

Article

Green Infrastructure Mapping in Almeria Province (Spain) Using Geographical Information Systems and Multi-Criteria Evaluation

Álvaro Navas González ¹, Richard J. Hewitt ² and Javier Martínez-Vega ^{2,*} 

¹ Department of Geology, Geography and Environment, University of Alcalá, Colegios 2, 28801 Alcalá de Henares, Spain; alvaro.navas@edu.uah.es

² Institute of Economics, Geography, and Demography, Spanish Research Council (IEGD-CSIC), Albasanz, 26-28, 28037 Madrid, Spain; richard.hewitt@cchs.csic.es

* Correspondence: j.martinez@csic.es

Abstract: Green infrastructure (GI) is increasingly prioritised in landscape policy and planning due to its potential to benefit ecosystems and enhance wildlife conservation. However, due to the uneven distribution of protected areas (PAs) and the fragmentation of habitats more generally, multi-level policy strategies are needed to create an integrated GI network bridging national, regional and local scales. In the province of Almeria, southeastern Spain, protected areas are mainly threatened by two land use/land cover changes. On the one hand, there is the advance of intensive greenhouse agriculture, which, between 1984 and 2007, increased in surface area by more than 58%. On the other hand, there is the growth of artificial surfaces, including urban areas (+64%), construction sites (+194%) and road infrastructures (+135%). To address this challenge, we present a proposal for green infrastructure deployment in the province of Almeria. We combine Geographic Information Systems (GISs) and multi-criteria evaluation (MCE) techniques to identify and evaluate suitability for key elements to be included in GI in two key ways. First, we identify the most suitable areas to form part of the GI in order to address vulnerability to degradation and fragmentation. Second, we propose 15 ecological corridors connecting the 35 protected areas of the province that act as core areas. The proposed GI network would extend along the western coast of the province and occupy the valleys of the main rivers. The river Almanzora plays a leading role. Due to its remoteness from the coast and its climatic conditions, it has not attracted intensive greenhouse agriculture and urban development, the main drivers of the transformation and fragmentation of traditional land uses. Around 50% of the area occupied by the proposed corridors would be located in places of medium and high suitability for the movement of species between core areas.

Keywords: green infrastructure; GIS; multi-criteria assessment; ecological connectivity; Almeria; Spain



Citation: Navas González, Á.; Hewitt, R.J.; Martínez-Vega, J. Green Infrastructure Mapping in Almeria Province (Spain) Using Geographical Information Systems and Multi-Criteria Evaluation. *Land* **2024**, *13*, 1916. <https://doi.org/10.3390/land13111916>

Academic Editors: Jaroslaw Janus, Hrvoje Tomić, Miodrag Roić and Goran Andlar

Received: 1 October 2024

Revised: 6 November 2024

Accepted: 8 November 2024

Published: 14 November 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

1.1. Challenges Facing Biodiversity Conservation

In recent decades, climate change (CC) has emerged as one of the greatest challenges to humanity and the environment [1,2]. Apart from well-documented impacts on land use and human activities generally [3,4], CC and climate variability have negatively impacted protected areas (PAs) [5,6]. Land use/land cover change is another key driver of global change which negatively impacts protected areas and their surroundings. Such impacts include processes of artificialisation [7], overexploitation of aquifers on which PAs are located [8,9], disturbance of their aquatic ecosystems [10], fragmentation of their natural ecosystems [11,12] and forest fires [13].

Because PAs play a fundamental role in the conservation of biodiversity and ecosystems, they have become an important focus of current environmental strategies and policies [14–16]. By extension, green infrastructures have attracted the attention of naturalists

and land managers because of their multiple functions related to biodiversity conservation: as ecological connectors of protected areas [17], as buffer zones of PAs to absorb impacts [18], and as recreational sites for urban populations [19].

1.2. The Leading Role of Spain, the European Union and Andalusia in the Conservation of Biodiversity

Spain was an international pioneer in biodiversity conservation legislation adopting the National Parks Law in 1916 [20]. This first law was an important step forward [21], although, in line with the ideas of the day, it focused on nature protection from a landscape perspective, seeking to preserve an idealised vision of pristine nature in isolated areas, from which traditional rural activities and ordinary people were excluded [22,23].

After the constitution of the Institute for the Conservation of Nature (ICONA) in 1971, the Spanish State passed Law 15/1975 on Protected Natural Spaces, which recovered the prominence lost in the 1957 Law on Forestry [21]. The new law made some clear steps forward. Along with the interest in conserving spaces for their scenic beauty, its motivation was to contribute to nature conservation by granting special protection regimes to areas that required it due to their singularity and natural values. However, it was not until the early 1990s that there was a real increase in policies that prioritised environmental conservation, an occurrence that was at least partly due to the second United Nations Earth Summit in Rio de Janeiro in 1992 [24].

Within this framework, the European Union began to design policies focused on the protection and planning of two elements: landscape and biodiversity [25]. In 1992, it launched an ambitious bid called the Natura 2000 Network [26,27], to ensure the long-term persistence of Europe's most valuable and threatened species and habitats, listed in both the Birds Directive (79/409/EEC, amended as 2009/147/EC) and the Habitats Directive (92/43/EEC). In 2000, it launched the European Landscape Convention [28].

In summary, these new regulations and instruments have evolved beyond the conservation of isolated spaces to advocate for a more holistic and integrated vision. Under this new paradigm, PAs are key to the maintenance and enhancement of the ecological structure of the territory. This vision builds on concepts and approaches that have emerged since the late 1990s, such as landscape ecology [29], ecosystem services [30], ecological corridors [31] or green infrastructure (GI) [32]. GI, which is the focus of this piece, can be defined as an interconnected network of green spaces that conserves natural values and ecosystem functions by providing associated benefits to human populations [33].

In the field of EU environmental planning, GI has gained prominence following the adoption of the Communication on *Green Infrastructure: enhancing Europe's Natural Capital* [34]. In it, member states are urged to develop their own GI strategies. In Spain, these EU policy provisions are reflected in the National Strategy for Green Infrastructure and Ecological Connectivity and Restoration, the strategic planning document that regulates the implementation and development of green infrastructure in Spain [35].

1.3. Geographic Information Technologies for Mapping Green Infrastructures

At the same time, several studies have highlighted the relevance of Geographical Information Systems (GIS) in making proposals for green infrastructures in the territory [36,37]. Among others, Aguilera et al. [38] and Velázquez and Rodríguez [39] combined GIS and multi-criteria evaluation (MCE) techniques that allow the integration of different landscape attributes and policy options. Gallardo and Martínez-Vega [40] and Mironova [41] delimited green infrastructure with GIS through analyses of spatial fragmentation. Caparrós et al. [42] delimited GI using cluster analysis based on a series of previously defined indicators. In addition to these works, there are methodologies and guides with different purposes, e.g., (i) to establish the scientific–technical bases for the definition and delimitation of a Spanish green infrastructure strategy [43] and the planning of regional networks of ecological corridors [44], or (ii) for the identification of the elements that a green infrastructure should contain [35].

1.4. Objectives

In the province of Almería, the object of this study, the Network of Protected Natural Areas of Andalusia (RENPA) comprises 35 different PAs with different levels of protection according to the IUCN [45]. There are different degrees of stringency (nature reserve (category I) or national park (category II)), as well as protected areas with multiple uses (category IV (natural parks) or category VI (Natura 2000 Network areas)). In addition to these 35 formally registered PAs, the province is home to a diverse range of complementary natural, semi-natural and agricultural habitats [40,46,47].

The main objective of this study is to design, using GIS tools, an integrated green infrastructure network for the province of Almería that connects the PAs belonging to the RENPA scheme, considering semi-natural and agricultural habitats and linear corridors (watercourses and livestock trails). To achieve this general objective, we set out the following specific objectives:

- Design a methodology to facilitate GI mapping.
- Identify specific threats to existing PAs arising from land use and land cover changes over a recent highly dynamic time period (1984–2007).
- Identify and map the current PAs which, due to their characteristics and high ecological values, will be integrated as a priority into existing GI.
- Locate and assess those areas, currently unprotected, which could be added to the existing GI resource, due to their characteristics and values.
- Assess the current connectivity between the different PAs of the RENPA and determine the barriers that may hinder or interrupt the flow of species.
- Assess the possible repercussions of GI on territorial planning.

2. Materials and Methods

2.1. Study Area

Andalusia was one of the first Spanish regions to develop specific planning instruments for natural area protection. At the end of the 1980s, it adopted the Physical Environment Protection Plans (PEPMF) and Law 2/1989, Inventory of Protected Natural Spaces of Andalusia (1989), which declared 60 new spaces occupying 17% of Andalusian territory. Later, in 1994, it approved almost all the natural resource management plans (PORN) and master plans for use and management (PRUG) of its natural parks. In 1997, it declared the Network of Protected Natural Areas of Andalusia (RENPA) [48]. This is defined as a set of high-value protected areas characterised by the conservation and regeneration of their natural resources, under environmentally compatible sustainable development principles [49]. Since the creation of RENPA, its surface area has increased to such an extent that it is now considered one of the most important regional networks of PAs in the European Union. It currently contains 249 PAs¹ that occupy 33% of the Andalusian territory [50].

Within this region, we chose the province of Almería as our case study, on account of the clear and growing threats to the integrity of its natural areas and the urgent need to effectively connect disparate elements of the RENPA scheme. Located in the south-east of the Iberian Peninsula, Almería is one of the eight Spanish provinces that form part of the region of Andalusia. It has an area of 8774 km² and is located between the provinces of Granada to the west, Murcia to the east and the Mediterranean Sea to the south (Figure 1). Geographically, it is very diverse. The high Betic and Penibetic mountain ranges (>2600 masl) alternate with the Mediterranean coastal plains. The mountain ranges act as a barrier to the humid westerly winds from the Atlantic. It is therefore considered the driest area in Europe with an average annual rainfall of 300 mm [51]. However, the climate of the region is currently transitioning from the continental hemiboreal Mediterranean climate of Sierra Nevada (Dsb, according to the Köppen–Geiger climate classification) and the Mediterranean climates with dry and mild summers (Csb) and with dry and hot summers (Csa), in the Betic Cordilleras, to the semi-arid (Bsk and Bsh) and arid (Bwh and Bwk) climates, typical of the southeast of Almería.

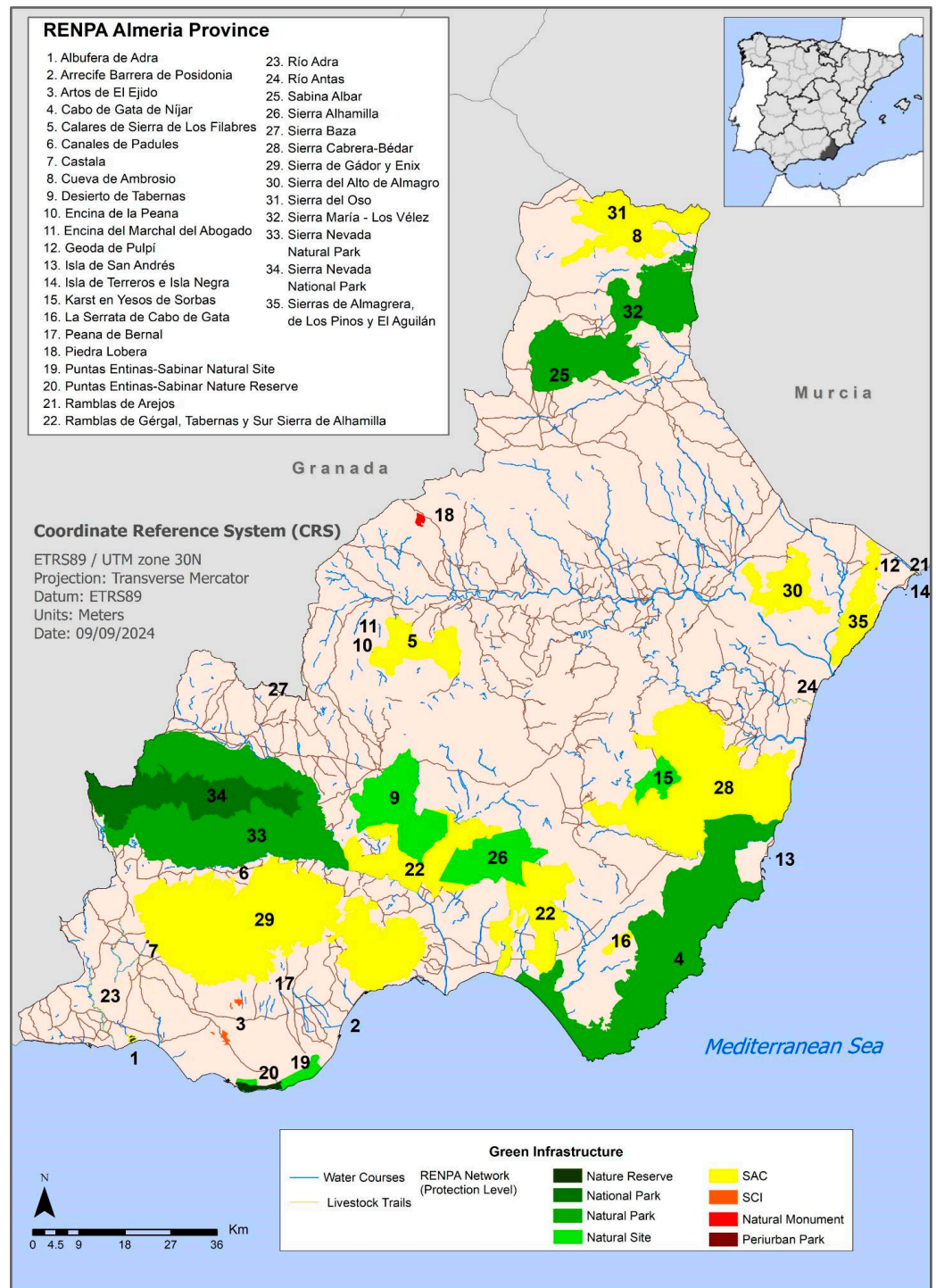


Figure 1. Location of the province of Almería. Distribution and categorisation of its protected areas, comprising the RENPA network. SAC = Special Area of Conservation; SCI = Site of Community Importance.

The province has undergone a profound evolution in recent decades, especially linked to the growth of greenhouses and the proliferation of mass tourism in the coastal area. The lack of other more profitable options to compete with intensive irrigation and the increased interest in the Almería coast tourism brand meant that land use planning was unable to halt the increase in the area covered by greenhouses [52] and the growth of tourist developments in the province [53,54]. The commitment to this productive binomial has generated numerous territorial tensions to satisfy the demand for these land uses. These pressures take on greater importance in a province that contains 13.86% of the surface

area of the entire RENPA and whose PAs occupy 45.81% of the provincial surface area. The magnitude of biodiversity in the province is evidenced by the presence of more than 2800 taxa of endemic flora and the existence of Habitats of Community Interest (HCIs) in more than 2900 km² of its territory [55].

2.2. Temporal Dimension

We used 1984 (t1) as the initial reference year and 2007 (t2) as the final year, taking advantage of the fact that the cartographic service of Andalusia has available, at a scale of 1:25,000, its own land use map series, the land use and vegetation cover map of Andalusia (MUCVA, by its Spanish acronym). The end date of the period analysed is important for assessing the connectivity of the PAs and the GI because it is a time of high spatial fragmentation. Land planners were unable to effectively manage the land demands of the main economic activities (intensive greenhouse agriculture and tourist activity) that experienced a strong expansion during that period [53].

2.3. Data and Methods

Figure 2 shows the main datasets used to develop our methodological proposal: the green infrastructure components, the topographic base, and the Digital Elevation Model (DEM). We opted for the 1:25,000 scale due to the availability of the MUCVA land use and vegetation cover mapping at this scale. The MUCVA land cover database and other geographic information (protected areas, Habitats of Community Interest, livestock trails, and urban areas) were downloaded from the Andalusian Environmental Information Network (REDIAM, 2024; see cartographic sources in the References). We downloaded other green infrastructure components (watercourses), map base elements (road network, railway lines, overpasses, solar plants, and wind farms), and DEMs from the Spanish Centre for Geographic Information (CNIG, 2024).

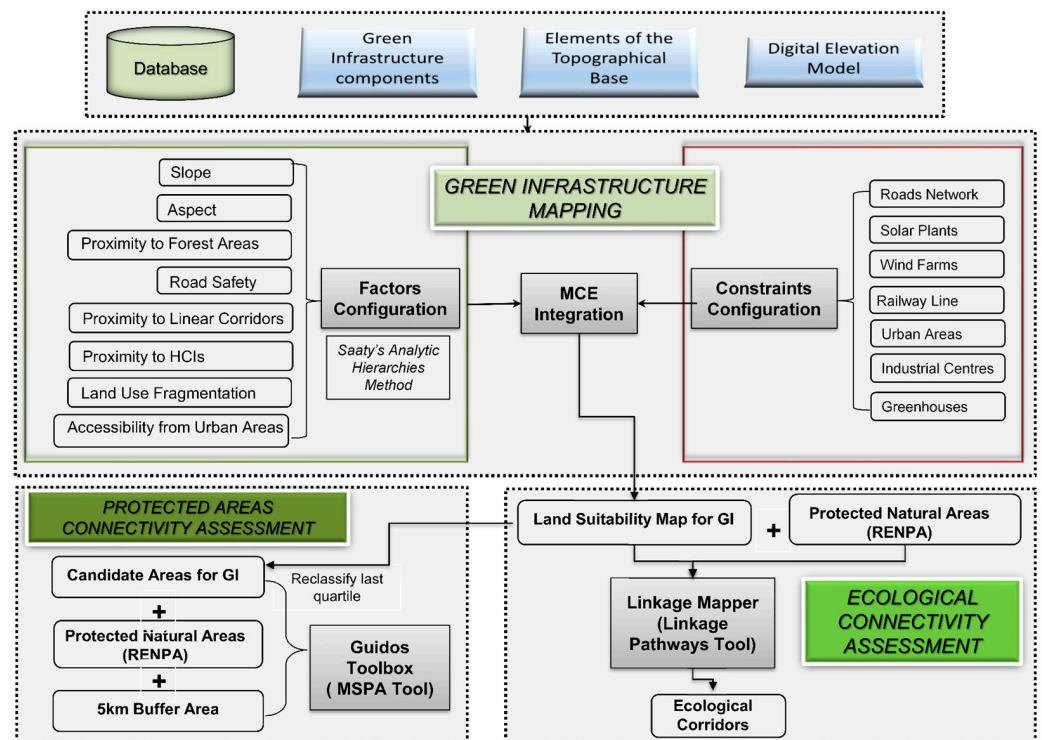


Figure 2. Research methods workflow.

Data preprocessing was undertaken in TerrSet 2020 software [56], which necessitated transformation of the vector data to raster format with a pixel size of 25 metres, coinciding with the spatial resolution of the Digital Elevation Model.

2.3.1. Green Infrastructure Components and Approach

To identify areas with good potential for green infrastructure, we adopted a three-stage approach (Figure 2) comprising the following:

- (1) Protected areas connectivity assessment;
- (2) Green infrastructure mapping using a multi-criteria evaluation (MCE) approach;
- (3) Ecological connectivity assessment.

These approaches are explained in order as follows, with reference to Figure 2.

Protected Area Connectivity Assessment

The starting point for the development of new green infrastructure is the identification of coherent functional areas of priority importance for biodiversity conservation [57]. In this sense, a wide variety of elements can be included within green infrastructure, from PAs to parks, gardens and other green areas in urban environments. Taking into account the provincial scale of our analysis, and based on the selection made by Valladares et al. [43], we considered the following components:

- *Core areas*: The conservation of fauna and flora is a priority in these areas due to their level of governmental protection. Core areas include the PAs themselves, Habitats of Community Interest, and other ecosystems of high ecological value (wetlands, gallery forests, forest areas, coastal plains, etc.).
- *Ecological corridors*: These seek to maintain the interconnection between core areas through links that guarantee the conditions for the movement and development of species. Linear corridors include rivers, gallery forests and livestock trails.
- *Buffer areas*: We define these as areas of influence of 5 km around the core areas. We consider them as transition areas to safeguard the ecological network. They allow land use that is compatible with biodiversity conservation.
- *Other multifunctional elements*: These are mainly composed of agricultural land that is managed sustainably.

We used the Morphological Spatial Pattern Analysis (MSPA) approach incorporated within the free Guidos ToolBox (GTB) application [58] to locate ecological corridors. The MSPCA approach is frequently used in disciplines such as landscape ecology [59], climate change [60], hydrological modelling [61,62], and biology [63], among others. We follow the methodology adopted by Wickham et al. [64] to detect and assess green infrastructure fragmentation. GTB requires an input raster with two classes of data: “background” (class 1) and “foreground” (class 2). When running MSPA, we divide the “foreground” area into seven classes: core (i), islets (ii), perforations (iii), edges (iv), loops (v), bridges (vi) and branches (vii). The background zone is divided into background (viii), CoreOpen (ix) and BorderOpen (x). In this phase of the study, we focused on the “Bridge” category to detect ecological corridors; taking as reference linear corridors such as rivers and cattle trails, we located those that interconnect two core areas, determining class 1 as the background and class 2 (foreground) as the set of rivers and cattle trails in our area.

Green Infrastructure Mapping Using Multi-Criteria Evaluation (MCE)

For the delineation of green infrastructure, we used multi-criteria evaluation, MCE [65], a well-known decision support method consisting of a set of processes and statistical analysis tools. Its objective is to define and evaluate alternatives that solve the proposed problem. In our study, we adopt what Gómez and Barredo [66] have referred to as the normative or prescriptive orientation, as opposed to the positive or descriptive approach. We selected the factors that favour the presence of GI based on a combination of “intuitively justifiable assumptions” [67] and comparison with case studies in similar Mediterranean areas [68,69]. After defining the predominant approach, we constructed the assessment criteria and divided them into factors and constraints.

In the MCE approach, criteria and factors determine the “implementation capacity” [56] of a specific variable compared to the pre-established objective. First, we adopted

Saaty's Analytic Hierarchy Process (AHP), which helps solve a decision problem by decomposing it into a hierarchy that captures its essential elements [70]. Secondly, we defined the key factors relevant (Figure 3) to the development of green infrastructure and ecological connectivity taking into account biophysical, socioeconomic and social criteria.

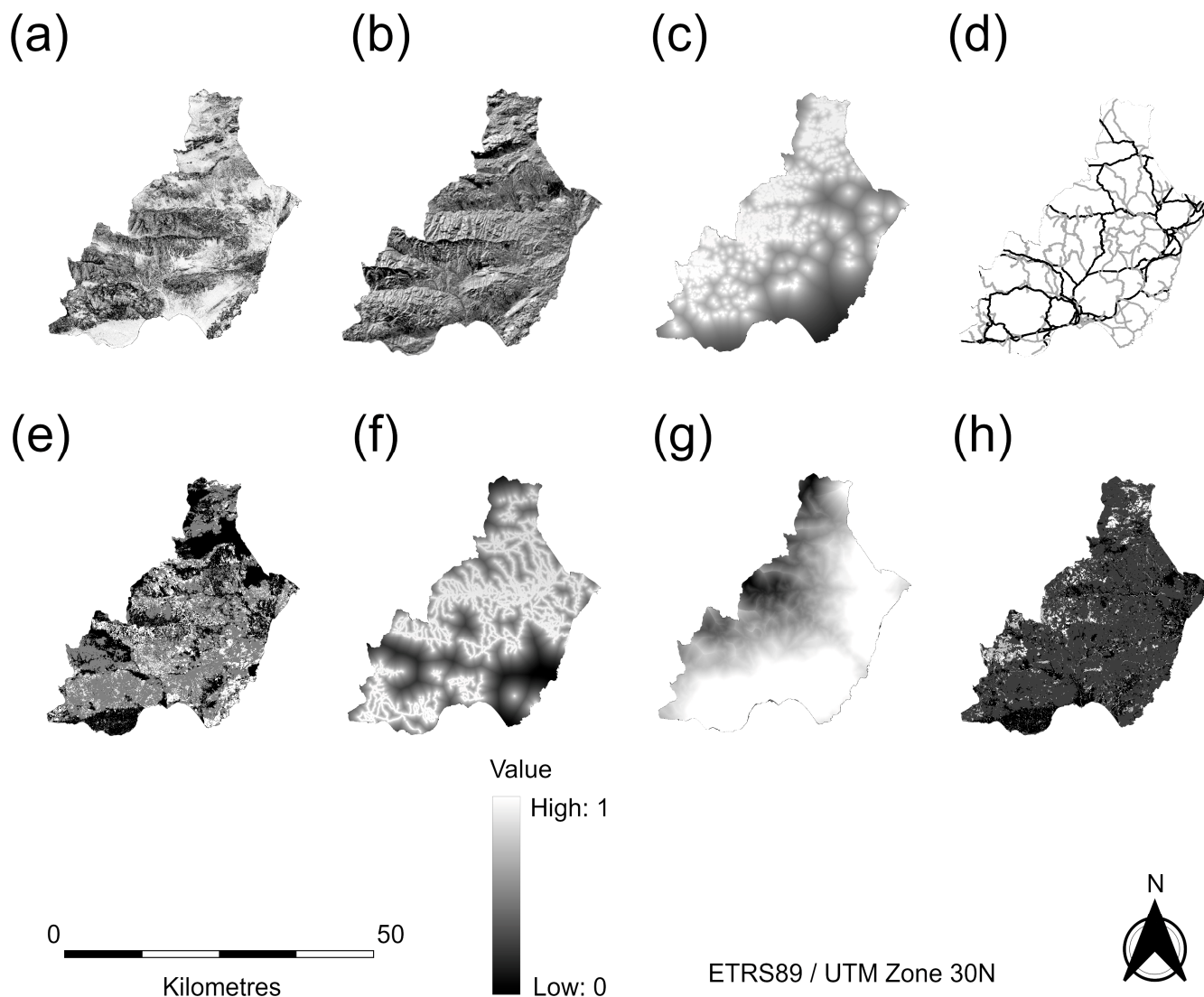


Figure 3. Factor maps: (a) slope; (b) aspect; (c) proximity to forest areas; (d) road safety; (e) Habitats of Community Interest; (f) proximity to linear corridors; (g) accessibility from urban areas; (h) land use and land cover fragmentation.

Biophysical Criteria

- *Slopes (S) and Aspects (A)*: gentle slopes and north- and west-facing sites tend to have lower exposure to direct sunlight, which affects soil stability and reduces the likelihood of landslides.
- *Proximity to forest areas (PEA)*: forest environments are suitable for GI, among other reasons, because of the ecosystem services they provide, because they are less fragmented and because of the biological diversity they harbour.

Social Criteria

- *Road safety (RS)*: The passage of wildlife crossing roads severely compromises their safety in their movements between core areas. For this reason, we give greater priority

to those infrastructures that support lower traffic densities and, therefore, entail less risk of accidents for the species.

- *Habitats of Community Interest (HCIs) and proximity to Linear Corridors (PLC)*: Habitats of Community Interest, rivers and livestock trails are fundamental elements in the GI as links between core areas, so we prioritise proximity to these areas.

Socioeconomic Criteria

- *Accessibility from urban areas (AUA)*: The definition of GI advocates that it should be accessible for the cultural enjoyment of the surrounding population. However, we consider that the proximity of densely populated urban centres may interfere with its protection. For this reason, we promote proximity to small population centres.
- *Land use and land cover fragmentation (LULCF)*: Less fragmented territories are more likely to form stable ecosystems that facilitate wildlife conservation. Therefore, we prioritise those land use/land cover (LULC) changes that contribute positively to the expansion of GI in our territory. First, we apply the reclassification of the MUCVA 1:25,000-scale map series developed by the DUSPANAC project [71,72] to two maps from different time periods, 1984 and 2007. Secondly, we prepared a fragmentation map following the cross-tabulation methodology (Table S1, Supplementary Materials) presented by Rodriguez-Rodriguez et al. [73]. From highest to lowest priority, we established four categories: non-fragmented categories, a with positive impact on GI (positive); fragmented natural or semi-natural categories (fragmented positive); categories with neutral impact (neutral); and categories with negative impact (negative).

Then, in a GIS environment, we applied a series of standard GIS analysis and processing operations to the source data to create and standardise the factors. In addition, we performed a correlation analysis between the factors to determine whether any were highly dependent on others.

We then assigned weights to each factor using the AHP synthesis method [70], which involved multiplying the weights of the factors by the corresponding weight of each criterion, giving a final score known as the weighted linear combination (WLC) (Table 1). The WLC of the factors and criteria, computed in TerrSet software, gives the green infrastructure land suitability map.

Table 1. Weight of factors using the AHP method.

Factors (Rows)	Criteria (Columns)			WLC Score
	Biophysical	Social	Socioeconomic	
Weighting	0.105	0.637	0.258	
Slope (S)	0.150			0.016
Aspect (A)	0.150			0.016
Proximity to forest areas (PFA)	0.700			0.073
Road Safety (RS)		0.100		0.064
Presence of HCIs ¹		0.300		0.191
Proximity to linear corridors (PLC)		0.600		0.382
Land Use fragmentation (LULCF)			0.600	0.155
Population Accessibility			0.400	0.103

¹ Habitats of Community Interest.

Configuration of Restrictions

Next, we drew up a map of restrictions, considering those land covers that are not suitable for inclusion in green infrastructure. The map of restrictions included urban and industrial centres, roads and railway lines, greenhouses, solar plants and wind farms. We draw a buffer of 500 m around the polygons of these last two classes.

2.3.2. Ecological Connectivity Assessment

Well-structured ecological networks that ensure connectivity between PAs must be carefully planned [41,74–76]. This is necessary for the identification of critical areas between them and other territorial elements such as road infrastructures and urban centres, which can compromise the survival of species transiting between core areas.

To assess the ecological connectivity between the PAs of the province of Almería, we used the Linkage Mapper tool of Arcmap 10.8.1 (ESRI Inc., Redlands, CA, USA), tested in previous studies [77–79]. Linkage Mapper requires a vector layer of the core areas of the habitats to be analysed and a resistance map to detect and draw connections between these areas of interest. It identifies core areas that are contiguous with each other and generates maps of routes with fewer obstacles between these areas [80].

We applied the Linkage Pathways function to generate a map of connections between the core areas of the territory. The algorithm indicates which are the least costly distances between two nodes, cell by cell. Thus, we were able to know the approximate value of connectivity that each pixel would have and identify which corridors favour movement between the core areas. The map of connection corridors generated in this way was then overlain onto the reclassified suitability map. This last step enabled us to calculate the surface area in each suitability class (constraint, none, low, medium, high) intersected by the connection corridors.

2.3.3. Assessment of the Impact of Land Use/Land Cover Changes on Green Infrastructure

Using the MSPA tool mentioned above [58,81], we assessed the potential impact of LULC changes on the proposed green infrastructure network. Considering 1984 and 2007, we compared the evolution of LULCs in core areas, candidate GI areas and buffer areas (5 km width).

In addition, we calculated the Habitat Fragmentation Index (HFI) [82]. This index ranges from 2 (lowest fragmentation) to 1 (highest fragmentation) and relates the area of each MSPA category to a previously assigned weight based on its resilience and spatial coherence [31].

3. Results

3.1. Analysis of Land Use/Land Cover Change from 1984 to 2007

Between 1984 and 2007, LULC changes in the province of Almería were driven by the expansion of intensive agriculture and urban growth (Table 2). The area devoted to greenhouses grew substantially (+58.39%), due to their high profitability, which led to a loss of natural areas such as scrubland (−4.57%).

The rise in greenhouse cultivation not only altered the province's landscape. It also influenced the availability of water resources, the demand for which increased substantially. On the other hand, woody crops, such as olive groves and vineyards, expanded under both irrigated (+89.28%) and non-irrigated (+98.10%) cultivation, following Spain's entry into the EU and the implementation of the Common Agricultural Policy (CAP).

During this period, protection and conservation policies also left their mark on the landscape. Reafforestation of pine forests was carried out in the Sierra Nevada Natural Park and other PAs in the province (+64.10%), as a measure to mitigate the loss of forest mass. This contributed to slowing down agricultural expansion in certain areas, favouring the recovery of natural spaces and, consequently, local biodiversity.

Urban growth (+63.84%) was another crucial factor in the transformation of the territory. Since the 1980s, with the development of tourism, the growth of industrial land (+209.67%) and the improvement and expansion of infrastructures (+134.86%), many areas of the province, especially along the coastal strip, experienced a notable increase in urban development, especially housing. This urban growth remained constant well into the new century, transforming land uses and fragmenting the landscape of coastal municipalities. The expansion of infrastructures and new real estate developments was directly propor-

tional to the increase in population, generating a notable impact on both the landscape and natural areas.

Table 2. Changes in land use/land cover between 1984 and 2007.

Land Use/Land Cover	Surface Area in 1984 (km ²)	Surface Area in 2007 (km ²)	1984–2007 Difference (km ²)	Growth 1984–2007 (Index in Base 100) ²
Urban	72.89	119.42	46.53	63.89
Industrial	8.18	25.34	17.16	209.67
Road, rail, air, port and other technical infrastructure	16.80	39.46	22.66	134.86
Water infrastructure, salt works and aquaculture	11.95	17.64	5.69	47.59
Mining, landfill and construction sites	29.01	85.29	56.27	193.96
Altered, eroded and felled	204.99	113.63	−91.36	−44.57
Intensive greenhouse crops	224.96	356.33	131.36	58.39
Intensive crops: irrigated woody crops	71.70	135.71	64.01	89.28
Intensive crops: other irrigated crops	531.30	424.85	−106.45	−20.04
Rainfed crops: other rainfed crops	1964.20	1783.31	−180.89	−9.21
Rainfed crops: olive groves and vineyards	31.99	63.37	31.38	98.10
Eucalyptus plantations	0.77	0.75	−0.01	−1.57
Pine forests	238.84	391.94	153.10	64.10
Other woodland or mixed woodland	30.90	42.48	11.58	37.48
Pasture	154.88	226.36	71.48	46.15
Scrubland	5070.73	4838.83	−231.89	−4.57
Rivers and natural watercourses	92.34	90.02	−2.32	−2.51
Natural lagoons	0.01	1.30	1.29	11,727.27
Natural coastal system	10.74	11.73	0.98	9.16
Non-tidal marshland	1.21	1.22	0.01	0.41
Tidal marshland	0.34	0.09	−0.25	−74.03
Sea and tidal areas	0.40	0.07	−0.33	−82.29

² Index expressing the growth of each LULC class between the initial and final years, expressed in base 100 (1984). Source: Own work based on MUCVA data (1984 and 2007).

However, the annual growth in the surface area dedicated to greenhouse crops slowed in 2007 as a consequence of the economic crisis. The same was true for the supply of hotel beds (Table S2, Supplementary Materials). Despite this change, these two activities continue to be the main drivers of the provincial economy.

3.2. Analysis of the Multi-Criteria Evaluation Factors

The correlation coefficients (r) between the selected factors showed very low correlations (Table 3). Only accessibility from urban areas (aUA) and proximity to forest areas (pFA) have a moderately high correlation (>0.5). This is perhaps due to the growing preference for new secondary residential developments in or around forest areas. The latter attract the former because of their scenic landscape quality, air quality and ecosystem services [83,84]. Similarly, PAs attract new urban areas to their surroundings [7].

Table 3. Correlation analysis between the multi-criteria evaluation factors: S = slope; A = aspect; pFA = proximity to forest areas; RS = road safety; HCIs = Habitats of Community interest; dLC = distance to linear corridors; LUF = land use fragmentation; aUA = accessibility from urban areas.

	S	A	pFA	RS	HCI	dLC	LUF	aUA
S		−0.070	−0.257	−0.179	−0.266	0.085	0.142	−0.082
A	−0.070		0.059	0.038	0.023	−0.022	0.067	0.037
pFA	−0.257	0.059		0.094	−0.019	0.241	0.259	0.569
RS	−0.179	0.038	0.094		0.099	−0.158	0.118	0.061
HCI	−0.266	0.023	−0.019	0.099		−0.105	0.169	−0.079
dLC	0.085	−0.022	0.241	−0.158	−0.105		−0.097	0.182
LUF	0.142	0.067	0.259	0.118	0.169	−0.097		0.181
aUA	−0.082	0.037	0.569	0.061	−0.079	0.182	0.181	

Analysis of the MCE model biophysical criteria shows firstly that slopes of less than 5% occupy almost 41% of the total surface area of Almería, demonstrating the flat nature of the province. The plains are located in the coastal areas and the basins of the rivers Antas, Almanzora and Adra. Secondly, the most suitable orientations for the GI (north and west) occupy 1721 km², almost 20% of the provincial surface. Due to their low elevation and lower exposure to sunlight, these areas facilitate the movement of species between core areas. However, at the same time, these are areas with strong anthropogenic disturbances. Thirdly, the most natural LULCs occupy 6% of the study area, while artificial LULCs occupy just over 15% of the total. Natural vegetation has been limited by the growth of artificial soil on flat and fertile land, related to the expansion of intensive agricultural areas and tourism and urban development.

Turning to the social criteria in the MCE model, the greatest danger linked to road safety occurs in areas close to motorways and railway lines. Regarding the presence of Habitats of Community Interest, 51% of the provincial surface contains areas classified as suitable for natural habitats. Those with the highest level of suitability, considered to be of priority interest, occupy around 17%. Finally, the areas located less than 100 metres from the corridors account for only 7.93% of our study area.

For the economic criteria, the most natural categories are those that remain unchanged in the analysis of LULC changes and fragmentation and therefore have the highest suitability. The second highest level of suitability is obtained by categories whose change over the period favours the development of GI. These are the LULC changes that we call “Abandonment of activity”, “Abandonment of irrigated crops”, “Abandonment of rainfed crops”, “Exchange between tree species”, “Exchange between wetlands” and “Forest restoration”. Finally, since proximity to small population centres is considered positive, as it enables public access to green space, areas located close to roads have higher suitability than those further away.

3.3. Analysis of the Constraints

Figure 4 shows the spatial distribution of the areas that we consider unsuitable to support the province’s GI. On the central coast, the urbanised area of the provincial capital and its port, in the centre of the Gulf of Almeria, stands out. On both sides, the large areas occupied by the vast greenhouses of Adra and El Ejido, to the west, and Nijar and Campohermoso, to the east, are prominent. Inland, another gap corresponds to the large marble quarries of Macael. Finally, on the northeast coast, the large developments of second homes and golf courses in Vera, Mar de Pulpí and San Juan de los Terreros are not conducive to the implementation of GI either.

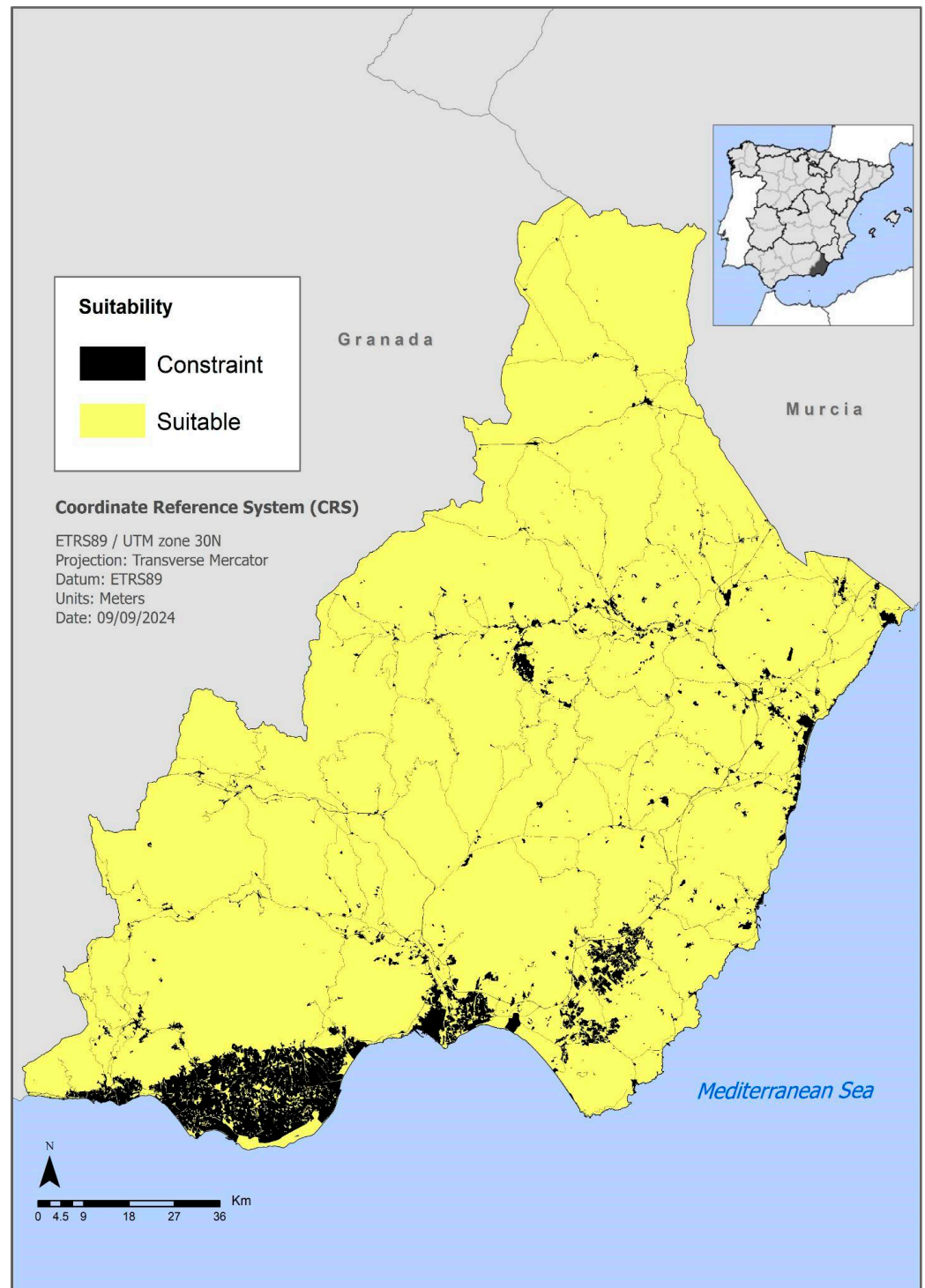


Figure 4. Green infrastructure restricted area map.

3.4. Land Suitability for Green Infrastructure

Figure 5 shows those areas that are highly suitable for integration into the GI proposal. They occupy 6.89% of the provincial surface. These mainly extend along the Almanzora and Adra river basin, and in the surroundings of the Sierra Nevada Natural Park, the Desierto de Tabernas Natural Park and the Special Area of Conservation (SAC) Calares de Sierra de los Filabres.

The rest of the provincial surface area belongs to the suitability categories “Medium” (36.04%), “Low” (49.43%), “Constraint” (6.19%) and “Null” (1.45%).

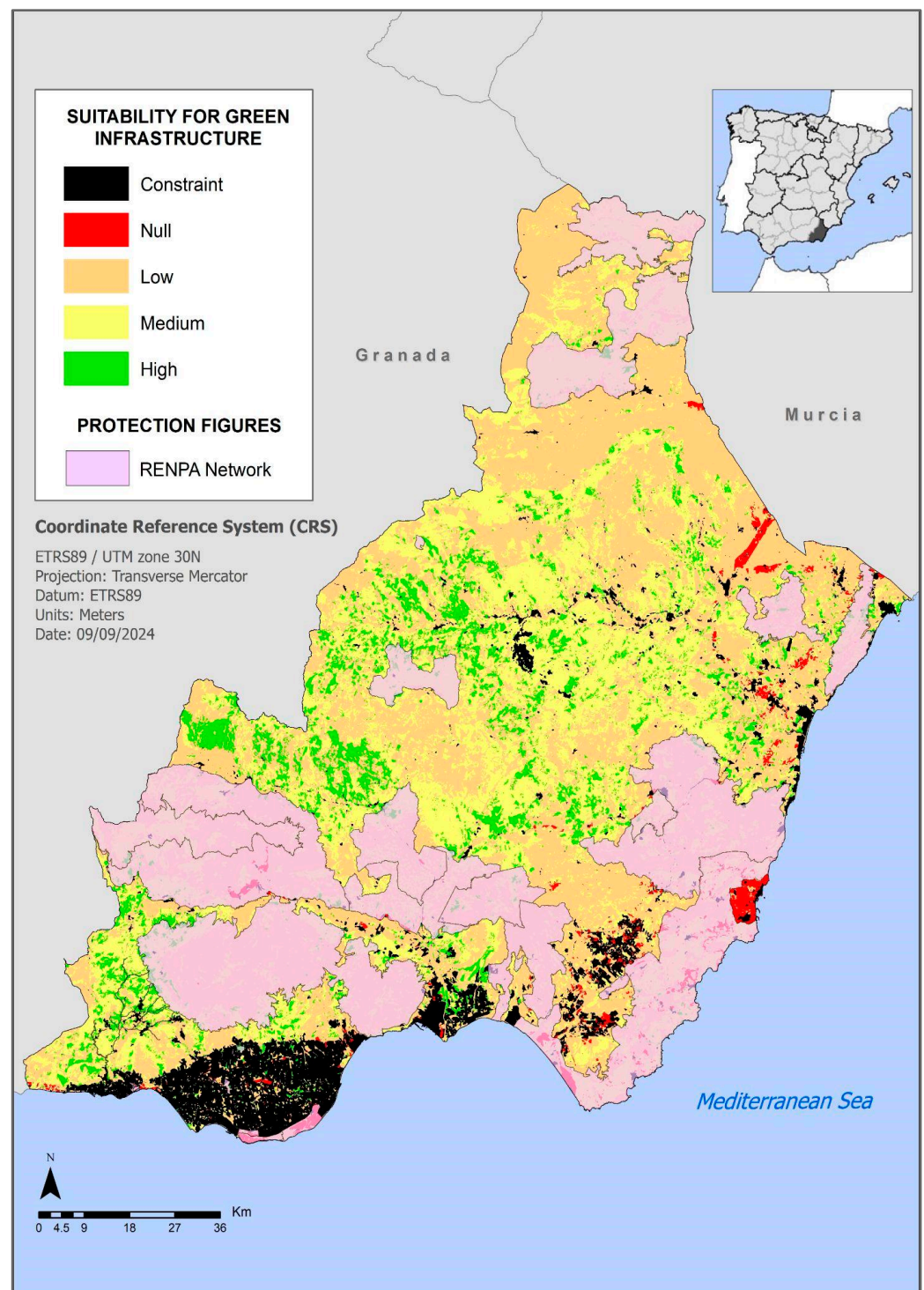


Figure 5. Suitability map for green infrastructure in the province of Almería.

3.5. Definition of Ecological Corridors

We generated a total of 45 ecological corridors. Of these, we selected the 15 longest corridors for the overlay analysis (Figure 6). We can observe that the distribution of the southern PAs, from west to east, from the Sierra Nevada National Park (no. 34 in Figure 1) to the Sierra de Cabrera-Bédar Special Area of Conservation (no. 28), already comprises an ecological network connecting the core areas.

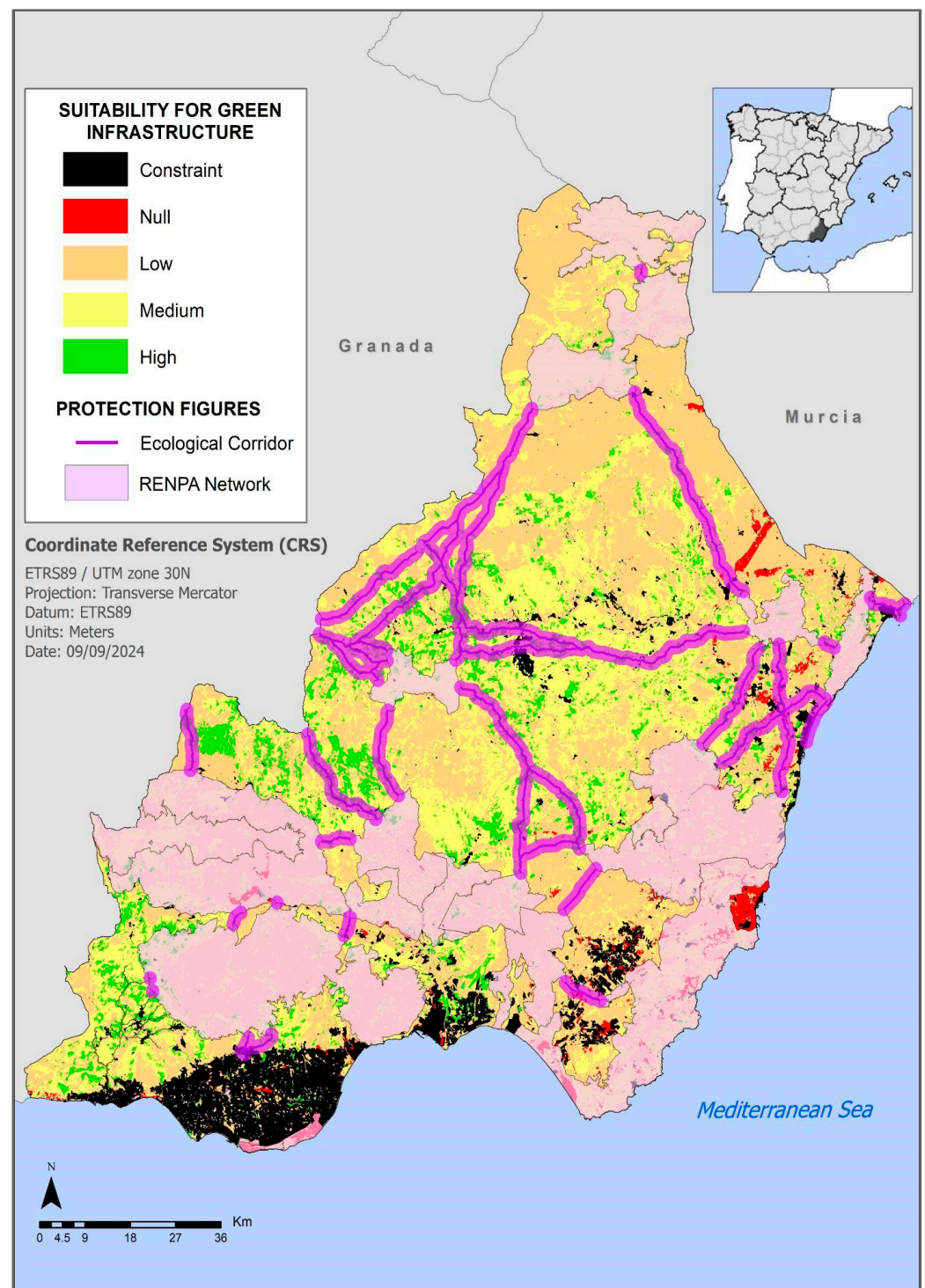


Figure 6. Proposal for ecological corridors in the province of Almería.

Among the main features of the proposed GI in the eastern half of the province, we highlight the connection of the Natural Parks of Sierra María-Los Vélez (no. 32 in Figure 1) and Sabina Albar (no. 25) with the Special Areas of Conservation (SACs) of the Sierra del Alto de Almagro (no. 30), Sierra de Almagrera, Los Pinos and El Aguilán (no. 35), and Sierra de Cabrera-Bédar (no. 28). In the western half, the four new corridors would communicate the Calares de la Sierra de los Filabres SAC (no. 5) with the Natural Monuments of Piedra Lobera (no. 18), Encina de la Peana (no. 10), and Encina del Marchal (no. 11), and with the other areas mentioned above. Another transversal corridor follows the river Almanzora,

from west to east, linking the Calares de la Sierra de los Filabres SAC (no. 5) with the Sierra del Alto Almagro SAC (no. 30).

The map of landscape suitability also highlights the isolation of some PAs, such as the Albufera de Adra Nature Reserve (no. 1), the Site of Community Importance (SCI) of Artos de El Ejido (no. 3) or the Punta Entinas Sabinar Natural Site (no. 19) and its homonymous Nature Reserve (NR) (no. 20). The situation of the latter two protected areas, surrounded and nestled between the coastline and the “plastic sea” [85], makes their connectivity with the rest of the PAs impossible. This is of course most serious in the case of the NR which enjoys the highest degree of protection available under national law, on account of its well-preserved dune systems and salt marsh ecosystems.

The results of the intersection between ecological corridors generated by the connectivity analysis and the suitability map (Table 4, Figure 7) show that suitability for GI is acceptable in most cases. In 11 out of 15 ecological corridors, >10% of the surface area was classed as having “High” suitability (Table 4, Figure 7), with 7 of these exceeding >20% surface area of “High” suitability. In 13 out of 15 ecological corridors, >40% of the surface area was classed as having “High” or “Medium” suitability (Figure 7), and in 8 of these, >50% of the surface area was classed as having “High” or “Medium” suitability (Figure 7). On the other hand, in 7 of the 15 ecological corridors analysed, >50% of the surface area was classed as having “Null” or “Low” suitability (Figure 7). This suggests that closer examination of some of the proposed corridors is needed to try to reduce the area of fragmented or degraded lands in the proposed GI network.

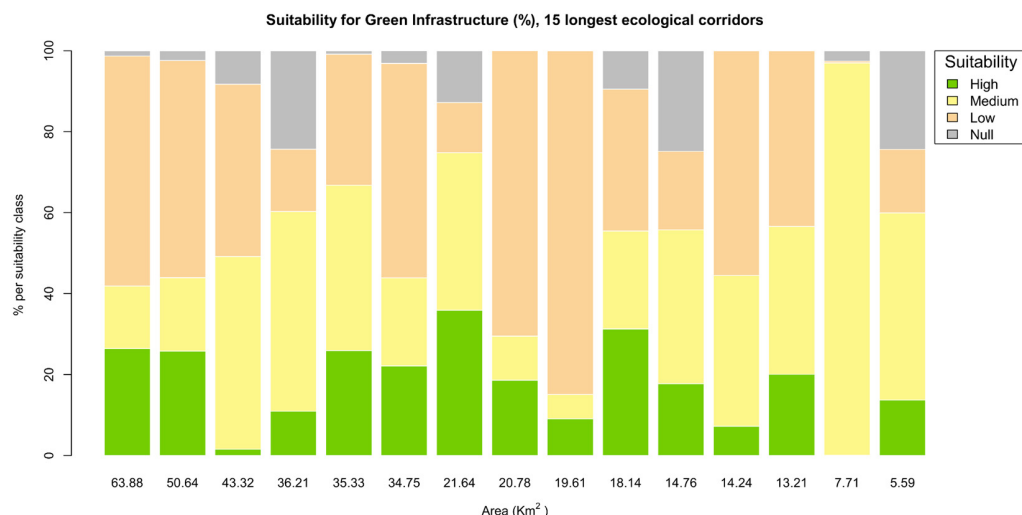


Figure 7. Results of overlay analysis between ecological corridors and suitability for GI. Each bar corresponds to an ecological corridor identified in the connectivity analysis, ordered by surface area from left to right along the x-axis from largest to smallest.

Table 4. Connectivity analysis: ecological corridors.

ID	Area (km ²)	Landscape Suitability			
		High (%)	Medium (%)	Low (%)	Null (%)
1	63.88	26.40	15.46	56.83	1.31
2	50.64	25.79	18.13	53.69	2.39
3	43.32	1.54	47.62	42.59	8.25
4	36.21	10.93	49.35	15.41	24.31
5	35.33	25.91	40.85	32.41	0.82
6	34.75	22.14	21.76	52.99	3.12
7	21.64	35.90	38.90	12.41	12.80
8	20.78	18.61	10.90	70.50	0.00
9	19.61	9.07	6.00	84.93	0.00

Table 4. Cont.

ID	Area (km ²)	Landscape Suitability			
		High (%)	Medium (%)	Low (%)	Null (%)
10	18.14	31.26	24.21	35.04	9.49
11	14.76	17.76	38.00	19.39	24.85
12	14.24	7.24	37.24	55.52	0.00
13	13.21	20.04	36.58	43.38	0.00
14	7.71	0.05	96.96	0.44	2.55
15	5.59	13.68	46.27	15.72	24.32

Source: created by the authors.

3.6. Connectivity of Almeria's Protected Areas

Table 5 shows the evolution over time (1984–2007) of the different categories of landscape fragmentation in each area analysed, whether they are PAs, their surroundings, or candidate areas for GI. There are notable differences between the different zones according to their protection stringency. The national park and the nature reserve have very low fragmentation values as a result of the strict limitations on land use within these areas. In the national parks, the Habitat Fragmentation Index (HFI) score has actually increased as a result of the reforestation programme initiated in the Nacimiento river basin in the early 1970s, as well as its subsequent designation as a national park in 1999 [86].

Table 5. Temporal evolution of landscape fragmentation in the territory occupied by protected areas, their surroundings and by green infrastructure candidate areas; data from the MSPA tool. HFI = Habitat Fragmentation Index.

MUCVA 1984										
	Core	Background	Branch	Edge	Perforation	Islet	Bridge	Loop	Total	HFI
Nature Reserve	5.59	0.18	0.01	0.11	0.14	0.00	0.00	0.00	6.02	1.94
National Park	137.41	6.16	0.10	0.03	3.66	0.00	0.01	0.27	147.63	1.94
Natural Park	887.28	68.70	1.54	1.09	20.63	0.10	0.41	0.64	980.39	1.91
Natural Site	219.29	13.78	0.25	0.34	4.44	0.02	0.09	0.15	238.36	1.93
Special Area of Conservation	1326.78	42.15	1.50	1.30	17.25	0.04	0.64	0.84	1390.50	1.96
Candidate GI	468.05	109.88	2.15	3.62	19.00	0.20	0.57	0.79	604.25	1.79
Other PAs	4.25	0.67	0.02	0.17	0.27	0.01	0.00	0.01	5.39	1.81
Buffer 5 km	2712.75	767.22	14.01	27.86	115.45	2.03	5.34	3.69	3648.35	1.76
MUCVA 2007										
	Core	Background	Branch	Edge	Perforation	Islet	Bridge	Loop	Total	HFI
Nature Reserve	5.56	0.18	0.01	0.12	0.15	0.00	0.00	0.00	6.02	1.94
National Park	140.11	3.76	0.05	0.01	3.42	0.00	0.00	0.28	147.63	1.96
Natural Park	885.03	69.55	1.64	1.50	21.08	0.10	0.63	0.86	980.39	1.91
Natural Site	221.58	11.59	0.19	0.13	4.68	0.01	0.03	0.15	238.36	1.94
Special Area of Conservation	1314.32	49.64	1.60	2.51	20.51	0.06	0.80	1.07	1390.50	1.95
Candidate GI	488.74	86.32	2.06	6.30	18.66	0.27	0.81	1.10	604.25	1.82
Other PAs	3.95	0.91	0.02	0.36	0.12	0.01	0.01	0.01	5.39	1.76
Buffer 5 km	2582.43	879.06	16.79	49.95	106.28	2.18	7.21	4.46	3648.35	1.72

Source: created by the authors based on Gallardo and Martínez-Vega [40]. Values in km².

At least on the basis of these quantitative landscape indices, natural parks and natural sites have undergone few changes. However, areas of ecological value have disappeared due to the construction and development of new infrastructures and urban areas. These include the construction of the A-7 motorway through the Karst in Yesos de Sorbas, and the A-92 through the Sierra Nevada and the Tabernas Desert.

The candidate areas for GI had a Habitat Fragmentation Index of 1.79 in 1984, which increased to 1.82 in 2007. This improvement is due to the tendency for candidate areas to be located in forest areas restored after 1984, which have become less fragmented over time as a result. However, the GI candidate areas also include agricultural and semi-natural areas that are much more dynamic and suffer more frequently from fragmentation and changes to their character, considerably reducing their Habitat Fragmentation Index value.

The areas of greatest concern are to be found in and around the Natura 2000 Network. Special Protection Areas and Sites of Community Importance are the most fragmented. The lack of an effective management plan in these enclaves causes an increase in the number of perforations. These openings in the core areas are related to the pressure exerted by greenhouses in their surroundings, even expanding into the interior of the Special Areas of Conservation of the Ramblas de Gérgal, Tabernas, and the south of the Sierra de Alhamilla, according to the 2007 MUCVA. The impact of the new communication routes in these areas is also perceptible, as mentioned above.

Finally, the buffer zones show the highest degree of fragmentation (Habitat Fragmentation Index of 1.72). Fragmentation has even increased between the two dates analysed in the PA buffer zones located near the coast of Almería, which has seen the largest share of the physical and economic transformation of the province in recent decades.

Despite the great richness of the natural heritage of the province of Almería, there are still unprotected areas with species whose conservation is crucial if a high degree of diversity is to be maintained, according to Mendoza-Fernández et al. [87]. These authors propose a network of micro-reserves, complementary to the RENPA PAs, which would help to protect the areas of highest botanical value.

4. Discussion

Previous research has shown that the most significant land use/land cover changes in the province of Almería since 1984 were directly related to the impacts of tourism and intensive agriculture. After the appearance of the first greenhouses at the end of the 1960s, the IRYDA (National Institute for Agrarian Reform and Development) progressively abandoned traditional models of agricultural development, opting for the expansion of irrigated greenhouse crops. This technique rapidly became consolidated [88] and has continued to the present day. This process of expansion of irrigated arable and woody crops has been documented not only in the province of Almería, but also in the Guadalquivir Valley and the Region of Murcia [89]. At the same time, the designation of the ‘Centres of National Tourist Interest’, the attractiveness of the Mediterranean climate, and the economic boom of the early 1980s led to a rapid and sustained increase in tourism [14] that continues to the present day.

More generally, our results are influenced by the dispersed distribution of habitats and the concentration of the forest landscape in the western half of the province. Both aspects condition the distribution and nature of ecological corridors [90–92]. We found less resistance to species movement in highly forested areas. In contrast, corridors through low-lying land areas were very challenging for ecological connectivity due to the density of agricultural and urban spaces and linear infrastructures [93]. This phenomenon is most pronounced along the coastal strip [94].

On the other hand, the multi-criteria Evaluation suitability map (Figure 5) tends to favour factors in specific locations that are widely known to have positive impacts on wildlife conservation. This is the case for the factors “proximity to forest areas”, “presence of Habitats of Community Interest” and “proximity to linear corridors”. These findings support the results of previous studies, for example, Mironova [41], Osewe et al., [60] and Dindaroglu [69], among others.

Further, we found that some of the proposed ecological corridors are located in semi-natural ecosystems. Nevertheless, these are important for conservation because they favour the dispersal of species [95]. Just over 50% of the area occupied by the proposed corridors has an acceptable suitability for the movement of species between core areas.

The results of the analysis carried out using the Morphological Spatial Pattern Analysis tools showed that GI candidate areas and buffer zones reached Habitat Fragmentation Index values close to 2, demonstrating their capacity to favour the conservation of fauna and flora. It is true that, as the level of protection decreases, the Habitat Fragmentation Index decreases, with buffer areas being the most fragmented in the region. Fundamentally, this is due to the commitment to intensive agriculture [96], which has led to a massive proliferation of greenhouses in Campos de Dalías [87] and Níjar [97], located on the peripheries of the Sierra de Cabo Gata-Níjar Natural Park, the Special Area of Conservation (SAC) of the Sierra de Gádor and Enix, Punta Entinas Sabinar Nature Reserve, Los Artos de El Ejido Site of Community Importance [98] and Albufera de Adra SAC, among others. In addition, there has been considerable expansion of residential areas and facilities related to tourism development of coastal municipalities [99,100].

A number of points of discussion emerged that offer interesting directions for future work. Firstly, some of the factors included in the multi-criteria evaluation model deal with generic aspects of the concept of green infrastructure (GI), and as a result, the role they play in determining suitability in this particular model is somewhat unclear. One way to resolve this question would be to apply a simple regression model to test the significance of the chosen factors in predicting suitable habitats. It may be that some of the chosen factors are not very significant and need not be included in a future model.

Another interesting topic for future work would be to explore the impact of complex variables related to the ecosystem services provided by GI on suitability: water availability, carbon sequestration, air quality, and soil organic matter [68,69]. Economic variables related to land use planning could also be included, to observe which areas would be available, in the future, for the growth of certain land uses and what impacts these would have on GI [101].

Thirdly, we suggest carrying out individualised analyses of the buffer zones of each protected area in Almería [40]. In this way, we could check which areas are under pressure and threatened by land use fragmentation. This would support our argument that coastal PAs and other areas of natural interest are disconnected, an idea that has become evident in the delimitation of ecological corridors. We have not delineated corridors in them because of the numerous restrictions in their surroundings.

Our research also has certain limitations that must be considered. Firstly, the most recent land use/land cover map used (MUCVA) corresponds to 2007, because no more recent maps are available in that cartographic series. For a more recent appreciation of the situation, other land cover databases would be needed. The possibilities include SIOSE [102,103], which maintains our scale of analysis of 1:25,000, as well as the Forest Map of Spain, MFE [104], and CORINE Land Cover [105,106] at 1:50,000 and 1:100,000 scales, respectively. Second, our suitability raster was constructed without empirical data on species distribution. Field measurements, if they could be obtained in future research, would improve the accuracy of our results. Third, our analysis has been conducted considering wildlife as a whole, rather than any specific species. However, other authors, e.g., Doko et al. [107] or Ghoddousi et al. [108], analyse the behaviour and possible distribution of ecological corridors for specific species. Finally, it should be noted that not all of the data used for the suitability map belong to the same time period. To minimise the problem, we took care to choose datasets from the closest available year to 2007 (see, e.g., [109,110]).

5. Conclusions

The preservation of habitats in the province of Almería depends on the conservation strategies adopted in its protected areas (PAs). Our study shows that, despite the intense degree of humanisation of the landscape, there are opportunities to ensure ecological connectivity between the PAs. In some cases, PAs have several possible corridors connecting them to their neighbours, offering planners some flexibility in implementing green infrastructure based on particular cases.

Most of the links we identified are located in the central area of the province of Almería, specifically in the Almanzora river basin. Due to its remoteness from the coast and its particular climatic conditions, it has been less attractive for intensive agriculture and urban development related to tourism, the main drivers of transformation and fragmentation of traditional land uses. Consequently, its ability to maintain a continuous and integrated ecological network, where faunal and floral communities can develop and move, is greater.

However, other corridors are located in areas that are highly resistant to the movement of species and close to the coastline, communication routes and highly artificialized zones that limit the capacity for the implementation of green infrastructure. In these cases, the corridors tend to follow river courses and livestock trails with lower degrees of alteration. It is precisely these elements that are the most critical for the survival of the corridor itself and should be considered areas of maximum priority for its future survival.

The scarcity of available suitable land, continued population growth and new economic demands are leading to a progressive increase in land areas that are intensively modified by human activity, resulting in considerable pressure on forest and semi-natural areas. Conserving the transitional routes of wildlife communities in environments so dominated by economic activity is a major challenge. Connectivity analysis and mapping of ecological corridors, as attempted here, are effective tools to guide future conservation decisions.

Finally, we highlight the continuing relevance of GIS and multi-criteria evaluation techniques in assessing ecological landscape suitability and vulnerability to degradation and fragmentation from specific sources. GISs are nowadays fully integrated into environmental management workflows at every level, and multi-criteria evaluation techniques are well documented in the scientific literature. When combined into a spatial multi-criteria decision model (MCDM), as achieved here, they become extremely powerful tools for strategic planning of conservation areas. In this case, we have proposed a new green infrastructure network in the province of Almería from a dual perspective: on the one hand, we have identified the most suitable areas for green infrastructure from an ecological point of view (Figure 5), and on the other, we have identified the most critical areas (river courses and livestock trails in severely degraded semi-artificial lands) for maintaining connectivity between core areas of high natural value. Close attention should be paid to these “critical pressure points” in order to preserve the character of the protected areas, their surroundings and the links between them.

The methodology used in this study could serve as a basis for similar initiatives at regional and national levels. In the regional context, it could be extended to the other seven Andalusian provinces in the framework of the Plan for the Improvement of Ecological Connectivity in Andalusia². This aims to improve ecological connectivity between Habitats of Community Interest by prioritising the design of nature-based solutions such as green infrastructure.

At the national level, the main goal of the Spanish Strategy for Green Infrastructure and Ecological Connectivity and Restoration³ is to identify the elements that can form part of green infrastructure. To the best of our knowledge, there is not yet a complete list of elements to be considered, nor are the characteristics and criteria that must be met to be considered as part of the green infrastructure clearly established. There is also no mapping of green infrastructure at the state level.

In future research, it would be advisable to include citizen participation through stakeholders in order to obtain their opinions and views on the proposed technological solutions.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/land13111916/s1>.

Author Contributions: Conceptualization, Á.N.G., J.M.-V. and R.J.H.; methodology, Á.N.G., J.M.-V. and R.J.H.; formal analysis, Á.N.G.; investigation, Á.N.G., J.M.-V. and R.J.H.; writing—original draft preparation, Á.N.G.; writing—review and editing, Á.N.G., R.J.H. and J.M.-V.; visualisation, Á.N.G.; supervision, J.M.-V. and R.J.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research presented in this paper was funded by the FUTUREGREEN project (PID2023-152776OB-C21), supported by the Spanish Ministry of Science, Innovation and Universities and the Environmental Remote Sensing and Spectroscopy Laboratory (Speclab) at the Spanish National Research Council (CSIC).

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest.

Notes

¹ The RENPA currently contains 311 Protected Natural Spaces. However, because two or more protected areas overlap in the same territory (two or more figures of protection concur), the term ‘protected area’ has been coined to designate the largest continuous geographical area over which one or more protection figures are established. Considering this interpretation, there are 249 protected areas in Andalusia.

² <https://www.juntadeandalucia.es/boja/2018/130/1> (accessed on 6 November 2024).

³ https://www.boe.es/diario_boe/txt.php?id=BOE-A-2021-11614 (accessed on 6 November 2024).

References

- Sarkodie, S.A.; Strezov, V. Economic, social and governance adaptation readiness for mitigation of climate change vulnerability: Evidence from 192 countries. *Sci. Total Environ.* **2019**, *656*, 150–164. [CrossRef] [PubMed]
- Alves, F.; Leal Filho, W.; Casaleiro, P.; Nagy, G.J.; Diaz, H.; Al-Amin, A.Q.; de Andrade Guerra, J.B.; Hurlbert, M.; Farooq, H.; Klavins, M.; et al. Climate change policies and agendas: Facing implementation challenges and guiding responses. *Environ. Sci. Policy* **2020**, *104*, 190–198. [CrossRef]
- Burrell, A.L.; Evans, J.P.; De Kauwe, M.G. Anthropogenic climate change has driven over 5 million km² of drylands towards desertification. *Nat. Commun.* **2020**, *11*, 3853. [CrossRef] [PubMed]
- Malhi, G.S.; Kaur, M.; Kaushik, P. Impact of Climate Change on Agriculture and Its Mitigation Strategies: A Review. *Sustainability* **2021**, *13*, 1318. [CrossRef]
- Barr, S.L.; Lemieux, C.J. Assessing organizational readiness to adapt to climate change in a regional protected areas context: Lessons learned from Canada. *Mitig. Adapt. Strat. Glob. Change* **2021**, *26*, 34. [CrossRef]
- Coldrey, K.M.; Turpie, J.K. The future representativeness of Madagascar’s protected area network in the face of climate change. *Afr. J. Ecol.* **2021**, *59*, 253–263. [CrossRef]
- Rodríguez-Rodríguez, D.; Martínez-Vega, J. Protected area effectiveness against land development in Spain. *J. Environ. Manag.* **2018**, *215*, 345–357. [CrossRef]
- Custodio, E.; Sahuquillo, A.; Albiac, J. Sustainability of intensive groundwater development: Experience in Spain. *Sustain. Water Resour. Manag.* **2019**, *5*, 11–26. [CrossRef]
- Camacho, C.; Negro, J.J.; Elmberg, J.; Fox, A.D.; Nagy, S.; Pain, D.J.; Green, A.J. Groundwater extraction poses extreme threat to Doñana World Heritage Site. *Nat. Ecol. Evol.* **2022**, *6*, 654–655. [CrossRef]
- Llamas, M.R. Conflicts between wetland conservation and groundwater exploitation: Two case histories in Spain. *Environ. Geol. Water Sci.* **1988**, *11*, 241–251. [CrossRef]
- Rodríguez-Rodríguez, D.; Martínez-Vega, J. Analysing subtle threats to conservation: A nineteen year assessment of fragmentation and isolation of Spanish protected areas. *Landsc. Urban. Plan.* **2019**, *185*, 107–116. [CrossRef]
- Santiago-Ramos, J.; Feria-Toribio, J.M. Assessing the effectiveness of protected areas against habitat fragmentation and loss: A long-term multi-scalar analysis in a mediterranean region. *J. Nat. Conserv.* **2021**, *64*, 126072. [CrossRef]
- Vilar, L.; Gómez, I.; Martínez-Vega, J.; Echavarría, P.; Riaño, D.; Martín, M.P. Multitemporal Modelling of Socio-Economic Wildfire Drivers in Central Spain Between the 1980s and the 2000s: Comparing Generalized Linear Models to Machine Learning Algorithms. *PLoS ONE* **2016**, *11*, e0161344. [CrossRef]
- García, F.J. Planeamiento urbanístico y cambio climático: La infraestructura verde como estrategia de adaptación. *Cuad. Investig. Urbanística* **2019**, *122*, 1–101. [CrossRef]
- UNEP-WCMC; IUCN. *Protected Planet Report*; UNEP-WCMC: Cambridge, UK; IUCN: Gland, Switzerland, 2016; 84p.
- He, M.; Cliquet, A. Challenges for Protected Areas Management in China. *Sustainability* **2020**, *12*, 5879. [CrossRef]
- Hermoso, V.; Morán-Ordóñez, A.; Lanzas, M.; Brotons, L. Designing a network of green infrastructure for the EU. *Landsc. Urban. Plan.* **2020**, *196*, 103732. [CrossRef]
- Coppola, E.; Roupheal, Y.; De Pascale, S.; Moccia, F.D.; Cirillo, C. Ameliorating a complex urban ecosystem through instrumental use of softscape buffers: Proposal for a green infrastructure network in the metropolitan area of Naples. *Front. Plant Sci.* **2019**, *10*, 410. [CrossRef] [PubMed]
- Cortinovis, C.; Zulian, G.; Geneletti, D. Assessing Nature-Based Recreation to Support Urban Green Infrastructure Planning in Trento (Italy). *Land* **2018**, *7*, 112. [CrossRef]

20. Ministerio de Fomento. Ley De 7 De Diciembre De 1916, De Parques Nacionales De España. *Gaceta de Madrid*, 18 December 1916, p. 575. Available online: <https://www.boe.es/buscar/doc.php?id=BOE-A-1916-5866> (accessed on 22 July 2024).
21. Mollá, M. Las políticas de parques nacionales en España. *Ería* **2015**, *97*, 157–171. [[CrossRef](#)]
22. Hewitt, R.; Martínez, F.J.E.; Pera, F. Cambios recientes en la ocupación del suelo de los parques nacionales españoles y su entorno. *Cuad. Geográficos Univ. Granada* **2016**, *55*, 46–84.
23. Ojeda-Rivera, J.F. Desarrollo económico, transformación de paisajes y protección de la naturaleza en Andalucía. *Cuad. Geográficos Univ. Granada* **1987**, *16*, 47–56. [[CrossRef](#)]
24. Tolón, A.; Lastra, X. Los Espacios Naturales Protegidos. Concepto, evolución y situación actual en España. *M + A. Rev. Electrónica Medioambiente* **2008**, *5*, 1–25. Available online: <https://www.ucm.es/data/cont/media/www/pag-41228/ART/A.TOLON/X/LASTRA.pdf> (accessed on 6 November 2024).
25. Elorrieta-Sanz, B.; Olcina-Cantos, J. Infraestructura verde y ordenación del territorio en España. *Ciudad. Territorio. Estud. Territ.* **2021**, *207*, 23–46. [[CrossRef](#)]
26. Bishop, K.; Phillips, A.; Warren, L. Protected for ever?: Factors shaping the future of protected areas policy. *Land Use Policy* **1995**, *12*, 291–305. [[CrossRef](#)]
27. Beaufoy, G. The EU Habitats Directive in Spain: Can it contribute effectively to the conservation of extensive agro-ecosystems? *J. Appl. Ecol.* **1998**, *35*, 974–978. [[CrossRef](#)]
28. de la Fuente, B.; Mateo-Sánchez, M.C.; Rodríguez, G.; Gastón, A.; de Ayala, R.P.; Colomina-Pérez, D.; Saura, S. Natura 2000 sites, public forests and riparian corridors: The connectivity backbone of forest green infrastructure. *Land Use Policy* **2018**, *75*, 429–441. [[CrossRef](#)]
29. Farina, A. *Principles and Methods in Landscape Ecology*; Chapman & Hall: London, UK, 1998.
30. Costanza, R.; d’Arge, R.; de Groot, R.; Farber, S.; Grasso, M.; Hannon, B.; Limburg, K.; Naeem, S.; O’Neill, R.V.; Paruelo, J.; et al. The value of the world’s ecosystem services and natural capital. *Nature* **1997**, *387*, 253–260. [[CrossRef](#)]
31. Lindenmayer, D.B.; Nix, H.A. Ecological Principles for the Design of Wildlife Corridors. *Conserv. Biol.* **1993**, *7*, 627–630. Available online: <http://www.jstor.org/stable/2386693> (accessed on 6 November 2024). [[CrossRef](#)]
32. Rodríguez, V.; Aguilera, F. ¿Infraestructuras verdes en la planificación territorial española? *Ciudad. Territ. Estud. Territ.* **2016**, *48*, 399–418. Available online: <https://recyt.fecyt.es/index.php/CyTET/article/view/76490> (accessed on 6 November 2024).
33. Benedict, M.A.; McMahon, E.T. Green infrastructure: Smart conservation for the 21st century. *Renew. Resour. J.* **2002**, *20*, 12–17. [[CrossRef](#)]
34. European Commission. *Green Infrastructure (GI)—Enhancing Europe’s Natural Capital*; Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Brussels, Belgium, 2013. Available online: <https://www.eea.europa.eu/policy-documents/green-infrastructure-gi-2014-enhancing> (accessed on 6 November 2024).
35. MITECO Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente. *Estrategia Nacional de Infraestructura Verde y de la Conectividad y Restauración Ecológicas*; MITECO: Madrid, Spain, 2021. Available online: https://www.miteco.gob.es/es/biodiversidad/temas/ecosistemas-y-conectividad/infraestructura-verde/infr_verde.html (accessed on 6 August 2024).
36. Chang, Q.; Li, X.; Huang, X.; Wu, J. A GIS-Based Green Infrastructure Planning for Sustainable Urban Land Use and Spatial Development. *Procedia Environ. Sci.* **2012**, *12*, 491–498. [[CrossRef](#)]
37. Firehock, K.E.; Walker, R.A. *Green Infrastructure: Map and Plan the Natural World with GIS*; Esri Press: Redlands, CA, USA, 2019; p. 282.
38. Aguilera, F.; Rodríguez, V.M.; Gómez, M. Definición de infraestructuras verdes: Una propuesta metodológica integrada mediante análisis espacial. *Doc. Anal. Geogr.* **2018**, *64*, 313–337. [[CrossRef](#)]
39. Velázquez, J.C.; Rodríguez, V.M. Identification and assessment of green infrastructure in the Community of Madrid. *Landsc. Res.* **2023**, *48*, 297–312. [[CrossRef](#)]
40. Gallardo, M.; Martínez-Vega, J. Modeling land-use scenarios in protected areas of an urban region in Spain. In *Geomatic Approaches for Modeling Land Change Scenarios*; Camacho, M.T., Paegelow, M., Mas, J.F., Escobar, F., Eds.; Springer: Berlin, Germany, 2018; pp. 307–328. [[CrossRef](#)]
41. Mironova, E.E. GIS modeling of green infrastructure of mediterranean cities for the management of urbanized ecosystems. *Arid Ecosyst.* **2021**, *11*, 149–155. [[CrossRef](#)]
42. Caparrós, J.L.; Milán, J.; Rueda, N.; de Pablo, J. Mapping green infrastructure and socioeconomic indicators as a public management tool: The case of the municipalities of Andalusia (Spain). *Environ. Sci. Eur.* **2020**, *32*, 144. [[CrossRef](#)]
43. Valladares, F.; Gil, P.; Forner, A. *Bases Científico-Técnicas Para la Estrategia Estatal de Infraestructura Verde y de la Conectividad y Restauración Ecológicas*; Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente: Madrid, Spain, 2017. Available online: https://www.miteco.gob.es/content/dam/miteco/es/biodiversidad/temas/ecosistemas-y-conectividad/basescientificotecnicaseeivcre_tcm30-479558.pdf (accessed on 6 November 2024).
44. Comunidad de Madrid. *Planificación de la Red de Corredores Ecológicos de la Comunidad de Madrid: Identificación de Oportunidades Para El Bienestar Social y la Conservación del Patrimonio Natural*; Consejería de Medio Ambiente, Vivienda y Ordenación del Territorio: Madrid, Spain, 2010. Available online: https://www.comunidad.madrid/sites/default/files/aud/urbanismo/cma_urb_es_memoria_corredores_ecologicos_-_parte_1.pdf (accessed on 6 November 2024).
45. Dudley, N. (Ed.) *Guidelines for Applying Protected Area Management Categories*; IUCN: Gland, Switzerland, 2008.

46. Dufлот, R.; Aviron, S.; Ernoult, A.; Fahrig, L.; Burel, F. Reconsidering the role of ‘semi-natural habitat’ in agricultural landscape biodiversity: A case study. *Ecol. Res.* **2015**, *30*, 75–83. [CrossRef]
47. Liu, J.; Jin, X.; Song, J.; Zhu, W.; Zhou, Y. Semi-natural habitats: A comparative research between the European Union and China in agricultural landscapes. *Land Use Policy* **2024**, *141*, 107115. [CrossRef]
48. Fernández, E.M.; Pérez, A.C.; Reyes, J.E.; del Corral, D.F.; Cruzada, S.M.; Mardones, F.C.; Vázquez, J.A.C. Lo natural es político. Las áreas protegidas y la construcción del medioambiente como objeto de gobierno en Andalucía (1978–1989). *Investig. Reg.* **2023**, *1*, 39–55. Available online: <https://recyt.fecyt.es/index.php/IR/article/view/94827> (accessed on 6 November 2024).
49. Junta de Andalucía. *Informe Medio Ambiente en Andalucía*; Consejería de Medio Ambiente: Sevilla, Spain, 1997. Available online: <https://www.juntadeandalucia.es/medioambiente/portal/acceso-rediam/informe-medio-ambiente/los-25-primeros-informes-de-medio-ambiente-en-andalucia-1987%E2%80%93932011> (accessed on 6 August 2024).
50. Junta de Andalucía. Áreas Protegidas de la Renpa. Available online: https://www.juntadeandalucia.es/medioambiente/portal/landing-page-%C3%ADndice/-/asset_publisher/zX2ouZa4r1Rf/content/mapa-actualizado-de-la-renpa/20151 (accessed on 16 August 2024).
51. Armas, C.; Rodríguez-Echeverría, S.; Pugnaire, F.I. A field test of the stress-gradient hypothesis along an aridity gradient. *J. Veg. Sci.* **2011**, *22*, 818–827. [CrossRef]
52. Mendoza-Fernández, A.J.; Peña-Fernández, A.; Molina, L.; Aguilera, P.A. The Role of Technology in Greenhouse Agriculture: Towards a Sustainable Intensification in Campo de Dalías (Almería, Spain). *Agronomy* **2021**, *11*, 101. [CrossRef]
53. Sánchez, L.M. Modelo territorial innovador y articulación urbana en el poniente almeriense. *Investig. Geogr.* **2013**, *59*, 57–74. [CrossRef]
54. Górgolas, P. *El Urbanismo en el Litoral Andaluz Tras la Última Burbuja Inmobiliaria—Cambio de Ciclo o Reincidencia*; Tirant Humanidades: Valencia, Spain, 2020; 215p.
55. Diputación de Almería. *Agenda 21 Provincia de Almería*; Diputación de Almería: Almería, Spain, 2009. Available online: [https://www.dipalme.org/Servicios/Anexos/Anexos.nsf/58C0DDAA24FEE3E3C1257650003A80FC/\\$file/Documento%20de%20diagnostico%20volumen%20I.pdf](https://www.dipalme.org/Servicios/Anexos/Anexos.nsf/58C0DDAA24FEE3E3C1257650003A80FC/$file/Documento%20de%20diagnostico%20volumen%20I.pdf) (accessed on 6 August 2024).
56. Eastman, J. *TerrSet 2020*. In *Geospatial Monitoring and Modeling System Tutorial*; Clark University: Worcester, MA, USA, 2020. Available online: <https://clarklabs.org/wp-content/uploads/2020/05/Terrset-Manual.pdf> (accessed on 6 November 2024).
57. Junta de Andalucía. *Plan Director Para la Mejora de la Conectividad Ecológica en Andalucía, Una Estrategia de Infraestructura Verde*; Consejería Medio Ambiente y Ordenación del Territorio: Sevilla, Spain, 2018. Available online: https://www.juntadeandalucia.es/sites/default/files/2021-06/PDMCEA_areas_estrategicas_2018.pdf (accessed on 6 August 2024).
58. Vogt, P. *User Guide of Guidos Toolbox*; JRC: Brussels, Belgium, 2017. Available online: <https://forest.jrc.ec.europa.eu/en/activities/lpa/gtb/> (accessed on 6 August 2024).
59. Wickham, J.; Riitters, K.; Vogt, P.; Costanza, J.; Neale, A. An inventory of continental US terrestrial candidate ecological restoration areas based on landscape context. *Restor. Ecol.* **2017**, *25*, 894–902. [CrossRef] [PubMed]
60. Osewe, E.O.; Niță, M.D.; Abrudan, I.V. Assessing the Fragmentation, Canopy Loss and Spatial Distribution of Forest Cover in Kakamega National Forest Reserve, Western Kenya. *Forests* **2022**, *13*, 2127. [CrossRef]
61. Clerici, N.; Vogt, P. Ranking European regions as providers of structural riparian corridors for conservation and management purposes. *Int. J. Appl. Earth Obs. Geoinf.* **2013**, *21*, 477–483. [CrossRef]
62. Rincón, V.; Velázquez, J.; Pascual, Á.; Herráez, F.; Gómez, I.; Gutiérrez, J.; Sánchez, B.; Hernando, A.; Santamaría, T.; Sánchez-Mata, D. Connectivity of Natura 2000 potential natural riparian habitats under climate change in the Northwest Iberian Peninsula: Implications for their conservation. *Biodivers. Conserv.* **2022**, *31*, 585–612. [CrossRef]
63. Schmid, M.S.; Aubry, C.; Grigor, J.; Fortier, L. The LOKI underwater imaging system and an automatic identification model for the detection of zooplankton taxa in the Arctic Ocean. *Limnol. Oceanogr. Methods* **2016**, *15*, 129–160. [CrossRef]
64. Wickham, J.D.; Riitters, K.H.; Wade, T.G.; Vogt, P. A national assessment of green infrastructure and change for the conterminous United States using morphological image processing. *Landsc. Urban. Plan.* **2010**, *94*, 186–195. [CrossRef]
65. Carver, S.J. Integrating multi-criteria evaluation with geographical information systems. *Int. J. Geogr. Inf. Syst.* **1991**, *5*, 321–339. [CrossRef]
66. Gómez, M.; Barredo, J.I. *Sistemas de Información Geográfica y Evaluación Multicriterio*; Ra-Ma: Madrid, Spain, 2005; p. 304.
67. Romero, C. *Teoría de la Decisión Multicriterio: Conceptos, Técnicas y Aplicaciones*; Alianza Universidad-Textos: Madrid, Spain, 1993; p. 195.
68. Cunha, N.S.; Magalhães, M.R. Methodology for mapping the national ecological network to mainland Portugal: A planning tool towards a green infrastructure. *Ecol. Indic.* **2019**, *104*, 802–818. [CrossRef]
69. Dindaroglu, T. Determination of ecological networks for vegetation connectivity using GIS & AHP technique in the Mediterranean degraded karst ecosystems. *J. Arid Environ.* **2021**, *188*, 104385. [CrossRef]
70. Saaty, T.L. *The Analytic Hierarchy Process*; McGraw-Hill: New York, NY, USA, 1980; p. 343.
71. Escobar, F.; Hewitt, R.; Hernández, V. Usos del suelo en los parques nacionales españoles. Evolución y modelado participativo. In *Proyectos de Investigación en Parques Nacionales*; Amengual, P., Asensio, B., Eds.; Organismo Autónomo de Parques Nacionales: Madrid, Spain, 2015; pp. 175–211.
72. Hewitt, R.; Van Delden, H.; Escobar, F. Participatory land use modelling, pathways to an integrated approach. *Environ. Model. Softw.* **2014**, *52*, 149–165. [CrossRef]

73. Rodríguez-Rodríguez, D.; Martínez-Vega, J.; Echavarría, P. A twenty-year GIS-based assessment of environmental sustainability of land use changes in and around protected areas of a fast developing country: Spain. *Int. J. Appl. Earth Obs. Geoinf.* **2019**, *74*, 169–179. [CrossRef]
74. Boitani, L.; Falcucci, A.; Maiorano, L.; Rondinini, C. Ecological Networks as Conceptual Frameworks or Operational Tools in Conservation. *Conserv. Biol.* **2007**, *21*, 1414–1422. [CrossRef]
75. Gurrutxaga, M.; Lozano, P.J.; del Barrio, G. GIS-based approach for incorporating the connectivity of ecological networks into regional planning. *J. Nat. Conserv.* **2010**, *18*, 318–326. [CrossRef]
76. Baguette, M.; Blanchet, S.; Legrand, D.; Stevens, V.M.; Turlure, C. Individual dispersal, landscape connectivity and ecological networks. *Biol. Rev.* **2013**, *88*, 310–326. [CrossRef] [PubMed]
77. Troy, A.; Wilson, M.A. Mapping ecosystem services: Practical challenges and opportunities in linking GIS and value transfer. *Ecol. Econ.* **2006**, *60*, 435–449. [CrossRef]
78. Cao, Y.; Yang, R.; Carver, S. Linking wilderness mapping and connectivity modelling: A methodological framework for wildland network planning. *Biol. Conserv.* **2020**, *251*, 108679. [CrossRef]
79. Cole, J.R.; Koen, E.L.; Pedersen, E.J.; Gallo, J.A.; Kross, A.; Jaeger, J.A. Impacts of anthropogenic land transformation on species-specific habitat amount, fragmentation, and connectivity in the Adirondack-to-Laurentians (A2L) transboundary wildlife linkage between 2000 and 2015: Implications for conservation and ecological restoration. *Landscape Ecol.* **2023**, *38*, 1–31. [CrossRef]
80. Gallo, J.A.; Butts, E.C.; Miewald, T.A.; Foster, K.A. *Comparing and Combining Omniscience and Linkage Mapper Connectivity Analyses in Western Washington*; Conservation Biology Institute: Corvallis, OR, USA, 2019. [CrossRef]
81. Soille, P.; Vogt, P. Morphological segmentation of binary patterns. *Pattern Recognit. Lett.* **2009**, *30*, 456–459. [CrossRef]
82. Chuvieco, E.; Martínez, S.; Román, M.V.; Hantson, S.; Pettinari, M.L. Integration of ecological and socio-economic factors to assess global vulnerability to wildfire. *Glob. Ecol. Biogeogr.* **2014**, *23*, 245–258. [CrossRef]
83. Hörnsten, L.; Fredman, P. On the distance to recreational forests in Sweden. *Landscape Urban. Plan.* **2000**, *51*, 1–10. [CrossRef]
84. Zhang, J.; Cheng, Y.; Zhao, B. Assessing the inequities in access to peri-urban parks at the regional level: A case study in China's largest urban agglomeration. *Urban. For. Urban. Green.* **2021**, *65*, 127334. [CrossRef]
85. Serrano, P.Y. *It Is What It Is: Local Resistances and Life-Sustaining Strategies in Western Almeria's Agro-Industrial Plastic Sea*; The University of Manchester: Manchester, UK, 2022.
86. Araque, E. Las adquisiciones de montes en la provincia de Almería (1940-1992). Los ejemplos de las cuencas del Andarax y Almanzora. *Nimbus Rev. Climatol. Meteorol. Paisaje* **2012**, *29*, 61–79. Available online: <http://hdl.handle.net/10835/2994> (accessed on 6 November 2024).
87. Mendoza-Fernández, A.; Martínez-Hernández, F.; Garrido-Becerra, J.A.; Pérez-García, F.J.; Medina-Cazorla, J.M.; de Giles, J.P.; Mota, J.F. Is the endangered flora of the Iberian southeast adequately protected? Gaps in the Network of Protected Natural Areas of Andalusia (RENPA): The case of the province of Almería. *Acta Bot. Gall.* **2009**, *156*, 637–648. [CrossRef]
88. Muñoz, A.; Requejo, J. *Recursos Naturales y Crecimiento Económico en el Campo de Dalías*; Agencia de Medio Ambiente: Sevilla, Spain, 1991; 256p.
89. Martínez-Vega, J.; Mili, S.; Gallardo, M. Modelling Land Use and Land Cover Changes in the Mediterranean Agricultural Ecosystems. In *Modeling for Sustainable Management in Agriculture, Food and the Environment*; Vrontzos, G., Ampatzidis, Y., Manos, B., Pardalos, P.M., Eds.; Routledge-CRC Press: Boca Raton, FL, USA, 2022; pp. 40–73.
90. Collinge, S.K. Spatial arrangement of habitat patches and corridors: Clues from ecological field experiments. *Landscape Urban. Plan.* **1998**, *42*, 157–168. [CrossRef]
91. Salviano, I.R.; Gardon, F.R.; dos Santos, R.F. Ecological corridors and landscape planning: A model to select priority areas for connectivity maintenance. *Landscape Ecol.* **2021**, *36*, 3311–3328. [CrossRef]
92. Zhou, D.; Song, W. Identifying Ecological Corridors and Networks in Mountainous Areas. *Int. J. Environ. Res. Public Health* **2021**, *18*, 4797. [CrossRef]
93. Martín, B.; Ortega, E.; de Isidro, A.; Iglesias-Merchan, C. Improvements in high-speed rail network environmental evaluation and planning: An assessment of accessibility gains and landscape connectivity costs in Spain. *Land Use Policy* **2021**, *103*, 105301. [CrossRef]
94. Alados, C.L.; Puigdefábregas, J.; Martínez-Fernández, J. Ecological and socio-economical thresholds of land and plant-community degradation in semi-arid Mediterranean areas of southeastern Spain. *J. Arid Environ.* **2011**, *75*, 1368–1376. [CrossRef]
95. Fonseca, A.; Zina, V.; Duarte, G.; Aguiar, F.C.; Rodríguez-González, P.M.; Ferreira, M.T.; Fernandes, M.R. Riparian Ecological Infrastructures: Potential for Biodiversity-Related Ecosystem Services in Mediterranean Human-Dominated Landscapes. *Sustainability* **2021**, *13*, 10508. [CrossRef]
96. Egea, F.J.; Glass, R. Almeria: A model for sustainable intensive production. In *Aspects of Applied Biology*; Rothamsted Research: Harpenden, UK, 2017; Volume 136, pp. 233–236.
97. Aznar-Sánchez, J.A.; Belmonte-Ureña, L.J.; Velasco-Muñoz, J.F.; Valera, D.L. Aquifer Sustainability and the Use of Desalinated Seawater for Greenhouse Irrigation in the Campo de Níjar, Southeast Spain. *Int. J. Environ. Res. Public Health* **2019**, *16*, 898. [CrossRef] [PubMed]
98. Entrena-Duran, F. (Ed.) Expansion of Greenhouse Farming in the Area of El Ejido: A Case Study on the Environmental and Social Consequences of Agroindustry in Southeast Spain. In *Food Production and Eating Habits from Around the World: A Multidisciplinary Approach*; Nova Science Publishers: New York, NY, USA, 2015; Chapter 3, pp. 29–44.

99. Sarrión-Gavilán, M.D.; Benítez-Márquez, M.D.; Mora-Rangel, E.O. Spatial distribution of tourism supply in Andalusia. *Tour. Manag. Perspect.* **2015**, *15*, 29–45. [[CrossRef](#)]
100. Díez-Garretas, B.; Comino, O.; Pereña, J.; Asensi, A. Spatio-temporal changes (1956-2013) of coastal ecosystems in Southern Iberian Peninsula (Spain). *Mediterr. Bot.* **2019**, *40*, 111–119. [[CrossRef](#)]
101. Yacamán, C.; Ferrer, D.; Mata, R. Green infrastructure planning in metropolitan regions to improve the connectivity of agricultural landscapes and food security. *Land* **2020**, *9*, 414. [[CrossRef](#)]
102. García-Álvarez, D. The Influence of Scale in LULC Modeling. A Comparison Between Two Different LULC Maps (SIOSE and CORINE, Lecture Notes in Geoinformation and Cartography). In *Geomatic Approaches for Modeling Land Change Scenarios*; Camacho Olmedo, M., Paegelow, M., Mas, J.F., Escobar, F., Eds.; Springer: Cham, Germany, 2018; pp. 187–213. [[CrossRef](#)]
103. Zaragoza, B.; Rodríguez-Sala, J.J.; Trilles, S.; Ramón-Morte, A. Integration of New Data Layers to Support the Land Cover and Use Information System of Spain (SIOSE, GISTAM 2020. Communications in Computer and Information Science): An Approach from Object-Oriented Modelling. In *Geographical Information Systems Theory, Applications and Management*; Grueau, C., Laurini, R., Ragia, L., Eds.; Springer: Cham, Germany, 2021; Volume 1411, pp. 85–101. [[CrossRef](#)]
104. MITECO. Mapa Forestal de España a Escala 1:50.000 (MFE50), Madrid, Spain. 2024. Available online: https://www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/mapa-forestal-espana/mfe_50.html (accessed on 29 August 2024).
105. Büttner, G. CORINE Land Cover and Land Cover Change Products (Remote Sensing and Digital Image Processing). In *Land Use and Land Cover Mapping in Europe*; Manakos, I., Braun, M., Eds.; Springer: Dordrecht, The Netherlands, 2014; Volume 18, pp. 55–74. [[CrossRef](#)]
106. Feranec, J.; Soukup, T.; Hazeu, G.; Jaffrain, G. (Eds.) *European Landscape Dynamics: Corine Land Cover Data*; CRC Press: Boca Raton, FL, USA, 2016.
107. Doko, T.; Fukui, H.; Kooiman, A.; Toxopeus, A.G.; Ichinose, T.; Chen, W.; Skidmore, A.K. Identifying habitat patches and potential ecological corridors for remnant Asiatic black bear (*Ursus thibetanus japonicus*) populations in Japan. *Ecol. Model.* **2011**, *222*, 748–761. [[CrossRef](#)]
108. Ghoddousi, A.; Bleyhl, B.; Sichau, C.; Ashayeri, D.; Moghadas, P.; Sepahvand, P.; Hamidi, A.K.; Soofi, M.; Kuemmerle, T. Mapping connectivity and conflict risk to identify safe corridors for the Persian leopard. *Landsc. Ecol.* **2020**, *35*, 1809–1825. [[CrossRef](#)]
109. CNIG. *Centro de Descargas*; Centro Nacional de Información Geográfica: Madrid, Spain, 2024. Available online: <https://centrodedescargas.cnig.es/CentroDescargas/index.jsp> (accessed on 6 August 2024).
110. REDIAM. *Descarga de Información Ambiental*; Red de Información Ambiental de Andalucía: Sevilla, Spain, 2024. Available online: <https://portalrediam.cica.es/descargas> (accessed on 6 August 2024).

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.