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Mapping and classification of ports and marinas for the definition of long-term development strategy

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ABSTRACT

Mapping and classification of ports may be of great help to define effective development strategies based on the concept of "intelligent, green and integrated port", within the frame of sustainable development. To this end, classification tools and knowledge of the initial situation are crucial points needed, just as an example, to boost the maritime and short-sea connectivity by promoting the creation of regional touristic port network, capable of implementing a smart, green, and integrated transport system. This work deals with the mapping and classification of ports and marinas. A possible methodology to define a priority matrix intervention rank is proposed and applied to all the harbors in the Puglia region, as a case study. The collected open data aim to describe several aspects: the services, the urban planning whereby the port is thought, the facilities and structures, the connection with multi-modal local transport. The mapping activity has been performed within the frame of the AI-SMART project funded by the European Regional Development Fund that aims to implement and develop a common port network in the Adriatic-Ionian area. The case study served to highlight the feasibility and applicability of the proposed method to a real case.

KEYWORDS

Mapping, weighted scoring method, Open data, maritime mobility, harbors infrastructures, harbors services, priority matrix, port planning

1 INTRODUCTION

One benefit in considering ports and marinas from the perspective of sustainability is that it highlights the relationship between the port and the neighbour urban region, hence it promotes the sustainable development of ports as part of a whole (Wakeman 1996).
Though no universally accepted definition exists, the World Commission on Economic Development (WCED) suggested, in the Brundtland Report, that sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987)." (Ahn et al. 2002).
From the tourism perspective, some researchers, since the first years of '90s, (e.g., Bramwell and Lane 1993) have broadened the meaning of sustainable development into a concept that implies the long-term viability of good quality natural and human resources.
McCool and Martin (1994) suggest that managing for sustainability requires: "(i) a technical planning system that addresses problems and forces explicit decision making, and (ii) a public involvement process that is oriented toward consensus building."
The modal shift from road transport to short-sea and inland waterway transport implies that a network of multi-modal logistical nodes is established in the hinterland of seaports, which are the main gateways to the hinterland (Dooms and Macharis 2003). Such a kind of sustainable development, intimately related to the development of ports, urban, rural and natural areas, cannot be implemented without a clear big picture of the state of the art and an objective tool that the stakeholder can use to define and ultimately implement a long-term strategy.
This paper aims to propose a methodology that, based on the results of a specific mapping, allows to define an ordered ranking of ports and marinas that can inform stakeholder in the definition of the long-term development strategy. The method is then applied to the whole set of harbors deployed along the coast of the Puglia Region (Italy) facing the Southern part of the Adriatic Sea and the Eastern part of the Jonian Sea. The results of the mapping activities have been then used to develop a Decision Supporting System aimed to foster a long-term strategy involving the harbors development along with the development of the hinterland, at the regional scale.
Section 2 illustrates the methodology approach. Section 3 describes how it has been applied to the Puglia Region ports, as a case study. Concluding remarks close the paper.

2 THE METHODOLOGY APPROACH

2.1 Aims and scopes

This paper aims to propose an objective method for the mapping and classification of regional ports, regardless of the standard classification based on the economic and maritime traffic. Just as an example, based on the regulation of the ports according to the Italian law (L. 28/01/94 n° 84) the national ports classification relies on the strategic relevance on the national security as well as the operational capacity, intended as commercial, industrial, fishery-related, and touristic. This approach does not take into account the role of the port in terms of strategic potentiality as an active tool for future developments. Then, the proposed method intends to integrate and broaden the "conventional" administrative classification accomplishing the objectives of both EUSAIR (Cugusi and Stocchiero 2016) and the 2030 European strategies for intelligent growth (EC 2019) that promotes and boosts natural and landscape resources of the hinterland within the frame of the concept of "Do Not Significant Harm" (DNSH).
In this regard, the aim to create and promote maritime transport as a short-range inter-modal and sustainable mode of transport, traveling, and exchanging seems to be an appropriate action to reach the goal of sustainable development of ports and marinas, especially with the European Agenda 2030 goals that valorize the industry,

innovation and infrastructure, sustainable cities and communities as well as climate action and preservation of life below water. The proposed classification method can be regarded as an activity of evaluating the efficiency and the potentiality of the regional ports network in order to implement and integrate the standard land transport of touristic passengers with maritime and multi-modal international routes. The proposed classification method can be viewed as a general tool, based on some features the method must comply to:

- objectiveness;
- repeatability;
- flexibility;
- clearness.

The ranking has to be performed in order to clearly and rationally assess the performance of the given port: the obtained score in the ranking has to be assessed unequivocally and not by the comparison among the ports. In other words, the proposed method is not comparative. In order to achieve a dynamical rearrangement, each port has to be easily re-classified and the review and update of the port classification have to be favored. In the end, the considered parameters in the classification need to be defined definitively in order to define a clear long-term development strategy. Hence, the classification aims to objectively assess, given the long-term strategy, the priority of interventions that a specific port would need to achieve better performances according to the adopted strategy. The strategy has to be planned and defined according to the regional strategy that the Public Authority pursues. It must then represent a useful tool for both the ports managers and Public Authority to plan a targeted goal for the services growth and increase. In fact, the proposed classification method, along with the mapping activities needed to “feed” the method, is functional to have a big picture of the situation regarding the state of the art at the regional scale of the ports, and, moreover, it is useful to eventually furnish the port stakeholder with information that is the basis of the evaluation of the touristic willingness of the port and exposing critical situations that might be ignored.

2.2 The Rationale

This section is aimed to illustrate the general idea behind the proposed methodology. Each step is then deepened in the following subsections.

The classification relies on the decision-making matrix, that summarizes the score of each port and categorizes it according to clear criteria. Actually, the proposed methodology is an exemplification of a multi-criteria decision making method (e.g. Triantaphyllou 2000) developed in the frame of the fuzzy logic (e.g. Baas and Kwakernaak 1977) using the weighted scoring approach (e.g. Ulrich 2003). In decision making, many aspects are to be considered, each with varying degrees of importance (e.g. Baas and Kwakernaak 1977). Different fields of application of similar approaches can be mentioned, computer sciences among the others (e.g. Jadhav and Sonar 2009), project management (e.g. Henriksen and Traynor 1999; Krawiec 1984), medicine and health (e.g. Lee et al. 2017, Hashmi et al. 2020).

The early stage in the method is to monitor and evaluate the efficiency of the existing structures and facilities (multi-modal terrestrial transports and services) that the ports (sometimes also referred to as harbors hereinafter) are capable to guarantee. The mapping stage regards all the ports included in the classification activity. It can be exploited at different spatial scales, i.e. at administrative regions, provinces, or Port Authority system scales. The first step to accomplish is to quantify the potentiality of the port. This can be done only if the exiting services in and around the port, structures, maintenance, and urban planning strategies in place are surveyed. Then, the identification and classification of intervention needs are necessary to define a long-term plan of action, including both the Public Authorities and the stakeholders. An effective and feasible way to map the state of the art can be based on surveys by parameters, that are summarized by means of indicators. Basically, the indicators could be summarized in two groups: the accessibility to the port and the operability within it. The former refers to the services for the incoming users and passengers that transit through the port, the latter stands for the potentiality of the port in terms of touristic development. Each of them has been assigned with a maximum score that represents the weight the actual score has to be normalized with. The maximum value represents the importance of the

strategy adopted by the manager: the higher the maximum score, the more the index contributes to the port performances, so does its importance. Indeed, the long-term strategy hidden in the maximum score selection is the keystone of the methodology. Different strategies scenarios can be adopted to rank the ports, and the comparison of them can be performed in order to help the decision-making phase to adopt the best long-term strategy according to the given purposes at the regional scale approach.
The conceptual phases of the method can be summarized as follows:

- collecting the data;
- clustering of the data (indicators);
- normalization and homogenization of indicators;
- weighted measure of port potential and accessibility (according to long-term development strategy);
- categorization according to pre-defined classes.

To elucidate and explicate the process behind the aforementioned items, the scheme in Fig. 1 illustrates the crucial steps of the method, as detailed in the following subsections.
As it can be deducted by Fig. 1, the methodology has been split into three different conceptual phases. Subsection 2.3 refers to the first step to be performed i.e. the mapping (in the red shaded box in Fig 1). Subsection 2.4 explains the classification criteria and in the end, subsection 2.5 clarifies the last stage of the classification.

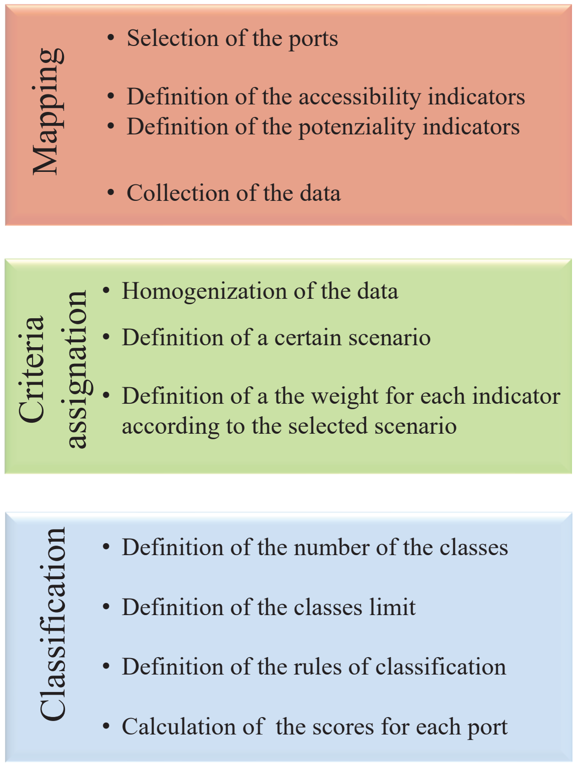

Figure 1: Scheme of the rational of the proposed classification method.

2.3 The mapping

Once the ports implied in the classification have been selected, the data need to be collected (Fig. 1, red box).
Fifty indicators have been chosen to describe the characteristics and the services of each port. They can be identified by four groups:

- port services and characteristics (Tab. 1 and Tab. 2);
- connections (Tab. 3);
- urban and territory planning (Tab. 4);
- port operability (Tab. 5).

Tables 1, 2, 3, 4, and 5 summarize all the considered indicators. For each group, the indicators to be mapped are briefly described. The abbreviations are useful to identify the indicators: the lowercase letter at the beginning of each indicator stands for the data type, whether it is boolean "b" or numerical values (either "f" as float or "i" as integer).
In addition to this general grouping, for the purpose of the ranking of the ports, the defined

indicators need to be divided into the two groups of accessibility and potentiality. The first aims to synthetically represent all the services and structures that allow an easy use of the port for incoming users. The latter group of characteristics refers to the capability of the port to enhance

Table 1: List of the indicators representing the services within the port.

Typology	Description	Abbreviation
Port services	Sanitary facilities	bSI
	Docks lighting	bIB
	Equipment for the disabled people	bAD
	Electricity on quay	bEB
	Showers	iSH
	Guarding	bG
	Availability of drinking water on quay	bAP
	Non-drinking water available on quay	bANP
	Slipway	bSA
	Crane	iGR
	Travel lift	bTL
	Fire-fighting service	bSAI
	Weather service	bSM
	Fuel on quay	bCB
	Waste collection	bRR

Table 2: List of the indicators representing the services in the neighborhood of the ports.

Typology	Description	Abbreviation
Port services in the neighborhood	Motorboat repair yard	bCRB
	Sailing boat repair yard	bCRV
	Scuba tanks recharge	bRBS
	Electronic accessories	bAE
	Fuel stations	bSC
	Electrical repairs	bRE
	Commercial services	bSCOMM
	Number of beds (hotel accommodation)	iRA
	Number of beds extra-hotel accommodation	iREA

Table 3: List of the indicators representing the multi-modal connection services in the neighborhood of the ports.

Typology	Description	Abbreviation
Connections	Number of parking places	iPA
	Numbers of caravans parking places	iACR
	Number of boats for rent	iNB
	Connection with local public transport	fLO
	Connection with suburban public transport	fPO
	Connection with national and regional cycleway plan	iPD[1]
	Connection with rail transport service	bRAPB
	Connection with air transport service	bTPU
	Connection with public utility services	bTPE

Table 4: List of the indicators representing the characteristic of the port for boats accessibility.

Typology	Description	Abbreviation
Services	Maximum mooring length	bCNR
	Maximum water depth at the berths	bSTF
	Number of berths	bSTA
	Automatic sensing system of available berths	bSPU

Table 5: List of the indicators describing the port operability.

Typology	Description	Abbreviation
Port operability	Marine-Weather Climate	bCM
	Exposure of mouths	bEI
	Annual average operativity	fOMANN
	Average winter operativity	fOMI
	Average spring operativity	fOMP
	Average summer operativity	fOME
	Average autumn operativity	fOMA
	Bathymetric surveys	bRB
	Internal agitation	bAI
	Maintance projects	bPROG
	Siltation issues	fINS
	Dredging activity	bDR
	Maintance need	bMAN

potential tourism attractiveness. Data categorized in the first four groups (Tab. 1, Tab. 2, Tab. 3, Tab. 4) have been selected as representative of the "Accessibility Data", while the indicators in the last group (Tab. 5) represent the "Potentiality Data".

Once the indicators have been selected, the collection of the requested data can be performed in several ways. Nevertheless, the feasibility of the mapping and the dynamical essence of the classification method proposed herein required that the data can be rearranged, modified, and updated. This open approach requires that the data should be available, transparent and shared, according to the basic principles of the Open Science and Open Data (Vicente-Saez and Martinez-Fuentes 2018). If so, it is possible also to share the results of the mapping activities and to keep them updated thanks to the update and modification of stakeholders and Public Authority long-term strategy.

2.4 The criteria and the long-term regional strategy: the weights

Taking a look at the indicators, a different nature of the data arises, i.e. some indicators are boolean (1-0 whether the service is present or not), other, on the other hand, are numerical values (either integers or floats). This underlies an inhomogeneity among the two types. For this reason, the data need to be re-mapped. Regarding the boolean data, the values switch between 0 and 1. The floats or integers need to be normalized by the formula:

$$X^*_{ij} = \frac{x^*_{ij} - x^*_{i\,\min}}{x^*_{i\,\max} - x^*_{i\,\min}} \quad (1)$$

where X^*_{ij} is the normalized value of the *i-th* indicator related to the *j-th* port, x^*_{ij} is the original numerical value, $x^*_{i\min}$ min and $x^*_{i\max}$ are respectively the minimum and the maximum value of the *i-th* indicator among all the considered ports. It should be noted that a different kind of normalization can rely on the estimation of the quantiles of the Empirical Cumulative Distribution Function (ECDF) of the mapped indicators. While this rationale perfectly works in normalizing the data, on the other hand, it hides a kind of comparison among the values related to each port (i.e. the quantiles of a given port are influenced by the values mapped for the others), hence the methods would become a comparative analysis.

Referring to the green box in Fig. 1, having homogenized the data, the following step to accomplish is the definition of the criteria, according to which the weight of each indicator has to be unequivocally assessed. Thus, it is possible to define objectively the indicators which, if improved, can lead to an increased ranking of a specific port. It is worth to stress the central role in the classification process of this phase. The choice of weights that defines a scenario is intended, then, as the quantitative implementation of the regional development strategy. Hence, identifying the strategic indicators means supporting the definition of a scenario of development. Indeed, each indicator can have different importance, depending on the policy of development and investments.

This importance is quantified on the basis of a series of weights which, in general, can be defined according to the Likert scale (Joshi et al. 2015), an approach widely used in psychology. In accordance with the Likert scale, values from 1 to 5 have to be assigned to each indicator. The lowest value indicates the worst desirable condition while the maximum value indicates the most favorable condition. In this contest, the proposed scale of ranking is:

1. not important;
2. slightly important;
3. moderately important;
4. important;
5. very important.

In order, each coefficient expresses the correspondent weight used to obtain a weighted average for standardized indicators. Just as an example, if an indicator is "moderately important" its weight will be equal to 3.

At this point, the weight of each indicator has been assessed. It is possible to evaluate, then, how each port lies in the ranking. It is achieved by considering the two aspects, "Accessibility" and "Potentiality", separately. For each group of information, as described in subsection 2.3, the score of the *j-th* port can be estimated by a weighted mean as

$$SC - \eta_j = \frac{\sum_i \alpha_{ij}\varphi_{ij}}{\sum_i \varphi_{ij}} \quad (2)$$

Where the index i refers to the i-th indicator. η stands for "A" as "Accessibility" or "P" as "Potentiality", since the procedure has to be performed for the two groups. α_i represents the potentiality or accessibility of the normalized indicators, while φ_i are the weights assigned in the criteria definition phase, i.e. the maximum value achievable for the *i-th* indicators according to the decided scenario. This procedure returns a pair of scores that characterize each port. Thus, it is easy to evaluate which is the total score of the port considering at the same time SC-A and SC-P in the matrix, according to the assigned grades.

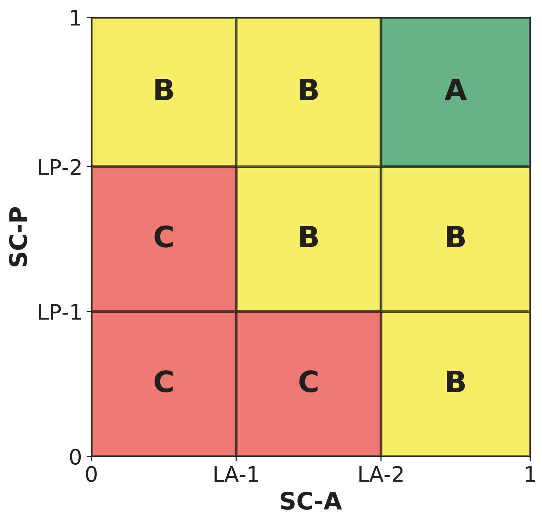

Figure 2: The decision-making matrix

2.5 The decision-making matrix and the classification

The last conceptual step (Fig. 1, blue box) is related to the choice of the rules whereby the gathered information is sorted. To accomplish the classification, a series of pre-defined classes has to be defined. Three ratings have been proposed: A, B and C, from the best to the worst. Each rating has a range of validity in terms of scores (from 0 to 1, since the normalization). These ranges have to be defined according to the set standards (i.e. the decision-making self-assessment of the actual situation). In general, let LA-n and LP-n be the limits of each classes for the accessibility and potentiality data respectively, with $n \in N$, $n \leq M - 1$ where M is the number of the classes, it is valid that $0 < LA - n < 1$ and $0 < LP - n < 1$. If, as in this case, the number of classes M is 3, then for instance $0 < LA{-}1 < LA{-}2 < 1$. The final classification can be summarized by the decision-making matrix, like the one represented in Fig. 2. The matrix whose dimensions are $M \times M$ (M is the number of ratings) assumes different aspects according to the rank assigned to each level. For the specific case of $M = 3$ it results to be a matrix 3x3, and the highest score "A" can be achieved only if the score for each group of indicators (i.e. accessibility and potentiality) exceeds the limits LA-2 and LP-2. The definition of the matrix characteristics and rules is also useful, therefore, for the definition of objective re-classification paths that can "inform" the development strategies in place. A port can enhance its ranking by increasing one of the two types of requirements (accessibility or potentiality) or both. Obviously, all this happens according to the scenario considered, i.e according to the selection of the importance of the indicators that hides the long-term strategy.

3 APPLICATION AT THE PUGLIA REGION REPORTS

3.1 The data

The proposed method has been applied within the frame of the AI-SMART project, ranging from the Puglia Region (Italy) and Ionic Islands to Epirus and Western Greece Regions (Greece). In particular, the methodology presented in the previous section has been applied to the Puglia Region (South-East Italy). It has involved all the 65 ports and marinas (sometimes very small harbors with a single mooring and with very limited facilities) in the region (Fig. 3). They differ for their functionality, for their economical and maritime relevance: there are ports that are nationally or regionally strategic and others, instead, that are mainly tourist oriented. Only for the purpose of presenting the ports, they have been grouped according to the Italian national law (L. 28/01/94 n° 84, art. 4) in Tabs. 6, 7, 8 and 9. The group "Category 1" includes 7 ports of international relevance (Tab. 6), 8 ports of national relevance are counted in the group "Category 2" (Tab. 7), "Category 3" (Tab. 8) counts 28 ports classified as regionally relevant and the 18 left are out of the Italian law guideline and they are grouped in the category "Others" (Tab. 9). It is worth specifying that all the military ports have not been considered in this classification.

During the mapping stage, the 50 indicators presented in Tables 1, 2, 3, 4 and 5 have been evaluated.
For each indicator, the required information has been gathered by the following sources:

- open source information;
- satellite imagery;
- official information.

Table 6: Category 4. Ports of international relevance according to the Italian law 84/94 art. 4.

Name
Bari - Porto Nuovo
Brindisi - Porto Interno
Brindisi - Porto Esterno
Taranto - Porto Mercantile
Taranto - Porto Industriale Esterno
Taranto - Porto Industriale Interno
Brindisi - Porto Medio

Table 7: Category 2. Ports of national relevance according to the Italian law 84/94 art. 4.

Name
Barletta
Manfredonia - Porto Industriale
Monopoli
Otranto
Molfetta
Gallipoli-Seno del Canneto
Manfredonia - Marina Cala delle Sirene
Gallipoli - Porto Mercantile

Table 8: Category 3. Ports of regional relevance according to the Italian law 84/94 art. 4.

Name
Savelletri
Gallipoli - Cala Fontanelle
I. S. Domino - Cala degli Schiavoni
Manfredonia - Porto Vecchio
Gallipoli - Darsena Fontanelle
Mola di Bari
Bari - Porto Vecchio
Vieste
Giovinazzo
Taranto - Taranto Yatch
Villanova di Ostuni
Polignano a Mare - Cala Ponte
Gallipoli - San Giorgio
S. Foca di Melendugno
Maruggio - Campomarino
Trani
I. S. Nicola - Porticciolo S. Nicola
Santa Maria di Leuca
Mattinata
Bisceglie
Gallipoli - Porto Gaio
Porto Cesareo
Marina del Gargano
Taranto - Lega Navale
Rodi Garganico
Torre San Giovanni d Ugento
Peschici
Taranto - Marina Taranto Molo Sant'Eligio

Table 9: Ports of minor economical relevance.

Name
Torre a Mare
Torre Canne
Santa Caterina di Nardo
Lido Gandoli
Tricase - Marina di Porto
Foce di Varano
Frigole - Lega Navale
Mon Reve
Torre Vado
Casalabate
San Cataldo
Foce del Capoiale
Palese
Torre Pali
Baia d'Argento - Porto Saguerra
Cala Portecchia
Cala San Giorgio
Marina di Andrano

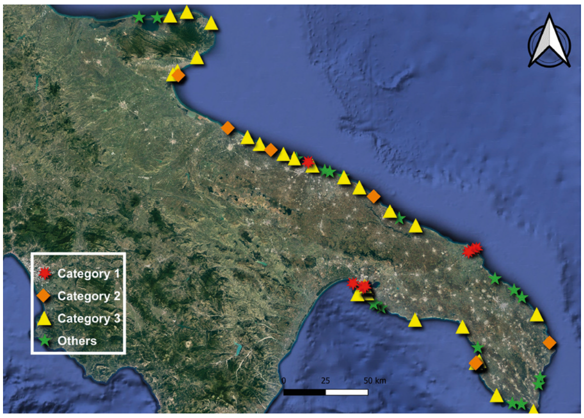

Figure 3: Maps of the mapped Puglia region ports.

Specific interviews with Port Managers are ongoing in order to improve the reliability of the mapping activities.

It has to be stressed that the whole data have been collected by using public domain information (i.e. services, privates, and administration websites). When some data were not directly available they have been calculated or deducted from open data. For instance, the operability indicators have been calculated by the significant wave height duration curve obtained from the data extracted from the ERA5 dataset propagated at the coast. The operability indicators (seasonal and annual) have been collected by calculating the days when the significant wave height resulted to be lower than 1.5 m.

3.2 The ranking of the Puglia region ports

According to the rationale illustrated in Section 2, it can be noted that the selection of weights to the individual indicators cannot be unique. It depends, among other things, on the development strategy that the stakeholders pursue. Therefore, with the aim of providing some examples of the results of applying the methodology, some scenarios have been defined. Each scenario gives more importance to some aspects than others. The considered scenarios are described as:

1. **Touristic, Scenario 1** larger weights have been assigned to all the indicators whose prerogative is to encourage tourism (for example, hotel accommodation);
2. **Social, Scenario 2** larger weights have been assigned to all the indicators that stress the attention of the ports to social issues (e.g. the presence of utilities for wheelchair access);
3. **Marina, Scenario 3** larger weights have been assigned to all the indicators whose prerogative is to encourage the marina activities (e.g. the services and the maintenance of infrastructures able to host yachts);
4. **Urban Planning, Scenario 4** a major relevance is given to environmental, urban, and harbor planning.

The qualitative description of the considered scenarios is transferred into a quantitative point of view, by assigning the weights synthesized in Tables 10 and 11.

The three different scores (A, B and C) have been assigned by using equally divided classes, i.e. for both the data groups, the limits have been divided into 3 groups by the following ranges:

- from 0 to 0.33 (LA-1, LP-1);
- from 0.33 (LA-1, LP-1) to 0.66 (LA-2, LP-2);
- from 0.66 (LA-3, LP-3) to 1.00.

The classification rules have been defined as:

- Rank A: SC-A>LA-2 and SC-P>LP-2;
- Rank B: SC-A≤LA-3 e SC-P>LP-3 or SC-A>LA-1 e SC-P>LP-1 or SC-A>LA-2; e SC-P>0
- Rank C: SC-A≤LA-2 e SC-P≤LP-3 or SC-A>LA-2 and SC-P≤LP-1.

Table 10: Accessibility indicators weights according to different decision making scenarios.

Indicators	Sc. 1	Sc. 2	Sc. 3	Sc. 4
Sanitary facilities	2	3	4	1
Dock lighting	1	1	3	1
Equipment for the disabled people	2	5	3	1
Electricity on quay	1	1	3	1
Showers	1	1	2	1
Guarding	1	1	4	1
Availability of drinking water on quay	1	1	2	1
Non-drinking water available on quay	1	1	2	1
Slipway	1	1	5	1
Crane	1	1	5	1
Travel lift	1	1	5	1
Fire-fighting service	2	2	5	1
Weather service	1	1	4	1
Fuel on quay	1	1	5	1
Waste collection	1	4	4	5
Boat repair yard	1	1	4	1
Sail repair yard	1	1	4	1
Scuba tanks recharge	1	1	2	1
Electronic accessories	1	1	3	1
Fuel stations	5	1	4	1
Electrical repairs	1	1	3	1
Commercial services	5	5	1	1
Number of beds (hotel accommodation)	5	5	1	1
Number of beds extrahotel accommodation	5	5	1	1
Number of parking places	5	2	5	2
Numbers of caravans parking places	5	1	4	1
Number of boats for rent	5	1	4	1
Connection with local public transport	3	1	5	1
Connection with suburban public transport	3	1	5	1
Connection with national and regional cycleway plan	5	1	5	1
Connection with rail transport service	1	1	5	1
Connection with air transport service	4	5	1	1
Connection with public utility services	4	4	1	1
Maximum mooring length	4	5	1	1
Maximum mooring water depth	4	4	1	1
Number of berths	4	4	1	1
Automatic sensing system of available berths	4	5	1	1

Table 11: Potentiality indicators weights according to different decision making scenarios.

Indicators	Sc. 1	Sc. 2	Sc. 3	Sc. 4
Marine-Weather Climate	1	1	1	1
Exposure of mouths	1	1	4	1
Annual average operativity	1	1	5	1
Average winter operativity	1	1	5	1
Average spring operativity	1	1	5	1
Average summer operativity	1	1	5	1
Average autumn operativity	1	1	5	1
Bathymetric surveys	1	1	3	5
Internal agitation	1	1	1	5
Maintance projects	1	1	3	4
Siltation issues	1	1	1	4
Dredging activity	1	1	3	5
Maintance need	1	1	3	5

3.3 Results and discussion

The mapping and classification activity results are presented in this section. First, the mapping of indicators led to basic statistics in order to describe the big picture of the actual situation within the Puglia region ports. It is worth recalling that the indicators have different features: some of them are boolean, others are numerical values. Figs. 4 and 5 show the percentange of ports of each category for which the boolean indicators have been mapped as true (in the abscissa), whose abbreviations are listed in Tabs. 1, 2, 3, 4 and 5, for the accessibility and potentiality class respectively. For the sake of simplicity, the bar charts are grouped according to the categorization given by Italian law.

On the other hand, to gain some insight into the numeric indicators, basic descriptive statistics indexes have been calculated among the ports of each category, i.e. the minimum, maximum and mean values and the mean percentage deviation between the ports indicator and the mean value. They are listed in Tabs. 12 and 13.

In general, the minor ports (i.e. "Others") present fewer services and also a number of services not present at all, in fact also the mean discrepancy in average is higher. As far as the potentiality numeric indicators are concerned, their variability is negligible, i.e. the mean discrepancy is zero in almost all the cases.

Table 12: Accesibility numerable mapped indicators for the Puglia region ports.

		iRA	iREA	iPA	iACR	iNB	fLO	fPO
Cat.1	Mean	331	376.2	572.8	31.3		37.5	13.7
	Max	618	1089	1800	80		40	23
	Min	0	0	0	0		0	8
	Mean dev.	-29%	-29%	-29%	-57%		-71%	0%
Cat. 2	Mean	803.4	689.9	210.3	1204.8		32.2	7.0
	Max	1133	1755	372	3164		110	15
	Min	0	0	0	0		0	0
	Mean dev.	-38%	0%	0%	-38%		-13%	0%
Cat. 3	Mean	623.8	650.3	234.6	735.9	20.7	22.7	4.1
	Max	2572	2600	982	4972	50	70	8
	Min	0	7	0	0	0	0	0
	Mean dev.	-11%	0%	-18%	-57%	-89%	-4%	-4%
Others	Mean	228.2	169.9	140.6	184		8.5	1.8
	Max	721	511	532	452		15	3
	Min	0	0	0	0		0	0
	Mean dev.	-44%	-6%	-11%	-78%		-28%	-11%

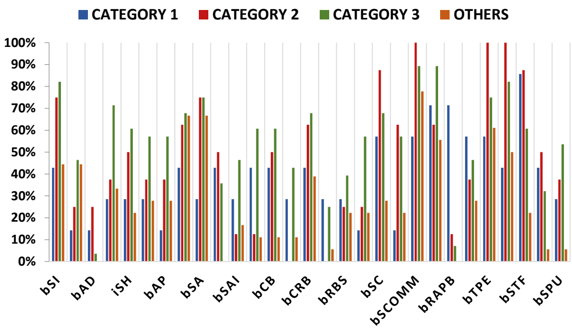

Figure 4: Accesibility of boolean mapped indicators for the Puglia region ports.

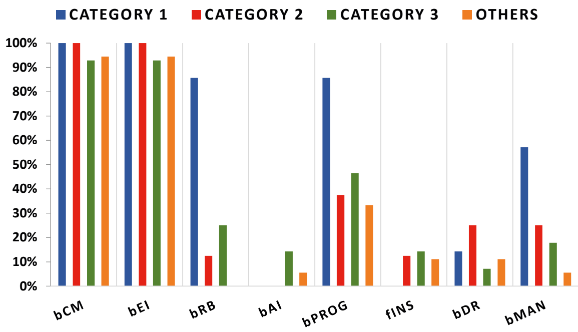

Figure 5: Potentiality of boolean mapped indicators for the Puglia region ports.

Fig. 6 represents the decision-making matrix, one for each considered scenario (the panels refer to the correspondent scenario previously presented). The ports are plotted with different markers according to the category of the ports. The matrices show how scenarios 1 and 2 give very similar results. Different is the case for scenario 3 but especially for scenario 4, which classifies 2 ports in the A rank, but on the other hand, the majority of the remaining ports lay on the lower rank C.

The counting of the ports for each rank and for each scenario is resumed in Tab. 14. The results inspection highlights that the selection of the weights is meaningful in magnifying the effects of the long-term strategy.

Table 13: Potentiality of numerical mapped indicators for the Puglia region ports.

		fOMANN	fOMI	fOMP	fOME	fOMA
Cat.1	Mean	0.96	0.94	0.98	0.99	0.94
	Max	0.97	0.94	0.99	1	0.95
	Min	0.96	0.93	0.98	0.98	0.93
	Mean dev.	0%	0%	0%	0%	0%
Cat. 2	Mean	0.97	0.95	0.99	0.99	0.96
	Max	0.99	0.98	1	1	0.98
	Min	0.96	0.93	0.98	0.98	0.93
	Mean dev.	0%	0%	0%	0%	0%
Cat. 3	Mean	0.97	0.946	0.99	0.99	0.95
	Max	0.99	0.98	1	1	0.98
	Min	0.91	0.85	0.96	0.98	0.85
	Mean dev.	0%	0%	0%	0%	0%
Others	Mean	0.96	0.93	0.98	0.99	0.94
	Max	0.97	0.95	0.99	1	0.97
	Min	0.92	0.86	0.96	0.98	0.85
	Mean dev.	0%	0%	0%	0%	0%

Table 14: The number of the ports ranked by the A, B and C rank for each considered scenario.

	Sc. 1	Sc. 2	Sc. 3	Sc. 4
A	1	1	3	2
B	36	39	27	13
C	28	25	35	50

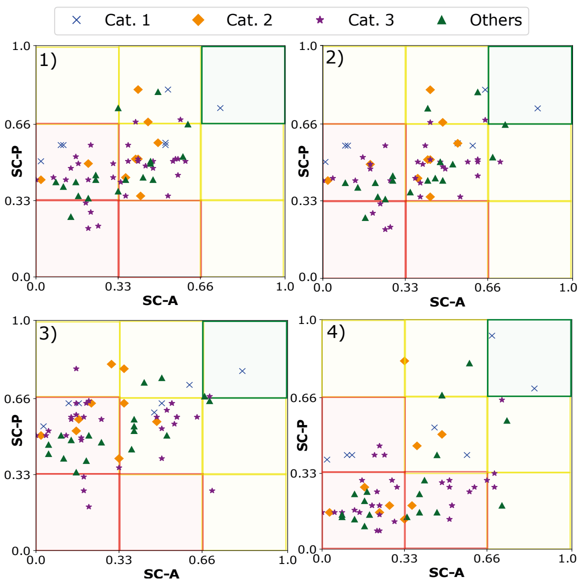

Figure 6: Decision-making matrix obtained from different scenarios: Sc.1 (panel 1), Sc.2 (panel 2), Sc.3 (panel 3) and Sc.4 (panel 4).

4 CONCLUDING REMARKS

This paper aims to present a regional-scale classification of ports and marinas that can be used to implement a long-term development strategy. The classification is based on the mapping of ports and marinas in terms of users- and transport-services. Indeed, the early stage to be implemented in the methodology is the mapping of the services, by means of indicators that range over different aspects, i.e. port services and characteristics, connections, and operability features within the ports. The mapped (open) data are homogenized and related to pre-defined ranking criteria. This aspect furnishes the method with a clear and objective strategy to be accomplished in order to obtain better performance on the services and infrastructure enhancement. In other words, the final goal of the classification is to give the Public Authority and the stakeholders a tool that can help the definition of long-term development strategy. The same classification can be also used to monitor the effectiveness of the strategy. Indeed, the approach is flexible and the results of the classification can be updated once the services of a given port have been enhanced. The methodology leads to the construction of a decision-making matrix, that exemplifies the performance of the ports in terms of accessibility and potentiality, and that ranks them, according to given grades.

The keystone in the method is the choice of the weights given to the indicators whose values are related to. Indeed, the weights are directly related to the long-term strategy: the weights are the quantitative implementation of the regional development strategy. The general method is intended also to support the port manager in defining effective actions in accordance with the regional development strategy. The classification update of a given port can be successfully achieved by acting on different paths: it can be obtained acting first on the requirements of accessibility and then on those of potentiality, or vice versa. In both cases the importance of the choice of the values of the weights can be observed: the higher values suggest a strategy whose aims are to improve primarily the aspects the indexes describe (and whose modification can be pursued by individual ports in order to achieve an improvement in classification).

To highlight its feasibility and applicability, the proposed method has been, then, applied to the Puglia region ports within the frame of the AI-SMART project. It results, for the different scenarios and for a three-ranks based classification (“A”, “B” and “C”, from the best to the worst), that in case of a touristic and social longterm strategy (i.e. when touristic and social indicators are considered as the most important), the probability (i.e. the relative frequency) of being classified as a “B” score port is the highest. For the marina and urban planning scenarios (i.e. when indicators related to marina activities and urban planning are considered as the most important), they present a greater number of low classified ports, but on the other hand, they present a higher number of ports ranked in the “A” class. The obtained results serve to highlight the applicability of the proposed method at the regional scale.

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