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Sustainable Tourism Supported by Drafting of the Cross-border Sustainable Mobility Plan (CBSMP) between southern Italy and Greece: Connections among Gallipoli, Brindisi, Thesprotia, and Igoumenitsa

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Abstract

The development of a Cross-Border Sustainable Mobility Plan (CBSMP) under the European Interreg Greece-Italy Cooperation Programme (2014-2020) highlights the critical need for a synergistic and systemic approach to creating sustainable accessibility models. These models are vital at both international and local levels for fostering environmentally, socially, and economically responsible tourism development. This research addresses the urgent need to design comprehensive sustainability solutions, with transportation playing a pivotal role. The CBSMP was meticulously developed by integrating international, national, and local transport plans and

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programmes, with particular emphasis on existing Sustainable Urban Mobility Plans (SUMPs). The plan not only proposes alternatives to highly polluting transport options but also lays the foundation for establishing new maritime connections between southern Salento (Italy) and Epirus (Greece), thereby enhancing cross-border mobility and fostering regional integration.

Keywords: Sustainable tourism, Regional development, Environmental planning policies, Sustainable transport, Spatial planning, Connectivity

Introduction

Although the past few years have been challenging in terms of liveability in Europe and globally-first due to the COVID-19 pandemic and more recently because of the war in Ukraine, which has deeply affected many-Europe and the world now, more than ever, need to feel connected and united. Sustainable mobility plays a crucial role in fostering this connection. As noted by Fusté-Forné (2021), the COVID-19 pandemic has significantly impacted global travel, posing challenges for sustainable tourism. The economic, sociocultural, and psychological effects on tourism systems are likely to disrupt businesses for years to come. Moreover, environmental considerations are becoming increasingly critical in the tourism sector (Pacheco et al. 2024). The sustainability of tourism systems depends on all elements of their broader environment. This underscores the need for governments and stakeholders to reshape their understanding of tourism, emphasizing ethical, responsible, and sustainable management and marketing strategies (Baloch, 2023). The uneven impacts of climate change across different regions and the crucial role of local responses further highlight the importance of understanding ports and their unique local contexts (Manios et al., 2024). Connective infrastructures that span sovereign borders take on unique characteristics, becoming more than just motorways or high-voltage lines; they function as shared utilities (Khanna, 2016). Regarding the impact of the Ukraine war, the UNWTO reports that Russia and Ukraine accounted for 3% of global spending on international tourism in 2020. Prolonged conflict could result in a loss of up to $14 billion in global tourism receipts by 2022.

More than one-third of EU citizens live and work in EU border regions (European Commission, 2015). Over the past two decades, border regions have gained prominence (Fadigas, 2010, 2015; Castro & Alvarez, 2015; Castanho et al., 2016), with cross-border cooperation (CBC) achieving numerous political, economic, environmental, and sociocultural successes (Nave & Franco, 2021). The concept of cross-border regions and cooperation has become increasingly significant in political and academic discussions across fields such as management, geography, sociology, international relations, and political economy (Medeiros, 2015; Nave & Franco, 2021).

However, while the permeability of borders facilitates cultural and commercial exchange, it also requires careful management to ensure environmental sustainability, particularly concerning how movements occur between more or less homogeneous areas. A sound conceptual foundation for the methodological approach to connectivity lies in recognizing that transportation systems, as integrated networks at various scales, are transforming their operations and influencing urban and regional development patterns (Castanho et al., 2017; Salov & Semerikova 2024).

Several authors have investigated the impact of transport infrastructure on regional development. However, despite these efforts, no definitive conclusions have been reached (Freiria & Sousa, 2024). Simultaneously, ongoing economic and social crises are encouraging collaborative approaches between countries (IGCC, 2020), influencing policies and processes related to trade and investment, migration, peace and security, regional integration, climate change, food security and the private sector (ECDPM, 2022). Many countries are striving to remove barriers associated with borders to foster integration and territorial cohesion through exponential cross-border movements (Nave & Franco, 2021). Therefore, countries must urgently adopt new strategies and approaches to achieve territorial cohesion and cooperation. Nonetheless, Cross-Border Cooperation remains a complex challenge (Castanho et al., 2016). Recent geopolitical events have revived lingering tensions from the Cold War and the Second World War (Dale, 2016; Holmes, 2016; Wall Street Journal, 2022). Factors such as linguistic, cultural, and socioeconomic differences further hinder cross-border cooperation (European Commission, 2015).

In recent years, countries have increasingly focused on enhancing sustainable mobility, particularly by: (1) Avoiding unnecessary transportation volume (2) Shifting transportation norms and practices (3) Improving the carbon efficiency of transportation systems (Griffiths et al., 2021). Administrative borders also create barriers to cross-border mobility. Efficient cross-border transport is crucial to reducing these barriers, improving citizens' mobility, and increasing the territorial integration of the European Union (EU). Various limitations impede this progress. According to Nijkamp et al. (1990), these include: physical barriers (e.g., mountains, rivers, artificial walls), technical barriers (e.g., incompatibility between railway systems of different countries), cultural, linguistic, and information barriers (e.g., discrepancy between supply and demand), fiscal barriers (e.g., visa costs), and institutional barriers (e.g., costs associated with crossing borders between different jurisdictions).

McGahern (2023) highlights the role of cross-border mobility in addressing diverse travel motivations and gender issues, particularly in the context of Israel. This analysis underscores the importance of the complex

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interconnections between mobility and the capital allocated to transport infrastructure, demonstrating how eliminating these gaps can promote equal and safe mobility. In this sense, sustainable tourism becomes inherently more socially inclusive and culturally open. Tourism development also induces sociocultural and environmental changes in local communities (Ap, 1992; Stylidis et al., 2014). Such transformations underline the need for responsible approaches to tourism that balance its growth with the well-being of host communities.

Literature Review and Hypotheses

Many scholars and institutions have recognized that Cross-Border Cooperation (CBC) projects offer numerous benefits to member states (Yigitcanlar et al. 2015; Castanho et al., 2016). First, they enhance opportunities to improve the quality of life. Second, CBC projects help mitigate the economic decline that many developed countries have faced in recent years (Roy & Ciobotaru, 2023). Third, they facilitate the development of resilient and collaborative border cities (Yang & Guangcheng, 2023).

To build resilient and sustainable cities, urban planners and policymakers have proposed new policy models for greener mobility worldwide (Tammaru et al., 2023). Additionally, scholars identified critical factors for successful CBC projects: (i) the definition of clear, common objectives and master plans; (ii) the promotion of political transparency and commitment to CBC-related decisions; and (iii) the encouragement of connectivity and movement between cities (Castanho et al., 2016). The third factor has guided this research, particularly in developing systemic sustainability solutions in which transport and sustainable mobility play central roles (Yejin & Sugie, 2025). Mobility is generally defined in geographical terms as a “crossing or displacement in space” (Kaufmann 2014; Beylier & Fortuné, 2022). Therefore, the quality and quantity of cross-border (CB) accessibility and transport options are crucial in shaping CB mobility, as they directly influence the number of CB commuters (Medeiros 2019). Although both regions fall within EU jurisdictions, facilitating the movement of people, joint planning—such as the adoption of a Sustainable Mobility Cross-Border Plan—can provide essential guidelines and regulations for fostering economic, environmental, and social sustainability in transport systems. In this context, Rietveld (2012) emphasized the importance of both direct costs (e.g., transport, taxes) and indirect costs (e.g., cultural, institutional, and fiscal differences) associated with border crossings. Schiebel et al. (2015) identified several travel characteristics—such as travel purpose, cost, departure time, distance, duration, travel chain, weather conditions, and interchanges between different modes of transport—as factors influencing citizens' behaviour and choices when crossing borders. Similarly, Rosselló-

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Nadal and Santana-Gallego (2024) analysed the impact of geographical distance on tourism flows, while Errico et al. (2024) highlighted the role of network effects in cross-border mobility.

Medeiros (2010) proposed subdividing the barrier effect into five main dimensions: (i) accessibility; (ii) cultural-social; (iii) environmental-hereditary; (iv) institutional-legal; and (v) economic-technological. Similarly, Wassenberge and Reitel (2015) categorized existing barriers as legal, political, economic, or cultural. This article considers the concept of barriers in terms of accessibility—not to suggest that the analysed areas are currently inaccessible, but to evaluate the potential for achieving more-sustainable accessibility that can contribute to sustainable economic, social, and environmental development. To analyse which barriers persist across EU borders after more than 25 years of EU cross-border cooperation Programmes, the online public consultation on border obstacles (2015–2016) conducted by DG REGIO (EC) revealed that EU citizens consider “legal and administrative” barriers as the primary obstacles to their daily lives when crossing borders. These are followed by language barriers and physical accessibility barriers, including transportation (Medeiros, 2019). The survey highlighted concerns regarding the lack and/or poor quality and security of physical cross-border (CB) infrastructure, the absence of integrated public transport systems at borders, differing rules and standards in transportation, the inadequacy of existing physical CB connections to meet current traffic flows, the low frequency of services, and excessive prices for CB transport connections in many EU border regions (EC, 2016). A Eurobarometer survey on barriers in EU-funded CBC programmes indicated that respondents in Italy reported accessibility-related barriers most frequently.

Keeble et al. (1982) also emphasized the connection between regional accessibility and economic competitiveness. From a governance perspective, the EU has recognized that a well-functioning transport system linking EU member states and neighbouring countries is vital for sustainable economic growth and citizen well-being. According to Dühr et al. (2010), EU transport and infrastructure policy is driven by three main goals: competitiveness, cohesion, and sustainability. Similarly, Knippschild (2011) highlighted that successful cross-border cooperation can drive development in areas such as economic clusters, labour markets, education and training, transport, tourism, and public services. The METIS study (2015) identified six main analytical components related to obstacles in cross-border transport, including road passenger transport and inland waterway ferry services (e.g., transport system quality, connection density).

Sustainable mobility is defined as “achieving an overall volume of physical mobility, modal splits, and transport technologies that efficiently meet basic mobility needs while supporting ecosystem integrity and limiting

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greenhouse gas (GHG) emissions to levels consistent with international sustainable development" (Griffiths et al., 2021). Cars, as part of a socio-technical mobility system, account for approximately 7% of global GHG emissions and more than 50% of total transportation emissions (Victor et al., 2019). Tang et al. (2023) explored the role of air transport in post-pandemic challenges, noting that air routes have a decreasing but positive impact on inbound tourism demand from long-haul markets, though they are less significant for short-haul markets. This analysis underscores the importance of factors beyond transportation in shaping tourism demand (Mazzola et al., 2022).

COVID-19 mitigation measures, such as restrictions on movements and reduced car usage, led to a significant reduction in global CO_2 emissions (Le Quéré et al., 2020). These changes have also influenced social behaviours, transportation patterns, and consumption habits (Wang & Wells, 2020). Many institutions have adopted strategies and green initiatives to promote long-term sustainable urban mobility (Ibold et al., 2020). Several approaches have been proposed to reduce transport demand and car use, improve road networks and vehicle technology, and promote alternative transport modes (Bakker et al., 2014; Marcucci et al., 2019). Holden et al. (2020) presented three "grand narratives" for sustainable mobility:

- Electromobility: Replacing fossil fuel-based vehicles with electric vehicles powered by clean energy.
- Collective Transport 2.0: Expanding public transportation and shared mobility options.
- Low-mobility Societies: Reducing the number and length of trips by cars and planes.

Literature on accessibility performance and indicators, as well as theoretical approaches to interspatial and disaggregated accessibility models, has been further developed by Gattuso and Malara (2018), Thiede et al. (2023), and Hidalgo (2024).

Theoretical Foundation and Hypotheses

Global data suggests that mobility is a significant contributor to CO2 emissions (approximately 25% of the total) and energy consumption (around 20%). However, public authorities and mobility operators often lack the necessary expertise to integrate energy efficiency into mobility planning and investment strategies. Consequently, CO2 emission reductions are frequently excluded from mobility strategies and services. The planning processes often fail to involve key stakeholders—such as service and energy providers, transport operators, and SMEs—or end users directly. Although frameworks like Sustainable Energy Action Plans (SEAPs) and Sustainable Mobility Plans

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

(SUMPs) aims to address these criticalities, their practical application and integration into implementation processes remain limited. This results in inadequate promotion and adoption of sustainable mobility models and restricted utilization of related services. This challenges are particularly pronounced in cross-border regions, characterised by fragmented transport systems, poor cooperation, and a lack of synergistic transport planning. There is a pressing need for systemic, integrated, and efficient mobility services along the Adriatic seacoast to mitigate the environmental impacts of mobility activities. This article presents findings from the Cross-Border Sustainable Mobility Plan (CBSMP), developed under the Interreg Greece-Italy cooperation Programme (2014–2020). The CBSMP seeks to enhance public-private cooperation to create a multimodal transport system, particularly for tourism. The plan focuses on improving connections between ports, airports, roads, and cycle paths to cultural and environmental destinations, ensuring service continuity across geographical and temporal dimensions. Stoffelen (2018) highlights the potential of tourism routes—such as hiking and cycling trails—as tools for fostering cross-border cooperation. These routes can utilize existing infrastructure, repurpose abandoned railway tracks, and bring together local stakeholders in collaborative projects, thereby enhancing mobility for both tourists and locals. Tourism, in general, is recognized as one of the most accessible means of establishing cross-border contact.

The starting point of this research is the urgent need to provide systemic sustainability solutions, emphasizing cross-border integration and collaboration, with transport as a central focus. While this challenge exists globally, localized action is essential to guide policies and implement tools effectively. Stoffelen (2018) further emphasises that tourism routes anchored in inclusive decision-making networks can stimulate cooperation and establish linkages between local communities, the tourism industry, and broader economic development.

The research underscores the potential for alternative tourism in the studied areas (Gallipoli in Italy and Thesprotia in Greece), promoting travel as a sustainable experience. However, assessing these destinations currently requires road travel to airports (Brindisi in Apulia and Corfu in Greece) before reaching the final destination, which is both environmentally and economically unsustainable. Encouraging transport intermodality through joint planning is critical in these small but densely populated regions. These areas, despite their sizes, attract significant seasonal tourism, impacting sustainability and liveability.

This article does not aim to innovate the accessibility model but to demonstrate that established models, when applied within a transport convention, can promote sustainable transport in tourist-oriented regions. The Cross-Border Sustainable Mobility Plan facilitates the movement of people

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

through sustainable transport modes, highlighting the importance of long-term planning in a sector sensitive to climate change, natural environments, and socio-economic development (Hyytiäinen et al. 2022). The CBSMP aligns with the recommendations of Karim et al. (2024), who stress incorporating natural elements to achieve sustainable goals.

The European Commission recognised this case study's significance, financing it under the Interreg Cooperation Programme. Stoffelen (2018) similarly underscores the role of Interreg projects in enhancing cross-border communication and social cohesion in European borderlands.

The Cross-border Sustainable Mobility Plan (CBSMP) spans South Salento (Apulia region, Italy) and Thesprotia (Epirus region, Greece), drawing from international, national, and local transport plans, particularly SUMPs (Sustainable Urban Mobility Plans). The CBSMP is built on coordinated actions with a focus on tourist mobility, meeting EU, and national regulatory criteria, including:

- A clear vision of objectives shared by European project partners
- A participatory approach involving citizens and stakeholders
- Balanced and integrated transport development favouring sustainable modes such as walking, cycling, and public transport
- A sustainability perspective encompassing economic, social, and environmental dimensions
- Integration with existing spatial and transport planning tools
- Comprehensive assessment of the plan's impacts, particularly its environmental and social benefits.

Theoretical Background

The scenario planning analysis utilized a network model and territorial accessibility indicators, related to the planning area's unique characteristics and the restructured interregional transport services. Although inspired by the principles of Sustainable Urban Mobility Plan (SUMP), the methodology for developing the Cross-Border Plan diverges significantly. Unlike SUMP, which primarily focuses on urban areas, this plan encompasses a broader spatial dimension, targeting the integrated interregional area of South Salento (Apulia Region, Italy) and the province of Thesprotia (Epirus Region, Greece). This model was constructed using context analysis, established transport models, scenario design, and impact assessment.

The scenario design specifically aims to enhance cross-border relations, with particular focus on the tourism sector. Its formulation drew from insights obtained through targeted surveys, communication, and participation activities. The design seeks to offer an alternative transport supply that fosters cross-border effects by addressing the following: facilitating intermodal exchanges via sea routes, improving accessibility to

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

urban areas and key tourist sites, and enhancing connections to tourist accommodations. Tourism, as an economic driver, generates a dual on local communities. Positively, it stimulates the development of hotels, transportation networks (both road and air), electricity and internet infrastructure, banking, and other essential services. However, tourism also has adverse social consequences, including: unequal access to essential services, the proliferation of negative societal issues such as prostitution, theft, and illicit trade in cultural heritage, and the uncritical adoption of tourists' lifestyles by local residents, leading to cultural homogenization (Alamineh et al., 2023). Sustainable tourism policies are vital for mitigating these negative effects while maximizing the benefits. The COVID-19 pandemic underscored the need for robust research into the impact of crises on tourism policies, emphasizing the importance of balanced and resilient strategies (Schönherr et al., 2023).

The scenario design was informed by a comprehensive analysis of existing tourist mobility flows and a systemic organization of data regarding the transport supply across the Greek-Italian border. Specific areas of focus included: intermodal transport supply (rationalizing and improving existing transport services, upgrading service quality to meet evolving demands, establishing guidelines and adopting best practices for sustainable transport solutions, etc.), potential demand estimation (assessing the projected demand for passenger mobility, with an emphasis on tourism), and investment cost assessment (conducting approximate evaluations of required investments to implement the proposed scenarios). The cross-border planning area's structure is illustrated in Figure 1, which presents the road network and the traffic zones, offering a clear depiction of the interregional transport connections and their integration.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

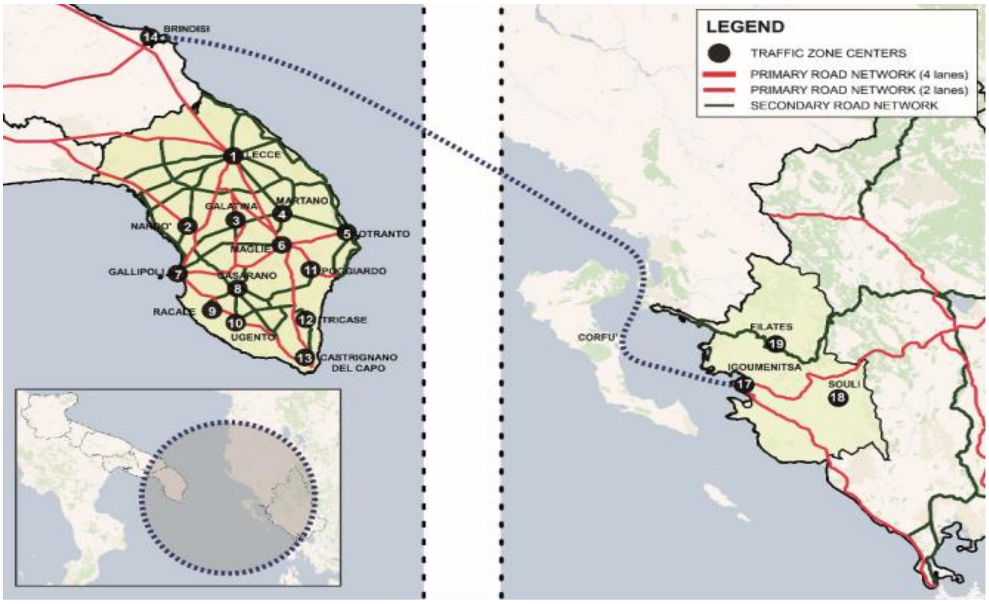

Figure 1. Cross-border Planning Area

Table 1 illustrates some sociodemographic data from the context of the plan. Apulia covers an area approximately twice of Epirus. Its population is much larger (with a ratio of 12:1), resulting in a density five times higher than that of Epirus. A similar ratio is observed at the sub-regional level: South Salento is 1.8 times larger than the regional unit of Thesprotia, but in terms of population, it is 18 times larger. The population density of South Salento is higher than that of the entire Apulia Region, while that of Thesprotia is even lower than that of Epirus.

Table 1. Land use data for the study area

	Area (Km²)	POPULATION (inhabitants)	DENSITY (inh./km²)	MUNICIPALITIES N.
APULIA	19.541	3.991.140	204,25	257
EPIRUS	9.203	336.856	36,60	18
SOUTH SALENTO	2.799	791.122	282,66	96
THESPROTIA	1.515	43.857	28,95	3

Source: 2019 data from the National Institute of Statistics, Italy

To build the current structure of the transport system in the analysis area, the existing plans were analysed, and the main elements were extrapolated and re-elaborated with reference to passenger transport.

Method

The scenario design is based on performance and accessibility indicators. As performance indicators, travel times and monetary costs are

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

computed in relation to the network supply. As an accessibility indicator, a mathematical model has been adopted, consisting of generalised cost functions associated with a transport network. Given a spatial system divided into *n* zones and a road network, the matrix of the minimum number of routes can be considered the starting point for accessibility measures.

In interspatial models, mathematical measures of accessibility express the potential of the transport system as functions solely of the travel cost variable. However , experience shows that other factors, linked to the system of local activities, contribute to determining the possibility of travelling between two zones i and j. In this analysis, in addition to various cost factors, accessibility is a key and relevant element that characterises the construction of the impedance function.

Transport impedance is expressed as a linear combination of times and monetary costs, and accessibility takes the following form:

$$A_i = \Sigma_j K_j^{\delta} \exp(\Phi(c_{ij})) \quad (1)$$

Here, $\Phi(c_{ij})$ is an impedance function that usually decreases with the cost c_{ij}. Over the years, different expressions have been used, depending on the author. Among these expressions are the following:

$$\text{Hansen's expression (1959):} \quad \Phi(c_{ij}) = c_{ij}^{-\alpha} \quad (2)$$

$$\text{Wilson's expression (1967):} \quad \Phi(c_{ij}) = \exp[-(\beta_1 t_{ij} + \beta_2 cm_{ij})] \quad (3)$$

$$\text{Ingram's expression (1971):} \quad \Phi(c_{ij}) = \exp(-d_{ij}^2/\Upsilon) \quad (4)$$

Where:
A_i is the weighted accessibility for people living in zone *I* and is related to zones *j* in region *D*;
K_j is a measure of activities and services located in zone *j*;
d_{ij} , t_{ij} , cm_{ij} are measures of costs (distance, travel time, monetary cost);
β, Υ are calibration parameters.

A possible impedance cost function (average utility function) associated with a user departing from zone *i* towards a destination *j* on an interregional transport network (see Figure 2) can be expressed as:

$$V_j = b_0 \log K_j - b_1 c_{ik} - b_2 t_{ik} - b_3 cp_k - b_4 t_{kl} + b_5 f_{kl} - b_1 cf_{kl} - b_1 c_{lj} - b_2 t_{lj} \quad (5)$$

$$\text{or } V_j = \log[K_j^{b0} \exp(-b_1 c_{ik} - b_2 t_{ik} - b_3 cp_k - b_4 t_{kl} + b_5 f_{kl} - b_1 cf_{kl} - b_1 c_{lj} - b_2 t_{lj})] \quad (6)$$

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Where:
K_j is an expression of the attractiveness of destination j (e.g., population or touristic accommodation attributes of the destination);
c_{ik} = monetary cost to reach the main node k (e.g., port, airport, or station) of departure (fuel, tolls, public transport fares, etc.);
t_{ik} = travel time to the port/airport/station of origin k (e.g., by private vehicle, public transportation, or multimodal combinations);
c_{pk} = parking fare for a private vehicle adjacent to a port/airport/station at origin k;
f_{kl} = average frequency of flights, ships, or trains between the origin k and destination l (e.g., daily or weekly);
cf_{kl} = average fare for sea/air/rail transport from k to l;
c_{lj} = average fare for maritime/air/rail transport moving from k to l;
t_{lj} = travel time from node l to final destination j (e.g., private vehicle, public transport, or multimodal combinations);
β_n = model parameters.

The travel time components can include penalties for modal transfers, waiting times, and early departures to reduce the risk of missing a connection (e.g., ship, plane, or train).

Accessibility measures that account for multiple transport modes (e.g., car, train, or bus) must weigh the accessibility of individual modes. This can be achieved using the *LogSum formula* (Ben-Akiva et al., 1985):

$$LogSum = log\ \Sigma_m\ exp^{\ Vm} \tag{7}$$

Where the summation considers all available modes m.

For practical applications of this methodological approach, data collection is necessary, focusing on user times and costs for tourist travel. These data are obtained through typical transport supply analyses (e.g., distances, speeds, energy consumption, parking costs, public transport fares), based on spatial and temporal network designs and information from public and private transport companies. Tourists may travel as single users or as families, which influences the model parameters. Specific values for these parameters can be adopted based on a review of specialized literature.

A Case Study: Gallipoli – Paramythia Accessibility

An application of the modelling tools for accessibility analysis was proposed as a case study in the context of the transborder planning area (Apulia-Epirus), focusing on different multimodal mobility alternatives across

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the Otranto Channel. For computational simplicity, the generalised cost function (average utility function V_j) was adopted as the accessibility measure. The cities of Gallipoli, as the origin, and Paramythia, as a cross-border destination, were used as references, and accessibility was calculated considering the following seven route alternatives (Figure 2) for an ordinary user (a single adult or member of a family of four):

- By car from Gallipoli to Brindisi's port, on a ferry to the port of Igoumenitsa, and by car to Paramythia;
- By car from Gallipoli to Brindisi's port, parking at the port, taking a ferry to the port of Igoumenitsa, and traveling by bus to Paramythia;
- By bus from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and traveling by bus to Paramythia;
- By train from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and traveling by bus to Paramythia;
- By bus from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and traveling by rental car to Paramythia;
- By train from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and traveling by rental car to Paramythia;
- By bike from Gallipoli to Brindisi's port, taking a ferry to the port of Igoumenitsa, and biking to Paramythia.

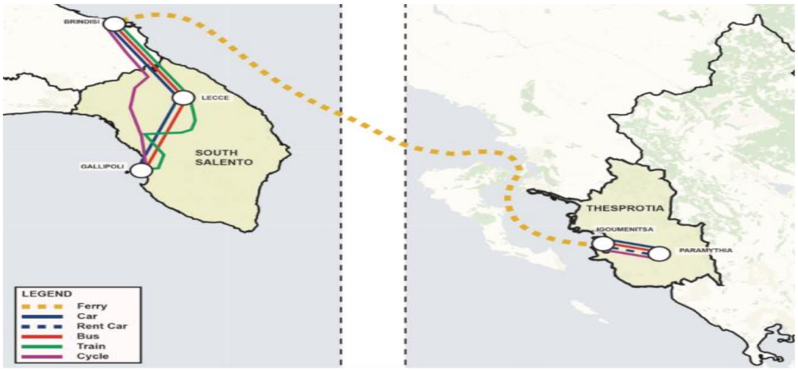

Figure 2. Outline of multimodal routes: Case study on cross-border routes

The results obtained form the basis for subsequent scenario analyses aimed at improving network connections. The following notation has been assumed, with reference to Figure 2, for travel simulation from Gallipoli (Italy) to Paramythia (Greece):

Gallipoli (GAL) = node i
Brindisi Port (BRI) = node k
Igoumenitsa Port (IGO) = node l
Paramythia (PAR) = node j
C_{xy} = monetary cost associated with moving from node x to node y

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

T_{xy} = time to move from node x to node y
T_{tot} = T_{xy} + T_a (where T_a is waiting time)
C_{pk} = parking cost

Assumed Departure Data:

- Distances: Gallipoli-Brindisi 79.8 km; Igoumenitsa - Paramythia 31.9 km
- Partial travel time: Gallipoli-Brindisi 1h 6min, Igoumenitsa - Paramythia 27min
- Average speed: Gallipoli-Brindisi 72.5 km/h, Igoumenitsa - Paramythia 70 km/h
- Energy consumption (litres of fuel): Gallipoli-Brindisi 5.8 L; Igoumenitsa - Paramythia 2.5 L;
- Parking time at the port: 1 week
- Transfer time from the car park to the port: 5min
- Train fare: €7.30 per person
- Gallipoli-Lecce: Salento by bus 52 min, €2.90 per person
- Lecce-Brindisi 40 min, €8.69 per person
- Car rental: € 135 for a week
- Fuel costs: Igoumenitsa - Paramythia € 3.27
- Routes: Suitable for cycling

Summary Overview

The monetary costs and travel times for the Gallipoli-Paramythia route, considering different travel alternatives, are presented in Table 2.

Table 2. Monetary costs and travel times for the Gallipoli-Paramythia route, with different travel alternatives

Travel alternatives	**People n.**	***C_{ij} (€)***	***T_{ij} (hh:mm)***
Travel by own car (small car) for the whole route	1	76,83	12:32
	4	169,83	12:32
2. Gallipoli - Brindisi by car/Igoumenitsa - Paramythia by bus	1	130,56	12:45
	4	238,56	12:45
Gallipoli - Brindisi by train/Igoumenitsa - Paramythia by bus	1	52,20	13:48
	4	181,80	13:48
Gallipoli - Brindisi by bus/Igoumenitsa - Paramythia by bus	1	56,59	13:12
	4	199,36	13:12
Gallipoli - Brindisi by bus/Igoumenitsa - Paramythia by rental car	1	189,86	12:59
	4	317,63	12:59
Gallipoli - Brindisi by train/Igoumenitsa - Paramythia by rental car	4	317,63	12:59
	1	189,86	12:59
Whole journey by bike	1	45,00	17:12
	4	180,00	17:12

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

It follows that family (of 4 persons) travel is cheaper in terms of overall impedance, since the monetary cost associated with the use of a shared car is significant. It is also generally more convenient to use public transport (train and bus) for inland travel. The travel time is not significantly different for motorised travel (range of 12:30 - 13:50 hours), as the travel times inland are fairly comparable. The penalties related to the advanced departure times of the ships are of the same order of magnitude. The trip by bike is certainly the cheapest option, but the travel time increases significantly (about 4–5 hours).

The accessibility function is assumed as follows:

$$V_j = b_0 \log K_j - b_1\ c_{ik} - b_2\ t_{ik} - b_3\ c_{pk} - b_4\ t_{kl} + b_5\ f_{kl} - b_1\ c_{fkl} - b_1\ c_{lj} - b_2\ t_{lj}$$

With parameters $b_0 = 1, b_1 = 1, b_2 = 15$ €/h, $b_3 = 1, b_4 = 5$ €/h, $b_5 = 5$

With the attractiveness parameter set to the population of the destination city (Thestroptia), where K_j = 7,900 inhabitants, the resulting utilities (accessibility levels) for each alternative multimodal travel to destination j (Paramythia) are calculated. The daily ferry frequency is assumed to be 2, and the accessibility values are expressed in euros.

Table 3. Accessibility for single traveller

Multimodal travel alternatives	V_j
By car for all travel	-141,322
Gallipoli - Brindisi by car, Igoumenitsa - Paramythia by bus	-200,452
Gallipoli - Brindisi by train, Igoumenitsa – Paramythia by bus	-135,152
Gallipoli – Brindisi by bus, Igoumenitsa - Paramythia by bus	-130,092
Gallipoli - Brindisi by bus, Igoumenitsa - Paramythia by rental car	-260,212
Gallipoli - Brindisi by train, Igoumenitsa - Paramythia by rental car	-265,272
Gallipoli - Brindisi by bike, Igoumenitsa - Paramythia by bike	-193,302

Table 4. Accessibility for a traveller as a component of a 4-person family

Multimodal travel alternatives	V_j
By car for all travel	-114,622
Gallipoli - Brindisi by car, Igoumenitsa - Paramythia by bus	-191,452
Gallipoli - Brindisi by train, Igoumenitsa – Paramythia by bus	-128,402
Gallipoli – Brindisi by bus, Igoumenitsa - Paramythia by bus	-123,342
Gallipoli - Brindisi by bus, Igoumenitsa - Paramythia by rental car	-149,752
Gallipoli - Brindisi by train, Igoumenitsa - Paramythia by rental car	-154,810
Gallipoli - Brindisi by bike, Igoumenitsa - Paramythia by bike	-193,302

Looking at Tables 2 and 3, it can be underlined that accessibility values are generally higher for a user travelling with their family, due to the distribution of some monetary cost items (e.g., shared car). Accessibility is greater for users who use public transport or their own car when traveling with their family (Table 4), and for those who use only public transport as well. However, the gap between the values in the tables shows a smaller

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

discrepancy, especially in the combination characterised by the use of a train together with the bus. The use of a rental car drastically reduces the accessibility values, especially in Table 3. The use of a car is convenient because travel costs are reduced, particularly in the case of family travel, where the monetary cost is shared. The bike trip occurs in an intermediate position; the lower accessibility compared to the private car is due to the longer travel times (4–5 hours longer).

Special attention should be given to bicycle travel. In both tables, the accessibility value is identical, and from a sustainability perspective, action should be taken on the components that most affect accessibility values. Obviously, the choice of a sustainable means of transportation is influenced by a tourism demand and supply strongly characterised by sustainability features. In summary, the use of rental cars significantly reduces accessibility for both an individual's trip and a family of four individuals (Table 4). This suggests that, in the pursuit of a sustainable vision, policies founded on the empowerment of public transportation and mobility aimed at reducing greenhouse emissions, such as the construction of bicycle lanes, could be key strategic choices.

Two planning scenarios were considered:
A. Same alternative routes to Brindisi-Igoumentisa ferry
B. Alternative routes to Otranto-Igoumentisa ferry

Scenario A, with strengthened connections, reduced the travel times of the same paths:

- The upgrade of the Lecce - Brindisi link (on highway features) translates into a consequent reduction in the travel time by car from 51 to 37 minutes.
- The upgrading of the railway network, in particular the Gallipoli - Lecce section, and the provision of fast regional trains (elimination of 4 stops with low demand) translates into a reduction in travel time from 2 hours and 8 minutes to 1 hour and 52 minutes.
- The improvement of the regional road network travelled by buses (Gallipoli - Lecce section) increases the average transit speed from the current 45.2 km/h to 55 km/h, with a consequent reduction in travel time from 52 to 42 minutes (-10 minutes).
- The use of cycling paths in reserved lanes is considered an improvement proposal, with an average speed increase of 4 km/h (from 14 to 18 Km/h), with a relative reduction in travel time from 5 hours and 12 minutes to 4 hours and 3 minutes.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Scenario B involves a maritime link by ferries between Otranto and Igoumenista:

- Distance Otranto - Igoumenitsa = 186 km
- Navigation speed = 25 knots (46.3 km/h)
- Travel time at sea = 4 hours
- Average boarding waiting time = 2 hours
- Time for access/egress, modal shift = 1 hour
- Total time: 7 hours
- Rate: 30 €/person; 100 €/car

It is also assumed that the Gallipoli - Otranto connections will be strengthened, leading to a consequent reduction in travel times.

- Gallipoli-Maglie section (32.1 km in 38 minutes): hypothesis of a fast and direct connection of about 34 km with an increase in the average speed from 51 to 90 km/h.
- Cycling lanes in separate lanes, with an increase in average speed from 14 km/h to 18 km/h, and a reduction in travel time from 3 hours and 25 minutes to 3 hours.
- In relation to the strengthening of the direct section between Gallipoli and Maglie (34 km), which is covered in about 29 minutes, and considering the Maglie - Otranto section (16.8 km) which is covered in 14 minutes, this results in a bus travel time of 43 minutes in total.

Table 5 presents the total travel costs and times between the two terminal sites. Compared with the current scenario, monetary costs are slightly reduced in the first scenario (range of 4-12%), substantially in the second scenario (range of 8-37%). The greatest reductions in percentage terms were found on routes with bicycles and cars.

Time costs are reduced by the order of 2-10% in Scenario A, and by a range of 25-37% in Scenario B. In the first, the biggest reductions are related to alternatives 5 (with bus in Apulia and car rental in Thesprotia) and 7 (travel by bike). In Scenario B, alternatives 5 (with bus in Apulia and car rental in Thesprotia), 4 (bus in both regions), 1, and 2 (use of own car) are registered.

Table 5. Monetary costs and travel times for the Gallipoli-Paramythia route, with different travel alternatives

		Current Scenario		**Future Scenario A**		**Future Scenario B**	
ALT.	**People**	**C_{ij} (€)**	**T_{ij} (hh:mm)**	**C_{ij} (€)**	**T_{ij} (hh:mm)**	**C_{ij} (€)**	**T_{ij} (hh:mm)**
1	1	76,83	12:32	70,83	12:19	48,32	8:07
	4	169,83	12:32	150,83	12:19	108,32	8:07
2	1	130,56	12:45	125,56	12:31	100,05	8:20
	4	238,56	12:45	225,56	12:31	205,05	8:20

3	1 4	52,20 181,80	13:48 13:48	47,20 168,80	13:32 13:32	40,00 160,00	9:40 9:40
4	1 4	56,59 199,36	13:12 13:12	51,59 186,36	12:57 12:57	41,00 164,00	8:23 8:23
5	1 4	189,86 317,63	12:59 12:59	184,86 304,63	11:44 11:44	174,27 282,27	8:10 8:10
6	1 4	189,86 317,63	12:59 12:59	180,47 287,07	13:19 13:19	173,27 278,27	9:27 9:27
7	1 4	45,00 180,00	17:12 17:12	40,00 160,00	16,03 16,03	30,00 120,00	12:17 12:17

Table 6 lists the synthetic "generalised cost" indicator of travel between Gallipoli and Thesprotia. The greatest reductions in generalized cost are recorded for an average family user.

In Scenario A, the greatest benefits are observed for: Alternative 5 (46.2%) with a bus in Apulia and car rental in Thesprotia; Alternative 6 (41.5%) with a train in Apulia and car rental in Thesprotia; Alternative 2 (37.9%) with a car in Apulia and a bus in Thesprotia. In Scenario B, the following alternatives show reduction in generalized cost: Alternative 5 (59.5%) with a bus in Apulia and car rental in Thesprotia; Alternative 4 (55%) with a bus in both regions; Alternative 1 (54.9%) and 2 (55, 9%) with the use of their own car, and generally, the values stand at high levels (47-60%).

Table 6. Generalised transport cost

		Current Scenario (C)	**Future Scenario (A)**	**Future Scenario (B)**		
ALT.	**People**	**GC_{ij} (€)**	**GC_{ij} (€)**	**GC_{ij} (€)**	**Δ % (C-A)**	**Δ % (C-B)**
1	I FC	139,33 104,96	132,33 99,21	88,87 47,32	5,02 5,48	36,22 54,92
2	I FC	194,31 123,39	188,06 76,60	141,70 54,47	3,22 37,92	27,08 55,86
3	I FC	117,60 110,85	109,85 73,20	88,35 58,40	6,59 33,96	24,87 47,32
4	I FC	122,59 115,84	116,34 76,40	82,90 52,15	5,10 34,05	32,38 54,98
5	I FC	254,86 144,41	243,51 77,69	215,12 58,49	4,45 46,20	15,59 59,50
6	I FC	254,86 144,41	247,02 84,49	220,52 64,64	3,08 41,49	13,47 55,24
7	I FC	131,00 131,00	120,25 90,25	91,40 68,90	8,21 31,11	30,23 47,40

I = Individual; FC = Family component

In terms of accessibility, Scenario A shows a slight improvement compared to the current state, with gains ranging from 3% to 12%, particularly in the case of mobility by bike (alternative 7). In Scenario B, the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

accessibility gain becomes much more significant, ranging between 21% and 38%. The most effective alternatives are 1 (own car) and 4 (all bus), while alternative 7 (bike trip) shows a significant improvement (+32.6%).

Table 7. Accessibility (V_j) of scenario alternatives: Family component

Alternative	Current Scenario (C)	Future Scenario (A)	Future Scenario (B)	Δ % (C-A)	Δ % (C-B)
1.	-114,62	-107,42	-71,22	6,3	37,9
2.	-191,45	-185,30	-136,10	3,2	28,9
3.	-128,40	-121,25	-97,00	5,6	24,5
4.	-123,34	-116,79	-77,80	5,3	36,9
5.	-149,75	-143,20	-104,21	4,4	30,4
6.	-154,81	-147,66	-122,41	4,6	20,9
7.	-193,30	-170,30	-130,30	11,9	32,6

Ultimately, it can be concluded that:

a. In both scenarios of the plan, the accessibility of cross-border route increases.
b. The most significant results for accessibility are found in the plan scenario with greater investment commitment (Scenario B, strategic), with increases between 21% and 38% compared to the current state.
c. In terms of generalised transport cost, results similar to points a) and b) are found; but with more marked percentage variations, particularly with percentage variations compared to the current scenario in a range between 47% and 60%.
d. The most effective alternatives in terms of both generalised cost and accessibility are 1 (own car) and 4 (all bus), especially with group travel (family).
e. The competitive advantage of travel alternatives 1 and 4 is amplified in Scenarios B; however, the cycling alternative gains importance.

Discussion

It is recognized that both the transport and tourism sectors and their interactions are problematic. Each sector has rising emissions, weak responses reliant on technological innovation, and is locked into mind sets that perpetuate business-as-usual, characterised by exponential growth. Coupled with issues of global climate change are more localised issues such as urban air pollution, with some research suggesting that while tourism-transport contribute to emissions, air pollution might also reduce tourism activities as destinations become less appealing (Hopkins, 2020; Rosselló-Nadal & Santana-Gallego, 2024). Nevertheless, some solutions can be implemented, and the following suggestions are provided for policy makers.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Transport Field

Concerning connectivity and multimodal transport, the following actions could be considered.

- Enhancement of the current connectivity. This will aim at increasing the flow of passengers among the areas, which can be achieved by increasing the number of scheduled trips that can operate for more months of the year. This can also apply to the operations of the ports and airports in the area. This factor will work together with other actions to promote tourism and other forms of tourism that can occur year-round, as mentioned in more detail below. This can be achieved using the following actions:
  - Increased frequency of ferry lines among project areas (GR-IT).
  - Increased frequency of flights from neighbouring airports of Ioannina and Aktio (also seek the potential of seaplane flights among the project areas).
  - Use of neighbouring sea and land Trans-European Transport Networks (connection of Italian ports with neighbouring Greek ports).
  - Seek the potential of seaplane flights within the project areas.
  - Creation of cycling routes linked to a cross-border network of cycling routes planned based on common specifications for the Plan areas (linked to the project).

- Enhance multimodal transport in project areas. This can be achieved through several actions and activities, including the following:
  - Activities that reduce the transport intensity of the economy.
  - Promote better organisation of transport services (e.g., the degree of use of logistics and intelligent technologies, especially traffic management technologies, and the organisation of last-mile transport).
  - Modernisation and creation of new railways, especially in Thesprotia, to connect the area to the rest of the network and to waterways.
  - Reductions in train journey times increase the competitiveness of rail transport compared to other less environmentally friendly modes of transport.
  - Improving the technical solutions for vehicles (powertrain and fuel) and infrastructure.

Tourism and the Environment

Concerning tourism and the environment (promotion of sustainable tourism destinations), the following actions have been considered:

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- Promotion of alternative forms of tourism enables increased tourist flow throughout the year. Such actions are also aligned with national policies and will contribute to the economic growth of the planning area in a sector that remains important and has considerable potential. Nature offers the opportunity to develop forms of tourism such as cycling, hiking, horseback riding, boating, and canoeing.
- Measures to protect the natural environment and areas of cultural importance. This can also be achieved through various projects or related actions. RDP programmes and other related sources offer significant potential.
- Promoting sustainable tourism enhances the idea of safe destinations. Sustainable tourism is also linked to safe experiences. Additionally, the promotion of tourist destinations will be linked to alternative forms of tourism, as previously mentioned. The role of tourist accommodation and services is crucial at this stage. It will not only include monuments and sites of touristic importance but also the services provided by the hotel sector, restaurants, and coffee shops in terms of safety regulations.
- Enhanced use of digital technologies. Digitalisation and the wider use of social media and apps will continue to play a key role in this context. Considering the previous case, it is assumed that passengers have learned to manage their trips in detail, with all the tools and information needed to do so.
- Networking among stakeholders in the planning area and sharing of best practises. Sustainable tourism development requires informed participation by all relevant stakeholders and strong political leadership to ensure broad participation and consensus building. Achieving sustainable tourism is a continuous process that requires constant monitoring of impacts, and the introduction of necessary preventive and/or corrective measures whenever necessary.

Conclusion

In the context of the Interreg cooperation programme Italy-Greece (2014-2020), one of the objectives was the development of a cross-border plan for sustainable mobility. Travel alternatives between southern Italy (Salento) and Greece (Epirus) were analysed to verify more sustainable travel modes between the two areas. The aim was to stimulate a sustainability sphere related to transport, one of the most polluting assets globally, and to assess the potential of an agreed and shared cross-border plan.

The results present accessibility indices and multimodal travel alternatives between the two areas for a single traveller and an average family of four, outlining three different development scenarios for the multimodal

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

transport system in the planning area (passive, proactive future, and reactive future scenarios). The proactive scenario is seen as the most realistic and immediate solution, while the reactive scenario is considered the most innovative and ambitious.

To stimulate the development of sustainable tourism in the identified areas, more concerted actions should be envisioned, both in terms of transport and tourism. Specifically, it would be beneficial to increase the current multimodal connectivity between the areas by strengthening maritime and seaplane connections. The creation of cycling routes on both sides, linked to a cross-border network of cycling routes, should also be considered, with common specifications for the plan areas. In this regard, the modernisation and creation of new railways, especially in the Thesprotia area, should be planned, with the goal of connecting the area to broader network and waterways, supported by advanced technological solutions. These measures should be complemented by the promotion of alternative forms of tourism to encourage deseasonalisation. Increased accessibility fosters mobility, translating into social and economic benefits for local communities. Being more easily accessible from the outside and more connected to each other, the regions can expect more incoming tourism and increased reciprocal exchange flows. The future perspective of the research recommends a systemic vision, considering the most recent results from the Adriatic-Ionian Macro-regional Strategy and the latest projects financed by directly managed programmes. These should be integrated with tools for mainstream and local planning to provide operational support to local policymakers in the fields of tourism and sustainable transport.

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