FRAGILITIES AND ADVANTAGES OF COASTAL AREAS IN THE MEDITERRANEAN BASIN[1]

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1. Introduction and policy framework

This research addresses a multisource analysis related to the responses of systems for the sustainable protection of the seas and resources, and it is also a contribution to the reading of sustainable development goals for United Nations 2030 Agenda, which aims to pursue the objectives of "Blue Growth" in the Mediterranean areas and to meet the challenge of climate change within the European Union (European Commission, 2021a).

The general framework in which this contribution rises, introduces a range of EU policies that address the interlinked thematic shared guidelines to preserve ocean health and safeguard marine ecosystems (see Table 1, Eurostat, 2022).

Marine Strategy Framework Directive (MSFD) that aims to ensure marine waters achieving good environmental status by being ecologically clean, healthy, and productive, has pushed for a better understanding of the pressures and impacts of human activities on the sea, and their implications for marine biodiversity, habitat and ecosystems. EU Bathing Directive lays down provisions for monitoring and classifying bathing water quality at designated sites.

EU Biodiversity Strategy for 2030 aims to enhance the protection of marine ecosystems with the objective of achieving good environmental status. Zero Pollution Action Plan for Air, Water and Soil sets out key actions to improve water quality by reducing emissions of waste, plastic litter at sea and microplastics (European Commission, 2021b).

Finally, the EU Strategy on adaptation to climate change aims to stop ocean acidification and encourages nature-based solutions to sustain Europe's seas.

In short, the EU is committed to improve water quality in marine waters and coastal areas in the sea basins around the EU, especially the Mediterranean Sea,

[1] The paper has been jointly written by all the authors but § 1, 2.2, 5, 6 and 7 can be attributed to A. P. M. Mirto, § 2.1 to E. Olla, § 3 and 4 to D. Vacca, while § 8 to all the authors. Italian maps in ArcGis have been created by E. Olla, European maps by L. D'Alessandro and F. P. Rizzo.

through a range of land-based and marine-based policies monitored by a defined set of indicators.

After a geo-mapping descriptive analysis, a statistical multivariate study has been applied to compare coastal and non-coastal areas classifying by different indicators the main components. In the end, some composite indicators have been identified, first for Italian municipalities and then for European regions, according to the main thematic domains: landscape, mobility, and demography.

Table 1 – *Main EU policy regulations about sea safeguard and soil protection.*

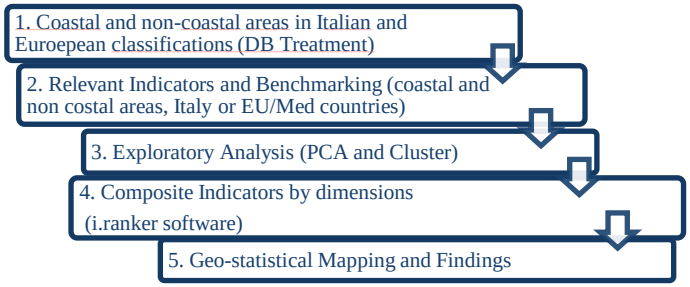
EU Legal Act	Theme	Main Objectives	References
MSFD	Marine water	Pressure of human activities on the sea and preservation of marine biodiversity and ecosystems.	Directive 2008/56/EC
Bathing Water Directive	Bathing Water quality	Classification of water quality	Directive 2006/7/EC
Biodiversity Strategy	Marine ecosystem	Protection of marine ecosystems	COM (2020), 380 final
Zero Pollution Action Plan	Water quality	Reducing emission of waste	COM (2021), 400 final
International Ocean Governance Agenda	Ocean sustainability	Providing a platform to discuss solution on the sea sustainability	JOIN (2016), 49 final
Strategy on adaptation to climate change	European seas	Stop ocean acidification and encourage nature-based solutions	COM (2021), 80 final

Source: European Commission - Marine Environment website.

2. Sources and methods

The methodological process underlying the project deals with the identification of coastal and non-coastal areas within shared classifications and the selection of relevant thematic indicators on a national and European levels (see Figure 1, Istat, 2020).

Figure 1 – *Main methodological steps.*



More in details geographical areas on European level have been classified according to the Nomenclature of Territorial Units in 2016 and 2021. Finally, Tercet

EU 2017/2391 Regulation identifies classification about municipalities related to the distance away from the coast. The classification of coastal areas is defined as either the territories bordering the coastline or where more than half of the population living on the coastline or territories less than 50 kilometers from the sea.

2.1 Sources and methods at Italy level

The fragilities and advantages of the Italian coastal zones were analysed by a set of indicators that represent the relevant dimensions: landscape, mobility, and demography (Istat, 2022).

Data used for the construction of the indicators of the demographic, geographical and social context are extracted from Istat sources, while those relating to the environment and protection of the territory come from Ispra (see Table 2).

Table 2 – *Relevant Italy indicators by domains.*

Domain/Indicator	Definition	Time
1. LANDSCAPE – Sources: Istat (1.3) and Ispra (1.1, 1.2, 1.4)		
1.1 Land Consumption (%)	% Land use	2020
1.2 Urban Waste per Inhabitant (kg)	(Urban waste / population) * 100	2020
1.3 Water Consumption per Inhabitant (L)	Water supplied in a day per inhabitant	2018
1.4 Separate Waste (%)	Separate waste / Urban waste	2020
2. MOBILITY – Source: Istat		
2.1 Tourist Accomodation Establishments per km^2	Number of establishments / Surface	2020
2.2 Nights Spent per Inhabitant	Number of nights spent / Population	2020
2.3 Composite Index of Tourist Density	Classification of municipalities according to their tourist vocation	2019
3. DEMOGRAPHY – Source: Istat		
3.1 Change in Population (%)	(Pop. 2021 – Pop. 2012) / Pop. 2012 *100	2012, 2021
3.2 Population Density	Population / Total Surface	2021
3.3 Aging Index	Ratio between population over 65 years and the population under 15 years * 100	2021

Over the last ten years, the number of Italian municipalities has decreased by over a hundred units (see Table 3) therefore the 2012 data had to be adjusted to be compared with 2021 data, by merging population, surface, and other geographical classifications[2] related to current municipality unions to obtain the *Change in Population* indicator.

[2] Istat elaborates classifications of Italian municipalities that are based on geomorphological characters or urban settlements, measured for statistical purposes only. A series of attributes are therefore assigned to municipalities, corresponding to the following physical and/or anthropological characteristics: coastlines, altitude zone, altitude of the main town, municipal area (km^2), urbanisation degree, coastal areas to which are added information related to area and population (legal and resident).

Another significant data processing was used for the *Nights Spent per Inhabitant,* in which some figures have been obscured to protect statistical confidentiality. In these cases, missing data were extrapolated from aggregated ones of all other municipalities within the same province.

Table 3 – *Population changes 2012-2021.*

	Italy			Coastal				Non-Coastal			
Year	Population	Mun.	% Pop. Change	Population	Nr	% Pop	% Pop. Change	Population	Nr	% Pop	% Pop. Change
2012	59.394.207	8092		20.295.724	1170	34,2		39.098.483	6.922	65,8	
2013	59.685.227	8082	0,49	20.364.115	1170	34,1	0,34	39.321.112	6.912	65,9	0,57
2014	60.782.668	8071	1,84	20.958.442	1169	34,5	2,92	39.824.226	6.902	65,5	1,28
2015	60.795.612	8048	0,02	20.971.579	1169	34,5	0,06	39.824.033	6.879	65,5	0,00
2016	60.665.551	8003	-0,21	20.923.670	1169	34,5	-0,23	39.741.881	6.834	65,5	-0,21
2017	60.589.445	7983	-0,13	20.903.428	1169	34,5	-0,10	39.686.017	6.814	65,5	-0,14
2018	60.483.973	7960	-0,17	20.856.229	1168	34,5	-0,23	39.627.744	6.792	65,5	-0,15
2019	59.816.673	7926	-1,10	20.496.248	1166	34,3	-1,73	39.320.425	6.760	65,7	-0,78
2020	59.641.488	7903	-0,29	20.411.913	1165	34,2	-0,41	39.229.575	6.738	65,8	-0,23
2021	59.236.213	7903	-0,68	20.258.799	1165	34,2	-0,75	38.977.414	6.738	65,8	-0,64

The last significant data elaboration regards *Urban Waste* indicators. The rubbish collection service often manages urban waste of many municipalities organized in unions and Ispra collected the total data of those aggregations (Ispra, 2021). To represent and compare these data for all single municipalities, the association values have been recalculated by relating the total measure to the individual population and area data.

2.2 Sources and methods at EU level

The primary source of European information is the Eurostat Data Browser that provides data at NUTS 2 level for the areas of the European Union countries and those washed by the Mediterranean Sea (Mirto and Ticca, 2017).

Data treatment in the European databases has been quite impressive, managing and imputing missing data as well as considering outliers for specific countries and time periods, especially concentrated in certain thematic areas. The selected relevant indicators were classified by three components: landscape, mobility, and demography (see Table 4).

Table 4 – *Relevant EU indicators by domains.*

Domain/Indicator	Definition	Territory - Time
1. LANDSCAPE – Source: Eurostat Data Browser and JRC EC (1.4 and 1.5)		
1.1 Artificial Land (%)	Areas characterized by an artificial and often impervious cover of constructions and pavement / Total surface	NUTS 2 – 2018 and 2012
1.2 Soil erosion (%)	% Estimated soil erosion by water	NUTS 2 - 2016
1.3 Land Use with heavy impact (%)	% Land use with heavy environmental impact	NUTS 2 - 2018
1.4 Heating Day degrees (absolute values and % var. 2021/2012)	Severity of the cold at a specific time, taking into consideration outdoor temperature and average room temperature	NUTS 3 – 2021 and 2012
1.5 Cooling Day degrees (absolute values and % var. 2021/2012)	Severity of the heat at a specific time, taking into consideration outdoor temperature and average room temperature	NUTS 3 – 2021 and 2012
2. MOBILITY – Source: Eurostat Data Browser		
2.1 Establishment per Km^2	Number of establishments / total surface	NUTS 3 – 2020, 2019 and 2012
2.2 Nights spent per inhabitant	(Number of nights spent / population) * 1.000	NUTS 2 – 2020, 2019 and 2012
2.3 Net occupancy rate of hotel bed-places	Total number of overnight stays divided by the number of bed places on offer (excluding extra beds) and the number of days when the bed places are available for use (net of seasonal closures and other temporary closures) * 100	NUTS 2 - 2019
2.3 Passenger Sea transport per inhabitant	(Number of passenger sea transport / population) * 1.000	NUTS 2 - 2019
3. DEMOGRAPHY – Source Eurostat Data Browser		
3.1 Life expectancy at birth – male, female and total	Number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life	NUTS 2 - 2020
3.2 Population Density	Population / Total Surface	NUTS 3 - 2020
3.3 Ageing index	Ratio between population over 65 years and the population under 15 years * 100	NUTS 2 -2021

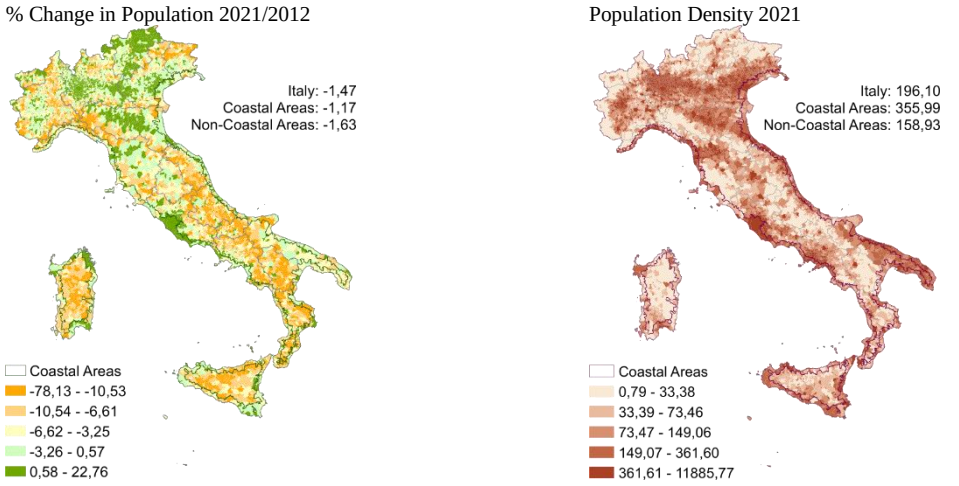
3. Main findings in Italian coastal and non-coastal municipalities

In Italy, as of January 1st, 2021, the coastal municipalities are 1,165, about 15% of the total amount. There are five regions without coastal zones (Lombardy, Trentino Alto Adige, Piedmont, Valle d'Aosta, Umbria). The record of the regional incidence of coastal municipalities belongs to Liguria with just under 60%, followed by Sicily, Puglia, and Calabria which have about 45% of their municipalities classified as coastal. The part of the population that lives in these areas has a lower aging rate than the national and non-coastal areas' average. There are 180 people aged sixty-five and over every 100 0-14 years old children against 183 Italians and 184 of non-coastal areas.

Analyzing the same year, the Italian resident population is 5,926,213, down from the year 2012 by 1.47% (see Figure 2). In ten years, Italy has lost about 871 thousand

people. In coastal areas the same trend is observed at national level, although it shows a lower intensity (-1.17%). On the other hand, not coastal areas go over the national average data with a variation of -1.63%.

Figure 2 – *Mapping % Change in Population 2021/2012 and Population Density 2021 by Italian municipalities.*



Anthropic pressure, measured with *Population Density*, is much higher in coastal areas, where it reaches 356 inhabitants for 1 km vs. 159 in non-coastal areas.

Coastal areas are also very attractive from a touristic point of view. During 2020, the nights spent at tourist accommodation per inhabitant are 5.36 in coastal areas, more than double the value of non-coastal areas (2.45, Figure 3). However, the level of tourist attractiveness in 2020 is affected by the reduction of mobility due to the restrictions of the pandemic period. In fact, in 2019, the value of this indicator was 7.30 at the national level, 11.26 for coastal areas and 5.07 for non-coastal areas.

9 out of 10 municipalities with the highest tourist flow per inhabitant (values above 298) belong to the non-coastal areas of Trentino-Alto Adige.

Also, tourism impact, in terms of accommodation establishment per km^2, is higher in coastal areas, where a rate of 2.11 was measured in 2020 vs. 0.43 in non-coastal municipalities. Among the top ten municipalities with a higher density of accommodation, (values higher than 47.6), six are in the coastal areas of the Adriatic coast (Jesolo, San Michele al Tagliamento, Lignano Sabbiadoro, Gabicce Mare, Cattolica, Riccione) and two in the Amalfi Coast.

Figure 3 – *Mapping main results in Italian coastal and non-coastal areas at municipal level – Mobility.*

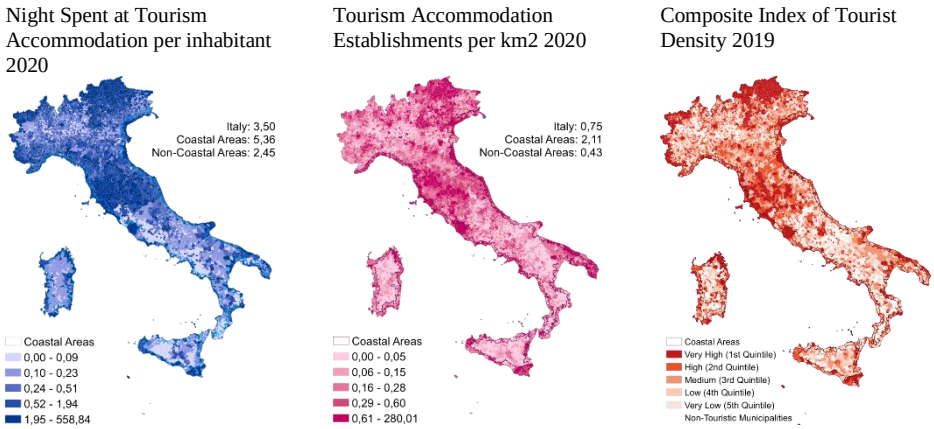
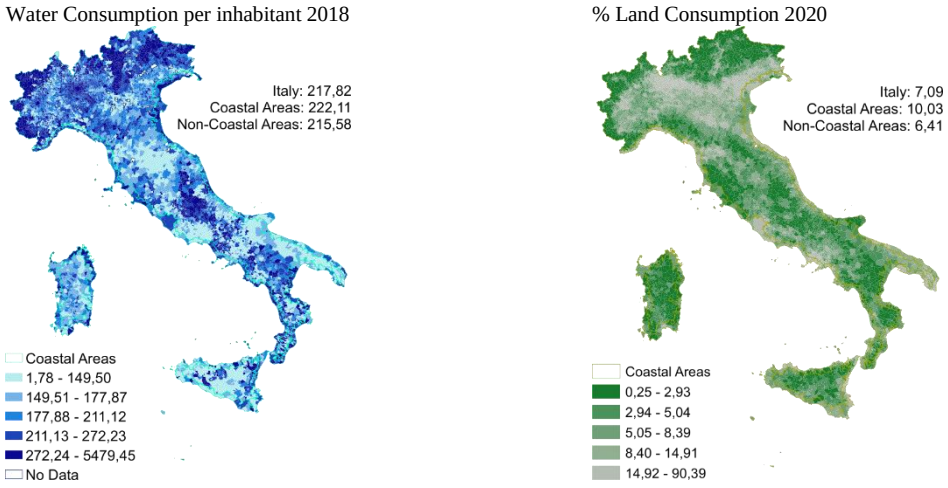


Figure 4 – *Mapping main results in Italian coastal and non-coastal areas at municipal level – Landscape.*



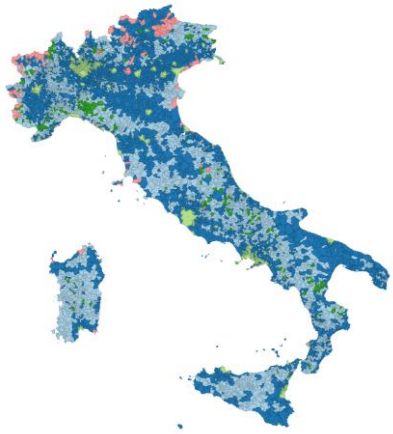
Another key factor is the condition of the municipal landscape and the natural resources' consumption. In coastal areas there is a greater production of municipal waste: 51.8 per 100 inhabitants against 48.9 in Italy and 46.9 in coastal areas.

As the Figure 4 shows, water consumption is also higher at 222 liters per inhabitant (218 in Italy and 216 in non-coastal). The same trend is observed through

the analysis of land consumption, which in coastal areas is 10% and in non-coastal areas is 6%.

Figure 5 – *Findings in Principal Component Analysis and Cluster for Italian municipalities.*

Cluster	Characters	Main Municipalities	% Costal Areas
CL1	Population criticality, low population density and low land use	Trapani, Savona	12,0
CL2	Propensity to population development and high land consumption	Messina, Parma, Taranto	16,5
CL3	Medium and large urban centres with high demographic attractiveness, high urban density and considerable tourist attraction	Roma, Milano, Venezia, Napoli, Bari, Palermo	26,3
CL4	Very small inner areas with a tendency to aging and population loss	Castelcivita, Montegiordano, Oriolo	3,7
CL5	Small towns located in coastal and mountain areas with good tourist attractiveness and high water consumption	Sorrento, Cattolica, Riccione, Caorle, Jesolo	22,1



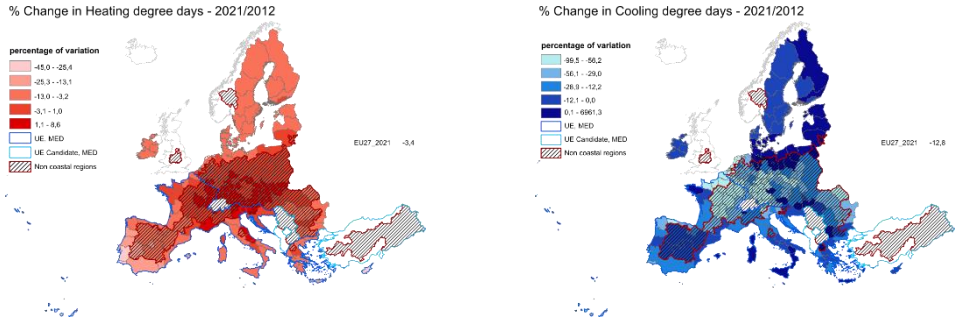
4. PCA and Cluster at Italian level

Multivariate analysis techniques[3] have been used to draw a synthetic profile of municipalities, representative of descriptive dimensions.

The municipal indicators were subjected to a preventive Principal Component Analysis (PCA) with the aim of reducing the size of the initial set of data to better grasp the information structure underlying the data. Three components were selected from PCA, with a cumulative proportion of variance of 0.5591 and a ratio of the total sum of squares of 0.5779. Figure 5 describes the main results of this analysis.

[3] Multivariate analysis was carried out with the Geoda software. For Principal Components (PCA) the SVD Single-Value Decomposition method was used, and the variables were standardized with the z-score method. The non-hierarchical (NHC) k-mean method was used for cluster analysis.

Figure 6 – *Mapping in Heating and Cooling Degree Days for NUTS 2 regions.*



5. Main findings in EU coastal and non-coastal regions

The Mediterranean area is a climate hotspot where temperatures have already recently increased by 1.5 C°, while the world average increase is 1.1 C° (see Figure 6). The warming effect in the Mediterranean is more intense now than in most of the world, with increasing risks associated to climate change (SDSN Mediterranean, 2020). Between 2021 and 2012 *Heating needs* have decreased less in Med countries while *Cooling needs* have increased more in north European countries over the time.

To analyse this effect and more in general the relation between human pressure and settlements in the different coastal and non-coastal areas, a specific analysis has been carried out by using principal component analysis and afterward a specific software "i.ranker"[4] to define some composite indicators.

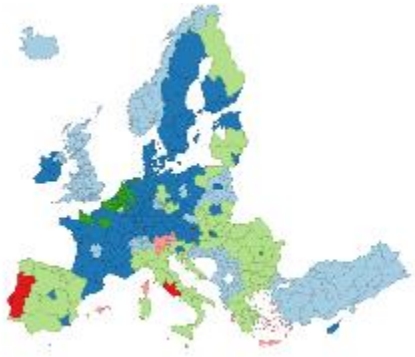
6. PCA and Cluster at EU level

Three components have been selected by Principal Component Analysis and the cumulative proportion of variance was 0.6864, while the ratio of between to total sum of squares was 0.7649. The main findings have been described in Figure 7.

[4] i.ranker is a software system that allows the calculation of synthetic indicators through the analysis and comparative evaluation of the main methods of statistical synthesis of elementary indicators available in the literature, https://i.ranker.istat.it/.

Figure 7 – *Findings in Principal Component Analysis and Cluster for NUTS 2 regions.*

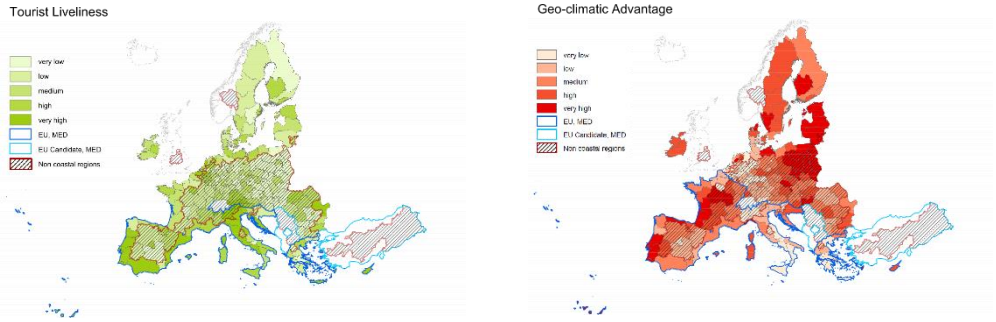
Cluster	Characters	Main regions
Cl light blue	Missing data	
Cl dark blue	Positive demographic change and moderate geo-climatic advantage	France, Germany, Ireland
Cl light green	Negative demographic change and good geo-climatic advantage	Italy, Spain, Slovenia, Romania
Cl dark green	High population density Urban areas with geo-climatic disadvantage	Paris, Budapest, Dusseldorf
Cl pink	High tourism density in low urbanized areas	Corsica, Baleares, Canaries
Cl red	High tourism density in highly urbanized areas	Lisbon, Lazio, Vienna



7. Composite indicators by domains at EU level

Ranker composite indicator software has been applied to identify three composite indicators for the different components: landscape, mobility, and demography (Mazziotta and Pareto, 2017). Therefore, according to Mazziotta-Pareto Index+ (in the positive variant) regions belonging to the groups characterised by dark red colours are those ones with a high geo-climatic advantage and localised especially in non-coastal areas. Moreover, according to the same index the regions with a high liveliness (dark green) are localised in the coasts.

Figure 8 – *Composite indicators by geo-climatic and tourism dimensions.*



8. Final remarks

Soil strategy is strictly linked to European Green Deal midterm goals to achieve good ecological and chemical conditions in surface water, and good chemical and quantitative conditions in groundwater by 2017. Coordinating water and soil policies is essential to achieve soil and aquatic ecosystem health through better soil and water management (COM (2021) 699).

According to the multidimensional analysis the principal findings are the following:

- Demographical dimension has been greatly influenced by the level of population as well as their health condition, but Italy shows different tendency in comparison to the European Union overall.
- Mobility dimension greatly related to the tourism flows has measured the anthropic impact in coastal areas at national level as well as European one.
- Geo-climatic indicators have shown an advantage especially in non-coastal areas belonging to the EU.

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SUMMARY

To pursue the goals of Blue Growth and meet the challenge of climate change, the multisource analysis related to the responses of systems for the sustainable protection of the seas and resources offers here a contribution to the reading of the objectives for sustainable development of the 2030 Agenda of the United Nations.

The article explores the issues of sustainability, including a set of indicators useful for assessing the human impact and land consumption of coastal and coastal regions in the Mediterranean basin and in the EU regions. A focus on the municipal scale deepens the same themes at the national level.

The conceptual picture of the anthropogenic impact on the environment of the coastal and non-coastal areas of the EU and Mediterranean countries may derive - as is well known - from demographic factors, tourist pressure, the presence of major commercial ports, the pressure of municipal waste per capita, sources of water supply and volumes of distribution networks in coastal areas as well as an increased risk of land cover transformation that inexorably impacts land consumption and the conservation of natural resources and landscape of the territories.

The development perspectives of this paper are oriented towards finding an appropriate synthesis method for assessing the impact of the anthropic action on coastal and coastal areas, with reference to the evaluation of the different demographic, environmental and natural dimensions that are offered by the territorial analysis.

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