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Inner Areas Regeneration and the Circular Economy Model

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An assessment method for governing Smart Tourism in a bioregion of Southern Sardinia (Italy)

Un metodo di analisi per lo Smart Tourism in una bio-regione nel Sud Sardegna (Italia)

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ABSTRACT AND KEYWORDS

An assessment method for governing Smart Tourism

In recent years, smart tourist management has witnessed a considerable revolution. It has shifted from focusing only on technology to prioritising location-specific issues and this has led in the identification of territorial ecosystems, which are connected to urban bioregions but not necessarily tied to administrative boundaries. The polycentric bioregional approach is particularly relevant for island regions, which suffer demographic and environmental problems because of their geographic location. This article aims to explore the potential of smart tourism as a strategy for developing inland areas by linking tourism goals with coastal regions in insular bioregions. The authors investigate the historical region of Sulcis Iglesiente in Sardinia to illustrate this perspective. Smart tourism is proposed as a crucial element in addressing depopulation, social marginalisation, and economic stagnation in inland areas. To evaluate the distribution of local resources, the authors apply a methodological approach that combines geospatial analysis and spatial syntax techniques. The study concludes by proposing centralisation and integration strategies for increasing the tourism potential of island bioregions.

Keywords: urban bioregion, smart tourism, space syntax analysis, smart governance

Un metodo di analisi per lo Smart Tourism

La gestione del turismo smart negli ultimi anni ha subito una significativa trasformazione: da una strategia esclusivamente tecnologica a una radicata negli elementi specifici del luogo. Di conseguenza, si introduce la nozione di ecosistema territoriale, quale entità legata alla bioregione urbana. La definizione di una strategia bioregionale policentrica è particolarmente importante nelle situazioni insulari, che presentano criticità di ordine demografico ed ambientale a causa della loro conformazione geografica. Lo scopo di questo capitolo è di indagare il turismo smart in una bioregione insulare come potenziale strategia di sviluppo delle aree interne. A tal fine, gli autori esaminano la regione storica del Sulcis Iglesiente. Il turismo smart è esaminato come un componente centrale degli interventi per gestire lo spopolamento, l'isolamento sociale e la stagnazione economica nelle aree interne. Per descrivere quantitativamente la distribuzione delle risorse locali, è stato usato un metodo che combina l'analisi geospaziale e l'analisi configurazionale. Lo studio si conclude con la presentazione di strategie di centralità e integrazione utili ad incrementare il potenziale turistico delle bioregioni insulari.

Parole chiave: bioregione urbana, smart tourism, space syntax analysis, smart governance

1. Introduction

In European politics, the value of tourism quality as a factor for increasing economic growth, employment, and social development in member countries has increased. This has been stressed especially after the Covid-19 pandemic caused significant disruptions (Zhang and Yang, 2016; Pillmayer et al. 2021). Smart tourist management has experienced substantial technological advancements during the last fifteen years.

This management approach involves not only the collection and elaboration of data to improve users' tourism experiences through smart end-user applications, but also the improvement of the economic potential, social, and experiential aspects of cities (Garau, 2017; Gretzel et al., 2015; Buhalis and Amaranggana, 2014). The concept of "smart tourism" has evolved over time and it remains one of the most frequently debated topics regarding tourist field and tourist industry. Indeed, researchers are paying growing attention to smart tourism, although no generally recognised definition has actually been developed (Wang et al., 2022). In the 2000s, a holistic approach prevailed, which viewed the smart tourism as an adaptive combination of demand, utilisation, and management techniques for both demand and marketing. Later, the ethical perspective has redefined its concept as a form of civic engagement (Li et al., 2017). Recently, smart tourism consisted mostly of a technology-centred industry that gathers together not only smart destinations, new generation of tourism, an intuitive exchange network that facilitates connectivity with smart cities; but also, statistical and big data, integrated application platforms, and personalised experiences (Gajdošík, 2018; Baralla et al., 2021; Garau et al., 2021; El Archi et al., 2023). Smart tourism plays a critical role in smart city strategies by integrating local development, big data on tourist movements and activities, consumption of products, and cultural and social resources (Zhang and Yang, 2016; Dias et al., 2021; Shin et al., 2023). This contributes to the creation of new market conditions by using dynamic mechanisms and cutting-edge technologies for selecting destinations. In 2018, the United Nations World Tourism Organisation (UNWTO) stressed the need to define tourism governance as a main tool for i) finding smart destinations, ii) connecting routes based on the inclusion of local communities, and iii) providing information to tourists (UNWTO, 2018).

Three interdependent aspects are essential for smart tourism. The first is the incorporation of ICT into the business purpose of local firms, which may facilitate the sharing of tourism resources and enhance the tourist experience (Law et al., 2014; Chai-Arayalert et al., 2023). The second is the tourist experience, which is intimately tied to the tourist himself/herself. Nowadays, tourists choose destinations based on the convenience of transit, booking, and services. Using personal technologies, they organise the optimal experience for themselves. The third aspect is the smart destination that enhances visitors' interaction and integration into the territorial context, improving the quality of the experience and residents' quality of life (Ivars-Baidal et al., 2021).

These three factors constitute a tourism ecosystem (Perfetto et al., 2018; Loch et al. 2023), and also Gajdošík (2018) supports that "nothing works individually, but it interacts within the ecosystem to evolve" (Gajdošík, 2018, p. 27). Similarly, Lu et al. (2023) argue that "tourism ecosystems are stable, dynamic, and sustainable" and that such ecosystems must have the capacity to "maintain its own structural and functional integrity in the face of disturbances, such as those caused by human tourism activities" (Lu et al. 2023).

Smart tourism is no longer solely dependent on the use of technology, statistical and big data, integrated application platforms, and the evaluation of individualised experiences, but it also requires the identification of appropriate place-based initiatives for managing and governing smart tourism policies. This can favour the economy's development, improve the tourist experience, and increase knowledge of places that are not yet purely touristic (Hernández-Martín et al., 2017; Buhalis et al., 2023; Pranita et al., 2023; Troisi et al., 2023). Administrative divisions may not be the optimal unit for decision-making for tourism planning and management as they may include several areas with distinct tourism functioning.

The selection of suitable sites for smart tourism policies can have several benefits. Firstly, it can contribute to the growth of the economy, particularly for small businesses located outside of the main tourist destinations. Secondly, it can improve the overall tourist experience. Finally, it may enhance awareness and planning for regions that have not yet been properly developed for tourism. The authors believe that a bioregion might be a suitable territorial structure for smart tourism governance because it permits an emphasis on hospitality for both visitors and permanent inhabitants. Due to its particular development challenges, the bioregion of Sulcis Iglesiente in Sardinia, Italy, is chosen as a case study. The authors explore the relationship between smart tourism and bioregionalism in an island context and highlight the potential for integrated smart tourism and place-based planning policies to benefit both inland and coastal areas. More precisely, section 2 focuses on the theories of bioregionalism linked to the polycentric settlement system of urban centralities and on their application to island territories. Subsequently, a method for the quantitative analysis of the smart-tourism potential is presented and applied to the case study of the Sulcis Iglesiente region. The methodological approach (section 3) combines geospatial and configurational analysis and defines a set of metrics that describes the distribution of sites of cultural importance, areas of environmental importance, opportunities for leisure activities, tourism-related services, and accessibility conditions. The results are presented and discussed in sections 4 and 5, respectively. Lastly, section 6 summarises the findings of the study.

2. The relationship between Smart Tourism and Urban Bioregion

Significant and recurrent environmental and demographic constraints pose greater obstacles for islands to attain the same degree of socioeconomic development as regions that are not islands (Garau et al., 2020a; 2022). Notwithstanding the limits caused by these structural impediments, islands can provide the potential to re-evaluate and restructure their territory (Garau et al., 2019; 2020b; 2022). Specifically, the insular setting facilitates the creation of circumstances favourable to internal social and economic networking, which may enhance daily living and quality of life for island users. Considering the disparities between coastal and inland areas, limited usable land, historical city-countryside dynamics, and a limited and seasonal economic sector (with tourism as primary source of income), place-based development is especially important in island regions (Booth et al., 2020; Croes et al., 2018; Garau et al., 2022). As Dominguez et al. (2017) state, "an island is an ecologically isolated self-contained territory with a principal and network of smaller cities and villages. In many islands, in recent decades, tourism has formed the main source of income" (p.236). To promote long-term sustainable development in such contexts, it is necessary to focus on governance systems that encourage active tourism (Araújo Vila, 2020) by creating dynamic relationships between the various points of interest in coastal and inland areas and by focusing on place-based enhancement. To achieve this, tourism policies should be designed and implemented at the most appropriate territorial level. Selecting the appropriate level within an island can be achieved through a polycentric system based on bioregional borders, which can promote socio-economic development throughout the region by analysing the functionality of urban settlements and their interconnections within the bioregion.

An urban region is a set of interconnected local spatial systems characterised by a bioregion and a variety of urban and rural centers. Namely, the urban region is a geographical area that encompasses a city and its surrounding suburban areas, characterised by high population density, extensive human-built infrastructure, and a concentration of economic, social, and cultural activities. Urban regions include residential, commercial, industrial, and institutional areas, along with transportation networks, such as roads, railways, and airports. In contrast, ecological boundaries rather than human settlement patterns define the bioregion. It is a region with comparable ecological, geological, and climatic characteristics, as well as flora and fauna. The natural characteristics of the land, such as its topography, climate, soil, vegetation, and fauna, define bioregions. Magnaghi (2014) defines an urban region as a set of interdependent local systems that comprise multiple urban and rural centers and are significantly interrelated by the environmental structures -valleys, mountain systems, hydrographic networks, coastal systems - that characterise a bioregion. This definition underlines the relevance of the bioregional paradigm as a planning and land management tool instrumental to reconfigure city-countryside relations (Duží and Fanfani, 2019) and, in an island context, the relations between coastal and inland areas.

Magnaghi (2018) observes that the bioregional approach is a planning and land management tool that promotes a coevolutionary balance between human settlement and the environment, by structuring the relations between the urban system and the environmental components of the surrounding bioregion. From this perspective, the bioregion's environmental components are conceptualised as factors that generate "long–lasting structures that altogether serve as the starting point for bioregional territorial planning and a new balanced polycentric urban system" (Duží and Fanfani, 2019, p.5).

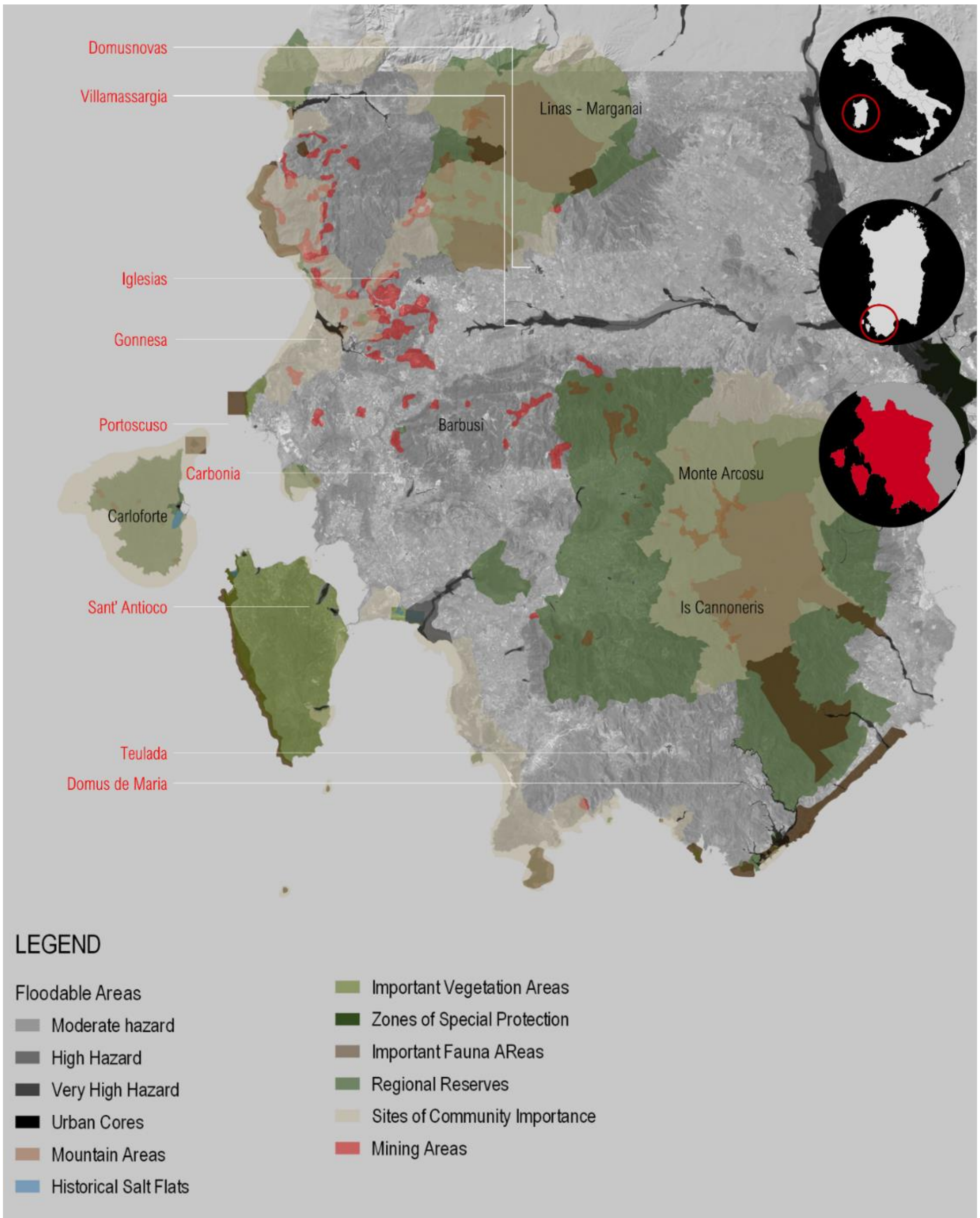
In literature, the planning system of an urban bioregion is linked to a polycentric settlement model, which can create systemic connections that change the socio-economic and productive aspects of the area while respecting historical and environmental ties (Duží et al., 2019; Goess et al., 2016). Such a cooperative behaviour can also increase the region's functional character and promote intra-regional governance.

According to Fanfani, smart tourism, supported by smart technological infrastructure, digital companies, and smart tourist sites, may become the primary socioeconomic element of an urban bioregion (2014, 82). Significant socioeconomic difference exists between coastal and interior areas on an island and the development of a polycentric tourist structure can contribute to the creation of a more balanced and homogeneous development. To explore how smart tourism governance can address these disparities, the authors examine Sardinia as a case study. The island's geological, political, and social characteristics have led to considerable economic disparities between its inland and coastal areas. Sardinia is also characterised by a variety of settlement conditions, including demographic concentration in coastal areas, lack of infrastructure and access to services in smaller centers, and absence of social and economic cohesion policies (Desogus, 2016; CRENOS, 2018; Strategia Nazionale per le Aree Interne, 2019). The study specifically focuses on the Sulcis Iglesiente bioregion to explore how a polycentric tourist network can promote cooperation between inland and coastal areas and contribute to the socioeconomic development of the bioregion.

3. Methodology

The region area of study (Figure 1) is the Sulcis Iglesiente historical Region. Its infrastructural and urban systems reflect the process of formation of an artificial landscape, related to mining and industrial activities, and its problematic relation with a multifunctional ecological system, that encompasses areas of environmental importance, natural reserves, Sites of Community Importance, important plant areas, and Special Protection Areas.

Figure 1. The Sulcis-Iglesiente Bioregion



The polycentric urban structure of the Region is focused on the major urban centers of Carbonia and Iglesias.

Smart tourism (as a paradigm focused on the optimisation of destinations management, promotion of sustainable tourism practises, and development of personalised tourism services) emerges as a relevant aspect of policies aimed at addressing depopulation, social exclusion, and economic stagnation. In addition, smart tourism combines the goals of providing tourists with an articulated, interactive experience and creating economic benefits with the objective of minimising negative impacts on the environment and local communities. The quantitative analysis aims to describe the potential of the bioregion in developing a polycentric tourist structure and in promoting smart tourism. This process involves six steps: identifying the area of study, defining the unit of analysis, determining categories that indicate specific dimensions of bioregion potential, identifying available databases, defining relevant sub-indicators, and collecting data, calculating sub-indicators, normalising and aggregating individual sub-indicators into category indicators, and determining a bio-region smart tourism potential index ($I_{\_SMART}$).

The unit of analysis is the 1000-meter-per-side cell of a regular grid overlaid on the area of study.

The size of the cell is selected based on two main criteria: ensuring that the area of study is adequately described with appropriate resolution and minimising the time and computation power required for the procedure. The categories of determinants of the bioregion potential are related to six different dimensions, which include natural potential, cultural potential, potential as a destination, potential as a central space, recreational potential, and infrastructural potential (Table 1).

For instance, the natural potential category is based on the distribution of components of ecological infrastructure and is calculated as the ratio between the individual cell comprising a habitat or area of community interest and the density of point components of the ecological and geomorphological structure.

The identification of components of the ecological infrastructure is based on categories of land use and land cover defined by the Regional Landscape Plan of the Sardinia Region. The relevant data is obtained from the territorial information system of the Autonomous Government of the Sardinia Region. These categories include areas with elevations exceeding 900 metres, historical salt flats, significant vegetation and animal habitats, areas managed and protected by the regional forestry agency, natural caves, areas designated for fauna protection, national and regional parks and reserves, areas of special protection, sites of community importance, dune systems, coastal buffer zones, and natural and artificial water basins. Moreover, the inverse of the density of road segments is considered, as it is an indicator of the negative impact of urbanization and human activities on ecological structures.

The cultural potential of an area is determined by the density of tangible cultural heritage components, museums, cultural services, and the ratio of surface area of cells in abandoned mining sites or historic urban centers. The potential of a cell as a destination or as a central location is dependent on the configurational properties of road infrastructure in the Sulcis Iglesiente region. Configuration refers to the interdependent topological relations embodied in a spatial structure. Configurational analysis focuses on two variables: Closeness centrality and Betweenness centrality. Closeness centrality relates to the to-movement potential of a space. It is measured by the indicator integration as the distance of a space, i.e. a street segment, from any other space in a spatial system. Betweenness centrality, which is measured by the Choice indicator, refers to the probability that a space is part of the shortest path from each space to any destination space in a spatial system. Thus, the Choice indicator signifies the through-movement potential of a space. These variables represent the accessibility potential of a space within a specific spatial system and can be evaluated using three alternative definitions of distance. Metric distance is simply the number of metric units between a starting point and an endpoint. Topological distance refers to the number of turns or intermediate spaces along the route from a starting point to an endpoint. Lastly, geometric distance is determined by calculating the sum of angular deviations along the route from a starting point to an endpoint. Thus, the shortest route refers to the straightest route. These definitions are presented in Hillier (1999, 2007), Hillier & Hanson (1984), Turner (2007), Turner et al. (2001) and Yamu et al. (2021).

The choice and integration indicators can also be calculated at distinct scales, defined by specific radii. When the radius parameter is set, the topological relations are measured considering the spatial elements located within a predetermined distance from each origin space. In the presented study, the potential of a location as a destination or as a central space is determined by the normalised mean of the configurational variables calculated at radius 2000, at radius 6000 meters, and at the global scale (Radius N).

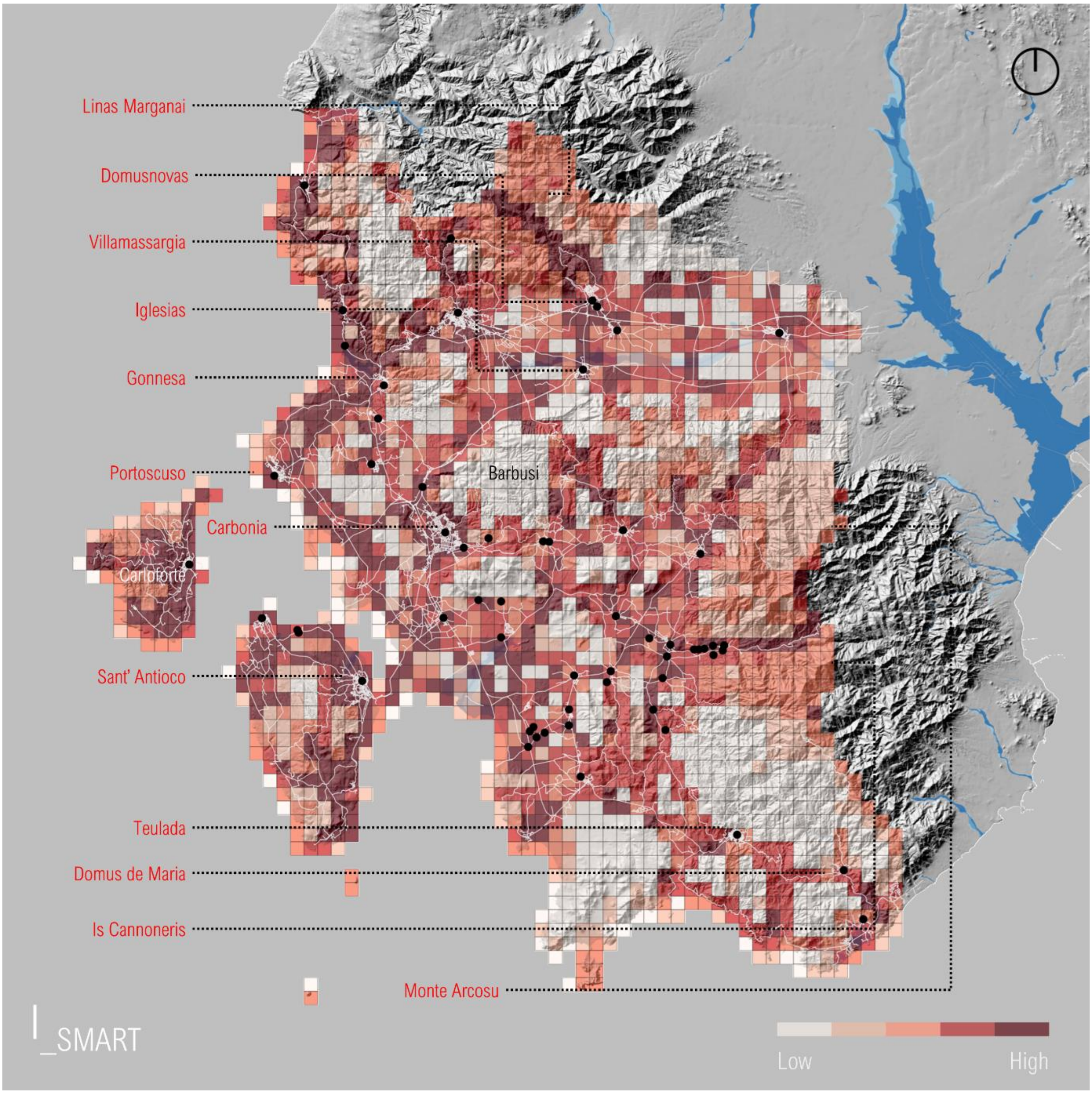
Table 1. Set of metrics utilised to calculate the Index of the bio-region smart tourism potential

Environmental Component	**Sub indicator**	**Formula**
Natural Potential		
Areas of special protection	R_ZPS	A (ZPS)i/ ACi A(ZPS)i = Surface area of areas of special protection in Cell i-th ACi= Surface area comprised in cell i -th
Historical salt flats	R_Salt	A (Salt)i/ ACi
Areas at elevation > 900m	R_900	A (900) i/ACi
Natural Caves	D_Cav	N(Cav)i/ACi
Important Plant Areas	R_IP	A (Plant)i / ACi
Important fauna habitats	R_Hab	A (Habitat)i / ACi
Areas managed by the regional forestry agency	R_For	A (For)i / ACi
Areas of fauna protection	R_Fauna	A (Fauna)i / ACi
Regional and national parks and reserves	R_ Res	A (Res)i / ACi
Sites of community importance	R_SIC	A (SIC)i / ACi
Dune systems	R_DS	A (DS)i / ACi
Coastal buffer zones	R_CB	A (CB)i / ACi
Natural and artificial water basins	R_Bas	A (Bas)i/ACi
Road Density	RDI	1-[L (R)i /ACi]

Natural Potential Indicator	**N_POT**	(N_POTi – NPOTmin) / (N_POTmax – N_POTmin) N_POTi = (R_900 + R_Salt + R_IP + R_Hab + R_For + D_Cav + R_Fauna + R_ Res + R_ZPS + R_SIC + R_DS + R_CB + R_Bas + RDI)
Cultural Potential		
Point components of the cultural heritage	D_CH	N_CH_Pts_i / ACi
Museums	D_Mus	N_Mus_i/ ACi
Nuclei of original urbanization	R_NOUrb	A_(NOUrb)i/ACi
Areas of the Geo-mining park	R_GMP	A (GMP)i / ACi
Cultural Potential Indicator	**C_POT**	(C_POTi - C_POTmin) / (C_POTmax - C_POTmin) CULT_POTi = (D_Ch_i + D_Mus_i + R_NOUrb_i + R_Min_i)
To-movement Potential		
Road segments Angular Integration	**INT**	(A_INT 2000*A_INT_6000*A_INT_N) A_INT_2000= Segment Angular Integration Radius = 2000 m A_INT_6000= Segment Angular Integration Radius = 6000 m A_INT_N = Segment Angular Integration Radius N
Through-movement Potential		
Road Segment Angular Choice	**NACH**	(NACH_2000*NACH_6000*NACH_N) NACH_2000 = Normalised Angular Choice Radius = 2000 m NACH_6000 = Normalised Angular Choice Radius = 6000 m NACH_N = Normalised Angular Choice Radius = N
Density of Tourist Points of Interest		
Density of Points of Interests (POIs)	**D_POIs**	N_POI_i / ACi
Infrastructural Potential		
Accommodation	D_ACC	N_Acc_i/ACi
Bus Stops	D_BS	N_BSi/ACi
Train Stations	D_TS	Dist_Ts < 500 m = 1 500 m < Dist_TS < 2500 m = 0.5 Dist_TS > 2500 m = 0
Parking Areas	D_PA	N_PA_i/ACi

Ports	D_Por	N_Por_i/ACi
Restaurants	D_Rest	N_Rest_i/ACi
Infrastructural Potential Indicator	**IN_POT**	(D_ACC+D_BS+D_TS+D_PA_+D_Por+D_Rest)
Index of the bio-region smart tourism potential	**I_{SMART}**	N_POT+C_POT+INT+NACH+D_POI+IN_POT

Figure 2. Distribution of values of the I_{SMART} indicator, indicating the potential for implementation of smart tourism policies in the Sulcis-Iglesiente Bioregion



The capacity for recreation of each cell can be measured by the number of tourist points of interest (POIs). These can range from coastal sites to sites of archaeological, historical, and aesthetic significance. Lastly, the infrastructural potential of a location can be assessed based on its available facilities, including accommodations, services, transportation options (e.g., bus stops, train stations, ports), and parking areas. To determine category indicators, the sub-indicators are added together. However, since these sub-indicators may be measured in different units, normalization functions are needed to convert them into a common quantitative measure. To achieve this, individual sub-indicators are normalised using feature scaling functions, which generate values ranging from 0 (representing the worst condition) to 1 (representing the ideal condition). The feature scaling function used to calculate the value NVi for a sub-indicator i is:

$$NV_i = (V_i - MIN(V_i)) / (MAX(V_i) - MIN(V_i))$$

Category indicators are then normalised and aggregated into the synthetic index of the bio-region smart tourism potential called $I\__{SMART}$ (Figure 2).
The results obtained are presented and discussed in the sub-sequent sections.

4. Results

The findings underline that the distribution of the smart tourism potential determines a reticular structure centred around major settlements, such as Carbonia, Iglesias, Portoscuso, Sant'Antioco, and Carloforte, as well as along the coastal regions. Particularly, Sant'Antioco and San Pietro islands distinguish themselves as central locations for smart tourism. This is due to the presence of areas of ecological and biological value, such as plant areas, areas of fauna protection, sites of community interest, a unique cultural heritage, and a high density and diversity of tourist points of interest (POIs).
Other relevant areas include Santadi and Pantaleo in the inner region, which present a significant natural potential due to the concentration of regional reserves, Forestry Agency-managed areas, sites of community interest, and fauna protection areas. Despite the existence of significant POIs, such as Chia and Domus de Maria, a large area along the southern coast presents marginal smart tourism potential.
The distribution of the values of the to-movement potential, measured by the angular integration indicator, underlines the centrality at the local and at the global scale of the urban areas of Iglesias and Carbonia (Figure 3).
The through-movement potential distribution, measured by the angular segment choice indicator, underlines the emergence of the reticular structure of the main road infrastructures, particularly of the national roads 130, 126, 195, and 293 (Figure 4).
Regarding ecological significance, the coastal areas, San Pietro and Sant'Antioco islands, as well as the Linas-Marganai Regional Park, Monte Arcosu and Is Cannoneris fauna protection areas, and the Sulcis Regional Park, are prominent. Sant'Antioco island is identified as an important plant area. The Normalised Difference Vegetation Index, measured via the Semi-automatic Classification Plugin and QGIS Raster Calculator tool (Congedo, 2021), indicates vegetation density in the area of study, and underlines the ecological significance of the core areas of the Linas-Marganai Park, Monte Arcosu and Is Cannoneris reserves, and areas contiguous to the Barbusi reserve (Figure 5).

Figure 3. Distribution of values of Angular integration at the local scale (Radius 6000 m) and at the global scale, in the Sulcis-Iglesiente Bioregion

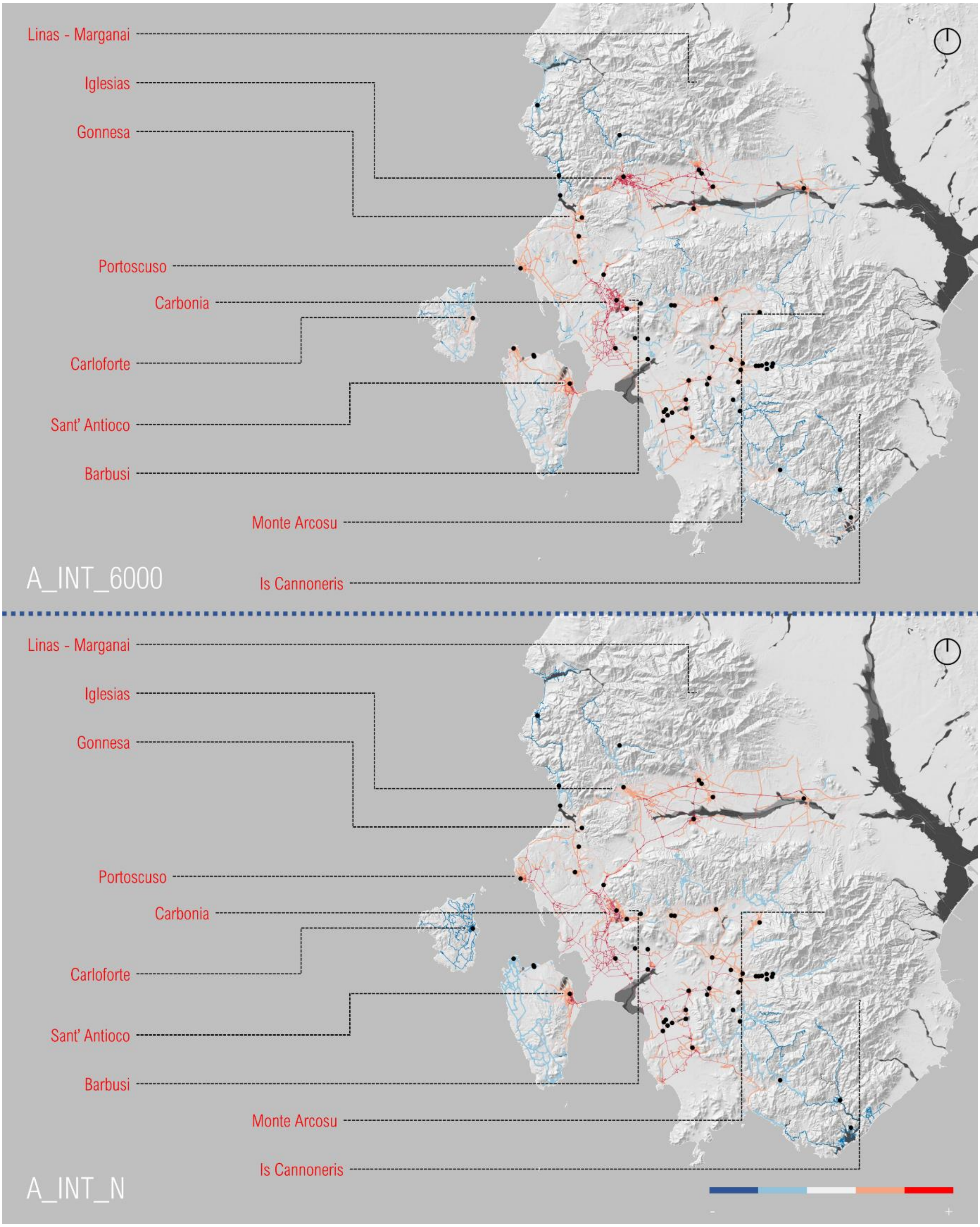


Figure 4. Distribution of values of Normalised Angular Choice at the local scale (Radius 6000 m) and at the global scale, in the Sulcis-Iglesiente Bioregion

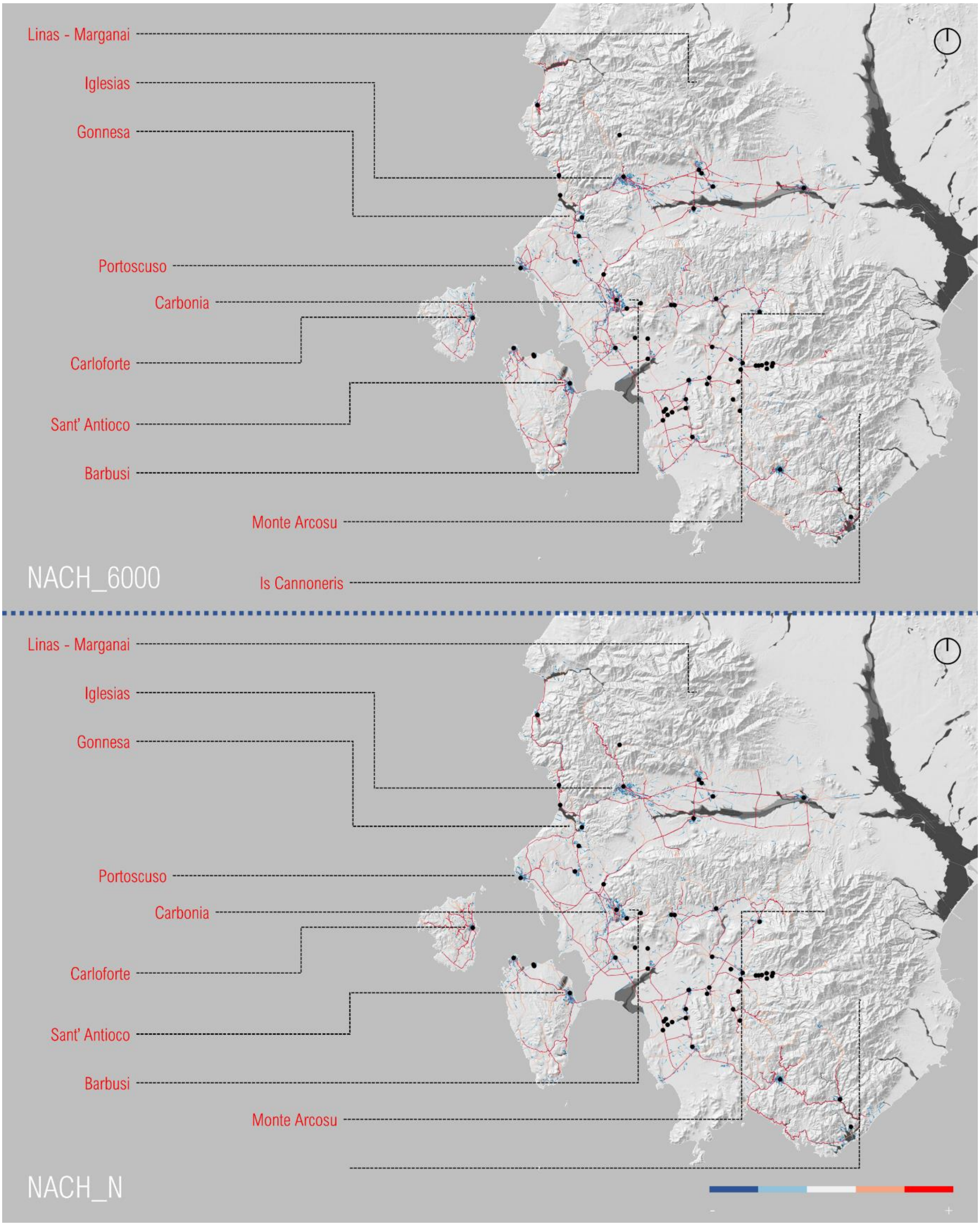
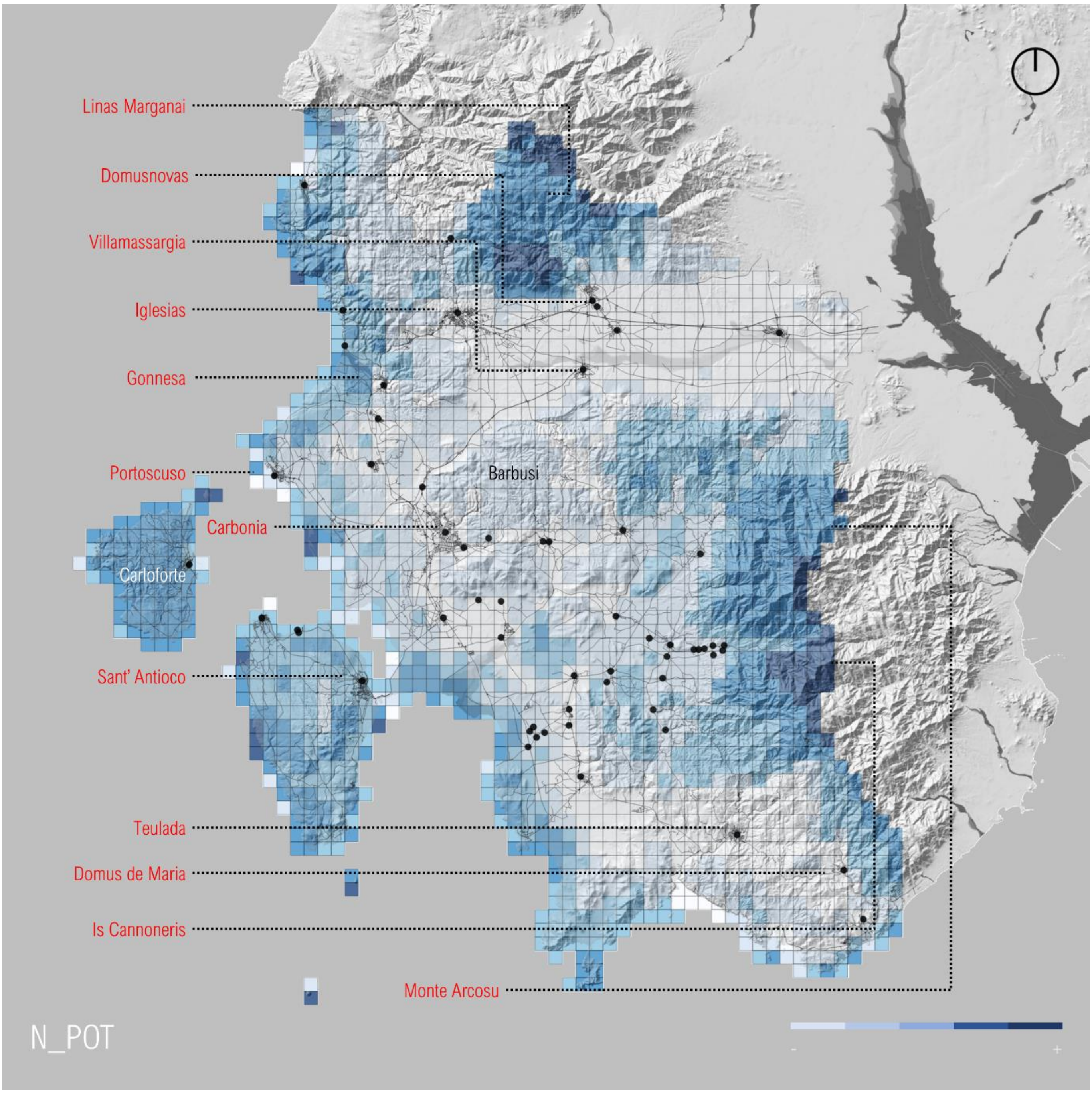


Figure 5. Distribution of values of the Ecological Potential in the Sulcis-Iglesiente Bioregion



The analysis of cultural potential reveals a concentration of relevant sites with a high density and diversity of tangible components of the cultural landscape on Sant'Antioco island, around Carloforte village, and along a linear system of urbanised nuclei polarised around the centers of Gonnesa, Bacu Abis, Iglesias, Carbonia, Tratalias, and Giba. This system of sites of cultural importance includes the Eneolithic and Neolithic necropolises of Marchiana and Montessu, the Nuragic sites of Seruci, Monte Sirai, and Is Collus, the Phoenician-Punic sites of Monte Sirai and Sulci, and the Roman-age settlements of Sulcis Iglesiente (Figure 6).
The number and diversities of points of interests or of available amenities is limited (Figure 7). However, the notable destinations for tourism are concentrated in the

historic districts of Iglesias and Sant'Antioco municipalities, and in the coastal areas of Gonnesa and Calasetta municipalities. The assessment of the area's infrastructure potential (Figure 7) includes the distribution of accommodation facilities and transportation nodes and reveals that urbanised areas such as Carbonia, Iglesias, Portoscuso, Carloforte, and Sant'Antioco are the focal points of the local system of infrastructure and services. These areas are connected by the Railroad and national roads 130 and 126. The analysis also confirms the existence of central and southern marginalised areas, bounded by Narcao, Villamassargia, Iglesias, Carbonia, Chia, Narcao, and Porto Pino municipalities. These areas present a modest smart tourism potential. The subsequent section comprehensively discusses the implications of these results for smart tourism policy development.

Figure 6. Distribution of sites of cultural relevance in the Sulcis-Iglesiente Bioregion, measured via the Cultural Potential indicator

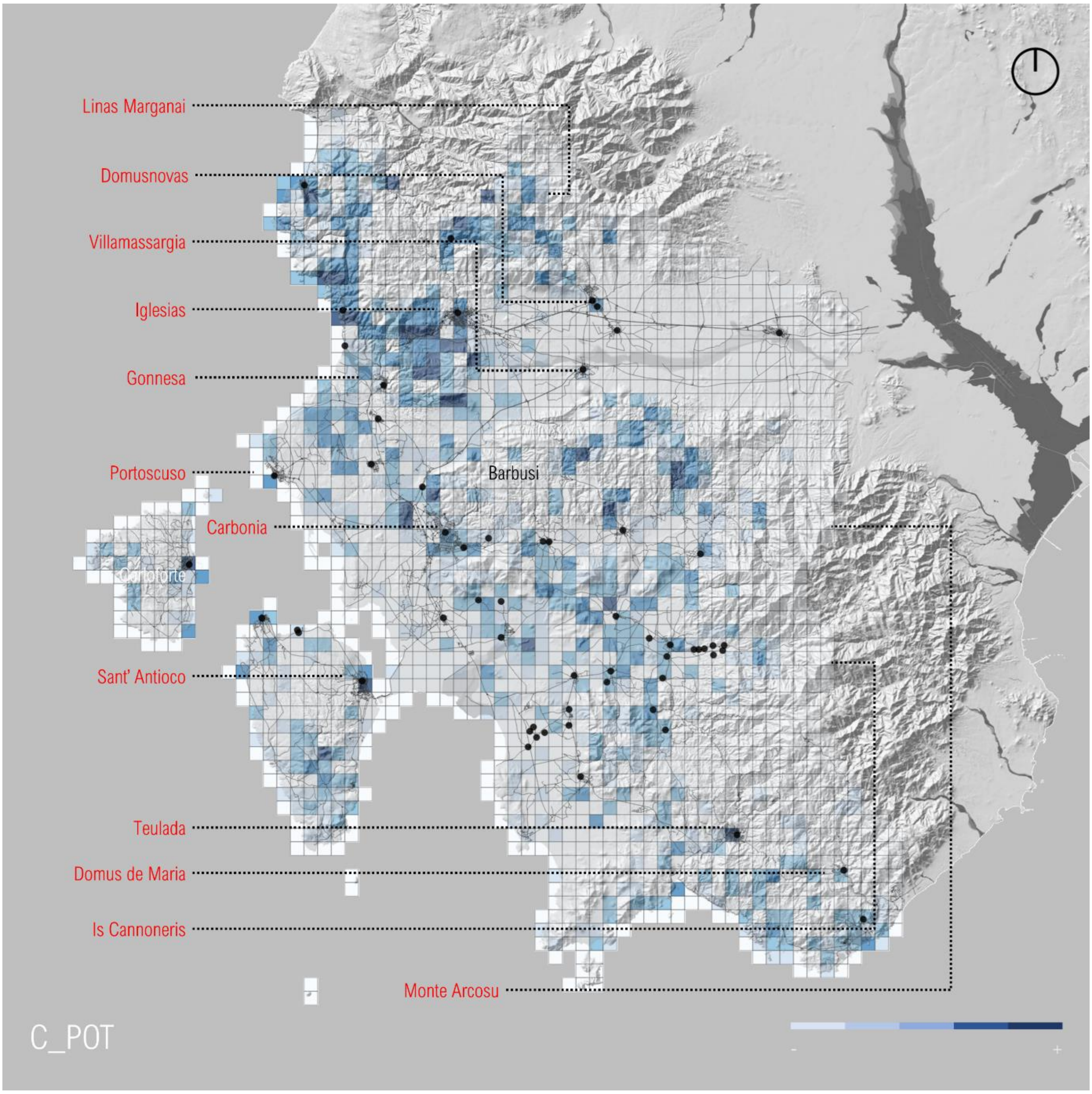
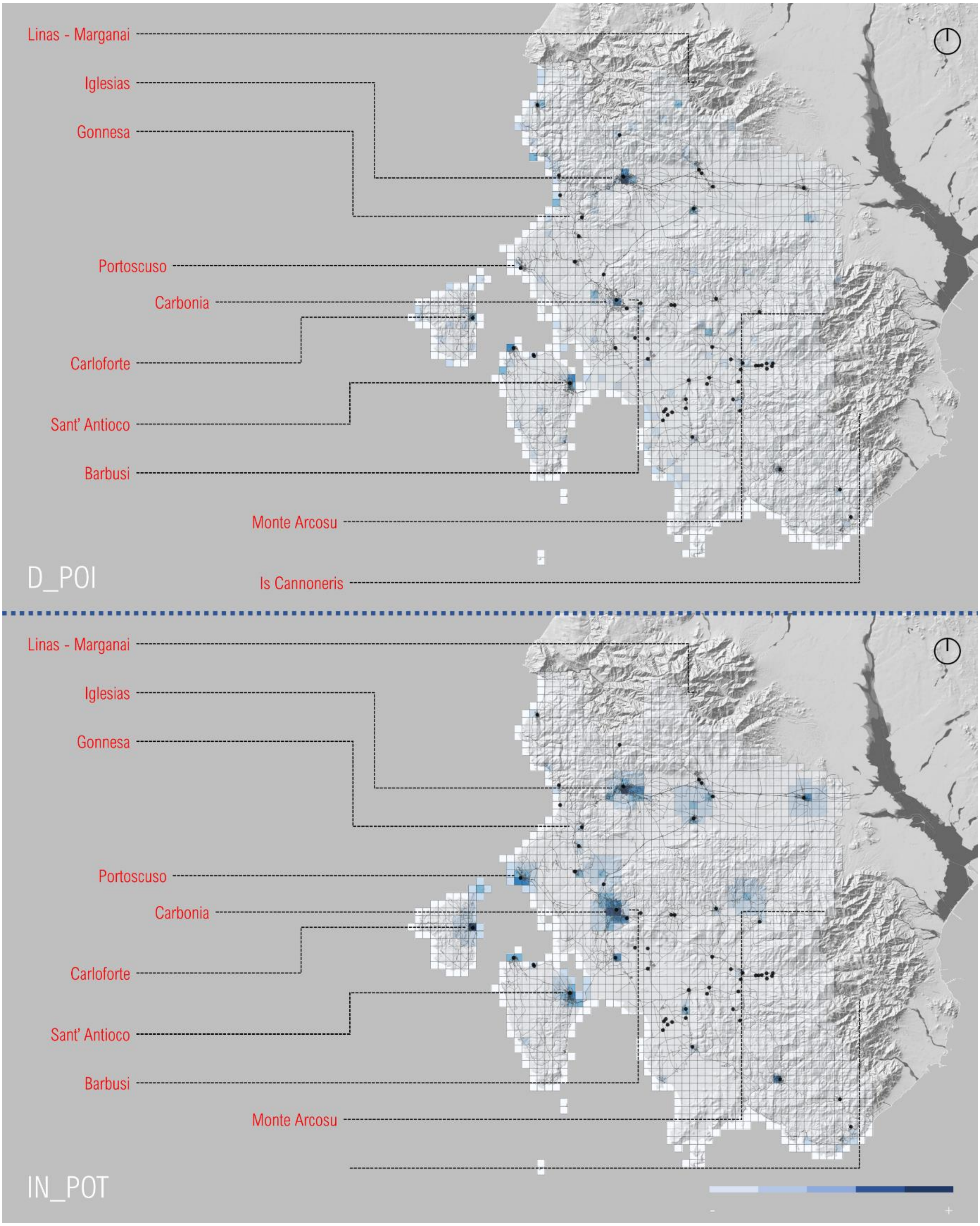


Figure 7. Distribution of values of the indicators Density of Points of Interest (D_POI) and Infrastructure Potential (IN_POT) in the Sulcis-Iglesiente Bioregion



5. Discussion

The results from the evaluation of the potential for smart tourism in the Sulcis Iglesiente bioregion, underline several significant aspects, for the definition of policies of development. Firstly, a reticular pattern has emerged, underlining a relevant concentration and variety of points of interest (POIs), cultural components, and natural areas across the irregular grid of road infrastructures and urbanised regions. The T structure including Iglesias, Gonnesa, Carbonia, and Portoscuso is the central system, while the V structure encompassing Calasetta, Sant'Antioco, Maladroxia's coastal area, and the Y- structure on San Pietro Island, including Le Tonnare, Capo Sandalo, Carloforte, and La Bobba's coastal area, are other significant territorial systems for smart tourism development.

Another important point is the existence of vast voids, indicating areas with marginal potential, such as the internal areas delimited by the road infrastructure reticular system and denser urbanised areas. These voids partly overlap with the peripheral areas between Iglesias, Musei, and Domusnovas, the undulating areas delimited by Narcao, Villamassargia, Iglesias, and Carbonia municipalities, and the southern areas near the municipality of Teulada and Capo Teulada's military base.

Furthermore, the bioregion's natural, cultural, and land-use diversity makes it well-suited for smart tourism development policies. The analysis reveals the centrality of the infrastructural system extending across the plain areas, defining corridors for re-development and regeneration policies. The disused infrastructural system, including railroads, secondary and local roads, which intersect the internal areas, provides an opportunity for constructing a dense system of greenways and soft mobility paths. The disused building stock, associated with the region's industrial past, represents an opportunity for distributing services and facilities for smart tourism and eco-tourism, and for reducing population segregation in dispersed settlement systems.

Lastly, there is a need to implement a territorial information system to support research and policy development for smart and eco-tourism. Constructing informative layers based on databases with current, consistent, complete, and accurate data is crucial for analysing the bioregion, identifying vulnerable areas, defining the objectives of site-specific policies, monitoring the impact of policies and enhancing tourists' experiences. Territorial data can also structure web-GIS applications, providing users with tools for retrieving information and visualizing multimedia content related to the bioregion's natural and cultural components, for route planning, and for locating services, amenities, and POIs.

6. Conclusion

This article presents a study that aims to define the concept of smart tourism in relation to the discourse on the bioregion. The study proposes a method for analysing the distinct dimensions of multi-functional landscapes, which can lead to the development of a more holistic form of tourism. This includes leisure activities, experiences of aesthetic and environmental values, spiritual and religious values, cultural diversity, and social relations, all of which are embodied in territorial structures of historical, ecological, and cultural significance. The proposed method provides a quantitative description of the bioregion landscape, identifying the distribution of cultural heritage components, natural areas, significant habitats and ecosystems, points of interest, infrastructure, services, and criticalities represented by segregated areas. In particular, the study shows that the Sulcis Iglesiente bioregion presents a distinctive polycentric structure, consisting of a system of territorial nodes, that includes major urbanised centres, sites of cultural, environmental importance, tourist destinations and a system of corridors with high centrality, integration, and density of services. The proposed method has two main benefits: first, it enables a synthetic and understandable description of a bioregion, identifying its resources and emerging criticalities, and guiding the definition of criteria and objectives for sustainable development policies and territorial planning strategies. Second, the method introduces space syntax techniques in the analysis of a bioregion, identifying patterns of centrality and integration that can inform planning decisions. By developing a set of metrics and an analytic method, the study aims to increase understanding of places and support territorial and infrastructural planning, which can promote the development of the tourism-related service economy in peripheral areas and improve the tourist's experience.

Author Contributions

The paper is the results of the joint work of the authors. "Abstract" and "methodology" and "Results", were written jointly by the authors. Chiara Garau wrote the "Introduction"; Giulia Desogus wrote "The relationship between Smart Tourism and Urban Bioregion in an island system". Alfonso Annunziata wrote "Discussion" and "Conclusions". Chiara Garau supervised the article.

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Conflicts of Interest

The authors declare no conflict of interest.

Originality

The authors declare that this manuscript re-elaborates and supplements the contents of the following paper: Annunziata A., Desogus G., Garau G. (2022), "An evaluating approach for smart tourism governance in an urban bioregion in southern Sardinia", in Moccia F.D., Sepe M. (a cura di), XIII Giornata Internazionale di Studi INU - 13°Inu International Study Day "Oltre il futuro: emergenze, rischi, sfide, transizioni, opportunità - Beyond the future: emergencies, risks, challenges, transitions, and opportunities" (Napoli, 16 December 2022), *Urbanistica Informazioni*, n. 306s.i., INU Edizioni, Roma, pages 583-587.

The authors also declare that the manuscript is not currently being considered for publication elsewhere, in the present of any other language. The manuscript has been read and approved by all named authors and there are no other persons who satisfied the criteria for authorship but are not listed. The authors also declare to have obtained the permission to reproduce in this manuscript any text, illustrations, charts, tables, photographs, or other material from previously published sources (journals, books, websites, etc).

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