RUSTIK

"Exploring the rural-urban continuum". Methodological framework to define Functional Rural Areas and rural transitions

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This report responds to the needs set out in Task 1.1 of the RUSTIK project:

- Critical review of rural change and rural area definitions
- Identification of the concept of Functional Rural Area and the differences/similarities with the current definitions of rural areas at the European level (including EU and non-EU countries). This implies analysing the functional characteristics of rural areas, their importance in the different contexts and interlinkages between urban and rural areas based on these characteristics
- Analysis of the different transition processes and their effects on rural areas
- Definition of a general typology of rural diversity

The report is structured into two main sections.

The first deals with the critical review of the most significant literature on rural areas' diversity, the related methods and criteria to define the concept of rurality. Different approaches are analysed, with their limitations and opportunities. Particular attention is given to the different interpretations of the functional area concept in exploring rural diversity. Finally, this section proposes a methodology to classify rural areas and test it in the fourteen RUSTIK Pilot Regions. Annex 1 presents a list of potential indicators and related sources of information to analyse the main rural functions quantitatively.

The second section explores the most relevant transition processes (socio-economic-demographic, environmental-climatic and digital). These transitions have different impacts on the diversity of rural areas and reflect their different response capacities, depending on, *inter alia*, the territorial and social capital in each territory. The section concludes by discussing the factors influencing the capacity of rural areas to respond to transitions and related policy issues, as well as the role of policies specifically linked to the three transitions (demographic, environmental and digital).

1. The conceptualisation of functional area

1.1 Different approaches

This chapter aims to evaluate the different approaches used to define the "functional area" concept in literature and critically review the pros and cons of their use. There are significant differences in the theoretical assumptions and criteria to define the meaning of "functional", especially as regards rural areas. Furthermore, the definition of rural areas has moved from simple indicators of population density and the population size of urban and peri-urban agglomerates to more sophisticated indicators, often combined, to obtain clusters of administrative units. In this evolution, agriculture has increasingly lost its role as a crucial defining variable, while economic, social and environmental relations between areas have gained importance.

The term "functional" is used very frequently in the literature but with different meanings and from different points of view. These differences depend on the disciplinary context (rural geography, sociology, regional economics) and the institutional context (European Commission, single Member States, sectoral administration). The concept has been developed more for

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metropolitan/urban definitions and related policies than for rural areas (OECD,2020). The efforts to overcome this urban bias is a very recent one. In particular, the preparation of the Long-term Vision for Rural Areas (LTVR) argued that rural areas provide important "functions" for our societies that are not covered by the previous list of services (European Commission, 2021b).

1.2 The structural approach

The "structural" approach considers criteria based on population settlements and social structures through basic socio-economic characteristics. This approach moved from simple criteria to more complex and finer-grained definition of the urban-rural difference (EUROSTAT, 2021). The most widespread method is that introduced by OECD and then adopted in a revised version by the European Commission as the urban-rural typology (EUROSTAT, 2010). It is based on the percentage of inhabitants municipalities and the magnitude of the core urban centre in each region. The new EUROSTAT methodology follows the OECD classification criteria based on the population share in rural Local Administrative Units Level 2 (LAU2), which defines three types of NUTS3 territories:

- predominantly urban (PU), if the share of the population living in rural LAU2 is below 15%;
- intermediate (IN), if the share of the population living in rural LAU2 is between 15 % and 50%;
- predominantly rural (PR) if the share of the population living in rural LAU2 is higher than 50%.

A region classified as predominantly rural in the previous steps becomes intermediate if it contains an urban centre of more than 200,000 inhabitants representing at least 25 % of the regional population. A region classified as intermediate in the previous steps becomes predominantly urban if it contains an urban centre of more than 500,000 inhabitants representing at least 25 % of the regional population.

The OECD methodology presented two main causes of inconsistencies: a) the considerable variation in the area of LAU2; b) the significant variation in the surface area of NUTS 3 regions and the practice in some countries to separate a (small) city centre from the surrounding region. To avoid these problems, the EUROSTAT revised methodology (2010) identifies the population in urban areas based on a population density threshold (300 inhabitants per km^2) applied to grid cells of 1 km^2. Consequently, the population in rural areas simply becomes those living outside the urban areas. According to the EUROSTAT document, the grid approach presents two significant advantages: 1) "*the one km^2 grid is likely to become the future standard and has the benefit that it can easily be reproduced in countries outside the EU*" (p. 242); 2) it creates a more balanced distribution of the population between rural and non-rural in EU countries.

In a most recent "Methodological manual on territorial typologies" (EUROSTAT, 2018), the urban-rural regional typology has been slightly revised to the following:

- predominantly urban regions (PUR), NUTS level 3 regions where more than 80 % of the population live in urban clusters;
- intermediate regions (IR), NUTS level 3 regions where more than 50 % and up to 80 % of the population live in urban clusters;

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- predominantly rural regions (PRR), NUTS level 3 regions where at least 50 % of the population live in grid cells outside urban clusters.

While the definition criterion for PRR did not change substantially, the other typologies have a revised lower threshold to include more rural grids (increased from 15% to 20%). In order to have meaningful international comparisons of statistical indicators along the urban-rural continuum, six international organisations focused on establishing a standard methodology based on this definition (PUR, IR and PRR). A publication: “Applying the Degree of Urbanisation. A methodological manual to define cities, towns and rural areas for international comparisons” was issued in 2021 (EUROSTAT, 2021). This methodology (aiming to identify the degree of urbanisation-DEGURBA) has continued chiefly following the abovementioned OECD-EUROSTAT approach. The main advantage of this methodology is that it allows a finer-grained definition and application of the territorial typology, even below the LAU2 level (Figure 1).

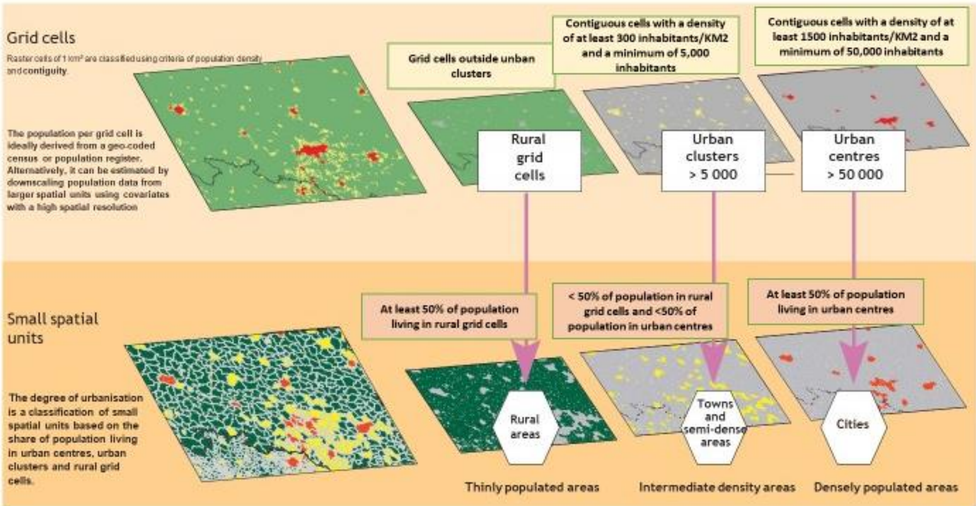

Figure 1 - Schematic overview of the degree of urbanisation (DEGURBA) classification

Source: EUROSTAT, 2021

The results of this new typology have been used in the most recent EC documents on the *Long-Term Vision for the EU’s Rural Areas* (LTVRA: EC, 2021). Moving from the grid cells level to the municipality level (LAU2) derived by the degree of urbanisation typology, and finally to the rural-urban typology (NUTS3 level), the area and population considered as rural change significantly.

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Share of land area and population	Type of cluster (contiguous grid cells of 1 km²)			Degree of urbanisation (LAU areas)			Urban-rural typology (NUTS level 3 regions)		
	Urban centres	Urban clusters	Rural grid cells	Cities	Towns and suburbs	Rural areas	Predominantly urban regions	Intermediate regions	Predominantly rural regions
% of land area	0.7	3.5	96.5	3.4	13.6	83.0	9.7	45.7	44.6
% of population	34.3	69.7	30.3	37.6	31.9	30.6	40.2	38.9	20.9

Table 1 – Share of land area and population using different typologies of classification

Source: European Commission, 2021, Note: Based on 2011 population grid, LAU 2011 delineation and NUTS 2016

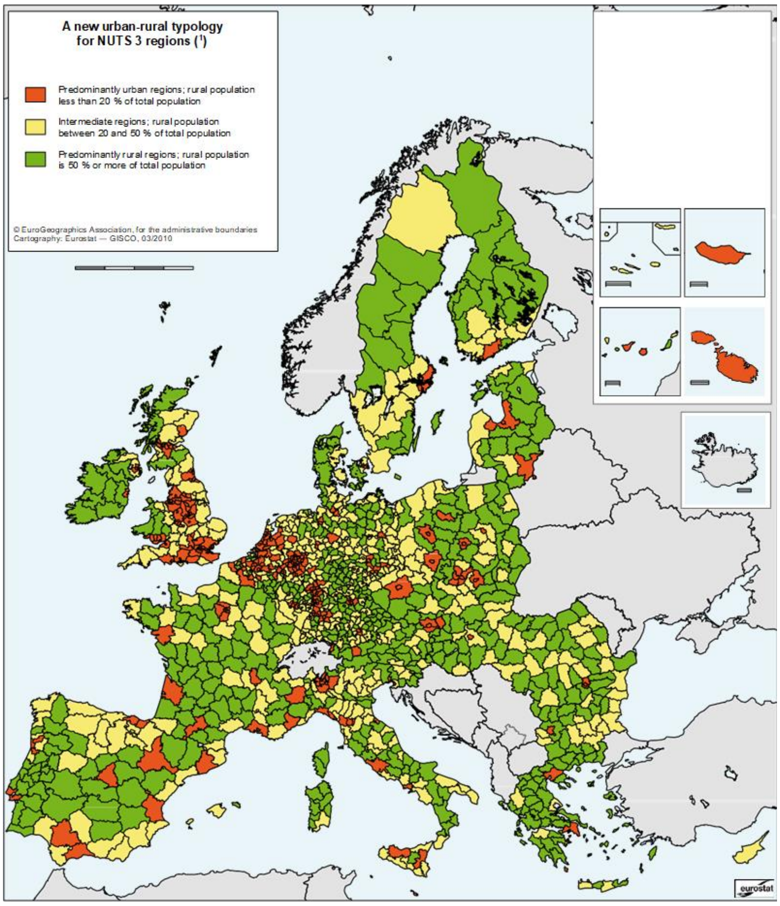

Figure 2 – EUROSTAT urban-rural typology for NUTS3 regions (1)

(1) This typology is based on a definition of urban and rural 1 km² grid cells. Urban grid cells fulfil two conditions: (1) a population density of at least 300 inhabitants per km² and (2) a minimum population of 5 000 inhabitants in contiguous cells above the density threshold. The other cells are considered rural. Thresholds for the typology: 50 % and 20 % of the regional population in rural grid cells. For Madeira, Açores and the French outermost regions, the population grid is not available. As a result, this typology uses the OECD classification for these regions.

Source: Eurostat, JRC, EFGS, REGIO-GIS. EUROSTAT, 2020

From these three tiers of granulation, it is clear that the amount of land classified as 'rural' will differ significantly between the three geographical scales. In the EU-27, the share of land covered by rural 1km² grid cells is 96.5%, by rural (LAU) areas is 83%, and by predominantly rural regions, only 44.6%. The impact on population is more limited, but still significant: changing from 30.3%

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of the EU-27 population in rural grid cells, to 30.6% in rural areas and only 20.9% in predominantly rural regions (Table 1).

Beyond these demographic-focused classifications, a similarly "structural" approach is also applied in other studies based on the economic activities comprising the socio-economic structure of a given territory (i.e., Bansky, 2003).

1.3 The approach based on multifunctionality

Rural and environmental geographers have focused on multifunctionality as the central dynamic driving rural change (Holmes, 2006 and 2012; McCarthy, 2005; de Groot, 2006). This concept of multifunctionality is different from that which was developed and used in policy circles during the 1990s, which had the ongoing reform of the Common Agricultural Policy (CAP) as an essential cornerstone (Renting et al., 2008 and 2009). In this newer form, the multifunctionality of rural areas focuses on the broader dynamics of rural change, within which agriculture is only one component. In this case, multifunctionality is an attribute of rural resource use in general and not limited to farming systems. Thus, the heterogeneity of rural areas can be explained by the different mix of functions across the rural space. This mix is also variable over time and can offer a tool to interpret rural areas' trajectories and transitions.

There is no general agreement on how to define these different functions. For example, Holmes (2006 and 2012) proposes categories of rural areas based on the relative share of production, consumption and protection functions as driving forces shaping diverse regional modes and trajectories within rural Australia. Production mainly refers to agriculture; consumption refers to urban penetration, residential, recreational and tourism use; while protection includes sustainable resource management, biodiversity preservation and landscape protection. In this ideal triangle (production, consumption and protection), a shift in the relative weight of the three functions implies, according to the model, a functional transition (Holmes, 2012). The different mixes of functions delineate seven types of rural areas (productivist, rural amenity, pluriactive, peri-metropolitan, marginalised agriculture, and conservation).

Other studies have followed a similar tripartite model. For example, Bansky and Mazur (2016) identify functions associated with productive activities (agriculture, forestry, manufacturing and construction), consumption activities (tourism, recreation, housing and services), and mixed production-consumption activities. Yin et al. (2021) use a tripartition based on production functions (agricultural and non-agricultural activities), living functions (basic living and welfare standards and ecological functions (ecological conservation and maintenance). These studies contribute to enlarging the concept of productive functions to include other activities unrelated to agriculture and introduce functions more related to the population's living conditions and quality of life. Also, EDORA-ESPON study has identified four different functions, but with a more sectoral-oriented approach (see 1.4 paragraph).

De Groot's study (2006) contributed to rural area classification based on ecosystem functions. He introduced a detailed definition of regulatory functions (i.e., climate regulation, water supply and regulation, soil retention and formation, pollination, etc.) and habitat functions (suitable living space for wild plant and animal species). His primary focus was on the benefits accrued by natural and semi-natural landscapes and their importance in monetary terms, because most of these benefits are not captured in conventional, market-based economic analysis.

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1.4 Functional area: a set of urban-rural relations within the geographical proximity

A different approach to rural areas' definition has been implemented through a better conceptualisation of the role of rural areas in regional development processes and their functional relations with urban areas. The concept of functional area is adopted in regional development economics, focusing on changing interlinkages between urban/metropolitan areas and rural areas, and within rural areas, in economic development. Functional linkages between urban and rural areas in the European Union have become consistently stronger over time, including in a cultural sense (SPESP, 2001). These interlinkages involve several aspects: labour market relations, access to services, relations between rural and urban enterprises, recreational and leisure use, development of urban infrastructures and supply of natural resources, communications and societal expectations.

Urban-rural relationships have changed radically over time. As Bengs and Schmidt-Thomé point out:

«*Urban-rural linkages are now moving beyond the single one-way exchange and demonstrate a more complex and dynamic web of interdependencies which are shaping the fortunes of cities and countryside alike. For example, as Howard Newby argues, "for the first time since the Industrial Revolution, technological change is allowing rural areas to compete on an equal basis with towns and cities for employment". This recognition of the complexity of urban-rural relationships has gained a new political salience both at national and European levels. This focus on the urban-rural continuum is justified by the visible and invisible flows of people, capital, goods, information and technology between urban and rural areas*» (2005, p. 87-88).

Urban and rural inter-relationships have changed not only in their nature and intensity but also because a recognition of new diversities has emerged, in both rural and urban settings. Intermediate areas between peri-urban and remote areas have become increasingly distinguished as a form of territorial organisation but are not uniform throughout Europe. The OECD (2013) calls the "rural-urban continuum" a heterogeneous patchwork of rural areas mixed with urban agglomerates that needs to be better explored.

Different approaches to classify these relations combine structural and proximity variables, where proximity is conceived as closeness to an urban/metropolitan centre.

The most frequently cited approach to rural areas' definition using this relational lens is the OECD classification, based on the relationships between rural and urban centres and the proximity to urban centres as factors conducive to economic performance and development potential. Brezzi et al. (2011) expanded the tripartite typology (predominantly urban, intermediate and predominantly rural) according to the methodology described in Figure 3. In operational classification, OECD adopted a two-stage method: the first is consistent with the classic structural typology, whilst in the second, territorial units are ordered based on the time needed to reach the primary urban centre. A region is considered close to an urban centre if half the population can reach an urban centre of at least 50,000 inhabitants in less than 45 minutes and is deemed remote if this is the case for less than half the population. Geographical proximity is stated as an essential predictor of rural growth: "*proximity allows stronger linkages between urban and rural places*" (OECD, 2016, p. 142), since it allows better access to services, healthcare, education and transport; thus, rural areas within or close to a Functional Urban Area (FUA) are more advantaged

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than remote rural areas. By applying this indicator of remoteness to the 1994 structural typology, the new categories (Brezzi et al., 2011) are the following: i) urban or predominantly urban regions; ii) intermediate regions close to an urban centre; iii) remote intermediate regions; iv) predominantly rural regions close to an urban centre; and v) remote predominantly rural regions.

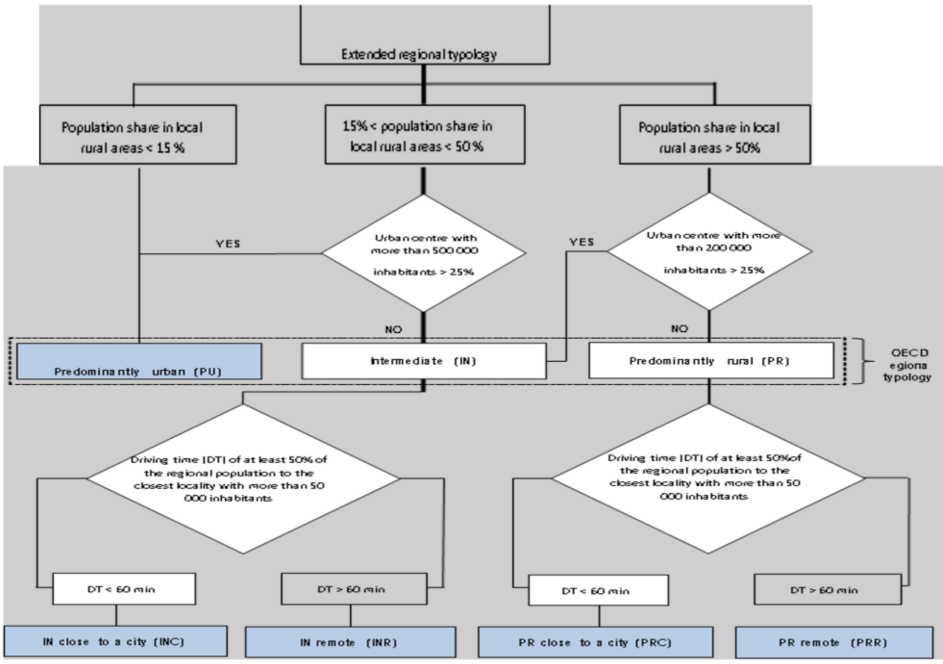

Figure 3: The methodology followed by the OECD urban-rural typology

Source: OECD, 2020, p. 129.

The OECD conceptualisation of rural areas' diversity relies heavily on theories of agglomeration (McCann & van Oort, 2019), which explain why urban/metropolitan areas accumulate over time, their comparative advantages, and external economies of scale or scope based on the territorial/spatial concentration of physical and financial capital, technological innovation, research and development activities, skills and human capital. Theories of divergent development and cumulative causation models (Myrdal, 1957; Hirschman, 1958; Krugman, 1995) are used to explain why inter-regional disparities persist and grow over time.

OECD has further developed a different definition based on the framework of the Functional Urban Area (FUA). A FUA includes a town and its surroundings consisting of less densely populated local units which are nevertheless part of the town's labour market due to commuting, i.e. people travelling from their place of residence to the labour market and/or to access services (healthcare, education, culture, shops, etc.) (Dijkastra et al., 2019). According to this definition, OECD has further developed the classical distinction of rural areas into a new typology:

a) rural areas within an FUA, which are an integral part of the commuting zone of the urban centre;
b) rural areas close to an FUA, which have strong linkages to a nearby FUA but are not part of its labour market;
c) remote rural areas, distant from an FUA and somehow connected through the market exchange of goods and services.

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Source/Year	Typologies of areas within each aggregate: Urban/Metropolitan areas	Rural-Urban continuum	Remote/Peripheral areas	Spatial differentiation criteria	Scale of analysis
SPESP, 2001	- Regions dominated by a large metropolis - Policentric regions with high densities	- Policentric regions with high urban and rural densities - Rural areas under metropolitan influence - Rural areas with networks of medium and small towns	-Remore rural areas	- Size of the city (>500k metropolitan; 200-500k medium-sized; <50k small towns) - Distance between administrative centres in minutes by road (60 minutes) - Primacy rate (share of the region's total population)	NUTS 3
EDORA-ESPON, 2011;	- Predominantly urban	- Agrarian - Consumption countryside - Diversified (secondary sector) - Diversified (primary sector)	- Agrarian - Consumption countryside	Each typology is defined by a set of minimum indicators exceeding the EU-28 average	NUTS3
OECD, 2011, 2013. 2018 and 2020	- Predominantly urban	- Intermediate close to a city - Intermediate remote - Predominantly rural close to a city	- Predominantly rural remote	- % population in local rural areas >50% - urban centre >200k inhabitants and < 25% regional population - driving time of at least 50% population to the closest city with >50k inhabitants	NUTS2 and 3
OECD, 2016	- Predominantly urban	- Rural areas within a FUA - Rural areas close to a FUA	- Remore rural regions		
Camaioni et al., 2013	- Cities	- Mixed economy - Manufacturing - Shrinking regions	- Remote regions - Peripheries - Nature-quality regions	Cluster analysis based on four categories of variables: i) socio-economic (7 indicators); ii) the role of economy (7 indicators); iii) land use (3 indicators); iv) geography/spatial dimension (7 indicators)	NUTS3

Table 2 – Comparison of main studies at EU level defining typologies of areas and related criteria

Source: Authors' own comparative elaboration

However, this classification did not find any significant application in current statistical comparisons. Furthermore, this tripartite definition of rural areas did not overlap easily with the previous OECD rural-urban typology.

Besides the OECD classifications, other studies combine structural and proximity variables to improve the representation of territorial differences. Table 2 presents some significant approaches to the definition of rural areas at the EU level (including the OECD ones), combining structural and locational variables that consider urban-rural differences and geographical relations. In this comparison, only studies that classify all EU countries and are in some respects comparable with the OECD approaches have been considered (SPESP, 2001; Bengs & Schmidt-Thomé, 2005; Copus and Hörnström 2011; Camaioni et al., 2013). The different typologies have been grouped under the three territorial aggregations: a) urban/metropolitan areas, b) urban-rural continuum and c) remote/peripheral areas. This enables us to understand how composite each category is, notably that of the urban-rural continuum.

According to these studies, urban/metropolitan areas differ in size and in the type of urban development. ESPON studies (notably the early phase of ESPON, i.e., the Study programme of European Spatial Planning: SPESP, 2001) introduced the concept of polycentric urban development. They highlighted how this could influence urban-rural relations and rural differences across the European territory. In all these cases, the underlying theoretical assumptions are similar, but what can vary is: a) the characteristics (size, etc.) of urban area considered as an agglomeration centre providing opportunities for development and/or service provision and b) the threshold variable (usually driving time) used to distinguish geographical proximity or remoteness.

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Geographical proximity to urban poles has been applied in several studies and official classifications used for policy design, at a national level.

For example, in Poland, transport-related accessibility has been adopted as the primary criterion for the typology of rural functional areas in the Concept for the Spatial Development of the Country 2030 (Bansky and Mazur, 2019). Nevertheless, in this case, the FUA is a fundamental reference element whose accessibility defines two types of rural areas: (1) those participating in development processes (very accessible) or (2) those in need of support for development processes (poorly accessible). The underpinning assumption is that areas far from large agglomerations cannot generate development processes without additional support.

In Italy, a criterion of travel time spent to reach a "service provision Centre"[1] (services of general interest: healthcare structures, train stations with frequent services and secondary schools) is currently used by the National Strategy for Inner Areas, a multi-fund programme initiated in the 2014-2020 programming period and continuing in the new 2021-2027 programme. This Strategy focuses interventions on the peripheral areas (between 40 and 75 minutes of travel time) and ultra-peripheral areas (more than 75 minutes) (Barca et al., 2014). In this case, the degree of remoteness of the territories (in a spatial sense) from the network of urban centres influences citizens' quality of life and their level of social inclusion. On the other hand, the functional relations that are created between service hubs and more or less remote territories can vary enormously.

Some other countries adopt a classification based on urban-rural connections. For example, New Zealand has adopted a definition that distinguishes between rural areas with high, moderate or low urban influence and those deemed rural-remote, by drawing on population density, place of employment and commuting data (Statistics New Zealand, 2016)

France is also developing/refining a definition considering accessibility but with a different methodology. The National Institute of Statistics and Economic Studies (INSEE) has developed a new typology based on access to the labour market area and varying population densities (INSEE, 2021). The typology distinguishes four types of rural areas: a) under the strong influence of an urban pole; b) under the weak influence of an urban pole; c) autonomous and low-density rural areas; d) autonomous and very low-density areas. The classification is implemented at the municipal level (LAU2). INSEE notes that a shrinking population and poor access to services increase migration from rural areas under strong urban influence on autonomous and very low-density rural areas. Nevertheless, it is worth noting that industrial activities are significantly dispersed in rural areas, notably in autonomous low-density ones. Moreover, it indicates that the secondary sector is not exclusively linked to proximity to an urban pole but is more broadly based, in a rural context.

[1] A "service provision Centre" is identified as a municipality or group of neighbouring municipalities able to provide simultaneously: a full range of secondary education, at least one grade 1 emergency care hospital and at least one Silver category railway station. The introduction of the rail services criterion, along with the access to the essential services of education and health, derives from the value rail mobility has taken in Italy in determining the access to other services or places that are citizenship constituents. Including medium-performance railway stations in the service provider network of Centres is therefore deemed crucial.

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1.5 Beyond geographical proximity: connected through networks

Since the first decade of the 2000s, a series of studies focused on the increasing role of social, institutional and business networks in enabling connectivity between rural areas, adjacent urban areas and mainly beyond geographical proximity.

Shucksmith (2012), Lowe et al. (2019), and Esparcia (2014) refer to a "networked approach" to rural development which seeks to link localities "*into broader interwoven circuits of capital, power and expertise, such as rural professionals, regional agencies, NGOs, companies, universities and research institutes*". They highlighted a vast number of networks in exploring the actors necessary for the setting-up, implementation and development of innovative projects in rural areas: actors involved in scientific and technical support (provided by research centres, technical staff in government offices, certifying agencies, etc.); knowledge and information (on specific and technical and more generic issues, provided by a wide variety of public bodies); physical infrastructure (needed for the everyday operation of the project, provided by public bodies, primarily local but, to a lesser extent, also national governments); organisation and marketing (provided by local governments, private organisations and NGOs); and finally the implementation of regulatory standards (provided mainly by local and regional governments). Gkartzios and Lowe (2019) describe a series of "hybrid neo-endogenous" frameworks where local and extra-local agencies collaborate in rural governance and development processes, mentioning in particular the role of universities in creating a research-practice rural network, and the role of in-migrants in rural areas in terms of the employment they can generate for locals, etc.

Copus (2010) outlines the importance of business networks in rural areas to transmit information and promote innovation. In these business networks, innovation depends, firstly, on their "bridging capability" to channel information from globally significant firms and secondly, on their "bonding capability" to distribute information among local firms and entrepreneurs. In other words, the role of business networks depends not only upon their local network density, degree of embeddedness and human and bonding social capital but upon their bridging connections to more distant sources of specialist information. In analysing the process of knowledge creation within a geographic cluster, Bathelt et al. (2004) outline that this process relies on both information exchange and learning processes within the cluster, achieved through informal day-to-day and face-to-face relations (the "buzz"), on the one hand, and more complex channels used in distant interactions (the "pipelines"), on the other. Finally, co-location and visibility generate the potential for efficient interpersonal translation of important news and information between actors and firms. In contrast, trans-local pipelines allow more information and news about markets and technologies to be "pumped" into internal networks.

More recently, Bock (2016), focusing on the problems of promoting rural development in marginal rural areas, outlined that these areas need more collaboration and linkages across space to give access to exogenous resources (bridging). In this regard, rural-urban linkages are essential, but broader connectivity and "virtual proximity" across space are also relevant for remote rural areas. Collaborations with nationally operating large businesses and external companies, third sector corporations like cooperatives, the presence of temporary residents, etc., can activate social innovation processes at the local level, including "the uptake of novel solutions developed elsewhere" (Bock, 2016, p. 17). This can be necessary, especially in those marginal areas where mobilising citizens, NGOs, third sectors, and business is problematic because "the local asset

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base is too weak" (Bock, 2016, p.17). Supporting networks in the most peripheral areas is seen as necessary to reduce physical and socio-economic isolation or counterbalance restrictive fiscal policies that are dismantling regional institutional structures. Bock calls this a "nexogenous approach" to rural development, since it emphasises the importance of reconnection and re-establishing socio-political connectivity, which allows for revitalisation if matched by endogenous actions.

Networks can work at different levels. For example, in a study on rural networks in the UK, Miller and Wallace (2012) define a typology of rural networks based on their geographical remit: a) locally based networks, b) national networks, and c) networks that transcend both national and international regions. From the networks identified, those operating within a locality tended to focus mainly on rural issues. In contrast, national networks were more likely to work on issues affecting both rural and urban areas. The three most common reasons for using rural development networks were to obtain advice and information, identify funding sources and share local learning and experience. This implies that a lack of funding for rural development networks can negatively affect communities. Other examples of transnational networks can be found in LEADER (Dwyer et al., 2022). For example, some Local Action Groups (LAGs) were able to promote innovative partnerships within the local area but also supported the creation of transnational networks lasting well beyond the project duration (as in numerous Italy-Austria transnational projects) (Dax, 2021).

Other types of networks, notably food networks that go beyond the territory where production is based, have been emphasised in other studies (Lamine et al., 2019; Lamine et al., 2012). These identify the linkages between collective brands, Geographical Indications (GIs) and alternative food networks, and groups of urban consumers. Some of these networks can transform to encompass civil society organisations and broader territorial agri-food systems (see the case studies analysed in both Lamine et al. papers). The variety of these networks depends upon the diversity of actors involved and their changing nature over time.

1.6 Inside the urban-rural continuum and its different functions

As already shown in previous sections, relations between rural and other areas (be they close or not) are manifold and complex. According to the OECD theoretical framework, «*the complexity of the relationships can be represented along an urban to a rural continuum from more to less densely populated areas and gradations in between. While there are no sudden breaks in those spatial relationships, there is great diversity in size and types of interconnections*» (OECD, 2016, p. 144). OECD analysis translates these concepts graphically (Figure 4) by depicting a distribution of urban (large dots) and rural (small dots) areas scattered through space, showing a continuum settlement pattern based on location, proximity and density characteristics.

It is challenging to summarise the results of literature on rural areas differentiations due to the different and often incomparable typological criteria, variables used and scale of analysis. The most recent literature, including EC documents, although not explicitly focused on the stratification of rural areas, allows evidence of significant internal differences within the definition of the rural-urban continuum. From our review, we can delineate some general types of rural areas and their functional characteristics.

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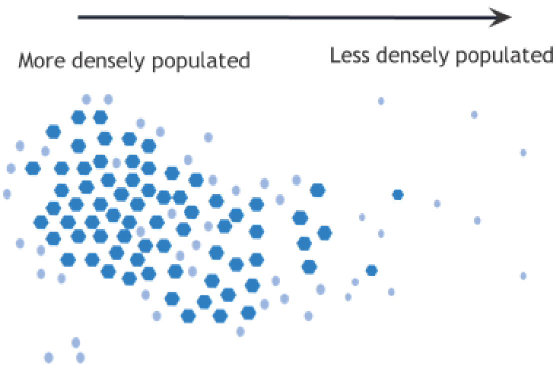

Note: The size of dots indicates relative population size. Large blue dots represent urban settlements and small light blue dots rural settlements (OECD, 2016, p.144)

Figure 4 – A continuum from more to less densely populated areas

1.6.1 Rural areas close to a large metropolitan centre or a medium-large city.

These are the areas most likely to be included in a FUA. Metropolitan regions are functional regions composed of one or more large urban cores where people and firms are highly concentrated, and a functionally integrated hinterland (OECD, 2013).

The core (or the network of cores in the case of a polycentric metropolitan structure), organises the whole regional space, while the countryside often becomes urban (peri-urban). The most appropriate definition is “urbanised countryside” (Beccattini et al., 2009). Within this integrated metropolitan region rural areas supply many functions, such as a) residences of high environmental and social quality; b) resources and space for economic activities, for example for large firms in the retail and manufacturing sectors, which often need space and fewer constraints on transport; c) rural amenities linked to the quality of environment (air quality, water resources, etc.), a less congested living environment, and closer social relationships (OECD, 2013).

1.6.2 Rural areas in well-connected and economically diversified regional economies.

These rural areas are territories with a network of small and medium-sized cities and diversified economic activities. Easy accessibility to an urban area, diversified territorial capital [2], and the richness of networks beyond geographical proximity allow these rural areas to develop manufacturing, tertiary services and activities in agro-industrial food chains associated with a viable agricultural sector. The proximity of a small-medium sized network of cities and diversified local economy make these areas “industrial and tertiaries countryside” (Beccattini et al, 2009).

In this case, rural areas perform various productive functions. They have become spaces for a cluster of small-medium sized manufacturing firms and related research and development services, especially in Western European countries. In-depth research conducted over recent

[2] For a definition of territorial capital see the discussion in paragraph 2.4

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years in the rural regions of Italy, The Netherlands and the UK has pointed out that rural areas can achieve viable agricultural systems in different ways: a) through local agri-food systems (LAFS), according to the definition of the French and Italian schools (Arfini et al., 2012; Lamine et al., 2019), or b) alternative food networks, representing more complex and sustainable pathways within the agri-food chain (Lamine et al., 2012; Sonnino & Marsden, 2005).

These areas also frequently attract new residents (OECD, 2013), but this is not always true. For example, some East European countries with industrial or agri-industrial function show a modest population shrinking rate, equally split between natural decrease and outmigration, and the slowest expected shrinking rate in the future (Copus et al., 2020).

The presence of these productive functions is sometimes associated with adverse ecosystem functions (externalities) due to the intense competition for land and landscape utilisation (OECD, 2013) and the effects of industrialised agriculture (such as soil and groundwater contamination, eutrophication of lakes and rivers, biodiversity losses due to specialisation and increasing farm size and productivity). But these externalities are positive in the case of above-mentioned alternative food networks.

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1.6.3 Rural areas in peripheral, low-diversified or shrinking economies.

This cluster includes more than just geographically remote areas but also rural areas in regions with shrinking economies. Peripheralisation processes are associated with geographical remoteness, poor provision/access to services of general interest and/or scarce connectedness of stakeholders and institutions to wider networks (Noguera et al., 2017). These processes translate over time into continuous population shrinking due to natural decrease and outmigration, ageing and increasing dependence ratio (OECD, 2013).

According to the OECD analysis, these processes involve notably the predominantly remote rural category (OECD, 2020). Nevertheless, a recent ESPON project (ESCAPE) showed that they are widespread in a large share of intermediate regions, and a few coastal and mountain regions, characterised by proximity to borders (including EU borders), poor accessibility, a high share of the primary sector and high rate of outmigration (Copus et al., 2020). These areas are notable in Eastern European countries (Baltic outside the capital regions, most of rural Hungary and Bulgaria, continental Croatia and South-Western Romania).

The PROFECY study (Noguera et al., 2017) estimated that peripheral areas cover approximately 45% of the European territory: 22.5% are those that lack access to centres and services; another 20% are represented by areas predominantly suffering from poor economic potential and demographic situation; and the remaining 2.5% are areas affected by multiple drivers. This study documented, among other things, how peripherality is not a process involving only rural areas but also a significant share of intermediate and urban metropolitan regions due to increasing unemployment, decreasing wealth (GDP per capita) and further impacts on outmigration.

Other studies (Copus et al., 2020) confirm that peripheral areas include not only remote areas from a geographical perspective but also rural areas that are close to industrial sectors under crisis/restructuring processes (i.e., Eastern Germany and some regions in Western Germany).

The production functions of these rural areas are strongly limited by the fragile economic system (marginal agriculture, low-diversified industrial structure, seasonal tourism activities, etc.), especially in the most remote areas. The production function can also be under a crisis/restructuring process, even in the most "central" areas, where the causes are not poor accessibility, but disconnection from economic development processes and socio-political networks.

In the most remote areas, ecosystem services may be among the most significant functions (e.g. regulating functions providing direct and indirect benefits to other areas such as maintaining clean air, water and soil, preventing soil erosion and biological control services). Natural and semi-natural ecosystems also provide refuge and reproduction-habitat to wild plants and animals and contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes. They also provide a resource for renewable energy (e.g., agricultural and forestry resources for biomass energy). Nevertheless, these functions are also present or needed in other rural areas, and even in the most remote areas, they may be under-recognised or under-valued.

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1.7 A proposal of rural typology and related indicators

Previous sections focused on the main approaches used to identify the differences between urban and rural and within rural areas. A wide range of research has examined these differences directly and indirectly. Summarising the main achievements, it is possible to say that:

- the stratification of rural areas within the urban-rural continuum is more complex than that deriving from proximity to urban centres;
- a proper assessment of urban-rural relationships needs to rely on precise information about flows of all kinds: goods, persons, capital and information. Comparable information on such flows is not available at the European level, but the geographical distribution of flows is very often influenced by and reflected in structural variables regarding population, labour markets, infrastructure and services;
- the functional area concept is usually applied to urban and regional development to identify the intensity and nature of urban influences upon the surrounding territory (including the networks of cities and towns in the case of polycentric regional development, where a multitude of urban centres, rather than one or two, gains significance). The concept of 'city-region' is strongly biased in favour of the urban part;
- studying functional relations in the case of rural areas implies focusing on the role that the countryside can play in production, consumption and ecosystem functions, not only for nearby urban areas but also for broader society and in relation to national and international markets, institutions and business actors;
- studying functional relations also implies using mixed approaches based on structural and locational methods and information available at the most granular level (grid), with information at LAU2/NUTS3 level from different sources. In this regard, using EUROSTAT's classification of the degree of urbanisation typologies, as described in section 1.2, can be helpful.

One of the objectives of this report is to provide a methodology to frame the concept of rural functionality and define coherent and practical criteria to be applied to rural areas. A five-step process should be implemented (see Figure 5). This methodology should be tested in the fourteen RUSTIK Pilot Regions. In addition, it will allow classifications to be shared over a set of different regions in respect of their size, administrative and socio-economic characteristics.

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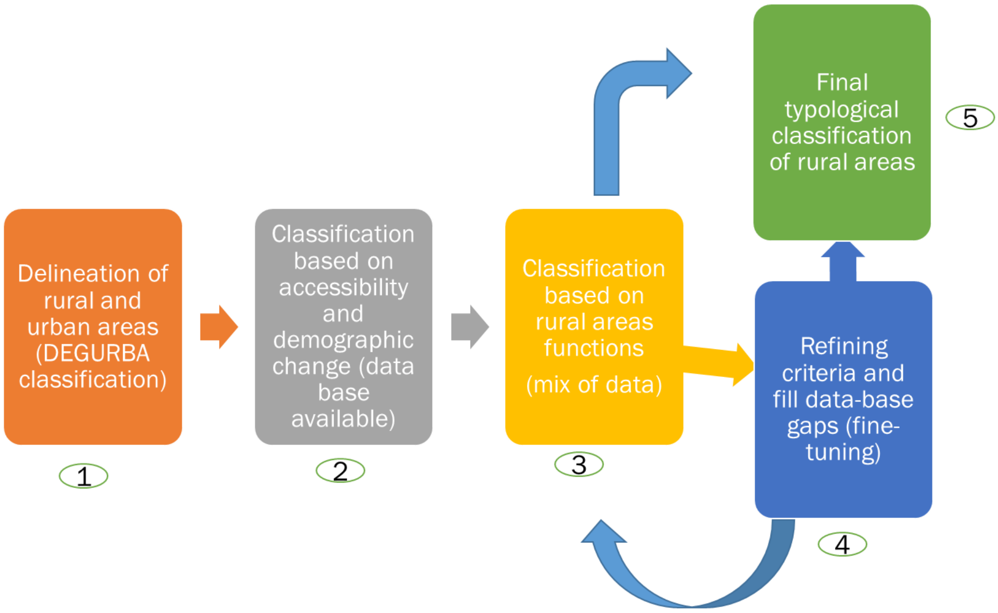

Figure 5 – Main steps in classifying a new typology of rural areas based on 14 Pilot Regions

Thus, in a first step, the project delineates rural and urban territories relying on the methodology followed by EUROSTAT with the degree of urbanisation (DEGURBA) classification (EUROSTAT, 2021). This classification provides three categories of units at the lower administrative level (LAU2): cities, towns and suburbs, and rural areas, in the 27 EU Member States. The GLS (Global Human Settlement layer) portal, run by the EC's Joint Research Centre (JRC), provides essential information for implementing the classification and visualising associated data (https://ghsl.ec.europa.eu/degurba.php). Similar information is now available from the Rural European Observatory (https://observatory.rural-vision.europa.eu).

In the second step, rural LAU2 units belonging to each Pilot Regions should be clustered according to a classification grid based on two variables (table 3): a) demographic change and b) accessibility.

Demographic change can be measured by following the ESCAPE approach, based on the geography of rural shrinking (Copus et al., 2020). Population dynamics can be derived from the intersection of two dimensions: a) the dynamics of the population change in the period 2000-2022 (positive or negative); b) the intensity of population change in three classes, using the indicator average annual population change for the period 2000-2022 (< -1% severe annual average shrinking; between -1% and 0% moderate annual average shrinking; > 0 % population growth).

Accessibility is a more complex component of the proposed typology. This issue has been theoretically defined and operationally implemented in the PROFECY project (Noguera et al., 2017). This study mapped peripheral territories (with low accessibility) based on two types of accessibility: poor access to regional centres (higher travel time to regional cities) and poor access to the Services of General Interest (SGI). Poor accessibility has been calculated in both cases at the grid cells' level and compared to surrounding regions. A unique map and database of regions with poor accessibility to centres and SGIs has been compiled.

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By mixing the two dimensions of rurality, it is possible to identify six different types of rural areas across the urban-rural continuum (Table 3). Starting from the most favourable conditions (good accessibility and population growth) and proceeding to the most disadvantaged (poor accessibility and population decrease), there is a gradient of socio-economic conditions explaining internal differences of rurality. This gradient includes a series of intermediate situations that can be positioned in the transition process as neither totally shrinking, nor completely disconnected. As a series of studies has documented, low accessibility and population shrinking interact over time in a vicious circle (Hirshman, 1958; Krugman, 1995; McCann & Van Oort, 2019; Myrdal, 1957). Diversity in territorial capital and specific social capital endowments can explain both why some areas do not lose population in conditions of poor geographical accessibility and, conversely, why accessible areas may lose population.

This typology can be applied to the 14 RUSTIK Pilot Regions both to explore potential internal differences between rural areas within each Pilot Region and compare the relative position of the 14 Pilot regions. Given that PRs are characterised by different sizes (in terms of territory, population and number of municipalities), the typology allows for highlighting potential territorial diversity within each PR.

Variables used for classification		Demographic dynamics		
		Population growth	**Moderate decrease**	**Severe decrease**
Accessibility to regional centres and SGIs	Good accessibility	Connected growing area	Connected intermediate area	Connected but shrinking area
	Poor accessibility	Peripheral but dynamic area area	Peripheral intermediate area	Peripheral shrinking area

Table 3 – Rural typology based on demographic dynamics and accessibility

Source: Authors' elaboration

In a third step, the objective is to complement the typological classification of LAU2 level with the analysis of functions. The objective of this analysis is not to identify one dominant function but the most significant 'function mix' within a given territory. From the literature analysis, there are three main categories: production, consumption and ecosystem functions. Figure 6 illustrates specific functions belonging to each of the three categories.

The analysis of production functions indicates what types of local economic specialisation (or not) characterise rural territories, following the assumption that rural areas are far from being predominantly agricultural-oriented (EDORA project, Copus and Hörnström, 2011 introduced a similar classification). Consumption functions are mainly oriented to leisure activities, tourism and residential functions (Holmes, 2006 and 2012; Copus & Hörnström, 2011; Bansky & Mazur, 2016).

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Ecosystem functions are more complex and need to explore different environmental components strongly associated with the capacity of rural areas to regulate a series of ecosystem services (Marechal et al., 2016; de Groot, 2006; Dwyer et al., 2020).

Production	Ecosystem functions	Consumption
• Agri-industrial • Forestry • Diversified economy (secondary sector) • Diversified economy (tertiary sector) • Mixed productions	• Regulating water availability and quality • Soil protection and functionality • Landscape and cultural heritage conservation • Maintaining/increasing biodiversity • Climate change mitigation and adaptation • Sustainable production of energy	• Leisure activities, tourism and activities related to cultural heritage • Residential • Provision of services of general interest (SGI): healthcare, educational, social activities

Figure 6 – Categories of functions and specific functions as complementary classification

Indicators are associated with each category of functions (Annex 1), to be quantified at the level of a PR, wherever possible. Access to EU-level databases (EUROSTAT, JRC, EEA, Rural Observatory, etc.) can provide a mix of different sources alongside national and local sources of information.

Comparing values at the Pilot Region level with national values of the same indicator and standardisation in classes of intensity (low, medium, high) means PRs can be positioned in each function. For example, PRs classified as demographically growing and well-connected may simultaneously face low or declining ecosystem functions while being strongly advantaged in production, as diversified economies (secondary sector). Likewise, ecosystem functions might be strong or increasing in shrinking and economically disadvantaged PRs, notably regarding soil and landscape conservation.

Annex 1 describes a series of indicators for each function and possible sources of information that are available at the EU level. Filling information gaps at the scale of the PR will be crucial in describing the different functions. Further work seems necessary in WP2 and WP3 to explore possible sources at the national, regional and local levels.

In a subsequent and critically important step, the list of indicators and information sources will need to be verified and completed, through the involvement of local actors and specific experts. At this stage, local participation is crucial to achieve understanding and prepare basic conditions for transformation capacity in the respective area. This might result in additional information demand on specific local issues which have not been envisaged in the common list of information.

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Once this is achieved, the defining function-mixes of each PR can be confirmed, refined and finalised.

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2. Diversity of rural areas and their capacity to face transitions

2.1 Introduction

The previous chapter has shown how diverse rural areas can position themselves under different notions of functionality. This section considers the diversity of rural areas in a changing world, how the changes variously impact rural areas and how they react differently to change.

This section describes the different drivers and trends of transitions (socio-economic/ demographic, environmental/climate and digital), and their impacts in diverse rural areas. These aspects will be elaborated on the basis of the current literature (articles, research reports and relevant policy documents). The section concludes with a conceptual framework explaining the capacity of rural areas to respond to transitions.

2.2 Socio-economic transition

2.2.1 Macro drivers and trends

From 1970 onwards, and particularly in the new millennium, technological progress and the long cycle of regional evolution have led to increasing regional divergence (Iammarino et al., 2018). According to an OECD study (2020), inter-regional disparities show different trends depending on the geographic level observed. Differences between regions in GDP per capita at the NUTS2 level peaked in 2010, after the global financial crisis, and then slowly declined. Nevertheless, when observed in greater detail, the inter-regional disparities in 2018 are much more significant than in 2008.

In a significant number of European countries (Slovakia, Poland, Czechia, Italy, France, Spain, Greece, UK, Belgium and Sweden), the GDP per capita gap between the top and bottom 20% of regions, regardless of the NUTS level, has remained unchanged or has increased in the period 2008-2018. Still, the polarisation across space is even higher and more pronounced when the gap is measured within regions (at NUTS3 level) because a more granular analysis can capture the differences between cities and low-density areas more precisely. This result reflects «*both an increasing concentration of economic activities in cities and the difficulties of small remote regions to keep pace with the national frontier*» (OECD, 2020, p. 55). The effects of the global financial crisis are more evident at the NUTS3 level than at the large-region level (NUTS2). The inequality index, used by the OECD to measure territorial disparities between countries (OECD, 2020), decreased for large regions from 2000 to 2009 and remained substantially stable until the next economic crisis in 2017. Inequality within countries, by contrast, is continuously increasing.

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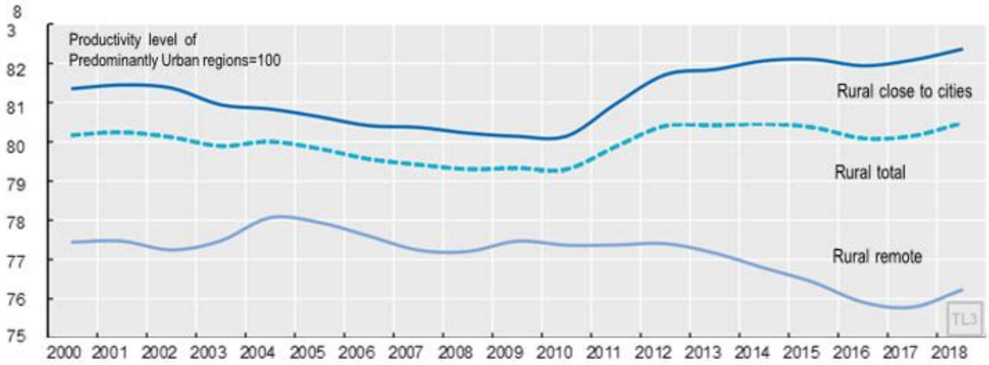

Figure 7 - Labour productivity growth in rural regions (NUTS3 level), 2000-18

Source: OECD, 2020, p.57

Rural regions close to cities displayed higher productivity growth before the 2008 economic crisis and higher resilience after the crisis began (Figure 7): they have successfully narrowed the productivity gap with urban regions, especially since 2010, and in 2018 their productivity levels reached 82% of urban regions' productivity. Contrary to this positive trend, remote regions were the most badly affected by the crisis, with an annual average drop of GDP per capita of -2.5%, almost ten times worse than GDP decline in rural regions close to cities. Figure 7 shows not only that these areas were unable to reduce their productivity gap in eighteen years, but also that their position has worsened in the last few years of that period.

Regarding demographic transition, Europe is experiencing a marked process of ageing and further and faster pressure in this direction is expected within the next decades due to a significant change in age structure resulting from the combination of three main drivers: low levels of natural population replacement; increasing life expectancy (resumed after the Covid-19 disruption) and median age; and reduced net migration rate.

The age pyramid tends to become a column: it becomes taller as baby-boomers[3] retire and move upwards, thinner as working-age turnover decreases and with a reduced base as birth rate continues to decline after Generation X[4] cohorts, characterised by steady decline since 1960, recovery in the 2000s, stabilisation in the 2010s, a drop during the Covid-19 pandemic due to excess mortality and decreased life-expectancy, and then back to pre-pandemic levels in 2021. Moreover, after the consistent growth of the last fifty years, and unlike global trends, Europe is projected[5] to move towards depopulation from 2029 onwards, worsening and amplifying the ongoing demographic imbalance resulting from low fertility and net migration rates (European Parliament, 2022; European Commission, 2023a).

[3] People born between 1981 and 1964
[4] People born between 1965 and 1980
[5] For detailed statistical information and data see: Eurostat – EUROPOP2019 population projections (online data: PROJ_19NP), and United Nations, Department of economic and Social Affairs (UNDESA) – World Population Prospects 2022 (available at: https://population.un.org/wpp/

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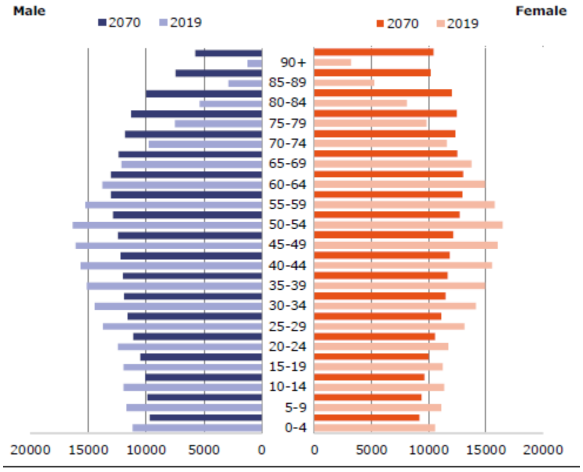

Figure 8 – Population by age groups and gender, 2019 and 2070 (thousands)

Source: European Commission, 2021c (data source: projections on Eurostat data)

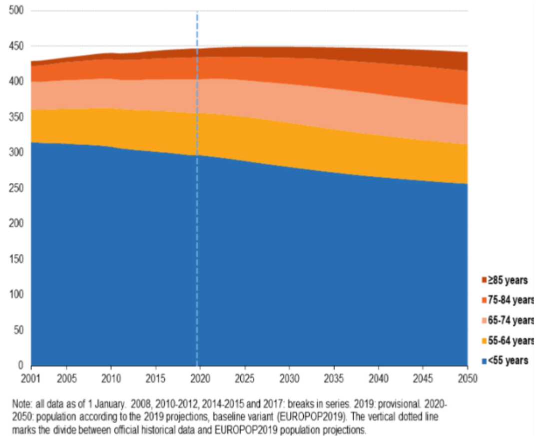

Figure 9 – Population developments by age class, EU-27, 2001-2050 (million inhabitants)

Source: Eurostat, EUROPOP2019, online data codes: demo_pjangroup and PROJ_19NP

Increasing ageing implies that people live longer and better than previous generations; the combination of depopulation and ageing brings a radical societal change that is expected to undermine European socioeconomic performance and exacerbate the conditions of labour market and welfare state in the long run. The projected growing number of old-age and retired people would place pressure on pension systems, health care and social services, and thus impact negatively on per-capita public spending and public debt.

Demographic macrotrends tend to converge at national, regional and local scale, however, several discrepancies emerge between and within Member States and impact European territories unequally. Depopulation and ageing are strictly interlinked and negatively influence each other, and it is relevant to gain insights into the vicious cycle that is endangering socioeconomic cohesion in Europe: territories experiencing long-term depopulation are characterised by higher ageing, territories with high numbers of elderly people undergo major depopulation (Reynaud and Miccoli, 2018; Aurambout et al, 2021). It has, in fact, been observed (Kashnitsky, de Beer and van Wissen, 2017 and 2020; Aurambout et al., 2021) that ageing dynamics, speed and age structures follow a geographical pattern per macro-regions (North-Western, North-Eastern and Southern Europe) and are mainly linked to dissimilar processes and patterns of urbanization (young adult people migrating to more urbanized areas) and counter-urbanization (young families and old adults migrating to rural or intermediate areas) more than to international migration flows. North-Western Europe is characterised by earlier demographic transition and faster ageing in rural peripheries, while in Southern Europe ageing is faster in urban areas, with a consequent decreasing urban-rural gap. Eastern Europe follows, instead, a path marked by the consequences of the dissolution of the Soviet era at the beginning of the 90s, that caused deindustrialisation and massive migration out of urban areas, suburbanization and counter-urbanization and a net migratory surplus in rural regions among the mature adult ages (Aurambout et al., 2021; Muntele et al., 2021; Copus et al, 2020).

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Eurostat 2019-based long-term demographic projections[6] to 2070 forecast an overall reduction of population in Europe (from 5.7% to 3,7% of the world population) and show partial convergence at NUTS2 level (2016 version) in the course of three main indicators: fertility not allowing natural replacement, low mortality, and low net migration. But at country level slightly different trends are observed: worse demographic performances are expected mainly in North-Eastern and Southern countries experiencing great waves of emigration, increasing trends are expected, instead, in most North-Western countries.

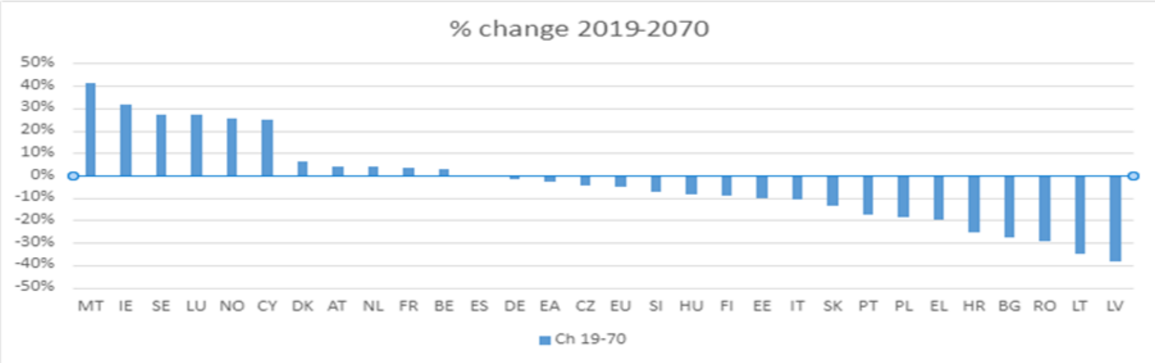

Figure 10 – Variation of population on 1st January by NUTS 2 countries (%, 2019-2070)

Source: Authors' elaboration on Eurostat data, EUROPOP2019, online data code: PROJ_19NP

With regards to fertility rate, there would be a slight rise in all European countries, but none of them reaches the level of 2.1 necessary for stable natural replacement in absence of migration and only France is supposed to maintain a stable fertility rate (above 1.8) by 2070. Life expectancy is projected, instead, to increase in all countries, both at birth and at 65, for males and females, particularly in Eastern countries while the lowest increase in life expectancy in old age would be in Spain and France, by around 4 years both for men and women. The combined effect of the trends of fertility and life expectancy would lead to an increased share of older cohorts in the population and in a general sharp increase in old-age dependency ratio (+24.7 points, from 34.4% in 2019 to 59.2% in 2070).

Generalised gradual ageing of the European population is even more unbalanced when people leaving outnumber people arriving. Between 2019 and 2070, net migration is predicted to decrease in absolute terms in most countries, especially in Spain, but also in the Netherlands and Germany, while it increases in many others, particularly in the North-East (Poland, Romania, Bulgaria), and Italy and France. Looking at cumulative projections in the different Member States,

[6] EUROPOP2019 population projections provide "what-if" scenarios based on various assumptions held constant over time. Projections cover the period 2019-2100. EUROPOP2019 data are available at: https://ec.europa.eu/eurostat/web/population-demography/population-projections/database . Statistical articles and methodology are available at https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_and_demography

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net migration turns positive in all countries, except for Latvia, Lithuania and Romania where negative flows are expected.

Combining all of these trends, the median age of the EU population would rise by 5 years (from 44 to 49), but in most Member States the increase would exceed this value, ranging from 6 years in Slovenia (from 44 to 50) to 12 in Poland (from 41 to 53). As a result, the old-age dependency ratio is projected to increase by 72% at European level and to follow different paths in the different countries, with increases ranging from 40-50% (Sweden and Germany) to +140-150% (Luxembourg, Poland and Slovakia). Rates exceeding the European average are expected mainly in the North-East and the South.

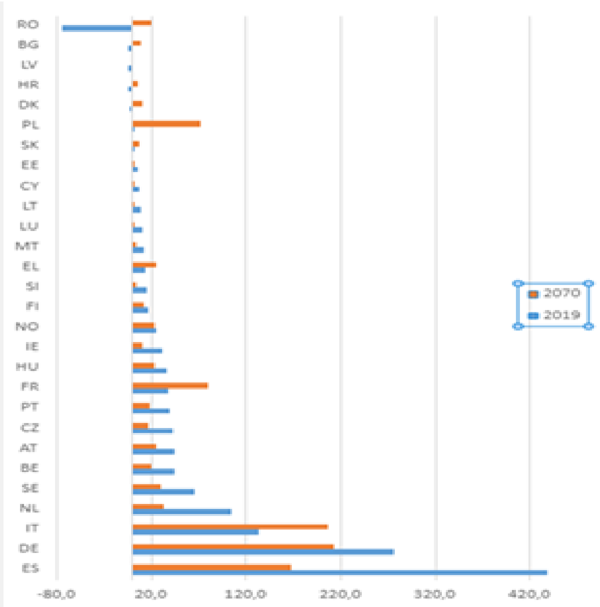

Figure 11 – Net migration by NUTS 2 countries (thousand) (2019-2070)

Source: Authors' elaboration on cross-country tables from European Commission, 2021c (data source: Eurostat, EUROPOP2019, online data code: PROJ_19NANMIG)

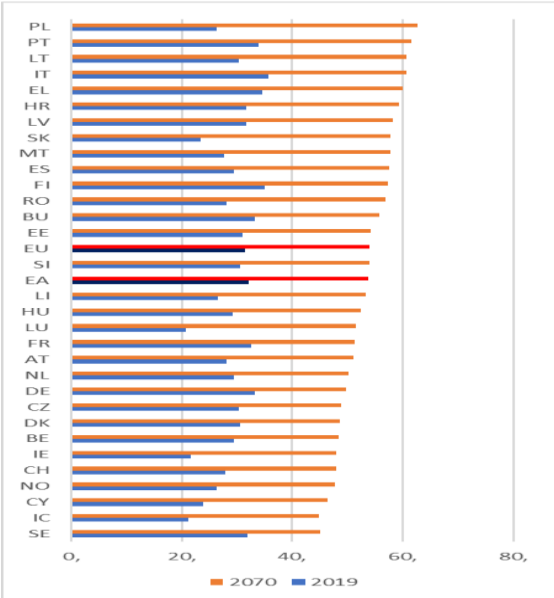

Figure 12 – Old-age dependency ratio 1st variant by NUTS 2 countries (population 65 years or over to population 15 to 64 years) (2019-2070)

Source: Authors' elaboration on Eurostat data, EUROPOP2019, online data code: PROJ_19NDBI

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2.2.2 Differentiated impacts at territorial level

Disparities between territories arise due to divergent trends in other significant socio-economic factors, including: a) unfavourable population dynamics; b) different opportunities in labour markets; c) different access to services of general interest and infrastructure; d) unequal distribution of market power; e) the digital divide.

Population trends suggest a generally slow growth rate in the coming years and a growing decline in the long term. However, this trend appears strongly differentiated between rural and urban areas and across EU countries (Perpiña Castillo et al., 2022).

By comparing the pre-crisis situation (2000-2007) in the labour market with the post-crisis period (2008-2018), Proietti et al. (2022) showed that the effects of the crisis were particularly adverse for remote areas in the EU, where employment dropped drastically by 10% across all economic sectors, except for the financial & business services sector, which increased by 3%. This drastic reduction contrasts sharply with the situation before the financial crisis, where employment in remote regions grew at an annual rate of 0.52%. Some years after the crisis (in 2012), employment in urban areas started growing again and overtook the pre-crisis levels up to 2020, when COVID-19 caused a new decline. However, this time employment decline affected all types of regions, and all locations. Rural areas (as defined based on the DEGURBA classification) have lost employment in three waves: a) at the beginning of the 2000s; b) as an effect of the 2008 financial crisis (with a positive peak just in 2008 and a trough in 2015); c) again in 2020 (effect of COVID-19). The employment decline contributed to the long-term population shrinking in all regions except for the urban regions.

The impact of the 2008 crisis on employment was differentiated at EU level. The remote regions' negative performance was not seen in all EU countries: Austria, Slovenia, Germany, and Finland had a slightly better economic performance than the other countries (Proietti et al., 2022). In contrast, a significant negative employment change rate (more than -0,5% per year) was registered in Portugal, South Italy, central Spain, Croatia, Greece, Estonia, Latvia and Eastern Finland.

JRC (Perpiña Castillo et al., 2022, p. 3) points out changes in labour market segmentation in the last 15 years: «*low-wage jobs are often concentrated in peripheral regions while higher-wage jobs are becoming more and more concentrated in capital regions, benefiting from employment growth and, at the same time, increasing social and territorial disparities. Moreover, substantial changes are expected in the way current jobs are carried out (e.g., example due to automation), which could further influence the concentration of skilled workers in urban regions with a negative impact on rural ones*».

Public transport and accessibility to essential services are typically better developed in city centres compared to peri-urban, rural and remote areas, where people have to travel further to reach a service or facility. Low-density-populated areas have to face the public and private increased costs of service provision due to insufficient economies of scale: for example, it has been estimated that on the EU average, providing primary education in villages costs 13% more per pupil than in cities (Perpiña Castillo et al., 2022). Higher costs in turn can trigger budget reshaping, restructuring, and generally reducing the scope of rural service provision: for example, more than 92% of rural municipalities faced an increase in distance to schools of between 2-4

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km (estimated between 2011 and 2018) especially for those with a small initial pupil population (Perpiña Castillo et al., 2022).

The digital divide may exacerbate these territorial disparities (see section 2.4). However, the recent COVID-19 crisis has accelerated the development and adoption of digital infrastructure and e-services, which could benefit the peripheral and rural areas.

Studies have been carried out in specific geographical areas that enrich knowledge and understanding of territorial differences in impacts and in the capacity of communities to react to trends and macro-drivers, even within apparently homogeneous rural areas.

The effects of globalisation processes have been studied, for example, in small mountain areas of east-central Europe (Sikorsky et al., 2020) after the accession to the EU in 2004 and up to 2016. These authors observed strong differentiation among villages in changes among business entities and in employment structure, including processes of dynamism in marginal rural villages, both in tourism services and the industrial sector. The authors argue that transformations due to macro-drivers are spatially heterogeneous and support exploring «*local focal points of economic development which spill over adjacent areas. Local symptoms of rural revival cannot be captured in analyses made for larger administrative units*» (p. 9).

A similar result was obtained in another study focused on a Mediterranean case study (Andalusia, Spain) (Sanchez-Zamora et al., 2014) in the pre-crisis period (2000-2009), analysing the determinants of successful territorial dynamics. The analysis identified 68 municipalities, across different rural types within the region as a whole, which obtained better results regarding population growth, per capita incomes, employment rate and several environmental indicators.

Demographic decline processes affect especially predominantly rural and intermediate NUTS 3 regions. According to Copus et al. (2020), almost 60% of rural and intermediate regions (687) are "*shrinking*" and account for 40% of European territory. Shrinking regions are characterised by "*substantial and sustained"* depopulation occurring with a certain intensity over a period covering one or two generations (e.g. 1993-2013 and 2013-2033).

Depopulation is usually attributable to demographic processes, such as low fertility, ageing, and low net migration rate, however it is also linked to socioeconomic factors that coexist and interact at territorial level, such as changes in economic structure (decline of agriculture and other activities), geographic disadvantage, peripherality and low accessibility, and disruptive events/transitions (Copus et al., 2020). Similarly, there is evidence that population and ageing discrepancies go beyond and across the rural-urban or mountain/non-mountain typologies and administrative boundaries and can be attributed to specific, place-based and age-based features of population, remoteness, access to services, economic opportunities, internal migration, and attractiveness (Aurambout et al., 2021)

Depopulation is not necessarily linked to the shrinking of rural areas, as can be seen in figure 13. In some North-Eastern countries there is a generalised population loss both in remote and in non-remote regions, while in some others and in some North-Western ones, population declines in remote areas but increases at national level. At municipal level, instead, the analysis highlights that population changes occur mainly in countries more distant from central Europe (Portugal, Spain, Southern Italy, Greece, Croatia, Romania, Bulgaria, Latvia, Estonia, Lithuania, North Finland and North Sweden), around cities and around major urban centres (mainly, Berlin,

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Bucharest, Madrid, Sofia, Tallin and Vilnius), probably due to outmigration to adjacent peri-urban locations.

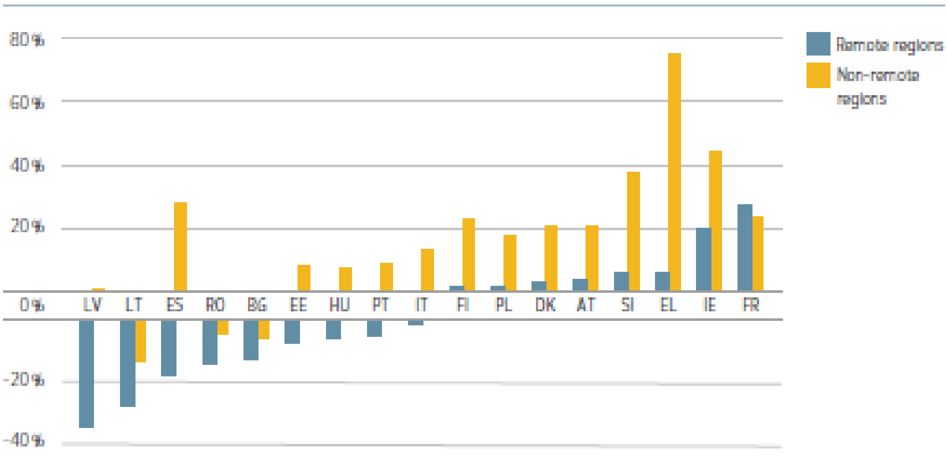

Figure 13 – Population change (in percentage) in remote versus non-remote regions between 2001 and 2021 (EU average 0.18 and 0.57, respectively)

Source: Proietti et al, 2022

2.3 Environmental-climatic transition

The challenges presented to us in the climate and environmental transition are complex and interlinked. They are not limited by national borders, nor will they be solved by individual actors alone. The response to such challenges requires comprehensive, coordinated, global action which recognises the linkages between climate change, the energy transition, land use change and biodiversity.

This section of the review considers the key EU documents which are driving the response to this transition, the risks associated with this transition and the factors affecting regions' capacity to react. In addition, it will provide key indicators used in previous studies to assess the changes occurring.

2.3.1 Drivers of environmental change

First, it is necessary to consider the drivers of climate and environmental change. It is widely acknowledged that current consumption, distribution and production patterns are unsustainable (Prevost et al, 2021). These patterns are driving significant changes in the natural world, such as:

- A 2.2°C increase in average temperature in Europe since the end of the 19th Century;
- A 22% increase in rainfall intensity in the Mediterranean region (European Council, 2022a);
- A 6% increase in the share of EU habitats with bad conservation status from 2012 to 2018 (European Environment Agency, 2020).

These changes have serious socio-economic consequences, including:

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- Over 138,000 lives lost in the EU due to extreme weather and climate related events from 1980 to 2020; and
- leading to €487 billion in financial losses across the EU27 (European Council, 2022a).
- A global loss of 4 to 20 trillion USD in ecosystem services, due to land cover change between 1997 and 2011 (OECD, 2019).

These unsustainable patterns are manifest in several sectors, most notably the energy sector, which contributes three quarters of the EU's greenhouse gas emissions (European Council, 2022b). Other sectors such as agriculture and forestry contribute to significant land use change such as the drainage of peatlands which demonstrates interlinked impacts; it contributes 5% of total EU emissions and has a significant impact on water quality and biodiversity (Tanneberger et al, 2021).

Systemic change to these patterns is vital if we are to address climate and environmental challenges. Although energy and primary sectors have driven environmental change thus far, it is through the same sectors that we may be best placed to address the issue, and there is evidence across Europe that innovations in policy and practice can deliver the changes required.

2.3.2 Macro drivers and trends in the response to environmental change

The following section considers the policies and legislation driving our responses to climate and environmental challenges.

The *European Green Deal* (European Commission, 2019a) is a significant driver of much current action to address these issues, demonstrating the EU's 'commitment to tackling climate and environmental challenges. The *Green Deal* included a commitment to an *EU Climate Law*, which has since been adopted by the European Parliament and European Council, enshrining the goal of a climate-neutral EU by 2050 in legislation (European Council, 2022c). The *EU Adaptation Strategy* provides actions that member states may take to improve their climate resilience by 2050 (European Commission, 2021a). The European Council (2022d) recognises that this transition will require significant investment: 30% of the EU's long-term budget (2021-2027) has been committed to climate-related projects. Similarly, the transition will require significant social investment (Sikora, 2021). Sikora (2021) states that the *European Green Deal* will require the engagement of each and every EU citizen, to ensure they are conscious of the risk of non-action towards climate change. This, Sikora (2021) further argues, will require unprecedented efforts at the EU institutional level and efficient implementation by all Member States to constitutionally entrench environmental protection and initiate a substantive attitude towards the climate and environmental crises at all levels.

Significant attention has been given to improving the energy sector to reduce emissions from energy production and consumption, notably through the *Clean energy for all Europeans* package which aims to decarbonise the EU's energy system (European Commission, 2019b). The *Renewable Energy Directive* sets a common target that 32% of the EU's energy must be renewable by 2030 (European Commission, 2023b). Specific funds aim to increase energy efficiency through infrastructure improvements and renewable energy production (European Commission, 2021b).

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The *Biodiversity Strategy for 2030* provides specific action and commitments to ensure biodiversity can recover (European Commission, 2020a). For the implementation of the *Biodiversity Strategy* to be successful, Member States must learn from previous attempts, adapt in the face of dynamic conditions and provide sufficient financial support (Hermoso et al., 2022). If this is not the case, the *Strategy* risks being insufficient, as previous efforts to halt biodiversity loss have been (Hermoso et al., 2022). The *Nature Restoration Law* aims to provide some structure, accountability and commonality across Member States; it will require them to submit National Restoration Plans within two years of the regulation coming into force, to demonstrate how they will contribute to the long-term provision of a biodiverse and resilient nature (European Commission, 2023c).

Meanwhile, the *Common Agricultural Policy* (CAP) must respond to the call to protect, conserve and enhance natural capital in the EU's member states (European Commission, 2019a); this includes ensuring that traditional farming practices are supported, and land is not abandoned (MacDonald et al., 2000). Agriculture and rural areas are considered central to the *Green Deal* and the new CAP is positioned as a key tool in the *Biodiversity Strategy*, and the *Farm to Fork Strategy* (European Commission, 2023d). The new CAP from 2022 requires countries to demonstrate greater commitments to environment and climate action (European Commission, 2023d). It is vital that the national CAP strategic plans ensure farmers and land managers are supported through this transition period. Was et al. (2021) suggest that the new CAP must also emphasise emissions-reductions. Although the 2014-2020 CAP delivered economic efficiencies and gains in the environmental footprint per unit of output, the European Commission found that the CAP had not delivered similar gains with respect to emissions (Was et al., 2021). Was et al. (2021) thus suggest that a better understanding of the impact of emission-reduction measures is necessary. Emissions reduction is a difficult, but necessary, task, as agricultural production itself is at risk from GHG induced global warming (Was et al., 2021). Although recognising the behavioural and financial challenges inherent to emissions-reduction in the food system, Was et al. (2021) argue that production techniques, consumer habits and global trade must all be addressed, as these currently represent systemic obstacles to low-emission agriculture.

The European Commission (2021b) suggests that rural areas are active players in the EU's Green Transition, particularly regarding climate change mitigation. At present, the potential for rural communities to respond to climate challenges is centred largely on the land-based sector, with a particular focus on actions within agriculture and forestry and their potential to mitigate climate change (Markantoni and Woolvin, 2015). However, there is a growing recognition of the potential for rural areas to provide spaces for renewable energy development. Although not without its challenges, including installations' perceived impacts on the natural and cultural landscape (Poggi et al., 2018), the assumed availability of land for development is driving interest in rural areas for renewable energy developments. This has the potential to foster economic development and improve rural competitiveness (Poggi et al., 2018).

Further, there is a risk that some rural mitigation strategies are ill-conceived: for example, participants in Peepson and Mikk's (2017) research argued that laying the blame of environmental pollution on grass-fed beef cattle is short-sighted, as it overlooks the positive aspects related to traditional grassland management; while other research has used a broader Life Cycle Analysis to demonstrate the relative climate neutrality of these systems when compared against more intensive livestock production that requires the use of large quantities of imported protein feeds (National Trust, 2012). The loss of such management systems may also have

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negative impacts on biodiversity and the socio-economic dynamics of rural communities (MacDonald et al., 2000).

Whilst climate strategies focus on EU level targets and trends, it is at the local and regional level where physical change will be implemented.

2.3.3 Differentiated impacts at territorial level

The European Commission (2021b) acknowledges that '*rural communities are potentially exposed to greater costs associated with the climate transition*'. The impacts of adverse climate events and biodiversity loss may be felt acutely by rural communities whose economic activities are focused on agriculture and forestry (Abaje et al., 2015). The changing climate poses differing challenges across Member States, as a result of their particular geography. For example, climate models predict more frequent summer droughts in Central Europe, which will affect species composition and agricultural yield (Bollig and Feller, 2014). The droughts of 2015, 2018 and 2019 affected several sectors in Central European countries including agriculture, energy production and water management (Piniewski et al., 2022). A multi-year period of drought has a cumulative socioeconomic and environmental impact: dry soils and depletion of groundwater tables affect yields, leading some states to spend millions of Euros in compensation to farmers (Moravec et al., 2021). The effects of drought will require alteration in production techniques to improve efficiencies and select crops suited to the changing climate (Eitzinger et al., 2012). Permanent grassland in mountainous regions may shift into the production of fodder crops; where this is not possible (for example in northern or south-eastern Austria), areas will see a decline in grassland productivity (Eitzinger et al., 2012). Forestry is also affected by drought; it can cause forest decline, with a notable example being the large-scale collapse of conifer plantations across Europe (Moravec et al., 2021). In addition, a 2016 bark-beetle outbreak triggered by drought led to an increase in salvage logging, with associated economic losses (Moravec et al., 2021). Sustained high temperatures associated with drought also lead to wildfires, for example 5,000 ha of the Biebrza National Park in Poland were affected by fire in spring 2020. (Piniewski et al., 2022). All these issues can have a significant impact on ecosystem functioning (Moravec et al., 2021); wildfires have long-term implications for soil productivity and hydrological services (Fernandez-Anez et al., 2021).

Water management is also a key issue. Europe is seeing an ever-increasing demand for water, which will likely exceed supply by 2050 (Haida et al., 2019). Addressing the challenges relating to water will require significant changes in consumption both of water and food, as the agricultural sector accounts for 89% of water consumption across Europe (Vanham et al., 2013). The integration of EU water policy objectives into the CAP has only partially been successful. Decisions regarding water and soil cannot be dealt with separately, as soil structure and conditions are fundamental for decisions concerning water management (Mantino and Forcina, 2018); thus, there remains tension between water and agriculture sectors (Carvalho et al., 2019). In addition to challenges around water for consumption and use, there are issues relating to the quality of water bodies as habitats. Despite the introduction of the Water Framework Directive, 60% of surface water bodies failed good ecological status in 2018, largely as a result of diffuse pollution from agriculture and rural dwellings (Carvalho et al., 2019).

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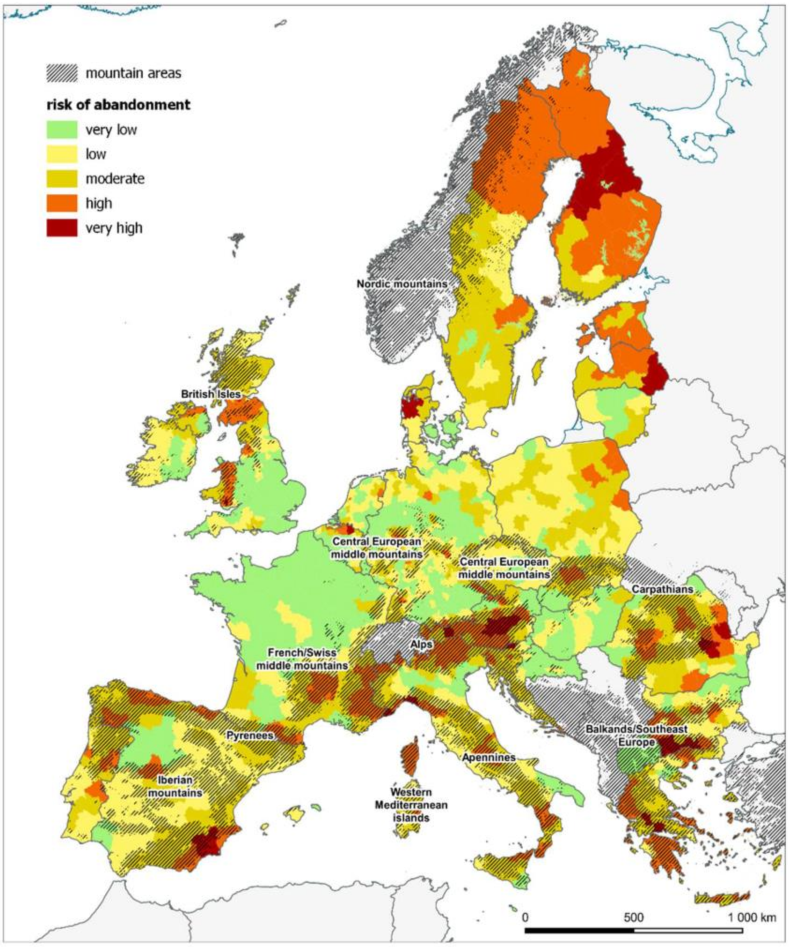

Figure 14 - Risk of land abandonment at NUTS3 level and mountain areas,

Source: Dax et al., 2021

Land use has been significantly affected as nations respond to both socio-economic and environmental challenges. In some regions, rural areas which saw an intensification of land management through the 1960s to the 1980s are now witnessing a drive for multifunctionality, in which farming and conservation practices occur simultaneously (Kuemmerle et al., 2016). This trend towards multifunctionality, however, appears rather diverse across countries and regions (Schuh et al., 2022). Globalisation has placed additional pressures on peripheral and traditional farming landscapes as locally-oriented agriculture is replaced by a culture where goods are increasingly purchased in supermarkets (Fischer et al., 2012). The loss of traditional farming landscapes in Europe presents a concern, as these systems are both important for cultural heritage and more resilient than the industrial agriculture that replaces them: their higher biodiversity and greater landscape complexity are considered to potentially provide more stable ecosystem services, and thus, improved adaptive capacity to climate change (Fischer et al., 2012; Filho et al., 2016). This loss was prominent in south-eastern Europe during the transition of the 1990s, when millions of hectares of farmland were abandoned in countries which saw fundamental restructuring of their agricultural economies (Filho et al., 2016). Dax et al. (2021)

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studied land abandonment in mountain areas of Europe and produced the map in Figure 14, which shows areas most at risk of abandonment in Europe.

Land abandonment has implications for societal development and the rural fabric, contributing to negative regional economic performance and demographic decline (Dax et al., 2021).

Future land use changes such as the installation of renewable energy infrastructure may have associated negative impacts on landscape character and identity, biodiversity and connectivity (Poggi et al., 2018; Van der Sluis et al., 2019). The diversification of regions traditionally dominated by primary sector activities requires careful planning to ensure natural and cultural landscapes are safeguarded, ecosystem services are not negatively impacted, and socioeconomic issues are considered (Poggi et al., 2018; Larkin et al., 2019; Baldock and Buckwell, 2021). To ensure key actors remain willing to participate, it is essential that policymakers tread a fine line to protect community interests and strike a balance between actions which support the transition to a more sustainable future, and retaining the sociocultural features which are of value to rural communities (Poggi et al., 2018).

Given the variation in climate-environment impacts, each country's responses prioritise the issues which are most likely to affect them: for example, in the Netherlands there is a significant focus on water-based adaptation (Hoppe et al., 2014), whilst in Poland strategies attempt to address high levels of air pollution, especially in rural areas (Piwowar and Dzikuc, 2019). Portugal has been particularly affected by wildfires, and thus, more money is dedicated to understanding the fire regime in the country, to mitigate its impacts (Fernandez-Anez et al., 2021). Challenges also vary locally, and national strategies should take this into account.

2.4 Digital transition

2.4.1 Macro drivers and trends

Digital transformation has become a high priority for all sectors and organisations (Brunetti et al, 2019). However, since digitalisation has such a wide-ranging impact it threatens to become a source of new inequalities (van Kessel et. al, 2022) and to increase already existing significant divides between levels of society and territories, as emerged during the Covid-19 pandemics between urban areas and rural and remote territories and between "t*hose who can fully benefit from an enriched, accessible and secure digital space with a full range of services, and those who cannot*" (European Commision, 2021b, p.2). Digitalisation needs are, in fact, particularly relevant and challenging in rural areas where, for example, 8.5% of households are not covered by any fixed network and 32.5% are not served by any NGA technology, 11% of rural households have no internet subscriptions (against 6-8% in cities-towns) and only 70% have a fixed broadband subscription (83% in cities), only 46% of people have at least basic digital skills (61% in urban areas), a condition not necessarily and simply linked to age since "*growing up in a digital world does not necessarily make you digitally savvy*" (European Commission, 2021f).

All these issues are the core of Europe's vision for digital empowerment of citizens and businesses by the year 2030 that was laid down between 2020 (Communication on '*Shaping Europe's digital future*') and 2021 (Communication on '*Digital Compass: the European way for the Digital Decade*'), but 2022 marked a watershed for the digital future of Europe. In January 2022, the

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European Commission proposed a declaration on digital rights and principles[7] to add to the Charter of Fundamental Rights of the EU and use as reference and guidance for digital transformation, and the European Council adopted the '*Path to the Digital Decade'* policy programme for digital transformation by 2030, in December 2022.

The EU policy programme sets targets and a governance framework and aims to tackle the issues preventing a successful digital transition, establishing steps and trajectories to follow to achieve each Digital Compass target and objective.

Europe's Digital Decade is focused on four areas of interest: digital skills, digital infrastructure, digital businesses, and digital public services. Each area is characterised by objectives and targets to be reached by 2030. And each target is pursued with Key Performance Indicators (KPIs) currently monitored in the Digital Economy and Society Index (DESI)[8], with more indicators to be introduced.

DESI covers four key areas: human capital, connectivity, integration of digital technology, digital public services. But past growth trends are insufficient to meet the targets in 2030, and there is a lack of convergence across Member States in all the digital targets. Therefore, each Member State has been required to prepare and follow national strategic roadmaps defining steps and progress to be made to meet the targets (European Commission, 2021e).

Digitally skilled population and highly skilled digital professionals – The basic digital skills 2019 baseline is 56% of adult people aged 16-74, and the target to reach by 2030 is 80%. Limited progress has been achieved (+2% and +0.9% annual growth rate between 2015 and 2019); however, greater progress is expected in the following years due to major use of technology during the pandemic, and Recovery and Resilience Plan investments. The most advanced Member States are the Netherlands, Finland, Sweden and Germany (70%), while Romania and Bulgaria lag behind (30%).

Secure and sustainable digital infrastructures - Connectivity infrastructure improvement entails Gigabit coverage of all European households (2020 baseline of 59%) and 5G coverage of all populated areas (2020 baseline of 14%), as preconditions for digital communication. The most Gigabit-covered countries are Malta, Luxembourg, Denmark and Spain (over 90%), the least is Greece (10%), but also other countries lag behind (Italy around 30%, as is the Czech Republic; Austria less than 40%; Hungary, Slovakia, France and Germany around 50%). Investments for 5G coverage are, instead, very recent; therefore, not all countries show deployment progress. High levels are seen in the Netherlands and Denmark (80%), Austria (50%) and Ireland (30%) .

Digital transformation of businesses - Europe's digital strategy calls for 75% of European enterprises to take up digital technologies and use Cloud computing services, Big data and

[7] The proposed rights and principles are: 1) Putting people and their rights at the centre of the digital transformation; 2) Supporting solidarity and inclusion; 3) Ensuring freedom of choice online; 4) Fostering participation in the digital public space; 5) Increasing safety, security and empowerment of individuals; 6) Promoting the sustainability of the digital future.

[8] The Digital Economy and Society Index (DESI) is a composite indicator developed to monitor the performance and the progress of European Member States performance in digitalisation. For more information: https://digital-strategy.ec.europa.eu/en/policies/desi

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Artificial Intelligence by 2030, with an accelerated path expected between 2020 and 2025 and a deceleration with higher diffusion.

Digitalisation of public services – Key public services are expected to be provided 100% online, both for citizens and for businesses, in future. The 2020 baseline is 75% for citizens and 84% for businesses and average past growth has been steady, but differences emerge at Member State level: leading countries are Malta (100%), Estonia and Luxembourg (90%), while most southern and eastern countries lag behind (around 50% Romania, Greece and Hungary).

2.4.2 Differentiated impacts at territorial level

The Digital Agenda includes a very wide range of technologies that are expected to have a cumulative effect and change radically the way people live, study and work. However, there are many challenges associated with digitalisation that may hinder the digital convergence process at European level.

The urban-rural digital divide, in fact, causes great concern and would requires more investments in infrastructure and in digital capacities in rural areas in order to close the gap, increase rural attractiveness and contribute also to boosting overall greening (European Commission, 2020e). In this regard, Brunori et al (2021) identify three basic conditions for successful digitalisation in rural areas: access to high quality technological infrastructures, skilled and competent human capital and economic gains from digital solutions. A further factor is the rise in the level of acceptance of the use of digital technologies in rural areas (Brunori et al., 2022). Moreover, in sparsely populated areas investments in digital infrastructure have low cost-efficiency and need public intervention to overcome market failures, adequate competences and skills and a wider participation of women are required to put these digital investments to good use and, most of all, the value created by the use of technologies should remain in local communities and businesses and serve as the launchpad for more innovation.

Therefore, the EU framework of policy programmes, targets, objectives and projects will impact Member States and the different areas in different ways, depending on initial endowments, conditions, targets and progress towards convergence.

Basic digital skills are a precondition for participation in future labour markets and society, and divides depend mainly on barriers to digital education and training due to economic factors (income), demographic factors (age) and geographic factors (limited connection in rural areas) (European Commission 2021e), whereas professional digital skills are essential for digital connectivity and the transformation of businesses, civic society, and public administrations.

Advanced connectivity infrastructures are considered as a precondition for private and public digital services and activities. Satisfying the connectivity needs of residents and businesses is essential for maintaining the attractiveness of towns and cities and preventing or limiting rural depopulation. There are important territorial disparities within Member States and across urban and rural areas in accessibility to broadband networks (Alberti et al., 2022). While fixed broadband accessibility (blue bars in figure 15) is almost equally accessible in all types of areas,

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Next Generation Access (NGA) and Very High Capacity Network (VHCN) coverage[9] significantly disadvantage rural households, mainly those located far from cities or in remote areas. All countries have broadband coverage (Figure 16), but it is lower in rural and remote areas and mainly in the North-East (Latvia, Romania, Slovakia, Hungary, Estonia, Poland, and Lithuania), in Finland and in Spain. High-speed broadband coverage at NUTS 3 level (Figure 29). is above the EU average (dark colours) in Scandinavian and Baltic countries, Poland, Romania, the Netherlands, Spain, Portugal and Malta in all types of areas, and below EU average (light colours) in all other countries and areas.

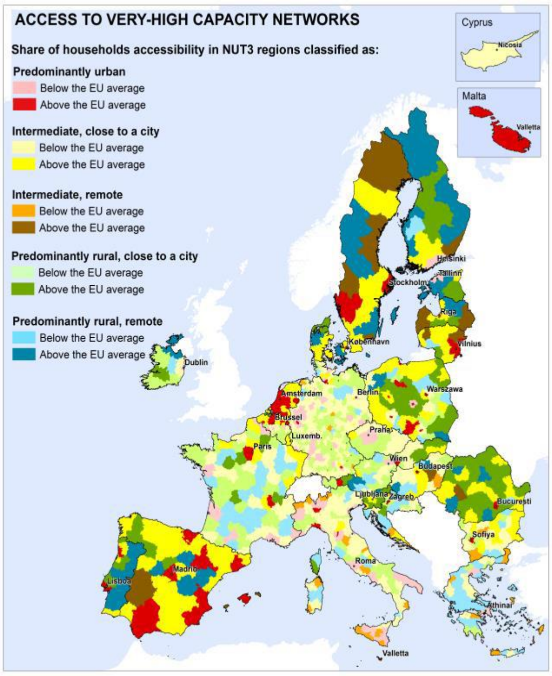

Figure 16: Percentage of households' accessibility to very-high-speed broadband (VHCN) coverage by urban-rural NUTS3 typologies, 2019

Source: Alberti et al., 2022

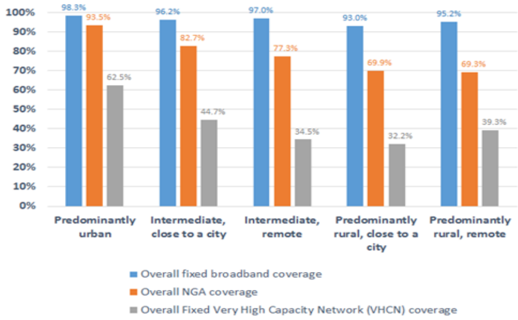

Figure 15: Household accessibility to fixed broadband, NGA and VHCN coverage per urban-rural NUTS3 typologies in the EU, 2019

Source: Alberti et al., 2022

2.5 The capacity of rural areas to respond to transition: a logical framework

Sections 2.2 to 2.3 have examined how macro-drivers and trends have affected Europe's rural areas within a context of strong differentiation. To interpret the interactions among transitions and rural areas' capacity to respond, a logical framework has been developed (Figure 17).

[9] Next-generation access refers to access broadband networks supporting speeds of at least 30 Mbps, whereas VHC Network refers to broadband networks supporting VHC speeds (where VCH – Very High Capacity Broadband connectivity is defined as speeds of at least 100 Mbps) (Cfr. European Commission Broadband Glossary)

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Transition is a dynamic process, relying on multiple interactions among different levels and proceeding as the outcome of multiple factors. The upper part of Figure 17 shows the two interrelated systems that influence transitions in many ways: the macro-economic context and the policy system.

Macro-drivers and trends act at the international level, and can generate shocks and risks, but also opportunities, at national, regional and territorial levels. The policy system can influence transition processes in different ways: by defining a set of goals (i.e. environmental goals to be reached by a certain period), and/or implementing regulations, incentives and advice/information campaigns which aim to facilitate and enable transition possibilities and pathways, etc. A fundamental role in supporting transition processes can be played by policies specifically targeted to transition challenges (see the next 2.6 paragraph) and/or focused particularly on those territories more sensitive to transitions (i.e. because they are unable to face transitions with own resources or because they are hard-to-reach with a generalised system of incentives).

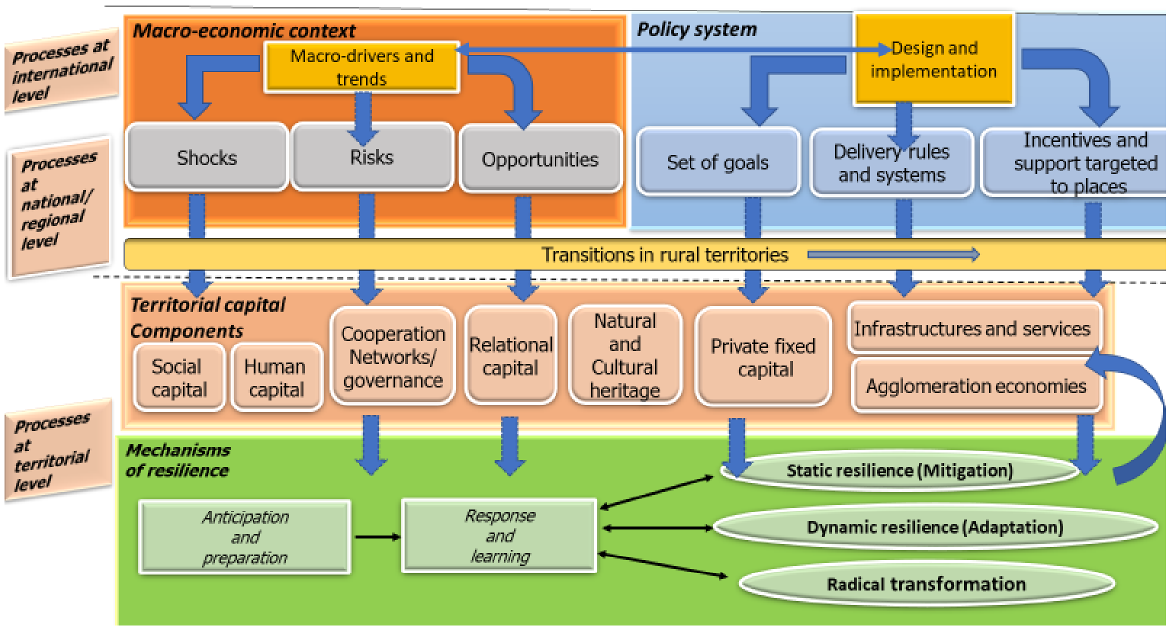

Figure 17 – Logical framework for transitions and capacity to respond to transitions

Source: authors' own elaboration

Different types of rural areas have different capacity to respond to shocks, risks and opportunities. Likewise, rural areas have different capacities to comply with and make use of policy transition goals, incentives and regulatory tools. Understanding whether and to what extent rural areas are ready to face transition means investigating their territorial capital. Rural areas' resilience largely relies on territorial capital and its various components; in the definition of these we principally refer to the theoretical framework developed by Camagni and Capello (2013).

To define the capacity to respond positively to external pressures, the concept of resilience has been used in various scientific disciplines. The concept of resilience applied to the territory, according to Sanchez-Zamora (2014), acquires a dual definition: a) static resilience, when a given territory responds to external pressures by returning to a level of equilibrium; b) dynamic

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resilience, when the territory creates or deploys new resources and capacities to adapt to change. Sanchez-Zamora, quoting Foster (2007), adopts a more operational vision by defining resilience as "*the ability of a territory to anticipate, prepare for, respond to, recover from and adapt to a shock or disturbance*". In a more recent work, Li et al. (2019, p. 139-140), emphasises three aspects of resilience; a) persistence, defined as "*capacity to buffer systemic shocks while conserving existing functions and structures*"; b) adaptability, defined as "*the capacity to deal with challenges such as uncertainty and surprise through renewal, reorganisation and learning within the current regime*"; c) transformability, defined as "*the capacity to create a whole new trajectory that is rooted in a radical change in the very nature of the system*". The authors conclude by defining these three stages in which rural areas respond in the changing external environment.

We adopt a similar conceptual approach in defining the different types of resilience (Figure 17). Furthermore, in our logical framework, the mode of resilience has feedback effects towards territorial capital components since local actor actions generate, in turn, positive/adverse impacts on some specific components over time (i.e., the introduction of new governance solution in the management of water resources improves the quality and quantity of natural resources for the local community).

To clarify this scheme, we need to explore what the available literature says about the different components of territorial capital and their influence on capacity to respond to transition challenges.

The capacity to respond to external pressure strongly relies on social capital, defined as "*the collective norms, trust and networks of affiliation [which] can reduce transaction costs, enhance people's access to information and resources, generate information spillovers, promote the transmission of knowledge and facilitate collective actions*" (Li et al., 2019, p. 138).

Regarding processes of socio-economic and sustainable transition, the importance of social capital has been widely studied in the most recent literature, as a relevant factor of social innovation (SIMRA, 2017; Bock, 2016). Municipalities with diverse internal relationships and strong external linkages are able to mobilise both internal and external resources to realise locally initiated actions and adjustments to respond to external changes (Li et al., 2019).

Regarding environmental transition, the capacity to respond is linked to levels of social capital and/or social learning, which can enable collective action across collaborative governance solutions at the local level (Adger, 2009; Mantino and Vanni, 2018; Hamilton and Lubell, 2019). Where actors share social norms and bonds, in addition to shared visions, individuals can be encouraged to cooperate and participate in local projects (Pretty and Smith, 2004; Broska, 2021). Social capital can be a strong motivator of pro-environmental behaviour in several sectors, including energy (Broska, 2021), water (Dean et al., 2016), and agriculture and land management (Pretty and Smith, 2004). Social learning improves the capacity of communities to learn about complex environmental issues and reach decisions on how to act (Pretty and Smith, 2004). Often, this will encourage individuals to support policies and local initiatives in their local area which are sustainable and can address environmental concerns (Dean et al., 2016; Mantino and Forcina, 2018; Broska 2021).

Cooperation networks and collaborative forms of governance represent a crucial mode to support mechanisms of adaptation to external changes.

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A significant number of studies have explored new forms of territorial cooperation that are emerging between rural and urban areas (rural-urban partnerships) to avoid over-exploitation and depletion of rural assets (land, soil quality, water, amenities and landscape, ecosystem services, etc.) and foster the valorisation of complementary functions (Copus, 2010). Rural-urban interactions find very different governance solutions across the European countries (Wood and Haley, 2017). However, a series of obstacles hampers cooperation: absence of trusting relationships, frictions between peripheral municipalities and the urban pole, power imbalances, inadequate financing and capacity constraints around personnel and time resources (Oedl-Wieser et al., 2020).

Other contributions emphasise the role of more formal mechanisms of social coordination such as contracts and employment rules: for example, market-oriented institutions where formal rules replace informal norms as a way of regulating relationships among workers and owners, producers and states (Li et al., 2019).

Hamilton and Lubell (2019) state that «*adaptive capacity is an emergent outcome of localised interactions distributed across polycentric governance systems*». They argue that no single, centralised institution can force actors to cooperate to design and implement policies and projects efficiently. Although regional level adaptation requires horizontal coordination, there must also be vertical co-ordination from local to global levels of policy making (Hamilton and Lubell, 2019). This will ensure local adaptation efforts receive appropriate financial support from international or national funding, which is particularly important in the less densely populated territories of south and eastern European regions (Aguiar et al., 2018). Municipal strategies must be supported by national policies that contain an element of flexibility, to ensure they can be adapted to local conditions.

Besides governance, human capital has been recognized as one fundamental factor of response to the climate and environment trends. An individual's inclination to act will depend on the information available to them and their understanding of the issues (Allred et al., 2022). For some, the impacts of climate change are a 'far away issue', which is unlikely to affect them in their lifetime (Talanow et al., 2021). The European Commission (2021b) states the contrary, arguing that by failing to act now, the cost of tackling climate change will continue to rise. The Commission therefore deems navigating the climate and environment transition the current generation's 'defining task', and as evidenced in documents such as *The Green Deal* and *The Long-term Vision for the EU's Rural Areas*, aims to ensure member states have the capacity to tackle the climate and environmental crises now.

To improve capacity at a municipal level, it is important that there is leadership from an individual who understands the complexity of the environmental challenge and the options available to them to make a difference at this level (Hoppe et al., 2014; Allred et al., 2022). Crucially, this individual must have the political motivation to act – where there is motivation to continue with business as usual, or support the status quo, then a municipality's capacity to respond to local issues is unlikely to improve (Hoppe et al., 2014). The continued development of the Covenant of Mayors for Climate and Energy (CoM) is promising in this regard (Tanneberger et al., 2021). When local governments join this initiative, they voluntarily commit to implementing EU climate objectives through bottom-up governance. The CoM provides its diverse membership with a common framework, through which they can implement and evaluate their climate actions (Covenant of Mayors, 2022). Creating a forum in which leaders may share best practices will allow smaller

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municipalities, who may not benefit from a given individual whose time is devoted to tackling climate issues, to benefit from knowledge exchange (Hoppe et al., 2014). Municipalities may access further advantages, such as networking to apply for funding opportunities, or boost local economic growth (Covenant of Mayors, 2022).

Other components of territorial capital that have been identified as of great relevance to facing transitions are the following (Camagni and Capello, 2013; Sanchez-Zamara et al., 2004; Li et al., 2019; Sikorsky et al., 2020):

- Diversified economies: territories with diversified economic activities are better prepared when faced with "shocks" and exhibit a higher level of resilience;
- Natural and cultural capital;
- Infrastructures and facilities.

2.6 Policies targeted to specific transitions (demographic, environmental and digital)

This section aims to explore more in detail how the policy system (the upper-right rectangle in figure 17) can address specific transitions.

Effective capacity to respond to transition might also rely on policies targeted to specific transition needs and/or to specific places. The second condition refer to the method of policy delivery. The quality of policy delivery also includes its ability to enable local actors and communities "*to make choices and transform those choices into desired actions and outcomes*" (Steiner, 2016). This is crucial for two reasons: a) to create an enabling policy environment for community-led initiatives; b) to allow new institutions and groups to emerge in less active places and facilitate action to address social, economic and environmental challenges (Shucksmith, 2012). In other words, enabling policies should help local actors and communities to develop and support transition resilience (Markantoni et al., 2018).

The effectiveness of strategies seeking solutions to demographic challenges depends both on political decisions and on territorial governance arrangements. In light of the evidence discussed in section 2.2, it is important that policy priorities focus on bringing together the numerous existing policy instruments and provisions, to achieve coherence and consistency (Copus et al, 2020). Demographic trends and governance were indicated as the most impactful and uncertain drivers in the foresight exercise carried out in the preparation of "A long-term Vision for the EU's Rural Areas" (European Commission, 2021b).

This requires, on one side, coordination of "*both growth-oriented and adaptation-oriented policy approaches, tailored to local conditions*" (ESPON, 2017) and, on the other, a shift "*towards a recognition of 'softer', more qualitative objectives in the realm of well-being*" prioritising equal opportunities, basic services, and "*more (spatially) inclusive rural development*". Podgorna et al. (2020) suggest that continued progress towards this goal requires optimised domestic socio-economic development policies. Such national policy initiatives have been developed in Spain (National Strategy to the Population Challenge, 2017), Italy (National Strategy for Inner Areas, 2012; Manifesto to Repopulate Remote Regions, 2020), Germany (National Commitment to Cope

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with Inequality and Population Shrinkage, 2020), Scotland (A Scotland for future, 2020) and France (Mission Document for Equal Chances of Rural Areas, 2020) to respond to rural demographic trends that influenced "*the evolution of wider rural development paradigms*" (Dax and Copus, 2022).

In particular, Italy and Spain territorial cohesion and reduction of depopulation in more vulnerable areas have been the core of place-based national programmes in marginalised areas. These national policies lie on two parallel and mutually reinforcing lines of policy action: increased access to basic services (education, healthcare, mobility) as a precondition of development, and the strengthening of local development.

Regarding the environmental transition, there must be vertical co-ordination from local to global levels of policy making (Hamilton and Lubell, 2019). This will ensure that local adaptation efforts receive appropriate financial support from international or national funding, which is particularly important in the less densely populated territories of south and eastern European regions (Aguiar et al., 2018). Municipal strategies must be supported by national policies that contain an element of flexibility, to ensure they can be adapted to local conditions. For example, Poland's transition from a conventional power industry to one characterised by renewable energies was hampered by national regulations in the wind sector. For the move from coal to be successful, Piwowar and Dzikuc (2019) argue that financial mechanisms and incentives will be required alongside awareness raising in rural areas. Even where residents may have an awareness of the environmental issues in their local area, Hoppe et al. (2014) found that funding must be provided for climate and environment action plans to be initiated, otherwise, they will be lost from local action plans completely.

In relation to recovering natural capital, Milculcak et al. (2013) argue that funding streams and policy measures are currently poorly suited to protecting existing biodiversity. They argue that, when states become EU members, there is a tension between implementing the rural development initiatives required and preserving and enhancing their existing biodiversity. However, there are many initiatives across member states which demonstrate that, when appropriately funded, farmers and land managers can continue to provide socio-ecological benefits whilst achieving other rural development goals. One such example is that of Austria's organic haymilk quality certification and marketing initiative (Nigmann et al., 2017, see also IfLS/CCRI 2017 for details of all PEGASUS case studies). Importantly, the Austrian approach continued to support the traditional agricultural practices which are essential for the maintenance of cultural landscapes and high levels of biodiversity (Nigmann et al., 2017), thus addressing Fischer et al.'s (2012) concerns regarding the impact of the loss of traditional practices on rural areas' adaptive capacity.

Regarding the digital transition, the Commission, together with the Member States, has to develop EU-level trajectories for each target under a 'Digital Compass'. This compass has four cardinal points: a digitally skilled population and highly skilled digital professionals; secure and performant sustainable digital infrastructures; digital transformation of businesses; and digitalisation of public services.

The Commission's commitment is important, as Codagnone et al. (2021) found that the achievement of digital targets will require significant reforms and investments at both European and national level. Crucially, their analysis found that several of the targets in the Digital Compass are over-ambitious. For example, a quantitative forecast demonstrated that three of the digital

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skills targets will not be achieved, despite experts and stakeholders considering this a key pillar for prosperity. Additionally, the results of the 2022 Digital Economy and Society Index show that despite significant digitalisation efforts, actions put in place by Member States cannot help closing the gaps in digital skills, digital transformation of SMEs and in the adoption of new technologies, such as Artificial Intelligence (AI) and Big Data technologies, and 5G networks (European Commission, 2021f).

To overcome these issues, Codagnone et al. (2021) argue for more coherence between policy packages to ensure objectives and targets remain consistent. To support the development of *high-performing digital education* across Europe, many initiatives and actions for digitalisation have been undertaken at European level, regarding training and awareness raising (Digital Skills and Jobs Coalition), digital literacy training (EU Code Week), education and competences (Digital Education Action Plan 2021-2027, and its Digital Opportunity Traineeships scheme), upskill and reskill of workforce (European Skills Agenda, Pact for Skills), basic skills of workforce (European Pillar of Social Rights Action Plan), and upskill of population and workforce (European Industrial and SME strategy, European Strategy for Data and Artificial Intelligence Coordinated Action Plan). Many other initiatives and actions heading in this direction are expected to be put in place at Member State level, including actions within the Recovery and Resilience Plans for digital skills training of pupils, teachers and adults, and digital proximity centres in more vulnerable areas. (European Commission 2021e). This commitment to training is essential, as Codagnone et al. (2021) argue that higher education institutions have been slow to react to market demand for courses that provide digital skills; thus, there remain an insufficient number of newly graduated digital specialists.

To ensure that strategies and initiatives put in place really benefit rural communities, digital transformation should go beyond closing gaps in skills and infrastructures. As acknowledged in Stein et. al (2022), most studies on rural areas' digitalization have a technology-oriented approach and "*the dominance of technology-focused endeavours even obscures the fact that areas follow their own specific path of development*". In the wake of this interpretation, policies are usually focused only on attainment levels and difficulties in digitalization in rural areas , thus overshadowing both the particular local context in which they are applied, and the role played by local actors and participatory approaches.

Communities "*respond differently to incentives to digitalisation*" therefore solutions have to be adapted to local problems and endowments adopting participatory and place-based approaches (Brunori et al, 2021). And thanks to this engagement, digitalisation affects the organisation of economy and society and changes the existing network of actors, reconfiguring economic and social relations (Brunori, 2022). Moreover, as highlighted by the European Commission (2022h, p. 39), albeit all 27 Member States include a digitalisation strategy for agriculture and rural areas within the new CAP framework, the support for digitalisation reveals different shortcomings, in particular limited consideration of digital technologies as enabling tool for other CAP objectives (particularly for environment, climate and rural-related objectives), limited focus on the development of digital skills which can help to close the digital divide, limited coherence between SWOT analyses, needs assessment and support to digital-related investments..

This evidence suggests that policy strategies in rural areas should put a stronger emphasis on governance and improved coordination and envisage proper pathways for digitalisation aimed not

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only to facilitate innovation for growth, but also to influence speed and direction of change according to specific local needs.

The above policies may influence the transition processes in Member States, both through defining goals and facilitating action in an enabling environment. It is also clear that social and economic investment across Member States will be vital in reaching policy ambitions. Although separated for the purpose of analysis, it is important to note that the three transitions are interlinked and, therefore, the impacts of transition-specific policies may reach beyond the transition at which they are aimed.

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2.7 Conclusions

This report responds to the needs set out in Task 1.1 of the RUSTIK project. To do so, it first conceptualises Functional Rural Areas through an analysis of existing literature on rural diversity. The definitions and criteria of five theorisations of 'functional areas' are evaluated and a five-step approach to classifying rural areas is developed. This approach will be trialled in RUSTIK's fourteen Pilot Regions. Classifying rural areas using this new typology will also require analysis of the production, consumption and ecosystem functions of the region. The report indicates specific functions in each of the three categories and proposes indicators for each function in Annex 1. Verifying these indicators and the associated information will involve the participation of local actors in each Pilot Region.

The macro-drivers and trends of the socio-economic and demographic, environmental-climatic and digital transitions are explored in section 2. In addition, the report considers the diverse impacts of these trends in rural areas across Member States. The factors influencing rural areas' capacities to respond to these trends are also considered, across a range of scales. A logical framework is developed to demonstrate the interactions between transitions and rural areas' capacity to respond; this framework includes consideration of the macro-economic context, the policy system, territorial capital components and mechanisms of resilience. The importance of the different components of territorial capital and a set of policies specifically addressing the transitions are also explored.

The report highlights the heterogeneity of rural areas and the need to appreciate place-based development paths. The overall aims of the European Commission in respect of the three transitions are explored in a general way, since a deeper analysis will be done in RUSTIK WP4. If they are to be achieved, greater attention must be paid to the capacity to scale-up successes at a local level with appropriate facilitation from Brussels and national governments. RUSTIK aims to improve understanding in each of the Pilot Regions for swift transition action and to take stock of the information and data available to actors which improves their capacity to respond. To do so, the rural typology and three functional categories will be tested in the fourteen Pilot Regions, and each will be asked to explore the policy drivers and capacities to respond to one or more of the three transitions. This process will simultaneously ensure the typology framework is robust and develop an advanced understanding of the characteristics, functionalities and capacities of the Pilot Regions in preparation for future Work Packages.

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3. Annex 1- List of functions and indicators

Function		Indicator	Source	NUTS level
Production	Agri-industrial	- % of total employment in primary activities	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % Utilised Agricultural Area (UAA) in total area	EUROSTAT; national statistics	NUTS2-3, LAU2
		- UAA per farm holding	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % of farm labour working full-time in farm holding	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % change rate of employment in food industry	EUROSTAT; national statistics	NUTS2-3, LAU2
	Forestry	- % of total area under forests	Rural Observatory/JRC, 2016	NUTS2-3, LAU2
		- % change rate of employment in forestry and logging	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % of employment in forest and forest-based industry	EUROSTAT; national statistics	NUTS2-3, LAU2
	Diversified economy (secondary sector)	- % of total employment in industry and construction	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % change rate of employment in industry and construction	EUROSTAT; national statistics	NUTS2-3, LAU2
	Diversified economy (tertiary sector)	- % of total employment in services and public administration	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % change rate of employment in services and public administration	EUROSTAT; national statistics	NUTS2-3, LAU2
Consumption	Leisure activities and tourism	- No. of overnight stays in hotels and similar accomodation (NACE group 55.1) per 1000 inhabitants	EUROSTAT; national statistics	NUTS2-3, LAU2
		- No. of overnight stays in holiday and other short-stay accomodation (camping grounds, recreation parks and trailer parks, NACE group 55.2 and 55.3) (NACE group 55.1) per 1000 inhabitants	EUROSTAT; national statistics	NUTS2-3, LAU2
		- No. of available rooms in accommodation establishments	Rural Observatory/JRC, 2016	NUTS2-3, LAU2
		- % of employment in hotels/catering	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % of ha under urban green leisure	Rural Observatory/JRC, 2016	NUTS2-3, LAU2
		- % of total area occupied by national/regional parks, reserves, and protected areas	EUROSTAT; national statistics	NUTS2-3, LAU2
			EUROSTAT; national statistics	NUTS2-3, LAU2
		- % of total area occupied by forests and semi-natural areas	EEA, 2018	grid resolution=500 mq
	Residential	- % ha under built-up area	Rural Observatory/JRC, 2016	NUTS2-3, LAU2
		- % ha under urban area	Rural Observatory/JRC, 2016	NUTS2-3, LAU2
		- % ha under infrastructures and industrial use	Rural Observatory/JRC, 2016	NUTS2-3, LAU2
		- density of rural settlement		
		- % of holding < 4 ESU	EUROSTAT and FADN	NUTS2-3
		- % of holdings with other gaining activities	EUROSTAT and FADN	NUTS2-3
	Provision of services of general interest (SGI)	- % of activities providing service to population on total activities	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % of social farming units on total farm holdings	EUROSTAT; national statistics	NUTS2-3, LAU2

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	Function	Indicator	Source	NUTS level
Ecosystem functions	Landscape and cultural heritage conservation	- % of total area occupied by forests and semi-natural areas	EEA, 2018	grid resolution=500 mq
		- % of abandoned agricultural land into the total agricultural land in 2030	JRC-LUISA territorial modeling platform, 2018	grid resolution= 1 kmq
		- % of organic cultivated area (under conversion+fully converted)	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % of organic livestock on the total livestock	EUROSTAT; national statistics	NUTS2-3, LAU2
	Maintaining/increasing biodiversity	- % of UAA farmed to generate High nature value (HNV) farmland	EAA-JRC, based on Corine land Cover, 2000 and 2012	
		- % rate of change in UAA in HHV 2000-2012	EAA-JRC, based on Corine land Cover, 2000 and 2013	
		- % of NATURA 2000 area on total area		
		- % of arable land with crop rotation	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % of total area occupied by biosphere reserves (MAB-UNESCO areas)	MAB-UNESCO	
	Soil protection and functionality	- Total soil organic carbon stocks in top soil (0-20)	JRC-LUCAS survey, 2018	
		- % of agricultural areas and natural grassland affected by moderate or severe soil-water erosion	JRC, 2010	
	Regulating water availability and quality	- % of land irrigable areas on total UAA	EUROSTAT; national statistics	NUTS2-3, LAU2
		- % of land irrigable on irrigated areas	EUROSTAT; national statistics	NUTS2-3, LAU2
		. Share of irrigation on total water abstraction		
		- Nitrates in freshwater (groundwater+surface water)		
	Climate change mitigation and adaptation	- GHG emissions (Gt CO2e)	JRC-EDGAR 2022	NUTS2
		- % change in wildfire burnt areas (ha)		
		- % change in drought incidence	Combined Drought Indicator	5km^2
		- % change in flooding events	JRC-EFAS	Grid from 100m to 50km
	Provision of sustainable energy	- Production of renewable energy from different sources/total consumption of energy in the region	Local statistics	
		- Bioenergy production on total energy production (%)		
		- Solar photovoltaic production on total energy productic		

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4. Annex 2- Variables/Indicators for the transitions

4.1 Variables/indicators used to describe the demographic transition

Demographic transition is a complex and multidimensional phenomenon and manifests differently across and within EU Member States.

Mainstream academic and political debates express a renewed interest in a more thorough understanding of population trends and ageing at local level and is highly focused on searching for more targeted responses and innovative solutions to reverse the negative trends. Demographic imbalances between areas have, in fact, direct negative implications on growth and quality of life and undermine socioeconomic cohesion, whereas policies impacting on demographic trends take time to obtain results.

According to Kirk (1996) demographic transition is the theory that states that modern societies "*progress from a pre-modern regime of high fertility and high mortality to a post-modern one in which both are low*", and when causes (socioeconomic, economic, institutional, cultural, etc.), timing and speed of transition are considered, then a great diversity emerges due to "*many possible combinations of nuptiality, fertility, mortality and migration at each stage of the transition*". The second demographic transition integrates sociological and economic component and explains a shift in wealth, education, self-realisation needs that made spatial outcomes more fragmented and unpredictable (Salvia et al, 2021; Lesthaeghe, 2014). The third demographic transition concerns the more developed countries and implies increasing mobility and migratory flows towards and great impact on labour market and welfare state. Therefore, demographic transitions are more heterogeneous outcomes and progressively less linked to geographical patterns.

It is, therefore, important to identify core indicators to examine the evolutionary paths of demographic trends, to grasp the diversity and, consequently, to inform the design of interventions to tackle the consequences of demographic dynamics shaping Europe. Studies and analyses across European Member States are mainly carried out at NUTS 2 and NUTS 3 level for reasons of data availability and comparability, but LAU-level analysis is more appropriate to bring out the differences between different areas within countries.

Basic indicators to assess demographic trends are usually derived by Censuses and are available at census years in all countries per individual municipality, but intercensal adjustments are made yearly. Main indicators used are population size, births and fertility, mortality, migratory movements (origin or destination). From these, other indicators can be derived: population density, population growth, share of population structure by age and/or sex, ageing index, elderly index, structural dependency indexes, active population, as detailed in the following table.

Indicator	Formulation	Source	NUTS level
Population	Total number of people residing in an area at a given time	EUROSTAT; national statistics	NUTS2-3, LAU2
Population density	Population/km^2	EUROSTAT; national statistics	NUTS2-3, LAU2

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Indicator	Formulation	Source	NUTS level
Population growth rate	Average annual rate of change of population size during a specified period	EUROSTAT; national statistics	NUTS2-3, LAU2
Total fertility rate	Mean number of children who would be born to a woman during her lifetime	EUROSTAT; national statistics	NUTS2-3, LAU2
Birth	Total number of births occurring in a population during the year (includes both live births and stillbirths)	EUROSTAT; national statistics	NUTS2-3, LAU2
Life expectancy at birth	Mean number of years a newborn child can expect to live if subjected throughout his or her life to the current mortality conditions, the probabilities of dying at each age	EUROSTAT; national statistics	NUTS2-3, LAU2
Life expectancy	Mean additional number of years that a person of a certain age can expect to live, if subjected throughout the rest of his or her life to the current mortality conditions . It is expressed as the number of years persons of different ages may expect to live starting from age zero	EUROSTAT; national statistics	NUTS2-3, LAU2
Mortality	Number of deaths that occur in a population for a given area during a given period	EUROSTAT; national statistics	NUTS2-3, LAU2
Natural population change	Difference between live births minus the number of deaths	EUROSTAT; national statistics	NUTS2-3, LAU2
Migration	Total number of migrants, people changing their residence to or from a given area (usually a country) during a given period (usually one year)	EUROSTAT; national statistics	NUTS2-3, LAU2
Immigration	Number of persons that establish usual residence in a territory (usually a country) for a period that is expected to be of at least 12 months, having previously been usually resident in another territory	EUROSTAT; national statistics	NUTS2-3, LAU2
Emigration	Number of persons having previously been usually resident in the territory (usually a country) that ceases to have usual residence in that territory for a period that is expected to be of at least 12 months	NUTS2-3, LAU2	NUTS2-3, LAU2
Net migration	Difference between the number of immigrants and the number of emigrants (plus statistical adjustment)	EUROSTAT; national statistics	NUTS2-3, LAU2
Young age dependency ratio (1st variant)	Population 0-14/Population 15-64	EUROSTAT; national statistics	NUTS2-3, LAU2
Old age dependency ratio (1st variant)	Population 65+/Population 15-64	EUROSTAT; national statistics	NUTS2-3, LAU2

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Indicator	Formulation	Source	NUTS level
Median age of population	The age that divides population in two groups numerally equal, younger and older	EUROSTAT; national statistics	NUTS2-3, LAU2
Ageing index	Population 65+/Total population	EUROSTAT; national statistics	NUTS2-3, LAU2
Elderly index	Population 65+/Population 0-14	EUROSTAT; national statistics	NUTS2-3, LAU2
Structural dependency index	(Population65+) + (Population 0-14) /Population 15-64	EUROSTAT; national statistics	NUTS2-3, LAU2

Source: our elaboration on Eurostat definitions

4.2 Variables/indicators used to describe the environmental transition

The indicators used in the assessment of environmental change have a substantial impact on the results. Froemelt et al (2017) state that these indicators must be chosen and used consistently to ensure comparative data is captured. The following section will describe some key indicators and the level at which they may be used.

For the purpose of analysis at a global scale, the *Transition Performance Index* (TPI) was developed. Prevost et al. (2021) acknowledge that the scale of the environment crisis justifies the inclusion of the environmental transition as a central element of the Transitions Performance Index. The TPI provides the following indicators for the environmental transition:

- Emissions reduction (Gross greenhouse gas emissions (tonnes per capita))
- Biodiversity (Terrestrial key biodiversity areas protected (%), freshwater key biodiversity areas protected (%), pesticides use per area of cropland (kg/ha))
- Material use (Resource productivity (PPP$ per kg), material footprint (tonnes per capita))
- Energy productivity (Energy productivity (PPP$ per koe))

The indicators provided above are used for global analyses, in which transitions are considered in a holistic manner. At a European level, the European Commission has developed a suite of indicators for monitoring the implementation of the CAP. These indicators are presented on a dashboard and are used annually to assess the general trends that may influence the implementation, achievements, and performance of the CAP (European Commission, 2023f).

The CAP indicators include Environment and Climate Action thematic indicators (summary of EU expenditures devoted to environment and main land use indicators, see Figure 33) and Climate Change and Air Quality thematic indicators (GHG and ammonia emissions from agriculture and CAP measures' contribution to climate action), Water Quality and Availability (pressures on water and CAP contribution to improved water management), Soil Quality (mapping of soil conditions and CAP contribution to soil quality preservation) and Biodiversity (overview on biodiversity monitoring and CAP contribution to biodiversity protection) - each of these themes is broken down into several indicators, which are displayed on an interactive dashboard on the European Commission's website. Data is available for the years 2015-2020.

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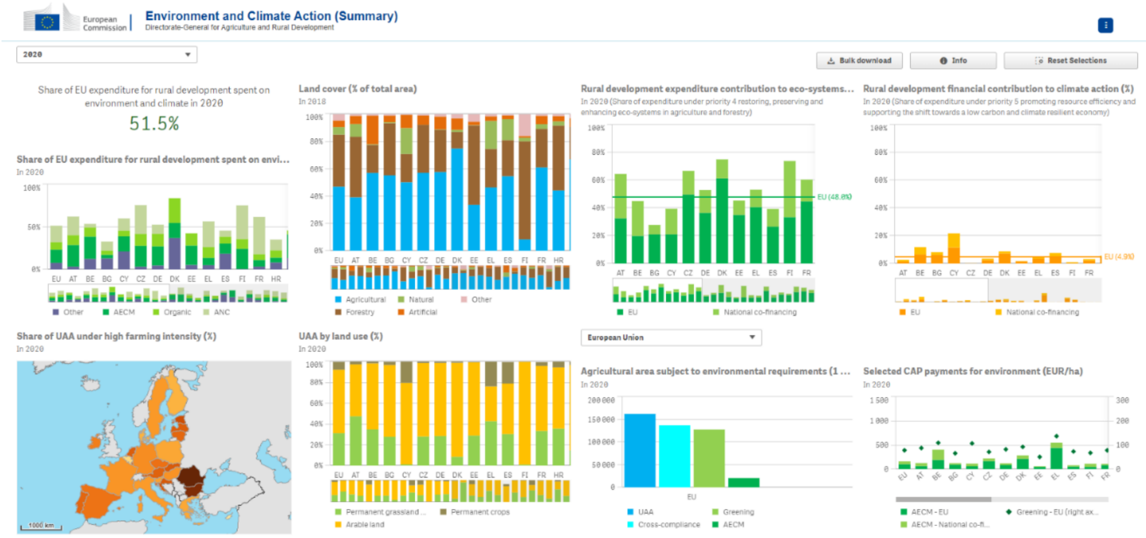

Figure 33: The Environment and Climate Action indicators (European Commission 2023f)

A further 17 context indicators are provided; these provide information on agricultural and rural statistics as well as general economic and environmental trends, some of which is available at the regional level (NUTS 2-3). For example, Figure 34 Shows the varying land cover across the continent, based on CORINE data from 2018.

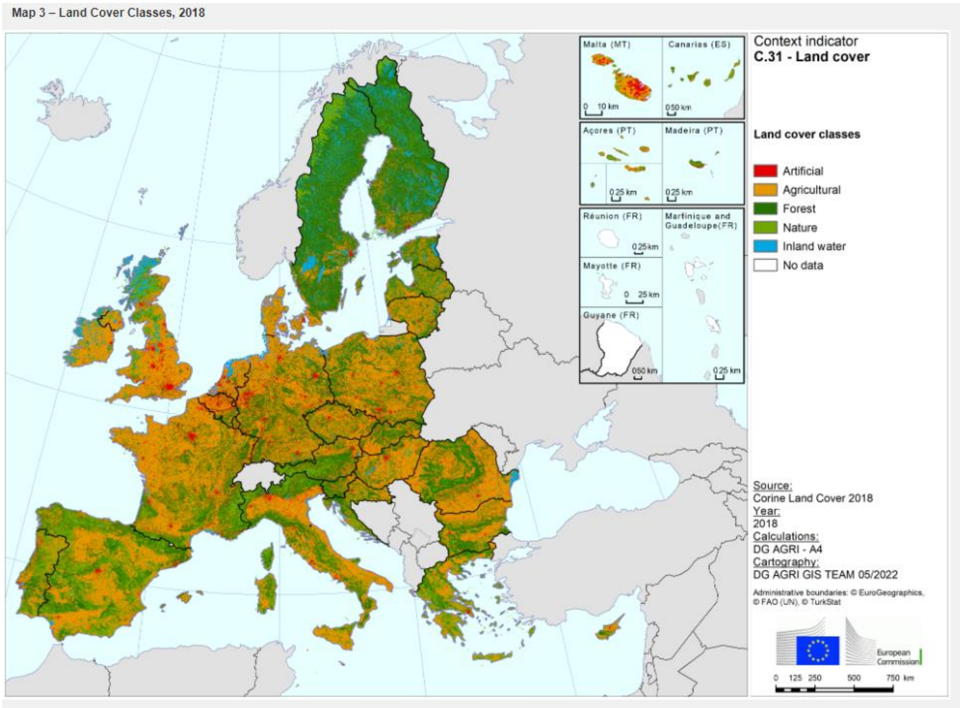

Figure 34: Land Cover Classes, 2018. (European Commission, 2023f)

There are many factors which contribute to landscape dynamics; therefore, it is important to use tools which capture as many of these as possible. The LUISA territorial indicators may be used to assess land use change at various geographical resolutions. These indicators can be grouped

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under six different land functions to aid cross-sectors integration and reflect the complex system dynamics under which this change occurs (European Commission, 2023g). The LUISA Base Map 2018 shows land use cover in Europe; this map is available to all who wish to examine land use across Europe in fine spatial and/or thematic detail and accounts for existing European policies and legislation (Castillo et al., 2021; Pigaiani and Batista e Silva, 2021). Castillo et al. (2021) use LUISA to model agricultural land abandonment at the European level, but also to examine land abandonment in relation to the type of land at the local level for the whole European territory (see Figure 35).

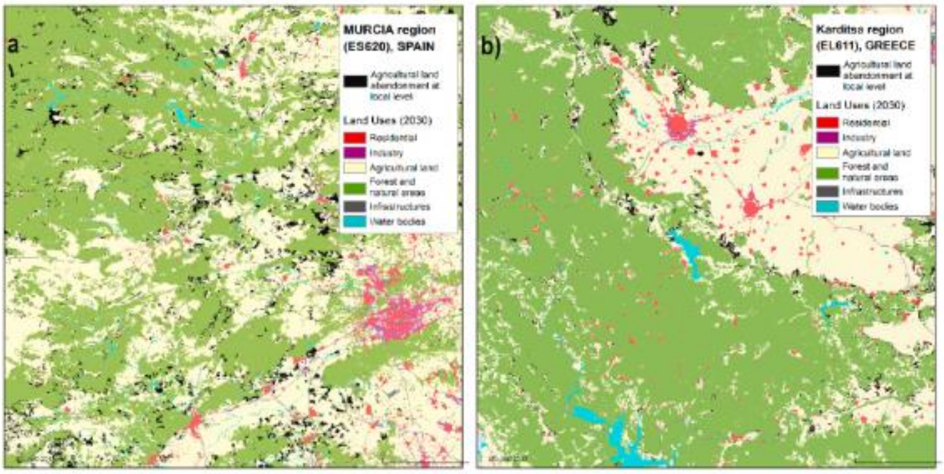

Figure 35: Black polygons represent land abandonment overlapping other land uses, in maps created by Castillo et al. (2021).

Land use may be assessed in other ways. For example, Kuemmerle et al (2016) assessed the changes in the extent and management intensity of land use across Europe. To do so, they compiled a database of land use change indicators (such as changes in area of cropland) from the CAPRI database and CORINE maps. To calculate changes in intensity, they collected data from the CAPRI database, grazing intensity maps and roundwood production maps. Based on the spatial differentiation they observed, they concluded that spatially-explicit assessments of land use dynamics are important in regionalised land-use policy making.

Van der Sluis et al (2019) adapt Holmes' (2008) Multifunctional Transition framework and suggest that it is another useful tool for capturing land use change. This framework considers two key systems which we must address in the environmental transition: production and consumption – and allows for the analysis of change based on several indicators including land use, land cover and land structure (the size, shape and arrangement of landscape elements). In their research, van der Sluis et al (2019) defined nine categories of landscape transition, based on the results in their six case study areas and assessed how these transitions affected the landscape services provided. They too, mention CORINE maps, but suggest that these may only provide an approximation of the transitions. For more detail, they recommend using a case study approach to capture the change processes observed at a local level, using aerial photographs or satellite imagery of the areas under analysis. In their research, they used map analysis and field inventories to assess the change in landscape services; however, they also refer to techniques employed by other researchers including map data and point observations (Gulickx et al., 2013);

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participatory mapping (Van Berkel and Verburg, 2014); and field surveys and map analysis (Crouzat et al., 2015).

Member states are required to prepare an annual, national GHG inventory which is submitted to the European Commission and the European Environment Agency. The methods used to estimate GHG emissions and removals are defined in the 2006 IPCC guidelines for national GHG inventories; these guidelines provide a comprehensive list of the ways in which emissions may be measured in the energy, industrial, agricultural (and other land use), and waste sectors (Figure 36). The figures contributed by these assessments are available to view on the EEA greenhouse gases data viewer (European Environment Agency, 2023b), which includes an indication of the EU27's annual emissions (ktCO2 equivalent).

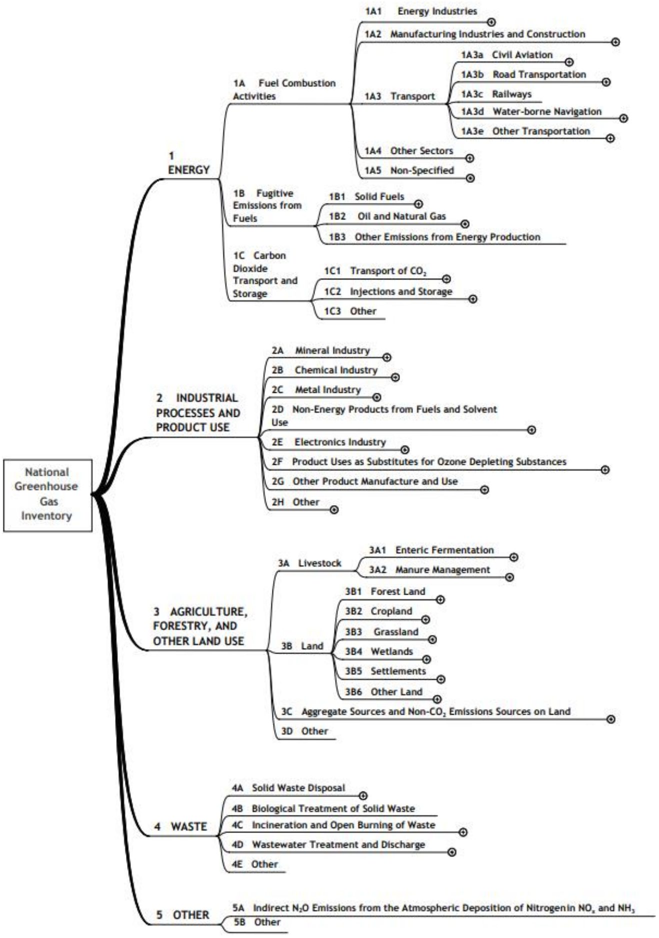

Figure 36: The main categories of emissions by sources and removals by sinks (IPCC, 2006).

Froemelt et al (2017) provide an alternative approach to estimating the emissions of a municipality, using two measurements for their case study's carbon footprint: a consumption-based footprint (CBF) and a footprint based on purely geographical accounting (PGA). Both approaches required energy and material flows within the municipality to be calculated through surveys, energy bills and municipal statistics, before the GHG emissions were estimated from process-based Life Cycle Inventory databases (see Froemelt et al. 2017: 95-96). Through their

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case study in Zernez, Switzerland, they demonstrate that the data generated by these approaches may be used by a municipality to address emissions issues, as areas where GHG emissions may be reduced are identified. For example, the approach may be utilised to address the energy performance issues in buildings. This approach could usefully be adopted by member states to ensure they are able to meet the renovation targets in the Energy Performance of Buildings directive.

With regards to energy production, spatial planning will be essential in ensuring future sites are effectively positioned and coherently integrated into municipal planning. Poggi et al. (2018) explored the impacts of renewable energy installations in Portugal. They recommend the use of ArcGIS' 'Solar Analyst' layer to enable the measurement of sunlight incidence, and in turn explore a given location's potential for generating energy through PV installations. In addition, they map wind intensity to determine the best potential sites for wind farms. These indicators may be used in conjunction with the LUISA base-map to better understand where renewable energy installations should be sited.

Quantifying biodiversity is not a straightforward task, and Purvis and Hector (2000) argue that it is not possible to reduce diversity to a single number. Rather, they suggest that multiple measures including species richness and species diversity must be correlated to ascertain dimensions of diversity. As with land use, scale matters: it is as important to assess the underlying processes affecting species at smaller scales as it is to understand large-scale patterns of change (Purvis and Hector, 2000). The European Commission (2023h) maintains an EU Biodiversity Strategy Dashboard which shows the available data for each of the targets of the *EU Biodiversity Strategy 2030*. This dashboard builds on the environmental indicators employed in EU Environment Policy Reviews. Current indicators include the percentage of land under protected area coverage, the percentage of land under Natura 2000 designation, marine protected area coverage, a common bird index, a grassland butterfly index, and the area under organic farming. Further indicators for other targets within the *EU Biodiversity Strategy 2030* remain under development; their use should be continued to ensure a holistic picture of biodiversity is developed across Europe and the impacts of changing biodiversity on ecosystem processes are captured. This may include employing model-based decision support, such as those explored by Zurell et al. (2022). In addition to the Dashboard, the European Commission maintain an Actions Tracker. This tool is designed to track the progress of member states towards the targets set out in the *EU Biodiversity Strategy 2030.*

4.3 Variables/indicators used to describe the digital transition

A considerable work on digital variables and indicators has been made at European level. Some indicators exist already, some others are to be defined or identified, however it is relevant that there is a definition of comparable indicators that eases cross-country comparison.

The following Table lists and explains variables and performance indicators used to define and monitor the targets of Europe's Digital Decade for each of the four areas of interest: digital skills, digital infrastructures, digital businesses, digital public services.

Indicator	Description	Baseline	Target	Data source	Level
DIGITAL SKILLS					

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Indicator	Description	Baseline	Target	Data source	Level
Basic digital skills*	Percentage of adult people aged 16-74 with 'basic' or 'above basic' digital skills in each area of the Digital Competence Framework	56%	80%	Eurostat Community survey on ICT usage in households and by individuals	Member State level
ICT specialists*	Percentage of the workforce employed as ICT specialists (broad definition based on ISCO-08 classification, includes jobs such as ICT service managers, professionals, technicians, installers and servicers)	8.4 million employed ICT specialists (19% women)	20 million employed ICT specialists and convergence between women and men	Eurostat labour force survey	Member State level
DIGITAL INFRASTRUCTURES					
Gigabit coverage*	Percentage of households covered by a network capable of gigabit speeds	59%	All European households will be covered by a Gigabit network	'Broadband coverage in Europe' studies by IHS Markit, Omdia and Point Topic	Member State level
5G coverage*	Percentage of populated areas, including the most remote regions, covered by at least one 5G network	14% of populated areas	All populated areas	'Broadband coverage in Europe' studies by IHS Markit, Omdia and Point Topic	Member State level
Cutting edge Semiconductors	Production of cutting-edge and sustainable semiconductors in Europe including processors	10% of world production in value	double EU share in global production and arrive at least to 20% of world production	SIA/ESIA, World Semiconductor Trade Statistics (WSTS)	
Data - Edge & Cloud	climate-neutral highly secure edge nodes	Not yet available	10,000 climate-neutral highly secure edge nodes distributed in a way that will guarantee access to data services with low latency (few milliseconds) wherever businesses are located	Annual study on edge deployment under CEF2 (as of 2022); European industrial technology roadmap for the next generation cloud-edge offering of 7 May 2021	

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Indicator	Description	Baseline	Target	Data source	Level
Quantum computing	first computer with quantum acceleration paving the way for Europe to be at the cutting edge of quantum capabilities by 2030	Not yet available	first computer with quantum acceleration	–	–
DIGITAL TRANSFORMATION OF BUSINESSES					
SMEs with at least a basic level of digital intensity*	percentage of SMEs using at least four of 12 selected digital technologies[10] (Late adopters)	60%	more than 90% of SMEs should reach at least a basic level of digital intensity	Eurostat Community survey on ICT usage and e-commerce in enterprises	Member State level
Take up of digital technologies*	percentage of enterprises using at least two artificial intelligence technologies (Tech up-take)	26% for medium-high sophistication cloud services ("advanced") 14% for big data take-up 25% for Artificial Intelligence take-up	75% of EU companies using computing services, big data and Artificial Intelligence	Eurostat, IPSOS	Member State level
Unicorns*	sum of realised 'unicorns' and unrealised 'unicorns'[11] (Innovators)	122	grow scale-ups and access to finance leading to double EU Unicorns	Dealroom	Only EU level
DIGITALISATION OF PUBLIC SERVICES					
Key Public Services*	Online provision of key public services for citizens: degree to which people can complete major procedures with the public administration completely online	75/100% (citizens)	100% online provision	e-government benchmark studies by Capgemini	Member State level

[10] The list of technologies varies every year.

[11] Realised 'unicorns' are companies founded after 1990 that have had an initial public offering (IPO) or trade sale above USD 1 billion; unrealised 'unicorns' are companies that were valued at USD 1 billion or more in their last private venture funding round, meaning the valuation has not been confirmed in a secondary transaction. *Cfr* European Commission 2021e.

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Indicator	Description	Baseline	Target	Data source	Level
	Online provision of key public services for businesses: degree to which businesses can carry out various steps in dealing with the public administration completely online	84/100% (businesses)	100% online provision	e-government benchmark studies by Capgemini	Member State level
e-Health	Access to medical record (electronic health-records, EHRs)	Not yet available	100% of citizens should have access to medical records online	–	Member State level
Digital Identity	Use of digital ID solution	Not yet available	80% of citizens should have access to digital ID	–	Member State level

** Currently existing Key Performance Indicators (KPIs)*

Table xx – Digital Decade indicators and targets

Source: Authors elaboration on data from European Commission, 2021e

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