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GIS-based relationship between pathway names and landscape. A multilingual case study: Euskadi, Spain

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Abstract Place names determine geographic units in space, encapsulate the description of places where inhabitants conduct their activities, and preserve the perception of the territory in past times. The very definition of landscape impacts two interrelated concepts: human action and perception. On another note, traditional pathways are structuring elements of the landscape, bearing witness to the dynamic relationship between the territory and its inhabitants by connecting residences and workplaces. This work aims to assess the relationship between the landscape mosaic and the toponyms of pathways and roads gathered in the current cartography of Euskadi (Spain), a territory influenced by the existence of two official languages. Given the spatial component of the data, this analysis is conducted through geographic information systems. Firstly, a corpus of 3072 pathway names selected from current official toponymic databases is compiled, as well as the content of the first edition of the National Topographic Map. Subsequently, the semantic content of the corpus elements is examined, as well as the nature of their referential content concerning the landscape units obtained from the Atlas of Spanish Landscapes. The results show common factors in characterizing landscapes and the etymology of names. Thus, it is noted that traditional agricultural, forestry, livestock, and traditional industry activities shape the toponymy in the most populated landscape units. Meanwhile, references to the orography typify the more mountainous landscapes. Therefore, the geographical study demonstrates the existence of common factors that link landscape and toponymy, validating one as a study source for the other.

Keywords Landscape · Place name · Odonym · Traditional pathway · GIS

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Introduction

Landscape and territory are as closely linked as the territory and its cartographic representation. As a support for the representation of the territory, geographic

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information can be a vehicle for identifying common or discriminating elements in the landscape study. From this perspective, cartography and its toponymy share variables with landscape management tools, being transversal tools in the multi-layered territory analysis (Nowosad and Stepinski, 2021).

Place names determine geographical units in space, synthesize the description of the same places they nominate, and treasure the perception of the territory through time. This description of toponymy is fully aligned with the concept of landscape. The Council of Europe signed the European Landscape Convention (ELC)[1] in 2000, setting a milestone in the recognition of the value and importance of landscape. This treaty provides a framework of protection and orients the concept of landscape towards the land use planning field, which has greatly impacted the scientific literature (Pătru-Stupariu and Nita, 2022). In said convention, the landscape is understood as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors." This definition has a bearing on two concepts intrinsically linked to place names: human action and perception. Hence, both toponymy and landscape become guardians of the cultural legacy (Altaba et al., 2022).

Furthermore, several disciplines are involved in the study of geographical names, such as anthropology, sociolinguistics, geography, or history, among others, for which toponymy is an auxiliary tool. Moreover, reciprocally, toponymy is nourished by all these sciences, which it also serves. Therefore, toponymy is a bridging discipline between all this knowledge, and its study requires an interdisciplinary approach. One of the values of toponymy is its memory (Çetin, 2018), that is, the value of containing geographically located chronological information, as long as the origin, meaning, and reason for the timely toponym are unraveled. This is also understood as etiology, which provides knowledge of synthesis (Arroyo Illera, 2009). The confluence of different languages in the same territory, multilingualism, generates a particular interest in the study of place names. This happens in several regions of Spain, including the Autonomous Community of the Basque Country, or Euskadi, an administrative region in the north of Spain (bordering France).

Pathways, those communication routes that allowed transportation and connections between different places of human activity development, have been pivotal elements of the territory (Porcal Gonzalo, 2011). Therefore, the analysis of elements related to the traditional transportation network provides a basis for its interpretation. According to Porcal Gonzalo, the traditional pathway can be understood as a dynamic type of cultural landscape, both due to its spatial scope and its representation of territorial exchange processes, illustrating human adaptability to the geographical environment.

From the perspective of the genesis of cartography, roads and pathways have been the structure that enables the cartographer to establish contact with the terrain under survey as a means of access to the territory. In this way, they condition the perception of the space on which the work of abstraction and synthesis has been performed in the compilation of the maps using classical techniques. This process is evident in articulating the topographic works of the first edition of the National Topographic Map of Spain (MTN), produced by the current *Instituto Geográfico Nacional* (IGN) (Instituto Geográfico Nacional, 2024a), the Spanish national mapping agency.

Regarding the urban environment, roads give support to its framework, modeling the morphological structure of the population settlements, together with other elements such as river courses or orographic features. Examples of these constrained structures can be the layout of buildings linearly on both sides of a road, the concentration of small nuclei at their crossroads, or the design of radial planes in different directions (Agboola et al., 2018). In addition to structuring the territory, pathway infrastructures also determine the landscape. Thus, once again, cartography and Geographic Information Systems (GIS) are indisputable supports for assessing these relationships.

Additionally, UNESCO recognizes several roads and pathways as world heritage[2]. Based on the ELC, the European Council drives the program of cultural itineraries (Council of Europe, 1987), among which various traditional routes can be found, such as the Via Regia, the Via Francigena, or the *Camino de Santiago* (Way of St. James). This program promotes the dissemination and enhancement of roads, as well as the reuse of disused transport infrastructures. Thus, it fosters an

[1] (CETS 176 - Draft European Landscape Convention as amended by the 2016 Protocol (coe.int)

[2] https://whc.unesco.org/es/list/

approach to rural environments that contribute to their socio-economic development, simultaneously meeting the increasing demand for eco-recreational countryside use. In Spain, the Natural Paths Program pursues similar objectives, focusing on natural landscapes (Orellana Moraleda, 2017). For example, Somoza Medina et al. (2022) analyze the successful case of the *Camino de Santiago*.

Delving further into the landscape-pathways pairing, it is worth emphasizing that the regional regulations (Departamento de Medio Ambiente y Política Territorial, 2014) outline the objective of "enhancing the value of traditional cultural pathways as exceptional points for accessibility and enjoyment of the landscape." Within these guidelines, pathways also find a place at various junctures. Firstly, in defining the content of the community's landscape catalogs, the spatial location of main routes and viewpoints from which the landscape is appreciated emerges. Additionally, there is a requirement for a "Landscape Integration Study" in construction projects that might significantly impact the landscape, particularly in the development of transportation or port infrastructures. Based on everything discussed so far, the authors believe that the significance of the relationship between the landscape and other elements within it, such as pathways, has not been addressed to date in Spain, especially in a bilingual environment.

This research aims to explore the relationship between place names and landscape units in the Basque Country. To this end, it is based on the idea that the perception of the occupants of a territory and their activity on it are the genesis and the driving force in the dynamics of both toponymy and landscape. Specifically, and given that traditional communication routes are structuring elements of the territory and the landscape itself, the work focuses on certain features that characterize the toponymy of pathways. Since the spatial component is the core of the analysis, it is carried out using GIS tools. Firstly, a toponymic corpus is compiled from the geographical information of the administrative entities related to the pathways in this territory. It must be noted that the toponyms related to communication routes are also known as odonyms. Finally, the analysis of these names, superimposed on the existing cartography of the landscape in the area, seeks to verify the correspondence between the differentiating characteristics of the landscape units and these names. For this purpose, the features taken into account are the distribution, geographic, and semantic referencing of the names.

Therefore, the main innovation of this research lies in systematically intertwining disciplines that work with the perception of the territory by its inhabitants through the analysis of elements that articulate or structure it, such as the pathways throughout the Basque Country territory.

Related work

This section presents a series of works related to the different disciplines that combine the study: landscape, toponymy, and traditional communication routes. Thus, it will show their close interrelation and the treatment they have received in the literature.

First of all, it is worth mentioning that Spain ratified the ELC on November 26, 2007 (the Spanish Official State Gazette, *Boletín Oficial del Estado-BOE* of February 2, 2008), which came into force on March 1, 2008. The effect of this implementation on landscape protection and management is reflected in Civitarese Matteucci and Franco Cartei (2022). The cultural landscape finds a specification in the rural landscape, characterized by natural components, diversity, and visual qualities (Picuno et al., 2019). The management and revitalization of linked rural areas are gaining more and more relevance, as evidenced by the European Commission's initiative "Long-term vision for rural areas of the EU up to 2040" (European Commission, 2011). Among its contributions is the establishment of 10 common objectives and the articulation of an action plan (Munroe et al., 2019).

The characterization of landscapes and their classification on the territory is another related and necessary subject in the areas of landscape management and planning contemplated in the ELC as a specific measure. Geographic information and cartography constitute support for its study through GIS (Tort-Donada and López-Leiva, 2023). In any case, the large number of variables and the complex relationships between them mean that landscape should be addressed as a broad and multidisciplinary field (Altaba et al., 2022). Usually, these studies center on physical elements and their visual component. In this aspect, analyzing place names provides the cultural component with which they are impregnated (Atik et al., 2022).

Furthermore, literature gathers some works related to odonyms. For instance, Bellosillo (1988) focuses their research on the study of "*cañadas reales*" (Royal Drove Road, transhumance route) through their toponymy, placing special emphasis on the phenomenon of transhumance and the impact of wolves within the area with merino sheep in Castile region, Spain. Another notable work is the compilation of terminology related to pathways in Spanish language and dialects, which is based on the generic part of the names of these geographical entities (Alcázar González and Azcárate Luxán, 2000).

If the perspective is broadened to the concept of landscape, it is also possible to find examples related to the cultural aspects of pathways. Spampinato et al. highlight the possibility of analyzing the richness and diversity of land cover in the past by studying phytonymy or place names related to plants (Spampinato et al., 2022). Hearn et al. (2024) interpret the change in certain rural landscapes through the toponymy related to vegetation, delving into the imprint that nomadic culture leaves on both the landscape and its toponymy. Gordova (2022) links landscape dynamics with the chronology of place names, relating their linguistic origin to the settlements of different peoples in the territory throughout history. The stratification of toponymy allows a similar approach, as seen in Martínez-Areta (2023). Nowosad and Stepinski (2021) connect the characteristics defining the classification system of landscape patterns with natural variables and place names. After registering place names, it is concluded that environmental aspects are mostly divided into factors of natural or human geography. Focused on the latter, recent studies use innovative methodologies with toponymy as the axis for the interdisciplinary study of architectural heritage, as in the case of Herzen et al. (2023), dedicated to analyzing Russian religious heritage. Membrado Tena and Fansa (2023) apply a semantic analysis of urban toponymy in Valencia (Spain), examining the persistence of rural landscapes within it. Another example of applying technological advancements, centering on artificial intelligence techniques, is the semantics of place names, which have also been used for geocoding place names themselves (Fize et al., 2021).

In Euskadi, different territorial planning figures have been developed in which the protection of cultural heritage from a territorial perspective has been covered in one way or another. In the region, an integral approach has been adopted. Thus, beyond the protection of a specific cultural heritage element, action is taken on its location and its surroundings, thus protecting the landscape context (Davila-Cabanillas, 2021). (Hersperger et al., 2020) stress the importance and applicability of landscape knowledge applied to territorial planning. This issue connects with the relationship of the 17 Sustainable Development Goals with territorial planning from a landscape approach in order to provide the rural environment with greater resilience in the face of transformation (Riva, 2020).

From another perspective, both pathways and infrastructures also condition the landscape (Lisiak et al., 2018). In this way, the temporal development of the settlement of the territory is reconciled with the geography and justifies the existence and evolution of these paths (Rosete Vergés, 2020). Thus, attending to modern dynamics, new residential and infrastructure developments generate discontinuities and provide an irregular plot in the forest cover of the territory (Munroe et al., 2019). Increasingly, traditional paths also seize value as part of local heritage and a result of history and culture. This perspective relates to the concept of cultural itinerary (Álvarez et al., 2022). Turner et al. (2023) show an interest in historical inventories of roads and a way to obtain them employing historical mapping. In addition, they have aroused great interest as a tourist and leisure resource, especially in mountain areas, enhancing their scenic content. Other axes of great value for their resources are the spaces linked to the riverbanks and riverbeds. Their patrimonial, economic, and cultural wealth is an essential asset for developing the rural areas where they are located (Cebrián Abellán and García Martínez, 2016).

Study area

The geographical location of this research is the Autonomous Community of the Basque Country or Euskadi, in the northern part of the Iberian Peninsula, bordering France, and adjacent to the Cantabrian Sea. It spans an area of 7234.83 km^2 and has a population of 2,186,517 inhabitants (inh) (Eustat Agentzia, 2023), resulting in an average density of 302.22 inh/km^2. It is composed of three provinces, whose capitals are indicated in parentheses: Gipuzkoa (Donostia/San Sebastián), Bizkaia (Bilbao), and Álava (Vitoria-Gasteiz, which is the capital of the autonomous community), as

Fig. 1 Study area. Euskadi / Basque Country Autonomous Community. Own elaboration from Instituto Geográfico Nacional (2024a). Frame coordinates in km

shown in Fig. 1. For historical reasons, these provinces enjoy a special regime according to their own laws (*fueros*), thus being recognized as Historical Territories.

Concerning topography and climate, the former is mainly mountainous, with a series of elevated orographic structures oriented from north to south, which organize the territory (Fig. 2). To the north are the coastal mountains, forming an alignment cut by the fluvial systems of the Cantabrian slope. To the south are the interior mountain ranges, which form part of the Atlantic-Mediterranean divide. Next, the middle pre-Pyrenean depression is developed, which forms the Álava plain (*La Llanada Alavesa*). Finally, the outer mountain ranges of the south are the last part of the territory. This orographic formation, along with the proximity to the sea and the region's latitude, shape the climate of the region. According to the Köppen-Geiger classification, the whole territory is in the climatic zone C (temperate) (Fig. 3). Contextualizing this classification in the territory, according to Euskalmet (2023), three climatic zones can be distinguished: the temperate oceanic climate of the Atlantic slope to the north, very rainy and moderate in temperatures; then, a transition zone in Álava; and, finally, in the extreme south, a Mediterranean climate characterized by a clearly dry and hot summer of continental type, with a winter of low rainfall.

Climate and terrain conditions determine land use. Population centers are located in valley bottoms. The main corridor links Bilbao and San Sebastián, with lesser connectivity along the axes connecting these capitals to Vitoria-Gasteiz. Consequently, substantial differences in density exist across the territory (Fig. 4), with two major urban areas: the larger one around Bilbao's metropolitan area and another around San Sebastián's. Conversely, in the case of Álava, the capital itself has experienced growth, attracting the majority of the province's population. In mountainous areas, there is a pattern of extensive and scattered agricultural settlement known as "*caserío*" SPA[3], hamlet, with no clear population center. Nevertheless, in Álava, besides the capital, the population concentrates on small settlements.

Silvicultural production covers many of the mountains in Gipuzkoa and Bizkaia and is characterized by

[3] ISO 639-2 language code for Spanish

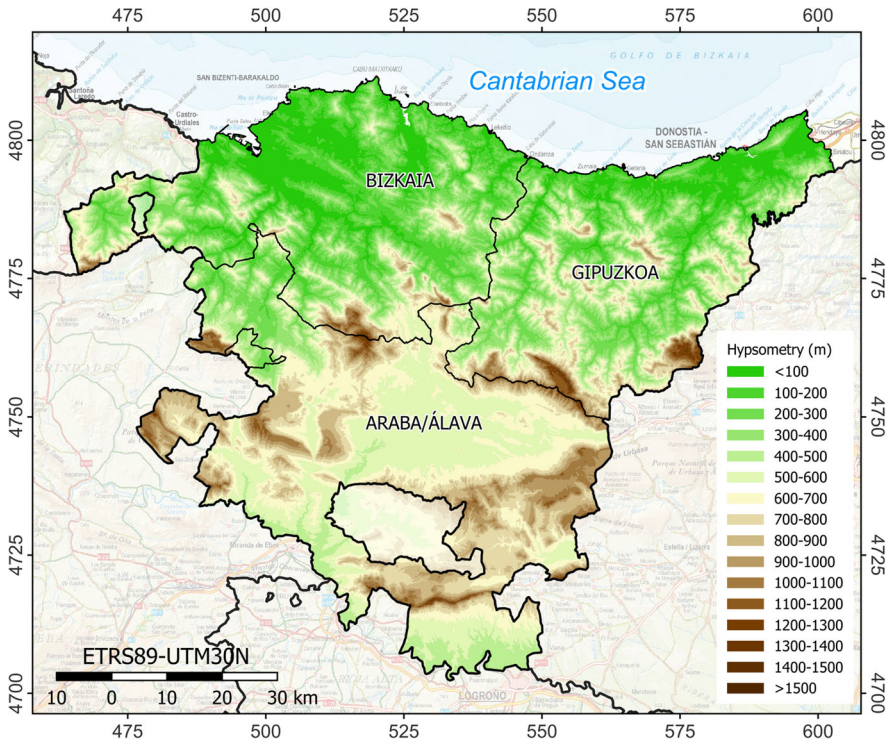

Fig. 2 Relief map of the study area. Own elaboration from geoEuskadi (2023) and Instituto Geográfico Nacional (2024a). Frame coordinates in km

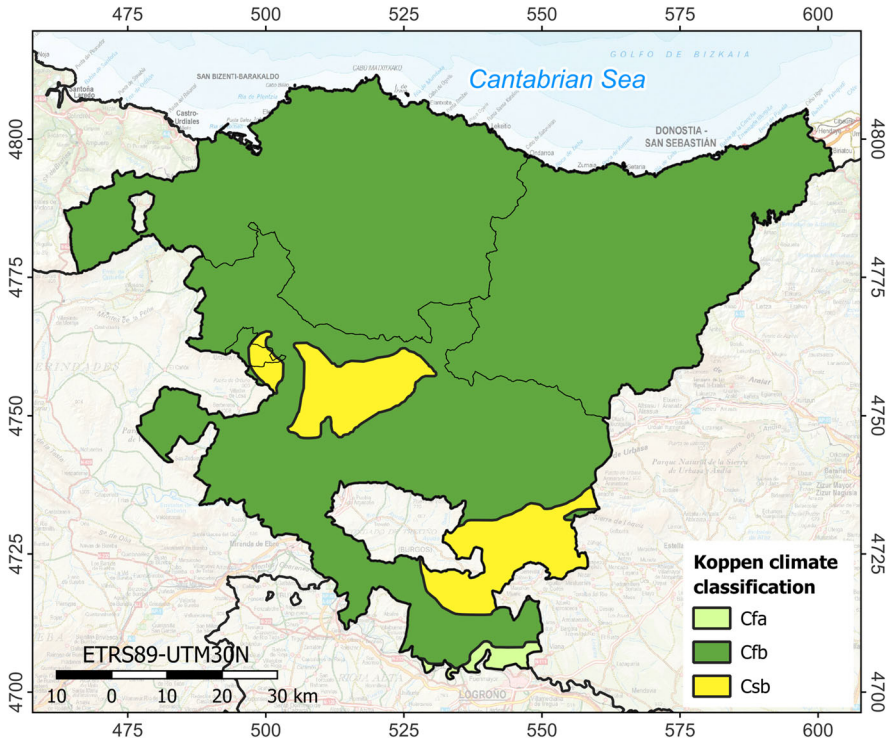

Fig. 3 Koppen climate classification. C: temperate climate; f: no dry season; s: dry summer; a: hot summer; b: warm summer. Own elaboration from (Instituto Geográfico Nacional, 2024b) and Instituto Geográfico Nacional (2024a). Frame coordinates in km

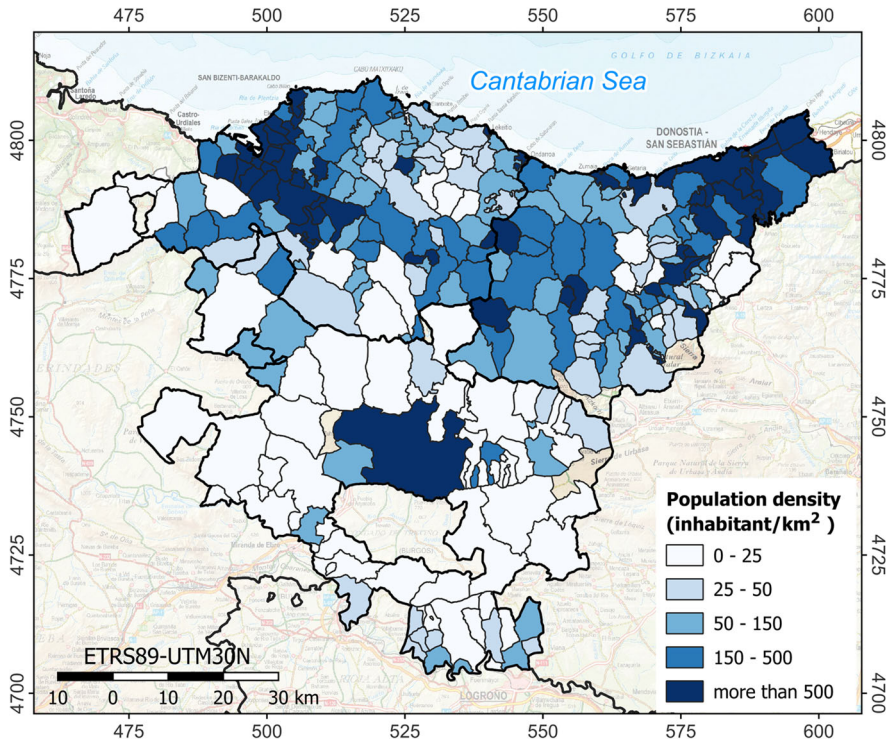

Fig. 4 Population density. Own elaboration from geoEuskadi (2023) and Instituto Geográfico Nacional (2024a). Frame coordinates in km

fast-growing species such as pine. In Álava, agricultural plains and vineyards dominate in the Rioja Alavesa, interspersed by the Montes Alaveses, with extensive masses of Mediterranean oak and holm oak groves (Palacios-Agundez, 2011).

In this environment, the communication infrastructures in the Basque Country have developed historically encouraged and conditioned by its strategic location as a passage to the continent and by the need to transport goods between the main seaports and the central plateau (*Meseta*) in the context of the Iberian Peninsula (Castillo and Valdaliso, 2017). This location, together with the agricultural poverty of the maritime provinces and part of the interior, in addition to its status as a free-trade zone, and the availability of hydraulic, mining, and forestry resources, determined the specialization of the Basque economy in the activities of trade, transport, mining, and industry (Valdaliso Gago, 2013).

Linguistically, within the geographical scope of this study, two languages coexist with equal status: the Spanish language (Castilian) and the Basque language (*Euskera*). This matter directly affects toponymy both in its origins and its development. These languages belong to different lineages, creating a considerable distance between them (Sanchez, 1974). Additionally, their situation is asymmetrical insofar as, according to the UNESCO Atlas of the World's Languages in Danger and the European Charter for Regional or Minority Languages, the Basque language is a marginalized and vulnerable language within its territory (Council of Europe, 1992).

Throughout history, the peoples inhabiting the area have named and transformed the territory, adapting names previously in existence to the usage of their language at each moment, thus bearing witness to past linguistic realities. García Sánchez (2023) discusses the etymon's original language and the toponym's receiving language, "corresponding to the most current linguistic stratum of the territory where they are found". A significant portion of the toponymic corpus in the study area, especially in minor toponymy, is the Basque language (i.e., from the Euskera language). However, language policies developed in more recent history have influenced the names on official cartography, resulting in toponyms in both languages, and the distribution of languages is not geographically homogeneous. The competencies to provide official status to geographic names are complexly distributed, whereas in terms of standardization, the Basque Language Academy (*Euskaltzaindia*) (Euskaltzaindia, 2023) is the sole

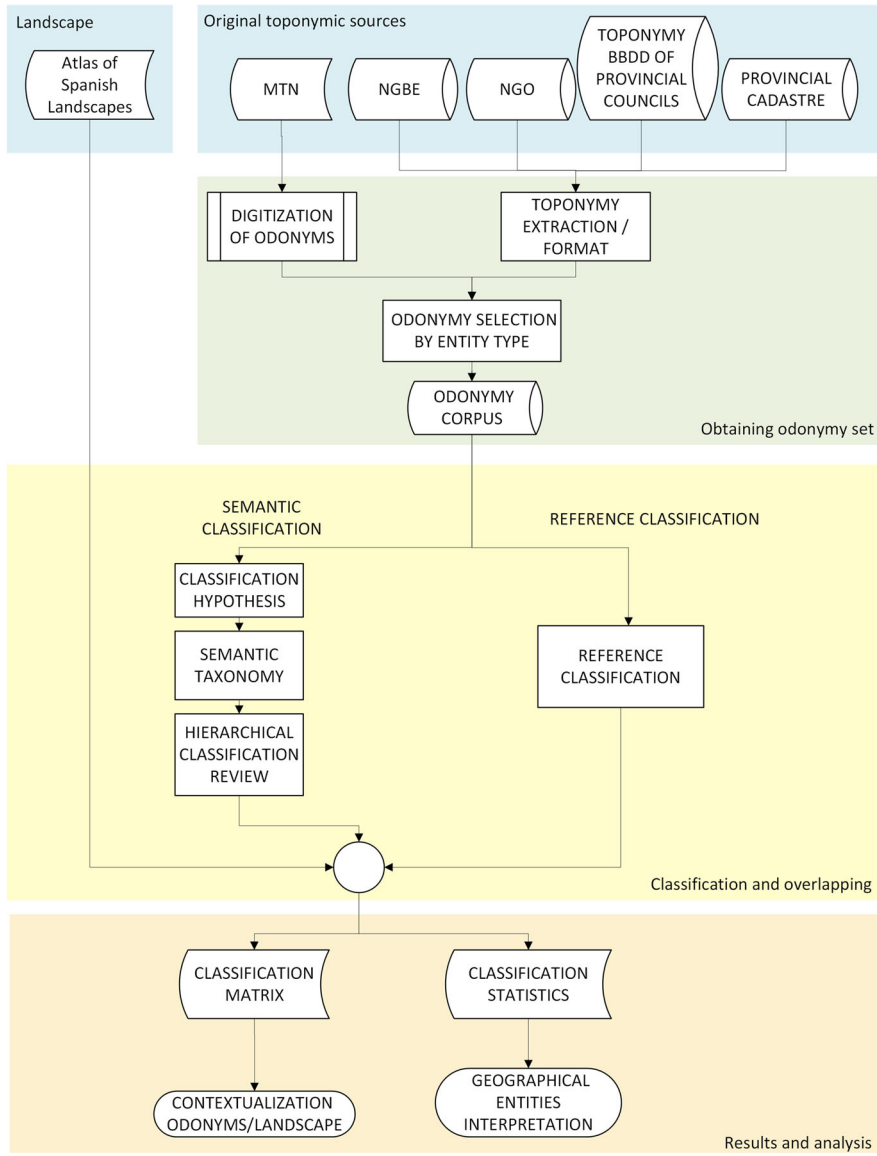

Fig. 5 Flowchart. Own elaboration

advisory board (Article 10 of Law 10/1982, of November 24, the fundamental law for the standardization of the use of Basque language).

Materials and methods

Following the principles of toponymic study methodologies with a geographical focus (Tort-Donada, 2022), attention will be given to the semantics, distribution, and interrelationships of place names. Typically, the structure of a place name is formed by a generic part that identifies the type of named geographical element and another specific part for each element, ”Calleja Albar” SPA (”White Pathway”). If the specific part alludes to another existing geographical entity, it is known as a referential toponym, for example, ”*Farolako bidea*” EUS [4] (”Lighthouse Pathway”). Our work addresses two types of classification: one based on this referential element, if it exists, and another based on the semantic content of the specific name. Finally, the relationship between the distribution of these names and different landscape characterization variables will be analyzed using GIS tools (Fig. 5). The two prepared classifica-

[4] ISO 639-2 language code for Basque

tions will offer different avenues for interpreting the relationship between toponymy and landscape.

The tools used were Extract, Transform, Load (ETL) and GIS tools; QGIS (www.qgis.org) in its version 3.30.0- s-Hertogenbosch was used as GIS tool, while FME software was used as ETL tool, specifically FME© Desktop 2021.2 (https://www.safe.com/fme/fme-desktop/) and, alternatively, the graphical process modeler of QGIS 3.30.0- s-Hertogenbosch itself.

Data sources on landscape

Spain ratified the ELC on November 26, 2007 (BOE of February 5, 2008), which entered into force on March 1, 2008. Similarly, the regional Basque Government agreed to adhere to this convention in 2009. To promote its development, five years later, it approved Decree 90/2014 on the protection, management, and planning of landscapes in the territorial planning of the Autonomous Community of the Basque Country as a tool to fulfill the objective of integrating landscapes into territorial planning. Therefore, with a well-established legal and administrative framework, both the definition of landscape and the instruments for its management are established, such as the *Atlas de los Paisajes de España* (Atlas of Spanish Landscapes) (Sanz Herráiz and Mata Olmo, 2003) at the national level and the Landscape Catalogs, Landscape Determinations, Landscape Action Plans, and Landscape Integration Studies for the autonomous community. The *Atlas de los Paisajes de España* is a study aimed at characterizing and identifying landscapes, providing an exhaustive classification of the territory by establishing a scalar taxonomy of landscape types. The project began in 1998 and was published in 2003. The last update of cartographic information dates back to August 2010. The regional Landscape Catalog of Euskadi also offers a homogeneous cartographic base in the study area for analysis. This tool includes evaluating and classifying landscapes in each functional area of the territory. Additionally, it integrates a set of descriptive chapters to identify landscape units, analyze their characteristics and values, as well as propose objectives for landscape quality for each unit. Furthermore, the geographical information materializes in a data set called "Cartography of the draft of the Catalog of Unique and Outstanding Landscapes of the Autonomous Community of the Basque Country at a scale of 1:25,000 (year 2005)" (IKT and PAISAIA, 2023).

This cartographic work results in a mosaic of 5604 landscape units, comprising 64 landscape units within the Basque Country as a whole. For the present regional scope study, the taxonomic scale provided by the aforementioned *Atlas de los Paisajes de España* proves suitable. Within this study's scope, this cartographic work presents a mosaic of 72 landscape units, grouped into 47 classes of landscape units, as depicted in the following Table 1 and illustrated in Fig. 6. In order to use a more compact list that facilitates an integrated interpretation of the data, a synthetic classification of 12 types of landscapes is alternatively chosen, as depicted in Table 2.

Data sources on toponymy

Concerning official cartography and geographic information in the study area, Spanish legislation outlines a scheme of competencies distributed among the different levels of administration. These competencies are distributed according to scale: from smaller scales for national coverage projects to the highest degree of detail for local projects. The geographic information production activity is coordinated among the administrations through an action model called the *Sistema Cartográfico Nacional* (Spanish National Cartographic System) (González Matesanz et al., 2015). One of its tasks is the coordination between administrations in the treatment of official and standardized toponymy. Consequently, for the present study, the toponymic sources of the administrations that provide services in the territory are used: national, autonomic (regional), and provincial (Batlle, 2023). The coordination between local and regional entities also allows the results of local toponymic works to be reflected in the regional database, which facilitates the integration of local knowledge.

Therefore, the combination of different sources requires a process of data harmonization. This harmonization of study data serves a dual purpose: firstly, integrating the toponymy from various sources, and secondly, establishing a format that enables the maintenance of the toponymic corpus while reflecting the traceability of each element. Thus, a dataset containing essential information will be formed, preserving the link to the original information to retrieve addi-

Table 1 Classification of landscape units

CODE	Landscape unit
11.01	Eastern Obarenes Mountains
11.11	Ordunte and Valnera Mountains
11.12	Salvada and Orduña Paramera Range
11.13	Gorbea Mountains
11.14	Urkiola Mountain Range
11.15	Urkilla and Aitzgorri Mountain Ranges
11.16	Aralar Mountain Range
11.17	Urbasa and Andía Mountain Ranges
11.18	Lóquiz and Valdellín Mountain Ranges
11.19	Izquiz Mountain Range
11.20	Codés Mountain Range
11.21	Cantabrian Mountain Range
11.22	Badaia Mountain Range
11.23	Arkamo-Sopeña Mountain Range
11.24	Devaldere]o-Valdegovia Mountain Ranges
114.02	Cantabrian Islands and Islets
29.01	Payueta-Peñacerrada Mountains
29.02	Mountains, Valleys, and Hills of Treviño
29.03	Vitoria Mountains
29.04	Mountains and Valleys between Deba and Orla
29.05	Mountains and Valleys of Middle Ibaizabal
29.06	Mountains and Valley of Igorre
29.07	Mountains and Valleys of Las Encartaciones and Guriezo
29.08	Mountains and Valleys of Balmaseda-Arceniega
29.16	Mountains of Arantza
29.17	Mountains and Valleys of Leizarán
29.18	Mountains and Valleys of Oiartzun and Bajo Bidasoa
37.03	La Llanada Alavesa
37.04	Miranda de Ebro Plain
37.07	Mena Valley
43.02	Ega Valley
52.03	Countryside between Oja and Najerilla
52.04	Vineyards of La Rioja Alta
52.06	Vineyards of La Rioja Alavesa
66.06	Upper Miera Valley and Asón Valley
71.01	Nervión Valley
71.02	Deba and Ibaizabal Valley in Durango-Eibar
71.03	Deba Valley between Escoriaza and Bergara
71.04	Orla Valley between Andoain and Beasain
83.02	Ebro Canyons between Trespaderne and Oña

Table 1 continued

86.01	Bilbao Estuary
89.01	Bay, estuaries, and coastal mountains of Eastern Gipuzkoa
89.02	Guernica Estuary
90.06	Marina of Castro Urdiales-Laredo
90.07	Plains, valleys, and coastline between Bilbao Estuary and Oka River
90.08	Plains, valleys, and coastline between Oka and Deba Rivers
90.09	Plains, valleys, and coastline between Deba and Orla Rivers

tional data if necessary. For this purpose, the source will be encoded, field names will be standardized, and the date of data acquisition will be recorded. Geometrically, a point-based database will be chosen, comprising original geometry for point elements and extraction of centroids for linear or surface features.

National level: NGBE and First edition of the National Topographic Map (MTN) at a scale of 1:50,000

In the geographical area chosen for the study, the Autonomous Community of the Basque Country or Euskadi, the first MTN coverage, in this case at a 1:50,000 scale (MTN50), was published from 1929 to 1944 (Urteaga González, 2001). The density of road labeling seems to be conditioned by cartographic criteria and, in areas where human activity offers a greater number of representation elements (Rosselló i Verger, 2004), the graphic possibilities of labeling are fewer. In addition, the methodology used for the topographic survey also conditions the quality of the toponymic survey, as will be explained later. Finally, the roads are structuring elements of the planimetric survey itself.

The digitization process of analogic cartography undergone in order to obtain the National Topographic Base, *Base Topográfica Nacional* (BTN), specifically

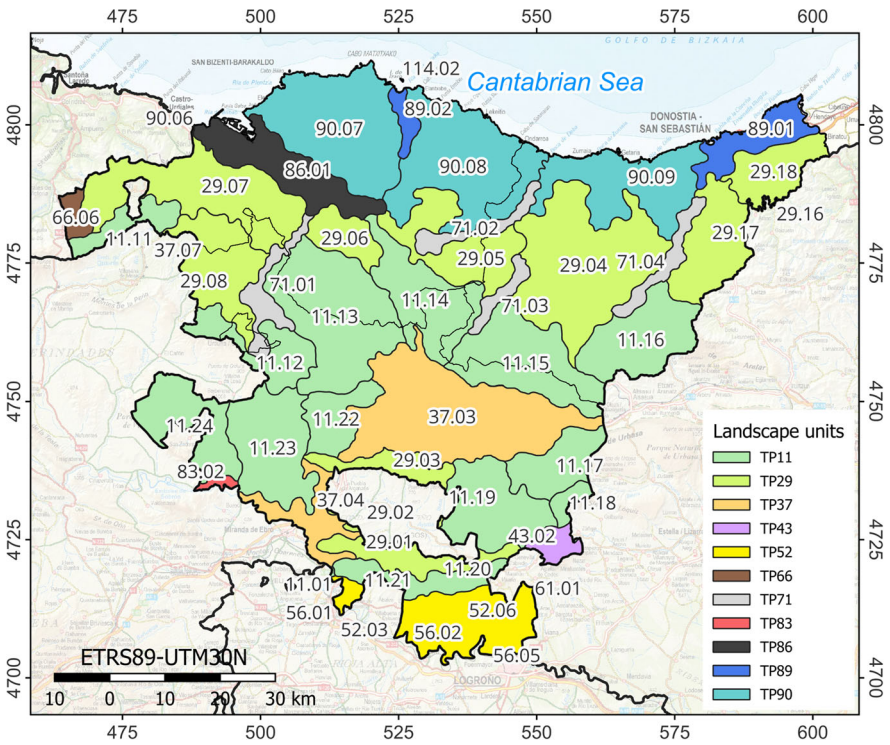

Fig. 6 Distribution of landscape units, including their types. Own elaboration based on geographic information from the *Atlas de los Paisajes de España* (Sanz Herráiz and Mata Olmo, 2003) and Instituto Geográfico Nacional (2024a). Frame coordinates in km

Table 2 Classification of landscape unit types

Code	Landscape type	km^2
TP11	Eastern mountain ranges and plateaus of the Cantabrian Range, Basque, and Navarrese mountains	2501.09
TP29	Basque mountains and valleys, Treviño County, and Navarrese Pyrenees	2180.16
TP37	Basque, Navarrese, and Cantabrian depressions	716.21
TP43	Cantabrian-Pyrenean corridors	44.10
TP52	Ebro Depression countryside	273.54
TP66	Cantabrian intramountain valleys	33.30
TP71	Basque industrial valleys	241.50
TP83	Upper Ebro canyons and gorges	11.46
TP86	Large cities and metropolitan areas	218.67
TP89	Cantabrian-Atlantic estuaries and bays	157.57
TP90	Cantabrian coastal marinas, mountains, and valleys	1129.44
TP114	Other Atlantic islands and islets	0.23

Own elaboration based on geographic information from the *Atlas de los Paisajes de España* (Sanz Herráiz and Mata Olmo, 2003) and Instituto Geográfico Nacional (2024a)

of the MTN in this case, cannot be ignored. Due to technical issues and difficulties of recognition, some of the names of linear elements were omitted in this process. To all intents and purposes, this means the loss of the toponym that has not been automatically recognized, which can only be corrected by manual digitization. Linear toponyms are especially sensitive in the process of digitizing and automatic recognition for the following reasons: the non-concatenation of characters of labels that develop along the geographic element; the orientation is not horizontal but is also arranged according to the geometry of the element; the filling with backgrounds and surface patterns of the map; and the impossibility of differentiating names of pathways with respect to water courses and other linear labels. After observing the failure in the automatic emptying of labels of linear elements, it has been decided to digitize the pathway labels manually. For all these reasons, both the odonymy of the BTN and the *Nomenclátor Geográfico Básico de España* (NGBE), Basic Geographical Gazetteer of Spain, and the set of digitized pathway names from the first edition of the map are handled in a combined way.

Regional level: Official Geographic Gazetteer of the Basque Country (NGO)

The toponymic corpus of the Basque Government acquired its current status through Decree 179/2019, dated November 19, regarding the standardization of institutional and administrative use of official languages in local institutions of the Basque Country under the European Charter for Regional or Minority Languages, ratified by Spain in 2001 (*Boletín Oficial del País Vasco*, Official Gazette of September 15, 2001). This regulation establishes the Official Geographical Gazetteer of the Autonomous Community of the Basque Country, *Nomenclátor Geográfico Oficial de la Comunidad Autónoma del País Vasco* (NGO), respecting competencies in linguistic normalization and the formalization of place names (Ugarte Garrido, 2021). This database originates from previous work collecting geographic names with a solid linguistic focus (Agirregoikoa, 2011). The gazetteer is linked to the harmonized topographic base at a 1:5000 scale, leveraging the geometric quality of this product for the study.

Provincial Level. Historical Territories: Geographical information 1:5000 and foral cadastres

Due to the historical particularity in the distribution of competencies, the three historical territories (Álava, Bizkaia, and Gipuzkoa) have developed cartographic tasks independently (Gómez Piñeiro and Sáez García, 1991), but with a common working scale of 1:5000. There is no vocational toponymic database, but toponymy is part of the information contained in such cartography. In addition, taking into account that the three provincial councils have competencies in cadastre, we want to take into account the place names con-

tained in this dataset since they have had a differentiated treatment and, as far as we know, have not served as a source for the creation of official gazetteers of any level of administration. In spite of seeking homogeneity in data coverage, it should be noted that, in the case of Bizkaia, the cadastral database lacks toponymic information.

Local Works

As outlined in the description of the study area, this territory has two co-official languages. Consequently, toponymy inevitably garners relevant interest both in the public sphere and within the administration, as well as among researchers. Hence, numerous local toponymic studies have been conducted (Mujika Ulazia, 2010), including examples of municipal or regional studies (Arbizu Varona, 2016; Elosegui Irazusta, 1969; Líbano Zumalacárregui, 2003; Sainz Echeverría, 1996). Since 2011, the regional government has promoted the creation of local toponymic maps following standardized procedures and characteristics (geoEuskadi, 2014). The content of these projects serves as the primary source for the review, updating, and enhancement of regional and local databases.

Selection of the odonymy in the complete toponymic corpus

The object of this study is not general but focuses on the place names of the roads and pathways, so-called odonyms. This sectorial approach allows us to target the interpretation in a more specialized way. Therefore, it is necessary to extract the entities representing traditional communication routes from the complete set of names, or in other words, the names of the roads must be selected. Given the heterogeneous nature of the sources, the catalog of entities is different in each dataset, making the use of ETL tools essential.

The combination of toponymic sources within the same territory involves analyzing the redundancy between databases. In this case, an automatic cross-check would be performed to mitigate this effect (Mitxelena-Hoyos and Amaro-Mellado, 2023). The graphical result of this selection of linear elements is shown in Fig. 7.

On the other hand, when the geographic information has undergone a higher degree of generalization, as is the case of national cartographic series, it is common to use the *paraje* site type, defining an extension of territory with similar characteristics, as a resource for unknown classification labels. Therefore, the existence

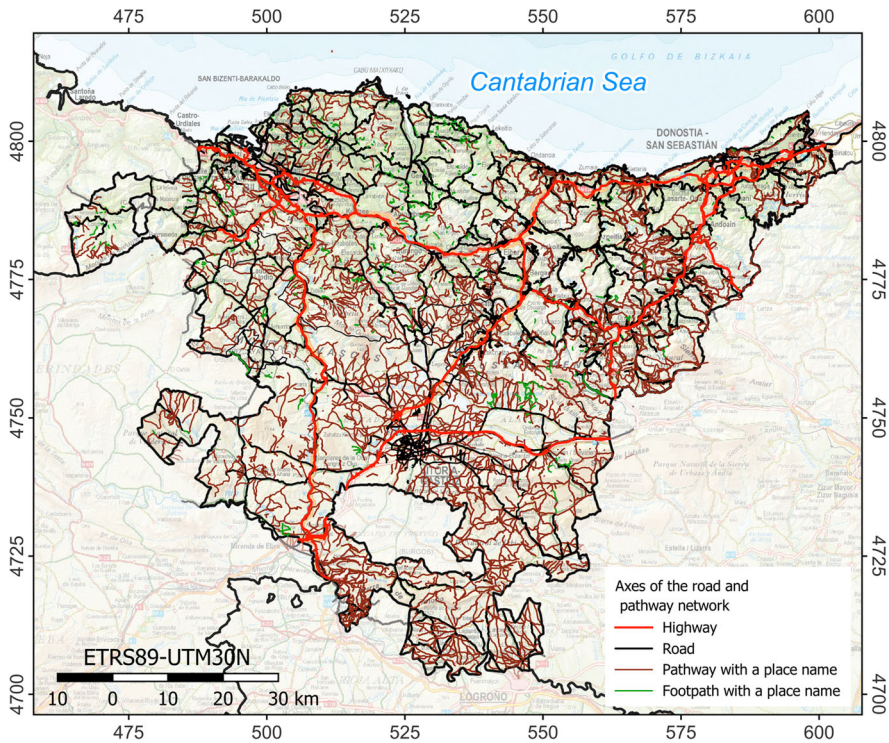

Fig. 7 Representation of pathways which have associated odonyms in the toponymic corpus. On occasion, a road with two separate lanes may appear to be a single road with double the width. Own elaboration from Instituto Geográfico Nacional (2024a), geoEuskadi (2023), and provincial governments. Frame coordinates in km

of places that explicitly contain the term "*camino*" SPA and "*bide*" EUS (pathway) as a generic part of the name will be verified. This fact implies differentiating these lexemes from the lexicalized etymons, which are already part of the specific part of the name. For this purpose, the position of the particles searched for in the string of characters that make up the complete toponym is analyzed. This result must be supervised.

On another note, given that linguistic standardization of Basque onomastics is relatively recent, current cartography includes non-standardized terms and even spellings that represent the oral variant of names. For instance, in Basque toponyms, it can be found "*kamino*" as a non-standardized graphical adaptation, or the lexeme "*kamio*," which is valid for this odonym extraction, albeit slightly different in meaning (Gorrotxategi Nieto, 2022). The semantic difference between the two lexemes, "*bide*" and "*kamio,*" lies in the former having a more general use, while the latter refers explicitly to a main road.

Classification of odonyms

Frequently, classification methods are closely related to each author's conceptual framework. For instance, Perono Cacciafoco and Cavallaro (2023) outlined different classification proposals historically used from the mid-20th century to the present, based on naming strategies within semantic blocks. Another perspective is offered by Santos Mansilla et al. (2023), who argue that the classification also relies on the conceptualization of the territory by its inhabitants. Considering the numerous possibilities offered by toponymic classification, a combination of two different perspectives has been chosen: one based on referential elements and another on semantic classification. These two classifications will complement each other in interpreting the results.

Grouping of odonyms based on the type of reference element

The etiology of the names of the roads and pathways can be very varied: among others, names that refer to their use, their morphological characteristics, and related landscape elements. On occasions, when the name of the road itself refers to the places it links, whether it is the origin, destination, or even an intermediate element "*Camino Vecinal del Alto de Gainza por Lejar a Utarte-Berri*" SPA ("Neighborhood Pathway from Alto de Gainza through Lejar to Utarte-Berri"), we can speak of a referential component in the name. In these cases, the road's name serves as an indication of direction so that, although its onomastic value is questionable, they collaborate in forming the mental representation of the spatial information of this territory (Reszegi, 2020). These reference landmarks can belong to both physical geography and human geography. In the case of physical geography, they can be, among others, oronyms like mountain peaks or mountain passes and hydronyms like streams or springs. Regarding human geography, the most common instances are urban centers, but functional destinations are also found-places where agricultural tasks or industrial activities take place, among others.

After reviewing the dataset, the classification is designed to make it exhaustive, logically ordered, and discriminating in as much detail as possible. Hierarchical classification is drawn at two levels of disaggregation in order to facilitate subsequent analysis. The classification concepts are included in the Table 3:

Grouping of the odonyms with semantic criteria

Onomasiology deals with the analysis of the lexicon of a language from its meanings. The semantic component of the name is related to the characterization of the landscape. In order to take this information into account, the transparency of the name is essential. Therefore, we must be able to understand its meaning, or, in other words, we need the semantic relationship between a lexeme and a reality in the language in which they are expressed to have reached our days. In the toponymic corpus analyzed, transparency is maintained in a large proportion. For this reason, it is even possible to identify dynamics in the landscape due to the lack of concordance between the semantic content of some names and the nominated reality. On occasions, it has been necessary to review the bibliography to fully understand borrowings from the past, traditions, or professions that have been lost. Language dictionaries (Lakarra et al., 2023; Real Academia Española, 2023) and geographical dictionaries (Departamento de

Table 3 Classification of place names based on their referential element

Theme	Type of referential element
CR00- Without references	CR0000 No referential elements
CR01- Population	CR0101 Population centers
	CR0102 Hamlet
CR02- Physical geography	CR0208 Reference to an orographic element
	CR0209 Reference to hydrographic element
CR03- Economic activities	CR0303 Place intended for industrial and traditional activity
	CR0310 Reference to an agroforestry exploitation
CR04- Communications	CR0412 Reference to an architectural element of the road
	CR0414 Reference to a road
CR05- Cultural	CR0505 Reference to a religious geographic element, architecture
	CR0506 Place with architectural value

Cultura, 2001; Rebolé Del Castillo, 2003) have also been consulted.

The initial semantic classification was completed by taking into account other works with the same subject matter: (Atik et al., 2022; Sousa and Garcia Murillo, 2001). Subsequently, a reading of the database was carried out in order to adapt the semantic groups to the existing casuistry in the study area. On certain occasions, geographic contextualization is essential to understand the meaning, so the review is undertaken using GIS tools. Each semantic group is shaded so as to reflect the completeness of the classification, as shown in Table 4.

Table 4 Semantic classification of odonyms

Class	Semantic subclass
CS01- Settlement	CS0101- Isolated buildings (farmhouses, huts)
CS02- Physical geography	CS0208- Orology
	CS0209- Hydrology
	CS0220- Geology (mineral)
CS03- Economic activities	CS0301- Land use
	CS0303- Economic exploitation
	CS0304- Functional destinations
	CS0307- Traditional professions or tasks
	CS0310- Phytonymy (agricultural, forestry, land use)
	CS0311- Zoonymy (agricultural activity)
CS04- Transport	CS0417- Pathway
	CS0412- Tautologies or unique elements of the road
	CS0413- Descriptors of the road
	CS0414- Isolated generics
CS05- Culture	CS0516- Personal names
	CS0505- Religious not constituting population centers
	CS0506- Historic buildings or monuments
	CS0518- Historical landmarks or terms
CS99- Unclassified	CS9999- Opaque terms. No information
CS00- Population centers	Without semantic interpretation

Combining placenames with landscape classification

Once all the original data has been processed, the information layers are combined to geometrically compare the distribution of toponymic data concerning the superficial layer information from the landscape catalog. The method used involves attribute combination by overlaying the layer of point-based toponymic elements onto the superficial layer of landscape classification using the GIS. Through this combination, the frequency of each combination can be calculated, forming a matrix of frequency distribution. Given that the classifications proposed for both landscape classification and toponymic classifications -referential and semantic- have different levels of disaggregation, two types of outputs are proposed according to this level, allowing for different types of result analysis.

Results and analysis

This section first presents the direct results of classifying the odonyms according to the established criteria. Next, the results of the combination of the two entries, toponymy and landscape, are presented. Once the original information has been processed, an overall descriptive analysis is carried out. Still, it is necessary to go into detail in situations of special interest. This interpretation is illustrated through examples.

Furthermore, in order to optimize the descriptive analysis, a suitable statistical index is required. Therefore, in addition to the frequency, the density of toponyms in each type of landscape is used. In this analysis, values obtained are related to the characteristics of each data set. In this way, the relationship between the characteristics of each landscape unit and the place names classified in that environment becomes evident.

Results and analysis of the referential classification

The referential classification gives information on which geographic element was highlighted as a reference to identify the access or passage route. This classification's results are shown in Table 5 and in Fig. 8. Unquestionably, population settlements are an important focus, in addition to economic activities, which are always closely related to primary activity.

With respect to the settlement, it is clear that the longer roads connect to population centers. Contrariwise, the more local pathways provide access to smaller settlements, or hamlets (*caseríos* SPA or *baserriak* EUS), which is the traditional form of dispersed settlement on the Cantabrian side of the study area. There are also a notable number of references to buildings

Table 5 Results of the classification of place names based on their referential element

Theme	Type of referential element	
CR00- Without references	CR0000 No referential elements	485
CR01- Population	CR0101 Population centers	1490
	CR0102 Hamlet	153
CR02- Physical geography	CR0208 Reference to an orographic element	408
	CR0209 Reference to a hydrographic element	130
CR03- Economic activities	CR0303 Place intended for industrial and traditional activity	126
	CR0310 Reference to an agroforestry exploitation	64
CR04- Communications	CR0412 Reference to an architectural element of the pathway	30
	CR0414 Reference to pathways	11
CR05- Cultural	CR0505 Reference to a religious geographic element	158
	CR0506 Place with architectural value	17
TOTAL		3072

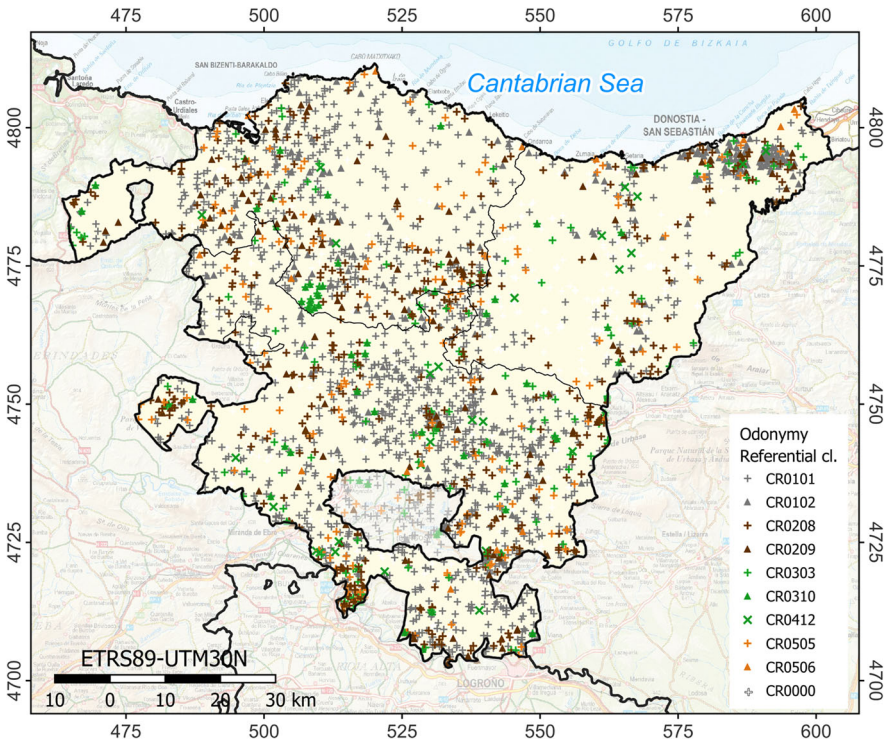

Fig. 8 Referential classification of odonyms. Own elaboration from Instituto Geográfico Nacional (2024a). Frame coordinates in km

of industrial activities such as weaving mills, mills, and forges, whose layout depends on the water courses, making them a destination for transport in two directions: the arrival of raw materials and manufacturing output.

Results and analysis of the semantic classification

The main difference between referential and semantic classification lies in the names of population settlements, where the reference is clear. Nevertheless, the name can have diverse origins: for example, a historical essence, political connotations, or connections with local lineages and onomastics. Therefore, these settlements have been excluded from the semantic classification, except for those that contain some explicit allusion to population settlements, such as "*Camino de las Chozas*" SPA ("Pathway to the huts") or "*Camino a los caseríos*" SPA ("Pathway to the hamlets"). As a result, 1411 names have been excluded from semantic interpretation. The results of this classification are presented in both Table 6 and Fig. 9.

Compared to the rest of the categories, numerous elements coincide equally in both modes of classification, such as "*Putzueta bidea*" EUS (Path of the wells); the reference and their semantic value are related to hydronyms. However, there are other cases where the semantic and referential essence differ. For instance, "*Camino Viejo de San Martín*" SPA ("Old San Martin Pathway") holds a religious reference but also a descriptive semantic aspect. Interestingly, in the section related to semantic classification linked to geology, there are numerous oronyms featuring characteristics of crags or rocky formations, often associated with geomineral exploitation, like "*Artxipi bidea*" EUS ("Path of small rock") referencing a quarry or "*Buztinzuri bidea*" EUS ("Path of white clay").

Results and analysis of the landscape-odonymy crossover

Once the frequency data for each type of name in the different landscapes are obtained, they are displayed in Table 7 for the landscape type aggregation level arranged for the classification of the name references. Descending to the level of disaggregation of landscape units, the matrix of results acquires such a volume that the representation employing a map is more compre-

Table 6 Semantic classification of odonyms

Class	Semantic Subclass	
CS01- Settlement	CS0101 Isolated buildings	17
CS02- Physical geography	CS0208 Orology	120
	CS0209 Hydrology	55
	CS0220 Geology	102
CS03- Economic activities	CS0301 Land use	77
	CS0303 Economic exploitation	52
	CS0304 Functional destinations	20
	CS0307 Traditional professions or tasks	60
	CS0310 Phytonym	171
	CS0311 Zoonym	64
CS04- Transportation	CS0417 Pathway	49
	CS0412 Tautologies or unique elements of the road	9
	CS0413 Descriptors of the road	391
	CS0414 Isolated generics	19
CS05- Culture	CS0516 Personal names	16
	CS0505 Religious	155
	CS0506 Historic buildings or monuments	16
	CS0518 Historical landmarks or terms	2
CS99- Unclassified	CS9999 Opaque terms	262
CS00- Population centers	CS0000 No semantic interpretation	1411
TOTAL		3072

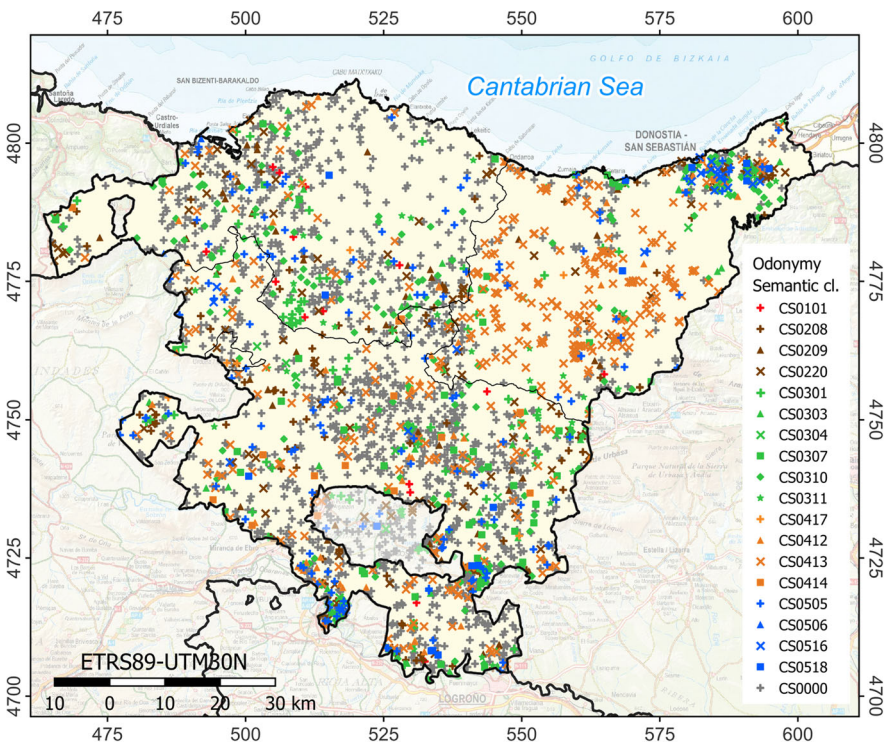

Fig. 9 Semantic classification. Own elaboration from Instituto Geográfico Nacional (2024a). Frame coordinates in km

Table 7 Distribution of odonyms, classified according to the referential element and by landscape units

	CR00	CR01	CR02	CR3	CR04	CR05	**TOTAL**
TP11	160	456	210	79	8	60	973
TP29	156	394	144	39	12	42	787
TP37	45	340	38	24	8	14	469
TP43	8	9	8	2	5	3	35
TP52	34	114	58	14	1	15	236
TP66	1	3	3	6	0	0	13
TP71	27	36	9	3	1	6	82
TP83	0	1	0	0	1	0	2
TP86	6	60	11	7	0	7	91
TP89	18	57	13	8	2	8	106
TP90	30	173	44	8	3	20	278
TOTAL	485	1643	538	190	41	175	3072

hensible (Fig. 10). In the same way, Table 8 and Fig. 11 are arranged for the semantic classification.

In order to obtain comparable results and find the maximum intensity of occurrence of a semantic phenomenon in a specific type of landscape, the density of occurrence is calculated from the frequencies of the semantic classification. The reading of this Table 9 and its disaggregated version will allow us to focus on the cases in which the density is anomalous, either due to abundance or scarcity. Although this indicator is not dimensionless, it has been decided to approach the analysis by keeping the information for each volume.

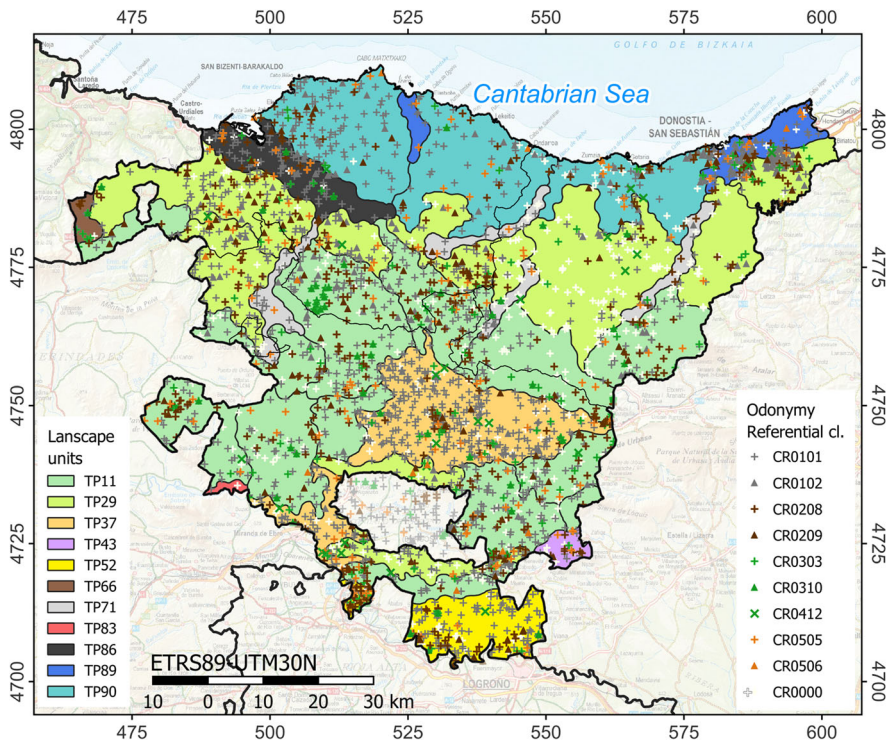

Fig. 10 Distribution of odonyms, classified according to the referential element, by landscape units. Own elaboration based on geographic information from the *Atlas de los Paisajes de España* (Sanz Herráiz and Mata Olmo, 2003) and Instituto Geográfico Nacional (2024a). Frame coordinates in km

Table 8 Distribution of odonyms, classified according to the semantics, by landscape units

	CS01	CS02	CS03	CS04	CS05	CS99	CS00	**TOTAL**
TP11	9	62	189	134	57	102	419	972
TP29	3	39	150	164	51	64	316	787
TP37	2	16	54	58	14	23	310	477
TP43	0	2	5	5	4	4	8	28
TP52	2	25	48	19	22	13	106	235
TP66	0	1	14	0	2	0	3	20
TP71	1	4	9	33	4	3	26	80
TP83	0	0	0	1	0	0	1	2
TP86	0	6	13	6	7	5	52	89
TP89	0	10	32	11	17	14	22	106
TP90	0	10	32	37	15	34	148	276
TOTAL	17	175	546	468	193	262	1411	3072

Overall considerations

Firstly, the observation of the data makes it unavoidable to focus on one of the sources of information used, which is the digitalization of the first edition of the MTN50. Out of the 1806 toponyms digitized from this historical cartography, 1222 correspond to populated places from where the pathway starts or to where it goes, which represents 68.7%. In contrast, in the rest of the databases, the proportion remains at 33% (426 of 1277). These places or urban centers can have different characteristics: small population centers formed by a group of houses around a church or hermitage, which is a common form of settlement in the *Llanada Alavesa*,

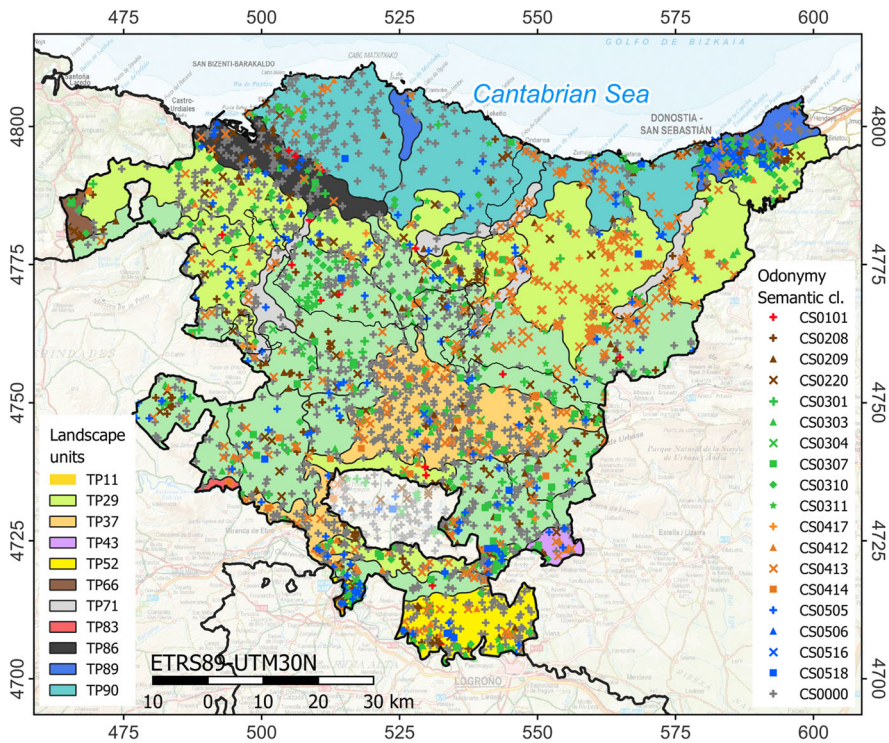

Fig. 11 Distribution of odonyms, classified according to the semantic value, by landscape units. Own elaboration based on geographic information from the *Atlas de los Paisajes de España* (Sanz Herráiz and Mata Olmo, 2003) and Instituto Geográfico Nacional (2024a). Frame coordinates in km

Table 9 Odonyms density by landscape unit

	CS01	CS02	CS03	CS04	CS05	CS99	CS00	TOTAL
TP11	0.4	2.5	7.6	5.4	2.3	4.1	16.8	38.9
TP29	0.1	1.8	6.9	7.6	2.3	2.9	14.5	36.1
TP37	0.3	2.2	7.5	8.1	2.0	3.2	43.3	66.6
TP43	0.0	4.5	11.3	11.3	9.1	9.1	18.1	63.5
TP52	1.1	9.1	17.5	6.9	8.0	4.8	38.4	85.9
TP66	0.0	3.0	27.0	0.0	6.0	0.0	9.0	45.0
TP71	0.4	1.7	3.7	13.7	1.7	1.2	10.8	33.1
TP83	0.0	0.0	0.0	8.7	0.0	0.0	8.7	17.5
TP86	0.0	2.7	5.9	2.7	3.2	2.3	23.8	40.7
TP89	0.0	6.3	20.3	7.0	10.8	8.9	14.0	67.3
TP90	0.0	0.9	2.8	3.3	1.3	3.0	13.1	24.4

or Mediterranean slope; or hamlets or groups of hamlets in areas of Gipuzkoa and Bizkaia, or Cantabrian slope (Fig. 12), with greater dispersion of the population.

Continuing with the oldest dataset analyzed (sheets published between 1929 and 1944) (Urteaga González, 2001), the distribution of these labels is not homogeneous throughout the territory. While in Álava, there are abundant labels referring to population settlements, this type of labeling is scarcely found in Gipuzkoa. The explanation for this difference lies in the methodology used to prepare this historical cartography. Whereas in Álava and Bizkaia, it was completed by classical topography, Gipuzkoa was surveyed by photogrammetry. The latter reduces the volume of field work and, therefore, the possibility of collecting toponymic information by means of oral surveys. These differences are illustrated in Fig. 13.

The cases in which these labels, which indicate destinations of population settlements, can provide a specific value are those in which the road route goes beyond two neighboring towns, linking more distant destinations and usually with greater importance, such

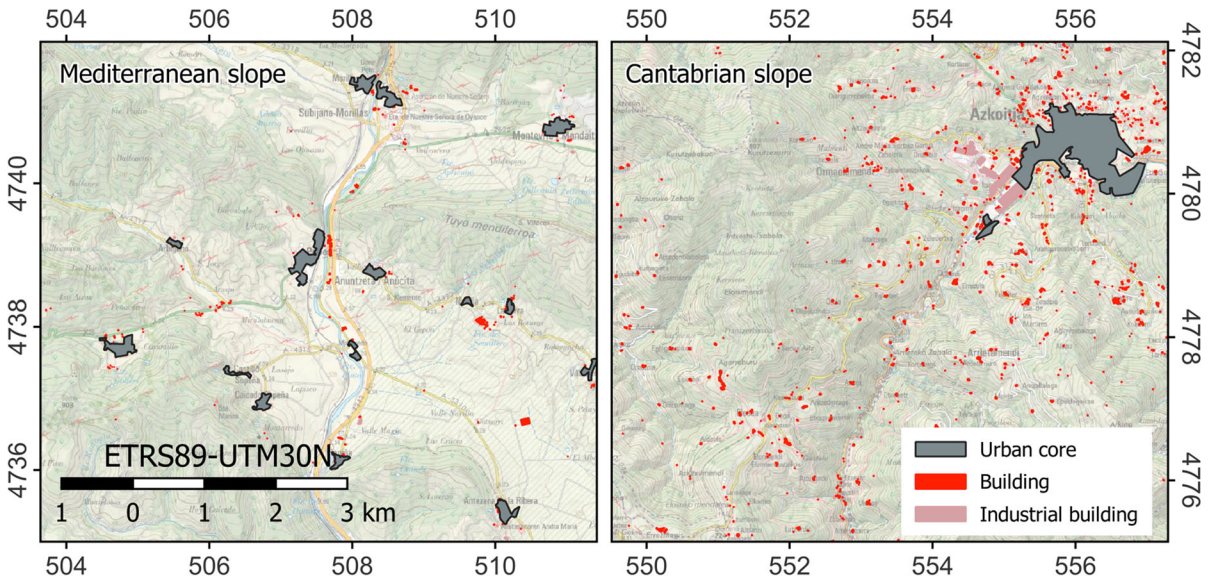

Fig. 12 Settlement type. Own elaboration from geoEuskadi (2023) and Instituto Geográfico Nacional (2024a). Frame coordinates in km

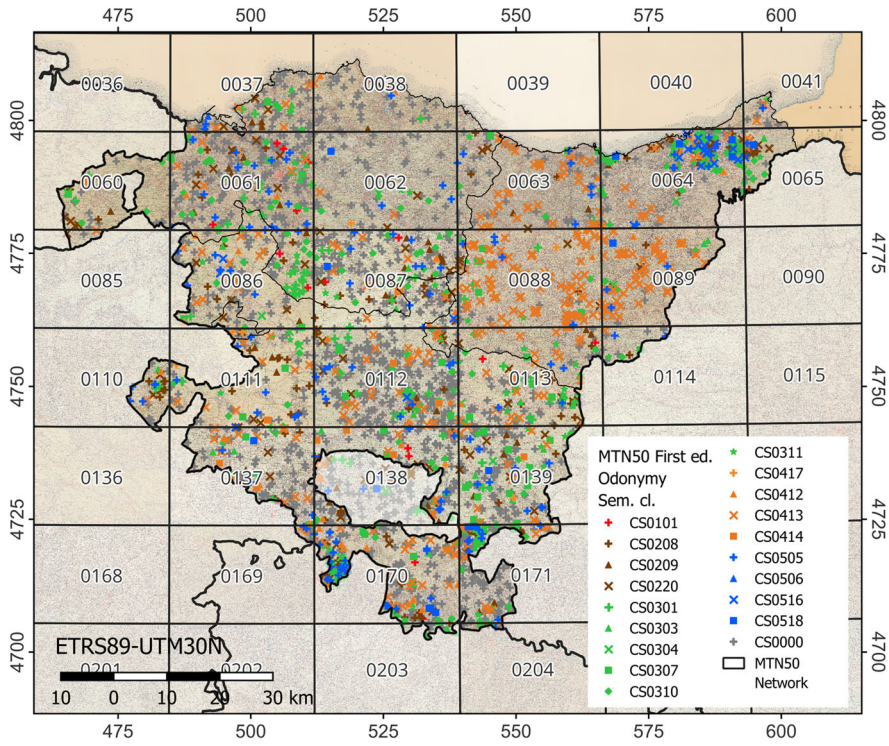

Fig. 13 Irregular distribution of pathway names in MTN50. Own elaboration from Instituto Geográfico Nacional (2024a). Frame coordinates in km

as the head of the region or the reference city of the environment. These roads that structure counties are usually called "*Camino real*..." SPA ("Royal Pathway...") (Ursúa Irigoyen, 1990). According to all the toponymic sources used in the study area, there are five cases in Spanish (three of them lexicalized "*Caminorreal*") and one in Basque "*Erregebide*" EUS ("Royal Pathway").

Going deeper into this concept of inter-county road, whether or not the qualification of "*Real*" (Royal) is written on the map, the fact of keeping the name of a town far from the surrounding area on the label, in itself, qualifies the road itself. This is because it gives it a regional entity as opposed to radial or local roads that link contiguous towns.

There is also the case in which the label indicates not only the origin and destination but also a place of passage. This circumstance allows inferring that there are roads with identical origins and destinations but different itineraries (Fig. 14). Finally, as a reference to traditional long-distance roads, there are two cases of "*Erremoesbide*" EUS ("Pilgrim's Way") that correspond to the *Camino de Santiago* (Gorrotxategi Nieto, 2022).

References to elements of physical geography appear more frequently in complicated orographic areas, with low population density, such as mountain passes, and environments in which there is also grazing and seasonal transhumance typical of the area. This group includes both proper names, like "*Camino del Gorbea*" SPA ("Pathway to Gorbea") and generic allusions to the orography, "*Camino del Vallejo*" SPA ("Small Valley Pathway"). In the case of hydrography, there are 30 explicit allusions to springs and streams, which are referred to by their specific names. There are also references to elements related to the hydrological infrastructure, such as the "*Camino de la Noria*" SPA ("Waterwheel Pathway") or "*Presalde bidea*" EUS ("Dam Pathway").

In the section on economic activities, the names related to professions, like "*Camino de carboneros*" SPA ("Pathway of Charcoal Burners"), have been semantically classified. There are also activities related to mining or mineral exploitation, such as "*Camino de la Calera*"SPA ("Lime Kiln Pathway"), "*Arrobitxulo bidea*" EUS ("Quarry Hole Path") or "*Camino del Marmol*"SPA ("Marble Pathway"). On the other hand, we have included the phytonyms that have traditional economic exploitation, such as "*Camino del Castañal*" SPA ("Chestnut forest Pathway"), "*Camino del Prado*" SPA ("Meadow Pathway"), or "*Pinu bidea*"

Fig. 14 Itinerary determination according to the name of the pathway. Own elaboration from Instituto Geográfico Nacional (2024a). Frame coordinates in km

EUS ("Pine Pathway"). As for the agricultural activity, the toponym "*Usaegieta bidea*" EUS ("Dovecote Pathway"), "*Camino de los corrales*" SPA ("Pathway to the Corrals") has been cataloged within this group. Functional destinations include indications to strategic destinations such as "*Camino al Sanatorio de Briñas*" SPA ("Pathway to the Briñas Sanatorium"), or "*Plazaolako Trentxikiaren Bidea*" EUS ("Pazaola Little Train's Pathway").

Considering the table of densities, we can observe that the landscape with the highest total number of labeled pathways is TP52 Ebro depression countryside (0.859 names per km^2). Nevertheless, if the population names are omitted, the maximum density is gathered in the Cantabrian-Atlantic estuaries or bays, TP89 Cantabrian-Atlantic estuaries and bays (1.263 names per km^2). This landscape has a large population density, both at present and in the past. However, there are comparatively few references to population settlements (20.75%), while there are many names related to economic issues (30.19%), among which those related to agroforestry activity (phytonymy 10.9%).

The lowest density of names of any semantic classification is reported in the type of landscape TP83 Upper Ebro canyons and gorges (0.175 names per km^2). The explanation for the latter may lie in the low population, inaccessibility and remoteness of large populations, and the small size of the area, so it may be necessary to resort to local toponymic studies.

Furthermore, the next lowest density corresponds to TP90, of marinas and valleys of the Cantabrian coast (0.244 names per km^2). Most of the names in this area refer to population settlements (148), with no semantic interpretation. In this territory, the most numerous semantic classification (37 names, 13.41% of the TP90) is that of pathway descriptors such as "*Bidezarretako bidea*" EUS ("Old Pathway"), "*Erdiko bidea*" EUS ("Middle Pathway") or "*Camino Particular*" SPA ("Private Pathway").

Overall, as shown in Table 9, we have worked with a very high number of references with content related to population, 1643 out of 3072. The next most numerous class is that of economic activities. Disaggregating this class into the different economic activities, we find that agricultural and livestock activities are very numerous (538 features). Given the classified elements, it has been considered that in the phytonymy analyzed and in the names related to geology, the functionality and the economic activity component prevail over the descriptive one, and that is why the semantic classes CS0320-Geology (mineral) and CS0310- Phytonymy (agricultural, forestry, land use), have been included in the class of economic activities. To illustrate this decision, we can find examples such as "*Meatzetarako bidea*" EUS ("Pathway to the Mines"), "*Camino de Cortabaso*" MUL[5], ("Pathway to the Forest of the Sheepfold"), "*Larrabide bidea*" EUS ("Pasture Pathway").

Comparatively, economic activities account for a third of the volume of names related to population settlements (CS01+CS00), as do semantic references to

[5] ISO 639-2 language code for multiple languages, in this case, Spanish and Basque)

the road itself and related elements and activities, such as sales, bridges, and descriptors. We find examples of the latter such as "*Bideberri*" EUS ("New Pathway"), "*Bidezarra*" EUS ("Old Pathway"), "*Caminorreal*" SPA ("Royal Pathway") or "*Camino de la Cuesta*" SPA ("Slope Pathway").

The names related to physical geography are more numerous in TP11, with 62 out of 175 names in this category, highlighting the use of names related to oronymy. Examples include "*Camino de Valleoscuro*" SPA ("Pathway of Dark Valley"), "*Lezeagako bidea*" EUS ("Pathway of the Caves"), or "*Arbarakoate bidea*" EUS ("Pathway of the Arbara Pass"). This territory has a lower population density, abundant forested areas utilized for timber harvesting, and mountainous pasture lands, encompassing the most extensive areas of communal forests (Fig. 15). In the Basque Country, communal lands bear witness to a traditional socio-economic organization, where the productive functions of these environments are essential (Bellosillo, 1988), especially traditional forestry and livestock uses. These lands have recently attracted interest for recreational, ecological, or cultural purposes. Consequently, there is a growing appeal and recognition of these areas (Alcázar González and Azcárate Luxán, 2000). In this environment, it becomes particularly relevant to pay attention to zoonymy (51, 9.2%) such as "*Otsaurte Bide Zidorra*" EUS (related to wolf), "*Mandobidea*" EUS ("Pathway of Mules"), "*Camino de las yeguas*" SPA ("Pathway of Mares") and "*Camino del guano*" SPA ("Pathway of the Manure", used as fertilizer). Additionally, phytonymy (24, 4.3%) plays a role with names like "*Camino Madero*" SPA ("Timber Pathway"), "*La Dehesa bidea*" MUL, ("Pasture Pathway"), and "*Senda la Ayera*" SPA ("The Beech Forest Footpath").

Discussion

This research work is based on the intimate relationship between toponymy and landscape, as well as on the link between these two disciplines and cartography, being the territory the pillar on which they are sustained. Specifically, we start from the premise that both toponymy and landscape are based on the perception of the inhabitants of a territory (Reszegi, 2020) in order to look for a correspondence between their geographical distribution. In this research, the usefulness of toponymy in describing and studying the territory is evident since it synthesizes the description of the places

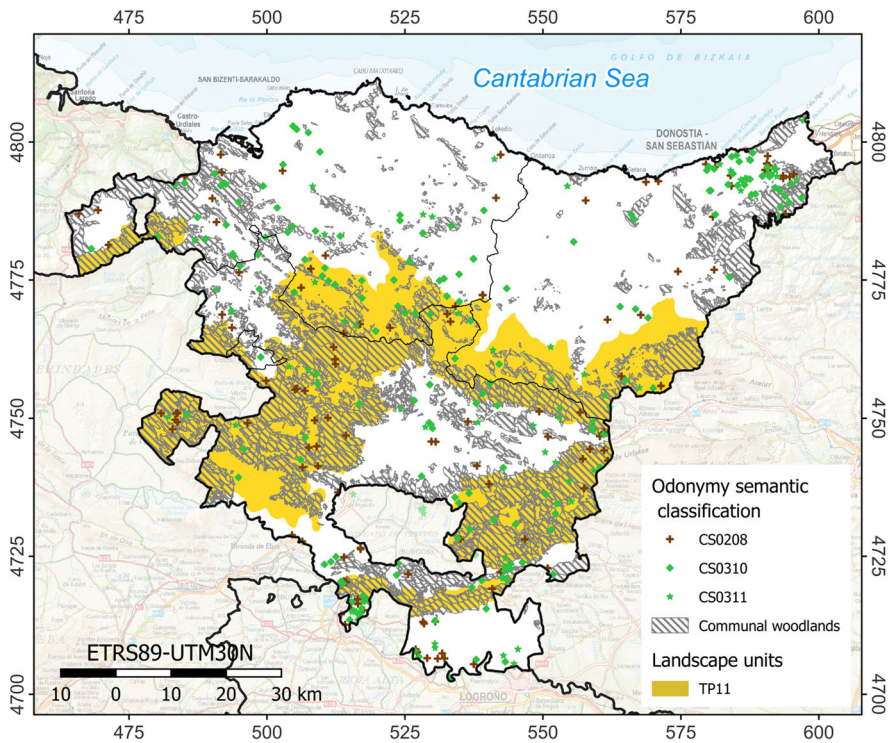

Fig. 15 Distribution of communal woodlands, coinciding with the type of landscape TP11. CS0208, CS0310 y CS0311. Own elaboration from Instituto Geográfico Nacional (2024a). Frame coordinates in km

themselves in place names. In this context, geographic data processing using GIS tools is fundamental.

Cartography is the natural medium for the expression and representation of toponymy, but it imposes its own limitations, as evidenced in this research. Each administration addresses the approach to the territory from a different scale and degree of detail, which characterizes the geographic information they generate. One of the most visible examples of the conditioning factors of the cartographic support can be seen in the series of the first edition of the MTN50 of the IGN; the sheets produced by classic topography differ from those produced by photogrammetry in their toponymic content, both in quantity and quality. Therefore, it is proven that the cartographic support conditions the toponymic content offered by scale, graphic issues, or the different data acquisition methodologies used. The integration of toponymic sources from different administrations has mitigated the bias that the specific features of each dataset may contribute to the toponymic corpus formed for this work.

The geographical entities studied in this research, which compose the traditional pathway network, are structuring elements of the territory, which are highly relevant for its understanding. There are works on pathway toponymy (Alcázar González and Azcárate Luxán, 2005; Bellosillo, 1988) and on the importance of pathways in the territory and landscape (Orellana Moraleda, 2017; Porcal Gonzalo, 2011; Rosete Vergés, 2020; Somoza Medina et al., 2022), also on landscape interpretation with the support of toponymy (Membrado Tena and Fansa, 2023; Nowosad and Stepinski, 2021; Sousa and Garcia Murillo, 2001; Spampinato et al., 2022). This work fits precisely at the intersection of these perspectives or disciplines and provides a systematic methodology for interpreting the landscape in a regional context. The success of this study lies in having identified common features in landscapes and place names based on a systematic classification of the latter, focusing on a specific geographical element, representing traditional communication routes. This is possible thanks to the functions of toponymy (Tort-Donada and López-Leiva, 2023): transparency, exceptionality, and territorial significance.

The work takes place in a bilingual environment that conditions the approach to dealing with toponymy, making proficiency in both official languages essential. Simultaneously, the complexity of multilingualism can serve as a stimulus for research in this field. In any case, it highlights the multicultural nature of the environment (Nyström, 2021).

Based on the landscape definition contained in the ELC, the intimate relationship between landscape and territory is understood; therefore, a landscape classification is a way of territorial classification based on landscape criteria. The classification of landscape units is founded on orographic concepts and land cover, where population and vegetation play a role, maintaining a visual and perceptual component as well (Marine, 2022).

Regarding the designed toponymic classification systems, while the referential classification focuses on key geographical elements for orienting within the network of roads, the semantic classification allows for a closer interpretation of the territory and the etymology of odonyms. As a trade-off, considering the complexity and diversity in the process of forming population names (Fort Cañellas, 1984), not always tied to the territory, it is preferable not to include this group of toponyms in the analysis systematically. The referential classification of place names allows for identifying traditional geographic focal points; it takes into account the toponyms that refer to or evoke geographical elements and classifies these references. The choice of these two classification methods has proven complementary in subsequent analyses.

As observed in the analysis of results, references to names linked to the population correspond to the distribution of settlement forms, scattered along the Cantabrian slope (except for more industrialized valley bottoms) and concentrated in small clusters forming a network along the Mediterranean slope. Agroforestry activities are present throughout the territory but are denser in mountainous areas, where traditional activities like forestry exploitation and high-altitude grazing are carried out, closely associated with communal land ownership, once again coinciding with specific types of landscapes.

Conclusions

In this work, two disciplines related to the perception of the territory, toponymy and landscape, have been combined, and the result confirms the coherence between them. The chosen geographical element for this study is the road network represented in official cartography, as traditional pathways have served as structuring ele-

ments of the landscape. Geographical contextualization of the data is crucial in this work, which is why GIS tools have been utilized. The analysis of odonyms concerning each type of landscape has evidenced the correspondence between the features of each landscape unit and the odonyms it contains. The distribution and semantic value of the toponyms have been used, along with their geographical referencing, where available. Therefore, the major innovation of this research lies in systematically intertwining disciplines that work with the inhabitants' perception of the territory by analyzing elements that shape or structure it, such as the roads throughout the Basque Country Autonomous Community.

The level of detail observed in cartographic sources that encompass existing landscape classifications allows for opening new lines of research by applying this analysis to local geographical areas and considering various geographic elements of the territory. Additionally, the scale at which each study is conducted corresponds to levels of closeness to the territory and the breakdown of the mosaic of landscapes.

Another line of investigation, analogous to other geographical studies (Altuzarra et al., 2018) and landscape studies (Alcántara-Manzanares and Muñoz, 2017; Erikstad et al., 2022), is the study of the relationship between toponymy and landscape using tools like tools multivariate analysis (MVA) and principal component analysis (PCA). Regardless, our research validates the toponymy of a place as a tool for analyzing different aspects of its landscape.

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Declarations

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References

Agboola, O. P., Rasidi, M. H., Said, I., Abogan, S. O., & Adejuwon, A. S. (2018). Morphological and GIS-based land use analysis: A critical exploration of a rural neighborhood. *Journal of Contemporary Urban Affairs, 2*, 106–121. https://doi.org/10.25034/ijcua.2018.4675

Agirregoikoa, J. (2011). El nomenclátor geográfico de Euskadi a partir de la base de datos de toponimia de la viceconsejería de política lingüística del Gobierno Vasco. In *Els noms en la vida quotidiana. Actes del XXIV Congrés Internacional d'ICOS sobre Ciències Onomástiques* (pp. 2344–2356). Barcelona, Spain. Onomástica. Biblioteca Técnica de Política Lingüística. https://doi.org/10.2436/15.8040.01.227

Alcántara-Manzanares, J., & Muñoz, J. (2017). Multivariate versus traditional methodology for the identification and classification of landscapes. *Geography papers, 63*, 39–51. https://doi.org/10.6018/geografia/2017/279791

Alcázar González, A., & Azcárate Luxán, M. (2000). Aproximación a la toponimia del repertorio de caminos de Guadalajara. In *Caminería hispánica* vol. 1 (1st ed., pp. 223–242). Centro de Estudios y Experimentación de Obras Públicas, CEDEX.

Alcázar González, A., & Azcárate Luxán, M. (2005). Toponimia: Normas para el MTN25. Conceptos básicos y terminología. Publicación técnica n. 42. Instituto Geográfico Nacional, Madrid, digital edition.

Altaba, P., García-Esparza, J. A., & Valentín, A. (2022). Assembling Cultural and Natural Values in Vernacular Landscapes: An Experimental Analysis. *Remote Sensing, 14*(17), 4155. https://doi.org/10.3390/rs14174155

Altuzarra, A., Alvarez, I., Tola, E., & Rodriguez, A. (2018). Urban socio-spatial differentiation: Mapping neighborhood stratification in Bilbao (Spain). *Scripta Nova, 22*, 601. https://doi.org/10.1344/sn2018.22.21273

Álvarez, L., Delgado, L. M., & Sánchez-Martín, J. M. (2022). Patrimonio cultural como herramienta de desarrollo en el mundo rural extremeño: El diseño y la creación de itinerarios culturales. *Lurralde, 44*, 657–690. https://doi.org/10.52748/lurralde.2021.44.118

Arbizu Varona, V. (2016). *Laudio haraneko toponimia azterketa*. PhD thesis, Universidad de Deusto.

Arroyo Illera, F. (2009). *Geografía y toponimia*. Jornada de la Comisión Especializada de Nombres Geográficos: La importancia del uso normalizado de la Toponimia.

Atik, M., Kanabakan, A., & Ortaçeşme, V., & Yildirim, E. (2022). Tracing landscape characters through place names in rural Mediterranean. *Catena, 210*, 105912. https://doi.org/10.1016/j.catena.2021.105912

Batlle, M. (2023). Language Policies in the Field of Toponymy: Perspectives on Spain. In G. O'Reilly (Ed.), *Place Naming, Identities and Geography. Critical Perspectives in a Globalizing and Standarizing World.* (pp. 299–323). Springer, Dublin. https://doi.org/10.1007/978-3-031-21510-0_13

Bellosillo, M. (1988). *Castilla merinera: Las cañadas reales a través de su toponimia*. Turner Publicaciones S.L.

Castillo, D., & Valdaliso, J. M. (2017). Path dependence and change in the Spanish port system in the long run (1880–2014): An historical perspective. *International Journal of Maritime History, 29*(3), 569–596. https://doi.org/10.1177/0843871417712636

Cebrián Abellán, F., & García Martínez, C. (2016). Use and management of landscape for tourism in rural areas. Theoretical approach and empirical analysis in Southeast of Castilla-La Mancha: Albacete. *Boletín de la Asociación de Geógrafos Españoles, 72*, 579–584. https://doi.org/10.21138/bage.2345

Çetin, R. (2018). Critical toponymy: Creating prestigious spaces through using urban names. *MEGARON / Yıldız Technical University, Faculty of Architecture E-Journal*. https://doi.org/10.5505/megaron.2018.05826

Civitarese Matteucci, S., & Franco Cartei, G. (2022). The impact of the European Landscape Convention on landscape planning in Spain, Italy and England. *Journal of Environmental Law, 34*, 307–330. https://doi.org/10.1093/jel/eqac004

Council of Europe (1987). Cultural routes of the council of europe programme. https://www.coe.int/en/web/cultural-routes

Council of Europe (1992). European charter for regional or minority languages (ets no. 148). https://www.coe.int/en/web/conventions/full-list?module=treaty-detail&treatynum=148

Davila-Cabanillas, N. (2021). El patrimonio cultural en la planificación territorial de la comunidad autónoma del País Vasco. *Lurralde: investigación y espacio, 44*, 635–656. https://doi.org/10.52748/lurralde.2021.44.117

Departamento de Cultura (2001). *Izen Geografikoen Glosarioa Euskal toponimoen normalizazioan erabiltzeko*, vol. 1 (1st ed.). Eusko Jaurlaritzaren Argitalpen Zerbitzu Nagusia.

Departamento de Medio Ambiente y Política Territorial (2014). Decreto sobre protección, gestión y ordenación del paisaje en la ordenación del territorio de la Comunidad Autónoma del País Vasco. https://www.euskadi.eus/web01-bopv/es/bopv2/datos/2014/06/1402623a.pdf

Elosegui Irazusta, J. (1969). Toponimia y denominaciones urbanas de la Villa de Tolosa. *Boletín de la Real Sociedad Bascongada de Amigos del País, 25*(2-3).

Erikstad, L., Bakkestuen, V., Dahl, R., Arntsen, M. L., Margreth, A., Angvik, T. L., & Wickström, L. (2022). Multivariate analysis of geological data for regional studies of geodiversity. *Resources, 11*(6), 51. https://doi.org/10.3390/resources11060051

European Commission. (2011). *Youth Opportunities Initiative*. Belgium: European Commission Brussels. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52012AE1579

Euskalmet (2023). Euskalmet. https://www.euskalmet.euskadi.eus/inicio/

Euskaltzaindia (2023). Euskaltzaindia. https://www.euskaltzaindia.eus/

Eustat Agentzia (2023). Euskal Estatistika Erakundea - Instituto Vasco de Estadística. www.eustat.eus

Fize, J., Moncla, L., & Martins, B. (2021). Deep Learning for Toponym Resolution: Geocoding Based on Pairs of Toponyms. *ISPRS International Journal of Geo-Information, 10*(12), 818. https://doi.org/10.3390/ijgi10120818

Fort Cañellas, M. R. (1984). Sobre onomástica aragonesa medieval. *Archivo de filología aragonesa, 34*, 553–579.

García Sánchez, J. J. (2023). Las lenguas de los topónimos. su pertinencia y relevancia en el "Toponomasticon Hispaniae". In *Nuevos senderos en la toponimia hispánica* (pp. 357–370). Pagès editors.

geoEuskadi (2014). Mapas municipales toponímicos de la comunidad autónoma del País Vasco. https://opendata.euskadi.eus

geoEuskadi (2023). Geoeuskadi, spatial data infrastructure of Euskadi. https://www.geo.euskadi.eus

Gómez Piñeiro, J., & Sáez García, J. A. (1991). La cartografía en la comunidad autónoma del País Vasco. RIEV. *Revista Internacional de los Estudios Vascos, 36*, 195–236.

González Matesanz, J., García García, J., Bermúdez González, J. L., Dalda Mourón, A., & Maza Vázquez, F. (2015). Series cartográficas y base de datos de información geográfica producidas en España. *Ciencias Espaciales, 8*(1), 491–508. https://doi.org/10.5377/ce.v8i1.2063

Gordova, Y. (2022). Comprehensive study of the toponymic landscape of the local territory: The area of the Ryazan villages of Dyadkovo and Vyshgorod. *Philology: scientific research*, *3*, 47–54. https://doi.org/10.7256/2454-0749.2022.3.36812

Gorrotxategi Nieto, M. (2022). Erromesbidea, el Camino en la toponimia vasca. In *Os camiños de Santiago de Europa a Galicia: Lugares, nomes e patrimonio* (pp. 415–437). Real Academia Galega. https://doi.org/10.32766/rag.404.17

Hearn, K., Atik, M., Kanabakan, A., & Ortacesme, V. (2024). Discovering change in agrosilvopastoral landscapes with toponymy in the Mediterranean Region. *Landscape and Urban Planning, 243*, 104955. https://doi.org/10.1016/j.landurbplan.2023.104955

Hersperger, A. M., Bürgi, M., Wende, W., Bacău, S., & Grădinaru, S. R. (2020). Does landscape play a role in strategic spatial planning of European urban regions? *Landscape and Urban Planning, 194*, 103702. https://doi.org/10.1016/j.landurbplan.2019.103702

Herzen, A., Herzen, O., Gordova, Y., Kostovska, S., & Khropov, A. (2023). Toponymical and cartographical methods of religious buildings in historical-geographical landscapes study. *Historical approach in geography and geoecology*, pp. 421–426. St. Petersburg, Russia. September 21–23, 2023. https://doi.org/10.33933/rshu/g1c23-67

IKT and PAISAIA (2023). Catalog of unique and outstanding landscapes of the autonomous community of the Basque Country. https://www.euskadi.eus/documentacion/2016/catalogo-de-paisajes-singulares-y-sobresalientes/web01-a2ingdib/es/

Instituto Geográfico Nacional (2024a). Instituto geográfico nacional. http://www.ign.es

Instituto Geográfico Nacional (2024b). Spanish national atlas. http://atlasnacional.ign.es/index.php?title=P%C3%A1gina_principal&oldid=66800

Lakarra, J. A., Manterola, J., & Segurola, I. (2023). Euskal hiztegi historiko-etimologikoa. https://www.euskaltzaindia.eus/index.php?option=com_ehhe&task=home&Itemid=1695&lang=eu

Líbano Zumalacárregui, A. (2003). La Montaña Alavesa y el Fuero de Bernedo: variaciones lingüísticas y toponimia. In *Pasado y presente de la Montaña Alavesa= Arabako Mendialdearen iragana eta oraina/Jose Ramón Díaz de Durana, E and Villanueva, E [eds]*. (pp. 45–52). Departamento de Cultura.

Lisiak, M., Borowiak, K., Kanclerz, J., Adamska, A., & Szymańczyk, J. (2018). Effect of linear investment on nature and lanscape. *Journal of Environmental Engineering and Landscape Management, 26*(2), 158–165. https://doi.org/10.3846/jeelm.2018.2271

Marine, N. (2022). Landscape assessment methods derived from the European Landscape Convention: Comparison of three Spanish cases. *Earth, 3*(2), 522–536. https://doi.org/10.3390/earth3020031

Martínez-Areta, M. (2023). Replications of Gaulish toponyms in Biscay: On the etymologies of Gorbeia, Orobio and Orozko. *Journal of Celtic Linguistics, 24*(1), 1–34. https://doi.org/10.16922/jcl.24.2

Membrado Tena, J. C., & Fansa, G. (2023). Supervivencia de paisajes rurales en urbes a través de la toponimia: el caso de Valencia. In *Geografía* (1st ed., pp. 615–624). Asociación Española de Geografía. https://doi.org/10.21138/CG/2023.lc

Mitxelena-Hoyos, O., & Amaro-Mellado, J.-L. (2023). A comparison of cartographic and toponymic databases in a multilingual environment: A methodology for detecting redundancies using ETL and GIS tools. *ISPRS International Journal of Geo-Information, 12*(2). https://doi.org/10.3390/ijgi12020070

Mujika Ulazia, N. (2010). Bilingüismo, toponimia y cartografía en la comunidad autónoma del País Vasco. In *Toponimia e cartografía* (pp. 73–102).

Munroe, D. K., Crandall, M. S., Colocousis, C., Bell, K. P., & Morzillo, A. T. (2019). Reciprocal relationships between forest management and regional landscape structures: Applying concepts from land system science to private forest management. *Journal of Land Use Science, 14*, 155–172. https://doi.org/10.1080/1747423X.2019.1607914

Nowosad, J., & Stepinski, T. F. (2021). Pattern-based identification and mapping of landscape types using multithematic data. *International Journal of Geographical Information Science, 35*(8), 1634–1649. https://doi.org/10.1080/13658816.2021.1893324

Nyström, S. (2021). *Multicultural Features in Scandinavian Toponymy*, pp. 197–212. Springer International Publishing. https://doi.org/10.1007/978-3-030-73186-1_13

Orellana Moraleda, E. (2017). Caminos naturales, una apuesta por la dinamización del medio rural. *Ambienta: La revista del Ministerio de Medio Ambiente, 118*, 20–29.

Palacios-Agundez, I. (2011). Los bosques del País Vasco y el cambio climático. In *Bosques del Mundo, cambio climático & Amazonía* (pp. 23–33). UNESCO chair on Cultural Landscape and Heritage.

Pătru-Stupariu, I. and Nita, A. (2022). Impacts of the European Landscape Convention on interdisciplinary and transdisciplinary research. *Landscape Ecology, 37*, 1211–1225. https://doi.org/10.1007/s10980-021-01390-9

Perono Cacciafoco, F., & Cavallaro, F. (2023). Place Names. *Cambridge University Press*. https://doi.org/10.1017/9781108780384

Picuno, P., Cillis, G., & Statuto, D. (2019). Investigating the time evolution of a rural landscape: How historical maps may provide environmental information when processed using a GIS. *Ecological Engineering, 139*, 105580. https://doi.org/10.1016/j.ecoleng.2019.08.010

Porcal Gonzalo, M. C. (2011). El patrimonio rural como recurso turístico. la puesta en valor turístico de infraestructuras territoriales (rutas y caminos) en las áreas de montaña del País Vasco y Navarra. *Cuadernos de turismo*, *27*, 759–784.

Real Academia Española (2023). Diccionario de la lengua española, 23 ed. [23.6 online version]. https://dle.rae.es

Rebolé Del Castillo, E. (2003). Toponimia y léxico vascos de Lumbier/Irunberri. *Euskera: Euskaltzaindiaren lan eta agiriak= Trabajos y actas de la Real Academia de la Lengua Vasca= Travaux et actes de l'Academie de la Langue basque, 48*(2), 795–822.

Reszegi, K. (2020). Toponyms and spatial representations. *Onomastica, 64*, 23–39. https://dx.doi.org/10.17651/ONOMAST.63.2

Riva, R. (2020). Cultural landscapes and Sustainable development: the role of ecomuseums. *Sustainable Mediterranean Construction, 11*, 25–29.

Rosete Vergés, F. A. (2020). *Caminos y paisaje: Aproximaciones desde la geohistoria*. Universidad Nacional Autónoma de México, Escuela Nacional de Estudios Superiores-Unidad Morelia. https://doi.org/10.22201/enesmorelia.9786073030717e.2020

Rosselló i Verger, V. M. (2004). El mapa topográfico nacional a 1/25.000. deu anys de perspectiva al País Valencià. In *Topominia, Geografía i Cartografia* (pp. 67–76). Universitat de Valencia. Servei de Publicacions, Valencia.

Sainz Echeverría, A. (1996). Materiales de toponimia vasca renteriana. *Bilduma: Revista del Servicio de Archivo del Ayuntamiento de Errenteria= Errenteriako Udal Artxibo Zerbitzuko aldizkaria, 10*, 9–27.

Sanchez, J. M. (1974). Bilingüismo, disglosia, contacto de lenguas. In *Anuario del Seminario de Filología Vasca" Julio de Urquijo"*, 8 (pp. 3–79). Basque Philology Seminar Institute.

Santos Mansilla, E. G., Cano González, J. L. E., & Ixjotop Puac, J. A. (2023). Normalización, clasificación y utilidad de toponimias a través de plataformas de geovisualización y webmap en Sacatepéquez, Guatemala, C.A. *Tlalli. Revista de Investigación en Geografía 9*, 58–95. https://doi.org/10.22201/ffyl.26832275e.2023.9.1902

Sanz Herráiz, C., & Mata Olmo, R. (2003). *Atlas de los Paisajes de España*. Ministerio de Medio Ambiente.

Somoza Medina, X., & Lois González, R. C., & Somoza Medina, M. (2022). Walking as a cultural act and a profit for the landscape. A case study in the Iberian Peninsula. *GeoJournal, 88*, 2171–2186. https://doi.org/10.1007/s10708-022-10745-x

Sousa, A., & Garcia Murillo, P. (2001). Can place names be used as indicators of landscape changes? Application to the Doñana natural park (Spain). *Landscape Ecology, 16*, 391–406. https://doi.org/10.1023/A:1017585101389

Spampinato, G., Crisarà, R., Cameriere, P., Cano-Ortiz, A., & Musarella, C. M. (2022). Analysis of the Forest Landscape and Its Transformations through Phytotoponyms: A Case Study in Calabria (Southern Italy). *Land, 11*(4), 518. https://doi.org/10.3390/land11040518

Tort-Donada, J., & López-Leiva, C. (2023). *Toponymy, Scale and the Change of Scale. A Geographical and Linguistic Challenge* (pp. 125–145). Springer International Publishing. https://doi.org/10.1007/978-3-031-21510-0_6

Tort-Donada, J. (2022). Toponymy as a tool for the geographical interpretation of the region: Some methodological foundations. *Abstracts of the ICA, 5*, 1–2. https://doi.org/10.5194/ica-abs-5-150-2022

Turner, H., Lahoorpoor, B., & Levinson, D. M. (2023). Creating a dataset of historic roads in sydney from scanned maps. *Scientific Data, 10*, 683. https://doi.org/10.1038/s41597-023-02574-5

Ugarte Garrido J.L.(2021). Toponimia eta EAEko Izendegi Geografiko [Congress session]. In II Congreso geoEuskadi, Bilbao, Spain, 14–15 October 2021.

Ursúa Irigoyen, I. (1990). *Toponimia Viaria en el Valle de Guesálaz*. In III Jornadas de Onomástica, Estella: Euskaltzaidia.

Urteaga González, L., & Nadal Piqué, F. (2001). *Las series del mapa topográfico de España a escala 1:50.000*. Madrid: Centro Nacional de Información Geográfica, 2001.

Valdaliso Gago, J. M. (2013). Las estrategias de desarrollo económico del País Vasco: Una perspectiva histórica. *Ekonomiaz, 83*, 146–174.