_3E$$

where:

TH = daily number of tourists using hotel accommodation
TNH = daily number of tourists using non-hotel accommodation
E = daily number of daily-trippers
c_1, c_2, c_3 = daily average per capita expenditure for each of the categories considered
z = total per diem outlays (which are assumed to be a good proxy for the net benefits paid by Venice visitors to the "tourist-dependent population")
The value of the function depends on the constraints expressed as follows:

$$a_i\, x \leq b_i + \theta_i$$

$$\text{with } x = (TH, TNH, DT) \text{ and } x \geq 0$$

where:

a_i = a_i is the vector of coefficients measuring the level of daily use of facility *i* by each category of visitors;
b_i = is the "aspiration level", optimal, according to the "non-tourist population", for the carrying capacity of the *i*th facility used by visitors to Venice;
$b_i + p_i$ = is the value, to be considered insuperable, at which the capacity expansion of the *i*th facility becomes unbearable for the population of Venice;

$\theta \in [0,1]$ = degree of violation of constraint b_i (at which environmental costs are zero) towards the insuperable limit $b_i + p_i$ which represents the maximum bearable pressure level of the i-th subsystem.

The linear programming technique has allowed to identify, for different values of θ, the optimal mix of visitors to obtain the maximum turnover, compatibly with the imposed constraints. In addition to the city of Venice, for which it was developed and applied by its creators, the model was applied over the years to other urban destinations, for example, the city of Rome (Feliziari, 2016).

7.2. Applying the concept of carrying capacity to a destination

Usability of the carrying capacity concept as a tourism planning tool

There are many contributions on carrying capacity coming from the literature, especially since the 1960s, and the understanding of this concept has been evolving in time. The focus of this approach has been shifting increasingly from the idea of determining a specific maximum number of tourists/visitors to the concepts of "acceptable change limits" and "spectrum" (Butler, 1996). This evolution is due to the fact that, even if modern literature is inclined to accept the theoretical approach described above, it also shows that it is difficult to apply it, especially when it comes to quantifying acceptability thresholds, which can be rather complex (Costa and Manente, 2000).

As partially discussed above, when evaluating a critical threshold, all the different reception capacities of physical, economic-financial and social constraints, must be taken into consideration. Hence, the first complexity met when measuring reception capacity pertains to its multidimensional nature, which makes difficult to define a single maximum value. Measuring the carrying capacity does not lead to the calculation of a single value, but rather to an interval within a minimum and maximum value.

Secondly, the carrying capacity and its various formulations depend on the goals set for the sustainable development of a destination and in which way that destination will be used; for example, a nature park destination should set its maximum reception capacity level lower than an amusement park. Moreover, where goals are the same, maximum levels may differ depending on the destination, including its physical characteristics and those of its stakeholders (for example, tourist characteristics are the number of presences, length of stay, behaviours and expectations), its type and level of use and the interaction between the various sets of actors, tourists and residents first of all, and between the actors and the actual locations (Costa and Manente, 2000; Cocossis et al., 2001; Chen and Teng, 2016). Of course, every tourist area has its own "carrying capacity", identified by environmental index but also closely linked to local socioeconomic aspects (Bimonte

and Punzo, 2004). These factors, indeed, are not fixed but may change over time, in relation to external drivers.

When tourism policies are drawn up for a specific destination, what indeed happens is that the decision-makers will probably measure constraints from different points of view, based on individual relationships, social balances and interests. (Costa and Manente, 2001). In this regard, UNEP (2004) highlights the importance of a process based on public participation, in order to involve the main stakeholders in defining the carrying capacity of the destination, starting from the balancing of the needs and priorities of each group of actors.

Furthermore, some exceptions may be accepted by the community, who may bear the exceed of critical thresholds at times of extremely intense use, keeping in mind that these are indeed exceptions. Hence, although critical thresholds may be exceeded on special occasions (major events like the Venice Carnival, the Palio di Siena, etc.), it is not advisable to do so for long periods of time (Costa and Manente, 2001).

As aforementioned the carrying capacity turns out to be an extremely dynamic concept, as related to variability of constraints, time span, territorial scale and destination type. Consequently, the use of this concept will lead to an array of admissible scenarios with different goals. The community's optimal choice, however, can only be political (Costa and Manente, 2000), even if it is always important to have monitoring and controlling tools available to detect issues and critical thresholds getting closer.

Some thoughts from the literature

Investigations have been done in the literature on the application of the carrying capacity to actual destinations and the identification of the constraints involved. Some studies focused on single cases of carrying capacity (physical, social or economic), others investigated the concept to determine maximum reception capacity (see for example Navarro et al., 2012; Chen and Teng, 2016; Carboni et al., 2017; Makhadmeh, 2018; Muler et al., 2018; etc.). A third group of scholars deepened the concept in its complexity (see for example Wagar, 1964; Canestrelli and Costa, 1991; Navarro et al., 2012; Salerno et al., 2013; etc.).

First of all, it would appear that each of the three carrying capacity components (physical, social and economic) will weigh differently depending on destination type, namely its basic tourism development structures and features (local resources, ecosystems, population, culture, etc.), the type of tourism being carried out and how the latter interfaces with the setting. Therefore, the literature makes it clear that it is important to approach each main resort category from a different angle (Cocossis et al., 2001):

- Coastal areas: as these destinations are often characterized by mass tourism in beaches, large-scale buildings and infrastructure as well as intensive space development and urbanization, their carrying capacity issues focus on tourist density, the use of beaches and infrastructure, marine pollution and beach erosion;
- Islands: island destinations are characterized by small-medium accommodation facilities often developed around pre-existing agglomerations, such as small towns, rural villages, etc. Consequently, their carrying capacity concerns revolve around how the host community responds to tourism, in terms of repercussions on the local society and system of production, e.g. quality of life, waste management and use of scarce resources such as water, etc.;
- Protected areas: the carrying capacity aspects of protected natural areas such as parks and nature reserves are concerned with the need to limit the development of infrastructure and take small scale actions that do not promote large tourist flows; for this reason, the carrying capacity evaluation revolves around indicators such as the number of tourists and their spatial concentration/distribution and the impacts on ecosystems (e.g. reduced plant growth, etc.);
- Mountain areas: in some respects, it may be compared to coastal destinations, especially where winter and ski tourism takes on the characteristics of mass tourism and is linked to large-scale infrastructure; in this case, the aspects considered in defining the carrying capacity relate to the impact brought onto the environment or landscape diversity and caused by infrastructures, including access roads to natural ecosystems, artificial snowfall and waste management;
- Historic cities and centres: in the case of cultural destinations such as art heritage cities, the critical issues of tourism development have to do with the flow of visitors into the historic centre, around the monuments, museums and other cultural attractions and in general. The impact of tourism concerns the integrity of the historical and architectural heritage and at the same time the crowding out effect.

For physical carrying capacity, the literature has dealt with it according to the following parameters:

- Specific natural components (e.g. water and air quality, flora and fauna, etc.);
- Ecosystems (e.g. coasts, islands, lakes, parks, etc.);
- Man-made resources (e.g. monuments, infrastructure, superstructures, etc.).

Determining the specific impact of tourism on these resources, and therefore the limit beyond which a resource is irreparably damaged, is not an easy task. This complexity is amplified by the

multiple interactions of tourist phenomena, making impossible to measure the total impact. Moreover, the choice of impact measuring indicators is affected by subjective factors (Costa and Manente, 2000).
For social carrying capacity, the literature on the social impact of tourism and its maximum limit includes the following effects:

- Socioeconomic environment, and therefore the social dimensions linked to production, distribution and consumption (being the crowding out effect a major factor);
- Sociocultural environment, and therefore the local community's values, lifestyles, traditions, etc.

In both cases, the impacts are caused by the interaction between tourists and local community, which can normally take place at three fundamental times: when goods and services are sold to tourists, when tourism businesses employ personal services (i.e. unskilled jobs) and when spontaneous meetings occur (for example, while taking public transport, which is an instance of consuming goods and services). Each of these interactions could generate positive relationships or conflicts. (Costa and Manente, 2000). Muler et al. (2018), deepened through interviews, the perception of residents about the impacts of tourism in a Spanish city rich in art heritage (Besalù in Catalonia) and their willingness to receive a greater number of tourists. The study also investigated whether and how the possibility of having a job in tourism influences the perception and willingness of each respondent: the results show that those local residents who have a job in tourism are more likely to agree to an increase in tourist demand.
From the economic carrying capacity perspective, although it expresses the limit that reduces the tourist demand, in many destinations it will not occur as a lower number of tourists. Indeed, it has been observed that excessive congestion, which reduces the quality of a visit, does not necessarily provoke less demand but rather a substitution of segments. It has been the case for many destinations where the number of tourists did not change, but at the same time their quality decreased in terms of lower capacity and willingness to spend money (Costa and Manente, 2001). For this reason, one indicator used to assess this carrying capacity has been the visitor's willingness to pay. An interesting example is a study carried out by Chen and Teng (2016), estimating the carrying capacity of a seaside destination on the southern tip of Taiwan. The study took into account the perceived level of overcrowding by tourists in relation to different scenarios (considering that the higher the perceived level of congestion, the lower the perceived quality of the tourist experience), detected through the administration of questionnaires with photos to a sample of visitors.

7.3. Threshold indicators and definition

The relationship between sustainable development and carrying capacity: comparative approaches and indicators

The identification of the most appropriate indicators for evaluating the carrying capacity cannot ignore the close relationship between the concept of carrying capacity and the sustainable tourism development.
In other word, the same indicator, or category of indicators, can be applied both as a reference for sustainable tourism development and as an expression of the constraints use to determine the carrying capacity. For example, in Cocossis et al. (2001), the two sets of indicators are closely related even though they perform a different, but still connected, function. On the one hand the indicators used for sustainability purposes are functional to describe and monitor the state of the destination's tourism system in relation to sustainable development on the social and economic context, and therefore the extent of the effects of tourism on the environment. On the other hand, they have the function to express what is the limit for accepting the pressure of tourism on the destination. While in the first case (sustainability) the indicator will assume a value corresponding to the actual situation in the destination at a given time and with respect to a certain variable, in the second case (carrying capacity) the value will be given by the maximum limit within which the same variable should remain.

Many of the most important international organizations have included sustainable tourism development on their agenda (World Tourism Organization; UNWTO - United Nations World Tourism Organization; European Commission; GSTC - Global Sustainable Tourism Council), in order to:

- Identify aa shared definition of sustainable tourism;
- Increase the international community's awareness on the need for a sustainable approach to tourism;
- Stimulate the exchange of good practices;
- Develop an indicator system to monitor the sustainability of a destination.

The "Guidebook on Indicators of Sustainable Development for Tourism Destinations" of the UNWTO

The UNWTO has promoted the use of sustainability indicators since the early 1990s, recognizing them as an important tool for planning and managing tourism development in destinations. Since then, the UNWTO Environmental Committee has developed the first set of sustainability indicators applicable to the internationally tourism sector. The work evolved over the years, until the

publication in 2004 of the Guidebook on Indicators of Sustainable Development for Tourism Destinations, which bring together the result of an in-depth study involving 62 experts from more than 20 countries.

The Guidebook identifies the main factors that make a destination sustainable and describes more than 40 issues related to sustainability: from the management of natural resources (water, energy, waste, etc.) to the protection of cultural and environmental heritage, from the management of seasonality to the distribution of the economic advantages of tourism, from the satisfaction of tourists to the well-being of the host community, etc. For each of these issues the Guidebook suggests indicators and techniques for their measurement with concrete examples and sources. The Guidebook also provides guidance to support destinations in developing destination-specific indicators, depending on the type of location (coastal, mountain, urban, etc.) and on the stage of development, and describes how to use information derived from indicators.

The following table shows the Baseline Indicators, namely a group of indicators considered essential for an effective and comprehensive measurement of the tourism's sustainability level of a destination.

Table 1 - Baseline Indicators contained in the Guidebook on Indicators of Sustainable Development for Tourism Destinations of the UNWTO

Issue	Indicator	Source
Satisfaction of the local community towards tourism	% of inhabitants satisfied	Survey among the resident population
Effects of tourism on the local community	Ratio between number of tourists and number of inhabitants (on average per year and in high season)	Statistical source
	Percentage of inhabitants who think that tourism has contributed to creating new services and infrastructures	Survey among the resident population
	Number and capacity of social services available to residents (% of those attributable to tourism)	Statistical sources and other
Tourist satisfaction	Average level of satisfaction of visitors (or% of satisfied visitors)	Survey among tourists
	Level of perception of the quality / price ratio	Survey among tourists
	% of repeaters	Survey among tourists
Seasonality of tourism	Arrivals by month	Statistical Data
	Occupancy rate of accommodation facilities (comparison between low and high season)	Statistical sources
	% of tourism firms open all year round.	Statistical sources and other
	% of jobs in the tourist's peak season	Statistical sources
Economic benefits of tourism	Number of employees in tourism and % of total employment	Statistical sources
	Turnover from tourism and in % on the total turnover of the destination	Statistical sources

Issue	Indicator	Source
Energy management	Average per capita consumption per day for each energy source referred to tourism activity	Statistical sources and other
	% of tourism companies that implement measures for energy saving	Survey among firms
	% of energy used in tourism sector and produced by renewable energy sources	Statistical sources and other
Water management	Liters consumed per day for tourist activity and liters per tourist per day	Other sources
	% of recycled water	Other sources
Quality of drinking water	% of tourism companies that adopt water treatment systems according to international standards	Survey among firms
	% of tourists with health problems related to water consumption	Other sources
Waste water treatment	% of treated waste water	Other sources
	% of tourism firms with wastewater treatment systems	Survey among firms
Waste treatment	Tons of waste produced per month in the destination	Other sources
	% of waste recycled out of total waste produced	Other sources
	Amount of waste dispersed in public areas	Other sources
Economic and urbanistic development control	Existence of a land use plan / policy, which also includes tourism	Public / destination management institution
	% of area under control/planning	Public / destination management institution
Use intensity control	Arrivals at destination (by month, in low and high season)	Statistical sources
	Number of tourists per square meter of a single attraction and per square kilometer of the whole destination	Statistical sources

Source: Baseline Indicators contained in the Guidebook on Indicators of Sustainable Development for Tourism Destinations of the UNWTO, 2004

ETIS indicators - European Tourism Indicator System

ETIS (European Tourism Indicator System) is a system of indicators launched for the first time by the European Commission in 2013 and revised in 2015. Starting from a common and comparable approach, it aims at supporting destinations in monitoring and measuring their sustainability performance for an economic, social and environmentally sustainable development. It is the result of the joint work of a pool of experts and two experimental phases (one between 2013 and 2014 and one between 2014 and 2015), in which the system was tested by more than 100 European destinations, in order to improve it precisely through the collected feedback.

ETIS aspires to be not only a simple system of indicators but also a management, information and monitoring tool specifically addressed to tourist destinations. The implementation of ETIS is based on a process started at the local level to collect and analyse information and data with the precise

purpose of evaluating and better managing the impacts of tourism in the destination. At this aim, it implies the involvement in the monitoring process of all those stakeholders that directly or indirectly are affected by tourism's activities (from institutions to businesses, from the local community to tourists).

ETIS is a completely voluntary tool for the support of tourism' decisions and management, undertaken by the destinations, through observation, data collection, data analysis, and self-evaluation. ETIS doesn't set minimum standards and doesn't assign a certification to the destinations that adopt the it.

ETIS is based on a set of sustainability indicators, consisting in 43 core indicators, common to all destinations, and a set of supplementary indicators, designed for specific types of destination or problems. The 43 core indicators cover the most important aspects of sustainability (destination management, environmental, socio-cultural and economic impacts) and allow comparison of sustainability performance among similar destinations. Although ideally all 43 indicators have the same level of importance and should therefore all be equally monitored to obtain a complete picture on the sustainability of the destination, flexibility in the choice of indicators is left, also in relation to the availability of data and information on which the destination can count. While some indicators are based on readily available data, others require specific surveys (for example to detect the satisfaction of tourists or residents or to detect the commitment of companies to sustainable development) or the integration with other data sources (for example by Chambers of Commerce or trade associations, etc.). Furthermore, ETIS can be integrated with another indicator systems.

ETIS is promoted among its members also by NECSTouR (Network of European Regions for Sustainable and Competitive Tourism), a network that was founded in 2009 by the three most touristic European Regions, such as the Spanish Cataloña, the French PACA and the Italian Tuscany Region, in response to the European Commission communication "Agenda for sustainable and competitive European tourism". To date, NECSTouR is composed by 30 European Regions and academic organizations such as universities and research centers, sustainable and responsible tourism organizations and associations and other networks from around 20 countries in the European Economic Area. The following table shows the 43 core indicators identified by ETIS.

Table 2 - Core Indicators of ETIS - European Tourism Indicator System

Sections	Indicators		
A.Destination management	A.1 Sustainable management of tourism in tourism businesses	**A.1.1**	% of tourism businesses in the destination that use certification / quality / sustainability labels or CSR on a voluntary basis
	A.2 Customer Satisfaction	**A.2.1**	% of tourists and daily trippers satisfied with their overall experience in the destination
		A.2.2	% of repeaters on total visitors (in the last 5 years)
B. Economic Vaalue	B.1 Tourist flows (volume and value) in the destination	**B.1.1**	Number of attendance per month
		B.1.2	Number of daily trippers per month

		B.1.3	Contribution of tourism to the destination economy in% of GDP
		B.1.4	Average per capita expenditure per day per tourist
		B.1.5	Average per capita expenditure per daily tripper
	B.2 Performance of tourism businesses	**B.2.1**	Average stay
		B.2.2	Occupancy rate of accommodation facilities per month and on average per year
	B.3 Quantity and quality of work	**B.3.1**	% of employed in tourism out of total employment
		B.3.2	% of seasonal employees out of the total employed in tourism
	B.4 Tourism Supply Chain	**B.4.1**	% of food, drink, goods, etc. sold by tourism businesses that are locally produced
C. Social and Cultural Impact	C.1 Social impact on the community	**C.1.1**	Number of tourists per 100 residents
		C.1.2	% of inhabitants satisfied with tourism (year and high season)
		C.1.3	Number of beds available for every 100 residents
		C.1.4	Number of second homes per 100 residents
	C.2 Health and safety	**C.2.1**	% of tourists who report a crime to the police
	C.3 Gender equity	**C.3.1**	% of women and men employed in tourism
		C.3.2	% of companies in which the top positions are occupied by a woman
	C.4 Inclusion / accessibility	**C.4.1**	% of rooms in accommodations accessible to people with disabilities
		C.4.2	% of accommodation facilities participating in certification systems / schemes recognized for accessibility
		C.4.3	% of public transport vehicles that are accessible to people with disabilities
		C.4.4	% of attractions that are accessible to people with disabilities or who adhere to systems / certification schemes recognized for accessibility
	C.5 Protection and enhancement of cultural heritage, local identity	**C.5.1**	% of inhabitants who are satisfied with the impacts of tourism on the cultural identity of the destination
		C.5.2	% of dedicated / focused events on cultural heritage and local identity
D. Environmentale impact	D.1 Reduction of transport impacts	**D.1.1**	% of tourists and daily trippers by means of transport used to reach the destination
		D.1.2	% of tourists and daily trippers who use soft mobility to move to the destination
		D.1.3	Km traveled on average by tourists and daily trippers to reach the destination
		D.1.4	Co2 emissions produced on average by tourists and daily trippers to reach the destination
	D.2 Climate change	**D.2.1**	% of tourism businesses that participate in climate change mitigation programs / schemes (eg CO2 offsets)
		D.2.2	% of tourism businesses and attractions located in vulnerable areas
	D.3 Waste treatment	**D.3.1**	Waste products per tourist per day compared to the waste produced per person per day by the inhabitants
		D.3.2	% of tourism businesses that practice separate waste collection
		D.3.3	% of recycled waste per tourist compared with% of recycled waste per inhabitant
	D.4 Waste water treatment	**D.4.1**	% of treated waste water
	D.5 Water management	**D.5.1**	Water consumed per tourist per day compared to the water consumed per inhabitant per day
		D.5.2	% of tourism businesses that adopt water saving measures
		D.5.3	% of tourism businesses that adopt water recycling measures
	D.6 Electricity consumption	**D.6.1**	Energy consumed per tourist per day compared to the water consumed per inhabitant per day
		D.6.2	% of tourism businesses that adopt energy saving measures
		D.6.3	% of energy consumed from renewable sources
	D.7 Management of biodiversity	**D.7.1**	% of tourism businesses actively involved in the protection, conservation and management of local biodiversity, the environment and the landscape.

Source: ETIS

The indicators of the GSTC - Global Sustainable Tourism Council for destinations

The Global Sustainable Tourism Council is an organization established in 2007 by UNEP (United Nation Environment Program) and UNWTO to promote sustainability and social responsibility in tourism sector, through the development and management of standards for sustainable tourism. The GSTC represents an international membership that includes United Nations Agencies, important tourism companies, national tourism bodies, etc., gathered around the common goal of sharing good practices for sustainable tourism.

The GSTC has developed Sustainable Tourism Standards and identified the minimum sustainability standards that companies, and destination management bodies should pursue to ensure socio-cultural, environmental and economic sustainability in destinations. The standards identified by the GSTC are the result of a consultation involving more than 80.000 stakeholders and 27 organizations that have reviewed more than 4.500 criteria linked to 60 existing certification systems. To date, two versions of Standard are available: the Destination Criteria (GSTC-D) and the Hotel & Tour Operator Criteria (GSTC-H & TO), addressed to hotel and brokerage tourism companies. These standards are the guiding principles and minimum requirements that each destination or company should achieve. The GTCS Destination Criteria is divided into 4 sections (A. Sustainable management, B. Economic benefits to the host community, C. Benefits to the community, visitors and the cultural fabric; C. Benefits for the environment) for a total of 41 criteria and 105 indicators. The criteria represent the basic commitments to which a destination tourist management organization should aspire if it wants to consider sustainability as an integral part of its strategy. The performance indicators are designed to provide references to measure the alignment and respect of the GTCS Destination Criteria. This set of indicators, regularly updated, is not a close and definitive system, but a starting point that the destination could integrate with other indicators according to its own characteristics. The following table shows some of the indicators proposed by the GTCS Destination Criteria (with reference to the criterion to which they refer).

Table 3 - Some of the main indicators contained in the GTCS Destination Criteria of the GSTC

Criterion	Indicator
A4. Tourist seasonality	A4.a. Distribution of visitors during the year
A10. Visitor satisfaction	A10.a. Visitor satisfaction data
B1. Economic monitoring (at least once a year)	B1.a. Visitor spending data, income per room available
	B1.b. Direct and indirect tourism contributions
	B1.c. Jobs related to tourism by gender and age group and investments
B4. Opinion of the local community	B4.a. Data on aspirations, concerns and satisfaction of residents with regard to tourism development and management
B5. Local access	B5.a. Natural and cultural sites open to the public
	B6.b. Data on behaviors and characteristics of local, domestic and foreign visitors to natural and cultural sites
C1. Protection of attractions	C1.a. Impacts of tourism on attractions
D1. Environmental risks	D1.a. Identification of the main environmental risks in the destination
D2. Protection of sensitive environments	D2.a. N ° of wild animals and sensitive and threatened habitats
D4. Greenhouse gas emissions	D4.a. Companies that measure, monitor and minimize greenhouse gas emissions

	D4.b. Companies that mitigate greenhouse gas emissions
D5. Energy saving	D5.a Energy consumption
	D5.b. Dependence on fossil fuels and use of renewable energy sources
D6. Water resources management	D6. Water consumption
D9. Waste water	D9.a. Adequacy of waste water treatment systems in relation to the characteristics of the destination
	D9.c. Companies with wastewater treatment systems
D10. Reduction of solid waste	D10.a. Waste produced
	D10.c. Companies that recycle / reuse waste
D12. Low impact transport	D12.a. Use of low-impact transport

Source: GSTC Destination Criteria

The most common indicators in the literature for carrying capacity

Before deepening the most frequently used indicators, it's useful to highlight that, given the three components of the carrying capacity, the indicators can be divided into:

- Indicators of a physical-ecological nature;
- Socio-demographic indicators;
- Indicators of a political-economic nature.

Taking inspiration from the elaboration proposed by Cocossis et al. (2001), the following table shows, for each category, the main variables, which better express constraints that contribute to determine the carrying capacity of a destination, in relation to its characteristics. It would be useful to highlight in the table below, which aspects of the main types of destination (coastal, island, protected areas, upright and city of art) assume a particularly significant priority.

Each of the listed variables can be expressed through one or more indicators that, depending on the objective, measures the tourist pressure or the state of the resources, the impacts, the effectiveness of the undertaken intervention management on destinations.

Table 4 - Categories of indicators and variables to which they refer

	Coastal destinations	Islands destinations	Protected destinations	Mountains destination	Art Cities
Indicators of a physical-ecological nature					
Natural environment and biodiversity	AP	AP	AP	AP	AP
Pollution / air quality			AP		AP
Sound pollution			AP	AP	AP
Power		AP			
water	AP	AP	AP	AP	AP
Waste	AP	AP	AP	AP	AP
Cultural heritage	AP	AP		AP	AP
Infrastructure and tourist services	AP	AP	AP	AP	AP
Soil	AP	AP	AP	AP	AP
Landscape	AP	AP	AP	AP	
Transport and mobility	AP			AP	AP
Socio-demographic indicators					
Demography		AP		AP	AP
Tourist flows	AP	AP	AP	AP	AP
Employment	AP	AP		AP	AP
Structure / social behavior		AP		AP	AP
Quality of the experience of tourists	AP	AP	AP	AP	AP
Quality of life for residents	AP	AP		AP	AP
Health & Safety	AP	AP		AP	AP
Politico-economic indicators					
Tourism turnover	AP	AP		AP	AP
Jobs	AP	AP		AP	AP

AP = high priority

Source: CISET elaborations on Cocossis et al., 2001

For each of the aspects highlighted above, the following table gives some examples of common indicators used to determine and monitor the carrying capacity of the destination. This list derives from the literature examined. It can be considered as an attempt to highlight the indicators that most frequently occur in studies and practical applications.

Table 5 - Indicators most commonly used to measure load capacity, by category

Indicators of a physical-ecological nature	
Natural environment and biodiversity	Number of tourists per area of protected areas (or naturalistic or endangered)
Pollution / air quality	Average annual number of days, during the tourist season, when the pollution levels defined by law were exceeded
Sound pollution	Average annual number of days, during the tourist season, when the pollution levels defined by law were exceeded
Power	Energy consumption linked to tourism activities on total energy consumption
	Energy consumption linked to tourism activities on the destination's energy supply capacity
water	Water consumption linked to tourism activities on total water consumption
	Water consumption linked to tourism activities on the destination's water supply capacity
Waste	Average daily waste production during the tourist season on average daily production throughout the year
	Waste production linked to tourism activities on total waste production
	Daily production of waste on daily waste collection capacity
Cultural Heritage	Number of visitors per site
	Number of visitors per site at risk
	Opening hours per day or opening days per site
	Average time to visit the site
	Average waiting time to access the site
Soil	Area occupied by tourist activities on the total area of the destination
Infrastructure and tourist services	Number of beds by category
	Occupancy rate of accommodation facilities by category
	Beds (by category) for total area of destination
	Number of places in catering activities
	Number of places in recreational activities (theaters, discos, etc.)
Transport and mobility	Average waiting time to use public transport
	Number of seats / journeys available in public transport vehicles
	Utilization rate of public transport vehicles per day (number of seats / journeys used on number of available seats / journeys)
	Number of available parking spaces / tourist buses
	Occupancy rate of parking spaces per day (number of seats used on number of available seats)
Socio-demographic indicators	
Demography	N ° of inhabitants
	Population growth rate
	Population structure by age
	Beds per inhabitant
	Daily attendance of tourists per inhabitant (in high and low season)
Tourist flows	Number of arrivals and overnights
	Number of daily tourists (maximum value in the peak month and minimum value in the least crowded month)
	Growth rate of arrivals and overnights
	Daily attendance of tourists by total area
	Arrivals and overnights per month (seasonality)
Employment	Residents employed in tourist activities out of the total population
	Number of seasonal employees in tourism activities on the total number of employees in tourism activities
Structure / social / commercial behavior	Movement of the population between areas of the destination or towards other municipalities
	Movement of commercial licenses and changes of use over the years
Quality of the experience of tourists	Share of tourists satisfied with the quality of the experience
Quality of life for residents	Share of residents satisfied with the level of tourism development of the destination
	Property or land prices between areas of the destination and in comparison with other non-tourist municipalities
	Prices of essential services land between areas of the destination and in comparison to other non-tourist municipalities
Health & Safety	Number of crimes (theft, etc.) between high and low season
	Number of crimes (theft, etc.) committed by tourists on total offenses
	Number of complaints from tourists / residents
Politico-economic indicators	
Tourism turnover	Availability to pay the tourist for the tourist experience in the destination / or for individual services
	Turnover deriving from tourism activities on the destination's GDP
Jobs	Number of employees in tourism activities on total number of employees

Source: CISET elaborations developed on the basis of the examined literature and sustainability indicators and starting from the classification proposed by Cocossis et al., 2001 and Navarro et al., 2012.

The choice of indicators and the definition of thresholds

Starting from the previous tables, for the determination of the carrying capacity in a territory is not required to use together all the indicators highlighted above.

It's not possible to specify a minimum number of indicators that would be right to consider in order to obtain a valid measurement. The choice of indicators among those proposed or among others, depends rather on the relevance of each indicator in relation to the characteristics, problems and objectives of development / management of the destination as well as the availability of the information necessary to detect the indicator. It's possible to select a sufficient number of indicators able to grasp the variety of the concepts related to carrying capacity, i.e. the physical-environmental, social and economic constraints. It implies that depending on the type of destination one component might be more relevant than the others. For example, in a cultural destination there is a need to balance the visit and the enjoyment of historical-artistic and monumental attractions with the need to preserve and protect this heritage (e.g. the maximum number of visitors allowed in the most visited sites, related to the days / hours of opening and the average time of visit that allow to express the maximum capacity of each site). Another example could be a destination with water scarcity problems, such as an island: in this case the indicators will be related to the water supply capacity, the water consumption due to the residents and to the tourist activities.

In a urban destination coexist at the same time social and economic functions in addition to tourism, in this case a relevant indicator would refer to the perception of residents about the impacts of tourism, such as tourist intensity (e.g. relationship between tourists and residents) and tourist density (e.g. ratio between beds and residents).

Once the indicators have been identified, the following step consists in defining the thresholds, i.e. the maximum value that this indicator can take and that ideally shouldn't be exceeded (ref. chapter 2.1). However, it's important to remind that the political choices could influence the thresholds setting.

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