Mapping Recreational Services and Beneficiaries in the Sardinia Region Using ESTIMAP with Tourism Insights

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Abstract. Ecosystem services (ESs) knowledge is key for urban planning as they provide essential resources to society. Mapping the beneficiaries of these services helps identify the levels of access to certain ESs, such as nature-based recreation, while also assessing residents' and tourists' dynamics and patterns across the region. This information aids in decision-making for planning green infrastructure that meets the needs of both residents and visitors. In this study, the ESTIMAP model is applied at a regional scale and subsequently a methodology for mapping the distribution of beneficiaries of recreational ES is introduced. The study further outlines the calculation of beneficiaries within varying buffer zones, considering both population and tourist numbers as well as different modes of transportation, including walking, cycling, public transportation, and private cars. The findings reveal that areas that potentially supply high levels of recreational ES (ROS9) in Sardinia are spread out across the region, ensuring accessibility by car for everyone within a 30-min drive. When walking is considered, the percentage of the population within 1 km of ROS9 areas is almost half that of tourists, as accommodation facilities tend to be situated nearer to ROS9 areas compared to population settlements. This highlights a disparity in walking access, which decreases when considering public transportation. The adaptable method highlights the effectiveness of the ES approach in guiding urban planning while supporting nature-based tourism.

Keywords: Ecosystem Services · Nature-based recreation · GIS

1 Introduction

The relationship between nature and society is at the core of urban planning studies. To understand and improve this relationship, Ecosystem Services (ESs) have become a prominent research domain in related fields. While many studies focus on the provision of ESs, the distribution and accessibility of these service is equally important [1]. Urban planning is a key tool for authorities to shape the distribution of ecosystems and ESs in cities, determining the number, location, and types of beneficiaries [1, 2]. Failing to disaggregate the distribution of environmental resources limits a full understanding of the various dimensions of equitable well-being, ultimately leading to the unequal provisioning of ESs among potential beneficiaries [1].

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Identifying the relationship between the supply and demand of nature-based recreation is key for integrating the ES approach into policy and decision-making processes that support sustainable tourism [3], since rapid urban sprawl is increasing the mismatch between supply and demand [4]. Addressing these imbalances can help identify areas in need of improvement and inform spatial and regional planning, enhancing sustainable tourism management and safeguarding natural ecosystems [3].

Research on methods to calculate the demand for ESs and map their flows remains ongoing. Models such as ESTIMAP provide frameworks for mapping both the provision and the demand of ESs; however, studies predominantly emphasize their economic valuation [5, 6]. At the European level, Vallecillo et al. compare the "actual flow of nature-based recreation in relative terms at the country level" [7, Fig. 7] with Italy ranking among the bottom three countries, indicating one of the lowest percentages of potential visits per inhabitant. Baró et al. [8] identify the unsatisfied demand for ESs in the metropolitan region of Barcelona, while Isola et al. [9] map the spatial distribution of both met and unmet demand for daily nature-based recreation in Sardinia, measured by the number of trips per year to areas that provide high levels of recreational services. Within this framework, this study aims to explore the provision of recreational ESs and offers a novel approach that integrates within the traditional ESTIMAP model both tourists' demand for outdoor recreation, and accessibility by different means of transportation. Since the demand for nature-based recreation varies, with some people seeking local ecosystems like urban parks and forests for activities such as walking or cycling, while others travel longer distances to visit national parks or hike in the mountains [7], mapping both the provision of ESs and different beneficiary groups enables practical strategies to enhance accessibility and ensure the equitable distribution of ES.

2 Case Study: Sardinia Region, Italy

2.1 Location

Sardinia, one of the 20 regions of Italy (Fig. 1), is located in the southern part of the country. The region is the Mediterranean's second-largest island after Sicily, covering an area of 24,100.02 km^2. With a coastline stretching 1,897 km, when considered together with its surrounding smaller islands, it has the most extensive coastal development of any Italian region, accounting for more than a quarter of Italy's total coastline [10].



Fig. 1. Sardinia and regional borders in Italy.

3 Materials and Methodology

3.1 Methodology

The ESTIMAP recreation model, developed by the European Commission's Joint Research Centre, is a GIS-based tool designed to assess ESs across Europe [11, 12]. The model comprises two modules: the Human Input (Proximity) map and the Recreation Potential (RP) map. As seen in Fig. 2, these two modules are cross-tabulated to produce the Recreation Opportunity Spectrum (ROS) map, which shows recreational opportunities according to their distance from the road network and populated areas.

The first module, RP, is an ecosystem-based potential map. The original model uses three parameters to map RP: i) the degree of naturalness in land cover, ii) the presence of protected areas, and iii) the presence of water-related features. However, these parameters are often adapted to fit the context of specific studies [9, 13, 14]. In this study, the parameters for the first module follow those established in Kobak [14], where the input parameters for the RP map were chosen as follows: i) the degree of naturalness in land cover, ii) the presence of protected areas, and iii) the presence of areas of interest.

The second module, HI, measures the distance from human settlements and road networks. The traditional ESTIMAP model focuses on non-motorized recreational activities, accounting for ESs that are supplied by high-quality ecosystems near urban centers, which shows only a portion of the total potential [9]. The proximity to population and the proximity to transportation infrastructure; road network and slow-mobility routes such as biking routes are the two parameters that create the HI. The data layers used to create these intermediate maps are presented in Table 1. After obtaining the final rasters for the RP map and HI modules, cross-tabulation is performed in QGIS to generate the final ROS map. This process results in nine distinct values representing the intersections between RP and HI classes, as shown in Fig. 3.

The ROS map can be considered as the final output of the adapted ESTIMAP model that aids in understanding which areas have high recreation potential while also showing

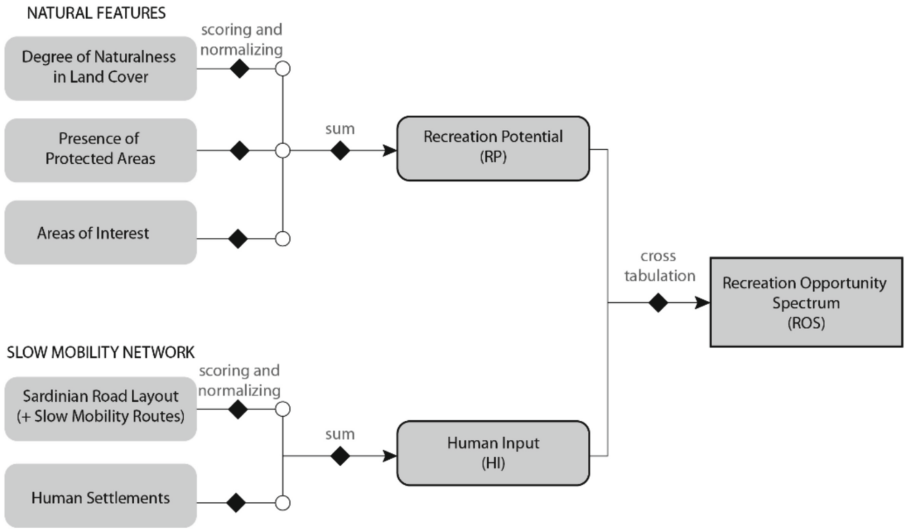

Fig. 2. Adaptation of ESTIMAP-Recreation Model for Sardinia. Modified after Zulian et al. (2013).

high accessibility levels. In order to further investigate the met and unmet demand of beneficiaries, an additional step is applied to the Sardinia Region.

To assess the demand for ES, the methodology presented in Vallecillo et al. [6] is used. In their study, also applied by Isola et al. [9], the met and unmet demand for daily nature-based recreation is calculated in terms of the number of trips per year to areas offering high levels of recreational services with the focus on trips within an 8 km round-trip distance, considering only resident populations, and excluding tourists and motorized transportation. Therefore, to provide a more inclusive analysis, this study considers additional parameters, including tourists and access by bus, train, and car within the proposed framework and it calculates the number of people that live or lodge within these vicinity buffers.

As shown in Fig. 4, the proposed methodology to calculate the beneficiaries of recreational services uses mainly two groups of data. The first group consists of raster files representing the number of people per pixel, including both residents and tourists residing in the region. These pixels are considered as starting points for potential visits to high-score recreational areas, defined as areas with a maximum score of nine on the ROS map (ROS9 areas). The second group of data consists of areas of interest, meaning specifically ROS9 areas, areas in their vicinity, and areas with transportation options that enable people to access them. These transportation options include walking, biking, taking the bus, train or car.

The first group of data, i.e., the number of people per pixel, is obtained for two groups: residents and tourists. While for the information regarding the distribution of population per pixel, the global data layer “GHS-POP R2023A - GHS population grid multitemporal (1975–2030)” [15] is used; the information on tourists is obtained by using a combination of different sources listed in Table 2.

Table 1. Input data for the intermediate maps of the ESTIMAP Model.

Data layer name	Data source	Parameter	Module
Corine Land Cover 2018	Copernicus Land Monitoring Service[a]	degree of naturalness in land cover	RP
N2000 sites, Sites of Community Importance (SCI), Special Conservation Zones (SCZ), Special Protection Areas (SPA)	Ministero dell'Ambiente e della Sicurezza Energetica (MASE)[b]	presence of protected areas	
Art. 142 - Parchi e riserve nazionali o regionali (dati indicativi)	Aree tutelate Sardegna Geoportale[c]		
cultural sites, caves, BP (Landscape assets), BI (Identity assets), ARCHEO (Archaeological assets), monumental trees, monuments	Aree tutelate Sardegna Geoportale[c]	presence of areas of interest	
Località italiane	2021 National Census[d]	Human settlements	HI
layer 01 "roads, mobility, and transport"	DBGT[e] Sardegna Geoportale	Road layout	
Biking Routes	Courtesy of Sardegna Ciclabile[f]	Slow mobility routes	

[a]Copernicus Land Monitoring Service. (2018). Corine Land Cover 2018. European Environment Agency. https://land.copernicus.eu/en/products/corine-land-cover/clc2018.
[b]Ministero dell'Ambiente e della Sicurezza Energetica (MASE) [Ministry of the Environment and Energy Security]. https://www.mase.gov.it [last accessed 5 March 2024].
[c]Aree tutelate Sardegna Geoportale [Official Website for geospatial data of the Sardinia Region]. https://www.sardegnageoportale.it/webgis2/sardegnamappe/?map=aree_tutelate [last accessed 5 December 2024].
[d]Istituto Nazionale di Statistica (ISTAT). [National Institute of Statistics] https://www.istat.it/notizia/basi-territoriali-e-variabili-censuarie/ [Last accessed 5 December 2024].
[e]Datatabase Geotopografico [Geotopographic Database]. https://www.sardegnageoportale.it/index.php?xsl=2420&s=40&v=9&c=95645&es=6603&na=1&n=100&esp=1&tb=14401 [Last accessed 9 October 2024].
[f]Sardegna Ciclabile [Official website showing all cycling routes in Sardinia] http://www.sardegnaciclabile.it/site/itinerari/ [last accessed 23 February 2024].

The second group of data, i.e., areas of interest, defined as the ROS9 areas, includes zones that facilitate transportation methods such as walking, biking, bus, train, or car. These areas are identified through buffer zones, whose size is determined based on studies specific to each transportation mode. Implementing more types of transportation methods as well as introducing the number of tourists was a strategical choice to overcome some of the limitations mentioned in earlier studies [7, 9].

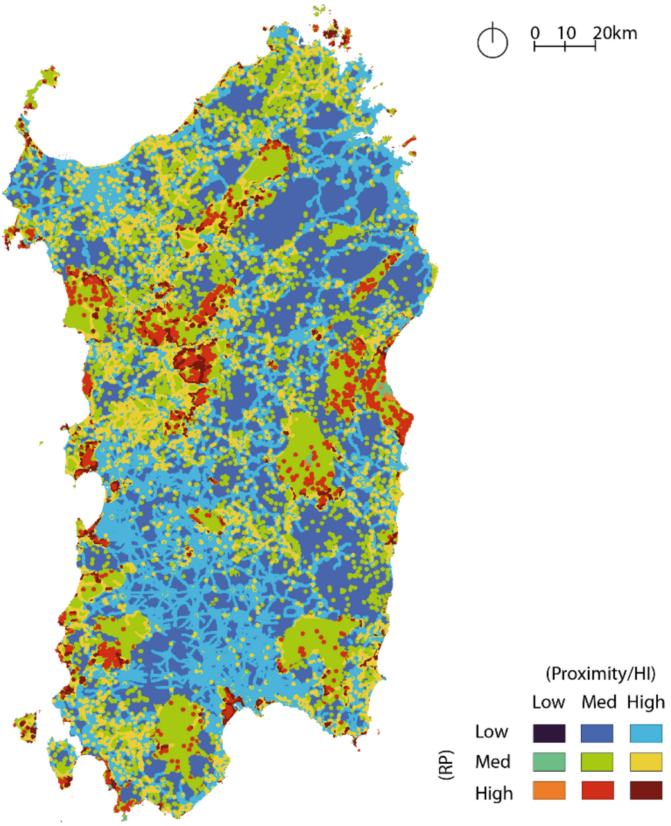

Fig. 3. Recreation Opportunity Spectrum (ROS) map.

Considering the access by walking, a 4-km buffer distance is considered as "met demand", representing the maximum distance people are typically willing to walk to a recreational area [7]. To account for variations in walking willingness, buffer distances of 1 km, 2 km, and 4 km were analysed, and the population within each distance was calculated to identify the number of beneficiaries.

For biking, an 8-km buffer distance is considered, reflecting the fact that most cycling trips are typically under 15 km, which aligns with the distance that greenway users travel to access the trail [16–18]. Regarding the number of people who might benefit from this service, physical ability is considered since not all people are able to bike. Even though most kids learn how to ride a bike at the age of 4–7 according to the American Academy of Pediatrics' bicycle guidance [19], for traveling by bike, adolescence is considered a suitable minimum age. For the maximum age, 64 is here considered as 65 is regarded as senior citizenship in most countries. According to the World Health Organization, adolescence[1], begins at the age of 10, while adulthood is defined as the age range of

[1] WHO. (2019). Adolescent health. https://www.who.int/health-topics/adolescent-health#tab=tab_1.

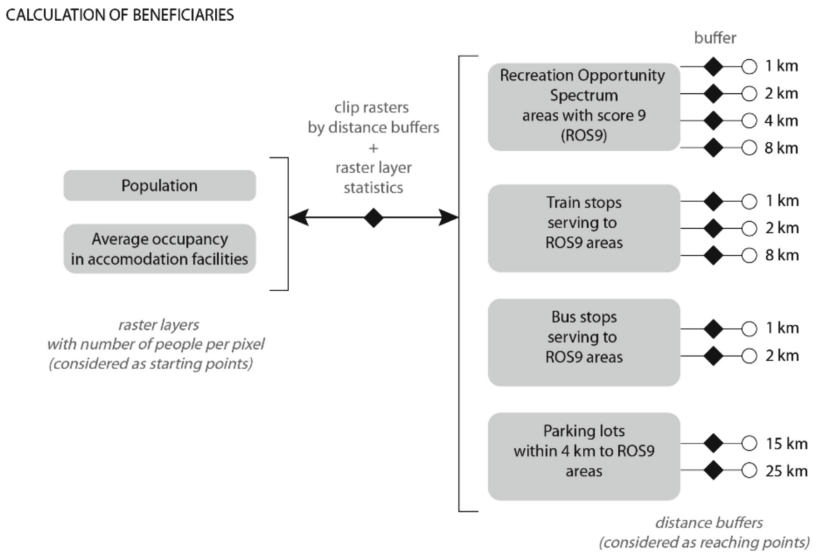

Fig. 4. Calculation of beneficiaries.

Table 2. Input data used to create raster layers for the calculation of beneficiaries.

Data layer name	Data source	Final Output
GHS-POP R2023A - GHS population grid (1975–2030) [raster layer]	European Commission, Joint Research Centre (JRC)	Raster layer depicting population per pixel for residents
«Strutture_Ricettive_RAS_20240833» [vector layer]	Courtesy of Directorate General of Tourism, Crafts, and Trade of Sardinia	Raster layer depicting population per pixel for tourists
Private accommodation capacity (Airbnb listings) [csv table]	BNB Toolbox Scraper for Airbnb	
OSM Tag: "amenity = parking" [vector layer]	Overpass Turbo Tool - Open Street Map (OSM)[a]	Parking lots
Dati fermate trasporti [Transport stops]	Sardegna Mobilità[b]	Bus stops / Train stops
Percorsi di linea TPL [Public Transport Line Routes]		

[a]Data mining by Overpass Turbo. OSM. https://overpass-turbo.eu/?template=key-value&key=amenity&value=parking [Last accessed November 10, 2024].
[b]Sardegna Mobilità. Open data – Percorsi [Routes]. https://www.sardegnamobilita.it/open-data/percorsi [Last accessed November 10, 2024].

18 to 64 [20]. Therefore, individuals aged 10 to 64 are considered capable of biking. Considering this age range, a rate of 68% was applied to population in Sardinia calculated according to the age distribution data of ISTAT [21] and a rate of 78% is applied to tourist numbers calculated according to the "Tourist Movement Data" available from Sardegna Turismo [22]. The data here is limited to individuals aged 15 to 64, as information for the 10 to 14 age group is unavailable.

For travelling by car, distances under 100 km are considered accessible, as traveling 100 km or more is generally regarded as a long-distance trip [23]. Parking lots within

4 km from ROS9 areas are considered as destination and buffer layers were created around those parking lots.

For travelling by bus, bus stops located within a 4-km radius of ROS9 areas were identified. Subsequently, the bus lines serving these stops were mapped, and all stops along these lines were regarded as stops that people can use to reach a ROS9 location. Individuals residing within 1 km and 2 km from these bus stops were identified as having the opportunity to access a ROS9 area via bus. For travelling by train, the same method used for calculating bus accessibility was applied, with one additional consideration: an 8 km buffer was included alongside the 1-km and 2-km buffers, accounting for the possibility that people might use bicycles to reach train stations, as bikes are permitted on trains and can also be utilized within recreational areas.

For the calculation of the number of people who benefit from at least one ROS9 area, the average occupancy rates (O.R.) are applied to both tourist numbers. This rate is 22% in for the AIRBNB listings in Sardinia in 2019, calculated by the percentage of days with a reservation out of the total number of days either reserved or available in a year, excluding blocked days [24]. For the other types of accommodation such as hotels, no information is available specific to Sardinia, but it is available for Italy. According to the statistics provided by Eurostat [25, 26], the average rate of occupancy in hostels and similar establishments in Italy is 51.6% in 2019, calculated by dividing the total sum of bedrooms in use by the total bedrooms available, adjusted for seasonal and temporary closures.

4 Results

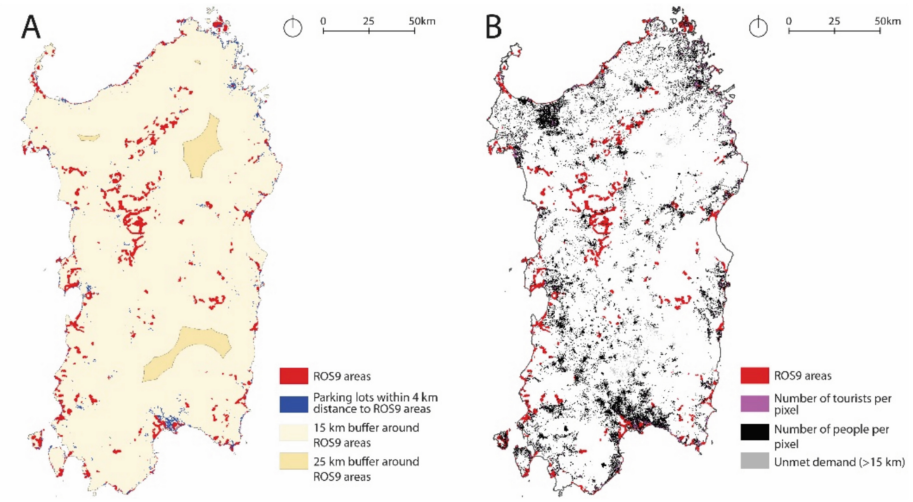

Fig. 5. Access by car; distances to ROS9 areas (A), distribution of beneficiaries (B).

Figure 5(A) shows the buffer layers around parking lots within a 4-km distance of ROS9 areas. Given the scattered distribution of ROS9 areas, a 25-km threshold was deemed sufficient to cover the entire island. This indicates that everyone in Sardinia lives within a 30-min (at 50 km/h) driving distance of at least one ROS9 area. If we consider a 15-km trip to a parking lot near a ROS9 area, approximately 97.97% of the population residing on the island can access a recreational area (ROS9) by car within around 15 min (at 60 km/h). This percentage is 98.43% for tourists, indicating that accommodation facilities are situated closer to recreational areas. The spatial distribution of residents and tourists staying in accommodation facilities is shown in Fig. 5(B). Since different sources are combined to calculate the tourist numbers, in Table 3, more detail is provided on the number of tourists, showing the difference in capacity between private accommodation facilities such as Airbnb, and other types of facilities. Table 3 also provides a summary of all distance buffers considered per transportation type and the numbers corresponding to those buffers.

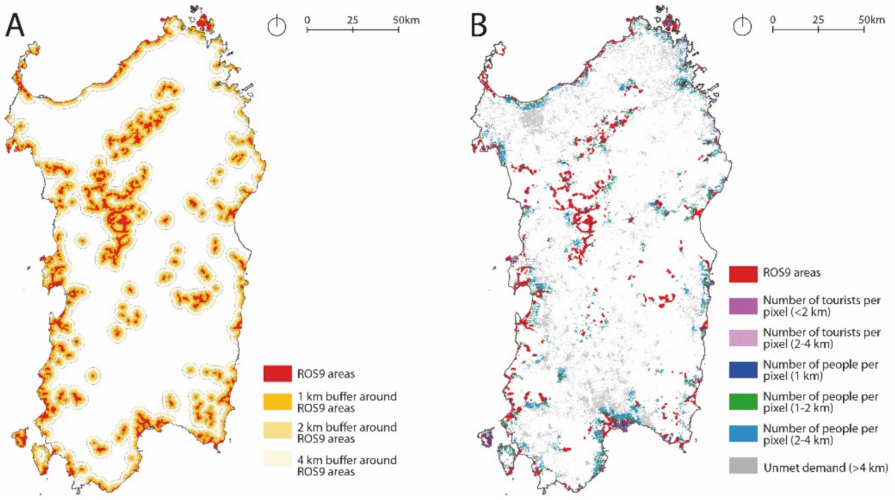

Fig. 6. Access by walking; distances to ROS9 areas (A), distribution of beneficiaries (B).

Figure 6(A) shows the buffer distances considered for pedestrian access, while Fig. 6(B) shows the distribution of beneficiaries within those buffers. Considering 4 km as the maximum distance people might be willing to walk (approximately 80 min of walking), 60.49% of the population (937,482 people) live within a 4 km radius of a ROS9 area, leaving around 40% of the population without access to a ROS9 area within walking distance. However, a 4 km distance may not be equally attractive to everyone. Therefore, distances of 2 km and 1 km should be considered more realistic and relevant for access to ROS9 areas. When considering a 2 km distance (around 30–40 min of walking), about 60% of the population does not have access to a ROS9 area. In contrast, 86.22% of tourists lodge within 4 km of a ROS9 area, and 71.49% within 2 km. Moreover, while 22.56% of the population lives within 1 km of ROS9 areas, this percentage rises to 54.09% for tourists, which indicates that accommodation facilities are

more likely to be located closer to ROS9 areas, as reflected in the higher accessibility percentages for tourists compared to the general population.

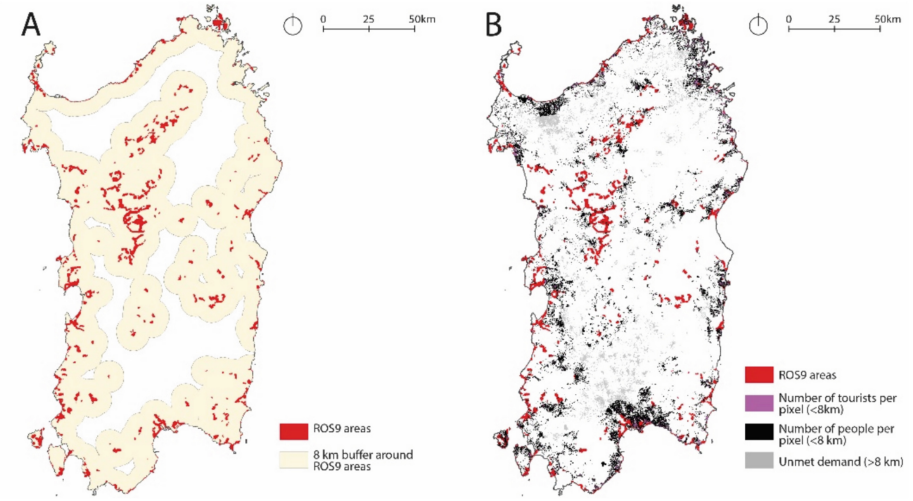

Fig. 7. Access by biking; distances to ROS9 areas (A), distribution of beneficiaries (B).

Regarding accessibility by biking, an 8 km buffer distance is considered, as shown in Fig. 7(A). For Fig. 7(B), after determining the number of people within the 8 km buffer, a rate of 67% is applied to the population of Sardinia, and a rate of 78% is applied to the tourist population, based on the age range identified, which reflects the physical ability to bike. For the tourist numbers, the occupancy rates are applied first, then the biker rate when biking is involved, as shown in Table 3. The results show that 94.81% of tourists capable of biking have at least one ROS9 area within 8 km of their accommodation, while 78.75% of the population in Sardinia capable of biking have at least one ROS9 area within 8 km of their residence. However, it should be noted that some places in Sardinia, such as the main city Cagliari, may not be suitable for biking due to high levels of slope and challenging topographical conditions. Therefore, while these percentages are promising, a more detailed analysis considering the topographical conditions is needed.

To calculate the number of people who can reach a ROS9 area by train, the train stops within a 4-km distance of ROS9 areas are first identified, and the train lines serving these stops are mapped, shown in Fig. 8(A). Buffers are then created around the stops along these lines. Distances of 1 and 2 km are considered as walking distances to a train station, while an 8 km distance is also taken into account to accommodate the fact that bikes are allowed on trains, and some individuals may prefer this option. The total distribution of beneficiaries is seen in Fig. 8(B). At a 1 km distance from train stations serving ROS9 areas, 145,968 residents (9.42%) and 1,006 tourists (1.62%) are within reach. At 2 km, the resident number increases to 302,642 (19.53%), and the tourist number rises to 1,733 (2.79%). Within an 8 km distance, 491,689 residents (47.35% of the population within the identified age range for biking) and 5,261 tourists (10.86%) can

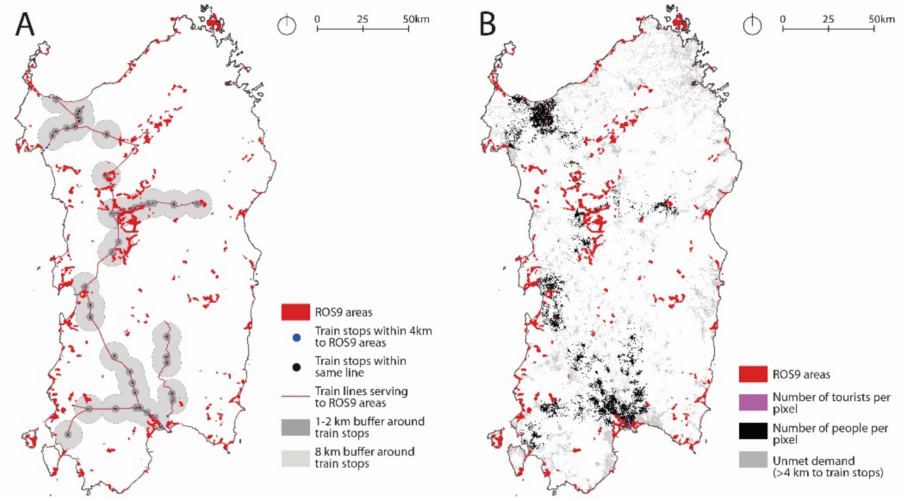

Fig. 8. Access by train; distances to train stops (A), distribution of beneficiaries (B).

access a ROS9 area by bike. Here, only people who live in close vicinity to a train station are considered, which explains the lower percentages compared to earlier calculations. For a more comprehensive analysis, if walking or biking directly to a ROS9 area is also preferred, Table 4, which shows all buffers cumulatively, should be considered for the calculation.

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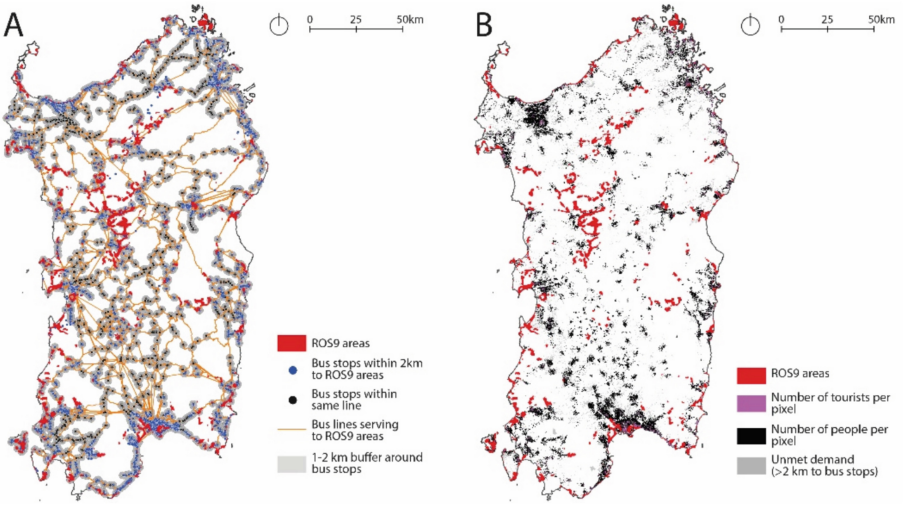

Fig. 9. Access by bus; distances to bus stops (A), distribution of beneficiaries (B).

To calculate the beneficiaries who can reach a ROS9 area by bus, the same method used for train stops is applied, considering only 1 km and 2 km distances as bikes are not allowed on buses. The results show that 1,467,368 people (94.68% of the population) live within 1 km of a bus stop that serves a ROS9 area, while for tourists this number is 46,855 corresponding to 75.46% of the total tourist numbers. Within 2 km, the population increases to 1,509,164 (97.38%), while tourists to 54,638 (87.99%). This indicates that the majority of people live in close proximity to a bus stop from which they can access a bus line to reach a ROS9 area. Here, the length of the bus trip is not considered. However, as shown in Fig. 9, ROS9 areas are not clustered in a few locations but are rather scattered across the region with numerous bus lines available to provide access. Therefore, it is assumed that the bus trip to reach a ROS9 area will not take too long. In the case of other regions, the trip duration could be considered.

Table 3. Distribution of population in terms of access to ROS9 areas, divided by type of transport.

	Population		Tourists in private accommodation (O.R. 22%)	Tourists in hotels and other facilities (O.R. 51.6%)	Tourists total O.R. applied	
All Sardinia	**1549772**		Max capacity: 67150 O.R. applied: **14773**	Max capacity: 91701 O.R. applied: **47318**	**62091**	
WALKING (distances around ROS9 areas)						
Distances	Population	% relative to the total in Sardinia	Tourists in private accommodation (O.R. 22%)	Tourists in hotels and other facilities (O.R. 51.6 %)	Tourist total O.R. applied	% relative to the total in Sardinia
1 km	**349624**	22.56%	Max capacity: 29867 O.R. applied: **6571**	Max Capacity: 52358 O.R. applied: **27016**	**33587**	54.09%
2 km	**633313**	40.86%	Max Capacity: 45445 O.R. applied: **9998**	Max Capacity: 66648 O.R. applied: **34391**	**44389**	71.49%
4 km	**937482**	60.49%	Max Capacity: 55863 O.R. applied: **12290**	Max capacity: 79927 O.R. applied: **41243**	**53533**	86.22%
BIKING (distances around ROS9 areas)						
8 km	Total: 1204902 Biker: **807284**	77.75%	Max capacity: 63142 O.R. applied: **13892**	Max capacity: 87168 O.R. applied: **44979**	Total: 58871 Biker: **45919**	94.81%
BY TRAIN (distances around train stops that serve to ROS9 areas)						
1 km	**145968**	9.42 %	Max capacity: 993 O.R. applied: **219**	Max capacity: 1527 O.R. applied: **787**	**1006**	1.62%
2 km	**302642**	19.53%	Max capacity: 2090 O.R. applied: **460**	Max capacity: 2467 O.R. applied: **1273**	**1733**	2.79%
8 km (biking)	Total: 733864 Biker: **491689**	47.35%	Max capacity: 7953 O.R. applied: **1750**	Max capacity: 9681 O.R. applied: **4995**	Total: 6745 Biker: **5261**	10.86%
BY BUS (distances around bus stops that serve ROS9 areas)						
1 km	**1467368**	94.68%	Max capacity: 52977 O.R. applied: **11654**	Max capacity: 68219 O.R. applied: **35201**	**46855**	75.46%
2 km	**1509164**	97.38%	Max capacity: 60418 O.R. applied: **13292**	Max capacity: 80128 O.R. applied: **41346**	**54638**	88%
BY CAR (distances around parking lots within 4km to ROS9 areas)						
15 km	**1518354**	97.97%	Max capacity: 65553 O.R. applied: **14422**	Max capacity: 90492 O.R. applied: **46694**	**61116**	98.43%

Figure 10 illustrates the aggregation of all buffers and transportation types considered, with scores assigned on a scale from 1 to 8, where 1 represents the highest preference. To prevent double-counting of beneficiaries, overlapping areas have been avoided. In cases of overlap, the area is assigned the higher score. The number of beneficiaries corresponding to these scores are presented in Table 4. This table provides the opportunity to calculate the sum of different transportation types while also providing

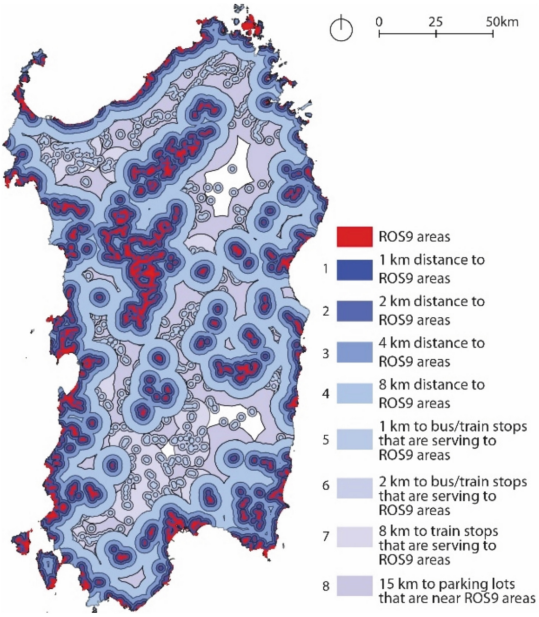

Fig. 10. Access to ROS9 areas by different types of transportation, distances with scores.

the option to include scores 1, 2, and 3 in the calculation to account for individuals who may walk directly to a ROS9 area. To calculate the sum, a cumulative addition from 1 to 8 is necessary.

5 Conclusion and Future Work

Results show that the ratio of tourists in vicinity to ROS9 areas is always higher considering access by walking and biking (see Table 3). Considering the vicinity to transportation options such as train or buses, the ratio of beneficiaries is higher in residents than tourists. This is logical since the active users of these stops are residents. However, when considering walking distance, while more than half of tourists can access ROS9 areas within 1 km and 2 km, less than a quarter of residents can reach a ROS9 area within 1 km, and this ratio is still under half within 2 km. This highlights the necessity for regional policies that focus on improving access for residents, ensuring equitable distribution of recreational services, and improving the overall quality of life for local communities; as uneven accessibility and availability of these services can limit marginalized communities' opportunities for nature-based recreation and the associated health and well-being benefits [27]. On the other hand, improving public transportation access in areas with accommodation facilities could be improved to promote sustainable tourism.

Acknowledging the importance of equitable distributions of ES across different target groups is key for environmental justice [27]. Research that aims to understand more deeply the relationship between supply and demand of ESs, as well as how policies can address inequalities in access, will enhance our understanding and help shape more

Table 4. Distribution of population in terms of access to ROS9 areas, all options scored.

ALL TYPES OF TRANSPORT (distances around ROS9 areas and bus/train stops)						
SCORES	Population	% relative to the total in Sardinia	Tourists in private accommodation (O.R. 22%)	Tourists in hotels and other facilities (O.R. 51.6%)	Tourists total O.R. applied	% relative to the total in Sardinia
1	**349624**	22.56%	Max capacity: 29867 O.R. applied: **6571**	Max capacity: 52358 O.R. applied: **27017**	**33588**	54.09%
2	**283688**	18.31%	Max capacity: 15578 O.R. applied: **3427**	Max capacity: 14290 O.R. applied: **7374**	**10801**	17.40%
3	**304169**	19.63%	Max capacity: 10418 O.R. applied: **2292**	Max capacity: 13279 O.R. applied: **6852**	**9144**	14.73%
4	Total: 267420 Biker: **179171**	17.26%	Max capacity: 7279 O.R. applied: 1601 Biker: **1249**	Max capacity: 7241 O.R. applied: 3736 Biker: **2915**	Total: 5337 Biker: **4164**	8.60%
5	**328383**	21.19%	Max capacity: 2986 O.R. applied: **657**	Max capacity: 3658 O.R. applied: **1888**	**2545**	4.10%
6	**8347**	0.54%	Max capacity: 547 O.R. applied: **120**	Max capacity: 273 O.R. applied: **141**	**261**	0.42%
7	Total: 2337 Biker: **1566**	0.15%	Max capacity: 19 O.R. applied: 4 Biker: **3**	Max capacity: 13 O.R. applied: 7 Biker: **5**	Total: 11 Biker: **8**	0.02%
8	**5610**	0.36%	Max capacity: 261 O.R. applied: **57**	Max capacity: 221 O.R. applied: **114**	**171**	0.28%
TOTAL [exc. (8)]	**1454948**	99.63%	14376	46306	**60682**	99.35%

**This table corresponds to* Fig. 10*. Overlapping areas are counted only under the highest score (1 being the highest, 8 being the lowest).*

inclusive strategies for sustainable ES management. Green Infrastructure planning is a valuable approach to respond to the challenge of ensuring equitable access to ESs, aiming to provide equal opportunities for all citizens while promoting both social well-being and sustainable urban development.

This method, applied in Sardinia, provides a framework that can be easily adapted to other regions, demonstrating its versatility and potential for broader and cross-scale application. It allows to introduce different types of transportation possibilities to access recreational services. To avoid creating a complex framework, demographic information is only included for biking distances, considering the age range capable of biking to ensure more realistic figures. Introducing a survey to assess people's willingness to use these transportation options, combined with more comprehensive data such as including topographical variations in terrain, would be beneficial for future studies.

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