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Geospatial analysis techniques for tourist flows: Sardinia study region (Italy)

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Abstract: The tourism sector has been dramatically affected by the COVID-19 pandemic. However, a significant recovery of the tourist flows has been recorded in 2022. As regards the air passenger traffic, it is expected to reach 2019 figures in 2023. The greatest increase in passengers' traffic in 2022 was recorded in Europe, with 2 billion passengers, that is 81.1% of 2019. Such dynamics also affect Italian airports, especially those of medium and small size such as Sardinia airports. In this framework, the goal of the paper is to use geospatial analysis techniques of tourism flows, preparatory to developing Mobility as Service (MaaS) solutions.

Keywords: Tourism flows; Sardinia Region; Geospatial analysis

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1. Introduction

The tourism sector has been severely affected by the crisis triggered by the COVID-19 pandemic. Just as the sector was starting to recover, the conflict between Russia and Ukraine presented a new obstacle to recovery prospects.

However, a significant recovery has been recorded in 2022, accentuated by the lifting of travel restrictions, which increased demand. Tourist flows, which include international arrivals and departures as well as nights spent in accommodation by visitors, are now recording a growing trend, although not homogeneous between countries due to the economic slowdown and geopolitical instability [1]. It is estimated that domestic tourism could return to pre-pandemic levels by 2023, while the full recovery of international flows is expected by 2025.

Air passenger traffic is expected to reach 2019 figures in 2023, after the pandemic and post-pandemic years that witnessed dramatic decreases in passenger's transport. The International Air Transport Association (IATA) estimated global airline industry losses for $84 billion for 2020 [2].

The trend is now increasing globally. The greatest increase in traffic last year was recorded in Europe, with 2 billion passengers, that is 81.1% of 2019. In particular, according to the Italian Association of Airport Managers (Assaeroporti, 2022) national air traffic is recording a period of recovery also in Italy, where the sanitary crisis has not only drastically reduced air traffic but has also changed the role of airports for national traffic, reshaping priorities and importance [3]. The drivers of the great recovery in national air traffic were above all medium and small airports, many of which even exceeded 2019 levels. These include the airport system of the the Autonomous Region of Sardinia (ARS), one of the major Italian islands, with the following three airports: Cagliari - Elmas (CAG), Olbia - Costa Smeralda (OLB) and Alghero (AHO).

The study analyze data relating to tourist flows in Sardinia (air and port passenger traffic; arrivals and presences) in the period between 2019 and 2022 (pre and post Covid-19 period), to assess whether elements of discontinuity can be recorded with respect to the past development trend of the tourism sector. The analysis is functional to promote sustainable transport policies, especially in connections to and from airports in the regional context, in line with the concept of Mobility as a Service (MaaS) [4].

Spatial analytical techniques such as Geospatial analysis (GIS), Kernel Density Estimation (KDE) and Local Indicators of Spatial Autocorrelation (LISA) are used to analyze the distribution and spatial characteristics of tourism flows in Sardinia, highlighting traffic patterns among the local airports and related destinations, thus supporting an integrated regional planning and the construction of MaaS solutions.

The manuscript is organized as follows: Section 2 - Area of study, provides a description of the transport system in Sardinia; Section 3 - Methodology, describes spatial analytical techniques (KDE and LISA) applied to the tourist flows data; Section 4 - Results and Conclusions, discusses results derived from the geospatial analysis.

2. Study Area

The Autonomous Region of Sardinia (ARS), with an area of 24,090 km^2, is one of the largest islands in Italy (third in Italy). The population, equal to 1,570,734 inhabitants, is distributed over the territory with a density of 66 inhabitants/km^2 (third to last in Italy). The ARS is composed of four provinces (Nuoro, Oristano, Sassari, Southern Sardinia) and a metropolitan city (Metropolitan city of Cagliari), distributed over 377 municipalities.

Sardinia has a strong marine-seaside tourist vocation, with peaks in the summer season in the coastal areas, where 90% of the accommodation and 80% of the destination of tourist flows are recorded. The air traffic of the three main airports in Sardinia (CAG, OLB, AHO) confirm the phenomenon of seasonality, which still prevails compared to other forms of sustainable tourism promoted by the ASR through a diversified tourist offer based on the valorisation of internal areas as well [5, 6].

The ASR road infrastructure system is characterized by 8,800 km of road network, 427 km of railway network and approximately 160 km of railway network replaced by the local public transport (LPT) service, 8 ports administered by the Port Authority of the Sea System of Sardinia and 3 airports. The infrastructure supply can be associated with public transport and companies that connect the small towns with the most important centers of the island. However, low levels of service emerge both in the infrastructure system (road network and railway network) and in the transport offer, which present significant differences between internal areas and urban areas. In this framework, the goal of the paper is to use geospatial analysis techniques for tourism flows, preparatory for the construction of a regional insular Mobility as Service (MaaS), with Sardinia as a case study.

3. Methodology

The methodology used for the geospatial analysis of tourism flows is based on the use of techniques that allow highlighting specific patterns and relationships and correlations between geographical data [7,8,9]: KDE and LISA.

The KDE transforms punctual events into a continuous density function distributed in the region of interest, allowing the phenomenon to be represented through a three-dimensional surface that expresses the variation in the density of punctual events in the study area [10]. The choice of the radius value depends on the nature of the data, the objective of the analysis and the characteristics of the phenomenon studied. With this technique it is possible to identify the spatial distribution of the phenomenon studied, highlighting regions of high density (clusters) or regions of low density (empty).

Spatial autocorrelation techniques allow us to analyze the spatial distribution of objects and to evaluate the spatial dependence between geographical entities, through various indicators [9]. Moran and Geary's global spatial autocorrelation indicators provide information on the autocorrelation itself, while the localization of high autocorrelation values is provided by local indicators [11]. The LISA is considered as a local Moran indicator and is directly proportional to the sum of all the local indices. Five cases can occur, in which the different places are characterized by: high values of the phenomenon and high levels of similarity with the neighborhood (high-high); low values of the phenomenon and low levels of similarity with the neighborhood (low-low); high values of the phenomenon and low levels of similarity with the neighborhood (high-low); low values of the phenomenon and high levels of similarity with the neighborhood (low-high); absence of significant autocorrelation.

4. Results and conclusion

The dataset of this paper relating to tourist flows derives from air and maritime passenger traffic in the three-year period 2019-2022 (pre and post Covid-19). In particular, the analysis as a whole was developed using the open data of the ASR of: a) Arrivals and departures in Sardinia's ports and airports; b) Arrivals and presences in the municipalities of Sardinia. Spatial analysis techniques have allowed us to highlight some elements of significance. In particular, the KDE for tourist presences (2019-2022 August) highlights high- and low-density regions and LISA instead correlated the same tourist presences (Fig.1 and Fig. 2). The results of the spatial analysis show a constant growth in arrivals, departures, and presences on the island from 2019 to 2022, with the exception of the years 2020 and 2021, in which, due to the Covid-19 pandemic, there was a decline.

The analysis confirms a substantial difference of arrivals, departures and presence between summer and winter season, which emphasizes the seasonal nature of Sardinian tourism, the concentration of tourists in the coastal areas and the low attractiveness of inland areas and rural areas. The LISA reveal a low-low autocorrelation for the internal zones, characterized by a low level of the phenomenon and low levels of similarity. The high-high clusters in major tourist destinations coincide with the KDE results.

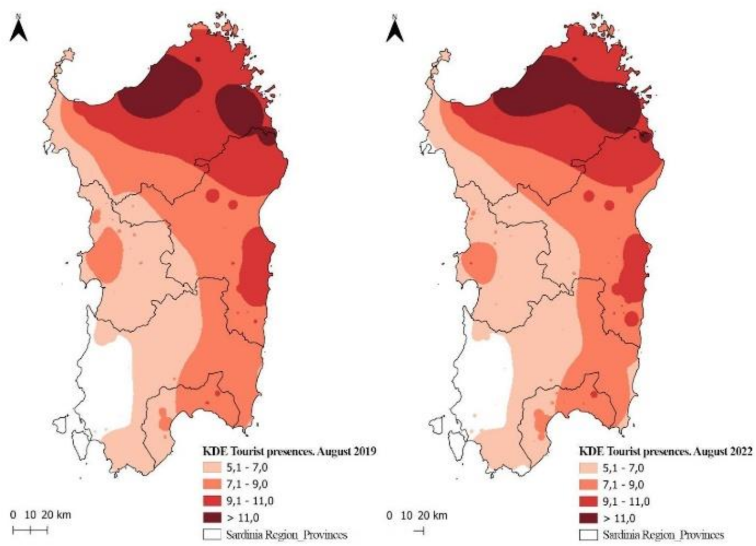

Figure 1. KDE. Comparison between the spatial distribution of the tourist presences in the Sardinia Region (2019 - 2022). R=5 km, cell of 500x500 m.

Another important element is the clusters of tourist presences near the urban/port-airport systems of the Island. The weak and unstructured transport supply makes it necessary to take action on internal mobility systems between the urban hubs and the access gateways, serving both tourist mobility and intra-regional mobility.

The spatial analysis developed represents the basic scenario in which to promote a sustainable transport system and the construction of a regional MaaS, within the most ambitious project to create a network of Sardinia airports [12].

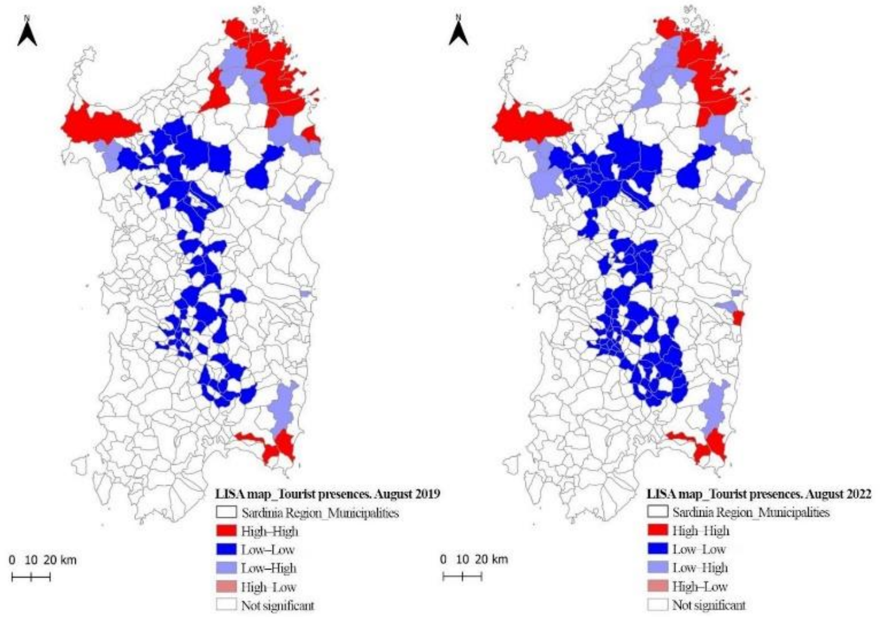

Figure 2. LISA maps from GeoDa application. Comparison between the spatial distribution of the tourist presences in the Sardinia Region (2019-2022).

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