GRANULAR

GRANULAR RURAL TYPOLOGY: A NOVEL TERRITORIAL TYPOLOGY FOR EU RURAL AREAS

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GRANULAR RURAL TYPOLOGY: A NOVEL TERRITORIAL TYPOLOGY FOR EU RURAL AREAS

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Acronyms

DEGURBA	Degree of urbanisation
EFTA	European Free Trade Association
EU	European Union
GDP	Gross Domestic Product
ISCED	International Standard Classification of Education
LAU	Local Administrative Unit
LTVRA	Long Term Vision for Rural Areas
SME	Small and Medium Enterprise

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Executive summary

This report presents the objectives, development process, methodological basis and added value of a territorial typology for EU rural areas. The *GRANULAR rural typology* was developed to provide a clearer and more useful way of understanding the diversity of rural Europe. Its purpose is to support research and policy by distinguishing different types of low-density territories, not only by how many people live there, but also by how rural areas relate to nearby towns and cities, landscapes, settlement patterns and demographic change. The GRANULAR rural typology is intended to support evidence-based decision-making in areas such as land-use planning, environmental management, rural development and territorial policy, while remaining compatible with established European classification systems.

The GRANULAR rural typology has been developed through a collaborative process involving researchers, project partners and rural stakeholders. This process began with a review of existing territorial typologies and continued through discussions on which policy questions the typology should support, and how it could remain transparent, reusable and relevant over time. The collectively defined aim was to create an analytical tool that can help researchers and policymakers recognise different expressions of rurality across Europe.

The GRANULAR rural typology was developed using a data-driven approach to refine how rural areas are understood within Europe's established classification framework. Specifically, the GRANULAR methodology classifies grid cells into clusters based on a set of multi-criteria, grid-based indicators. These automatically defined clusters become classes of the GRANULAR rural typology through interpretation, naming and validation. The clusters are defined exclusively within rural strata, as identified in the existing grid-level Degree of Urbanisation (DEGURBA) classification, Level 2. The GRANULAR rural typology therefore builds on DEGURBA while adding a more detailed reading of rural territories. Instead of treating rural areas as a single residual category, it highlights the diversity within low-density Europe and makes it possible to distinguish remote and sparsely populated areas from rural places that are closely connected to towns, cities and peri-urban regions.

The added value of the GRANULAR rural typology lies in showing that rural areas differ not only by settlement density, but also by their physical setting, built form, accessibility, landscape character and demographic trajectory. These dimensions help reveal forms of rurality that are difficult to identify through density thresholds alone. The technical choices behind this classification, including the indicator selection, data preparation and clustering procedure, are explained in the methodology section.

The results show a broad and coherent gradient across rural Europe. As rural settlement becomes denser, built structures, landscape modification and accessibility generally increase, while elevation tends to decline. This confirms that the typology remains consistent with the basic logic of DEGURBA while also providing a more nuanced understanding of the rural categories within it.

The most important contribution of the GRANULAR rural typology is its identification of peri-rural areas: low-density territories that are formally rural but functionally connected to nearby urban systems. These areas account for a small share of all rural grid cells, but they are highly significant because they show that rurality is not always defined by remoteness or decline. In countries and regions such as England and Wales, the Benelux countries, western Germany and northern Italy, rural areas may be strongly shaped by greater accessibility to urban centres.

For policy, this means that rural areas should be understood through both settlement density and functional integration. Remote rural territories, village-based rural settlements and low-density areas close to major urban centres may require different responses, even when they fall within the same broad rural classification. By making these differences visible, the GRANULAR rural typology provides a stronger basis for targeted rural policy, sustainable land-use planning, environmental management and support for community well-being across Europe's diverse low-density territories.

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1. Introduction

Task 4.6, led by NOR with contributions from IAMM, IIASA, CNRS, HUT and TI, aims to develop a multi-criteria territorial typology for EU rural areas aligned with key policy priorities and observed territorial dynamics. The task responds to the need for a richer and more nuanced understanding of rural diversity and of the relationships that shape the rural–urban continuum in Europe. It produces two main outputs: first, a screening and comparative assessment of existing territorial typologies across Europe; and second, a new territorial typology designed to classify and analyse rural areas across the EU.

The first output was delivered in GRANULAR's *Typology Scoping Report*, published in May 2023. This work reviewed existing territorial typologies across Europe and assessed how they are used for analysis and policy support, how they are constructed, and what strengths and limitations they present. This scoping exercise provided the starting point for the subsequent typology development by clarifying the purpose of the work, identifying relevant methodological options, and establishing a set of guiding principles. It also highlighted the need for a rural typology that is data-driven, transparent and able to capture the diversity of rural Europe while remaining compatible with established European classification frameworks.

The second output of this research task is the novel GRANULAR rural typology presented in this report. It is designed as a transparent and flexible tool for analysing the diversity of rural territories across the EU. Building on DEGURBA Level 2, the typology applies an incremental and hierarchical approach that refines existing territorial classifications while retaining compatibility with established frameworks. It was developed at the 1 km² grid level and uses a data-driven classification procedure to capture variation within rural areas in a consistent and reproducible way. The GRANULAR rural typology is based on open data sources and documented methods, enabling future updates and supporting both academic research and policy-relevant analysis.

This report presents the conceptual basis, development process, design criteria, methodology, results and policy relevance of the GRANULAR rural typology. It first situates the work within existing territorial typologies and the DEGURBA framework, before describing the participatory process through which the typology's purpose, scope and guiding principles were defined. It then sets out the key design criteria underpinning the typology, including transparency, accessibility, multidimensionality, spatial granularity and automatic classification. The methodology section explains the clustering approach, the spatial units and data sources used, the construction and pre-processing of indicators, and the validation of the clustering results. The report then presents the resulting rural classes, their spatial distribution, indicator profiles and expression within the GRANULAR Living Lab areas, before interpreting the main findings in relation to rural differentiation, peri-rural dynamics and the limits of density-based classification. The final section draws conclusions on the added value of the GRANULAR rural typology for European territorial analysis and policy, followed by references and appendices providing access to background data and documenting the validation workshops and key development steps.

2. Characterising territorial diversity in rural areas

Urban-rural classifications have historically varied significantly across national jurisdictions, producing statistical data that lack international comparability. This fragmentation undermines evidence-based policy making and limits the ability to conduct meaningful cross-national research on demographic, economic, and environmental trends. To address this challenge, a number of territorial typologies have been developed to identify, delimit, and classify areas in order to address their inherent complexity over time (Copus et al. 2007).

Territorial typologies employ diverse methods to capture their unique characteristics for various purposes, including statistical reporting and regional planning. Two primary methodological approaches are zoning for the purpose of delimiting spatial units, and classifying based on predetermined boundaries, categorising rural areas according to stocks or flows (Féret et al. 2020). *Delimitation* focuses on homogeneous spatial units using parameters like travel time, population density, service availability, or demographic flows. The EU Functional Rural Areas is one example of territorial typology where zoning was defined on the basis of parameters such as travel time and population (Dijkstra and Jacobs-Crisioni 2023). *Classification* categorises rural areas according to their stocks (structural characteristics) or flows (dynamic features). This method involves predefining spatial boundaries, typically at the regional level, based on criteria like the type of main economic sector, presence of natural resources, demography, population dynamics, commuting patterns, or distribution networks.

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Classification is often achieved through various strategies: Structural approaches describe rural areas according to their socio-economic and environmental characteristics by analysing variables such as population size, density, accessibility to services, landscape features, employment, and built environments. The scientific literature debates whether demographic features should be considered structural aspects of rurality or not (Dická et al. 2019; Acadie and Magali Talandier 2023; Hedlund 2016). Systemic approaches aim to address the critique that stock-based typologies often imply deficiencies in rural areas (e.g., lack of services). These approaches emphasise how rural areas contribute to various sectors, including productive economies, tourism, transition activities, and human life cycles. Despite limitations due to data availability, proxies are used to infer flows from stock variables within the main domains: space and physical resources, activities and enterprises, and people and life trajectories (Acadie and Magali Talandier 2023).

This overview shows how rural areas can be delimited and classified using different approaches that consider various criteria of rural development. In the European context, the most established classification is the typology developed by Eurostat on behalf of the European Commission (EC 2021). The typology classifies 1 km² grid cells into three types, according to the population density in the individual grid cells and the combined population level of clusters, where clusters are made up of contiguous cells. Urban centres (High-density clusters) include clusters of contiguous grid cells of 1 km² with a density of at least 1,500 inhabitants per km² and a minimum population of 50,000 after gap-filling. Urban clusters include clusters of contiguous grid cells of 1 km² with a density of at least 300 inhabitants per km² and a minimum population of 5,000 inhabitants. Rural grid cells are those outside high-density clusters and urban clusters.

Based on the cluster types defined at the grid level, DEGURBA is further developed into two specific territorial typologies at the administrative levels, addressing specific policy needs:

- Degree of urbanisation (DEGURBA): Classifies Local Administrative Units (LAU) based on the share of its population living in cluster types: densely populated areas (>50%), intermediate density areas (<50% of the population in urban centres and <50% in rural grid cells), and thinly populated areas (≥50% in rural grid cells).
- Urban-rural typology: Classifies regions (NUTS3 level) into predominantly urban, intermediate, and predominantly rural based on the proportion of population living in urban clusters: >80%, 50-80%, or <50% respectively.

A significant constraint of this framework lies in its coarse treatment of the urban-rural spectrum in the underlying typology of clusters. While cities represent clearly delineated settlements sortable by population thresholds, the remaining two categories exhibit considerable heterogeneity without specifying distinct settlement types. Specifically, the designation for towns and semi-dense areas conflates actual towns with less densely built environments. Similarly, rural zones combine villages and sparsely inhabited territories under the same class.

To address this gap, a secondary tier sub-classification scheme (Level 2 of DEGURBA) was implemented to map the complete settlement hierarchy across large, medium, and small communities, functioning as a hierarchical refinement of Level 1. Its purpose is to pinpoint medium-sized and smaller settlements, such as towns and villages. The refinement adheres to a consistent logical structure building on specific terms corresponding to defined thresholds. Moreover, Level 2 of the DEGURBA classification follows the same two-stage methodology employed in Level 1. The initial phase involves categorising grid cells according to three criteria: population density, population totals, and geographic contiguity. Specifically, Rural grid cells are categorised into three types:

- A *rural cluster* consists of contiguous (using eight-point contiguity) grid cells with a density of at least 300 inhabitants per km^2 and a collective population between 500 and 4,999 in the cluster.
- *Low-density rural* grid cells are rural grid cells with a density of at least 50 inhabitants per km^2 and are not part of a rural cluster.
- *Very low-density rural* grid cells are rural grid cells with a density of less than 50 inhabitants per km^2.

One of the key limitations of the DEGUGBA approach used is the use of rigid population density thresholds for the delimitation of towns and villages. In the latest revision of the DEGURBA methodology (Eurostat 2026a) (2026), the density thresholds were adjusted from 300 to 900 people per km², reducing the minimum population from 5,000 to 2,500 inhabitants, and removing the requirement for physical contiguity between settlements. The new rule also switches from ‘8-point’ to ‘4-point’ contiguity, better reflecting how dense towns and city centres are defined.

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Other methodological changes include:

- In the previous versions a neighbourhood could be labelled as suburban even if 70% of its residents lived in a city centre or dense town. This was due to the largest single category among non-city cells being classified as suburban, regardless of actual population distribution. To address this issue, the 2026 release considers the entire population of an area, not just a subset.
- The 'majority filter' used in DEGURBA 2011 and 2021 included grid cells in a city boundary if most of their surrounding cells belonged to that city. However, water-covered cells were counted as surrounding cells, making it harder for coastal or riverside cells to qualify. This issue has been resolved by excluding water-covered cells from the count.
- The previous releases required at least 50% of a small area's population to live in relevant type of grid cells for classification as a dense town or village. To provide more flexibility, the new version allows national authorities to classify an area as a dense town (if at least 30% of residents are in dense urban or city cells) or a village (if at least 30% are in rural cluster or urban cells), even if it falls just short of the original threshold.

However, the revised spatial layers for the 2016 DEGURBA revision have not been officially released yet[1]. Hence, this work refers to the 2021 version, which remains the primary classification framework for rural and urban statistics across EU institutions and is widely used as the reference system for territorial analysis in research, policy monitoring, and programme design at European scale.

3. Towards the GRANULAR rural typology

The construction of the GRANULAR rural typology followed a transparent and participatory framework in which technical and operational objectives, scope and purpose were collectively defined by a broad community of stakeholders. Contributions from this community were formalised through a series of online validation workshops that guided each stage of the typology's development. This section outlines the principal activities carried out during the preparatory work, thereby illustrating the decision-making process leading to the GRANULAR rural typology. A detailed chronological account is presented in Appendix 2.

The initial phase of the process focused on a systematic inventory of existing rural and territorial typologies across Europe. The objective was to catalogue current frameworks and undertake a comparative assessment of their characteristics, application contexts, construction methods, strengths and limitations. This task was carried out in close collaboration with the extended GRANULAR community, including academic partners, participants in the Living Labs and Replication Labs, and other experts, who jointly identified relevant typologies and evaluated them against predetermined criteria.

The collective outcomes were incorporated into the *Scoping report on European rural typologies*, released in May 2023. The report provides an extensive inventory of territorial typologies at both EU-wide and national/local levels, accompanied by a comparative analysis of their analytical uses, construction methodologies and relative merits. The comparative assessment emphasised that territorial typologies are inherently simplifications of the complex phenomena they aim to represent; no single classification can fully capture all relevant dimensions or every nuance of reality. Consequently, the report concludes that the choice of typology should not be guided by an assumption that one method is intrinsically 'right' or more accurate than another. Instead, technical decisions, such as the analytical approach, territorial scope, data sources and selected variables, must be driven by the specific objectives of the study and the particular metrics that need to be measured. Similarly, the comparison highlighted that, to maximise practical value, typologies should be explicitly aligned with the research questions or policy goals for which they are intended. This alignment ensures that the resulting categories provide meaningful insights rather than merely descriptive labels.

Finally, the comparative review showed that the robustness of any typology ultimately depends on its comparability, reliability and replicability. Using recurring, comparable data sources ensures that the classification remains consistent over time and facilitates future updates. Reliable measurement protocols and clear documentation further

[1] At time of writing (May 2026), the 2026 DEGURBA release is not available for download from the Eurostat GISCO platform.

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enable other researchers to reproduce findings, thereby strengthening confidence in the typological framework and supporting evidence-based decision-making. Equally important is a transparent acknowledgement of the typology's limitations. By openly communicating potential biases and gaps, users can interpret results with appropriate caution and avoid overgeneralisation.

The second phase of the typology development process focused on defining the design criteria for producing the new GRANULAR rural typology, as described below. The process was structured around a series of workshops, presentations and events in which the main strategic elements and building blocks of the typology were discussed with a broad community of actors, including project partners and external stakeholders.

3.1. Purpose and intended areas of use

The GRANULAR rural typology was agreed to serve primarily as an analytical tool for research, while remaining closely aligned with EU policy priorities, including rural development, cohesion, climate resilience, digitalisation and sustainable agriculture. This makes it applicable across several key sectors and contexts:

- **Research**: The GRANULAR rural typology should support research on issues such as rural diversity, spatial inequality and rural-urban linkages. By adopting a grid-based resolution, the typology should allow spatial patterns, resources, infrastructure and environmental attributes across different rural settings to be examined. It should also enable comparisons of rural areas against broader socio-economic and environmental benchmarks, helping to describe spatial inequalities and rural-urban connections through indicators such as travel times to urban centres and accessibility measures.
- **Land-use planning**: The GRANULAR rural typology should provide information on the distribution and characteristics of different expressions of rurality. By combining information on multiple dimensions, including topography, the built environment, population dynamics, accessibility and modified natural features, the typology should inform planning approaches that consider both development needs and land pressures. Along these lines, it may support analyses focusing on agricultural land, urban growth boundaries and the allocation of public services.
- **Environmental management**: The GRANULAR rural typology should explicitly acknowledge the role of rural landscapes in wider ecological systems and resilience. As such, it should capture relationships between topographic features, natural habitats and modified landscapes. The typology could, for example, inform targeted assessments of biodiversity, carbon storage potential, water resources, and erosion or flooding risks, and may therefore support conservation, water governance and climate adaptation planning.
- **Rural development strategies**: The GRANULAR rural typology should support rural development strategies by bringing together information on population dynamics, accessibility, economic context and infrastructure conditions. This information can help describe where different types of support may be relevant, including measures related to livelihoods, local economies, access to services and inclusive growth. Possible uses include policy analysis at national, regional and local levels; targeting of EU cohesion funds and rural development programmes; and monitoring and evaluation of policy outcomes.

Overall, the GRANULAR rural typology is intended to support spatial analysis of diverse rural territories and inform policy discussions. By describing rural territories through several complementary dimensions, it provides a structured basis for linking research findings with policy-relevant questions.

3.2. Transparency and accessibility

As part of the typology design process, it was agreed that the GRANULAR rural typology should be transparent and accessible. Making its components available through public repositories should allow other researchers to validate, replicate, update or extend the typology. Transparency was therefore framed around three pillars that support openness in the typology's construction, application and future development:

- **Open data**: All data sources underpinning the GRANULAR rural typology should be obtained and made accessible through public repositories. By making the background data publicly available, other researchers

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may scrutinise, replicate or extend the typology, thereby promoting scientific rigour and collaboration in rural spatial analysis. Along these lines, it was agreed that the typology itself should be published in the Zenodo repository under open licences, ensuring alignment with the FAIR Guiding Principles for scientific data management.

- **Reproducibility**: As part of the FAIR principles, the methodology and algorithms used in the GRANULAR rural typology should be documented as open-source code. This commitment to transparency ensures that researchers can trace, validate and build upon the computational methods used to derive GRANULAR's dimensions and classifications. It also allows independent verification of results, consistent application across diverse contexts, and continuous improvement based on community feedback.
- **Stable updates**: Recognising that typology development is an ongoing process, it was agreed that the GRANULAR rural typology should incorporate mechanisms for regular updates reflecting refinements to data sources, methodological modifications or emerging research insights. These stable revisions could be managed through controlled versioning practices and maintained within a publicly accessible repository. This design ensures continuity and enables policymakers and other stakeholders to monitor changes over time, fostering an informed dialogue on the implications of such updates for rural policy design.

This holistic approach to openness fosters trust in the typology and empowers researchers and policymakers by providing robust tools grounded in evidence-based insights, adaptable to evolving circumstances and capable of facilitating well-informed decision-making in rural contexts.

3.3. Conceptual alignment with the GRANULAR Rural Diversity Compass

One of the intended ambitions of the GRANULAR rural typology has been to ensure overall conceptual consistency with the Rural Diversity Compass presented in GRANULAR Deliverable D2.2 (Oostindie et al. 2024). The Compass highlights multi-spatiality and multi-functionality as key elements of rurality. It aims to illuminate rural diversity by focusing on place-specific functional differentiation across the residential, productive, environmental and recreational functions of rural areas. These four functions are characterised through 24 components that emphasise typical features and interconnections in specific rural contexts. By combining these components, the Compass provides a framework for understanding the distinctive characteristics of each function and their relationships within particular settings.

Deliverable D2.2 highlights that cross-referencing between core functionalities is often necessary to understand their complex interactions, and argues that a multi-spatial lens is crucial for understanding contemporary rural differentiation. Building on this orientation, the GRANULAR rural typology also treats rural diversity as emerging from the combination of multiple spatial and territorial conditions. However, rather than operationalising the full set of Compass functions and components, the typology adopts a more pragmatic, data-driven strategy. As described below, it uses a shorter set of harmonised grid-level indicators to capture selected dimensions that are relevant to rural multi-functionality and multi-spatiality, while remaining feasible for pan-European application. In this sense, the Compass provides the wider theoretical vocabulary of rural multi-functionality and multi-spatiality, while the typology offers a reproducible territorial classification that partially translates these ideas into empirical analysis. The GRANULAR rural typology can therefore be understood as a feasible first step towards operationalising the Compass, rather than as its complete empirical translation.

3.4. Multidimensionality

As a pragmatic operationalisation of some of the Compass's core ideas, based on the series of workshops and interactions with GRANULAR actors, it was decided that the GRANULAR rural typology should adopt a multidimensional approach, incorporating six distinct dimensions that provide a holistic view of rural areas:

- **Topography**: This information is instrumental in characterising the physical features of rural landscapes, providing insights into natural resource availability and management potential. It can be used, for example, to evaluate soil types, water bodies and vegetation patterns that support distinctive ecological conditions. These data may also aid in assessing suitability for specific rural uses such as agriculture, forestry or conservation, thereby informing land-use policies aimed at balancing economic development with environmental preservation.

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- **Land modification**: An essential aspect of GRANULAR's multidimensional approach is the incorporation of environmental features. By tracking changes to vegetation types, land-cover shifts due to urban expansion, or degradation resulting from anthropogenic activities, the typology enables a nuanced understanding of the balance between preserved natural landscapes and modified zones.
- **Built environment**: Consideration of the built environment was included as a way to inform potential infrastructure development needs in some rural areas, for example to accommodate growing populations while preserving natural resources and ecological integrity. By integrating this information into the GRANULAR rural typology, it should also be possible to examine the impact of urban encroachment on local rural landscapes, informing policies for balanced growth and the management of interactions between urban and rural areas.
- **Population dynamics**: This supports planning for future resource allocation and infrastructure needs, accounting for population growth or contraction in different areas. By including information about population change, the GRANULAR rural typology can help evaluate pressures on local resources, assess demand for public services, and reveal challenges related to housing, transport, water supply and waste management that rural communities may face as a result of demographic change.
- **Accessibility**: This dimension offers valuable insights into rural-urban linkages, socio-economic outcomes and environmental impacts. By examining these connections, the typology can promote balanced development and foster mutual benefits between rural and urban populations.

By offering a comprehensive, spatially explicit characterisation of rural areas, the GRANULAR rural typology aims to provide scientific evidence that contributes to more informed decision-making on sustainable development in diverse rural contexts.

3.5. Key methodological building blocks

Alongside the definition of the design criteria described above, the series of internal technical workshops and other exchanges with the broader community of GRANULAR actors led to the definition of three critical methodological principles underpinning the GRANULAR rural typology:

- **Incremental and hierarchical**: The first agreed methodological principle of the GRANULAR rural typology is grounded in the iterative refinement of existing classifications based on DEGURBA Level 2. The process begins by recognising the established boundaries that define rural areas and then progressively narrows these delineations to achieve a more nuanced characterisation within rural territories. Specifically, the GRANULAR rural typology refines DEGURBA class 31: *Mostly low density cells*. By building on existing classifications, GRANULAR ensures continuity while enhancing spatial granularity, ultimately providing a more nuanced understanding of complex rural conditions. The incremental approach also makes it possible to examine the diverse conditions within rural areas in greater depth, capturing subtle differences between them.
- **Granular**: The second core methodological principle of the GRANULAR rural typology is its commitment to granular spatial resolution through the use of a 1 km² grid for mapping and analysing rural territories. This high-resolution approach makes it possible to discern intricate patterns, subtle differences and localised characteristics within the rural environment, accounting for the heterogeneity inherent in rural areas. Moreover, while the typology is designed primarily for high-resolution analysis, its flexibility also allows aggregation to broader spatial resolutions. This scalability ensures that users can benefit from the detail of the 1 km² grid while shifting their focus to broader geographical contexts when needed. Such a high-resolution and versatile approach maintains its utility across diverse rural scales while delivering consistent, accurate insights that support informed decision-making and policy development.
- **Automatic classification**: The third key methodological aspect agreed for the GRANULAR rural typology was the use of an unbiased, data-driven algorithm for the classification of rural areas. By treating each dimension as a distinct set of features, this approach identifies patterns within the data that may not be immediately apparent to analysts working without automated tools. Consequently, GRANULAR mitigates

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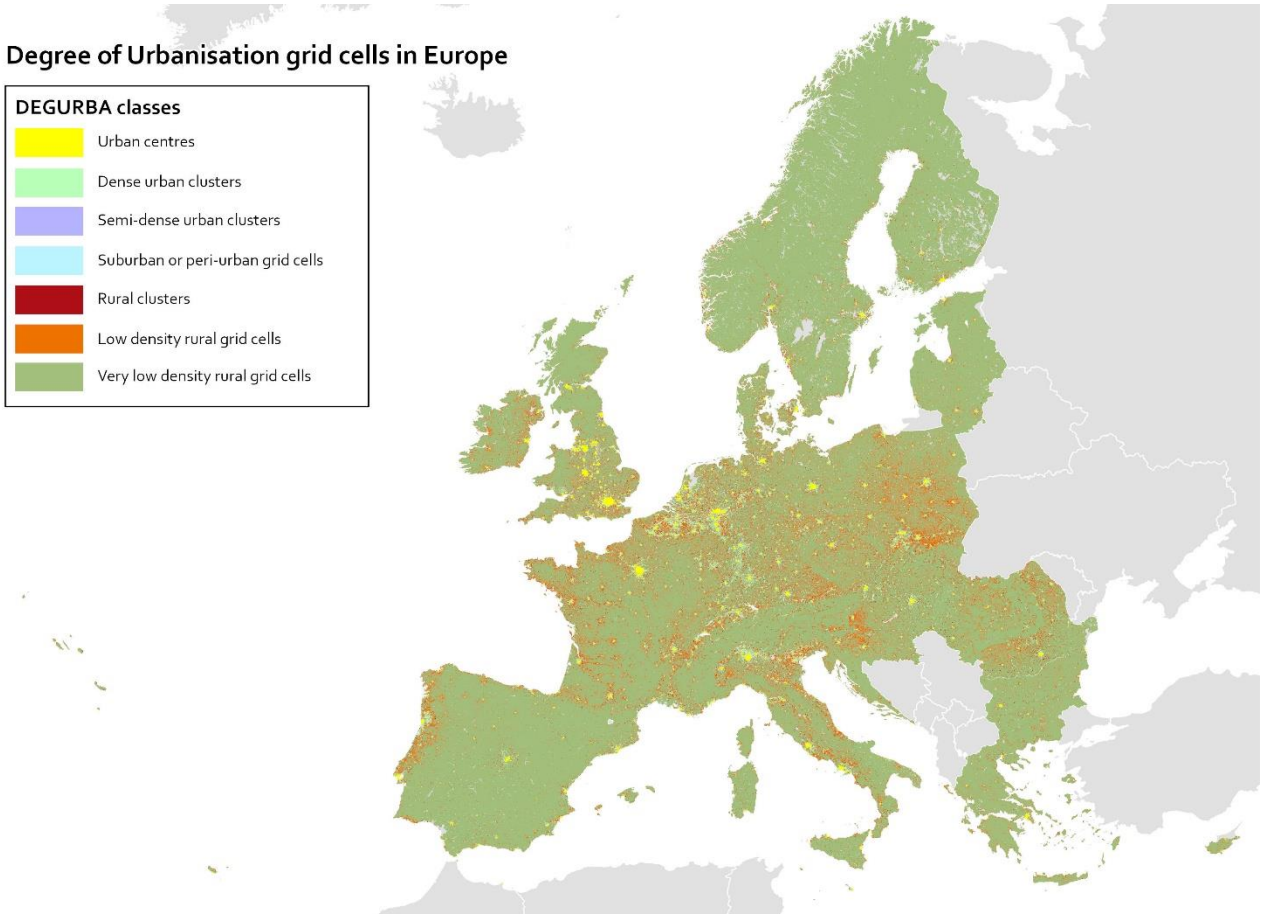
potential biases introduced by human interpretation and subjective judgements, leading to more consistent and reliable characterisations across diverse rural contexts.

In essence, the three interconnected methodological principles underpinning the GRANULAR rural typology are expected to improve understanding of subtle patterns within diverse rural environments, ensuring robust, accurate and reproducible findings that inform evidence-based decision-making in rural studies.

4. Methodology

As outlined in the previous section, the GRANULAR rural typology is developed from the rural classes delimited by the DEGURBA classification (see Map 1).



Map 1: DEGURBA class distribution across Europe

The DEGURBA framework primarily operates on a 1 km² population grid, classifying each cell according to its population density and spatial contiguity with neighbouring cells (Dijkstra et al. 2021; European Commission. Statistical Office of the European Union. 2021). This grid-based approach ensures that the classification reflects the physical distribution of population across the landscape rather than administrative boundaries, which vary considerably in size and composition across European countries. At Level 1, all cells are assigned to one of three broad categories: cities, towns and suburbs, and rural areas. At Level 2, each category is further subdivided to capture meaningful internal variation. For rural areas, this produces three sub-categories: very low-density rural grid cells (class 311), low-density rural grid cells (class 312), and rural clusters (class 313).

The present study uses DEGURBA Level 2 rural sub-categories as the stratification framework within which the clustering analysis is conducted. By running the classification separately within each of the three rural sub-categories in DEGURBA Level 2, the GRANULAR rural typology functions as a hierarchical sub-classification that accounts for fundamental differences in settlement structure before any additional indicators are introduced. This ensures that clustering captures variation within comparable territorial contexts, rather than conflating forms of rurality that differ

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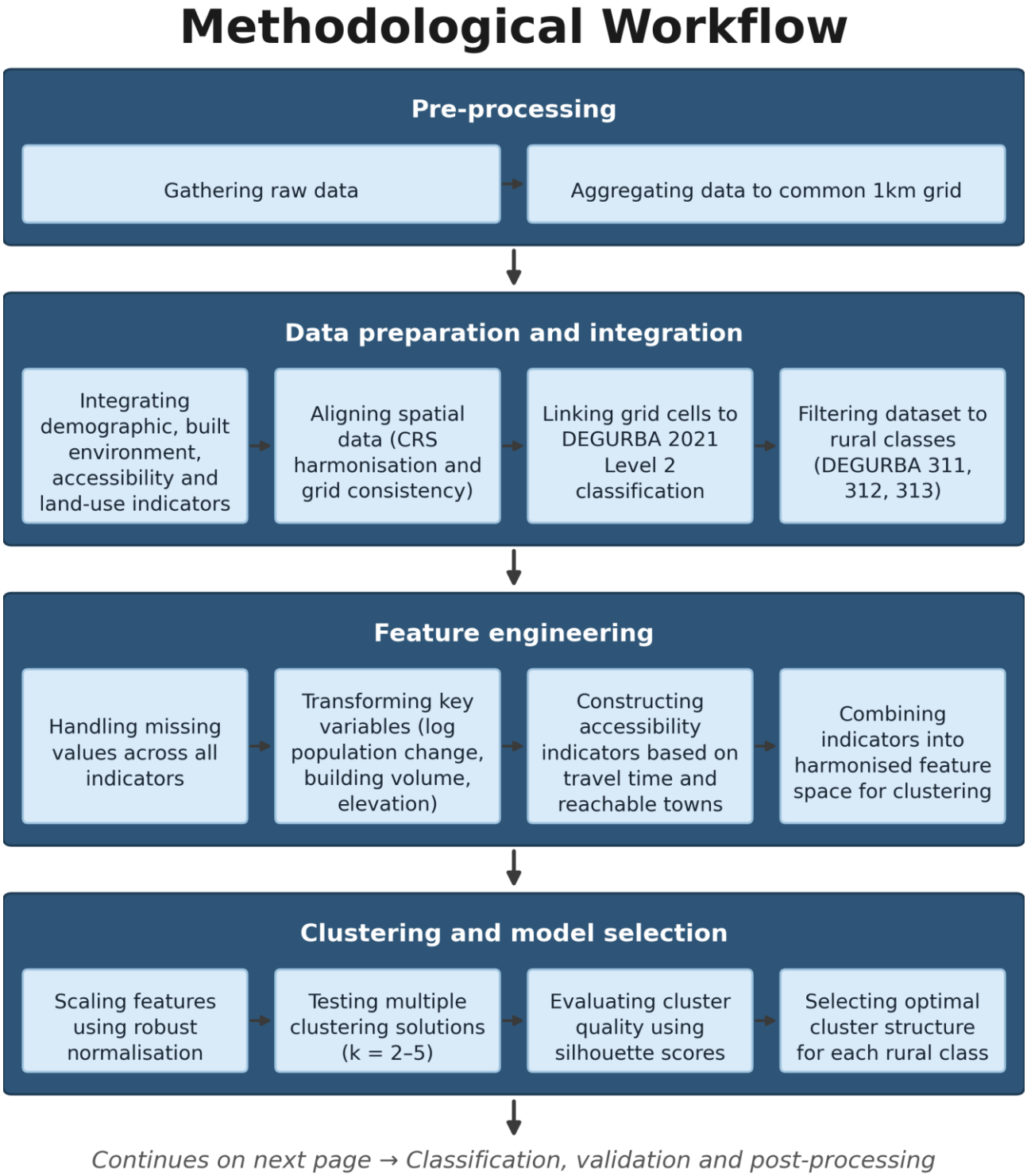
in their most basic demographic and morphological characteristics (European Commission. Statistical Office of the European Union. 2021).

The following sections describe the datasets used, the construction of analytical indicators, and the clustering procedure applied to generate the rural classes.



Continues on next page → Classification, validation and post-processing

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Methodological workflow (continued)

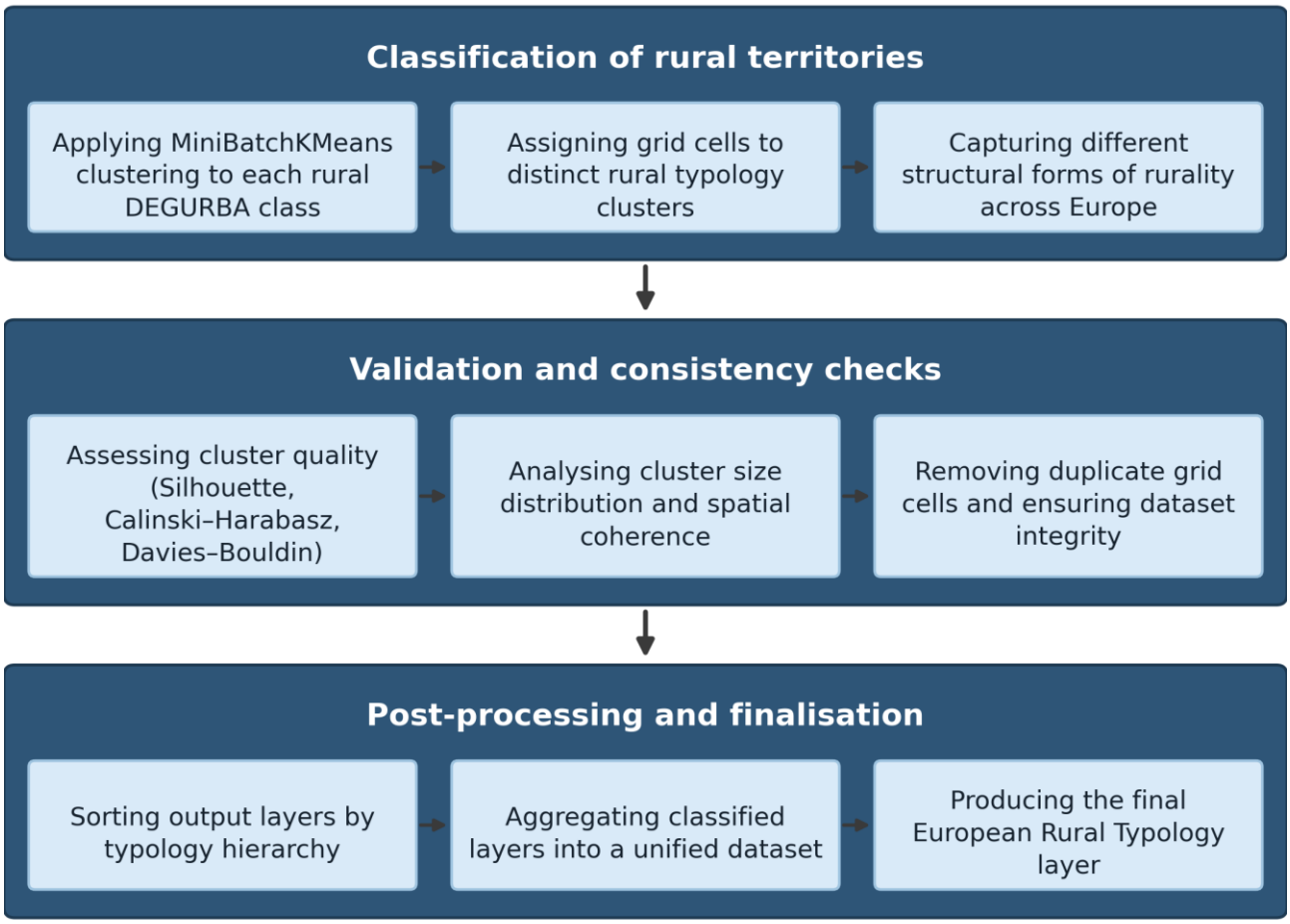

Figure 1: Methodological workflow of the GRANULAR rural typology

4.1. Spatial units and data coverage

The spatial domain covered by this work is EU27+EFTA+UK, excluding Iceland (Map 2). The spatial format is based on the 1 km² population grid for Europe (European Commission, Eurostat GISCO 2025). Each grid cell represents a standardised spatial unit to which multiple datasets are linked, ensuring spatial comparability across countries.

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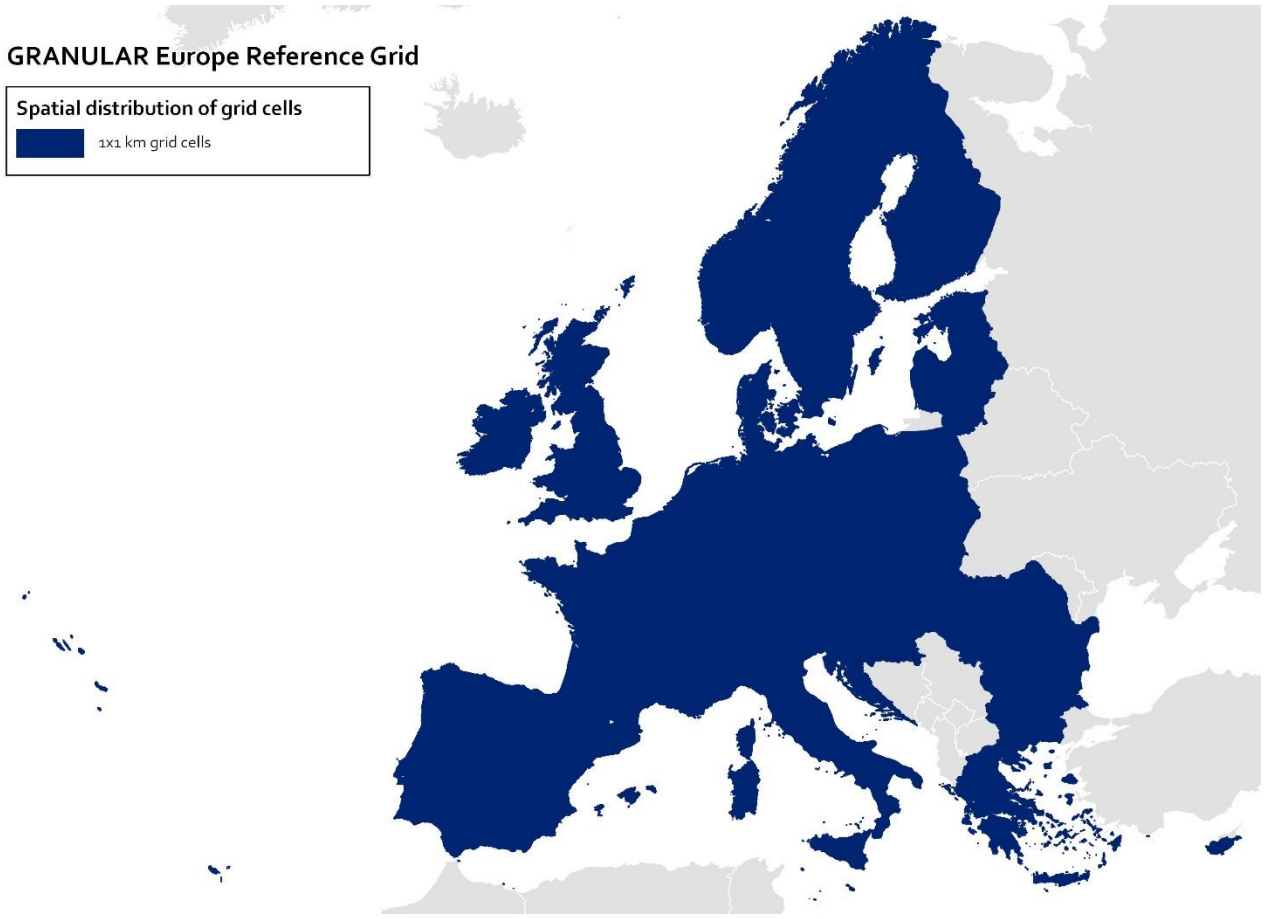

Map 2: The spatial extent of the GRANULAR Europe reference grid (also referred to as the common grid), including the UK

4.2. Data model definition

The classification integrates several Europe-wide datasets capturing different dimensions of rurality. In total, seven indicators are used to represent key characteristics of rural territories. These indicators are grouped into five core dimensions, as outlined below.

4.2.1. Demographic dynamics

The inclusion of demographic change directly responds to the growing recognition in European rural research that rural areas are not a homogeneous category in decline, but a highly differentiated set of territories experiencing simultaneous processes of contraction, stability and growth (Woods 2011; Li et al. 2019). Rural decline driven by ageing populations and outmigration coexists with peri-urban growth, amenity-driven in-migration and demographic stabilisation in areas with successful local development strategies (Stockdale 2006; Fielding 1982). While DEGURBA relies heavily on static population density to capture the current condition of a territory, it cannot distinguish between grid cells with similar densities but opposite development trajectories, for example one undergoing rapid depopulation and another attracting new residents. Such divergent dynamics require targeted policy responses, making temporal trajectory information essential for effective territorial governance.

Absolute population change between 2011 and 2021 is used here to capture long-term demographic trends affecting rural areas. The 2011–2021 period encompasses a significant decade, including post-financial-crisis economic recovery and the early effects of renewed urbanisation pressures, capturing important transitional patterns across EU rural areas (Dijkstra et al. 2015; Kabisch and Haase 2011). Demographic dynamics reflect the net result of economic opportunities, service accessibility, quality-of-life factors and migration patterns operating over extended temporal horizons (Li et al. 2019). Implicitly, the indicator captures whether rural areas are experiencing contraction characterised by ageing populations and outmigration, maintaining stability typical of traditional agricultural regions,

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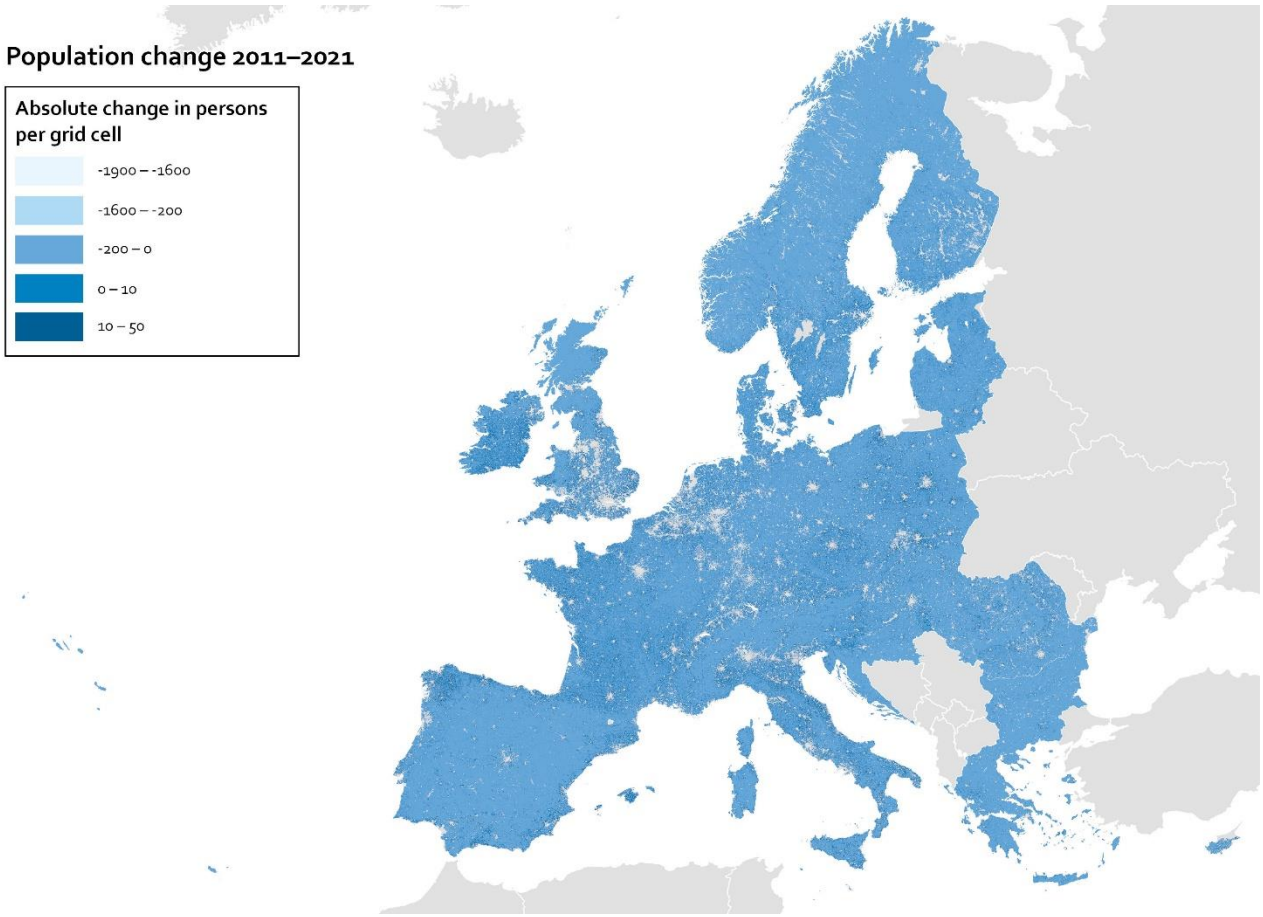
or growing through peri-urbanisation, amenity-driven in-migration or successful local development interventions. By incorporating this temporal dimension, the GRANULAR rural typology can distinguish among these varied contexts, enabling more nuanced identification of areas requiring different policy interventions related to economic support, infrastructure investment or demographic management.



Map 3: Absolute population change at grid level (2011–2021), on the common grid

Population change figures, expressed as absolute change in persons per km² between 2011 and 2021, are derived from the raw Eurostat population grids. The data were retrieved from GEOSTAT, using the total population for both included years (Eurostat and GISCO 2016, n.d.). An exception was made for UK population data for 2021, given that it was no longer included in the 2021 GEOSTAT population grid. Instead, bespoke data were provided by the James Hutton Institute, based on 2021 Census population counts calculated for the GEOSTAT 1 km² grid (2011 version) for the UK (Carnell et al. 2025)[2].

[2] The UK dataset was produced using the following workflow: census geographies (Scottish Government 2011, 2024; Office for National Statistics 2024; Northern Ireland Statistics and Research Agency 2023; Office for National Statistics 2023) and 2021/2022 Census data (Carnell et al. 2025; Office for National Statistics 2021a, 2021b; Northern Ireland Statistics And Research Agency 2021, 2022) were cleaned and reprojected to WGS84, with total population counts derived from the CEH Census 1 km grid raster (Carnell et al. 2025), following reprojection to British National Grid. Median age and sex ratio were calculated from Lower Layer Super Output Area and Data Zone (LSOA/DZ) level data (Scottish Government 2011, 2024; Office for National Statistics 2024; Northern Ireland Statistics and Research Agency 2023) and allocated to grid cells via spatial join, assigning the value of the LSOA/DZ polygon underlying each grid cell centroid; median age was derived from single-year age figures (Office for National Statistics 2021a; Northern Ireland Statistics And Research Agency 2021, 2022). It should be noted that the grid includes only those 1 km cells that were populated in 2011, consistent with the broader GEOSTAT grid structure (Eurostat and GISCO 2016), and all spatial data are provided in WGS84. Analysis was conducted in R (R Core Team 2024), using the sf (Pebesma 2018; Pebesma and Bivand 2023) and terra (Hijmans 2025) packages.

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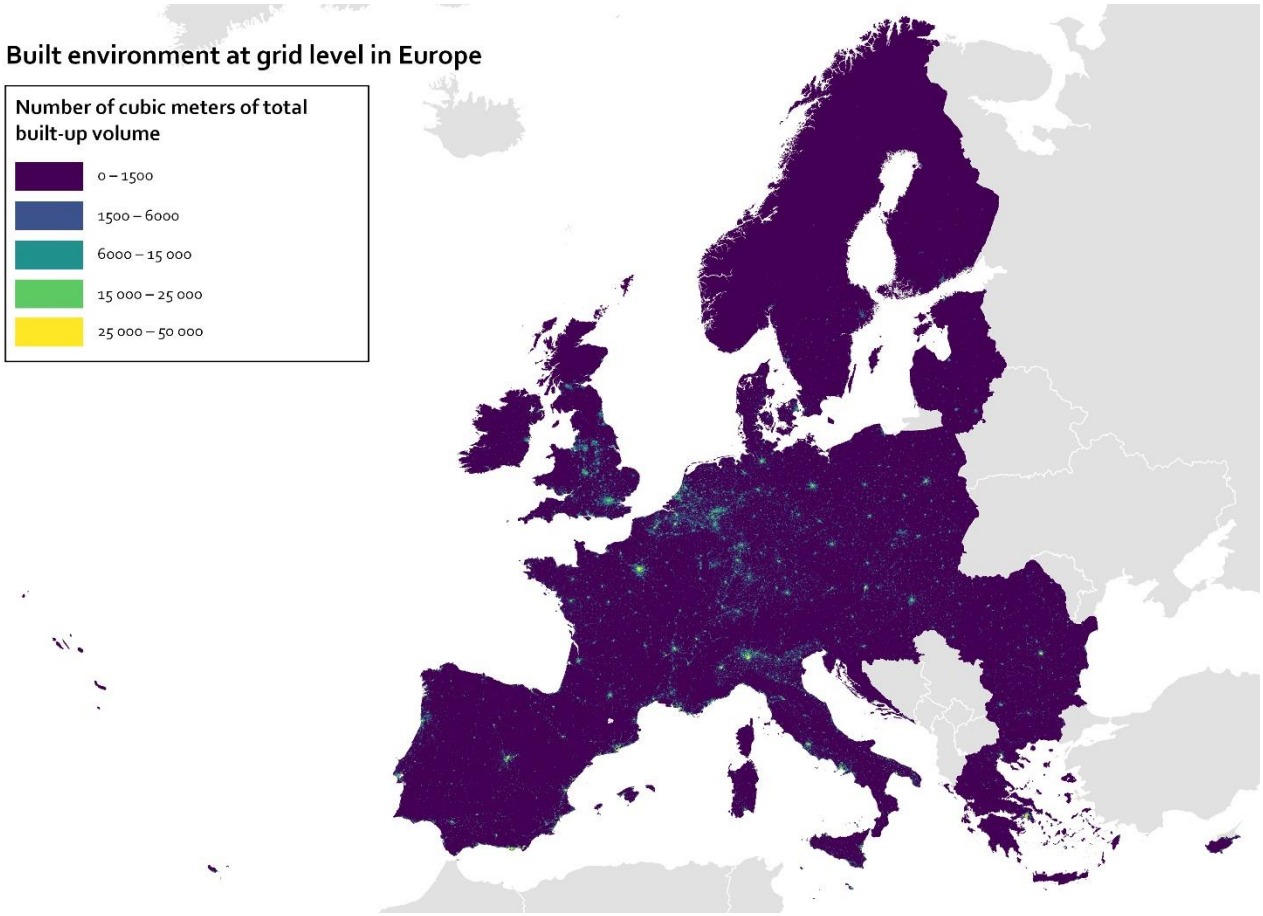
By incorporating population change dynamics, the GRANULAR rural typology distinguishes among these varied contexts, enabling nuanced identification of areas requiring different policy interventions regarding economic support, infrastructure investment, or demographic revitalisation. However, it is important to bear in mind that, strictly speaking, absolute population change does not distinguish natural change from migration flows.

4.2.2. Built environment

The morphology of the built environment is a critical but frequently underrepresented dimension in territorial typologies. Settlement form shapes infrastructure delivery costs, service accessibility, land-use intensity, environmental pressures and social cohesion in ways that population metrics alone cannot detect (Salvati and Carlucci 2015). For instance, two territories can have identical population densities yet exhibit very different spatial configurations, ranging from compact villages surrounded by open land to scattered housing dispersed across an entire grid cell, or mixed residential and light commercial developments along transport corridors. Spatial organisation has direct consequences for the feasibility of public service provision, transport requirements and long-term development possibilities. Research has consistently shown that built-environment indices capturing metrics such as built-up area proportion, settlement patch size and structural density help differentiate functional rural forms. This allows productive, residential and recreational configurations to be distinguished, while capturing the spatial organisation of nucleated villages relative to dispersed farmstead patterns (Salvati and Carlucci 2015; Meeus and Gulinck 2008).



Map 4: Built environment (building volume)

Building volume estimates derived from the Global Human Settlement Layer (Pesaresi and Politis 2023) are used here as the indicator of built-environment morphology. Building volume, calculated as height multiplied by ground area, captures the vertical dimension of settlement that building counts and footprint area omit, and therefore provides a fuller measure of the scale of built fabric within a grid cell. Because the quantity of built structure is conceptually linked to land-use intensity and to the infrastructure and services it requires, volume offers a reasonable and consistently available proxy for built-up intensity at pan-European scale (Pesaresi et al. 2024). A single large

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institutional building or industrial facility has a disproportionate impact on the character of a grid cell compared with numerous small dwellings, a distinction captured effectively through volumetric measurement.

The building volume indicator was retrieved from the Global Human Settlement Layer (GHSL). Total built-up surface and the non-residential (NRES) component of built-up volume (GHS-BUILT-V) were retrieved in 1 km resolution GeoTIFF format in World Mollweide projection for the 2020 epoch (Pesaresi and Politis 2023). The data were then transformed, re-projected and joined to the GRANULAR 1 km common grid. The raw data are expressed as cubic metres of total built-up volume by epoch, and their values are expressed as 32-bit integers (uint32) representing the number of cubic metres of built-up surface in the cell. In the transformation process to the GRANULAR 1 km common grid, these cell values were retained at grid level (Pesaresi and Politis 2023).

Within the semi-dense, low-density and very-low-density grid cell sub-classes defined by DEGURBA Level 2, building volume helps differentiate internal configurations without requiring higher-resolution zoning data that would compromise cross-national comparability. This distinction matters for understanding functional diversity: compact nucleated settlements differ substantively from linear ribbon developments or dispersed farmstead patterns in terms of public service viability, transport requirements and land management implications. Incorporating built-environment morphology directly addresses a recognised gap in population-only typologies, revealing the physical form of settlement that shapes everyday experience and long-term development possibilities.

4.2.3. Physical geography

The physical characteristics of territory exert a fundamental and enduring influence on the structure and development potential of rural areas, shaping possibilities and constraints across agricultural productivity, settlement patterns, infrastructure costs and accessibility. Topography and elevation have long been recognised as key determinants of rural differentiation in the European context, underpinning the distinction between Alpine valleys, Mediterranean hillsides, Scandinavian uplands and the lowland agricultural plains of Central and Eastern Europe (MacDonald et al. 2000; Tasser et al. 2017). In mountain environments, steep terrain and harsher climatic conditions limit agricultural productivity, increase the cost of infrastructure provision, constrain settlement expansion and restrict transport connectivity, producing a set of structural disadvantages that persist regardless of population density or administrative classification. These conditions are directly acknowledged in EU policy through the designation of areas facing natural constraints under rural development regulations, and through the specific provisions for mountain areas in the Common Agricultural Policy (European Parliament and Council of the European Union 2013).

Elevation serves in this analysis as a stable, computationally efficient and cross-nationally consistent proxy for the broader category of physical geographic constraints. Unlike socio-economic indicators that require periodic recalibration, topography remains constant, providing methodological stability across time periods and ensuring full cross-national consistency through the application of a single harmonised digital elevation model at continental scale. Elevation also functions as a proxy for mountain and hilly area classifications required under EU regional policy, natural handicap designations for agricultural subsidy programmes, and landscape character identification for planning purposes. This aligns the GRANULAR rural typology with existing regulatory frameworks and funding eligibility criteria across Member States, such as designations of disadvantaged areas under Article 32 of Regulation (EU) No 1305/2013 on rural development, or implementing Natura 2000 network requirements in mountain zones.

The digital elevation data were retrieved from the European Digital Elevation Model (EU-DEM), produced under the Global Monitoring for Environment and Security (GMES) Geospatial Reference Data Access (RDA) project. EU-DEM is a digital surface model (DSM) representing the first surface captured by sensors, produced under the Copernicus programme by the European Commission's Directorate-General for Enterprise and Industry. The dataset was retrieved in GeoTIFF format (LZW compression for tiles) in ETRS-Lambert Azimuthal Equal-Area projection (ETRS-LAEA, EPSG: 3035) at approximately 30-metre resolution, covering the 39 member countries of the European Environment Agency and other cooperating countries. It was then transformed, re-projected and joined to the GRANULAR 1 km common grid. The raw data are expressed in metres of vertical elevation above the EVRS2000 geoid (EGG08), with the spatial reference system based on horizontal datum ETRS89 and ellipsoid GRS80 (EPSG: 4258). The dataset has an overall vertical accuracy of 2.9 metres RMSE, with a near-negligible bias of −0.56 metres, well within the contractual specification of 7 metres RMSE (European Environment Agency and Copernicus Land Monitoring Service 2014). In the transformation process to the GRANULAR 1 km common grid, cell values were aggregated using a weighted averaging approach.

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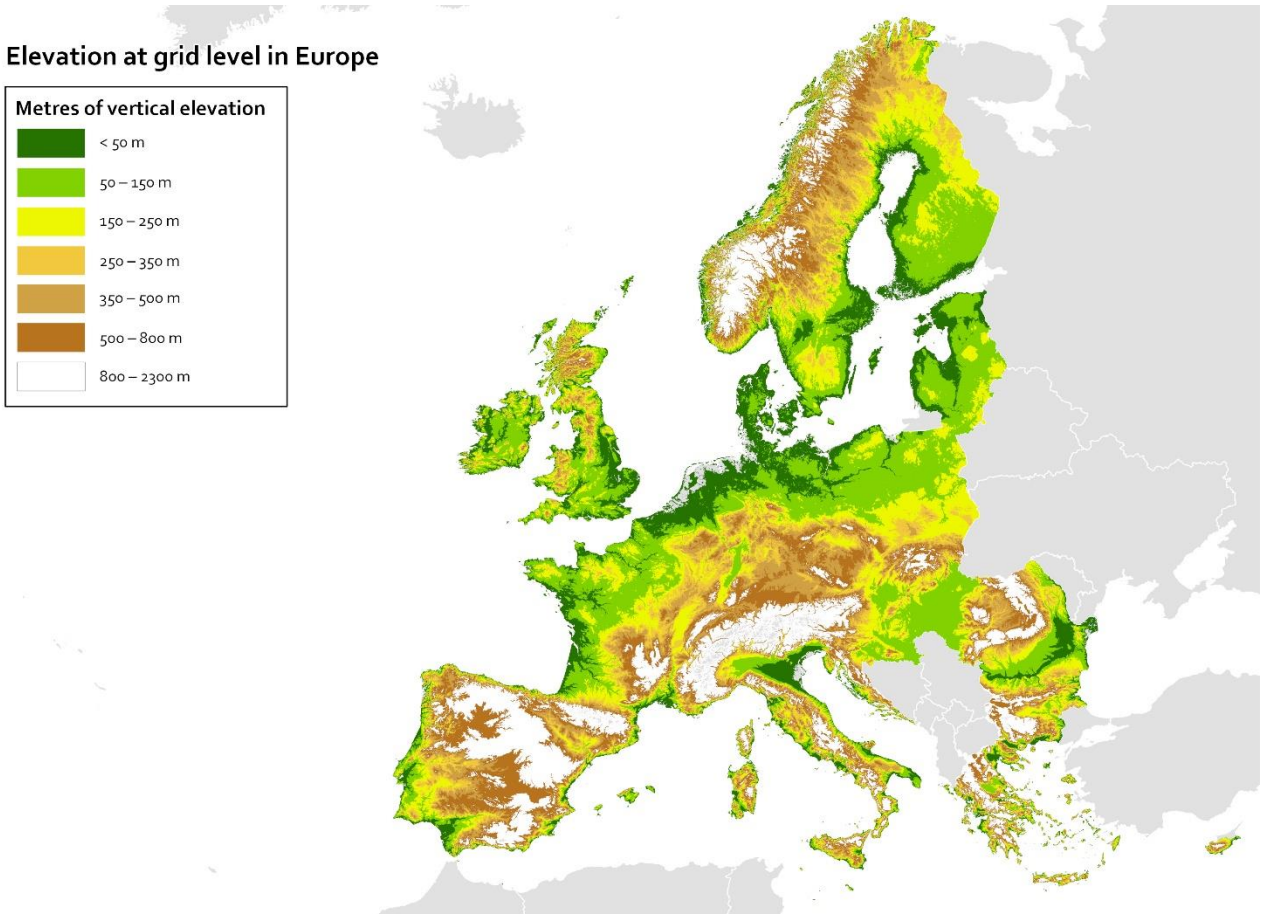

Map 5: Topography (Elevation)

The computational advantages of elevation data extend beyond stability to processing efficiency, as grid-cell values remain straightforward to calculate and integrate at European scale without complex harmonisation procedures. Furthermore, unlike socio-economic indicators requiring periodic updates and recalibration, topography remains constant, providing methodological stability across time periods while ensuring cross-national consistency through application of the same digital elevation model source throughout the continental-scale analysis.

4.2.4. Landscape modification

The degree of human-induced landscape modification directly responds to growing recognition within EU policy frameworks that rural areas function not merely as production zones but as providers of ecosystem services requiring integration into biodiversity conservation, sustainable land-use planning and green infrastructure development strategies. Research consistently demonstrates that areas classified identically by population metrics may differ dramatically in ecological value and conservation priority, necessitating differentiated management approaches (Kroll et al. 2012). Including this dimension enables integration of the GRANULAR rural typology with environmental monitoring systems already functioning across Europe, facilitating coordinated implementation of territorial policies spanning demographic, economic and ecological objectives.

The hemeroby index is a measure of human modification of landscapes, reflecting potential environmental impact and land-use intensity in a single metric. Derived from CORINE land cover classifications, the index typically ranges from level one, representing natural or near-natural landscapes with minimal human intervention, to level five and above, indicating intensively modified environments including urban areas and intensive agricultural zones (Eurostat 2026b). Applied within the three DEGURBA Level 2 sub-classes, it helps distinguish semi-dense clusters, which are likely to exhibit moderate to high hemeroby from intensive land management around settlements, from low-density cells showing variable patterns depending on whether they represent extensive agriculture, forestry operations or protected natural areas.

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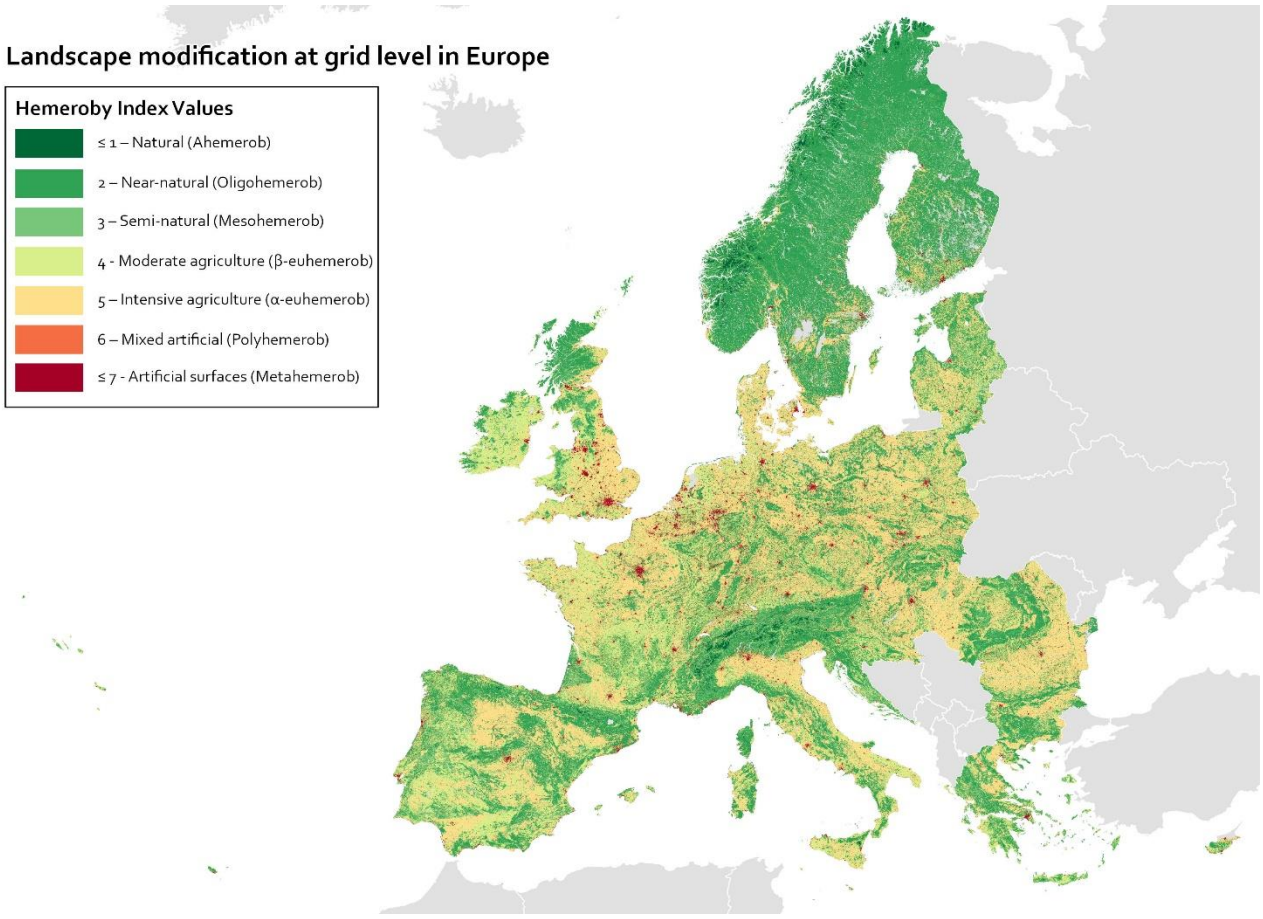

Map 6: Hemeroby index

The hemeroby data used here was produced the GRANULAR project (Berchoux 2026). For the calculation of the index, each CORINE land cover class is assigned a hemeroby value reflecting its level of anthropogenic disturbance, and the index for each 1 km² grid cell is calculated as an area-weighted average across the underlying land cover classes (Paracchini et al. 2008). However, two data limitations apply. First, the hemeroby scale is ordinal, and its use as a clustering input treats it as quasi-continuous, a pragmatic assumption defensible when the analytical purpose is to distinguish broad landscape character rather than compare precise values (Kaufman and Rousseeuw 1990). Cluster comparisons involving hemeroby are therefore reported in categorical terms, and differences of less than 0.5 units should not be over-interpreted. Second, CORINE's minimum mapping unit of 25 hectares means that grid-cell hemeroby values are coarse spatial averages that may not capture fine-grained land-use heterogeneity within cells (Paracchini et al. 2008).

4.2.5. Functional connectivity

Accessibility to urban centres is a structurally defining characteristic of rural territories that shapes daily life, economic opportunity and long-term development potential in ways that neither density nor physical geography alone can capture. Modern rural geography has increasingly moved away from conceptualising rural areas as isolated entities and towards understanding them as territories embedded within wider functional systems, in which the relationship between rural and urban areas is a primary axis of differentiation (Bengs and Schmidt-Thomé 2006; Boyle and Halfacree 1998). This perspective, rooted in central place theory (Christaller 1933) and its subsequent elaborations in regional science, holds that the spatial and economic relationship between a rural territory and the urban centres within its reach fundamentally determines its access to labour markets, healthcare and education services, commercial activity, and exposure to urban-driven cultural and demographic change. Travel-time metrics capture commuting potential and labour-market integration, access to specialised services, market access for agricultural producers, and the extent of urban spillover effects that influence investment decisions, consumption patterns and innovation adoption. Unlike Euclidean distance measures, travel time accounts for road-network quality, terrain obstacles and transport infrastructure provision, factors that genuinely structure the daily mobility choices and economic decision-making of rural residents.

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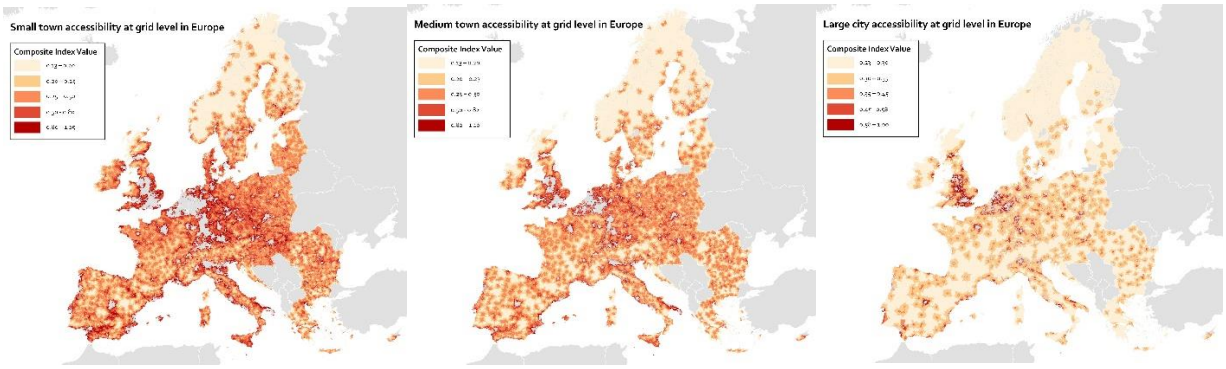
Differentiation by multiple urban-centre size thresholds reflects the realities of hierarchical urban systems, where small towns provide basic services including grocery retailing and primary healthcare, medium-sized cities offer secondary services such as specialised medical care and secondary education facilities, and major metropolitan areas deliver tertiary and quaternary services including universities, hospitals and cultural amenities. A rural area accessible only to small towns faces fundamentally different constraints from a territory within reasonable commuting range of major metropolitan centres.

Three accessibility indicators capturing connections to urban centres of different sizes are considered for the construction of the GRANULAR rural typology:

- Accessibility to small towns (5,000+ inhabitants)
- Accessibility to medium towns (10,000+ inhabitants)
- Accessibility to larger cities (50,000+ inhabitants)

These indicators combine travel time and the number of reachable settlements within a defined travel threshold, providing a measure of both proximity and network density. Variation by centre size adds important granularity, as each type of centre provides a different set of essential services to rural communities. This hierarchical approach enables classification into rural-accessible zones within reasonable commuting distance, representing potential for residential development and commuting-hub establishment; rural-peripheral areas characterised by isolation and requiring stronger public service provision and targeted development support; and transitional zones occupying intermediate accessibility positions, where policy impacts vary considerably. Incorporating multiple urban-centre thresholds provides the granularity necessary for identifying areas benefiting from proximity-driven development versus those requiring compensatory infrastructure investments to overcome locational disadvantages.

The data covering travel time and the number of reachable settlements were a product of the WP3 package within the GRANULAR project (Ysebaert et al. 2024). Travel times were computed between all populated 1 km grid cells (origins) and nearby towns and cities (destinations) using the OSRM routing engine based on OpenStreetMap road networks. To ensure computational efficiency while maintaining spatial relevance, destinations were limited to towns and cities within a 100 km buffer of each urban area in DEGURBA. This produces a comprehensive origin-destination travel-time matrix representing car travel times across most of Europe. The exception to this general rule was Scandinavia. Here, sparse populations and distant, relatively small urban areas leave most of the region uncovered by the accessibility analysis to urban areas of 50,000 inhabitants or more under the 100 km buffer. Consequently, in this region, as well as westernmost areas in Ireland and Denmark, the accessibility analysis for large cities was fine-tuned by adding a randomly selected set of 30,000 populated points beyond the 100 km buffer zones to be used as origins in a complementary accessibility calculation. This accessibility information was combined with the calculations for the rest of Europe.



Maps 7-9: Composite accessibility score for each town size tier

Accessibility indicators are constructed from this matrix by combining the inverse of travel time to the nearest destinations, and a count of the number of towns accessible within a 30-minute travel threshold. For each town size tier, the indicator is then calculated as:

$$Accessibility = (1 / (\log travel\ time + 1)) + (town\ count / 10)$$

The travel-time component is inverted so that shorter travel times produce higher accessibility values. The town-count component captures the density of accessible urban opportunities within the threshold, with a scaling factor of 10 applied to prevent the count from dominating the travel-time term. The scaling factor was selected to approximately equalise the typical ranges of the two components across the study area. No formal sensitivity

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analysis of this parameter was conducted, and results may vary under alternative specifications. The result is a composite score in which higher values consistently indicate better accessibility, whether driven by proximity to nearby centres, by the density of reachable towns, or by both simultaneously.

The composite accessibility index was calculated separately for towns grouped by population size of 5,000+, 10,000+ and 50,000+ inhabitants, yielding three accessibility indicators representing connectivity to small towns, medium-sized towns and larger cities, respectively (Maps 7–9). Together, these indicators provide a consistent representation of functional accessibility that captures both proximity and opportunity across the rural grid cells included in the analysis (Ysebaert et al. 2024).

Table 1: Summary statistics for the input datasets[3]

Variable	Min.	1st quartile	Median	Mean	Std.	3rd quartile	Max.
Population change	-3,174.06	0.00	0.00	0.03	36.49	0.00	3,067.00
Built environment	0.00	4.21	49.56	254.19	968.02	187.27	83,488.99
Topography	149.45	102.80	230.95	381.21	411.84	526.22	4,504.19
Landscape modification	1.00	2.00	3.00	3.31	1.39	5.00	7.00
Small town accessibility	0.11	0.21	0.34	0.46	0.39	0.55	7.41
Medium town accessibility	0.12	0.20	0.22	0.33	0.23	0.36	4.62
Large city accessibility	0.22	0.28	0.30	0.31	0.07	0.32	1.70

4.3. Data pre-processing

Prior to clustering, the collected data were reviewed to detect and correct errors or inconsistencies. Particular attention was given to anomalous values that could stem from unit mismatches, typographical errors and similar issues. In addition, non-standard symbols and superscripts were removed. This step helped ensure that the dataset was clean, consistent and suitable for subsequent statistical analysis.

Missing values were further handled through variable-specific imputation prior to clustering. For demographic change, missing 2011 and 2021 population values were filled with zero before computing the absolute difference, a defensible assumption for grid cells with no recorded population in either period. Building volume and town-count variables were likewise filled with zeros, reflecting the absence of built structure or accessible towns rather than a data gap. For elevation, missing values were replaced with the within-class median. For the hemeroby index, missing values were replaced with the cross-class mode, consistent with the ordinal nature of the variable. Travel-time variables were filled with the cross-class median rather than forward or backward fill, to avoid leaking values across neighbouring rows or countries.

Following data cleaning, values were transformed into a format suitable for analysis. This is necessary to mitigate skewness and normalise the distributions. In most cases, a signed logarithmic transformation was applied. However,

[3] The log-transformed values were used as clustering inputs; untransformed figures are reported here to facilitate direct interpretation.

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due to the specific numerical properties of the indicators, slightly different logarithmic transformation methods were used (see Table 2).

Table 2: Transformation methods used

Variable	Transformation method	Description
Absolute population change 2011-2021	$f(x)=sign(x)\cdot log(\|x\|+1)$	For these values, which can be negative, a signed logarithmic transformation was applied, preserving the direction of change while compressing the scale of extreme values.
Topography (Elevation)	$f(x)=log(x+1)$	The values were transformed using a standard logarithmic transformation to reduce the influence of extreme values while retaining zero-value cells. The constant 1 is added to avoid undefined values at zero.
Built environment (building volume)	$f(x)=log(x+1)$	This transformation method was used to reduce the influence of extreme values while retaining zero-value cells. The constant 1 is nonetheless added to avoid undefined values at zero.
Accessibility indicators (travel time to nuclei of 5, 10 and 50 thousand inhabitants, by car)	$f(x)=log(x+1)$	Travel time values are first log-transformed prior to entering the composite, consistent with the log transformations applied to other skewed variables in the analysis.

The hemeroby index was excluded from transformation. As described above, hemeroby is an ordinal classification of landscape modification ranging from 1 (near-natural) to 7 (heavily modified), rather than a continuous magnitude where multiplicative differences carry comparable meaning across the scale. Applying a logarithmic transformation to this variable would not address any genuine distributional issue and would instead distort the relative spacing between hemeroby degrees in a way unrelated to their substantive meaning. The index was therefore retained in its original form.

Prior to clustering, all variables were scaled using a robust scaling approach. This ensures that variables with different units and ranges contribute equally to the distance calculations underlying the clustering algorithm. Robust scaling relies on the median and interquartile range rather than the mean and standard deviation, which means the scaling itself is less susceptible to distortion by extreme values. Robust scaling was chosen here because several of the clustering variables, particularly building volume, accessibility scores and population change, show pronounced right skew and extreme values in peri-rural and high-connectivity contexts, and a mean-based approach would have given those extremes undue influence on the results. The method was applied separately within each DEGURBA class, so that the median and interquartile range used to scale each variable reflect the distribution of that class alone and cross-class differences in variable distributions do not enter the distance calculations. This is particularly important in spatial datasets where extreme values, such as very high accessibility in peri-urban areas or very low population densities in remote regions, could otherwise pull cluster formation in misleading directions.

4.4. Clustering

The GRANULAR rural typology is generated using the mini-batch k-means algorithm, a computationally efficient and scalable extension of the k-means clustering method. The latter is an established iterative partitioning algorithm that assigns observations to a predefined number of clusters by minimising within-cluster variance, typically expressed as the sum of squared Euclidean distances between observations and their respective cluster centroids (MacQueen 1967). The objective of the k-means algorithm is to identify compact and internally homogeneous groups while maximising separation between clusters. The clustering process partitions grid cells into groups by minimising the

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distance between each observation and the centroid of its assigned cluster. In practice, this results in clusters that capture distinct combinations of demographic dynamics, landscape characteristics and accessibility conditions, allowing rural typologies to emerge empirically from the data rather than being imposed a priori. K-means clustering represents an alternative to manual classification schemes, which typically rely on predefined thresholds and assumptions about which indicators matter most, thereby introducing subjectivity and limiting consistency across the highly heterogeneous regional contexts found across Europe. Given the scale of the analysis, a manual approach would also be computationally and practically infeasible to apply consistently.

The mini-batch k-means implementation addresses the computational challenge by adopting stochastic optimisation based on small, randomly sampled subsets of the data (mini-batches) rather than repeated passes over the full dataset. While the classical k-means algorithm requires multiple full iterations over all observations, making it computationally intensive for datasets with millions of grid cells, mini-batch k-means incrementally updates cluster centroids using these subsets. This substantially reduces processing time and memory requirements while still approximating the same objective function and converging towards a stable clustering solution (Sculley 2010).

The algorithm was run independently on each of the DEGURBA Level 2 classes (311, 312 and 313). To assess the stability of the solution, the algorithm was run multiple times with different random initialisations and mini-batch sequences. Results were highly consistent across runs, with only marginal variation in cluster boundaries that did not affect the substantive interpretation of cluster types. This stability supports the robustness of the identified groupings, although the language of 'natural groupings' should be understood as referring to patterns that are stable and reproducible under repeated sampling rather than to mathematically unique solutions. This interpretation is maintained throughout the results and interpretations provided below, where cluster profiles are presented as internally coherent and geographically consistent clusters rather than as uniquely determined or exhaustive partitions of the data.

The optimal number of clusters is determined using silhouette analysis, a common method for evaluating clustering quality (Kaufman and Rousseeuw 1990). For each rural DEGURBA Level 2 class, clustering solutions are tested for two to five clusters. The silhouette score measures how similar each grid cell is to its own cluster compared with neighbouring clusters. Scores range from −1 to 1 (Rousseeuw 1987), where higher values indicate clearer separation between clusters. In general, values above 0.5 indicate good separation and values above 0.7 indicate strong cluster separation (Kaufman and Rousseeuw 1990). The final number of clusters is selected according to the following procedure:

- Candidate solutions with two to five clusters are evaluated.
- Silhouette scores are calculated for each solution.
- The solution with the highest silhouette score is selected as the optimal number of clusters.

Silhouette values above 0.5 were achieved for all DEGURBA classes, which indicates that the selected features capture meaningful variation across rural territories and that the algorithm successfully identified distinct spatial patterns (Rousseeuw 1987). The resulting clusters are stable and reproducible, and their profiles are broadly coherent with established patterns in European rural geography. The automatic cluster selection procedure consistently returned this structure across repeated runs, which supports the robustness of the classification approach.

As a complementary validation measure, several metrics were used to evaluate the quality and robustness of the clustering results (Halkidi et al. 2001). Two additional commonly used clustering validation indicators were calculated (Caliński and Harabasz 1974; Davies and Bouldin 1979):

- Caliński-Harabasz index: This index evaluates clustering performance by comparing dispersion between clusters with dispersion within clusters. Higher values indicate a clustering structure where clusters are compact and well separated (Caliński and Harabasz 1974). In this analysis, higher values of the Caliński-Harabasz index were generally observed in more sparsely populated rural environments, reflecting greater absolute variation between rural landscape types.
- Davies-Bouldin index: The index measures the similarity between clusters based on the ratio of within-cluster dispersion to the distance between clusters. Lower values indicate better clustering performance, with zero representing an ideal separation (Davies and Bouldin 1979).

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These complementary metrics provide additional evidence that the clustering solutions identified through silhouette analysis produce statistically coherent and well-separated rural classes, serving as validation checks in the workflow. The approach captures the multidimensional nature of rural territories by combining demographic dynamics, physical landscape characteristics and functional connectivity, allowing natural groupings across these dimensions to emerge directly from the data rather than being imposed through fixed rules (MacQueen 1967).

5. Results

In this chapter, we present two types of related analyses for cluster profiles: validation metrics, spatial distributions, and indicator values. These elements reveal patterns across rural Europe, identify grouped territories, assess cluster separation, and highlight differences between them. The interpretations that follow are not mechanically derived from the clustering but stem from theoretical judgments about the data's underlying reflections. Readers should view these interpretations as informed readings, rather than definitive findings of the clustering itself. The contextual and historically grounded sections serve to enhance the typology without expanding its empirical boundaries. They provide additional information that complements the quantitative analysis, offering a more comprehensive understanding of the study's subject matter.

5.1. Overview of key findings

Table 3 presents each resulting cluster based on DEGURBA class, GRANULAR cluster code, share of total cells, and a brief profile description. In accordance with the DEGURBA naming policy, clusters have been assigned two names: technical and short names. The technical names adhere to Eurostat's classification methodology and density thresholds, ensuring statistical rigor in publications. These names serve as the primary identifiers for each cluster. In contrast, the short names cater to non-specialist audiences by providing a concise representation of the cluster. Although less precise than their technical counterparts, they are essential for clear communication when dealing with lengthy descriptions. Designed to fit within legends, charts, and maps, short names facilitate easy understanding across various visual representations.

Table 3. Clusters of the DEGURBA stratified typology

DEGURBA CLASS	GRANULAR CLUSTER CODE	CLUSTER NAME	PERCENTAGE OF TOTAL CELLS	PROFILE
Very low-density grid cells (311)	**3111**	**Very low density grid cells close to mostly low density cells (open rural cells)**	**83.51%**	The elevated, and sparsely built baseline of European rurality.
Very low-density grid cells (311)	**3112**	**Very low density grid cells close to moderate and high density clusters (open rural cells in peri-rural areas)**	**2.85%**	Rural territory embedded within or adjacent to Europe's most urbanised regions.
Low-density grid cells (312)	**3121**	**Low density grid cells close to mostly low density cells (rural settlements**	**11.19%**	The widespread rural fabric of Europe, sustaining a broad and varied pattern of villages and dispersed settlements in broad demographic stability.

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		in peri-rural areas)		
Low-density grid cells (312)	**3122**	**Low density grid cells close to moderate and high density clusters (rural settlements in peri-urban areas)**	**0.66%**	Rural areas embedded within Europe's most densely connected lowland territories.
Semi-dense, small clusters (313)	**3131**	**Semi-dense, small clusters close to mostly low density cells (rural towns in peri-rural areas)**	**1.67%**	The traditional nucleated town fabric of the continent.
Semi-dense, small clusters (313)	**3132**	**Semi-dense, small clusters close to moderate and high density clusters (rural towns in peri-urban areas)**	**0.09%**	Accessible rural cluster towns with high functional connectivity to urban systems.

The clustering results reveal consistent patterns across European rural areas. Within each DEGURBA class, two distinct typological groups emerged, maintaining stability across contexts. This indicates a general trend of varying rural complexity, with greater internal differentiation in denser areas and more compact, uniform clusters in less dense regions. This gradient is primarily influenced by the correlation between input variables and DEGURBA density classes used for strata. The method's consistency offers reassurance but does not constitute its main analytical contribution. The significant findings lie in what the clustering uncovers beyond this gradient, particularly in the peri-rural minority clusters and the urban-proximity dimension. These clusters become apparent only when incorporating additional indicators into the analysis, demonstrating the importance of considering various factors in understanding rural dynamics near urban environments.

Within very low-density rural areas (DEGURBA class 311), the analysis identifies two structurally distinct clusters. The dominant cluster, *3111 - Very low density grid cells close to mostly low density cells*, covers most of the very low-density rural territory and typifies European sparsity with remote, elevated landscapes. It features low accessibility, minimal population change, and lightly modified terrain. The smaller cluster, *3112 - Very low density grid cells close to moderate and high density clusters*, is found in areas functionally constrained by nearby moderate or high-density clusters. Characterised by higher accessibility, increased built intensity, and active population growth, this rural area is prominently located in England and Wales, the Benelux countries, and western Germany.

Within low-density rural areas (DEGURBA class 312), the analysis again identifies two clusters. The dominant cluster, *3121 - Low density grid cells close to mostly low density cells*, forms the widespread rural fabric of the continent: moderately accessible, moderately altered natural environment, and relatively stable demographics. The smaller cluster, *3122 - Low density grid cells close to moderate and high density clusters*, is found within Europe's most densely connected territories. These rural areas exhibit significantly higher accessibility, increased built density, lower elevation, and robust population growth. This minority group is predominantly present in the Benelux countries, western Germany, and the Po Valley.

In DEGURBA class 313 (rural clusters), two distinct groups are identified: The dominant cluster, *3131 - Semi-dense, small clusters close to mostly low density cells*, embodies the conventional nucleated village pattern across Europe. This group is distinguished by high building density, extensive landscape modification, and moderate demographic

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decline. It predominantly exists in regions like England, Wales, parts of Ireland, and southern Scandinavia. The smaller cluster, *3132 - Semi-dense, small clusters close to moderate and high density clusters*, shares the high accessibility seen in its counterparts in classes 311 and 312. However, it stands out for recording the most severe population decline among all clusters in this typology. This observation underscores depopulation processes occurring even within functionally high-accessibility rural settlements. These patterns emphasise how traditional rural patterns coexist with more dynamic, densely accessible areas, highlighting the complex interplay between urban and rural development across Europe.

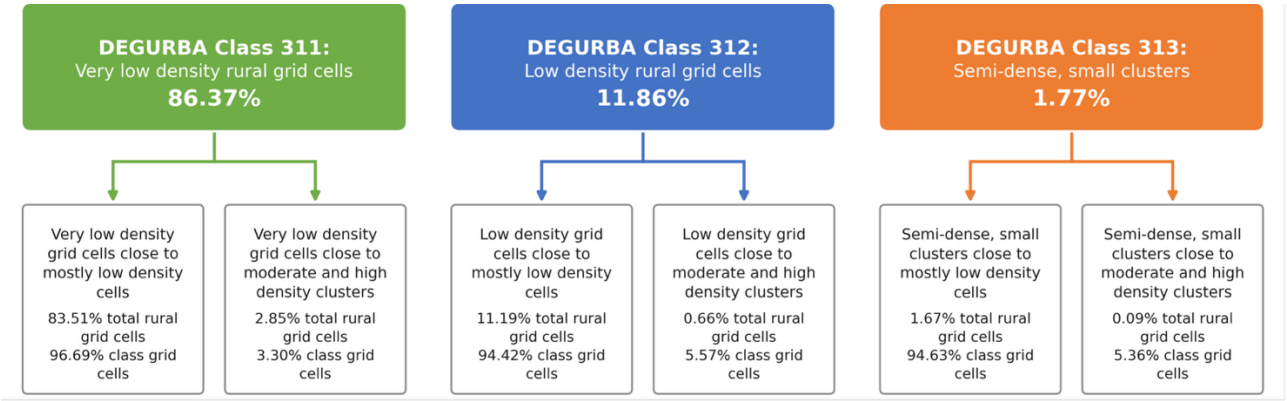

Figure 2. Percentage statistics of GRANULAR rural typology clusters

The selected indicators effectively reveal meaningful variations across European rural territories. Cluster profiles demonstrate resilience during repeated runs and align with established geographic patterns, indicating that the automatic selection procedure successfully identifies genuine structures rather than noise. A broader observation is that rural Europe is not a uniform entity but displays significant internal diversity. This diversity manifests differently depending on the examined region, showcasing the dynamic and multifaceted nature of European rural areas.

5.2. Spatial distribution and characteristics of typology classes

This section delves into the spatial distribution and indicator profiles of the six rural DEGURBA clusters, categorized by the GRANULAR typology. For each class, it examines the geographical spread of these clusters across Europe using class distribution maps and geographic patterns as reference points and how they differ along the seven indicator dimensions used in the classification: building volume, elevation, hemeroby index, population change, and accessibility to small towns, medium towns, and large cities. Table 4 presents the mean indicator values aggregated at the DEGURBA class level, acting as a comparative reference for the within-class comparisons provided below.

Table 4. Cluster indicator means by DEGURBA class

DEGURBA class	Building volume	Elevation	Hemeroby Index	Population change	Small town accessibility	Medium town accessibility	Large city accessibility
Very low density rural areas (311)	181.13	404.55	3.12	0.15	0.42	0.30	0.30
Low density rural areas (312)	666.61	233.65	4.31	1.23	0.69	0.45	0.34
Rural clusters (313)	1057.24	230.84	5.44	-13.88	0.76	0.47	0.34

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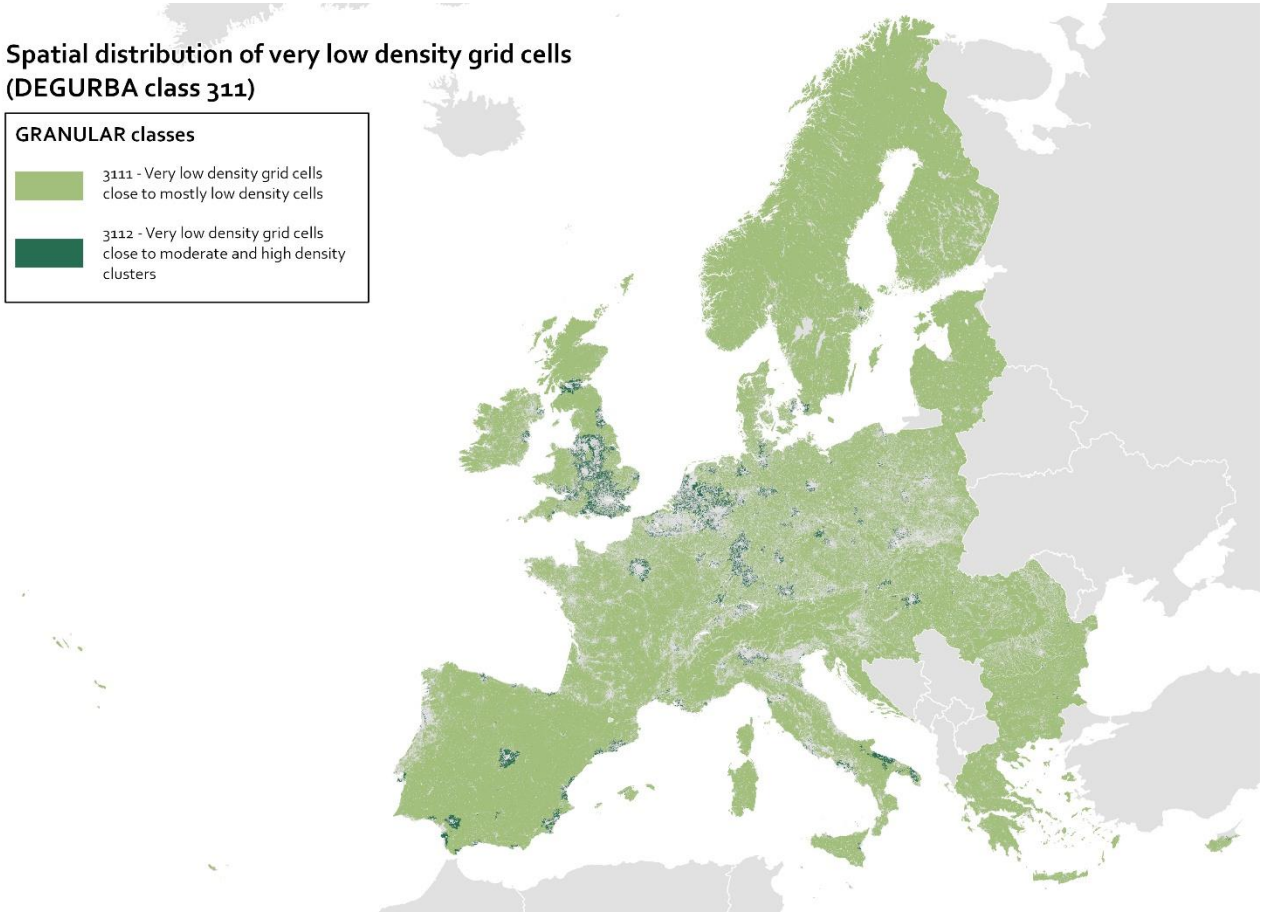
Among the indicators considered in the GRANULAR rural typology, the one that shows a greater divide on its mean value across DEGURBA classes is population change, which becomes negative in rural clusters. This reflects the general trend in Europe's rural areas, which have long been characterised by persistent population decline (Perpiña Castillo et al. 2024). Nonetheless, while this pattern is widespread across the continent, research indicates considerable variation in depopulation intensity among European rural areas (Alonso et al. 2025; Tóth and Kincses 2025). This contrasting landscape of declining villages and towns near rural areas experiencing growth has been comprehensively explored in Task 4.5 of the GRANULAR project. Here, the focus shifts to investigating the co-evolution of all the indicators within the typology, thereby providing a more nuanced understanding of rural depopulation and its co-occurring factors.

The examination unfolds in two stages per class: The first looks at the spatial footprint of each cluster, drawing on class distribution maps to analyse relevant geographic patterns. The second examines the indicator profiles, placing the quantitative differences between clusters in their broader territorial and structural context. Section 5.2.4 then transitions from the European scale to scrutinise how the six clusters appear within the seven GRANULAR Living Lab territories.

5.2.1. Very low density grid cells (DEGURBA class 311)



Map 10: Spatial distribution of class 311 clusters

The spatial distribution of very low-density rural areas across Europe is varied but follows a legible territorial logic. The two clusters capture two quite different expressions of rural sparsity. The first, cluster *3111 -Very low density grid cells close to mostly low density cells*, is associated with higher elevation, low building volume, a lower hemeroby index, declining population, and very limited accessibility to towns and cities. This profile is consistent with sparsely built, largely natural or semi-natural landscapes undergoing depopulation, and is concentrated in regions such as Scandinavia, inland Spain, and other peripheral parts of Europe. The second, cluster *3112 -Very low density grid cells close to moderate and high density clusters*, is associated with lower elevation, substantially higher building volume, a higher hemeroby index, population growth, and considerably better accessibility to small and medium towns.

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The first cluster is by far the dominant spatial expression of sparsely populated territory across Europe. Its distribution broadly follows the overall class 311 pattern. Scandinavia is covered almost entirely: vast forested interiors and lake-rich territories produce expanses of sparsity broken only by the relatively few major urban centres, which tend to be concentrated in the southern parts of the peninsula. Comparably extensive and uninterrupted coverage characterises Ireland, most of Great Britain outside the English Midlands and southeast, France, the Iberian Peninsula, and Central and Eastern Europe, including Poland, Romania, Bulgaria, and the Balkans. Mountain systems, among them the Alps, Pyrenees, Apennines, Carpathians, and Balkan ranges, fall predominantly within this cluster. The second cluster has a markedly different distribution. Rather than forming a continent-wide fabric, it appears in two distinct modes: a spatially extensive presence across central England, Wales, the Benelux countries, and western Germany, and a set of fragmented, discrete concentrations elsewhere that are almost without exception anchored to major urban centres.

The pattern holds consistently across the full distribution. Where this cluster appears extensively, it does so because urban influence is itself extensive and continuous, as in the north-western European core. Where it appears in isolation, it does so in direct functional proximity to major cities. Across Scandinavia, the Iberian interior, Eastern Europe, and other sparsely urbanised regions it is largely absent, turning up only in isolated concentrations around cities such as Stockholm, Copenhagen, and Madrid.

Table 5. Indicator means by cluster

Cluster	Building volume	Elevation	Hemeroby Index	Population change	Small town accessibility	Medium town accessibility	Large city accessibility
3111 - Very low density grid cells close to mostly low density cells	152.92	412.97	3.09	-0.25	0.38	0.28	0.29
3112 - Very low density grid cells close to moderate and high density clusters	1006.41	158.06	4.05	12.13	1.68	1.09	0.55

The indicator profile of cluster *3111 -Very low density grid cells close to mostly low density cells* describes a general low-density rural condition that plays out across a wide range of physical settings. Mean elevation of approximately 412 metres, slightly above the class 311 average of 404 metres, reflects the inclusion of major mountain systems such as the Alps, Pyrenees, Apennines, Carpathians and Scandinavian ranges alongside lower-lying but sparsely settled territories. Building volume is very modest at around 152 cubic metres, consistent with a lightly inhabited pattern of small villages, farm complexes, and rural service nodes. Hemeroby values fall in the low-to-moderate modification range, with a mean of 3.09, pointing to relatively limited human alteration of the natural landscape. This sits well with agricultural, pastoral, or forestry-based land use that does not generate a dense physical footprint, though it should be noted that the clustering variables do not directly measure economic activity. Accessibility is low across all urban tiers, with mean scores of 0.38 for small towns, 0.28 for medium towns, and 0.29 for large cities, suggesting that distance from urban networks is a defining structural feature of this cluster rather than an incidental one. In demographic terms, mean population change of approximately −0.25 persons per grid cell indicates modest net decline across this dominant cluster.

Cluster *3112 -Very low density grid cells close to moderate and high density clusters* has a geographically distinctive profile that does not fit conventional assumptions about very low-density rurality. Despite accounting for only around 3.30% of class 311 cells, it is structurally different from the dominant cluster in most key respects. Mean elevation is approximately 158 metres, well below both the dominant cluster and the class 311 average, confirming a predominantly lowland character. Given that this cluster is concentrated in the north-western European lowlands

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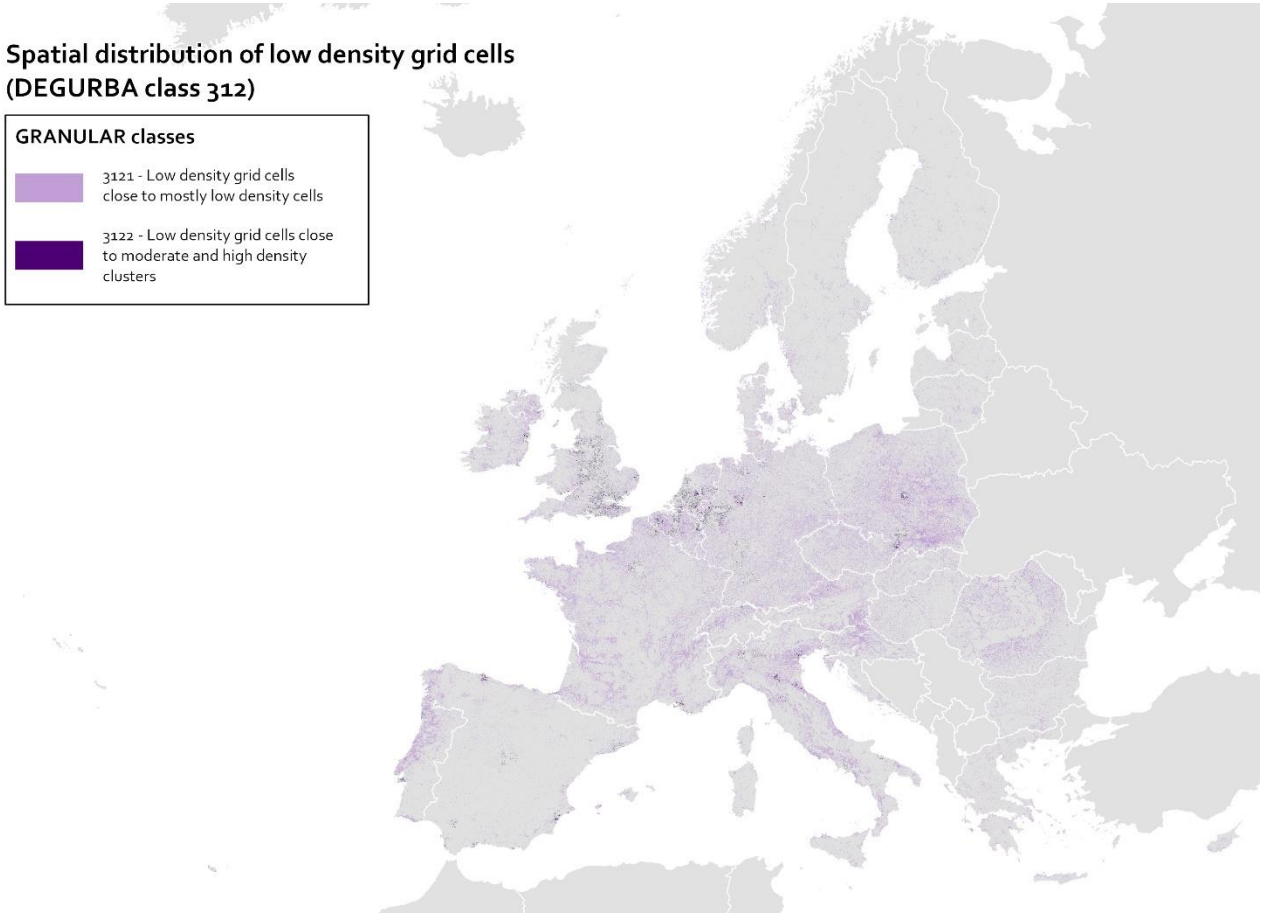
and coastal plains of southern Italy, this is broadly in line with expectations. The most striking differentiating feature is building volume, which at approximately 1,006 cubic metres is more than six times higher than that of the dominant cluster. Hemeroby values sit in the moderate modification range, with a mean of 4.05, reflecting somewhat greater human modification of natural landscapes, though both clusters fall within the same broad categorical band. Accessibility scores are substantially higher across all urban tiers. Mean scores for small towns reach 1.68 compared to 0.38 in the dominant cluster, and for large cities 0.55 compared to 0.29. These figures suggest that the cluster includes formally sparse grid cells embedded within or immediately adjacent to functional urban regions. Mean population change of approximately +12.13 persons per grid cell is markedly above both the dominant cluster and the class 311 average.

5.2.2. Low density rural grid cells (DEGURBA class 312)



Map 11: Spatial distribution of class 312 clusters

The spatial distribution of DEGURBA class 312 territory is more fragmented and dispersed than class 311, appearing across Europe in a fine-grained mosaic closely interwoven with urban and peri-urban systems. This is particularly evident across Central and Western Europe. Within this broader distribution, the two GRANULAR clusters follow quite different spatial logics: one is broadly distributed and represents something close to a universal rural built fabric, while the other appears in discrete concentrations of large building volumes, typically within Europe's most urbanised regions.

Cluster *3121 - Low density grid cells close to mostly low density cells* accounts for most of what is visible in the full-class map and forms the widespread inhabited rural continuity of low-density Europe. Its distribution across Central Europe is dense and largely uninterrupted, stretching from northern France and the Low Countries eastward through Germany, Poland, and into the western Balkans. This Central European band is the most cohesive concentration of the cluster. Further patches appear along the northern coastal plains of Italy, the north-western coast of Spain, and across Ireland. In the Nordic countries and Europe's major mountain ranges the picture is more fragmented, with cells following valley corridors and lowland pockets rather than forming continuous surfaces.

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Cluster *3122 - Low density grid cells close to moderate and high density clusters*, by contrast, has a notably selective spatial footprint. Rather than a diffuse continental presence, it forms a small number of distinct regional concentrations. The most prominent lie in England and Wales, alongside the Benelux countries and western Germany, where the cluster aligns with some of Europe's most densely urbanised and infrastructurally connected territories. A clearly identifiable concentration also appears in northern Italy, particularly within the Po Valley. Beyond these zones, the cluster is sparse, appearing in scattered patches across parts of southern Poland and Czechia and at isolated locations along the Mediterranean corridor in Spain and southern France.

The two clusters together describe a clear spatial gradient within low-density rural Europe. Cluster *3121 - Low density grid cells close to mostly low density cells* forms a widespread and moderately continuous rural fabric rooted in the Continental interior, with extensions into Atlantic-facing regions such as Ireland and the north-western Iberian coast. The concentrated footprint of cluster *3122 - Low density grid cells close to moderate and high density clusters* is the most cartographically distinctive feature of this class and the clearest spatial expression of the accessibility and intensity gradient that separates the two cluster profiles.

Table 6. Indicator means by cluster

Cluster	Building volume	Elevation	Hemeroby Index	Population change	Small town accessibility	Medium town accessibility	Large city accessibility
3121 - Low density grid cells close to mostly low density cells	602.18	240.95	4.31	-0.81	0.61	0.40	0.32
3122 - Low density grid cells close to moderate and high density clusters	1758.12	110.04	4.41	36.04	1.95	1.29	0.67

The profile of cluster *3121 - Low density grid cells close to mostly low density cells* describes a general low-density rural condition playing out across a wide range of physical settings, from broad agricultural plains and rolling hill country to river valleys, coastal lowlands, and the lower margins of major mountain systems. Mean elevation of approximately 241 metres reflects this diversity, incorporating both lowland agricultural territories and the foothill zones of mountainous systems. Building volume averages around 602 cubic metres, consistent with a structurally coherent pattern of villages, dispersed farmsteads, and small rural service nodes. Hemeroby values, with a mean of 4.31, reflect a landscape shaped by agriculture, managed forests, and village-based settlement, where human influence is persistent but not intensive. Accessibility scores decrease with urban centre size: mean scores of 0.61 for small towns, 0.40 for medium towns, and 0.32 for large cities. This follows the straightforward geographic reality that rural areas are more numerous and more widely distributed than large cities and so tend to sit closer to small urban centres than to major metropolitan ones. The overall connectivity levels are sufficient to sustain dispersed populations and everyday rural life across a wide range of settings, placing this cluster within the hinterlands of small and medium-sized towns rather than major metropolitan systems (Bengs and Schmidt-Thomé 2006). In demographic terms, mean population change of approximately −0.81 persons per km² reflects modest net decline, consistent with gradual demographic pressure through ageing or outmigration across large contiguous areas.

Cluster *3122 - Low density grid cells close to moderate and high density clusters* accounts for approximately 5.57% of class 312 cells and has a structurally distinct profile that sets it apart from the dominant cluster in most key respects. Mean elevation of approximately 110 metres, well below both the dominant cluster and the class 312 average, confirms a predominantly lowland character that sits well with its principal concentrations in the north-western European lowlands and the Po Plain. The most striking contrast with the dominant cluster is building volume, which at approximately 1,758 cubic metres is more than three times higher, pointing to a landscape of comparatively

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dense built fabric. The hemeroby index of 4.41 places this cluster in the same broad modification category as the dominant cluster, but here the modification reflects agricultural intensification, land consolidation, and peri-urban expansion rather than the more diffuse rural influence seen elsewhere. Accessibility scores are considerably higher across all urban tiers: mean scores for small towns reach 1.95 compared to 0.61 in the dominant cluster, for medium towns 1.29 compared to 0.40, and for large cities 0.67 compared to 0.32. These are not moderately connected rural territories, but formally low-density grid cells embedded within or immediately adjacent to functional urban regions. Mean absolute population change of approximately +36 persons per grid cell contrasts sharply with the mild decline observed in the dominant cluster, in line with documented patterns of demographic growth in peri-rural areas.

5.2.3. Semi-dense small clusters (DEGURBA class 313)

Map 12: Spatial distribution of class 313 clusters

Class 313 has a dense but fragmented presence across much of Europe. Grid cells are somewhat more concentrated in Central and Eastern Europe than elsewhere, though the class extends broadly across the continent. Coverage thins out in the Nordic countries and across large parts of the Iberian Peninsula, and the class is largely absent from Alpine high-elevation zones and the most remote northern and eastern peripheries.

Cluster *3131 - Semi-dense, small clusters close to mostly low density cells* is the dominant class and its distribution broadly mirrors the full-class map. It extends across Central and Eastern Europe as well as France, Germany, and large parts of southern and western Europe. Cluster *3132 Semi-dense, small clusters close to moderate and high density clusters* is scattered in small portions across the continent. The most notable concentrations appear in the Benelux countries, Germany, and the United Kingdom. Elsewhere the cluster is present only in isolated and modest patches, and it is largely absent from mountain zones, Nordic regions, and the eastern and southern peripheries.

Table 7. Indicator means by cluster for dense and semi-dense clusters

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Cluster	Building volume	Elevation	Hemeroby Index	Population change	Small town accessibility	Medium town accessibility	Large city accessibility
3131 - Semi-dense, small clusters close to mostly low density cells	1051.67	237.55	5.45	-9.82	0.69	0.43	0.32
3132 - Semi-dense, small clusters close to moderate and high density clusters	1155.37	112.54	5.30	-85.46	1.94	.1.25	0.63

The profile of cluster *3131 - Semi-dense, small clusters close to mostly low density cells* describes a general rural condition across a varied range of physical settings. Mean elevation of approximately 237 metres reflects this diversity, taking in both lowland agricultural territories and the foothill zones of major mountain ranges. Building volume is high at approximately 1,051 cubic metres, consistent with nucleated village and cluster settlement forms. Such nucleated settlement has long historical roots in Europe (Curtis 2013), shaped in central and eastern Europe by the region's distinctive agrarian and land-tenure history (Cerman 2008). In demographic terms, the cluster shows a mean population change of approximately −9.9 persons per grid cell. Hemeroby values sit in the high modification range, with a mean of 5.45, pointing to a substantial degree of human landscape modification associated with long-established agricultural mosaics, managed land, and village-based settlement systems where human influence is persistent and pronounced. Accessibility scores are moderate across all urban tiers, with mean scores of 0.69 for small towns, 0.43 for medium towns, and 0.32 for large cities. As with previous clusters, this reflects closer functional integration with small towns than with major urban centres, suggesting a pattern of rural settlement drawing on nearby market towns for services and daily mobility.

Cluster *3132 - Semi-dense, small clusters close to moderate and high density clusters* stands out most clearly in its accessibility scores, which are the highest in the class by a considerable margin across all urban tiers: mean scores of 1.94 for small towns, 1.25 for medium towns, and 0.63 for large cities. The large-city score is particularly notable: at 0.63, it is approximately twice that of the dominant cluster at 0.32, indicating considerably greater physical proximity to large cities. Building volume averages approximately 1,156 cubic metres. Mean elevation of approximately 113 metres is low, in keeping with the predominantly lowland character of the urbanised corridors where this cluster concentrates. The hemeroby index of 5.30 is close to the class average, suggesting intensive but not exceptional landscape modification relative to other rural cluster types. Population change shows a mean of approximately −82.8 persons per km², though this figure should be read with some caution given that the cluster comprises only 4,248 cells, around 5.34% of class 313, and shows high standard deviation, pointing to considerable internal variation. More than a coherent geographic territory, this cluster might best be understood as a shared functional condition, i.e. as rural areas persisting in close proximity to dense urban systems across a range of national and regional contexts (Bengs and Schmidt-Thomé 2006).

5.2.4. GRANULAR rural typology presence in the GRANULAR Living Labs areas

This section looks at how the six GRANULAR rural typology clusters are expressed within the seven territories that anchor the project's Living Lab network: P10 in the Netherlands; Pays Pyrenees Mediterranee in France; the Val di Cecina Rural District in Italy; Northern Sweden; the West Pomeranian region in Poland; rural Scotland in the United Kingdom; and the area covered by the International Observatory of Rural Research in the Galicia region, located in Northwest Spain. Where previous sections examined cluster distributions across the EU as a whole, here we shift

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to Living Lab scale, showing how the six clusters summarised in Table 1 interweave locally within and around each Living Lab boundary.

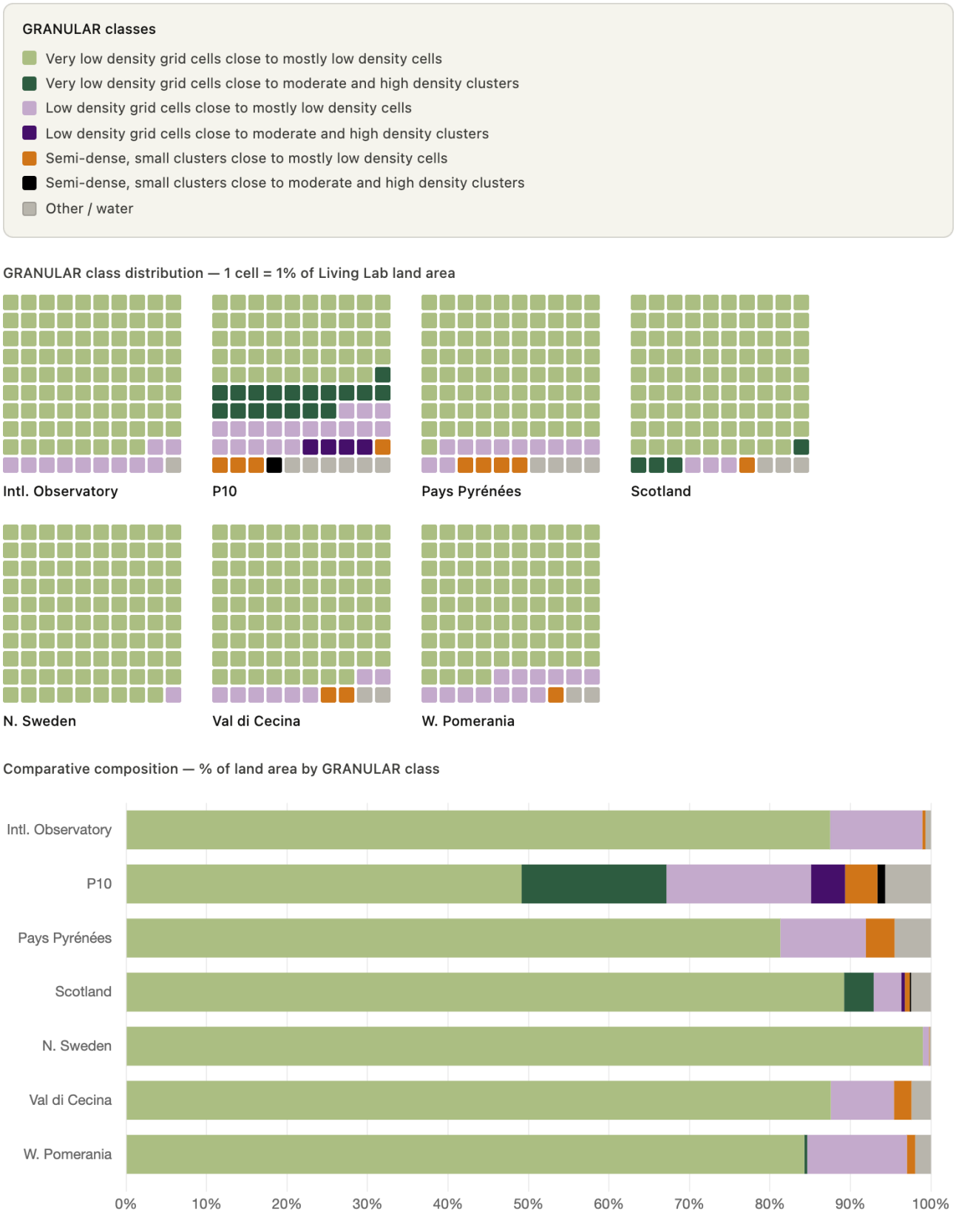

Figure 3. GRANULAR class distribution amongst Living Lab Areas

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Because P10 is an inter-municipal network of geographically dispersed rural municipalities rather than a single contiguous district, the Living Lab boundary appears as several separate polygons spread from the northern and eastern provinces to the south-western coast and the Wadden Islands, rather than the single bounded area shown for the other Living Labs.Map 13 shows a markedly different balance from the EU-wide maps in section 4.2. Across the P10 territory and its surroundings, the 3112, 3122, 3131 and 3132 clusters that form small, scattered minorities elsewhere in the typology cover large contiguous areas, while the 3111 and 3121 baseline clusters that dominate most of rural Europe are confined to a comparatively small share of cells. The pale grey patches threading through the map are the country's main urban centres, among them Amsterdam, Rotterdam, The Hague and Utrecht, and it is precisely around these that the moderate and high density-adjacent clusters concentrate most heavily.

This map offers the clearest illustration in the Living Lab series of the peri-rural phenomenon discussed above. In a country with one of the EU's highest overall settlement densities, even grid cells that meet DEGURBA's sparsity thresholds fall overwhelmingly into the *'close to moderate and high density clusters'* class, covering clusters 3112, 3122 and 3132, rather than the *'close to mostly low density cells'* branch that dominates the EU as a whole. These three clusters share a common profile of lower elevation, a denser building footprint, and greater accessibility than their class-dominant counterparts. Their dominance here signals a landscape that is lowland and closely integrated with the surrounding urban fabric, which is broadly what one would expect wherever formally low-density land sits inside or against a major conurbation. Clusters 3112 and 3122 also register population growth, in line with the urban-proximity expansion pattern described in section 4.4.2, whereas cluster 3132 is distinguished by the steepest demographic decline of any cluster in the typology despite its high accessibility. The Netherlands map therefore illustrates that proximity and dense building stock do not by themselves guarantee demographic stability, a finding directly relevant to the Dutch Living Lab's focus on sustaining housing and service provision across a network of small, dispersed rural municipalities.

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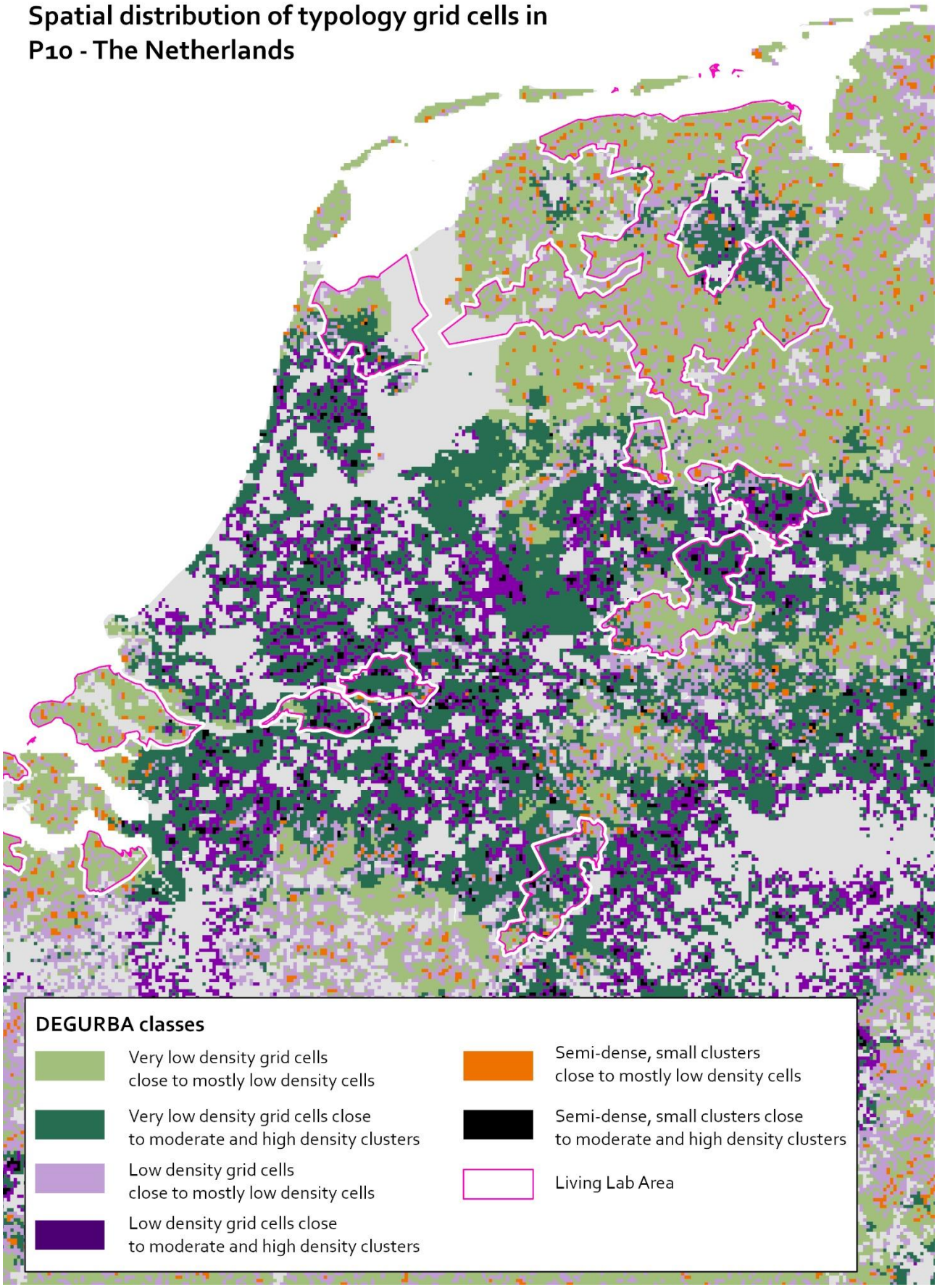

Map 13: GRANULAR rural typology grid cells in P10 – The Netherlands

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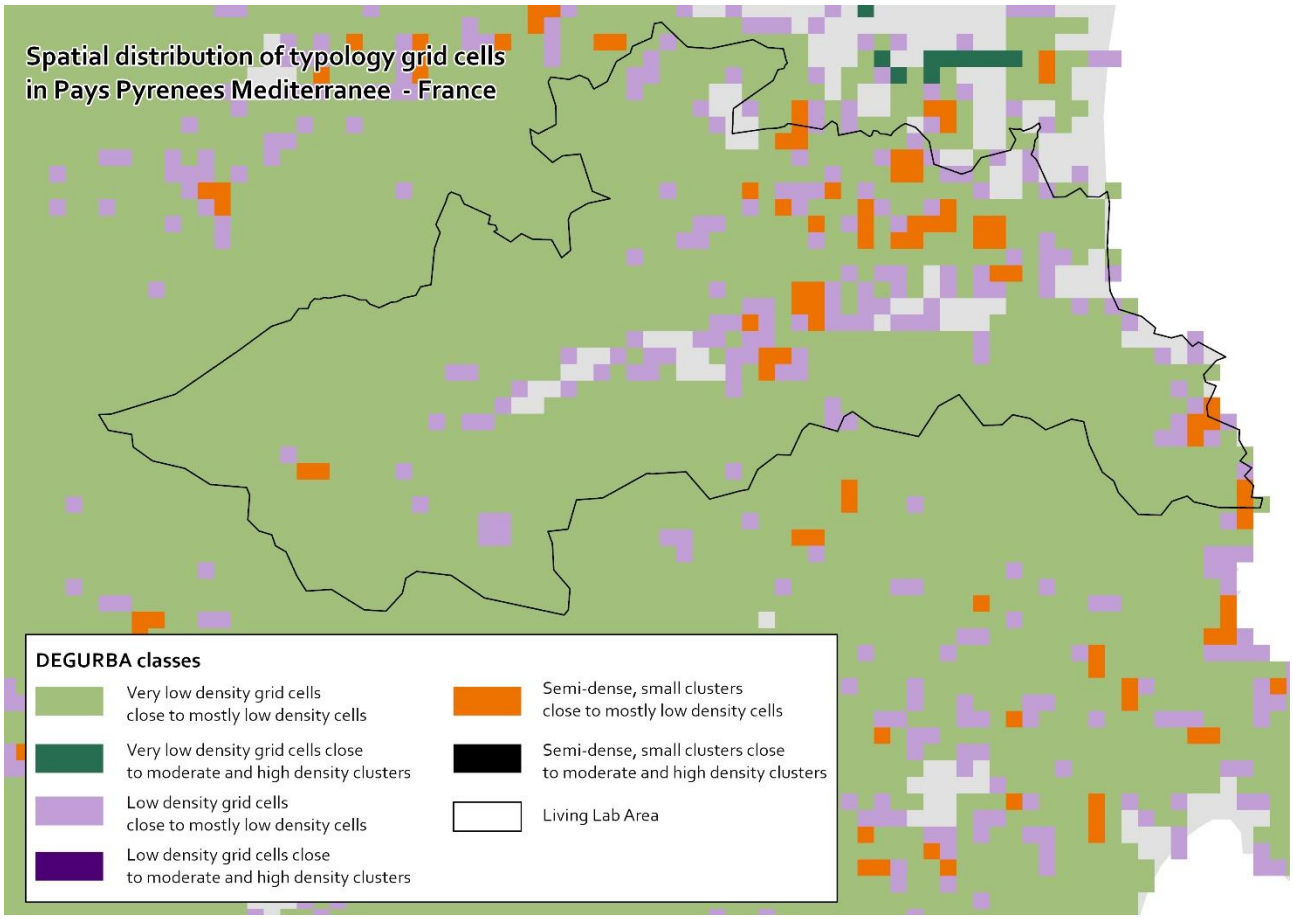
Map 14 shows a single contiguous Living Lab area stretching from the Mediterranean coast inland towards the Pyrenean foothills. Cluster 3111 forms a near-continuous background across virtually the entire territory, both inside and outside the Living Lab boundary, in line with the overall description of this cluster. Scattered 3131 and 3121 cells are interspersed throughout, with 3131 cells noticeably more frequent towards the eastern, coastal edge of the map than in the mountainous interior. Cells belonging to the moderate and high density-adjacent minority clusters, 3112, 3122 and 3132, are essentially absent, and the small grey patches visible inland and along the coast mark the few urban centres within the wider mapped area.

The near-total dominance of cluster 3111 reflects the Pyrenean foothill terrain that covers most of this territory. As noted above, this is the cluster with the highest elevation, the lightest building footprint, and the least modified landscape in the GRANULAR rural typology, combined with the lowest accessibility scores recorded anywhere in the study: in short, a genuinely remote, lightly modified terrain. The scattered 3131 cells sit at the opposite end of nearly every one of these measures, with a heavier building footprint, the most intensively modified landscape of any cluster, and moderate accessibility. They mark the nucleated towns and villages of the coastal plain and the main valley corridors, and their concentration towards the coast plausibly reflects the touristic, seasonally occupied settlements that characterise part of this territory. Unlike the Netherlands, Italy, or Poland Living Labs, this area shows almost no expression of the urban-proximity dimension discussed earlier. The GRANULAR rural typology here is structured almost entirely by the gradient logic, with elevation and settlement intensity rather than proximity to a major city as the dominant axis of variation.



Map 14: GRANULAR rural typology grid cells in Pays Pyrenees Mediterranee – France

Map 15 shows the Val di Cecina Living Lab as broadly dominated by the same cluster 3111 baseline seen in the French Living Lab. Cells from clusters 3121 and 3131 are interspersed across the territory at a higher overall frequency than in Pays Pyrenees Mediterranee, with 3131 cells forming a fairly dense scatter, particularly in the northern part of the map. At the north-western edge, just outside the Living Lab boundary, a small patch of 3112 cells sits alongside the grey footprint of the coastal towns themselves.

The frequent 3131 cells carry the same nucleated, intensively modified hill-town signature identified in the French Living Lab, here embedded within an otherwise extensively low-density, elevated landscape. This fits well with the Tuscan hill-town fabric characteristic of Val di Cecina, where settlement is scattered across agricultural and forested

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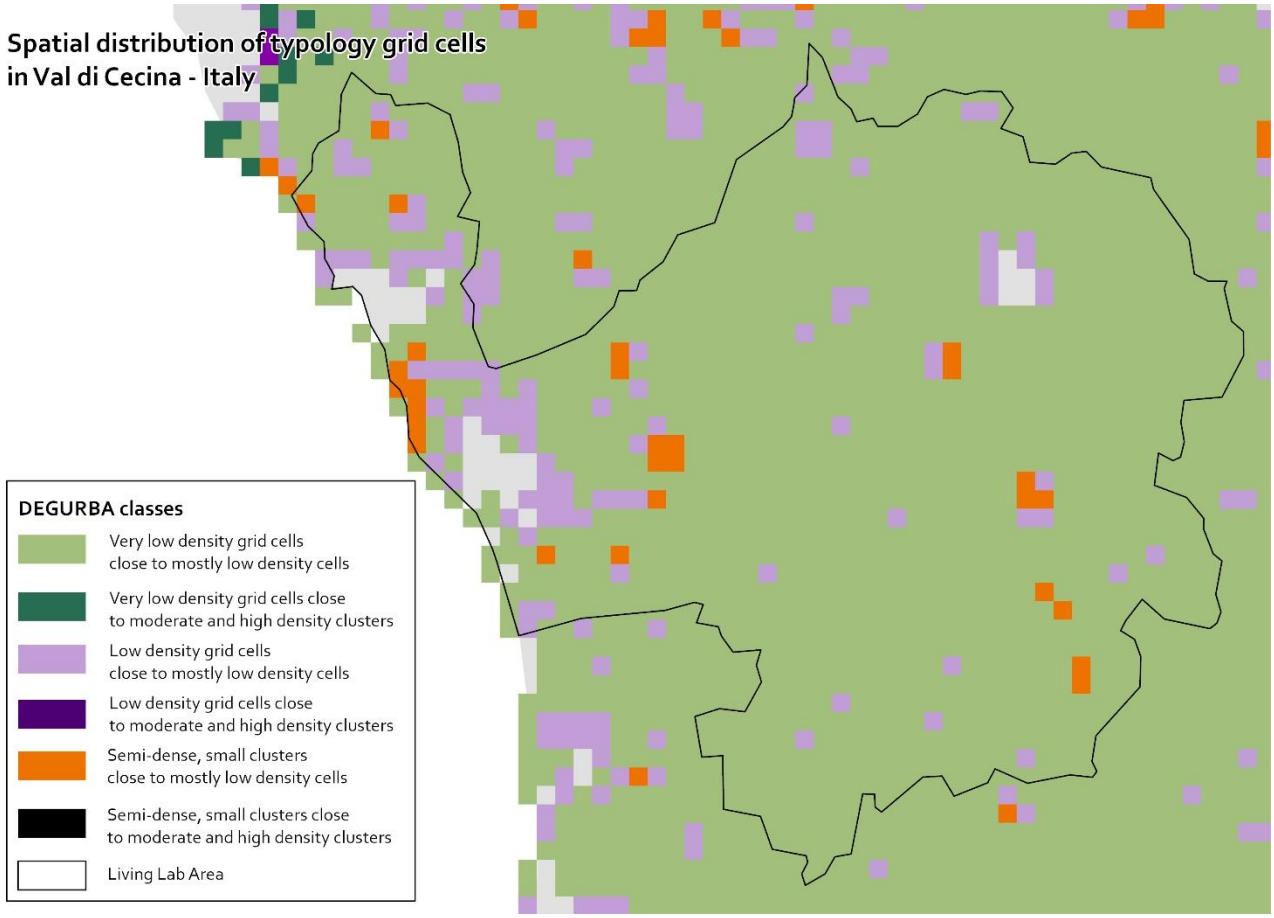
land rather than concentrated in a single centre. The small concentration of 3112 cells at the coastal edge of the map, just outside the Living Lab boundary, shows the urban-proximity mechanism discussed above. As in the Netherlands, this is the cluster of markedly lower elevation and greater accessibility, and its appearance precisely where the rural area meets the coastal towns marks a transition from the terrain-driven sparsity that dominates the Living Lab itself to the functionally constrained sparsity of the urbanised coastal margin.



Map 15: GRANULAR rural typology grid cells in Val di Cecina – Italy

Map 16 covers a much larger territory than the other Living Lab maps, reflecting Northern Sweden's status as a consortium of the country's four northernmost counties. The map is dominated almost entirely by cluster 3111, with the small grey patches breaking up this otherwise uniform expanse marking urban centres rather than any other rural cluster. These are noticeably more frequent and larger along the Baltic coastline than across the inland counties.

This is the most spatially homogeneous of all seven Living Lab maps and the purest expression in the typology of the baseline cluster: elevated, lightly built, and lightly modified terrain with the lowest accessibility scores of any cluster. Read against that profile, the near-total dominance of a single cluster here says less about settlement density as such than about terrain, specifically a vast, elevated interior set apart from the urban networks that drive the moderate and high density-adjacent clusters elsewhere in the GRANULAR rural typology. The small number of urban centres visible along the coast reflects peri-rural concentrations formed around major cities even within otherwise sparsely settled regions. Compared to the Netherlands map, Northern Sweden anchors the opposite end of the spectrum identified in Section 5.2.2: a Living Lab where terrain and elevation, rather than functional constraint or urban proximity, are the overwhelming drivers of low density.

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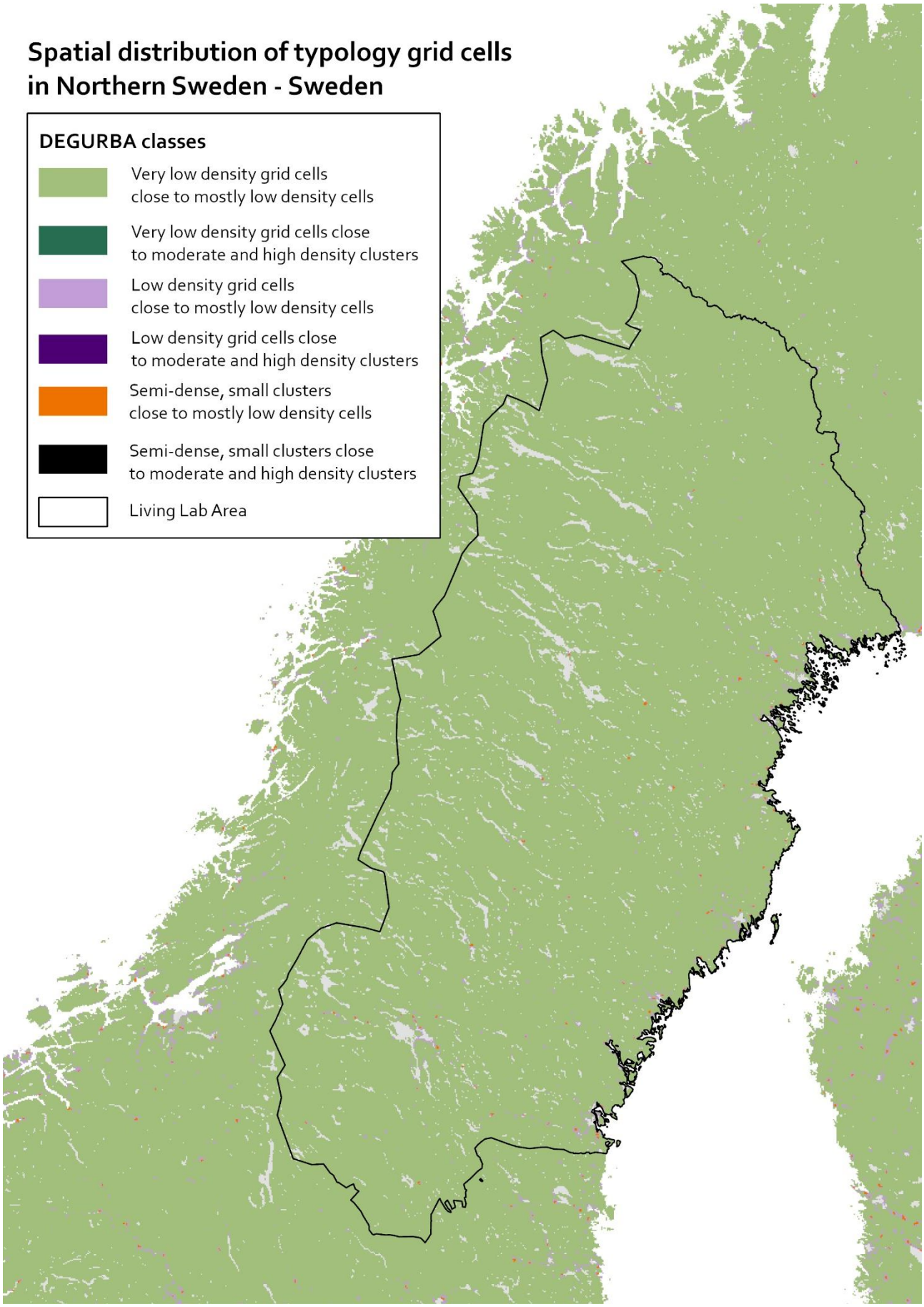

Map 16: GRANULAR rural typology grid cells in Northern Sweden

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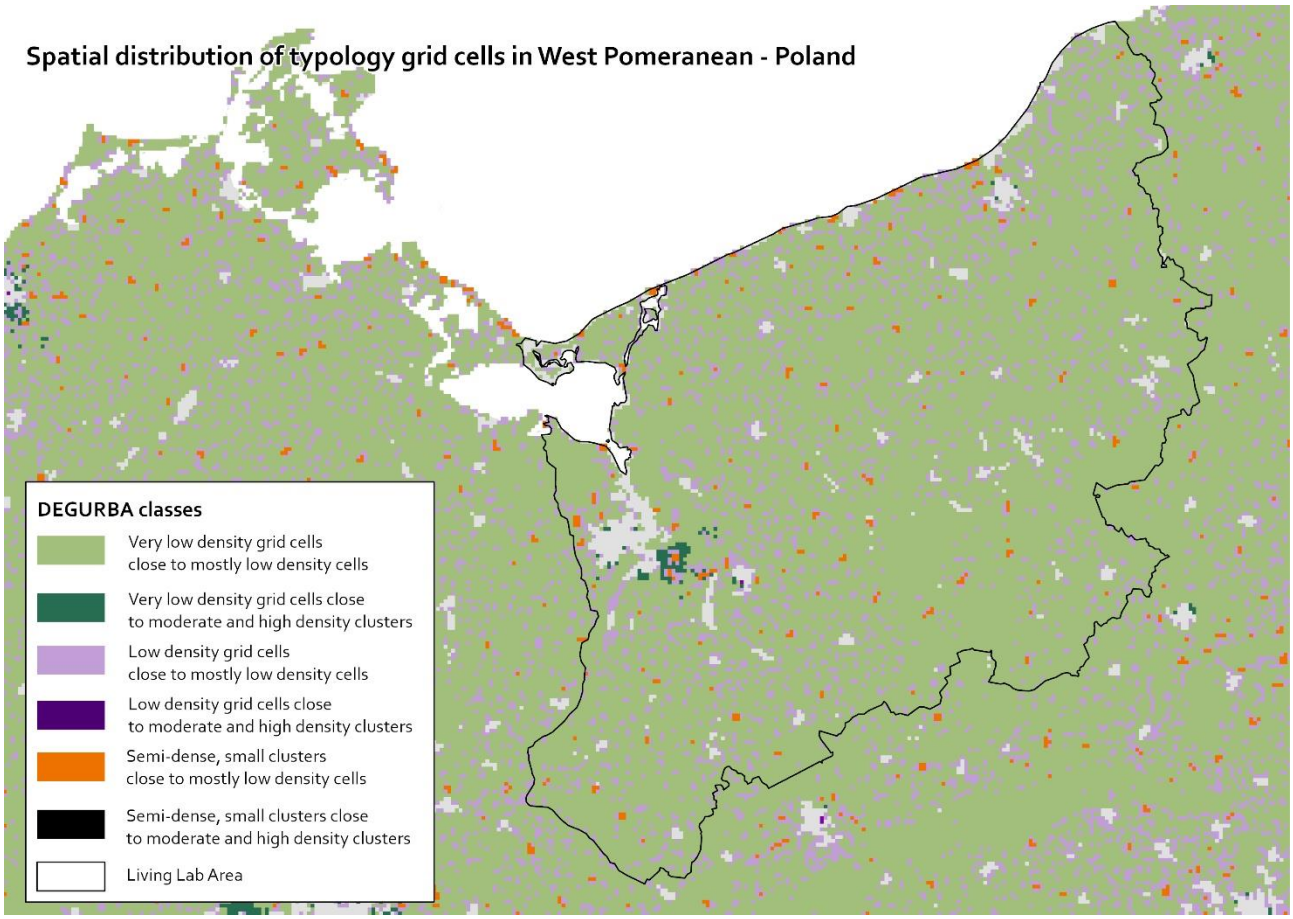
Map 17 shows the West Pomeranean Living Lab as a single large polygon covering most of the visible territory, bordering the Baltic coast and the Szczecin Lagoon to the north. As in Northern Sweden, cluster 3111 covers the great majority of the map, but it is interrupted by a noticeably denser and more even scatter of 3131 cells than in the Swedish Lab, together with occasional 3121 cells. A single concentrated patch of 3112 cells, sitting directly alongside one of the Living Lab's own urban centres, appears close to the southern edge of the lagoon, inside the Living Lab boundary.

The even scatter of 3131 cells across the territory carries the same nucleated small-town signature seen in the French and Italian Living Labs, but here it forms a regional fabric rather than a scatter of individual hill towns. This is relevant to the West Pomeranean Living Lab's focus on short food supply chains, which depend on a dense network of such small towns for local distribution. The single concentrated patch of 3112 cells near the lagoon is best read through the lens of section 5.2.2. As elsewhere in the typology, this cluster signals lower elevation and greater accessibility than the surrounding baseline, so its appearance here marks a localised instance of the same urban-proximity mechanism that produces much larger contiguous zones in the Netherlands, in this case triggered by a single secondary urban centre on the lagoon shore rather than by a broad metropolitan region. The absence of the most accessibility-intensive minority clusters, 3122 and 3132, suggests that this regional rural fabric, while diverse, has not reached the level of connectivity found in the most urbanised Living Lab regions.



Map 17: GRANULAR rural typology grid cells in West Pomeranean – Poland

Map 18 focuses in the Scottish Living Lab and shows the sharpest spatial discontinuity of any GRANULAR Living Lab map. The Highlands and Islands are covered almost uniformly by cluster 3111, with only a thin scatter of other clusters even near the larger island settlements. This uniform expanse abuts a single, tightly bounded zone of intense cluster diversity corresponding to the Central Belt around Glasgow and Edinburgh, where the grey patches are the cities themselves. A second, comparable concentration is visible at the southern border with England, around the Newcastle conurbation.

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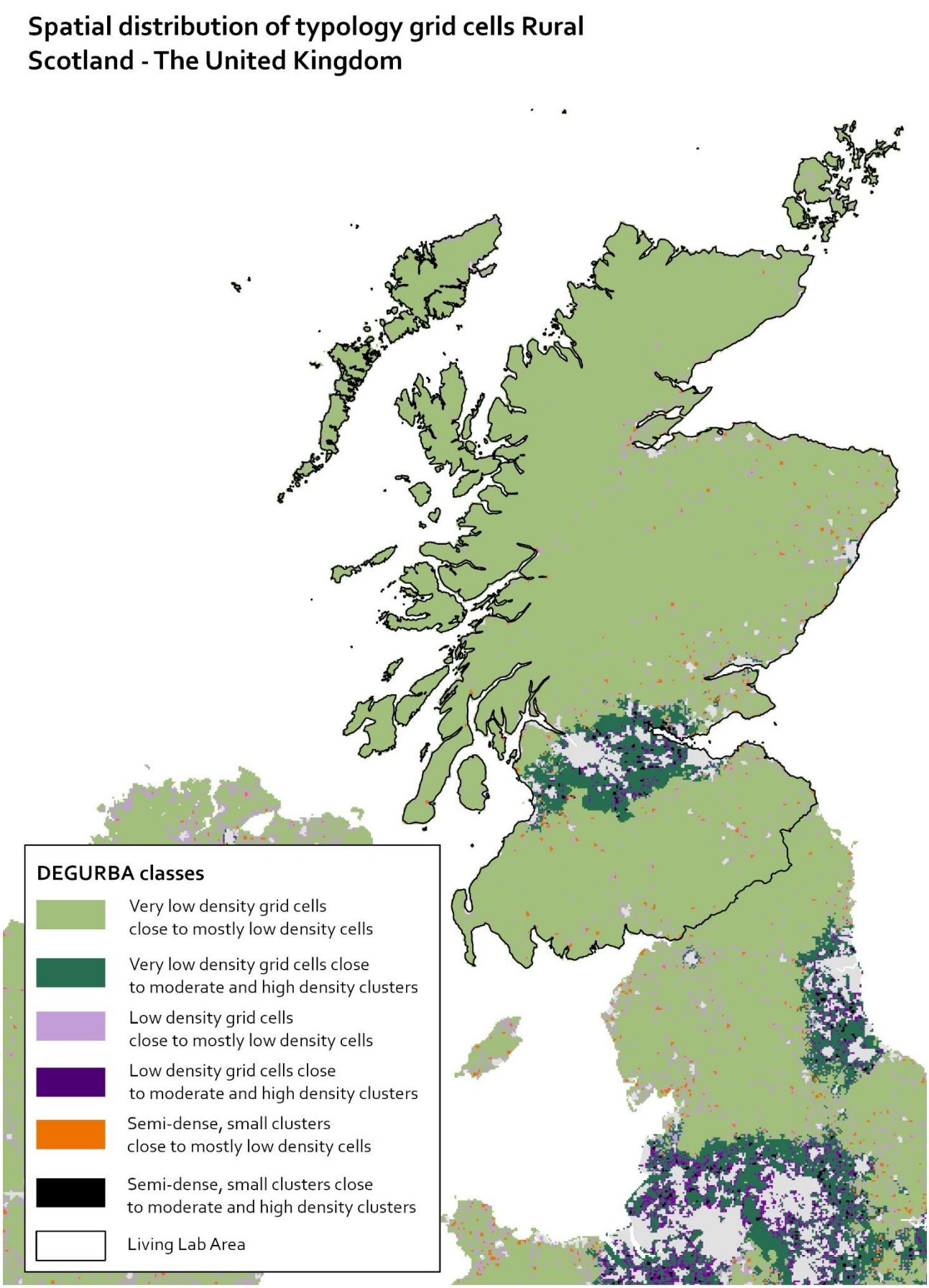

Map 18: GRANULAR rural typology grid cells in Scotland – The United Kingdom

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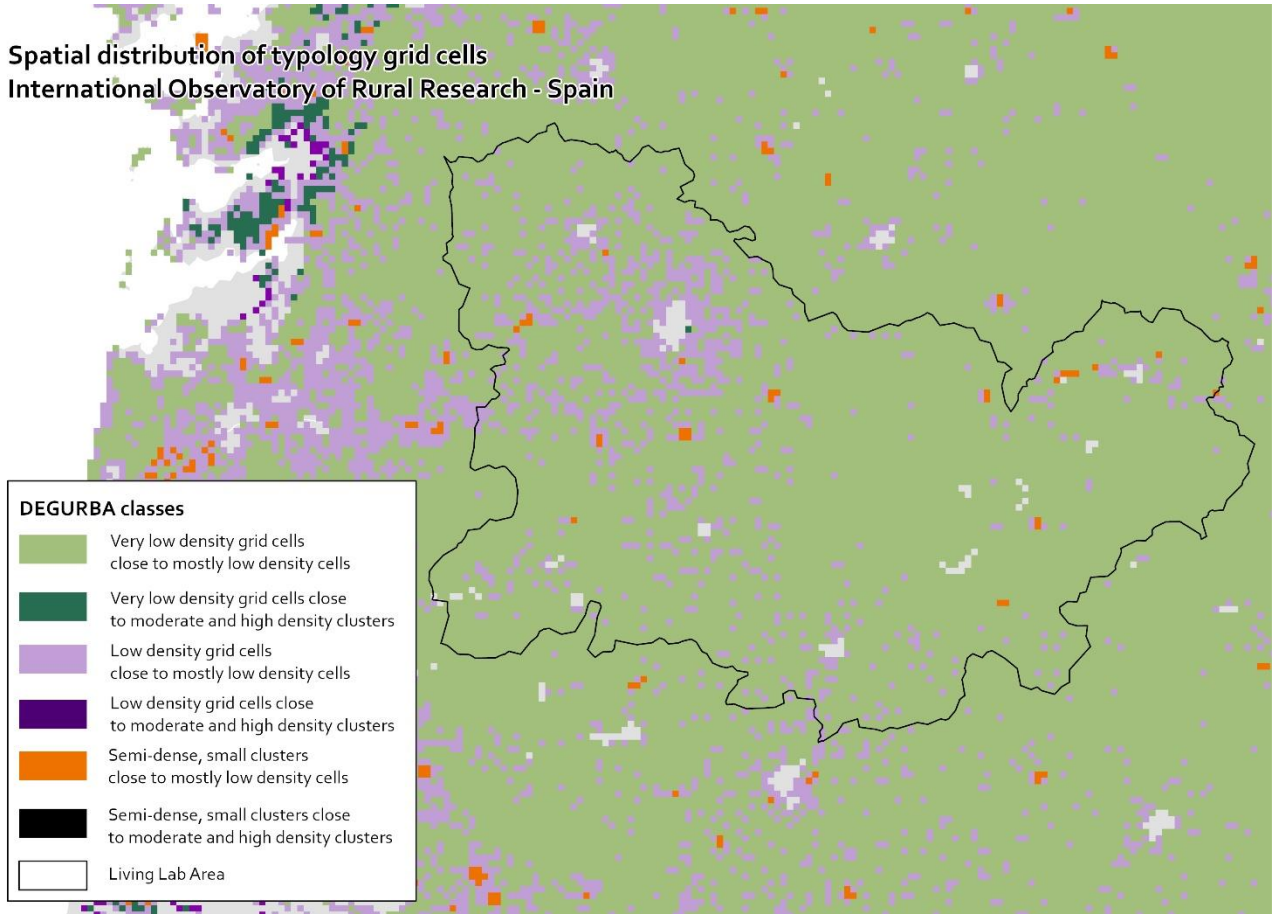
This binary structure is the most compressed expression in the typology of the urban-proximity gradient discussed in section 5.2.2. The Highlands and Islands' near-total reliance on the same baseline cluster identified in the French and Swedish Living Labs signals elevated terrain set well apart from any urban network. The Central Belt cluster mix signals precisely the combination identified in the Dutch Living Lab: low elevation, a dense and heavily modified building stock, and some of the highest accessibility scores in the GRANULAR rural typology. Where the continental Living Labs, the Netherlands and Poland, show that combination spread across broad lowland regions, and Italy and France show it only as scattered patches, Scotland compresses the entire gradient into a narrow transition zone around its two largest cities. This reflects the concentration of the great majority of the Scottish population within the Central Belt, consistent with the observation in section 5.2.1 that most of Great Britain outside England's Midlands and south-east falls within cluster 3111. For a Living Lab whose rural geography spans crofting communities and island settlements at one extreme and Glasgow and Edinburgh commuter areas at the other, the map illustrates why a single density-based classification would struggle to capture the range of challenges, from service delivery in sparsely populated communities to peri-urban development pressure, that fall within a single, undivided rural territory.

Map 19 shows the Spanish Living Lab boundary as a single polygon set inland, away from the coastal strip visible in the upper-left corner of the map, where a cluster of grey cells marks the Vigo agglomeration. Within the boundary itself, the mix is finer grained than in the Swedish or Scottish baseline: 3121 cells are interspersed with the 3111 category appearing at a higher frequency than in most other Living Labs, and 3131 cells scattered throughout at a moderate frequency. The moderate and high density-adjacent minority clusters, 3112, 3122 and 3132, are concentrated almost entirely at the coastal margin alongside the urban centres themselves, rather than within the Living Lab.



Map 19: GRANULAR rural typology grid cells in the International Observatory of Rural Research – Spain

The absence of those minority clusters within the Living Lab boundary is worth noting. The demographic and settlement pressures that elsewhere in the typology accompany high accessibility and dense building stock are concentrated in the coastal urban band, while the Living Lab area itself more closely matches cluster 3121, the moderately built, moderately accessible counterpart to the 3111 baseline described in section 5.2.2. The relatively even mix of these two clusters, rather than the dominance of either one, fits with a traditionally dispersed, village-

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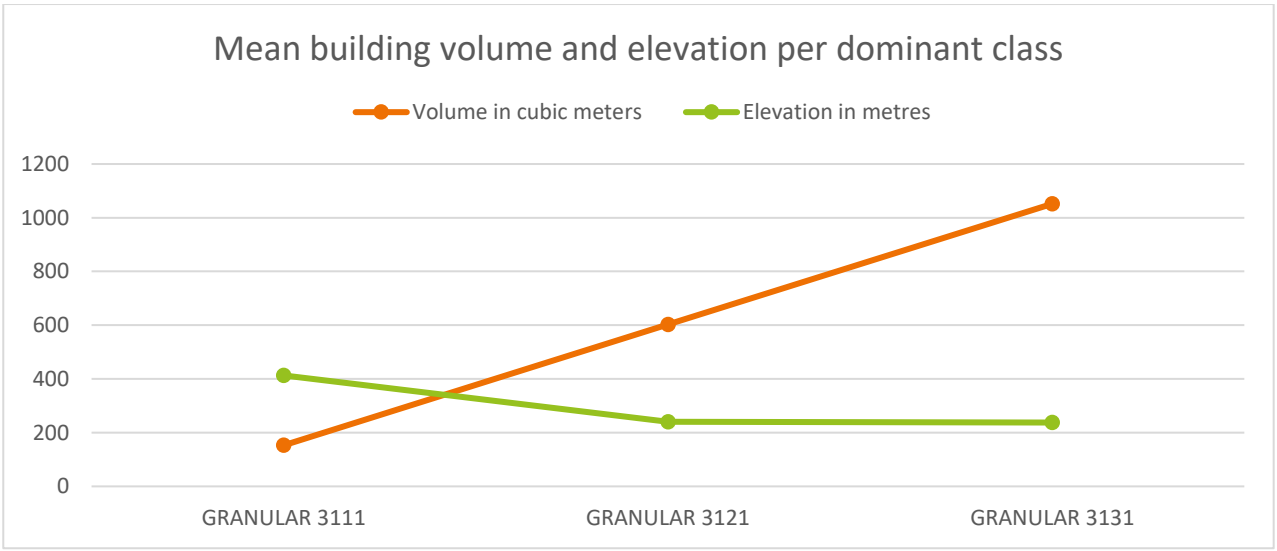
based settlement pattern, neither an elevated interior nor a well-connected lowland. It also supports a reading in which demographic decline within the Living Lab is more plausibly linked to outmigration toward the coastal cities than to the proximity-driven growth that characterises the peri-rural minority clusters elsewhere in the GRANULAR rural typology.

5.3. Interpretation

5.3.1. The gradient of rural differentiation

The transition from very low-density to denser rural settlement across DEGURBA classes 311, 312, and 313 follows a coherent gradient in which building volume, landscape modification, and accessibility all increase as elevation declines. This reflects the structural embeddedness of denser rural settlement within more accessible, lower-lying, and more intensively managed landscapes, and it comes through most clearly in the dominant cluster of each class: *3111 - Very low density grid cells close to mostly low density cells*, *3121 - Low density grid cells close to mostly low density cells*, and *3131 - Semi-dense, small clusters close to mostly low density cells*. Together these three clusters account for 92.8% of all rural cells analysed and trace a consistent progression across the full density spectrum.

Mean elevation declines from class 311 to class 313, and building volume rises in the opposite direction, with a near-sevenfold increase from the lowest to the highest density class. This follows the inverse relationship between elevation and building volume and reflects the transition from extensively settled landscapes, where built fabric is scattered and dispersed, to the nucleated village settlement forms with concentrated building volumes that characterise class 313. Hemeroby values rise accordingly across the gradient, from the low-to-moderate modification range in *3111 - Very low density grid cells close to mostly low density cells*, through moderate modification in *3121 - Low density grid cells close to mostly low density cells*, to the high modification range in *3131 - Semi-dense, small clusters close to mostly low density cells*. This progression reflects the intensification of human landscape modification from remote and lightly managed rural land to long-established agricultural and village settlement systems. Accessibility scores increase consistently across classes and in the expected direction within each class, with scores to small towns always exceeding those to medium towns and large cities. The dominant clusters of classes 311 and 312 show low to moderate accessibility, while *3131 - Semi-dense, small clusters close to mostly low density cells* reaches moderate scores, in keeping with integration into small and medium town hinterlands.



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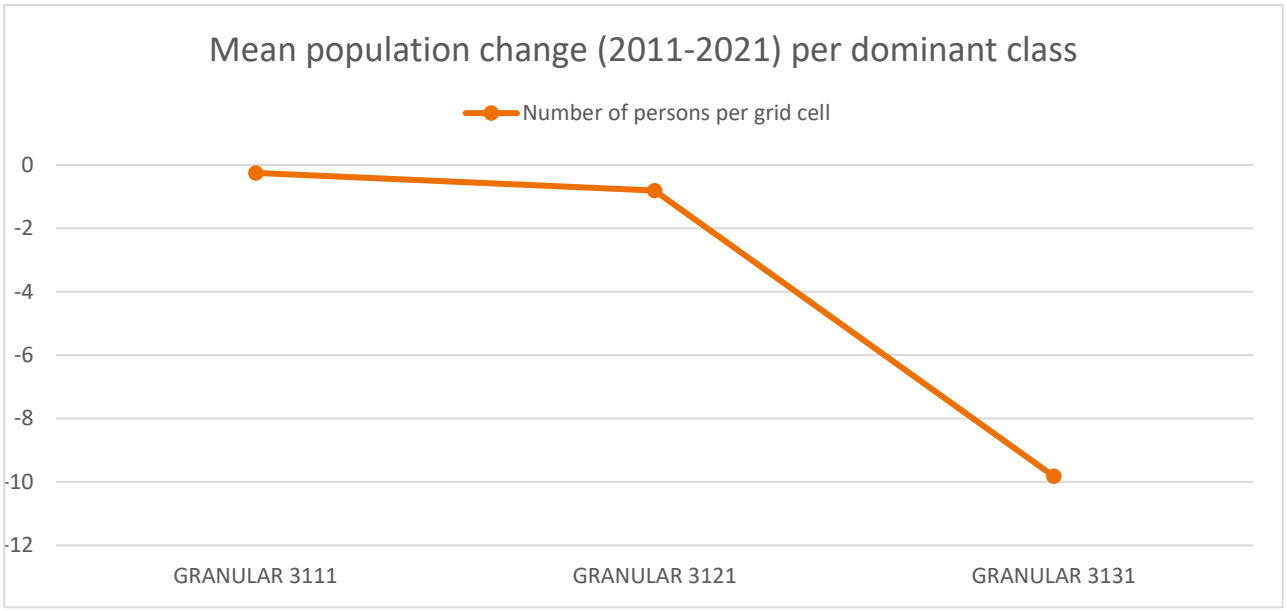

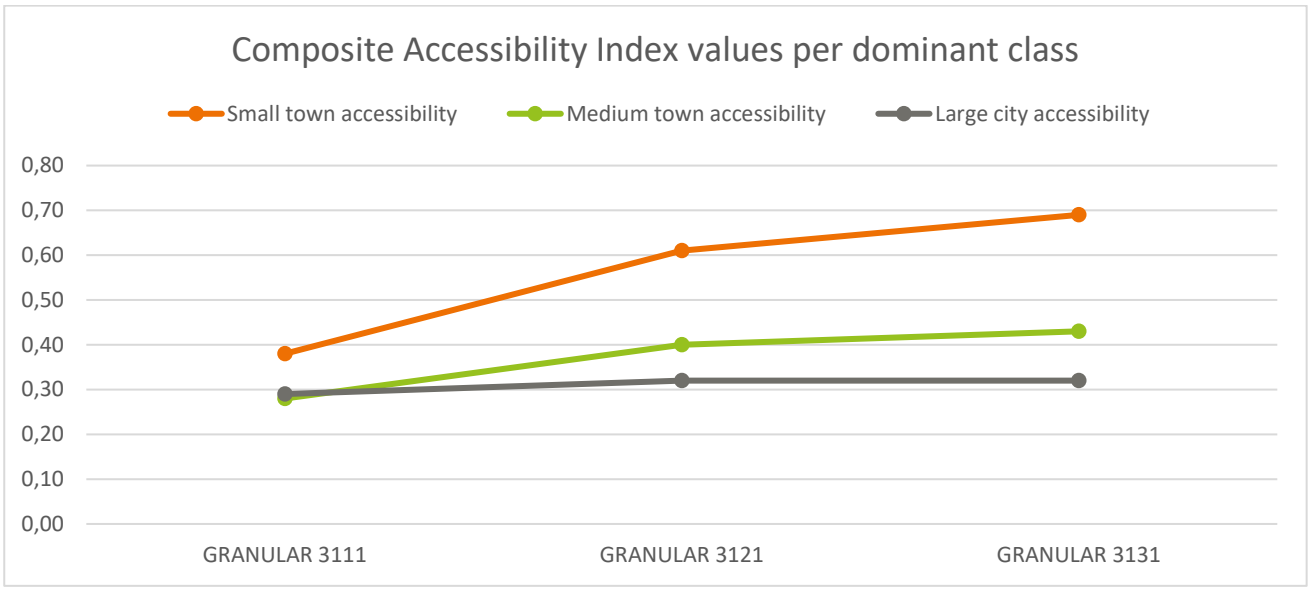

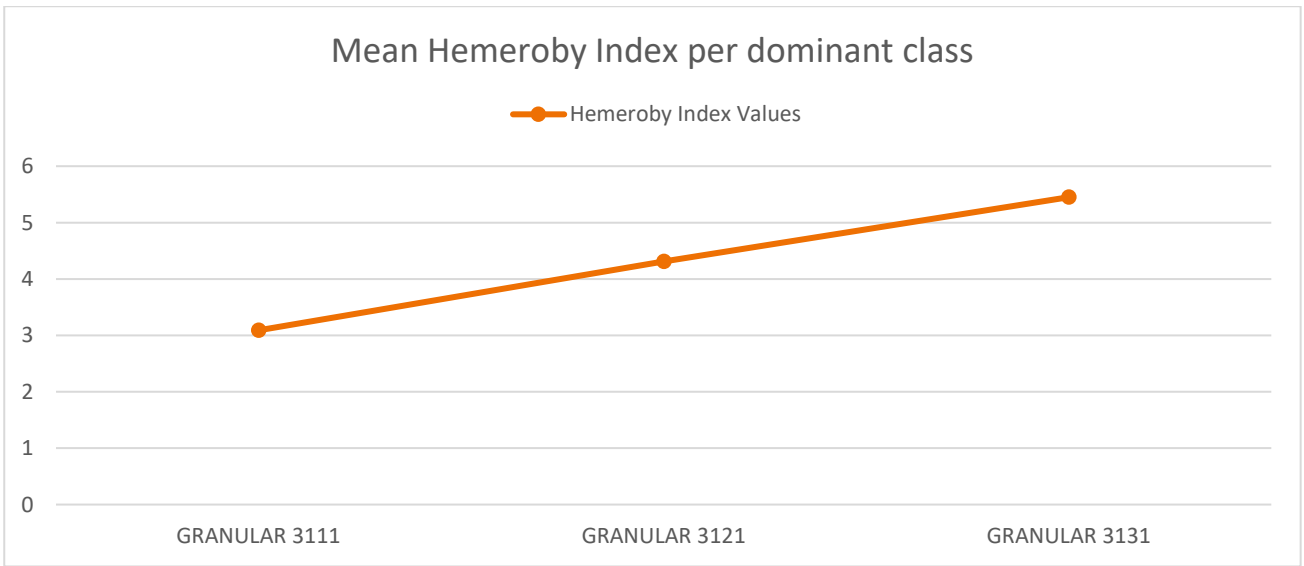

Figure 4. Cluster indicator variability across class dominant clusters

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That this gradient broadly confirms the internal logic of the DEGURBA stratification is not a surprising result. Since DEGURBA classes are defined by population density, and population density correlates structurally with building volume, accessibility, and landscape modification, the gradient is better understood as a methodological consistency check than as an independent empirical finding. It confirms that the clustering variables are coherent inputs and rules out the possibility of systematic data artefacts. The empirical contribution of GRANULAR's rural typology lies in the systematic spatial delineation of the minority clusters and the cross-cutting urban-proximity patterns, which the density stratification alone does not differentiate.

Among the clustering variables, accessibility scores, intensity of landscape modification, and building volume all tend to move together. Areas with higher accessibility tend to show a greater built footprint and more intensive land use. This co-variation reflects a fairly deep geographic logic: the same conditions that make a location accessible, in particular flat terrain and proximity to urban centres, also tend to support denser settlement and more intensive land use (Bengs and Schmidt-Thomé 2006). Because the measured variables are strongly correlated, they form a single dominant gradient rather than multiple independent axes of variation, which naturally produces a two-cluster structure separating moderately integrated rural systems from those more deeply embedded within highly connected regional systems.

The dominant cluster of each class captures the modal territorial condition: the widespread, internally varied but broadly coherent rural type that defines each density category across most of Europe. The clustering does not subdivide this modal condition further because doing so would impose boundaries on what the data suggest is a broadly continuous distribution. Within class 312, Low density grid cells close to mostly low density cells dominates across a wide arc of Europe because this is where the conditions for widespread, stable, moderately connected rurality are most extensively met: low to moderate elevation, dispersed but sustained settlement systems, and reasonable proximity to small and medium-sized towns. In mountain systems such as the Alps and Carpathians, topographic constraints intensify fragmentation, while in the Nordic countries comparable effects arise from climatic conditions rather than terrain. In both cases the cluster becomes more corridor-bound, though even there it retains a dispersed presence at a higher baseline of settlement continuity than the sparsest rural classes. The broad representativeness of this cluster is itself a geographic statement: moderately connected, continuously inhabited rurality is the dominant structural condition of low-density rural Europe.

The recurrence of a single dominant cluster accounting for around 95% of cells within each DEGURBA class is not surprising but it is worth explaining. It follows directly from what the DEGURBA stratification achieves before clustering begins. By separating rural cells into classes defined by settlement density, the framework already removes the most fundamental axis of variation. This produces a necessary baseline, one without which the more analytically significant findings could not be isolated. The distinctive contribution of the GRANULAR rural typology lies in what sits alongside that baseline: the minority peri-rural clusters, which no population-density-based classification would separate out, and which the DEGURBA stratification neither produces nor predicts.

5.3.2. The peri-rural phenomenon and the limits of density-based classification

One of the more significant findings of the GRANULAR rural typology is the consistent recurrence of a structurally distinct form of rurality across all three DEGURBA density classes. *3112 - Very low density grid cells close to moderate and high density clusters*, *3122 - Low density grid cells close to moderate and high density clusters*, and *3132 - Semi-dense, small clusters close to moderate and high density clusters* are each small in aggregate, together accounting for around 5.0% of all rural cells analysed, yet their shared structural logic gives them a significance out of proportion to their size. Each of these clusters records substantially higher accessibility scores and building volumes than its class-dominant counterpart, and each is geographically anchored to Europe's most urbanised macro-regions, most prominently the north-western European core of England and Wales, the Benelux countries, and western Germany, with additional concentrations in northern Italy. This cross-class consistency, visible regardless of which density stratum a cell belongs to, points to urban proximity as a structural force operating at every level of the rural density spectrum.

Cluster *3112 - Very low density grid cells close to moderate and high density clusters*, presents the sharpest contrast of the three, a cluster that is formally sparse but records building volume nearly seven times that of the dominant class and accessibility scores more than four times higher. These are not remote or declining rural areas but low-density cells embedded within (or immediately adjacent to) heavily urbanised territory. This suggests that functional constraint and land use configuration are the primary drivers of sparsity here, rather than remoteness, physical isolation, or demographic decline. The specific mechanisms vary by location. Heathlands, floodplains, nature

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reserves, and forest remnants in the north-western European context have been documented as preserving pockets of very low demographic intensity within an otherwise thoroughly urbanised territorial system (Meeus and Gulinck 2008). That the indicator profile remains consistent across such varied geographic settings suggests that functional constraint and land use configuration, rather than any regionally specific factor, are the common thread running through these cells (Shaw et al. 2020).

Cluster *3132 - Semi-dense, small clusters close to moderate and high density clusters* shows the same pattern at higher density: formally low-density rural cells recording disproportionately high building volume and accessibility scores relative to the dominant cluster of their class, with large-city scores roughly double those of cluster 3131. This reflects the same underlying condition seen in the other peri-rural clusters, namely rural cells persisting within or immediately adjacent to urbanised territory, expressed at a higher baseline density. The moderate positive population change in this cluster is consistent with documented suburbanisation and urban overspill pressures, where households seek rural residential environments within commuting distance of major urban centres (Salvia et al. 2020). The diffuse spatial footprint mirrors the patchwork character of peri-rural survival more broadly: rural cells persist as islands within an otherwise urbanised matrix where urban development has been restricted by planning regulations, or where topographic or land use conditions have limited urban expansion.

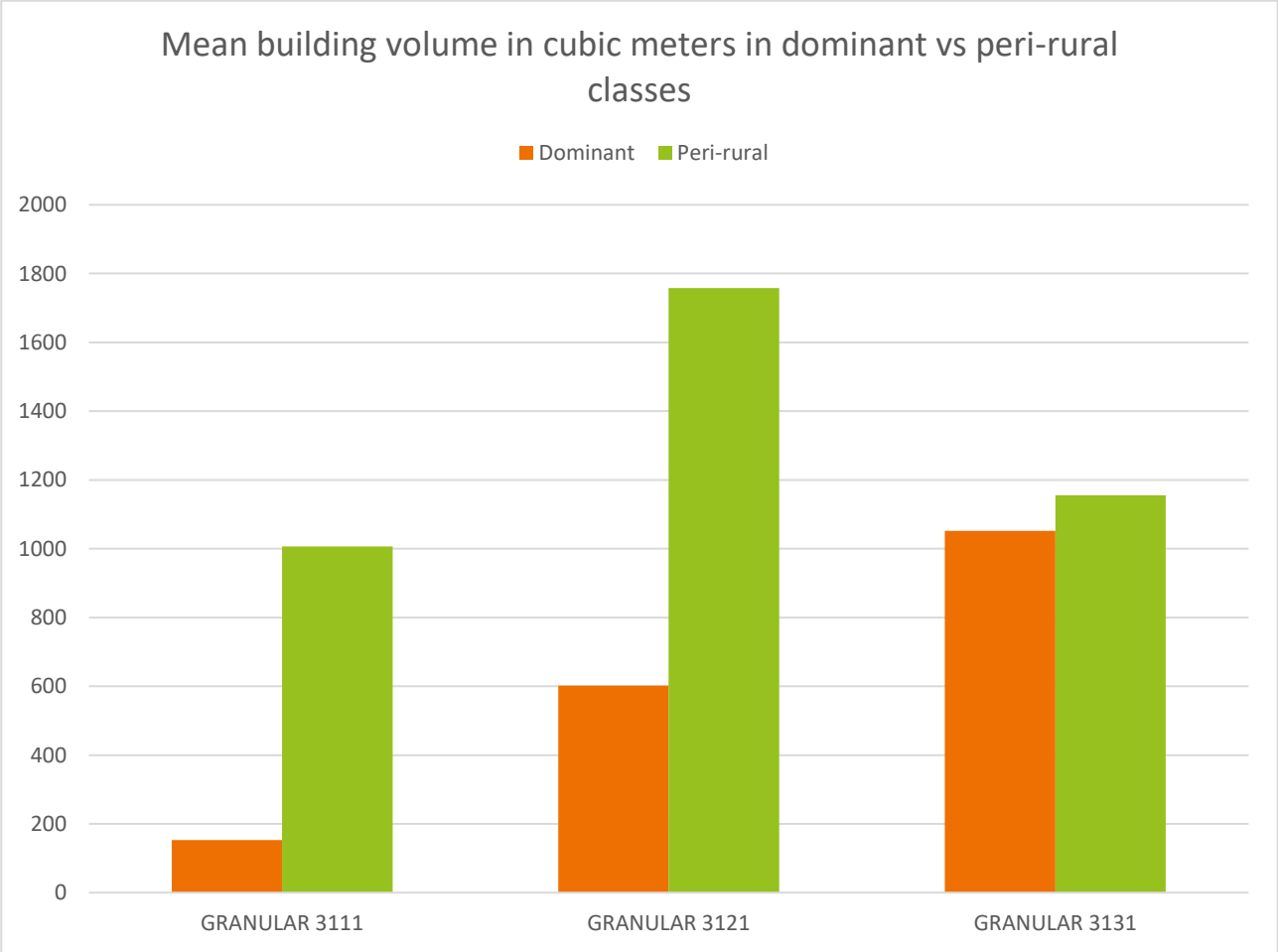

Figure 5. Peri-rural vs. dominant clusters across all three classes comparing building volume.

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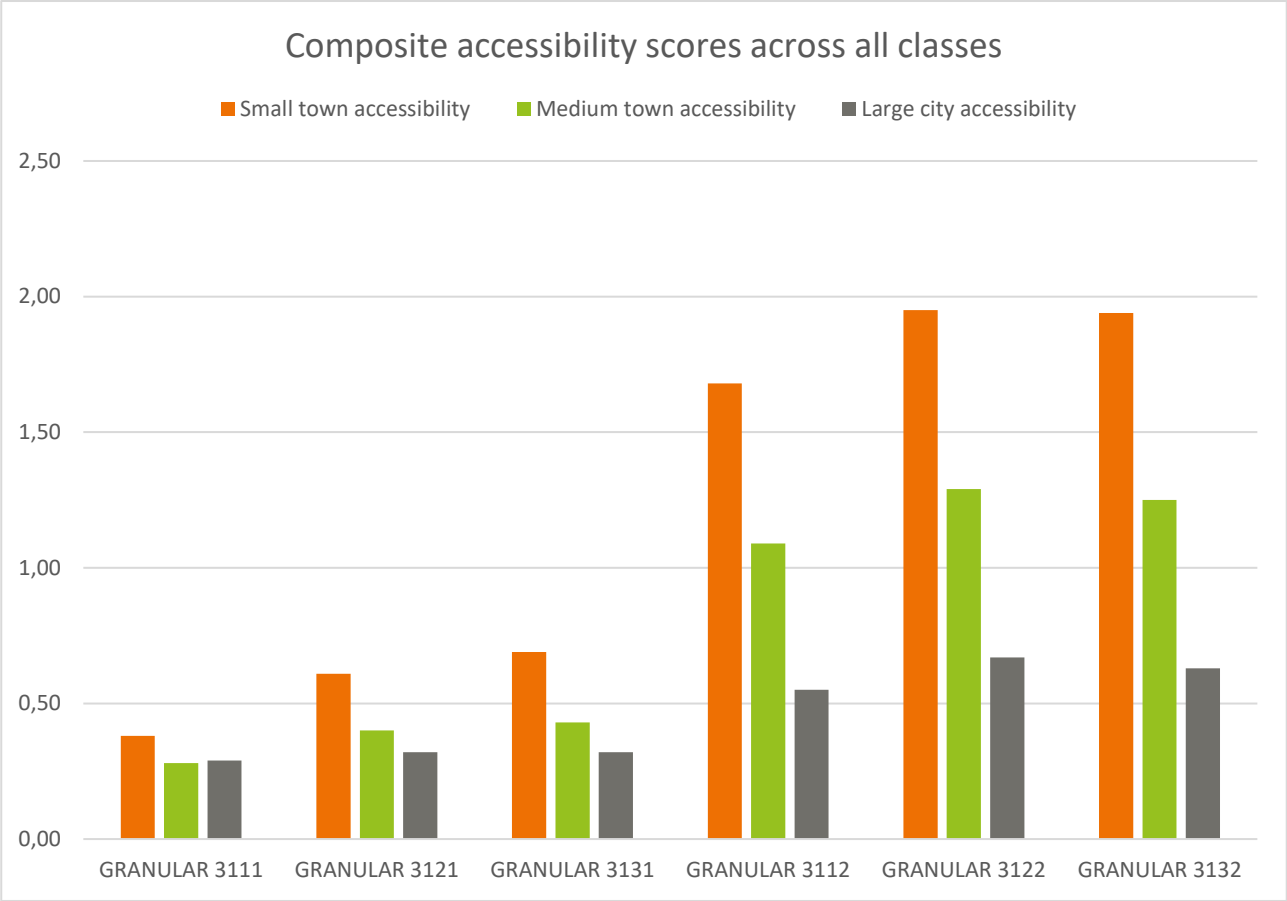

Figure 6. Composite accessibility scores across all classes

Taken together, these clusters represent the typology's primary analytical contribution and point to a structural limitation of classifications that rely on population density as their sole differentiating criterion. As the peri-rural clusters make clear, DEGURBA does not distinguish between demographic sparsity driven by physical remoteness and sparsity persisting within functionally connected, high-accessibility territories. Low population counts in these cells reflect land use configuration and functional constraint, not isolation. The smaller peri-rural clusters identify the consistent presence of formally rural territory that is functionally, morphologically, and demographically distinct from the modal condition of its density class and concentrated in some of Europe's most economically significant and policy-relevant territories.

The GRANULAR rural typology presented here does not replace DEGURBA, nor is it intended to. The stratification by settlement density class remains methodologically sound and practically necessary, and the clustering results confirm that it captures real and meaningful variation in rural structure across Europe. In fact, the dominant clusters in the GRANULAR rural typology should be read as empirical confirmation of DEGURBA. What the new GRANULAR rural typology adds is a set of multi-dimensional criteria that together highlight urban proximity as a key analytical axis, one that operates within each density stratum and reveals structurally coherent rural conditions that a density criterion alone cannot differentiate. Rural Europe differs not only in how sparse or dense it is, but in whether that density, whatever its level, is associated with remoteness and physical constraints or otherwise with functional integration within urban-dominated territorial systems. Any policy or analytical framework addressing rural Europe needs to be sensitive to both dimensions if it is to engage adequately with the structural realities of low-density territory across the continent.

6. Concluding remarks

Despite their inherent simplifications, territorial typologies play an indispensable role in comprehending the complexities of diverse geographical contexts across Europe and beyond. Each classification system possesses unique strengths and weaknesses, rendering no single method universally superior. This acknowledges that decisions regarding technical aspects, such as classification techniques, territorial levels, data sources, and

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variables, should be meticulously informed by the typology's intended purpose and its corresponding research questions or policy objectives.

In the GRANULAR rural typology, these aspects have been decided through a collaborative approach to decision-making that has been integral to its development process. By engaging a broad spectrum of researchers and rural stakeholders, the project has harnessed diverse expertise and perspectives, thereby enriching the typology's design and ensuring its relevance in addressing various geographical contexts. This collaborative effort underscores the value of incorporating multidisciplinary insights and local knowledge into territorial classification systems to maximise their utility and applicability. The collaborative decision-making process employed exemplifies how territorial typologies can transcend their simplifications by embracing diverse perspectives and expertise. This approach not only bolsters the relevance and accuracy of the GRANULAR rural typology but also fosters inclusive development, ultimately strengthening its capacity to inform evidence-based policies and enhance our understanding of complex geographical contexts.

The GRANULAR rural typology resulting from this process positions itself as a bridge between structural and systemic approaches, rather than as a pure example of either one. On the one hand, the typology has a structural foundation that evaluates measurable territorial stocks in a grid-based classification. On the other, it leverages those indicators to reveal relational rural conditions, especially the peri-rural areas where low density is shaped by functional integration with urban and peri-urban systems rather than by remoteness or decline. This gives the typology a more systemic reading, as it shows that similar structurally low-density conditions result in different expressions of rurality, depending on relational aspects, including proximity, connectivity, land-use constraint, settlement morphology and demographic trajectory. This dual structural and systematic characteristic is also what enables conceptual alignment with the GRANULAR Rural Compass. While the Compass is a broader conceptual framework, the typology is a pragmatic, data-constrained territorial implementation that partially reflects the core residential, productive, environmental and recreational functions highlighted by the Rural Compass.

Methodologically, the GRANULAR rural Typology has three distinctive features. First, it adopts an incremental and hierarchical classification framework anchored in DEGURBA. This provides continuity with an established European classification system while allowing the analysis to move beyond a purely density-based reading of rurality. Second, the typology is built on the EU 1 km² grid, which provides sufficient spatial resolution to map and analyse rural landscapes at a fine territorial scale and to capture variation that would be hidden at broader administrative levels. Third, it applies an automatic, data-driven clustering algorithm within each DEGURBA rural class. This reduces the role of subjective threshold-setting and supports a consistent, reproducible characterisation of rural territories across Europe. The design philosophy of the typology emphasises transparency, reproducibility and multidimensionality. It relies on open and harmonised data sources and combines indicators that capture complementary dimensions of rural territory.

Taken together, these features allow the GRANULAR rural typology to strengthen existing European territorial classifications by introducing multidimensional criteria that distinguish different rural, peri-urban and peri-rural landscapes. Across all rural grid cells, the analysis identified six cluster types organised within a coherent analytical structure: two clusters within each rural class included in DEGURBA Level 2. The results confirm that rural Europe is not a homogeneous category but a differentiated territorial system in which low population density is produced and sustained through different combinations of physical geography, demographic performance, landscape modification, accessibility, and proximity to urban systems. By complementing DEGURBA's density-based framework, the typology reveals a clear gradient across rural Europe: as settlement density increases from very low to moderate levels, building volume, landscape modification and accessibility tend to rise, while elevation generally declines. This progression confirms the internal coherence of DEGURBA while also showing where a density-based approach alone is insufficient. In particular, the GRANULAR rural typology highlights peri-rural clusters that remain formally low-density but are functionally connected to nearby urban systems, making them distinct from remote or physically constrained rural areas.

The minority peri-rural clusters identified by GRANULAR, which together account for around 5.0% of all rural cells, provide a useful lens for understanding how low-density territories can remain functionally connected to surrounding urban and peri-urban areas, even when urban and intermediate areas are excluded from the analysis by design. These clusters show that proximity to urban centres can significantly shape rural characteristics, including in territories formally classified as low-density. This is particularly evident in regions such as England and Wales, the Benelux countries, western Germany, and northern Italy, underscoring that rural designations need not be solely defined by physical isolation or demographic decline. On the contrary, they can also reflect great dynamism, often through functional integration with nearby urban centres. This recognition is essential for policymakers as they strive

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to maintain the unique characteristics of low-density territories while leveraging their potential for enhanced connectivity with urban areas.

Rural policy therefore needs to consider both settlement density and functional integration. A density-based classification remains useful, but it does not fully capture the different ways in which rural areas relate to urban systems. Policies for remote, physically constrained rural areas will differ from those needed in low-density territories close to major urban centres, where housing demand, land-use pressure, commuting patterns, service provision, and environmental management may be shaped by greater accessibility to essential services. A more nuanced approach can help policymakers design targeted strategies that support sustainable development, protect resources, and improve community well-being across Europe's diverse low-density territories.

Against this background, the GRANULAR typology contributes to European territorial classification by showing how density, accessibility, built form, landscape modification, and demographic change interact across rural space. Its main added value is not simply to create new categories, but to reveal forms of rurality that are difficult to identify through density thresholds alone. By highlighting the interplay between low-density territories and urban systems, the GRANULAR rural typology provides a basis for more precise analysis and better targeted policies for Europe's changing rural landscapes.

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Appendices

Appendix 1 Data and code used for the development of the GRANULAR rural typology

The data and software scripts used in this work are available for download from the Zenodo repository, with DOI: 10.5281/zenodo.21098954

Appendix 2 Timeline in typology development

This appendix summarises the sequence of work carried out under Task 4.6 since the start of the project in 2022. It outlines the main meetings, events and activities, as well as the key decisions made at different stages of the typology development process.

GRANULAR kick-off meeting (online), 12 October 2022

- The GRANULAR kick-off meeting on 12 October 2022 was the first opportunity to present the GRANULAR rural typology work to the full consortium. The presentation focused on the work planned for the first six months and aimed to align the next steps with consortium partners and participating stakeholders.
- The meeting also introduced preliminary points of departure for the typology development. DEGURBA was identified as an important starting framework, while the need to incorporate multiple dimensions of rural diversity and to work at grid level, with possible aggregation to higher territorial levels such as LAU, was also recognised. More detailed principles and design choices were left for later stages of the task.

WP4 kick-off meeting (online), 5 December 2022

- Compared with the project-wide kick-off meeting in October, this meeting provided WP4 partners with a more detailed presentation of the work plan towards the development of the GRANULAR rural typology.
- The meeting also introduced a proposed adjustment to the original Grant Agreement. Instead of producing a preliminary rural typology as the first deliverable, the task team proposed that the first output should be a report presenting the results of the typology scoping exercise and the comparative assessment of identified typologies. The report would also include an initial work plan for the development of the European-wide rural typology.
- This approach was considered a stronger basis for the subsequent typology development, while an interim typology was seen as less useful and potentially confusing. Partners participating in the meeting agreed that the proposed approach offered a more meaningful way to meet the overall aims of the task.

Scoping of European rural typologies and gathering inputs from project partners, December 2022–April 2023

- Following the decision to conduct a scoping review of rural typologies across Europe, the task team agreed that the work should be carried out through close engagement with project partners. The consortium's combined knowledge and expertise was considered the most appropriate way to identify relevant rural and territorial typologies and to assess them comparatively. The work followed five steps:
    - Step 1: Preparation of a typology scoping template to identify national and regional typologies, followed by circulation to task partners for comments, including a proposed allocation of countries to each partner.
    - Step 2: Validation of the template by all WP4 partners.
    - Step 3: Circulation of the template to all GRANULAR partners before December 2022.

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- Step 4: Completion of the template by partners by the end of February 2023.
- Step 5: Analysis and integration of partner input into the typology scoping report by April 2023.

GRANULAR General Assembly (Montpellier), 1 February 2023

- At the General Assembly in Montpellier, the work plan towards the development of the GRANULAR rural typology was presented together with an overview of the first outputs produced since the kick-off meeting and the planned steps for the following six months.
- The presentation included an initial overview of the typologies identified by the task team and other consortium partners, covering both European-wide typologies and national or regional typologies developed in different countries.
- The presentation also outlined the work planned until the next General Assembly in Q4 2023. This included finalising the typology scoping report, followed by preparation of a work plan for developing a European-wide typology, including analytical steps, stakeholder validation and feasibility considerations.

GRANULAR Executive Board meeting, 17 February 2023

- The work plan towards the development of the GRANULAR rural typology was discussed again at the GRANULAR Executive Board meeting, with a focus on the ongoing typology scoping work. The presentation provided an update on the status of the work and the inputs received so far.
- One issue discussed was whether the publication deadline for the typology scoping report could be extended by two months, from March to May 2023. It was agreed that the extension would allow a more comprehensive selection of European typologies to be included, strengthening the basis for the subsequent work in the task. The Executive Board approved the extension.

Scoping report on European rural typologies, May 2023

- The first deliverable from Task 4.6 was the Scoping report on European rural typologies (D4.6), published in May 2023. The report provides an inventory of existing territorial typologies across Europe and a comparative assessment of how they are used for analysis and policy support, how they are constructed, and what strengths and limitations they present. The report examines European-wide typologies, particularly from Eurostat, the OECD, ESPON and other EU policy contexts. It also reviews 51 national and regional typologies from 27 countries.
- The work was coordinated by Nordregio, which prepared and circulated a template to GRANULAR partners to collect information on the typologies. The template covered technical aspects, including construction, approach, data and territorial level; broader background and policy context, including purpose, definition of rurality, areas of use and actors; and assessment, including strengths, weaknesses and update mechanisms. The typologies were identified with support from GRANULAR partners, who provided key information on national and regional examples across Europe. Nordregio researchers compiled and synthesised this material.
- The scoping report formed the first operational step towards the construction of the Task 4.6 typology. It provided a way forward based on existing approaches to characterising rural areas in Europe and on lessons learned from the reviewed examples.

Blog post about typology scoping report, July 2023

- In a blog post on the GRANULAR website, the authors of the typology scoping report presented key considerations for developing an EU-wide rural typology in GRANULAR, drawing on the main lessons from the report.

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WP4 monthly meeting. 6 September 2023

- The work towards the development of the GRANULAR rural typology was discussed at the WP4 monthly meeting in September 2023. The presentation focused on the results and key takeaways from the typology scoping report, with particular attention to the considerations that should guide the next stage of typology development.
- A key outcome from the discussions was the decision to use DEGURBA as the starting point for demarcating rural from urban areas in the project and as the basis for developing the GRANULAR typology. DEGURBA was considered advantageous because it is well established and flexible, operating at both 1 km² grid and LAU levels. Other points included the need to keep the typology relevant over time, which requires regular updates and freely available data sources, and the importance of anchoring the typology with project partners, including Living Labs and Replication Labs.
- The proposed direction was to deliver a multi-criteria grid-based typology using the rural cluster types defined in DEGURBA Level 2. Using this classification as a starting point, rural areas would then be further characterised by indicators such as population size and density, accessibility and land use at grid level. It was also noted that the typology could potentially be scaled up to LAU level and used for further analysis, including with additional variables.
- The next step was to develop a detailed work plan for the European-wide typology. This included agreeing on method, spatial level, data and other key considerations within the consortium, while ensuring that the development process was informed by other work packages and tasks.
- The meeting also included an initial discussion of the following questions:
    - Which dimensions, such as population, accessibility and land use, are most relevant and feasible to include in the GRANULAR typology?
    - What data could be useful for the typology development?
    - Could data from other tasks or work packages be relevant?
    - Are there other pan-European datasets that could be relevant?

GRANULAR General Assembly, 12 October 2023

- All WP4 tasks were presented to the full consortium and key stakeholders. As regards to the typology development work, the focus was on the main lessons from the typology scoping report and on the elements that would guide the typology development.
- The presentation also outlined the steps planned for the following months to develop a detailed work plan for a multi-criteria European-wide typology.
- Key points included the organisation of an online workshop with task partners before the end of 2023 and the aim of agreeing on method, spatial level, data and other key considerations in early 2024. Stakeholder exchange and validation of the typology's goal setting were also highlighted as central.

First online workshop focusing on the typology development in Task 4.6 (6 December 2023).

- A key principle for typology development in GRANULAR was that the process should be well anchored within the consortium and allow all partners to provide input. To support this, a series of online validation workshops was planned with project partners. The first workshop was held in December 2023 and included partners from WP4, other work packages and the GRANULAR Executive Board.
- The workshop discussed an initial work plan for the typology development and agreed on key aspects of the work ahead. Three main points were addressed:

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- the purpose of the typology and its main areas of use;
- key guiding principles for typology development;
- key technical considerations for typology development.

- On the purpose and intended uses of the typology, participants agreed that the typology should primarily be seen as an analytical tool for research, while remaining closely aligned with key policy priorities. It should provide a more nuanced understanding of rural areas and support policy and planning. Participants also emphasised the need to communicate intended uses clearly and to ensure flexibility across different geographies.
- On guiding principles, participants agreed that the typology should classify rural areas across Europe, be multidimensional but not overloaded with too many dimensions, and remain relevant over time. This requires the possibility of future updates, supported by data sources that are regularly updated and freely available.
- On technical considerations, participants agreed that the typology should be grid-based and scalable to LAU level to enable further analysis with additional variables. DEGURBA Level 2 was highlighted as the starting point for demarcating rural areas and for classifying them using additional grid-level indicators, such as population, accessibility and land use.

Presentation at Executive Board meeting, 16 February 2024

- A key result from the meeting, which included participants from most Living Labs, was the definition of the overall aim of producing a territorial typology for EU rural areas that is aligned with key policy priorities. The typology should be multidimensional without being overfitted, grid-based and scalable, and able to support a functional perspective. It was also noted that stakeholder validation steps would be implemented throughout the typology development process, including engagement with Living Labs and Replication Labs.

Presentation at Knowledge Transfer Accelerator webinar, 23 February 2024

- The typology scoping report was presented at the second GRANULAR Knowledge Transfer Accelerator webinar, which focused on understanding rural diversity through the lens of rural multifunctionalities. The event engaged a wider group of stakeholders beyond the consortium and brought together findings from the Horizon Europe RUSTIK and GRANULAR projects.

GRANULAR General Assembly, 28 March 2024

- The GRANULAR rural typology task was presented briefly at the General Assembly together with the other WP4 tasks. The presentation provided an overview of recent progress and the next steps. It was noted that the next phase would involve organising a series of validation workshops to guide the typology development.

Second online workshop focusing on the typology development in Task 4.6 (10 April 2024).

- Participants were partners from across WP4 and its different tasks. The workshop continued earlier discussions, with greater emphasis on technical aspects of typology development and on the dimensions that should be covered.
- The Nordic urban–rural typology, developed by Nordregio, was introduced as a potential source of inspiration for methodological aspects. The Nordic typology classifies all territories in the Nordic countries and builds on population, land use, accessibility and built environment. It includes seven territorial classes:

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inner urban areas, outer urban areas, peri-urban areas, local centres in rural areas, rural areas close to urban areas, rural heartlands and sparsely populated rural areas.

- The second discussion point concerned how well the dimensions in the Nordic typology covered what the GRANULAR typology should capture, and how far they reflected the four types of functionalities in the Rural Diversity Compass: residential, productive, environmental and recreational.
- The third discussion point concerned the overall approach. The starting point was to create a typology that was not overly complex or overloaded with too many data sources and indicators. Participants discussed whether a "basic" typology could be developed first and then used as a basis for additional sub-typologies with further data.

GRANULAR General Assembly, 19 November 2024

- At the General Assembly, the latest progress and next steps in the GRANULAR rural typology development process were presented together with the other WP4 tasks. The presentation included the key principles identified with partners:

1) Purpose of the typology and main areas of use

- an analytical tool for research purposes, aligned with key policy priorities;
- a tool to provide a more nuanced understanding of rural areas and support policy and planning;
- intended areas of use should be clearly communicated;
- flexibility across different geographies is important.

2) Key guiding principles for the typology development

- a typology for classifying rural areas across Europe;
- a multidimensional typology that does not include too many dimensions;
- relevance over time, requiring the possibility of updates and data sources that are updated and freely available.

3) Key technical considerations for typology development

- a grid-based typology that can be scaled up to LAU level to enable further analysis with additional variables.

Third online workshop focusing on the typology development in Task 4.6 (11 December 2024).

- This final preparatory workshop was organised to validate and agree on the core principles, approach and steps for typology development, and to gather further input from partners before technical development began in 2025. Representatives from the Living Labs and Replication Labs participated to ensure that the work was aligned with their interests, in line with Milestone 22.
- The first discussion point focused on the definition of three points to guide the next steps (agenda setting):

1) Relevant territorial typologies that could be included in an updated version of the typology scoping report.

2) Key principles, steps and approach for typology development.

3) Key dimensions to be included in the GRANULAR typology.

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- The second point, concerning key principles and approach, was the most important for setting the framework for the work ahead. Participants agreed on the overall approach and following methodological steps.

Key principles	Approach

• Purpose and intended areas of uses
  ○ An **analytical tool** for research purposes, which is aligned with key policy priorities.
  ○ Provide a richer understanding of rural areas, and thus also useful for **supporting policy and planning**.
• Typology for classifying rural (non-urban) areas across Europe.
• It should be **multi-dimensional** but not include too many dimensions (4±1 dimensions).
• Aiming for **relevance over time** (stability, transparency and replicability - possibility to update).
	• Two versions of a rural typology envisaged
	  ○ Main typology (based on a few key dimensions: e.g., population, land-use, accessibility)
	  ○ Potential add-on typology(ies) (main typology complemented with additional data, e.g., functional and dynamic features)
	• Methodologically, building further on Nordic Urban–Rural Typology (developed by Nordregio and Ubigu) and DEGURBA (level 2).

- The third discussion point concerned the key dimensions to be included in the GRANULAR typologies. Two versions were envisaged: a main typology based on a few key dimensions, such as population, land use and accessibility; and add-on typologies that would complement the main typology with additional data, including dynamic features. The proposed main typology would build on dimensions also included in the Nordic typology: population, land use, accessibility and possibly built environment.
- Participants generally agreed that the suggested dimensions were relevant. For the complementary information to be included in the potential add-on, or Tier 2 typology, participants suggested considering links with and potential datasets generated by other GRANULAR tasks, drawing on the policy pillars of the Long-Term Vision for Rural Areas, and focusing on dynamic and functional aspects that are often neglected by existing territorial typologies.

GRANULAR WP4 Monthly Meeting, 11 June 2025

- This meeting focused on the technical developments in the construction of the GRANULAR rural typology during the first half of 2026.
- Particular attention was given to how the Nordic urban–rural typology could guide the development of a European rural typology, including technical details and implications. The presentation covered the Finnish urban–rural typology, the Nordic urban–rural typology, and how an upscaled version of the Nordic typology relates to DEGURBA.
- Key points included that the GRANULAR typology would be inspired by the Nordic typology, focus strongly on rural areas, and be developed at grid level with the potential to scale up to LAU level. The typology would be multidimensional and incorporate diverse indicators. It would also use open data with the aim of being reproducible and updateable over time.
- Participants agreed that the typology should be based on a few key dimensions, similar to those included in the Nordic typology: population, land use, accessibility and built environment.
- For complementary information in the potential add-on, or Tier 2 typology, participants suggested considering links with and potential datasets generated by other tasks, drawing on the Long-Term Vision for Rural Areas policy pillars, and focusing on dynamic and functional aspects often neglected by existing territorial typologies.

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- The meeting also presented an outlook on the steps planned to construct the typology during autumn 2025.

Final online workshop focusing on typology validation in Task 4.6 (12 December 2025).

- A final validation workshop was held on 12 December 2025 to validate the first version of the typology. The workshop took place as part of the Annual Knowledge Exchange Meeting (AKEM), organised in cooperation with WP6. One week before the meeting, participants received an outline of the methodology and a link to an interactive map presenting the preliminary GRANULAR typology for Europe's rural areas. Project partners, members of the Living Labs and Replication Labs participated.
- The workshop helped confirm the relevance of the classification across EU rural areas. Based on the discussion, two incremental changes were made to the typology construction workflow:
    - First, it was decided to replace building height with building volume, on the assumption that the latter would better capture the building footprint. It was also recognised that building regulations vary between countries and may produce structurally different built landscapes, with some rural areas showing denser urbanisation than others.
    - Second, it was agreed to add a topography indicator to the classification. This was intended to further differentiate rural areas located in floodplains and coastal areas from those in mountain areas.

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