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COMMUNICATION

Depopulation in Spain and its educational treatment aimed at achieving sustainable ways of life and behaviour

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ABSTRACT

This communication aims to explain the origin, objectives, and format of educational materials developed by the authors for use in the classroom, specifically in geography or any subject dealing with knowledge and analysis, with students aged 14–18. It focuses on the depopulation process that has occurred in rural areas of Spain since the beginning of the 20th century (exemplified in the autonomous community of Aragon). This process has shaped their territory, population distribution, aging demographics, and the social issues that arise from it. To achieve this, its stages, characteristics, causes, consequences, and potential policies to halt depopulation are identified and analysed. To implement efficient teaching and learning processes aimed at students acquiring not only relevant and useful concepts but also skills or competencies in geographical knowledge techniques, an intensive use of Geographic Information Technologies (GIT) is proposed. Moreover, when GIT is integrated into educational strategies focused on competency-based didactic formulations ("know-how"). This transformation shifts geographical knowledge from rote memorization to a tool enabling the understanding of the environment in which students develop their lives and education. Thus, the educational materials presented here does not solely aim for an understanding of the depopulation process affecting the Spanish territory. Alongside this knowledge, the materials aim to facilitate competency acquisition in GIS (geographic information systems) and, consequently, in artificial intelligence.

Keywords: demography; population; landscape; depopulation; rural; geographic information systems; GIS; education

1. The concept of depopulation

The concept of depopulation served as the starting point for developing educational materials. Researchers consulted agreed that it involved a gradual loss of population due to two main causes: migration to other territories and the progressive aging of the population remaining in the areas of origin of those migrations. The interrelations between these causes and the factors causing them (differences in income generated by agricultural activities versus other economic sectors, rural accessibility issues regarding service providers, negative consequences in rural areas due to the layout of land transport networks, etc.) were also undisputed.

The challenge lay in differentiating depopulation from other migratory processes that resulted in population loss but didn't lead to the abandonment of the territories inhabited by those migrating human

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societies. In other words, merely analysing the negative evolution of population density in a space might label areas with few inhabitants, even very few, and very low or negative demographic growth figures as depopulated. This could overlook situations such as in the Spanish inland regions, where a significant part of spaces considered a priori in a depopulation process has experienced an expansion of agricultural exploitations seeking higher profitability through larger spatial dimensions and maintenance or reduction of production costs[1]. This restructuring has resulted in the abandonment of these exploitations by former agricultural entrepreneurs who have retired (demographic aging) or have migrated to other territories and job opportunities.

Hence, it's not surprising that in these inland spaces where significant depopulation processes have occurred, there is a higher percentage of large-scale exploitations. In essence, the number of inhabitants has decreased, but human intervention in these territories persists to a certain extent: certain forms of human intervention have been lost, but more profitable alternatives have emerged, such as those related to rural tourism, part-time agriculture, or intensified forms of exploitation including confined livestock farming, selection of plant and animal species based on productivity or market acceptance, and intensification of artificial cultivation methods, among others. The conclusion drawn is that while a decrease in population density can hint at potential cases of depopulation, it isn't sufficient to definitively identify them. A second criterion is necessary to ensure they truly fit the definition: depopulated territories have seen a drastic reduction in human activity within them[2]. Completely eradicating this human intervention is nearly impossible, given that the technological advancement in our societies leads to an increased ecological footprint to the extent that very few truly "wild" territories remain[3], and these are situated in latitudes far removed from our own.

Where can we establish the threshold to consider that decrease in population as a depopulation process?

Firstly, following recent regulations on the subject established by the European Commission[4], these stages have been established in the depopulation process for the preparation of these materials: a population "nucleus" with 6–10 inhabitants is at serious risk of depopulation, those with 2–5 inhabitants are in a situation of very serious risk, and those with one or zero inhabitants are considered depopulated.

Secondly, the estimation was based on a territorial scope: population nuclei (dispersed or not). This choice requires clarification: the "dispersed" are difficult to identify and locate unless at a large scale, while some of the "disappeared" dispersed settlements have not led to depopulation but rather a shift from dispersed habitats to concentrated "population nuclei" of larger dimensions, occasionally with urban characteristics. In this regard, recital 45 of the aforementioned Regulatio states that "the ERDF should address the problems of disadvantaged areas, especially rural areas and those suffering serious and permanent natural or demographic disadvantages, such as demographic decline, lack of access to basic services, etc.". Consequently, the EU's territorial policies establish criteria for grouping population nuclei around concepts such as disadvantaged territories, situations of crisis, etc., which act as organizing factors for these territories.

Thirdly, to measure the loss of intensity of human action in the territory, three methods have been utilised:

a). Comparing aerial photographs from the American flights series

A (1945–1946) and B (1956–1957) with the most recent PNOA Flight (2020), visible in **Figure 1**.

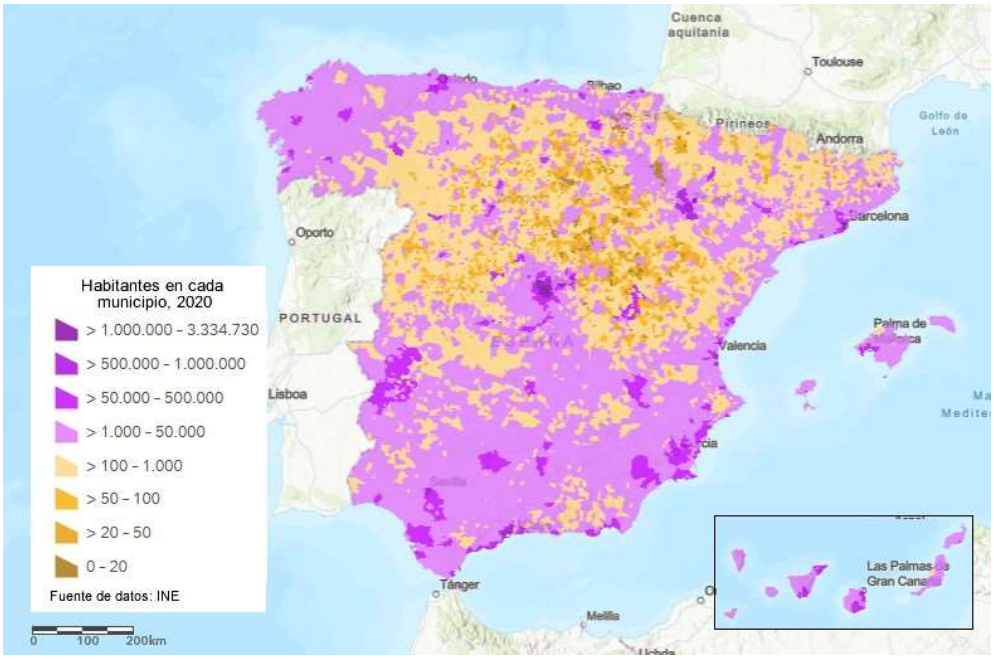

Figure 1. Population density (municipalities without borders).

b). Comparing the Forest Map of Spain at a scale of 1:400,000 from 1966 (MFE400) with the Forest Map of Spain at a scale of 1:50,000 completed in 2006 (MFE50).

c). Comparing the distribution of land uses (CORINE Land Cover) in 1990 and 2018. These comparisons sought to identify traces of disappeared agricultural activities, transport infrastructure, buildings, or any other evidence identifying territories that have been human habitats. Additionally, the goal was to identify the replacement uses, thereby measuring the loss of intensity in human actions and the physical environment's capacity to revert to its "wild" state prior to human intervention. Therefore, we have dismissed the practice of representing depopulation processes based on population density by provinces, or "Nomenclature of Territorial Units for Statistics" or NUTS 3[5], estimating that those with lower figures have experienced these processes more intensely. The European Commission uses this criterion to identify sparsely populated areas as NUTS 3 with a density below 12.5 inhabitants/km^2. This representation method poses several issues:

- The first, of a scientific nature, is that depopulation processes were and are not only inter-provincial migratory movements, but also intra-provincial. That is, within provinces, there are often territories that have been and are sources of migratory movements and others that were and are their destinations.
- The second issue is the ignorance of migratory processes associated with the diffuse growth of cities. Thus, this method of representing depopulation ignores the different rural and urban realities and the differences between them. To address these issues and manage aid and cohesion funds more fairly and efficiently, the commission has introduced two modifications to the criteria it has been using.
- The NUTS 3 classification is still used to identify sparsely populated areas, but municipalities and groups of municipalities are incorporated as spatial units, maintaining the criterion of 12.5 inhabitants/km^2.
- Another identifying element is added: having experienced population losses exceeding 1% in the last decade. This approach focuses on and specifies depopulation processes in the territory and reinforces action to try to halt those currently occurring.

Another way to represent the spatial distribution of depopulation is through the population density map by municipalities. This map gains precision compared to the provincial one, yet it doesn't consider that Spain has undergone municipal reorganization processes, leading to one population entity, usually the most populous, acting as the municipality's capital (**Figure 2**), locating its town hall, and a set of other entities (with lower demographic dimensions or experiencing depopulation or even being depopulated) that were previously municipalities and are now included and part of it. Therefore, this municipal population density map can be used to detect less populated spaces and hence imply that they might have experienced depopulation processes, but it cannot accurately identify and locate these processes.

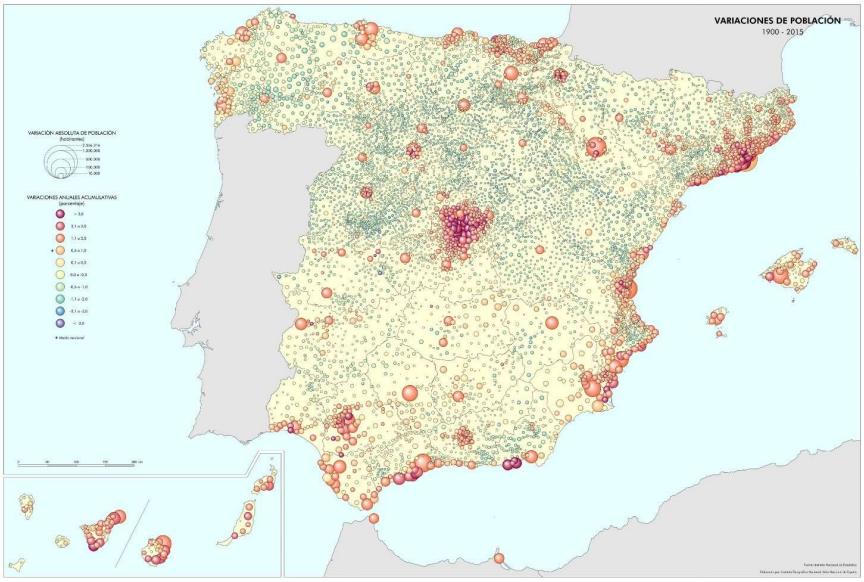

Figure 2. Population variation, 1900–2015.

Lastly, since the 1990s, there has been frequent use of representing population distribution across the territory through a grid of squares, typically one kilometre in size, symbolizing the number of people inhabiting each square. By comparing maps of this type from different years, it is possible to identify the location of depopulation processes that have occurred or are ongoing. However, an issue may arise: the absence of population in an area spanning several squares only means that its inhabitants are scarce or none, but it doesn't imply a drastic reduction or absence of human action on that territory. Only by adding other information, such as land uses, road networks, etc., can more conclusive conclusions be drawn in this regard.

From an educational standpoint, the choice between different cartographic formats depends on their educational efficiency, primarily their ability to implement competency-based learning. Cartography is a science aimed at obtaining data and measurements of a territory and constructing symbolized representations of that territory: a map. For a long time, in education, maps have served two main purposes:

- Memorizing the distribution in the territory of an element: population, water resources, vegetation, etc. This distribution was often portrayed using provinces (**Figure 3**), units of the hydrographic network, relief units, inhabitants, crops, industrial employment, and so on. We say memorizing because what was represented in school maps was exclusively the distribution of these elements, usually without adding any other information that would enable students to describe that distribution based on its relation to other elements forming that territory, much less venture into understanding its causes.

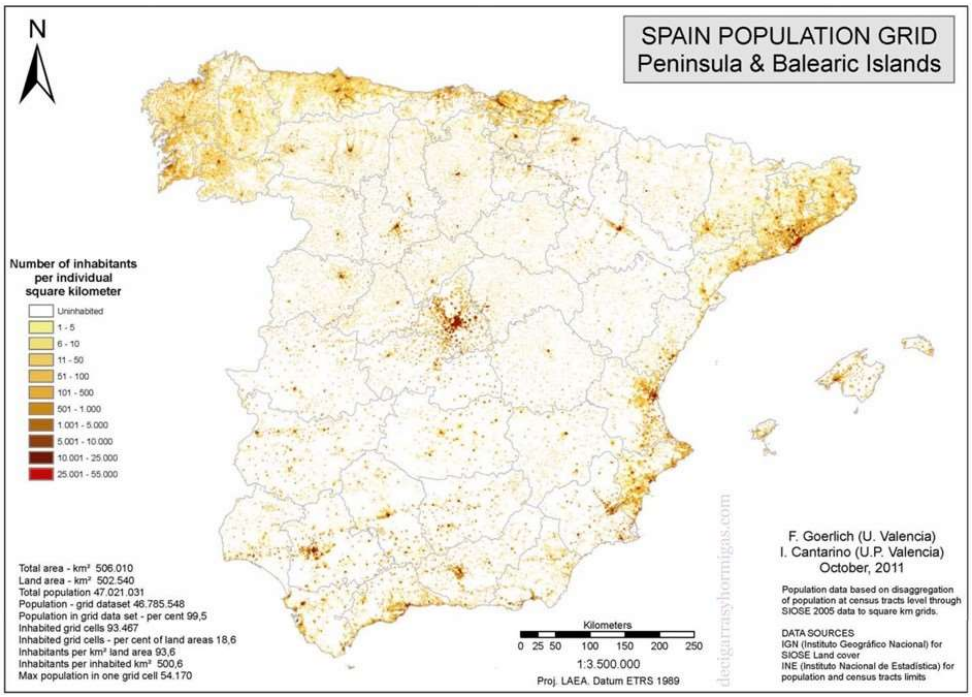

Figure 3. Population density, 2011, using the number of inhabitations in each 1 km side box of a network that covers the Spanish surface.

- Illustrating or visually representing what was being conveyed in the written part of the book or in the oral explanation.

However, the science of cartography creates maps for a much more relevant and useful purpose: to solve, or help solve, problems. Educationally, this function is essential, as it involves identifying the elements that compose and shape the territory and the relationships between human societies and the territory itself[6]. Thus, when used for these purposes, it becomes a tool for competency-based learning, enabling the identification and understanding of territorial issues, analysing them, and generating interest and strategies to address them adequately.

Models in rural depopulation processes. Based on the study of these processes in the Spanish province of Huesca, we have been able to establish six models or ways in which depopulation occurs, primarily depending on spatial factors.

The most common one affects rural spaces that lack very specific characteristics and are extendable to the rural spaces of inland Spain. In this model, two processes happen simultaneously:

(1). The rural areas compete with other spaces based on:

- The predominant activities carried out in each of them (agricultural activities in rural areas and secondary and tertiary sector activities in urban areas), employment (quality, salaries), and incomes they offer.
- Simultaneously, the ease or difficulty of accessing services differs in these spaces.
- The generalization of a negative perception of rural life, deemed outdated and unproductive, attributes blame to its inhabitants. These ideological conceptions, which we will discuss in more detail later, didn't just originate and continue with the urban population but also penetrated and continue to penetrate rural society[7].

(2). Agricultural activities, seeking greater productivity, subsequently greater competitiveness, and incomes, initiated a modernization process:

- Introduction of technologies that enhance productive processes: mechanization, extensive use of fertilizers and phytosanitary products, larger farm sizes, land consolidation, a noticeable increase in irrigated areas, etc.
- The proliferation of "market-oriented" agriculture, leading to increased production specialization, challenges the previous model of self-consumption and holistic land use. In Spain, this trend emerged when international markets began globalizing. Consequently, agricultural activities in general and those in specific spaces encountered competitiveness issues against products originating from regions and countries with lower production costs and multinational companies that could organize production spatially to compete advantageously due to their size and reduced production costs.

The outcome of these processes resulted in a migratory flow of young-adult rural populations toward urban areas, particularly major cities and their surroundings, significantly impacting dispersed nuclei, small population centres, and unproductive areas that found it challenging to adapt to the modernization previously described: large arid regions in inland Spain, unproductive soils, small-scale farming regions, etc.

As the rural population decreased and aged, a "vicious circle" deepened the crisis in these spaces: consumption habits adapted to an older population with lower incomes, and concurrently, the consumer base diminished. In this scenario, service providers found no "demand threshold" making it profitable (in public services, where service provision became more expensive) to maintain services in the rural world, therefore retreating to urban centres and, for essential services provided by public administrations, to regional centres. Simultaneously, the aging population hindered their mobility toward these decentralizing services[8].

This reduced "accessibility" to services further facilitated emigration from rural spaces, now predominantly by an older population.

A second model occurs in disadvantaged areas where limited accessibility, remoteness from areas undergoing economic modernization, and physical constraints (soils, climate, etc.) hindered, if not prevented, changes in economic activities, especially agriculture. Moreover, these constraints were homogeneously distributed over extensive territories. For instance, in mid-mountain areas excluded from major transportation networks[9].

In these circumstances, migration flows were powerful, leading to the complete abandonment of buildings and agricultural activities. These lands, as a residual use, were left for forestry or extensive cattle farming, involving seasonal shifts.

A third model occurs in rural spaces close to larger urban centres or smaller municipalities undergoing economic modernization processes due to their strategic location concerning major transportation networks, availability of natural resources, commercial tradition, or other factors.

Depending on how migration occurred (from rural areas to new growth centres or by the spatial expansion of these centres toward the former), two models can be identified.

Firstly, the population from nearby rural spaces migrated to municipalities, witnessing secondary and/or tertiary activities and economic modernization. However, the proximity between their places of origin and destination led to specific dynamics: the population abandoned residences in their original nuclei, resulting in two processes:

- Some buildings and groups of buildings fell into ruin, while others found new purposes: some were repurposed as agricultural buildings (warehouses, silos, etc.), others as secondary residences, and more recently, as accommodations for "rural tourism".

- Land use underwent changes: in most of these spaces, traditional uses persisted (sometimes combining them with new practices), albeit with increased mechanical and chemical inputs, often linked, as mentioned earlier, to the development of "part-time" agriculture.

A second format of this model occurs when urban spaces or municipalities implementing economic modernization dynamics expand and encroach upon rural neighbourhoods[10], modifying them in two ways:

- Absorption into the urban network typically occurs in new neighbourhoods. This process transforms the morphology and land uses of these spaces, which shift toward purely "artificial" land uses, in CORINE Land Cover terminology. These absorption processes were frequent until the 1980s, when cities followed a compact growth model.
- Repurposing the surrounding rural spaces into suburban areas, suburban developments, various industrial zones, or large commercial areas, while traditional residential areas progressively transition toward urban models, and spaces allocated for agricultural purposes also experience a gradual decline.

A fourth model is observed in areas where irrigation systems have been extensively adopted over a short period (over the past two decades, this adoption has been accompanied by strong technological and digital advancements in work and management). This model requires most agricultural practices to undergo significant changes, resulting in a population having to adapt quickly to these changes.

- Reduction in the necessary workforce.
- Changes in workforce typology: increased qualifications in some groups, prevalence of wage earners, temporary work, etc.
- New workforce location models tend to concentrate in larger localities with a transportation network facilitating easy and quick commuting to workplaces.
- A considerable increase in farm size is linked to the profitability of the investments needed to operate these "new" agricultural enterprises.

The result of these changes is resource reassignment.

- Reduction in the number of inhabitants (depopulation).
- The disappearance of old residential centres (depopulation) was replaced by large agricultural operations.
- Relocation of the remaining population to existing or new localities is now experiencing population growth.
- Rejuvenation of the population.

Another model, the fifth, occurs due to the construction of large public works, especially hydraulic ones (reservoirs, dams, etc.), causing substantial impacts on spaces:

- Submerge a significant portion of lands used for vital economic activities, affecting income levels.
- Replace agricultural lands with other uses (forest reforestation to prevent landslides or erosion, which would lead to rapid reservoir siltation, for example).
- Flooding residential areas.
- Depopulation, due to these reasons, causes fractures in economic and social structures (complementarity of economies among different population centres, etc.), inducing depopulation processes in unaffected areas as well.

These large-scale public works are usually carried out by public administrations with the capacity to acquire lands and buildings from their inhabitants at low prices, subsequently displacing them to other locations.

Finally, it is worth including as a model, even though it shares only the causative factor for depopulation, the abandonment of obsolete activities that once attracted people to rural spaces. These include inns, taverns, roadside inns, military or police barracks, flour mills and oil mills, railway stations, etc. These establishments were previously scattered throughout rural areas and were significant in attracting residents. However, technological modernization, the establishment of robust commercial networks, or the existence of efficient transportation systems have rendered residing in these places unnecessary.

(3). The disappearance of human intervention in spaces. Depopulation as an environmental issue.

Up to this point, we have observed how processes of depopulation occur, where population centres lose inhabitants or are left without them, yet the area or space they occupy maintains agricultural or other activities. In fact, some depopulated centres lost their population because people tended to cluster in larger hubs with better services and accessibility. However, this process cannot be considered depopulation as long as human intervention persists.

For a depopulation process to truly occur, it's necessary for the areas losing their population to have a certain dimension, soils that are difficult to utilize, and such scarce transportation infrastructure that it makes it unfeasible to continue human intervention with an intensity that allows these spaces to remain the territories of those human societies. This becomes evident when comparing **Figures 1**–**4**.

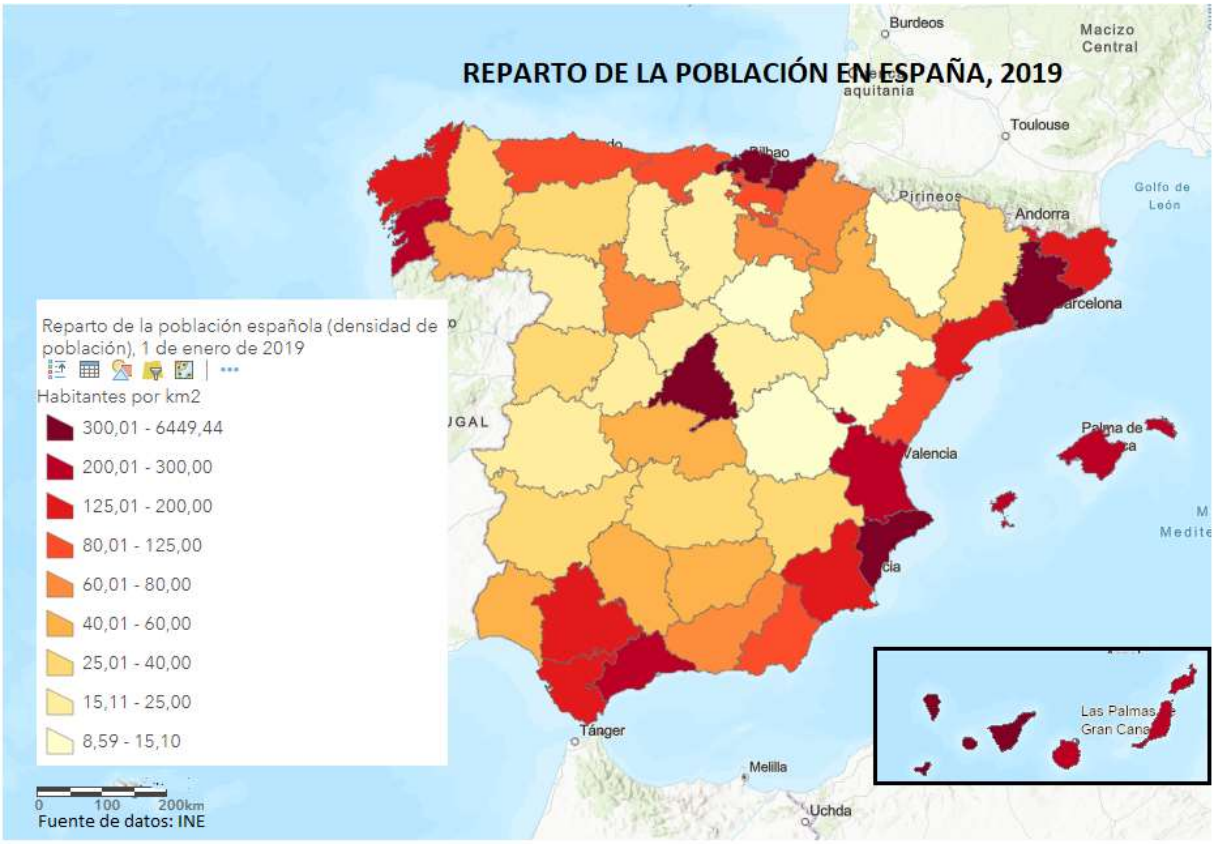

Figure 4. Distribution of Spanish population by provinces (2019).

The redistribution of the Spanish population across the territory occurred through the massive exodus of people from the interior towards the major cities, most of which, except Madrid, Seville, Zaragoza, Pamplona,

Valladolid, and some smaller ones, are situated along the coastline. However, this depopulation does not result in a similar reduction in the Agricultural Utilized Surface (SAU), nor in the land used for pastures or forestry activities (**Figures 5–7**). Only in areas where depopulated spaces were adjacent, reaching large dimensions, and where accessibility was very limited, can we observe an abandonment of anthropic land uses. If we analyse the map of depopulation in Huesca (Spain) in **Figure 8**, these conclusions are reinforced. It's notable that there is a strong concentration of depopulated nuclei in the area corresponding to the middle Pyrenean depression, the southern slope of the interior mountain ranges, and the northern slope of the outer mountain ranges. This area had a road network primarily composed of tracks and paths, as seen in **Figure 9**. The map in **Figure 9** represents, shaded in gray, the clusters of depopulation. It's clear how these groups of nuclei are organized around tracks, remaining detached from highways and national roads, and are scarcely connected by regional roads.

If we compare how those spaces were and how they are today, the uses that were given and are given now, etc., we will see that in that accumulation zone, significant changes have occurred as a result of a withdrawal of human intervention: agricultural uses of the land have been largely abandoned, replaced by shrubs and wooded areas; the former population centres are in a ruined state, and the road networks show signs of abandonment, among other things. To do this, let's compare the aerial photographs from the "American flight" of 1956–1957 (**Figure 10**) with the orthoimage (**Figure 11**) of the same areas today (to do so, click on this link). We'll confirm what we previously anticipated about the intensity of depopulation and the changes in spaces they generate: it's not difficult to recognize where there has been a depopulation and abandonment of land use, and where this depopulation has not led to drastic changes in the area.

Figure 5. Agrarian land used.

Figure 6. Meadows distribution.

Figure 7. Wooded forest soils.

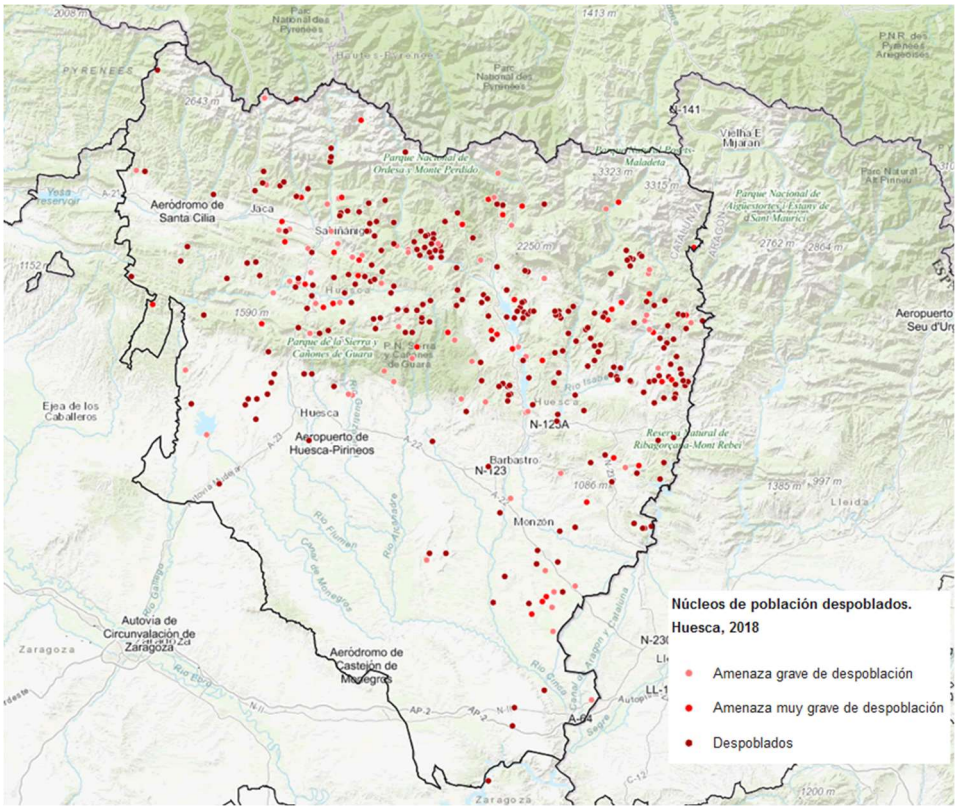

Figure 8. Depopulation spots. Huesca, 2018.

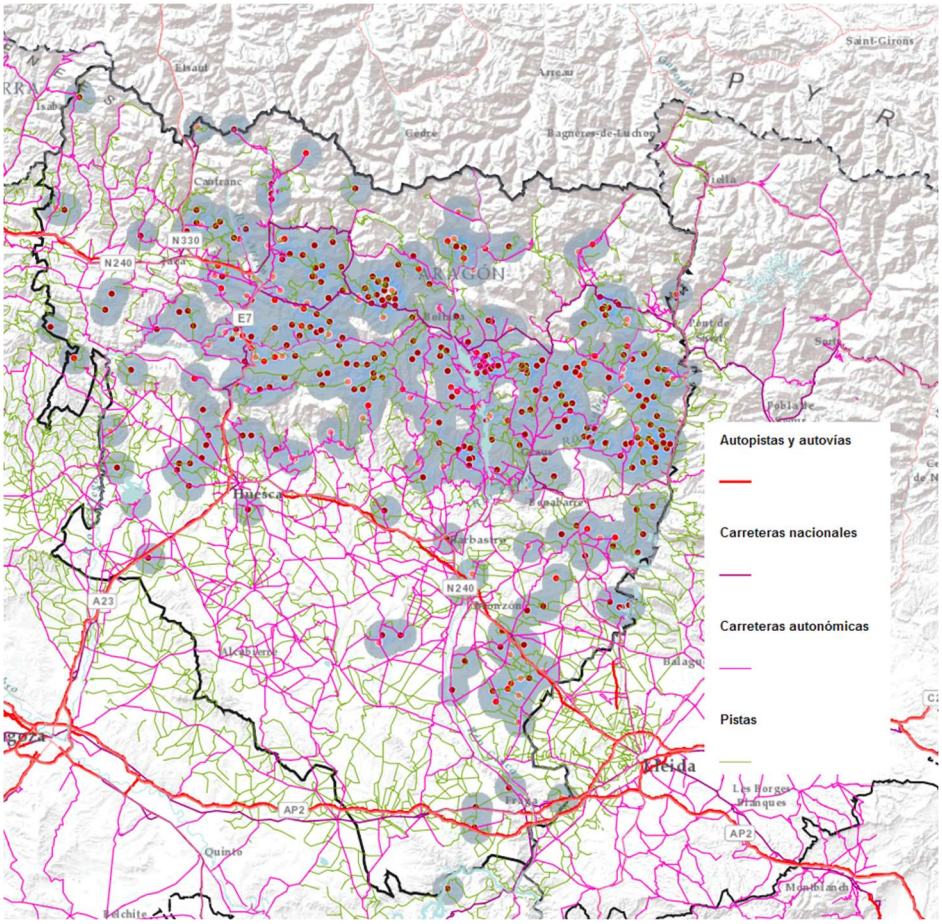

Figure 9. Depopulation and accessibility.

Figure 10. Arial photograpghy, 1956–1957.

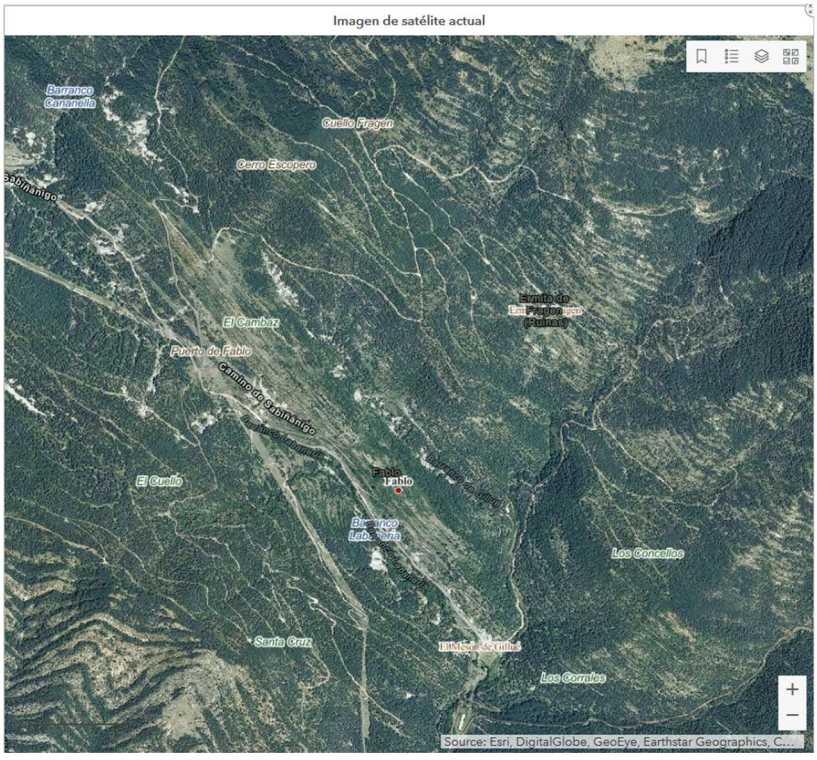

Figure 11. Orthoimaging, 2018.

(4). Depopulation and demographic deserts

It's important, to understand depopulation processes and their consequences, to differentiate between "demographic deserts" and "depopulated spaces". The former are spaces that, due to physical factors (altitude,

climate, etc.), have always been uncultivated, and thus, following the terminology of Ellis et al.[3], have experienced negligible or null anthropic modification (**Figure 12**).

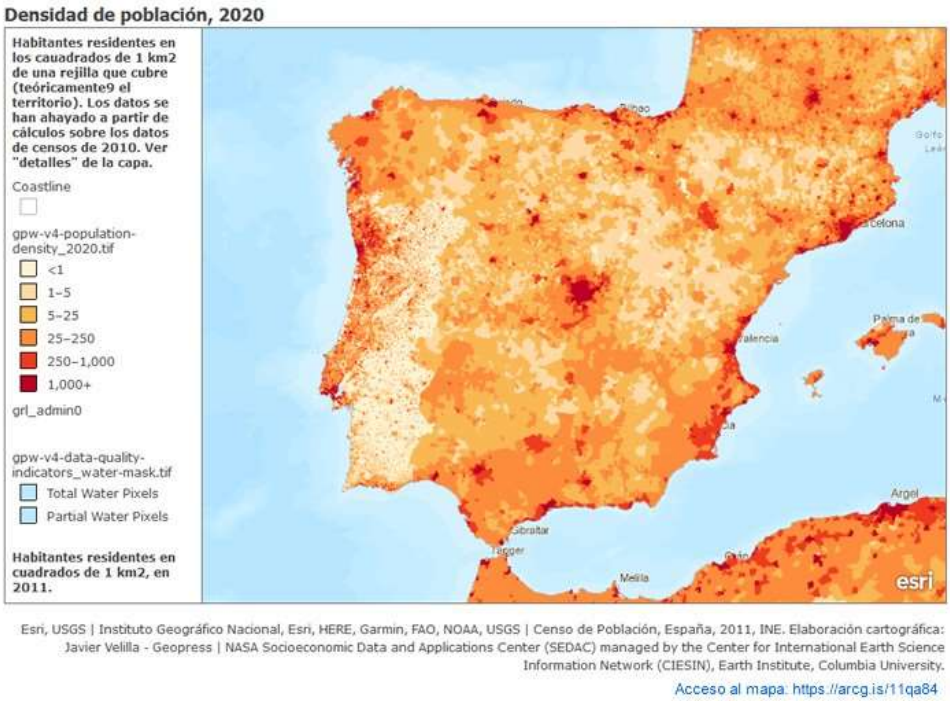

Figure 12. Population distribution in the world.

Therefore, they are considered natural or wild spaces and not "anthropogenic biomes". The significance of this lies in the fact that biomes modified by human societies have been shaped through interrelations between the physical environment and these societies, generating interdependencies between both (**Figure 13**).

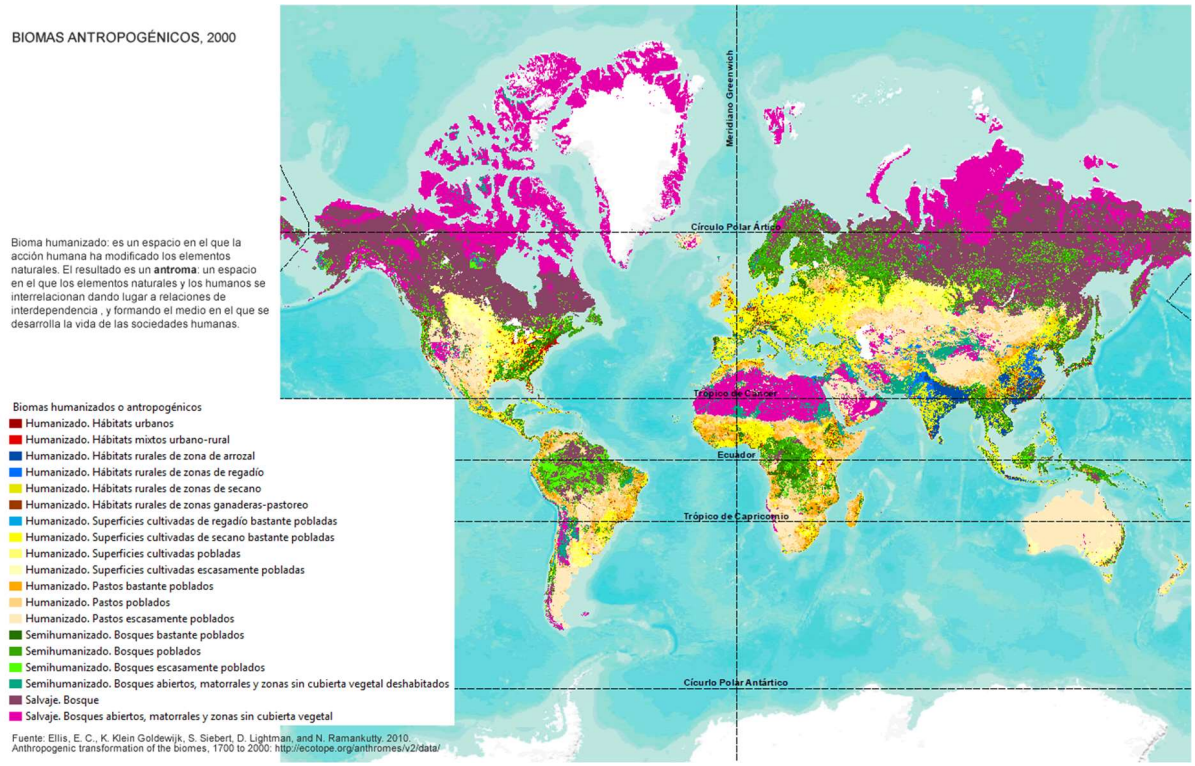

Figure 13. Anthropogenic biomes. 2000.

Has the population exodus directly resulted in an abandonment of the environment where the people who left those spaces lived? By analysing changes in land use, we can find answers to these questions: spaces where human activity has drastically reduced, usually due to the abandonment of agricultural land, dwellings, and transportation infrastructures, are scarce and concentrated in disadvantaged biomes where factors such as climate, soil, terrain, communications, etc., make competitive agricultural activities in the market more challenging. In the rest of rural areas, population departure hasn't led to the abandonment of cultivable lands, which have been taken over by other inhabitants of the same or nearby population centres. Only poor soils or those following obsolete cultivation systems (mixed forestry-agricultural uses, for instance) have been abandoned in this latter case.

From these arguments, three fundamental ideas can be deduced:

- Can spaces where human activity persists to some extent, even though people no longer reside in them, be considered depopulated? Wouldn't it be more accurate to say that these spaces have undergone a relocation of the societies that compose them into anthropogenic biomes, reserving the concept of "depopulated" or "emptied" for those where human intervention has ceased or occurs at a very low intensity?
- Are the dimensions of the territories in which pre-industrial societies lived, and from which they obtained what they needed to live, the same as those of the territories where current societies are settled? The answer is negative: the development of infrastructure, transportation, and communication means has enabled an expansion of these dimensions in line with the requirements of an economic system that has multiplied its production capacity and the size of its markets. The concept that best captures this idea is the "ecological footprint": the surface necessary to supply the production apparatus and to accommodate its waste, plus, as we add, the one that is essential to ensure the functioning of economic branches related to management, distribution, communication, transportation, etc., which constitute today's market economies.

In this way, the abandonment of population centres, if these are located in areas near spaces undergoing intense anthropogenic processes, does not, from our point of view, signify an abandonment or disappearance of human action on the occupied space but rather a replacement of old forms of intervention in it with new ones, more capable of organizing, modifying, and giving it a specific morphology.

- This concept of depopulation, used in the sense mentioned earlier, raises very relevant issues about the sustainability of these processes: depopulation, by minimizing human intervention in the environment, questions the continuity of these biomes since it cannot be expected that natural factors alone can generate natural biomes (in a climactic or potential sense). Natural spaces (wilderness) are the result of a very long process of adaptation to environmental changes since the last glaciation. Therefore, anthropogenic biomes, especially those that have been intensely modified by human action (as is the case with developed countries, including Spain, and emerging ones), when this is drastically reduced, are in a critical situation: natural factors can no longer go through the lengthy evolutionary process that we mentioned in their formation (their starting point is the current situation of relief, climate, vegetation, water, etc., not the factors in which their formation occurred), and moreover, those factors have undergone significant modifications (elimination of potential plant and animal species, introduction of invasive species, modification of relief, etc.) that limit their ability to reconstruct "wild" biomes.
- But it's not just that the abandonment of human societies leaves biomes in a situation of no return; it's that these "andromes" could cope with or minimize the effects of natural disasters through the collaboration of natural factors and human action: forest fires, landslides, meteorological phenomena,

floods, etc., have much more dramatic consequences when those societies no longer inhabit those spaces and their intervention in them has ceased: they no longer immediately respond to extinguish fires, the terraces that protected their slopes are in a ruinous state, their water conduits have been abandoned, their communication networks as well.

- It's not just that the abandonment of human societies leaves biomes in an irreversible state, but these "andromes" could confront or minimize the effects of natural disasters through the collaboration of natural factors and human action: forest fires, landslides, weather phenomena, floods, etc. have far more dramatic consequences when these societies no longer inhabit these spaces and their intervention in them has ceased: immediate responses to put out fires are absent, the terraces that once protected their slopes are in ruin, water conduits have been abandoned, and communication networks, too.

2. Mapping and perception of depopulation

How to represent depopulation? What types of maps to use? What scales? What information? These are not easy questions to answer. In fact, there are various cartographic formats found in the study of this topic. The issue is that the answers to these questions determine how the depopulation process is represented and subsequently interpreted. Let's examine several formats:

The problems increase when we consider that not only has human-modifying action on the natural environment decreased in these "depopulated" areas, but also the societies' ability to protect these anthropogenic biomes has been reduced: society's access to these environments has diminished as populations move away; traditional transport infrastructures have vanished or are in the process of doing so, etc. In this situation, natural disasters (forest fires, landslides, the consequences of weather phenomena, etc.) are more likely to occur and have more severe consequences.

As mentioned earlier, maps representing population by provinces, assuming that provinces with lower population density had undergone more intense depopulation, lack objectivity. Several issues render these maps less meaningful. Firstly, several provinces with low densities have been experiencing this situation for three or more centuries, linked to their physical environment, transportation networks, and the onset of migrations from the interior to the coast, among other factors. However, the most relevant issue is that the map does not indicate where depopulation processes have occurred: in a province, localized depopulation processes have often taken place, as seen in the case of Huesca, in specific spaces, while in others, population increases have occurred. One way to incorporate this information is to use the demographic size of municipalities, either on the map (**Figure 2**) or in an accompanying figure (**Figure 14**). This approach represents the number of municipalities that have, for example, less than 50 or 100 inhabitants, which, although it does not pinpoint the location of depopulation processes, provides an approximation of their significance in each province.

REPARTO DE LA DESPOBLACIÓN SEGÚN TAMAÑO DE MUNICIPIOS. MUNICIPIOS SEGÚN SU TAMAÑO Y POBLACIÓN RESIDENTE EN ELLOS. ESPAÑA, 2018

Porcentajes

Provincia	Número de municipios	Habitantes	Municipios < 50 habitantes	Población residente municp. <50 hab.	Municipios de 1 a 100 habitantes	Población residente municip. 1-100 hab.	Municipios de 100 a 500 habitantes	Población residente municip. 100-500 hab.	Número municipios >50.000 habitantes	Porcentaje municipios >50.000 habitantes	Porcentaje población residente municip. >50.000 hab.
Soria	183	88.600	37,16	2,15	63,39	5,96	26,23	10,81	0,00	0,00	0,00
Guadalajara	288	254.308	34,38	1,17	62,15	3,38	23,96	5,38	1,00	0,35	33,09
Burgos	371	357.070	19,41	0,71	43,13	2,49	41,51	9,24	1,00	0,27	49,18
Rioja, La	174	315.675	18,39	0,27	34,48	0,93	43,10	5,40	1,00	0,57	47,83
Teruel	236	134.572	15,68	0,89	38,56	3,83	42,80	16,92	0,00	0,00	0,00
Segovia	209	153.342	15,31	0,70	35,89	2,79	41,63	11,98	1,00	0,48	33,75
Cuenca	238	197.222	13,03	0,50	31,51	2,14	42,86	12,51	1,00	0,42	27,82
Ávila	248	158.498	12,90	0,76	36,29	3,57	47,98	16,43	1,00	0,40	36,69
Palencia	191	162.035	12,04	0,50	37,70	2,67	46,07	11,60	1,00	0,52	48,69
Zaragoza	293	954.811	9,56	0,10	27,30	0,50	41,98	3,02	1,00	0,34	69,64
Valladolid	225	519.851	8,00	0,13	25,78	0,70	48,89	4,74	1,00	0,44	57,65
Navarra	272	647.554	5,51	0,09	15,81	0,39	40,81	4,06	1,00	0,37	30,44
Salamanca	362	331.473	4,97	0,21	20,99	1,57	63,81	16,32	1,00	0,28	43,57
Castellón/Castelló	135	576.898	4,44	0,04	13,33	0,19	35,56	1,86	2,00	1,48	38,11
Huesca	202	219.345	3,47	0,12	13,86	0,94	57,92	12,48	1,00	0,50	23,81
Zamora	248	174.549	2,02	0,12	10,89	1,11	70,16	25,66	1,00	0,40	35,74
Tarragona	184	795.902	1,63	0,02	3,26	0,05	31,52	1,97	2,00	1,09	29,48
Madrid	179	6.578.079	1,12	0,00	6,15	0,01	10,06	0,07	23,00	12,85	84,17
Barcelona	311	5.609.350	0,96	0,00	3,54	0,01	17,68	0,25	19,00	6,11	64,26
Alicante/Alacant	141	1.838.819	0,71	0,00	2,13	0,01	21,99	0,48	8,00	5,67	51,87
Toledo	204	687.391	0,49	0,00	1,47	0,02	24,02	2,09	2,00	0,98	24,30
León	211	463.746	0,47	0,01	2,37	0,08	44,55	6,14	2,00	0,95	41,21
Valencia/València	266	2.547.986	0,38	0,00	1,13	0,01	17,29	0,55	5,00	1,88	42,24
Albacete	87	388.786	0,00	0,00	1,15	0,04	25,29	1,63	1,00	1,15	44,45
Almería	103	709.340	0,00	0,00	0,97	0,01	33,98	1,43	3,00	2,91	53,13
Araba/Álava	51	328.868	0,00	0,00	0,00	0,00	35,29	1,47	1,00	1,96	75,10
Asturias	78	1.028.244	0,00	0,00	0,00	0,00	11,54	0,29	4,00	5,13	60,68
Badajoz	165	676.376	0,00	0,00	0,61	0,01	12,73	0,97	2,00	1,21	31,01
Balears, Illes	67	1.128.908	0,00	0,00	0,00	0,00	4,48	0,09	1,00	1,49	36,01
Bizkaia	112	1.149.628	0,00	0,00	0,00	0,00	18,75	0,63	3,00	2,68	45,57
Cáceres	223	396.487	0,00	0,00	3,59	0,17	40,81	7,01	1,00	0,45	24,19
Cádiz	45	1.238.714	0,00	0,00	0,00	0,00	2,22	0,04	8,00	17,78	68,63
Cantabria	102	580.229	0,00	0,00	1,96	0,02	15,69	0,86	2,00	1,96	38,60
Ciudad Real	102	499.100	0,00	0,00	0,98	0,00	18,63	1,19	1,00	0,98	14,96
Córdoba	77	785.240	0,00	0,00	0,00	0,00	6,49	0,25	1,00	1,30	41,51
Coruña, A	93	1.119.351	0,00	0,00	0,00	0,00	0,00	0,00	3,00	3,23	36,46
Gipuzkoa	88	720.592	0,00	0,00	0,00	0,00	26,14	0,88	2,00	2,27	34,45
Girona	221	761.947	0,00	0,00	1,81	0,05	38,01	3,12	1,00	0,45	12,99
Granada	174	912.075	0,00	0,00	0,00	0,00	16,67	1,04	2,00	1,15	32,15
Huelva	80	519.932	0,00	0,00	1,25	0,01	18,75	0,95	1,00	1,25	27,91
Jaén	97	638.099	0,00	0,00	0,00	0,00	4,12	0,27	2,00	2,06	27,06
Lleida	231	432.866	0,00	0,00	5,63	0,24	46,75	6,42	1,00	0,43	31,73
Lugo	67	331.327	0,00	0,00	0,00	0,00	1,49	0,07	1,00	1,49	29,58
Málaga	103	1.641.121	0,00	0,00	0,00	0,00	16,50	0,34	8,00	7,77	69,80
Murcia	45	1.478.509	0,00	0,00	0,00	0,00	2,22	0,03	4,00	8,89	55,47
Ourense	92	309.293	0,00	0,00	0,00	0,00	4,35	0,55	1,00	1,09	34,15
Palmas, Las	34	1.109.175	0,00	0,00	0,00	0,00	0,00	0,00	5,00	14,71	499,20
Pontevedra	61	941.772	0,00	0,00	0,00	0,00	0,00	0,00	2,00	3,28	39,89
Santa Cruz de Tenerife	54	1.018.510	0,00	0,00	0,00	0,00	0,00	0,00	3,00	5,56	42,83
Sevilla	106	1.939.887	0,00	0,00	0,00	0,00	0,94	0,01	4,00	3,77	48,96
Ceuta	1	85.144	0,00	0,00	0,00	0,00	0,00	0,00	1,00	100,00	100,00
Melilla	1	86.384	0,00	0,00	0,00	0,00	0,00	0,00	1,00	100,00	100,00

Fuente de datos: INE (Padrón y Estadística del Padrón Continuo)

Figure 14. Significance of depopulation processes in each Spanish province.

Nevertheless, as previously indicated, the most common method is to represent population density by municipalities on a choropleth map (**Figures 2** and **3**), using relevant indices in the legend's ranges to comprehend the depopulation process.

Moreover, the ways in which municipalities are constituted have varied according to the locations and the administrations responsible. Hence, in areas where severe depopulation processes have occurred, there might be the preservation of small municipalities, housing some depopulated nuclei, but they are associated within collective entities, such as parishes, hamlets, or councils. In other areas, where individual entities predominate, larger municipalities have been created, which may or may not include depopulated nuclei.

Therefore, we believe that this type of cartography approaches demonstrating the intensity of depopulation in different territories but does not allow for sufficient precision. For example, can these maps

identify population processes related to the crisis of dispersed habitats or differentiate low densities due to physical constraints from those resulting from depopulation?

3. Factors

The depopulation of the rural world (illustration 17) was the result of the reallocation of resources, in this case humans, driven by the market to implement economic modernization, where subsistence agricultural practices, which had previously prevailed, no longer fit since they couldn't compete with more advanced agricultural practices oriented towards producing for that market.

While this process was common to all areas where agricultural activities predominated, in those that made integral use of the territory by combining agricultural, livestock, and forestry activities aimed at self-consumption, they proved unfeasible (**Figure 15**), as they couldn't integrate into a market focused on intensity and mass production[11]. A significant part of the Aragonese territory, especially in the Pyrenean and Iberian Mountain spaces, constitutes a relevant example of this abandonment of traditional land uses and its consequences, as well as the introduction of tertiary activities into the territory[12].

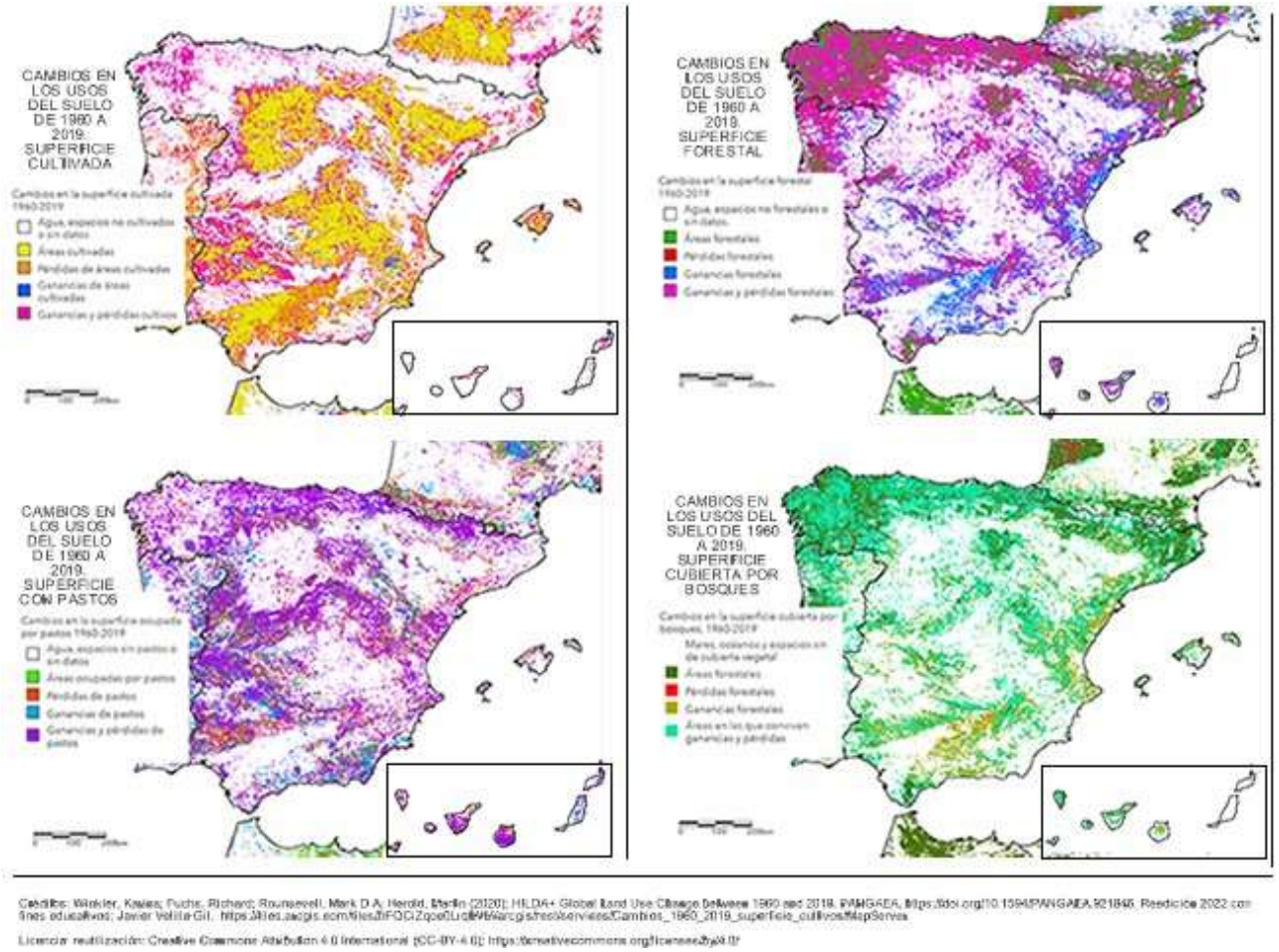

Figure 15. Changes in land use, 1960–2019.

This population, facing a profound crisis that made the activities that had provided sufficient resources for their livelihood unfeasible, now finds new attractions in:

- Large cities (later in spaces nearby or well-connected with them) and neighbouring municipalities that welcomed new industrial activities and service providers, both public and private, are now being

established. Furthermore, this economic development allowed them to offer income levels and service availability superior to those found in a rural world where agricultural activities predominated. The gradual liberalization of markets, parallel to the establishment of global markets since the end of World War II, accentuated the crisis of agricultural activities, which encountered serious problems competing with the prices and products of multinational companies from "developing" countries, which had lower production costs. On the other hand, the most acute depopulation processes occurred in "disadvantaged areas"[13], transitional areas between mountain economies where the physical environment acted as an anecumene factor and, simultaneously, favoured the development of an extensive livestock and forestry economy that provided resources to these small populations. These areas of transition, situated in the Aragonese case between 700 and 1400 m of altitude, had practiced a subsistence economy where resources came from the integral use of space, which was now unfeasible.

- The establishment of this market economy was accompanied by the development of new and more efficient transport infrastructures connecting management centres (major cities), becoming the network through which economic, social, administrative, and political activities circulated. A large part of rural areas remained outside this new spatial organization. Thus, accessibility to transport infrastructure and major cities served as an attraction for migratory movements.
- The construction of reservoirs, which flooded cultivated areas and sometimes whole population centres, was a determining factor for certain migratory movements in populations losing their sources of resources. Again, this process was more pronounced in mid-mountain areas, where the largest hydraulic works were built.
- This demographic emptying (**Figure 16**) resulted in a spatial and social "dismantling": the departure of a significant percentage of the population put these traditional societies in crisis, reducing their capacity to respond, leaving them defenseless in facing a process of loss of institutions, customs, and norms that had hitherto served to organize and exploit the space they inhabited[14]. The abandonment of solidarity customs and traditional values that had hitherto allowed them to face crises and problems affecting these societies periodically is particularly important.
- This process of deruralisation of social organization forms and values, economic structure, spatial organization, etc., favoured, as previously mentioned and will be further developed below, the implementation of an urban-inclined idiosyncrasy, predisposing the rural population, especially those in spaces with greater problems, to migrate seeking income, services, and opportunities offered supposedly by cities and the activities developed within them.

The result was a process that presents three distinct phases:

- From the late 19th century until 1936, the population outflow was slow and limited. Women and men migrated for a few months or years to seek additional income to complement family earnings.
- From 1950 to 1975, the process intensified, witnessing the depopulation of most currently deserted population centres. This phase represented definitive emigration, seeking settlement in major Spanish cities and, if unsuccessful, moving to other European countries and, to a lesser extent, Latin American countries.
- From 1976 on, there was a slowdown in population outflow, connected with a significant reduction in rural areas' population and a notable aging of the same.

The territorial results of this process have been shown in **Figure 17**.

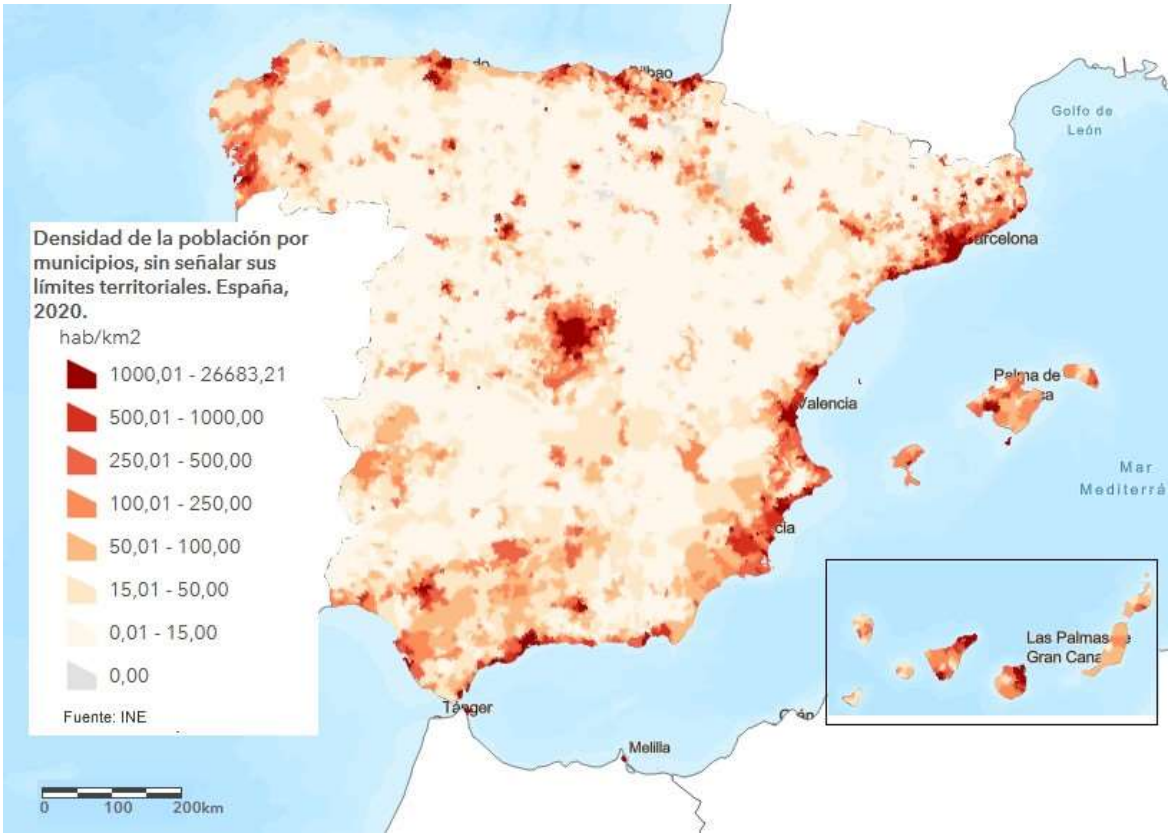

Figure 16. Population density by municipalities (without indicating their limits), 2020.

DISTRIBUCIÓN DE LA POBLACIÓN Y DEL ENVEJECIMIENTO, SEGÚN EL TAMAÑO DEL MUNICIPIO DE RESIDENCIA. ESPAÑA, 2014

Municipios tamaño	Porcentaje de la población española	Porcentaje menos de 16 años	Porcentaje de 16 a 64 años	Porcentaje mayores de 64 años	Total Edades
<100 habitantes	0,15	4,71	54,62	40,68	100,00
100 - 500 habitantes	1,42	8,83	58,20	32,97	100,00
500 - 1.000 habitantes	1,58	11,53	60,91	27,56	100,00
1.000 - 5.000 habitantes	9,47	14,45	63,61	21,94	100,00
5.000 - 10.000 habitantes	8,34	16,70	65,82	17,48	100,00
10.000 - 30.000 habitantes	18,67	17,22	66,61	16,17	100,00
30.000 - 50.000 habitantes	8,23	17,41	67,27	15,33	100,00
50.000 - 100.000 habitantes	12,44	17,13	67,29	15,58	100,00
100.000 -250.000 habitantes	16,43	16,18	66,64	17,18	100,00
250.000 - 500.000 habitantes	7,21	15,10	66,23	18,67	100,00
>500.000 habitantes	16,06	14,66	65,48	19,86	100,00
Total	100,00	--	--	--	--

Fuente de datos: INE (Padrón y Estadística del Padrón Continuo)

Figure 17. Population distribution and aging.

The emergence of two clearly differentiated spaces: relatively small urban areas (in the 145 municipalities with over 50,000 inhabitants) concentrating 52.7% of the Spanish population, while the remaining

municipalities (7979) are occupied by the remaining 47.3%. Naturally, this creates two Spains: one densely populated, one urban, and another with very low densities, especially in mountainous areas or areas with very limited accessibility. Population aging and negative demographic growth in most rural spaces are consequences of these migratory currents, further accentuating the differences between the two spaces.

Depopulation has been accompanied by population aging (**Figure 18**). The population's emigration limits its biological renewal possibilities, reducing the number of family members and the percentage of young people, fostering a negative natural growth, and subjecting the territory to a vicious cycle of depopulation that is challenging to break free from[11]: the population does not grow naturally, but emigration decreases its number. Consequently, the average age of the population ranges between 52.6 and 57.8 years in municipalities with fewer than 500 inhabitants and between 41.6 and 43.4 years in those with over 50,000 inhabitants. These statistics highlight the challenges rural areas face in achieving a 'replacement rate' that allows them to anticipate negative growth figures.

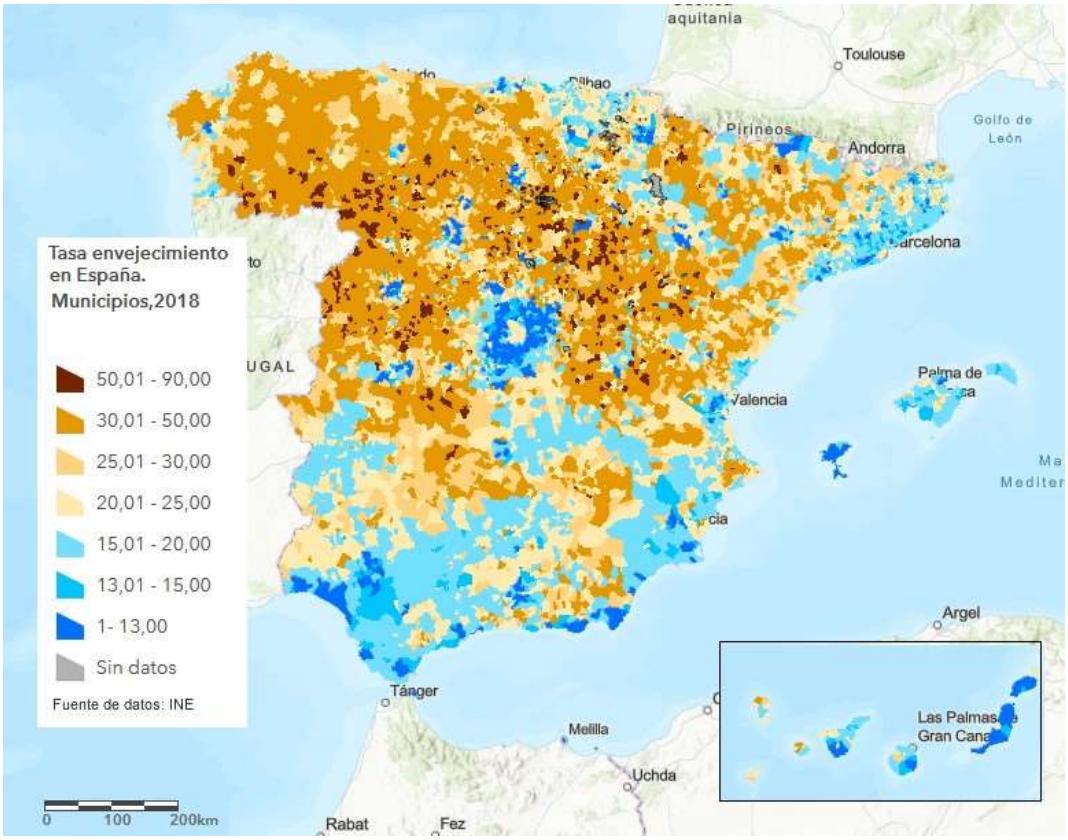

Figure 18. Aging rates in Spain, 2018.

4. Perceptions of rural depopulation

In 1951, as rural exodus in Spain began to accelerate, the film "Surcos" (**Figure 19**), directed by José Antonio Nieves Conde and based on a script by Eugenio Montes and adapted by Gonzalo Torrente Ballester, was released. After the credits, the first twenty seconds of the film offer a declaration of intentions, which is worth reproducing here: "Even the remotest villages are influenced by the city, inviting farmers to abandon their land with promises of easy wealth. Confronted with city temptations, unprepared to resist or handle them, these peasants, who have lost their connection to the land without gaining a very difficult civilization, are rootless trees, fragments of the suburbs that life destroys and corrupts. This constitutes the most painful problem of our time. This is not a symbol, but rather, unfortunately, a too frequent case in today's life.

Figure 19. Surcos movie: Picture frame.
Note: Images: Film frame from the movie "Surcos," obtained from the RTVE website of the program "Historia de Nuestro Cine," dedicated to the movie "Surcos," aired openly on 15 May 2015[15].

In social processes, ideologies play a determinant role, both by influencing the way they are interpreted and by acting as factors in their development. These processes, such as rural depopulation, are perceived as they occur and afterwards, according to the value system generated by the dominant social group, which ultimately consolidates its position. It's not surprising, therefore, that the extraordinary transfer of population from rural to major Spanish cities was accompanied by the establishment in the collective imagination, of both rural and urban inhabitants, a negative view of the former as something outdated, uncultured, and destined to fail, while the latter was seen as the engine of development, innovation, and wealth. From there, it was easy to consider rural societies, their ways of life, and economies as a burden for modern, dynamic urban societies.

Even today, the RAE dictionary provides three significant definitions of "rústico" (rustic): "belonging or relating to the countryside, rough (unworked, unpolished), and countryman." Conversely, "urbano" (urban) is defined as "belonging or relating to the city, and courteous, polite, and in good taste." Similarly, "pueblerino" (villager) is defined as "native or inhabitant of a village" and, when used pejoratively, as "someone lacking refinement in manners or tastes, or lacking breadth of ideas or perspectives."

This perception, a product of ideological positions implementing the Spanish developmental model, was reflected in the information conveyed by media, cinema, etc., serving both to interpret and justify the process as it occurred and to create in the minds of the less privileged inhabitants of the rural world the idea that the city held a "golden" promise, where they could escape the misery in which they lived.

With few exceptions, such as "Surcos" and a few others, very few voices were raised against the humiliations, disillusionment, and uprooting of those who abandoned their social organization and economic models to join new ones, where they were discriminated against and felt alienated. It wasn't until the 1980s that alternative perspectives on the rural depopulation process began to emerge, and the first criticisms of how it unfolded appeared. Among others, Miguel Delibes with his "Los santos inocentes" in 1981 and "Castilla Habla" in 1882, or Julio Llamazares with his "Lluvia amarilla" in 1988, were among the first to call for a review of the values on which previous ideological formulations were based.

These formulations don't seem coincidental or trendy but rather arise within a contextual framework that explains and justifies them. If since the late 19th century, the perception of rural exodus and the emptying of Spain's inland regions spread as something necessary and synonymous with progress, from the 1980s onward, the invasion of rural spaces by urban population and activities, along with their social and environmental

consequences, was seen as bringing progress to these areas and improving the quality of life for those new migrants.

It's interesting to note that these formulations don't stem from coincidence or trends but arise within a context that explains and justifies them. If, since the late 19th century, the perception of rural exodus and the draining of Spain's inland regions was widespread as something necessary and synonymous with progress, from the 1980s onward, the invasion of rural spaces by urban population and activities, along with their social and environmental consequences, was seen as bringing progress to these areas and improving the quality of life for those new migrants.

5. Depopulation: A geographical problem

In recent years, the issue of depopulation in extensive rural territories has been gaining increasing attention in the media, consequently influencing public opinion and administrative initiatives. However, in geography curricula, especially in pre-university education, it is scarcely addressed, and when it is, it's always associated with rural exodus as a historical process (in the literal sense: it structured realities of the past but has concluded), ignoring that it remains a present-day reality for today's citizens.

But why should geography, rather than other subjects, be responsible for teaching and learning the set of contents associated with depopulation? Because, as indicated by RD 217/2022, geographical thinking can be described as a "set of skills to analyse, understand, and transform knowledge of space around concepts such as proximity, connection, location, or spatial distribution, using the appropriate scale in each case, from local to global".

There's another argument to consider: identifying, understanding, and analysing depopulation issues (and those related to repopulation) require recourse to learning related to relief, climatology, natural resources, demographic dynamics, economic activities, and their spatial manifestations, etc. In summary, the problems of rural depopulation can perfectly serve as an articulating axis for the curricular contents of geographical teaching-learning processes, starting from the study of the nearby context: the environment in which the student lives, processes from the recent past that have shaped their way of being and thinking, and issues they will coexist with in the future. Don't aging, problems with environmental conservation, and territorial imbalances in resource distribution have an intimate relationship with depopulation? Furthermore, these issues hold significant added value, offering a unique formative interest, as they present spatial context knowledge as something that isn't neutral: addressing depopulation/repopulation is not just about understanding it; it's about acknowledging that resources are not distributed evenly or according to social equality or environmental quality criteria.

Depopulation in Spain: School project (students aged 14–18) to address the depopulation process in Spain

The curriculum materials presented are available at: https://arcg.is/0mGizDs. They revolve around contents related to depopulation and repopulation processes and aim to foster competency-based education using GIS tools and, in general, those offered by new technologies. These strategies involve student participation and collaboration in constructing their learning, engaging in activities with some playful content, and empowering students (the only tool to learn to learn and make appropriate decisions when facing problems).

These materials have been developed by the authors of this article with the collaboration of a "working group" of secondary education teachers focused on digital cartography use for competency-based learning. The format is that of a digital book that breaks down the contents based on the following index:

- Instructions for use in a brief introductory chapter.

- Location and description of Ainielle (Huesca), an abandoned village, emphasizing spatial changes from depopulation to the present.
- Concept of depopulation and differences from "demographic desertification", and its manifestation in Spain: Spanish abandoned villages.
- Relationships between depopulation, negative population growth, and aging.
- The situation and issues of agricultural activities in Spain and their relationship with demographic decline in certain spaces and towns.
- Quality of life in rural areas is evaluated based on two criteria: available services and accessibility, and their relationship with depopulation processes and recent repopulation processes.
- Concepts of "territorial imbalances" and "territorial planning". Problems associated with depopulation and policies and initiatives taken in response to this process, both by the European Union and Spanish administrations, even by the affected society itself.
- An example of repopulation: Granadilla, Cáceres.

The didactic model we adopt is the "bimodal curriculum"[16]: we classify materials into two types. Firstly, we identify and explain basic and essential concepts for learning, and secondly, we propose a set of "project-based" activities aimed at the learner's knowledge construction. In essence, the lack of understanding of these basic concepts should not hinder task completion. On the contrary, the completion of these tasks should reinforce knowledge construction and understanding of the conceptual pillars on which it relies.

Teachers using these materials can opt for three ways to use them:

- Use only the pre-designed maps (along with other format-based information to guide discovery) to solve the problem presented in each of these maps.
- Utilize only applications that come with a set of tools (**Figure 20**) geared toward students using the map, its layers, etc., aimed at active learning tasks that prioritize spatial analysis skills and knowledge construction. An example of these applications can be found here: https://arcg.is/1mG1XP focusing on "part-time" agriculture.
- The third option involves using all the materials, both those designed for teaching and those for learning purposes.

The use of GIS tools is directed at three objectives:

- Identifying the elements that shape that space and the relationships they maintain, resulting in territory and its most apparent manifestation in the landscape.
- Employing strategies that involve students working with GIS, without the difficulties derived from learning their use becoming a stumbling block or essential content in learning.

Figure 20. Toolbar in the GIS used.

Moreover, geographic information systems (GIS) have significantly advanced in recent years in their effort to provide new and more efficient ways of communicating spatial issues. Starting from the map or maps, as elements representing space or what occurs within it, different communication formats can be developed, such as images, videos, texts, graphics, data tables, etc. These complement the communicative process,

resulting in clearer and more evident information. Currently, Hypertext Markup Language, in its version 5, allows the creation of sets of content, resembling digital books or Story Maps, that are "immersive". This means they attract the reader and guide them through the contents and proposed learning experiences, providing support where they may face difficulties or need to make decisions while advancing through the presented discourse.

Conflict of interest

The authors declare no conflict of interest.

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