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RUSTIK

REPORT AND GUIDELINES FOR LL ON DATA SOURCES, COLLECTION METHODS, INFORMATION SYSTEMS AND ANALYTICAL METHODS FOR IMPACT ASSESSMENT *(D2.1)*

MCRIT Multicriteri

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Report and guidelines for LL on data sources, collection methods, information systems and analytical methods for impact assessment

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	SEN	Sensitive, limited under the conditions of the Grant Agreement	

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Introduction

Based on outcomes of task 1.1 (D1.1) that identified concepts related to functional rural areas and transitions, and suggested relevant indicator sets to address such concepts, Deliverable 2.1 then sets the base for implementing the concepts and indicator sets from data available today, or that potentially obtainable through innovative data collection methods.

Deliverable D2.1 conducted a state-of-the-art review on methods and technologies used to gather data and information suitable for RUSTIK, and in particular, suitable for tasks to come in WP3 Living Labs and European indicators in WP4.

The most has been taken from the thematic expertise fields of the contributing partners in order to create a report that sets the basis for data collection, design of data bases and preparation of Living Lab activities.

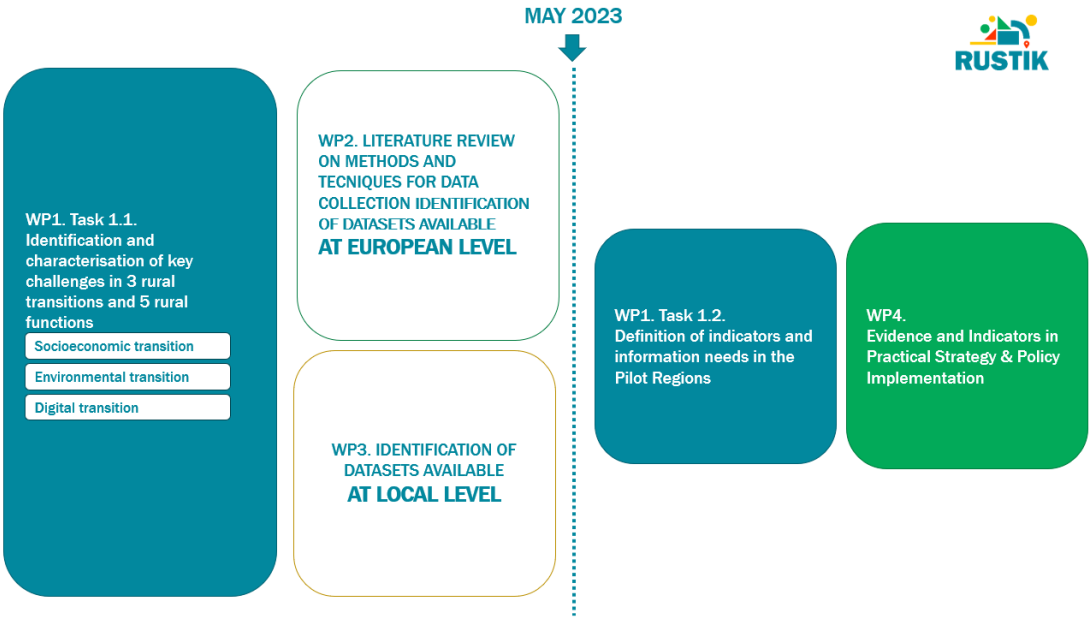

Figure 1: Fitting of the 2.1 deliverable in relation to the related RUSTIK work packages.

In Chapter 2, a literature overview of practices of information access, communication channels, and preferences of stakeholders in local development processes is carried out. In this chapter, an exploration on the understanding on how practices can help local governments and development practitioners to effectively engage with stakeholders and ensure their participation in decision-making processes is conducted.

Based on the review of a selected set of papers, Chapter 3 focuses on the translation of functional rural areas and transitions into suitable indicator sets. This chapter explores specific problems related to the RUSTIK transitions topics, develops sets of indicators, and uses various sources of data and methods of analysis with the purpose of suggesting evidence-based scenarios and particular strategies to facilitate decision-making at different policy levels.

In the following chapter, bottom-up data collection and citizen science techniques to retrieve data on socio-economic and demographic, climate-environmental, and digital transitions are presented. This section is structured bottom-up, from the local scale to the European. Methods such as social networks, crowd sourcing, and citizen science in general are explored.

To continue, Chapter 5 reviews how PPGIS methods can be used to collect map-based data in rural areas and how this can fill identified data gaps in relation to the rural transitions. Specifically, this section draws on how the use of PPGIS can be applied within the transitions identified in Task 1.1 (D1.1).

Chapter 6 conducts a state-of-the-art review on methods and technologies used to gather relevant data and information to design and assess policy-impacts on rural areas at national and European scale. These methods are reviewed and their scope, suitable scales, implementation procedures, cost estimations, and technological and skill requirements are described. This includes novel data sources applicable in the national and European scales.

The review on methods and technologies is complemented in Chapter 7 with a focus on novel data processing technologies (Data Cubes, AI and Machine Learning), on data collection tools at different scales (UAVs and Small Satellites) and on remote sensing technologies and sensors (Radar, LiDAR and Hyperspectral).

Lastly, in Chapter 8 the analysis of data requirements for policy design, and assessment methods and tools particularly focused on rural areas, such as agent-based microsimulation and participatory deliberative processes, and the analysis on how raw data and information are represented, visualised, and embedded into politically meaningful reports is also covered.

1. Literature review on rural change and rural classification. Review of rural classification methodologies.

Drawing on the state-of-the art review of literature on Task 1.1 (D1.1), this chapter further develops the discussion about rural change and rural areas definition, as well as the characterisations of the transitions. Specifically, notions of rural change and rural classification are further analysed, as a basis for the review of data sources and collection methods that seek to reflect rural functionalities, transitions, and resilience.

1.1. Introduction: Rural Functional Areas and Regions

Whenever a region is intended to be delimited, two basic questions should be addressed to understand the essence of the applied region's notion (Mazur and Mazurek 2020):

- For what purposes a region is being distinguished.
- What is the decisive factor for its cohesion and distinction with respect to a broader space?

With respect to the objective of identifying a region, Kazimierz Dziewoński (1967) makes three basic distinctions: regions as an **instrument of study**, as an **instrument of action** and as an **object of cognition**.

The first of these meanings arises from the process of analysis of the areas (Wróbel 1965), featuring relatively homogeneous characteristics, taking the form of a **taxonomy of the geographical space**. The boundaries of the region, are designed flexibly, so they can be adapted in the best possible manner to the spatial differentiation of the analysed space.

In the second sense, region is an organisational unit, as in the case of administrative units or countries. This sense of the region is the most applicable in terms of initiation, supporting and controlling the territory-specific development processes, although, at least before common acceptance of FRA's definition and the precise ranges of each individual FRA region, it is much less applicable for FRA analysis. The reason for this statement is that boundaries of such regions' are formal and pre-defined. At the same time, the concept of FRA is not necessarily coincident with administrative boundaries but often goes beyond these.

The third meaning of the term region constitutes a definite spatial unit, which is distinguished by its unique features, as a concept. Its unique character causes that cognition of the region ought to be individualised, adopted to its specific features. This sense of the region can be applicable for FRAs analysis when their imprecise nature of unclear boundaries is accepted and in-depth study (e.g. Living Labs) is a priority. Defining a region as an object of cognition usually leads to the identification of the uniqueness of the particular regions. Based on a contemporary literature survey, it can be stated that Dziewoński's distinctions remain still valid.

The second of the fundamental questions concerning the understanding of the notion of region refers to the role of its **internal structure** and **factors of cohesion**, which are applied as a criterion to identify the regions. The nature of **areal** (or zonal) regions is the basis for undertaking studies on distinguishing artificial, relatively homogenous spatial units, which form an area of similarity regarding a given feature and the subject to detailed analysis. However, this stays in opposition to regions called **functional** or nodal, which are not solely the research objects, but which have a relatively closed nature strengthened by the internal functional-spatial

links and which exist objectively in geographical space (Hartshorne, 1959). It is exactly these internal links that are decisive for the identity of the inhabitants of the region, the area of their economic and social activity, and only in further course, over a longer time horizon, this complex, but relatively closed functional-spatial structure may lead to the formation of the unique features, distinguishing a given region from the other ones.

The parallel functioning of these two ways of conceiving a region results in the essential differentiation of research approaches applied in the studies on regions. Areal regions, by virtue of definition, are characterised by relative internal homogeneity, and a description of their internal spatial structure appears to be unjustified. The range of Functional Urban Areas is usually defined by means of intensity of various relationships and flows between core and neighbourhood (e.g. commuting and migration directions and intensity, public transport network accessibility and frequency etc.). However it should be noticed that the parallel with FRA is not complete in this regard. When we neglect the relationship between rural area and an urban centre, the internal spatial structure of FRA is not an essential issue. In such cases, the criterion of FRA's internal similarity become a crucial one, as it may indicate co-functionality of given area (e.g. development of adjacent rural areas based on advantageous natural conditions for tourism or agriculture). Therefore, contrary to the nature of FUA, one can agree to perceive FRAs as areal regions.

The aim of this report is to define the concept of territorial classification and typology and to systematize the practical variants of the method, as well as to identify the possibilities to apply this method for the purpose of defining Functional Rural Areas. Taking into account that a local system of notions and methods (adjusted to particular purposes of the given research) is already proposed in several literature and applicable studies, the RUSTIK project will also ambition to compose a consistent system.

1.2. Methods of the rural space taxonomy

The usefulness of taxonomy of geographical space in rural research results from the fact that it is an efficient and objective method of synthesizing specific information. The idea of geographical space taxonomy according to some features is related to the observation that Tobler's first law of geography: *everything is related to everything else, but near thing are more related than distant things* (Tobler 1970), can be deployed, because spatial units constituting homogenous functional types are more related than their neighbouring units which are classified into different functional types. Recently, the practical need for classification of rural areas has been additionally reinforced by a territorial approach in development policies, including the current financial perspective 2014–2020, under which the distribution of funds depends on, inter alia, type of rural areas (Mazur and Czapiewski 2016). The taxonomy of geographical space is usually called classification or typology. However, two meanings of the commonly used term of classification need to be distinguished. The notion of **classification** in the **broad sense**, is equivalent to the notion of 'taxonomy of geographical space' and will be further called '**territorial classification**'. On the other hand, the notion of **classification** in the **broad sense** includes only synthesis of the already existing set of some indivisible items of geographical space (spatial units). When the notion of classification/typology does not cover the issues related to determination of the spatial units size and delimitation method, this excludes the entire procedure of their definition (regardless whether it is needed or not), it will be called '**classification of spatial units**' (Mazur and Czapiewski 2016). It is also worth to mention, that in colloquial use the meaning of the notion of classification/typology, regardless of whether it is

used in the broad or strict sense, is narrowed down also from the meaning of the entire method as a procedure to the context of its final product only (e.g. map with results). The methods of the rural space taxonomy can rely on the synthesis in two basic dimensions: a spatial and a descriptive one.

1.3. Synthesis of rural space: Regionalization

The first of these dimensions relies on the identification of some disjunctive and internally continuous parts of space, called regions, which are relatively homogenous or coherent and can be studied further as indivisible records. This procedure is called **regionalization**. Although in practice, the process of defining spatial units to be investigated can often be skipped, as such, it should be treated as an inherent, important part of a territorial classification/typology. It significantly determines obtained results and, in the case of certain types of classifications, also the set of criteria and categories. Due to data availability issues and the applicability of the results, the units of national administrative divisions at different level are foreseen as the most adequate subset of spatial units being studied in details as FRAs in RUSTIK project. Therefore the regionalization procedure is not an obligatory in this case.

1.4. Synthesis of rural space features: Classification and Typology of spatial units

The synthesis in the second dimension relies on identification of some relatively similar subsets of spatial units, which are the effect of previous regionalization or just taken as some predefined set (e.g. units of administrative division at certain level or of spatial aggregates of available statistical data). Assessment of the spatial units' similarity is conducted by means of their attributes, which can vary from soft features expressed by text to formal indexes of different complexity level, which are based on quantitative data.

Not all authors of spatial unit classifications make an explicit distinction between the terms classification and typology. If those terms are not used interchangeably, a variety of criteria are used to distinguish between them and characterise their relations. Classification is sometimes treated as a special case of typology, which meets the condition of assigning exactly one type to each spatial unit. However, in numerous cases the relation between the two notions is reversed, since classification is treated as a more general concept, and typology is its special case meeting additional conditions, i.e. simultaneous coverage of numerous characteristics of the analysed phenomenon. The variety of the contexts can lead to confusion. Regardless of a lack of commonly agreed definitions, it should be necessarily defined (at least) for the purposes of the RUSTIK project to avoid misunderstanding.

Therefore, the **classification of spatial units** will be understood as a method consisting in organising the set of such units based on a set of general classes with generalisation of their specific characteristics, fulfilling the condition of assigning exactly one element from the set of classes (uniqueness) to each element from the set of spatial units (completeness) (Mazur and Czapiewski 2016). However, for the completeness and uniqueness conditions to be met at the same time, the set of classes must meet specific conditions. Due to the need to assign at least one class (completeness) to each analysed spatial unit, the set of criteria used for determining the set of classes should cover the entire empirically identified scope of variability of the analysed set of characteristics. In view of the need to assign maximum one class (uniqueness)

to each analysed spatial unit, the set of classes should include disjoint or hierarchically organised elements (e.g. to consider as of rural tourism function predominance only these spatial units, which have not met the criteria of urban areas). Spatial unit classification should be therefore treated as a systematic task consisting in two actions:

- → Determination of a set of disjoint classes covering the entire scope of variability of the analysed combination of characteristics, according to which the set of spatial units will be systematized.
- → Determination of a function assigning the set of analysed spatial units to a set of classes, based on characteristics of those units.

The special case of classification, when identified final subsets (categories) of spatial units are multidimensional and qualitatively diverse, will be called **typology of spatial units** (Mazur and Czapiewski 2016). Therefore, in opposition to classification, the typology function is not assigning a set of classes being a category of one characteristics, but a set of types, which constitutes a model of configuration of more than one analysed characteristics.

In each of these two cases of rural space synthesis, as well as in the common case of combining both, the synthesis ends up with model of the rural space, which simplifies it in order to allow for better understanding by neglecting the local specificity.

1.5. Types and examples of rural area classifications

Sustainability in Agriculture and Rural Development (SUSTAG) action of the AgriLife unit (IPTS institute) set up its research agenda for the support of the European Rural Development Policy in the area of socio-economic analyses of functioning of rural areas and the policy impact assessment in 2006. It introduced the issue of a spatial perspective of the assessment of rural development and policies in European strategic documents as essential. The particular concerns are to provide characterisation of rural areas (strengths and weaknesses, functioning, long-term trends, economic integration) with the effort to define a “typology” of rural areas. In parallel, the research agenda on rural development policy assessment assumes to review, select, further develop and apply modelling tools with a regional break down for simulating/evaluating the functioning of the rural economies and the impact of rural development policies in different types of rural areas (Copus et al. 2008). It increased demand for rethinking basic notions and definitions in this regard as well as for applying methodology of rural space by means of synthesis of reach, although dispersed, empirical materials. At the EU level, such methods of spatial synthesis were being elaborated in the framework of the ESPON programme, in, for example, projects such as EDORA (Copus et al., 2011; EDORA, 2011), TOWN (2014), and EULUPA (Banski and Garcia-Blanco, 2013). The concept of regionalising the Common Agricultural Policy pens up the possibility of spatial modelling, corresponding to the expected or planned transformations of rural areas. A better solution appears to be identifying the areas that, owing to their internally coherent socio-economic properties, can be distinguished from among a broad spectrum of rural areas (Bański and Mazur 2016).

As a principle, it needs to be emphasized that while a very wide variety of methods of spatial (incl. these of rural space) synthesis exists in the literature, no consistent system of their systematics and nomenclature has been accepted commonly so far. Methods of rural space’s synthesis takes place at a range of levels, from simple conceptual/qualitative models, such as “core-periphery”, “Type 1” and “Type 2” rural areas as described in the Future of Rural Society document (EC 1988), to highly quantitative “operational” methods, demanding large amounts of

empirical data. Some of these have been tested within a specific regional or national context, whilst others (generally those which have been specifically designed for EU policy evaluation) have been implemented across all or most EU regions (or Member States). Some kinds of operational models attempt to capture spatial processes affecting the rural economy (and society) in general (Roberts 1995, Hughs and Holland 1994). Other ones address single themes or specific aspects, such as demographic change, employment structure, patterns of human capital, rural and urban interdependence and linkages, or agglomeration processes. There are also models embracing policy processes more directly by assessing or projecting the impacts of CAP reform upon farm incomes or farming systems.

The universality of the classification method generates a diversity of its possible variants, approaches and applications. In order to investigate this wide spectrum of opportunities for rural area research, it is worth organising the information on various approaches to territorial classification and possibilities to use them to analyse the diversity of spatial structures at the local scale. In this section the abovementioned variety of the previous approaches to application of classifications and typologies will be systematized. Two major diversities exists in this regard: diversity of the formal construction of classifications/typologies of spatial units and diversity of their merit content (further called cognitive focus).

1.6. Formal construction of rural area classifications

Spatial units' classifications, including those of rural areas, are prepared very differently. The variants may be organised based on formal and methodological, or substantive criteria. From a formal and methodological perspective, individual classifications may be analysed in terms of (Mazur and Czapiewski 2016):

- The number and interdependence of analysis dimensions.
- Hierarchy of the set of spatial units and the set of classes.
- Generalisation of classes.
- Recurrence of functions.

The number of characteristics of spatial units, the combinations of which area analysed under a given classification, may be considered the number of its dimensions. It is worth noting that those dimensions are at times interdependent, like when a certain characteristic of a spatial unit within one attribute determines or excludes the existence of a specific characteristic within another attribute. As a result, the classification is an efficient method of synthetic description of the structure, where extremely low or extremely high share of one element excludes the possibility of certain values of the share of other elements. Examples of such spatial unit classifications include the d'Hondt method of successive quotients (Kulikowski 1981) applied for typologies of agriculture.

Each spatial unit's classification requires the adoption of a specific starting point which may be a set of spatial units along with their specific characteristics or a set of classes. The adoption of a specific hierarchy in this regard has significant methodical consequences and to a large extent affects the obtained result. In practice, it consists in adopting one of the two method for determining the set of classes, namely, ex ante (e.g. Bański 2009) or ex post (e.g. Bański and Stola 2002). The ex-ante determination of the set of classes results from it being treated as a superior part of classification. The aim is then to find a set of classes which will allow to achieve the purpose of classification to the greatest possible extent. The ex-post determination of the

set of classes results from the adopted assumption about superiority of the set of spatial units. In such case, the searched set of classes is the one that may be considered optimal from the perspective of adjustment to empirically identified variety of the elements of the spatial unit set. Each of the presented approaches has some advantages and disadvantages.

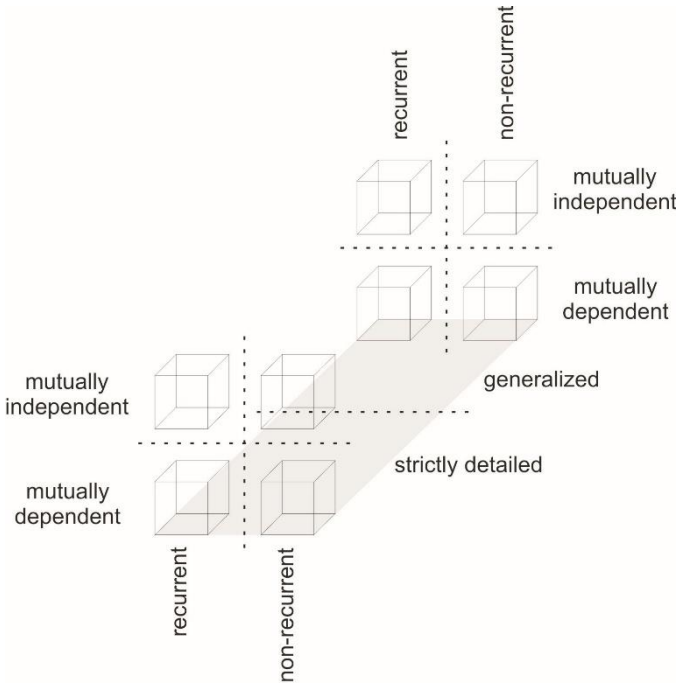

Figure 2: Schematic division of spatial unit classification taxonomy according to formal and methodological criteria. Source: Mazur and Czapiewski 2016.

Regardless of the adopted hierarchy between the set of spatial units and the set of classes, authors of classifications may aim at specifying the maximum number of classes to perform a more thorough analysis, or generalise them, reducing the number due to the small size of the set of spatial units assigned to some specific classes or due to their substantive similarity. The generalisation of the number of classes, which leads to identification of more general categories, is usually accompanied by the reduction of the level of measurement of information that describes them. Quantitative presentation, frequently used in analytical publications, in the form of specific values of individual statistical indicators is then abandoned for the sake of an ordinal scale (e.g. low, medium, high), and sometimes also a nominal scale (e.g. agricultural, forest, tourist). Such reduction of the level of measurement only seemingly results in the reduction of information about a given area. A great advantage of this operation is the fact that it organises the information about a given area, thus facilitating its synthesis and identification of general regularities, highlighting the aspects of relevance for the objective of the study.

Variants of spatial unit classification differ not only in terms of the method of determining the set of classes, but also in terms of the way of assigning the elements from the set of spatial units to the elements of the set of classes. Classifications of rural areas use recurrent (cf. Banski 2009; Komornicki and Śleszynski 2009) or more often non-recurrent functions. A recurrent function consists in successive assignment of classes to spatial units in subsequent steps (iterations), where the results of the subsequent stage of assignment depend on the

results of its previous stage. This method is often used in the case of distinguishing the hierarchically organised classes (e.g. Bański 2009). In such case, superior classes, e.g. intensive functions, are assigned first, while subordinate classes, e.g. extensive functions, driven out and losing to competition, and may be assigned only to the spatial units with no superior class assigned. Another example of using a recurrent function in spatial unit classification is assigning a class to a given unit based on i.a. the classes assigned to neighbouring units. Such a procedure is very useful for spatial generalisation of the results of spatial unit classification (e.g. Mazur et al. 2015). A non-recurrent function is a function that assigns a given class irrespective of the results of assignment of other classes or assignment to other spatial units.

1.7. Cognitive focus of rural area classifications

The **cognitive focus** of rural areas' **classifications** is diverse as well (Bański and Mazur 2016). One usually encounters three types of these approaches in the literature of the subject, namely: (1) **locational** (Psaltopoulos et al. 2006; Bollman 2008), (2) **structural** (Banski and Stola 2002; Vidal et al. 2005; Dijkstra and Poelman 2008; Brezzi et al. 2011), and (3) **combined** (Ferrao and Lopes 2003; Dijkstra and Ruiz 2010; Copus et al. 2011; Banski 2012; Eupen van et al. 2012).

While the location is a cognitive focus of rural areas classification, the principle of an urban-rural continuum is used (from the core areas to the peripheries), allowing for general distinctions among towns and their spheres of influence (e.g., the suburban zone, the metropolitan area), traditional rural areas, and peripheral areas. Development of the concept of potential and gravity models as a method of geographical space analysis trigger off interest of geographers in the problems of distance and proximity (Bunge 1962; Chojnicki 1999). Distance and isolation became to be perceived as a principal geographic condition for local development, a measure of exogenous potential and exposure for external impulses of growth (Nystuyen 1963). It is worth to notice, that the notion of distance is understood as broad here. The criterion of ordering of the territorial units is most often the time it takes the inhabitants of a given area to commute to the central city or other indicators of transport accessibility. Time of travel is a basic, commonly accepted index of spatial accessibility. It is usually assumed, that it is reflection one of the key rules of human behaviour, which is a willingness to trade-off between maximizing contact with potential destinations and minimizing effort to keep it (Karlqvist 1975). Nevertheless, there are also numerous works on accessibility issue using a measure of various physical distance metrics (e.g linear orthodromic or by use of road network) or economic measures (eg. financial cost, environmental cost estimated by fuel consumption etc.) (Baradaran and Ramjerdi 2001; Geurs and van Eck 2001; Gutierrez 2001; Spiekermann and Neubauer 2002).

Location, however, is rarely the sole element differentiating the rural areas; more often, it is only one of the classification criteria. The typology based on the location criterion was applied, for example, in the ESPON EDORA (2011) project, in which rural areas were classified into: intermediate accessible, intermediate remote, predominantly rural accessible, and predominantly rural remote. This classification refers in a clear manner to one of the criteria suggested in the classification of regions of the European Commission with the following classification: predominantly urban, intermediate close to a city, intermediate remote, predominantly rural close to a city, and predominantly rural remote (Dijkstra and Poelman 2008). In Poland, the location criterion was applied by Komornicki and Sleszynski (2009). Although in this cognitive focus, the classifications deals indirectly with urban-rural functional relationships and with pre-conditions for rural functions diversity, the direct basis for analysis is

transport-based accessibility. Delimitation of rural areas, featuring various intensities of large town influence, is founded on two components: the range of functional influence of urban centres and, usually, multimodal time-wise accessibility to road and railway transport (Komornicki et al., 2010; Rosik, 2012). Transport-related accessibility is also the basic criterion in the classification of rural functional areas in the Concept for the Spatial Development of the Country 2030 (MRR, 2011). In accordance to the concept of functional region (Dziewoński 1967), a functional area in this study is a compact spatial setting composed of functionally interlinked patches characterised by common conditioning and envisaged homogeneous development goals. The key element in the classification are FUAs, whose accessibility implies two basic types of rural areas: (1) those participating in the development processes (very accessible), or (2) those in need of support for the development processes (poorly accessible). It is assumed then, a priori, that areas situated far from large agglomerations are determined as zones, which are not able to generate the development processes and are dependent from the exogenous development stimulus, although poorly exposed to them in terms of space.

The **structural** cognitive focus allows for grouping rural areas with respect to their social and economic features. It is worth to notice, that this dichotomy within possible cognitive focus of rural areas classifications is much deeper and more essential than just change of the aspect of development we consider. It is some kind of shift between the sphere of conditions for rural areas development, like accessibility and many others, and the sphere of expression of the development processes, thus the final effect of influencing system of various development factors. The most general approach is aiming to **assess the spatial units'** socio-economic structure according to its '**rurality**' itself. An example of such studies is provided by the OECD classification. The criterion of ordering of the regions is the percentage of inhabitants of villages (Dijkstra and Poelman 2008; Brezzi et al. 2011). In that way, the territorial units are classified into: predominantly urban (share of rural population below 15%), Intermediate (share of villages' inhabitants between 15 and 50%), and predominantly rural (share of rural inhabitants exceeding 50%). An additional criterion, modifying this classification, is the magnitude of the core urban centre in each of the regions. If the rural region has an urban centre of more than 200,000 inhabitants, which shares at least 25% of the total population of the region, then this region is included in the Intermediate group. Accordingly, if an urban centre with more than 500 000 inhabitants is located in Intermediate region and shares at least 25% of the regional population, then this region is classified as Predominantly Urban. The structural perspective was also the basis for the Local Authority Classification in the United Kingdom, where the diagnostic features were the population and the share of urban population (Bibby and Shepherd 2005). These features enabled the distinction of 6 categories of areas, which included three rural categories: Significantly rural (districts with more than 37,000 inhabitants or more than 26% of their population in rural settlements and larger market towns), Rural-50 (districts with at least 50% but less than 80% of their population in rural settlements and larger market towns) and Rural-80 (districts with at least 80% of their population in rural settlements and larger market towns).

Another approach to the structural cognitive focus of classifications is to **identify the type of leading economic functions of rural spatial units** instead of assessment of their 'rurality' degree itself (Stola 1987; Banski and Stola 2002; Banski 2009). This approach seems to be potentially the most applicable in the context of defining of FRA within the RUSTIK project, as it is focused on rural functions. Functional analysis indicates in a synthetic manner the sectors of economic activity that dominate the socio-economic structure of a given territory. These sectors are usually indicated on the basis of a set of diagnostic indexes referring to various elements of the

structure in the given spatial unit. Thus in this approach, the most commonly distinguished functions are: manufacturing, services, trade, communication and transport, tourism, forestry, housing, and agriculture. In theory, because we account for the combinations of the components listed here, at least several dozen types of functional areas could be designated. In such case, the classification achieves the conditions of multidimensionality and qualitative nature of the classes, thus becomes a typology. In practice, after the generalisation, we address, as a rule, only a couple of functional types. They are an expression of the most common co-occurrence of the functions.

The **combined** approach to the rural areas classification, which naturally converges it to the conditions of typology, has a more complex character and usually links the criteria used in the locational and structural approaches (Rosner 2008; Prieto-Lara and Ocana-Riola 2010; Banski 2012; Banski et al. 2013; Copus 2013). An example of this approach is provided by the typology of regions of the General Directorate for Regional Policy of the European Commission, being a modification of the OECD typology (Dijkstra and Ruiz 2010). The methodology consisted of two essential study stages. The first conforms to the OECD typology, while in the second the criterion for the ordering of the spatial units is the time needed to reach the main urban centre. When this commuting time exceeds 60 min., then the region is included in the remote group; in the opposite case, it is classified as close to a city. Consequently, 5 types of regions are distinguished: (1) Predominantly Urban, (2) Intermediate Close to a City, (3) Intermediate Remote, (4) Predominantly Rural Close to a City, and (5) Predominantly Rural Remote. Another example of this type of approach – but accounting the influence of the forces associated with function derived from agricultural activities, residential function, and other market-oriented functions – is the proposal to distinguish among four types of rural formations (Murdoch and Marsden 1994; Marsden 1998). These types include: (1) the preserved countryside, characterised by stagnation and conservative attitudes among the local decision-makers; (2) the contested countryside, situated in the zone of influence of the cities but outside of the main suburban catchments, and featuring strong influence by the landowners-farmers on the directions of development; (3) the paternalistic countryside, where the leading role is played by the owners of large estates; (4) the clientelistic countryside, where the development processes are strongly dominated by the farming sector. This typology differs distinctly from the previously considered examples because it has a qualitative character, incorporating expert knowledge, without the explicit use of the concrete diagnostic features. Thus, it cannot constitute an instrument for quantitative-formal identification of rural types in space. The final step in development of the rural areas' classification is to add a third dimension within the framework of the combined approach (fig. 3 and 4): the temporal dynamics of the assessment of spatial units' location and socio-economic structure (Bański and Mazur 2016). Its value for the applicability of classification method can not be overestimated. This new dimension allows to monitor the development processes and desire for their support at different levels of governance. Depending on individual needs of studies, different classifications and typologies of the spatial units can be planned as an entire quite complex system of complementary methods, as it happened in case of ESPON IRIE project for instance (fig. 4).

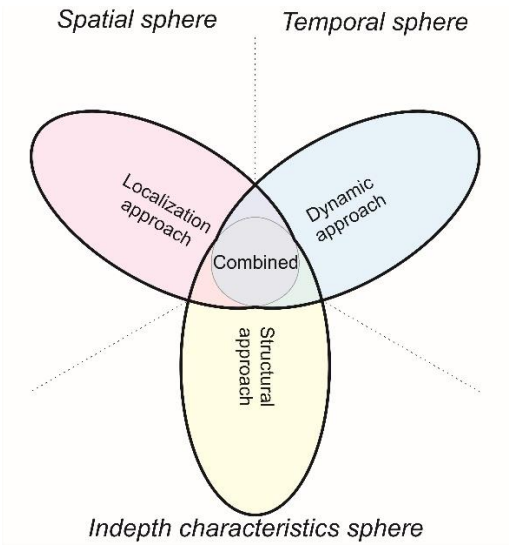

Figure 3: Schematic division of spatial unit classification variants according to criterion of cognitive focus. Source: Mazur and Czapiewski 2016

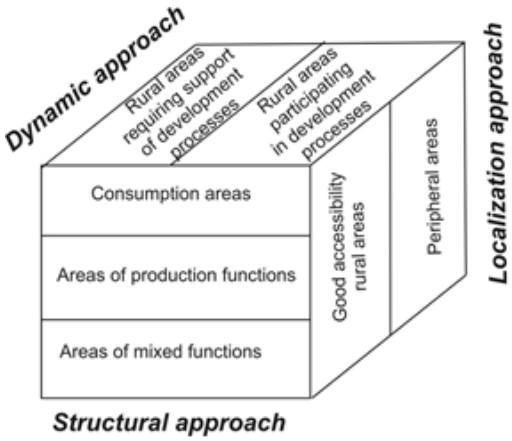

Figure 4: Synthetic scheme of the cognitive focus of one of rural areas classifications. Source: Banski and Mazur 2016

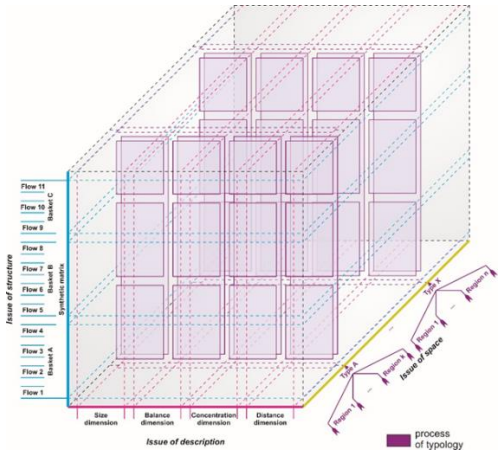

Figure 5: The role of flow unrelated (upper left), two-dimensional (upper right) and structural (at the bottom) typologies in ESPON IRiE project. A typology as a spatially synthetic input, descriptively synthetic output or structurally synthetic output. Source: Rosik et al. 2022

2. Literature review on practices of information access, communication channels, and preferences of stakeholders in local development

2.1. Preferences of stakeholders in local development processes regarding data management. European versus local data

Local development requires various stakeholders to access, understand and use a range of data to inform policy decisions. This section of the review considers who these stakeholders are, the data with which they are concerned, their preferences for accessing and using this data, and why this matters.

2.1.1. Who are the stakeholders?

In local governance, stakeholders include people, groups or organisations who "have a direct or indirect influence on the functioning of the institution/organisation/government, its activities, achievement of objectives, or even retroactively influencing them" (Vitalisova et al., 2021: 3). Stakeholders usually cluster into groups, either internal or external to the institution. From a local governance perspective, internal stakeholders can include elected officials, employees of public administration and other bodies operating within the local government. External stakeholders comprise citizens, local businesses, non-profit organisations, and local community groups (Vitalisova et al., 2021).

Stakeholders with the authority to participate in local policymaking, including its implementation and control, are considered formal stakeholders. Those who do not have this authority but aim to influence local policy to ensure it aligns with their interests are considered informal stakeholders (Vitalisova et al., 2021). With the rise of public participation in local governance, and improved access to data, this line is blurring, as those ones considered external are invited to contribute to decision-making processes and increasingly have the expertise to do so. At the same time, it is important to remember that stakeholders are rarely homogeneous or politically neutral. Rural development initiatives can be prone to 'elite capture' (Shortall & Warner 2010) and different groups can prefer different data indicators for different purposes (Tomaney 2017).

2.1.2. What open data is reachable by the stakeholders?

The way we access and manage data is changing. The collection of data for use in policymaking was traditionally conducted by the public sector (central governments), as they had the need, resources and will to acquire it (Sivarajah et al., 2016). However, the last decade has seen an increase in the number of Open Government Data portals (OGDP), through which people can freely access information gathered at a range of levels. These OGDPs collate various levels of data, from local to European, with the aim of improving the transparency and accountability of public institutions (OECD, 2023). In some situations, stakeholders no longer need to complete Freedom of Information requests, nor comprehend complex statistical reports, as data is made available in user-friendly formats (Nikiforova and McBride, 2021). The OECD (2023) suggests that through this process, governments may also 'promote business creation and innovative, citizen-centric services'.

The European Commission runs data.europa.eu, a site containing 1,608,857 European public sector datasets. This portal provides users with a central point of access to European open data harvested from international, EU, national, regional, local and geodata portals (data.europa.eu, 2023a). The portal's vision aligns with that of the OECD, in that it aims to create "a well-informed EU, empowered by timely and effective access to trustworthy information and knowledge and benefiting from all the opportunities this brings to society and the economy" (data.europa.eu, 2023a). To do so, it will 'provide better access, transparency and use' (Figure 5).

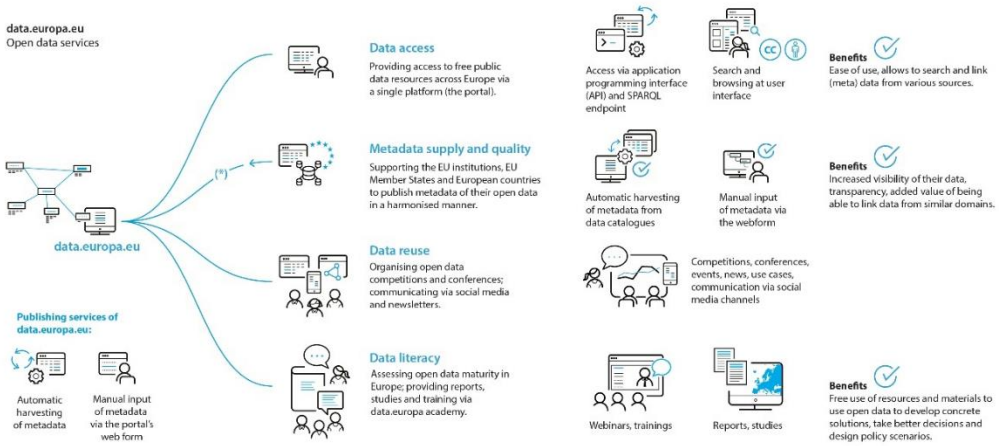

Figure 6: How the data.europa.eu portal improves access, transparency and use (data.europa.eu, 2023a).

Figure 6 demonstrates the search capabilities of the data.europa.eu site, displaying data collected by the EC's Joint Research Center relating to the environment, with reference to local development, in PDF format. Each dataset has a unique page containing metadata (information about the data) and links to all available data in various formats, including code, raw data, and maps.

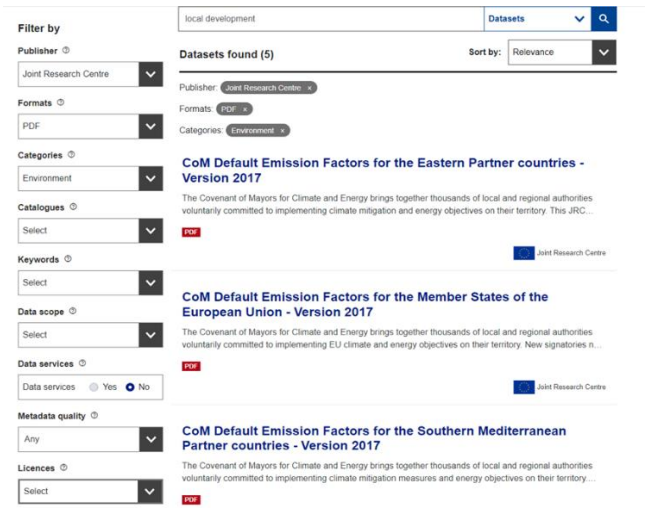

Figure 7: An example search of the 1,608,857 datasets available on the data.europa.eu website (data.europa.eu, 2023b).

These portals result partly from increased legal requirements to maintain and release data in open formats, but also from the belief that publishing data will lead to benefits and increased

demand by citizens, which would enable greater democratization of local decision-making processes. In view of that aspiration, and since participatory governance processes are becoming more common, it is important that stakeholder preferences regarding data use and management are considered as part of the process, so that the data made available to them is not simply overwhelming, but can be both robust and directly useful. EU Horizon 2020 projects are an example of this process. Researchers are obliged to create a data management plan to demonstrate how research data will be managed throughout a project's lifecycle to ensure it is findable, accessible, interoperable and reusable (FAIR) (Kvale and Pharo, 2021). However, Balest et al. (2022) argue that despite the aspiration to ensure data is FAIR, there remains an ever-increasing amount of data that is not available to stakeholders. They state that further work is required on the interaction between data, societies and economies to ensure data is accessible and usable by everybody.

The scale of data is also changing. While the European Communities have explicitly pursued regional policy objectives since DG-REGIO's formation in 1968, the introduction of 'territorial cohesion' as one of the three principles of EU Cohesion Policy following the 2007 Lisbon Treaty has marked a turning point in attention to data at NUTS2 level. The 2009 'Barca Report' on the future of Cohesion Policy has been particularly pivotal in the policy turn to 'place-based' approaches. These approaches aim to empower local communities and mobilise endogenous knowledge, in contrast to 'space-blind' approaches that assume that 'one size fits all' (Barca 2019). Recent concerns about 'geographies of discontent' (De Ruyter et al. 2021) have reinvigorated interest in measuring 'what counts' (Stiglitz 2019) for people at the local scale where they experience their well-being (Tomaney 2017). Milcu et al. (2013) use the example of cultural ecosystem services to argue that the measurement of the most easily quantifiable services may conceal the services that really matter to people. Researchers and policymakers have to discern if certain services are overemphasised and assess if these are really representative of cultural ecosystem services as a whole (Milcu et al., 2013).

2.1.3. What are stakeholders' preferences?

Stakeholders demonstrate an awareness of data security, suggesting that data, and the organisations to whom this is entrusted, must be trustworthy (Vandercruysse et al., 2019). Citizens, in particular, expect their data to be used effectively for their benefit, for example to improve the services that they receive (Vandercruysse et al., 2019). In addition to the requirements of legitimacy and security, data must also be available at the scale and resolution required for the small 'service areas' covered by local authorities (Elwood, 2008; Vandercruysse et al., 2019). Stakeholders involved in the collection and management of this type of data are aware of their responsibilities and recognise that citizens must trust their service providers (Vandercruysse et al., 2019).

The language in which data is published is important. Nikforova and McBride (2021) found that if users cannot access the data in their native language, or in English, it slows down their analysis and the subsequent publication of findings that can be used in decision-making processes. Users of data.europa.eu are able to access the interface in any of the 24 official languages of the European Union. The portal also translates all metadata it receives into these languages, so users can access it in their native language.

Regardless of preferences, data must be displayed in an easy-to-comprehend format and the infrastructure in which it exists should also be easy to navigate, so that stakeholders can discover, plan, analyse and visualise the data in which they are interested (Nikiforova and

McBride, 2021). In the same vein, stakeholders must be equipped with the analytical tools and other skills to use the data for their needs (Sivarajah et al., 2016). To this end, countries are making greater efforts to ensure that data from all levels of government are available in one database (OECD, 2021). data.europa.eu represents a good example of this, as it collates datasets from millions of sources onto one site and also offers training courses for individuals interested in learning more about accessing and using the available data.

The typical user of an OGDP has been found to be more experienced with IT than the general public (Nikforova and McBride, 2021). The level of users' IT experience will affect stakeholders' preferences regarding how data is presented. For example, stakeholders who do not have as much experience with data analysis generally prefer to have data presented in a visual format (e.g. in infographics). Others who work with data regularly (such as data scientists), may prefer to work with raw data, using it to build models and derive real-time insights (Pansare, 2021). To encourage users to develop their skills, data.europa.eu provides eleven courses on data communication for a variety of audiences including academics, civil servants and the staff of non-governmental organisations.

It should be noted that although a citizen may be considered a stakeholder, this does not mean that every individual will have a direct influence on how data is used or presented to inform decision-making. In many contexts, more specialist 'data officers' are designated, who must consider the perspective of the average citizen in how they influence data access and analysis.

2.1.4. Why does this matter?

More participatory approaches to identifying, collecting and using data notably depart from technocratic attempts based on 'objective list' theories (Parfit 1984) of what matters for 'good lives'. Several sources state that understanding stakeholder preferences regarding to data is essential in ensuring available data is transformed and, crucially, used. Nikifora and McBride even judge that if data is not used to inform decisions, then it is not valuable (Nikiforova and McBride, 2021). Others emphasize that, where data is used to inform decisions, it must be crafted into narratives which are 'culturally congenial' to target audiences to ensure everyone can access and understand what data means (Lyebecker et al., 2016): this is part of the wider issue of ensuring data accessibility, transparency and rigour in the collection and processing (Balest et al., 2022). For example, to encourage further use of data harvested on the data.europa.eu platform, 'data stories' are published monthly; these short publications aim to demonstrate current open data trends and highlight examples of good practice and innovative techniques, to inspire and inform users (data.europa.eu, 2023a).

When stakeholders are actively engaged in the planning, collecting and analysis of data, this can encourage 'buy-in' (so users feel a shared interest in the data that is gathered and used) and sustainability (so they are more likely to continue to help gather the data, over time). The process also provides an opportunity to create common goals amongst diverse groups of stakeholders and improve communication between groups. When stakeholders are involved in all stages of the process, it can enable data systems to be built with the users' needs at the centre, thus enhancing their potential to be effective in policymaking. However, in many cases such as formal policy evaluations, stakeholder involvement may be limited to extractive requests or requirements in which they simply provide data for other users. There are many such findings reported in EU policy evaluation studies.

2.2. Practices of information access, communication channels, and preferences of stakeholders in local development processes

National (Managing Authorities, Paying Agencies) and local (Local Action Groups) actors in EU Member States implement LEADER/CLLD approach based on multi-level governance model, whereas EU, national and local legislation, policy frameworks and strategies are strongly interlinked. During the current EU programming period, Member States implement the model based on the agreements to reform EU Common Agricultural Policy and national CAP strategic plans. During this process, stakeholders, and other actors in the field of local and rural development played an active role in participating in policy making. The EU's strategic policy instruments related to rural development are:

- The Long Term Vision for Rural Areas (LTVRA) adopted in June 2021 by the European Commission
- The Rural Pact framework/community (launched in June 2022)
- The EU Rural Action Plan/the European Rural Agenda.

In 2019 ELARD Aisbl. (ELARD, 2019) highlighted the interlinkages of global rural and sustainable development goals by stating that:

- The achievements of LEADER/CLLD have shown that Local Action Groups (LAGs) are able to defend the European values, if recognised as local drivers for change and development and enabled to innovate in their areas. In consequence, LEADER/CLLD is a powerful tool to implement the UN 2030 Agenda in rural areas;
- LEADER/CLLD and LAGs are the right instrument to localize, implement, follow-up and review the Sustainable Development Goals in rural areas. Involvement of rural areas is essential for the achievement of the SDGs.

This refers to the need for clear communication that both international and national actors as well as LAGs acknowledge this role and data/information collection modes that facilitate the process of integration of global goals and local/regional activities.

In addition to the interlinkages between governance levels (global, EU, national, regional, local) and an effective information exchange mechanisms to facilitate this, there is a need for coordination and connection between different EU instruments to ensure the effective implementation of LTVRA. EU EESC (2021) have called for more consistency in rural and urban development strategic approaches to avoid overlaps and discrepancies between strategies (e.g. LAG strategy, Integrated Territorial Investment strategy, local development strategy, regional development strategy) and to facilitate their implementation by local actors in development processes and investments. Furthermore, EESC (ibid) recognises the importance of EU-funded research to explore ways of promoting equitable, sustainable rural/urban development and of revitalising the economic development of rural areas.

Accurate data and up-to-date information are essential for preparing, monitoring and evaluating functional and effective local development strategies: EU CoR (2019) calls for clear and simple evaluation and monitoring models of CLLD local development strategies. Evaluation has to be a part of a community's learning process and it is therefore very important to continuously collect information and evaluate the implementation of LAG strategies. Advanced IT solutions for data

collection and analysis should be introduced, combined with participatory processes and qualitative analysis. The challenges and shortcomings related to the monitoring and evaluation (M&E) of the implementation of Local Development Strategies (LDS) have also been pointed out by ECA (2022) by the most common M&E indicators do not support meaningful assessment of the costs and benefits of the LEADER approach - the indicators used are mainly input and output indicators and do not measure results or added - value of the spending programmes. There is a need to take steps to ensure that M&E frameworks on EU, national and local level can account for benefits of the LEADER approach and that monitoring should be directed towards indicators of such benefits, efficiency and effectiveness, rather than implementation.

On 9th of May 2020, Day of Europe, the members of ELARD are sharing their opinion (ELARD, 2020) on how CLLD can assist in the recovery work of Europe now and in future programmes. In the field of information access and communication, the position highlighted the role of (F)LAGs in educating local stakeholders in using various digital tools, and that (F)LAGs also serve as service providers by, for example, providing platforms for conferences, making libraries available or supporting schools in teaching technology. Also, digital platforms animated by (F)LAGs are widely used to to boost local commerce and supply home deliveries, especially in food products. In 2020 (ELARD, 2020) 10% of the LAGs indicated that they perform that role.

It is highlighted by Jouen (2021) that there is a crucial need for genuine rural data, to assess the level of fragility, weakness, decline and the opportunities of places, the possible targets to be achieved and to better identify successful/effective policies. It also makes it possible to capture the “value” of rural areas. This data would also make the total amount of financial resources visible - EU (EAFRD and the ESIF, as well as Horizon 2020, ICE, JTF etc), national or regional funds -, and their distribution to rural areas in comparison with other areas, weighted by inhabitants as well as by square-kilometres. Such data constitutes a prerequisite for developing accurate measures.

There is an evident consensus between European rural development actors to call upon citizens and policymakers at all levels to mobilise resources and people, and ensure policies and programmes are coherent and rural-proofed (ERP, 2022). For the effective and holistic rural proofing, the signatories of Rural People’s Declaration of Kielce (ibid) acknowledge a need for a vision and objectives to reflect genuine rural agenda at European and national levels, devoting appropriate funding for it and including rural development within the broader political framework. Restructuring of public sector linkages will be critical to a more integrated, strategic approach. Cooperation between all who are responsible for rural areas in European, national and regional level is vital. A holistic and integrated approach needs to involve all policy areas and levels to reflect the diversity of rural life.

The European Rural Manifesto (ERP, 2022) touches upon the issues of communication and digitisation as follows: access to high-capacity telecommunications is crucial to the social, cultural and economic life of all Europeans and to the provision of vital services. Because of their distance and sparse population, rural areas especially have needs for effective telecommunications. However, many rural areas in Europe are still gravely disadvantaged by weaknesses in telecommunication systems. Digital technologies should be considered as an enabler to transform the rural economy and rural society. Digitisation efforts and the Smart Village processes should benefit large rural areas throughout Europe, not only the wealthiest countries. Governments, multi-national funders, and telecommunication providers should work on facilitating access to high-speed broadband and mobile services for all rural populations, including remote areas, with harmonised tariffs throughout Europe. Rural communities should

not be expected but be enabled to take action in partnerships to ensure this service. Access for digital infrastructure should be ensured also for the disadvantaged and digital capacities should be strengthened. Access to appropriate statistics and data for decision-making should be readily available to rural stakeholders.

3. How to translate concepts of functional rural areas and transitions into suitable indicator sets

A set of papers was selected for review at this stage (T1). The papers explore specific problems related to the RUSTIK transitions topics, develop sets of indicators, and use various sources of data and methods of analysis. All three papers have an ambition to explore an identified specific problem in rural areas with the purpose of suggesting evidence-based scenarios and particular strategies to facilitate decision-making at different policy levels. The findings identified in these papers are reviewed to extract the following elements: 1) problem formulation and key concepts to address the problem; 2) set of indicators and variables describing different concepts; 3) type of data collected; 4) type of analysis applied; 5) results. The objective of the review is to delve into the rationale behind the pathway, which includes problem and concept identification, definition of indicators and variables, identification of data sources and data collection methods, analysis, and solutions. This review will not follow a systematic and analytical approach, but rather explore each paper in detail. This review aims to provide Living Labs partners with ideas and examples on how to think about rural functions and problems and to inspire how they can structure their work.

Table 1: Papers under review

№	Paper	RUSTIK Transition topic/ theme and rural functions	Country	Scope of the research and policy levels	Purpose
1	Copus A., Kahila P., Fritsch F., Dax T., Kovács K., Tagai G., Weber R., Grunfelder J., Löfving L., Moodie J.,Ortega-Reig M., Ferrandis A., Piras S. & Meredith D. (2020). European Shrinking Rural Areas: Challenges, Actions and Perspectives for Territorial Governance (ESCAPE), Final Report.	Socio-economy and demography Sub topic: shrinking process Function of Rural area: to develop strategy how to address rural shrinking.	A comparative EU members states study; Case studies in 8 EU countries	EU member states (statistical data) and 8 qualitative data case studies conducted in: Finland, Spain, Germany, Poland, Hungary, Bulgaria, Croatia, Greece EU policy level; National, regional and local policy level (more general advice on how to address the complex shrinking problem)	To identify clusters of shrinking rural areas in the EU member states; To define pathways of shrinking in different areas; To design step-by-step procedure to develop evidence- based policies, tailored to different clusters of rural areas and taking into account their specific shrinking pathways.
2	Reuter-Oppermann M, Nickel S,Steinha¨user J (2019) Operations research meets need related planning: Approaches for locating general practitioners' practices. PLoS ONE 14(1):general	Socio-economy and demography: Sub topic location of health care services in rural areas (GPs); Function of rural area: wellbeing of population	Germany (South East)	Regional; Regional, and town/ municipality level (mayors, municipal and regional councils) - very specific and area customized modelling and analysis	To build data-based models and scenarios about the location of primary health care services (General practitioners practices)
3	Houghton, A., Austin, J., Beerman, A., Horton., C. Journal	Climate change	USA	Regional – the region of Regional and town level	To produce evidence/ data-based climate

	of Environmental and Public Health Volume 2017, https://doi.org/ 10.1155/2017/3407325	Sub topic: vulnerability of rural population to climate change Function of rural area: to assess climate risks and their impact on population and to develop measures to protect social groups in risk		with potential to be expanded at State level and on national level	change vulnerability assessment of rural areas; To elaborate a set of indicators to measure climate change and its impact on rural population

3.1. European Shrinking Rural Areas: Challenges, Actions and Perspectives for Territorial Governance (ESCAPE), Final Report.

3.1.1. Problem definition and key concepts to address rural shrinking

The ESCAPE research team found through a literature review that the exogenous rural development that took place in Europe from the 1990s to the end of the first decade of the new millennium (relative time limits) positioned rural areas as an 'appendix' and 'food and provisions' unit of urban areas. This contributed significantly to long-term on-going rural depopulation processes. To address the problem of population decline in rural areas, ESCAPE adopted Grasland et al's concept. (2008, p.25) of rural shrinking: "a region that is 'shrinking' is a region that is losing a significant proportion of its population over a period greater than or equal to one generation [P.S: between 20 and 25 years]"and goes beyond it. Copus et al. (2020) argue that in addressing existing problems it is not enough to focus only on rural demography. A new rural concept needs to be developed to explore complex socio-economic, demographic, environmental and technological process and to help rural areas to adapt to more endogenous or neo-endogenous/ nexogenous types of policies and measures (Gkartzios and Lowe, 2019). The ESCAPE project further developed and worked with the concept of complex shrinking saying that in reality, shrinking regions face more complex developmental challenges than depopulation. These challenges involve a range of interrelated issues, including levels of economic activity and employment, sectoral re-structuring, productivity, investments, social capital, territorial management, institutions, and governance capacity. While "simple shrinking" in the understanding of Grasland (et al) is relatively easy to measure, the interaction between demographic trends and these wider dynamics generates diverse and multi-faceted "syndromes" of decline, often associated with "vicious cycles" that tend to self-perpetuate. In the ESCAPE final report (Copus et al, 2020), these phenomena are referred to as "complex shrinking". (Copus et al, 2020, p.2) In addition, the authors state that complex shrinking and in particular population, change is driven by four dynamics: "1) rural populations which are currently being depleted by out-migration (active shrinking) 2) and those which contract (often despite in-migration) due to their age structure and "natural decrease" (legacy shrinking). 3) It is also helpful to distinguish between active shrinking driven by regional or national rural-urban processes, and those implicated in European-wide, 4) or intercontinental (globalized) flows." (p.2)

To develop a model of complex shrinking the project identified a set of indicators/ categories and related variables isolated on the base of the following rationale:

"The selection of the variables included in the clustering process was broadly inspired by established development economics models of migration and labour-allocation, which have, for many years, inspired policy; namely the Lewis dual economy model (Lewis, 1954), and the Schultz neoclassical migration model (Shultz, 1964). The Lewis model assumes that surplus labour in the agricultural (rural) sector moves to the modern (urban) sector driven by job availability; the Schultz model postulates that migration is primarily driven by the intersectoral wage differential (here represented by the relative GVA per working unit), with distance (accessibility) affecting migration costs and thus the final decision. In a situation of economic restructuring, there is a progressive movement of labour from low-productivity agriculture to the industrial and tertiary sectors; deindustrialisation and automation reduce industrial employment to the benefit of services, or of other regions; and state withdrawal results in less public jobs. Thus, we expect movements between both territories and sectors, driven by their relative competitiveness and expansion or recession. The EU CAP and Cohesion Policy can act as counteracting forces in poor or agricultural regions. Changes in land-use (farmland abandonment, building of residential areas) are an outcome of such movements." Copus *et al*, 2020, p.12-23

The purpose of developing this model is not to confirm or to reject causal relationships between these variables but to identify "sets of characteristics which tend to display jointly in certain units. In this sense, our *simplified*, *descriptive* typology seeks to find order in the complex and interrelated phenomena observed in shrinking regions."(Copus *et al*, 2020,p.13)

3.1.2. Key topics of complex rural shrinking, indicators, variables and analysis

More than 70 identified variables comprised the five big categories/indicators producing the EU map of complex shrinking in rural areas. Cluster analyses were conducted subsequently. The five key indicators are:

- Geography (specificities, macro-regions etc) - 17 variables.
- Demography (population distribution and change) - 13 variables.
- Economy (GVA, GDP, employment, productivity) - 32 variables).
- Environment (land use, erosion) - 8 variables.
- Policy (payments by ESI Funds) – 4 variables.

Following an iterative process of experimentation with clustering, a subset of 29 variables, (Table 2) reflecting demographic dynamics, economic structures/restructuring, and locational disadvantage (accessibility), were incorporated in the final version of the clustering algorithm. Variables were excluded from the clustering procedure for a variety of practical and theoretical reasons, such as high levels of missing data, or "redundancy" (correlation with other variables). Two last categories of variables namely Environment and Policy were excluded and only variables describing the first three categories (Geography, Demography and Economy) were used.

A Ward's linkage hierarchical clustering algorithm (Ward, 1963), which minimises the total within-cluster variance instead of considering a single measure of distance between the units, was deemed the most appropriate to detect the underlying cluster structure. The optimal number of clusters was identified by looking jointly at statistical indices and at geographic patterns (NUTS 3 region) emerging from the mapping of different solutions.

Table 2: Adapted overview of the final 29 variables used in the clustering analysis of "complex shrinking". (p.14)

Indicator	Variable	Data source
Geography	1. Multimodal accessibility index at NUTS3 level in 2014	ESPON
	2. Change in the multimodal accessibility index at NUTS 3 level from 2001 to 2014	
	3. Concentration of population (0-1) between LAUs in 2011	
Demography	4. Change in concentration of population between LAUs (2001-2011)	National statistical institutes/ Eurostat
	5. Share of population living in shrinking LAUs (2001-2011)	
	6. Population density (2016)	
	7. Share of working age population 16-64 (2016)	
	8. Rate of natural change from 2001 to 2016 as a percent of the 2016 population	
	9. Rate of net migration from 2001 to 2016 as a percent of the 2016 population	
	10. Yearly rate of population change from 1993 to 2013 as a share of the 1993 population	
	11. Yearly rate of population change from 2013 to 2033 as a share of the 2013 population	
	12. Number of decades of shrinking from LAU data (1961-2011)	
Economy	13. Share of GVA produced by the primary (NACE rev.2 sector A) in 2016	
	14. Share of GVA produced by secondary sector (NACE rev.2 sector B-F) in 2016	
	15. Share of GVA produced the service sector (NACE rev.2 sector G-N) in 2016	
	16. Share of GVA produced by the public sector (NACE rev.2 sector O-U) in 2016	
	17. Relative change in the share of GVA generated by the primary sector (2001-2016)	
	18. Relative change in the share of GVA generated by the secondary sector (2001-2016)	
	19. Relative change in the share of employment in the primary sector (2001-2016)	
	20. Relative change in the share of employment in the secondary sector (2001-2016)	
	21. GVA per working unit as a percent of the national level in 2016	
	22. GVA per working unit in primary sector as a percent of the national level in 2016	
	23. GVA per working unit in the secondary sector as a percent of the national level in 2016	
	24. Convergence to the national GVA per w. u. (abs. % points, 2001-2016)	
	25. Convergence to the national GVA per w. u. in sector A (abs. % points, 2001-2016)	
	26. Convergence to the national GVA per w. u. in the secondary sector (abs. % points, 2001-2016)	
	27. GDP per capita (Purchasing Power Parity) in 2016	
	28. Convergence to the EU GDP per capita (absolute percent points, 2001-2016)	
	29. Convergence to the national GDP per capita (absolute percent points, 2001-2016)	

3.1.3. Results: clusters, pathways, and processes

Five clusters of complex rural shrinking were identified through cluster analysis of the selected variables:

- **Agricultural, very low income regions with severe legacy and active shrinking:** These regions are declining due to their disadvantage relative to national centres, which fuels outmigration, and they generally do not have a strong sector to rely on to reverse this trend. In geographic terms, it presents the largest share of intermediate regions, few coastal and mountain regions, and is characterised by proximity to borders (including EU borders) and poor accessibility (despite sizeable improvements). These regions shrank rapidly in the past (but this trend is more recent that in other clusters) but are expected to shrink less than the second cluster in the future. From an economic point of view, the primary sector is relatively larger than in other clusters, especially in terms of employment, but its importance is declining rapidly. The service and public sectors are relatively small. Cohesion Fund payments are the highest in these regions, but this is compensated by below-average payments of other funds.
- **Industrial mid-income cluster of regions with severe legacy and active shrinking:** This cluster is catching up through economic restructuring, which is reducing low-productivity jobs, but also damaging an already weak population structure. Thus, these regions are ranked worse than other, diverging but demographically healthier ones. Two thirds of these regions are predominantly rural.
- **Agro industrial, low-income cluster of regions with moderate, mostly legacy shrinking:** Being comparatively weak at national level, these regions are losing population through some outmigration besides natural decrease; however, they are more central, and with a relatively stronger economy than the first cluster. Geographically, four fifths are post-socialist, over half are border regions, and their accessibility is quite poor despite a sizeable improvement. They show the most modest shrinking rate (-4.7%), equally split between natural decrease and outmigration, and the slowest expected shrinking rate in the future. The population is more evenly distributed than in other clusters, and local shrinking rates are not particularly severe – only 57% of the population lives in shrinking LAUs. From the economic point of view, the GDP per capita is slightly above 50% of the EU average and is converging faster than in the other clusters (13.1%), but is also slowly diverging from the national average. The share of agriculture in GVA is 6% but its relevance in occupational terms is much larger (18%); the industrial sector is relatively large (38%) and growing in both product and occupational terms; services, and especially the public sector, remain small despite a rapid relative increase.
- **Servitised mid-low income regions with moderate legacy shrinking:** These regions have grown in the past despite a "difficult" territory and a weak secondary sector; although their economy is healthy enough to prevent massive outmigration, its state has been worsening, and the "distorted" population structures have resulted in "legacy shrinking". There are several regions with geographic peculiarities: 42% coastal, 52% with a majority of mountain population, and a relevant share in Italian islands. The share of unused land is by far the largest (22%) and increasing, while farmland is shrinking and soil erosion is also an issue. Accessibility is almost as poor as in the first cluster, but has improved less. In economic terms, the secondary sector is underdeveloped and losing importance, while the service and public sectors are large (42% and 28% on average) and gaining importance.

- **Industrial or servitised, mid-income regions with moderate mostly legacy shrinking:** These are regions with weaker-than-national-average, but still robust economies, which are shrinking due to distorted population structures and low fertility rates.

Authors of the Report underline that for an appropriate reading of the results, three caveats need to considered. First, being a NUTS 3 typology, sub-regional differences (apart from those captured by population distribution indices) are not reflected in it. The ESCAPE case studies localities can thus differ significantly from the type assigned to their region. Second, being a macro (EU) level typology, differences within the same country, or between countries from the same macro-area, may become less visible. Third, to guide the reader through the complexity of the matter the following discussion is based on average values, but there is relevant residual diversity within the clusters. (Copus et al, 2020, p.15-18)

The identification of clusters has illustrated the fact that similar rural and regional demographic trends can be the consequence of a range of specific, and complex, socio-economic processes. Indeed, "simple shrinking" is not necessarily accompanied by economic decline, but by relative rather than absolute economic weakness, often associated with geographic disadvantages such as peripherality, low accessibility, or a "difficult" territorial structure.

The cluster analysis suggests some interesting recurrent patterns, from which the following inferences may be drawn (Copus et al, 2020, p.19):

- First, shrinking rates in different clusters differ mainly because of migration: peripheral regions, especially in Eastern Europe, are unlikely to retain their population if they lack a comparative advantage (a promising sector).
- Second, national convergence matters probably more than EU convergence, because internal migration costs are lower: EU convergence (at the MS level) has been hiding increasing territorial disparities that need to be addressed, especially in monocentric post-socialist countries.
- Third, geographical differences become less relevant in the presence of agglomeration economies and servitization, so that rural Mediterranean regions and sparsely populated Nordic regions can easily cluster together.
- Fourth, sizeable financial support from the EU, or a large public sector, are not enough to prevent shrinking in the long-run in the presence of an unfavourable geography and weak secondary and service sectors.
- Finally, even a sizeable improvement in accessibility is not enough to prevent shrinking in peripheral regions.

The ESCAPE project developed a mixed research methodology based on modelling/ clustering of existing statistical data (no survey data) and of qualitative study based on case-study methodology. This approach allows going beyond the "big picture" as it is described by the quantitative cluster analyses and to illustrate better contextual rural differences. Eight case studies were selected by the project across Europe, representing 8 rural areas in 8 EU member states: Finland (FI), Spain (ES), Hungary (HU), Bulgaria (BG), Austria (AT), Germany (DE), Greece (EL), Croatia (HR). The combination of clusters calculated on the base of statistical data represents shrinking as an "end results", e.g. measuring which regions shrink and to which degree, the qualitative data based on semi-structured interviews, focus groups and desk research of documents allow description of shrinking pathways and better processual explanation as to how the "end results" were achieved. Thus, two shrinking pathways were identified:

- Long-standing issues of peripherality and locational disadvantage pathway, consolidated by several rounds of urbanisation (metropolisation), or by gradual spatial restructuring (concentration of resources in the coastal area), which delivered intense selective out-migration, leading to distorted age structures and strong legacy effects (Spain and Finland).
- "Events and transitions" shrinking pathway causing rapid and systemic changes in social and economic structures, which have been termed "peripherisation". This pathway could be termed "disrupted rural development". It has its roots in the radical political shift in Eastern Europe in the aftermath of World War II. Since German unification and rounds of EU accession in 2004, 2007 and 2013, an ongoing outmigration wave, driven by opportunities for making a better living in the West, has depleted "deep" rural areas beyond the suburbs.

One of the most important messages provided by the qualitative study is that population shrinking is not necessarily coupled with economic decline, but unfavourable demographic processes can be both causes and consequences of wider socio-economic challenges of an area. The challenge of economic adaptation was more acute in regions with mono-industrial structures or a few dominant activities, which collapsed or declined as their position in global markets was weakened or lost. Besides primary activities, most case study regions, and Lovech (BG) in particular, show employment in traditional manufacturing branches above the national average. Examples include the food industry (HU, FI and ES), textile industry, (BG and ES), fur industry, (EL), soapstone mining and metal working, (FI) and copper mining, (DE).

Based on this mixed methodology, the ESCAPE project defined four different types of shrinking processes:

- Economic Restructuring: The phenomenon of shrinkage is commonly linked to the decrease of the agricultural workforce. Most European rural regions have witnessed a dramatic change of agricultural structures with severe socio-economic consequences, and the effects are still observed in many Southern and Eastern European rural regions. In some contexts, the process has been exacerbated by the decline of traditional extractive or manufacturing activities. Such economic restructuring is generally accompanied by other adverse territorial trends that impact well-being and cultural life negatively; such as the loss of scope for associated economic activities, reduced basic public services, degradation of natural spaces, abandonment of settlements, weakening of local identity, deterioration of material and immaterial cultural heritage, and decrease in local governance structure and capacity (Sanchez-Sanchez, 2016). Land abandonment may be associated with ecological effects or soil erosion.

- Locational Disadvantage: Rural shrinkage is also often associated with "negative" locational characteristics (isolation, sparsity, lack of natural resources, poor quality agricultural land etc), which are perceived as hampering pathways to economic growth. These are often associated with isolation, sparsity and proximity to borders.

- Peripherisation: This shrinking process should not be confused with peripherality, which is a locational disadvantage (Copus et al., 2017a,b). Peripherisation is distinguished by being the consequence of macro-scale processes of spatial reorganisation of economic activity (Lang and Görmar, 2019) and globalisation. Peripherisation occurs at different spatial scales, often compounding the effects of pre-existing locational disadvantage.

- Disruptive Events and Political/Systematic Transitions: The final type of rural shrinking process involves the impact of historical events or transitions, such as those experienced by the CEEC countries during the course of the establishment of state socialist regimes in the 1950s, and at the end of the socialist era in 1989, the Balkan wars in the 1990s, or the EU integration process in the 2000s. Such changes can bring severe repercussions in regions with weak economic structures, triggering shrinkage at both national and rural levels. Persistent gaps in economic performance, institutional legacies and inertia in governance adjustment can contribute to low self-perception of regional actors and slow improvements in quality of life in affected regions.

3.1.4. Evidence-based strategies for how to address the varieties of rural shrinking

Based on these evidence-based findings the ESCAPE project designed four different strategies how to address the varieties of rural shrinking (Copus et al. 2020, p.52 - 55). The four types are: Compensation, Relocalisation, Global Reconnection and Smart Shrinking (Fig.1). These strategies can be used in the policy-making process at different levels and to guide the development of specific measures. The four types of strategy do not map onto the above-mentioned four types of shrinking in a one-to-one way.

In addition to the typology of possible strategies, the project recommended a pathway of specific actions to policy makers (Copus et al. 2020, p.51) structured in four key topics:

- Vision and goals requiring a clear problem identification acknowledging fundamental distinction between “accumulating” and “depleting” rural areas and setting up policy goals addressing inclusion, wellbeing, social justice and just transitions.

- Evidence, Diagnosis and Policy Rationale which helps to better distinguish between the symptoms observed (e.g. depopulation) and problems behind (e.g. legacy or active shrinking). Evidence-based visions allows to take appropriate policy decisions, e.g. to acknowledge that most shrinking is due to the legacy effect rather than active migration and to accept policy measures aiming to attract in-migration for example (for more examples in this direction p.51).

- Implementation of evidence-based vison and problem formulation needs to be tailored as a response at appropriate scale (regional, local) and should be long-term oriented although designed in small and specific steps).

- Governance, Empowerment and Capacity Building requiring efforts to support local capacity development and participation, facilitate strategic input to design and financing of initiatives or interventions, based on national policy good practices and innovative partnerships.

3.1.5. How the ESCAPE study can be relevant to the RUSTIK Living Labs work

The results of the project can support the RUSTIK living labs for different purposes and at different stages of their work. First, the LLs could use them to perform a self-assessment of their situation in terms of complex shrinkage in order to identify a problem (phase 1). The fact that the ESCAPE project works with the notion of complex shrinkage can guide the labs to work on issues related to socio-economic and demographic shrinkage and on other factors such as ecology and climate, digitalization. The LLs can also formulate problems to work on related to the "paradoxes" observed by the project, such as the fact that demographic shrinkage is not only a consequence of the economic development of a region or may even be unrelated to it.

The RUSTIK Living Labs can also use the ESCAPE example to structure the stages/ phases of their work by first formulating a problem based on data and literature research, crafting a vision of what they would like to change based on the observed problem. The labs can formulate concepts to address it and from which to derive appropriate indicators that can be described in terms of variables and for which data can be recorded. Subsequently, these data can be analysed and included in an informative decision-support tool.

In terms of the data sources it works with, ESCAPE uses a classical approach. It works with mainstream publicly accessible databases (ESPON and EUROSTAT data, enriched by National statistical Bureau data) that research teams process with various quantitative methods. From this point of view, the results of the project provide a good basis to understand what data exist for rural areas, and provide the direction for the required enrichment of data and data sources within the RUSTIK project. At the same time, ESCAPE is a good example of a combined approach, using qualitative and quantitative data to record the scale of the phenomenon of complex shrinkage and the symptoms through which it manifests (quantitative data), but also using qualitative data to explain how complex shrinkage phenomena happens in different ways but arriving at the same consequences. Perhaps RUSTIK labs can use this approach too, but also go a step further by trying to quantify systematically recorded qualitative data, or to develop data registration tools that can be used by citizens and different communities to structure and collect unstructured data (for example about social habits to heat their houses during the winter months, or to use their free/leisure time/ or to measure intensity of social inclusion and networking, etc).

3.2. Operations research meets need related planning: Approaches for locating general practitioners' practices

The second paper is also related to the topic of socio-economic transition but is focused on a more specific issue – to provide evidence-based scenarios on how to locate general practitioners' (GPs) practices in aging rural area.

3.2.1. Problem definition and key concepts to address rural shrinking

This article addresses an increasingly common problem in rural areas - remote access to primary health care and the declining number of physicians (GPs) interested in working

in rural areas. With an aging population, the problematic gets more severe as they have more difficulties related to mobility, even when public transport and transport connectivity is available. The provision of health care is a vital part of the endogenous functions of rural areas and is an indicator of how self-reliant/sufficient they are in providing health services and are able to attract doctors to come and work in the area, and patients are not forced to travel to the city for primary health care services. The ESCAPE project discussed above also shows that lack of primary health care is among the main motives for rural complex shrinkage. The study was conducted in the administrative region of South Baden Wurttemberg in Germany, and the main problem formulated is which is the best scenario to spatially plan/ to locate new GPs' practices.

3.2.2. Indicators, data, methods

To conduct the study several indicators were isolated, and a mixed data collection method was applied.

Table 3: Indicators, variables and data sets

Indicator	Variable	Type of methods	Data set
Demography	Age structure of the population of 21 municipalities for 2013 and estimations for 2023; Number of inhabitants for 2013 and estimations for 2023 (calculated values for 3 years intervals)	Quantitative	Regional statistical data base
Economy	Access cost to Primary health services	Quantitative	Health care statistical set
Geography	Travel time by different public and private transport means; Distance between GP location and patients homes (longue, medium and short and)	Quantitative	Google Distance Matrix API stored in a resulting distance matrix1
Patients demand/ preferences	Maximum, medium and minimum services coverage	Quantitative	Survey
GP preferences	Determinants against less common GPs practices (e.g. groups practice of 3 GPs rather than classical model of one GP per practices) Number of patients per GP Type of practice (individual or collaborative) GPs working on full time GP working on half time GPs expected retirement time/ moment	Qualitative	Telephone interviews with GPs; GPs Registry

The authors used operations research (OR) methods to determine future locations for general practitioners' practices. Operations research is a discipline applying quantitative techniques in order to make the best possible decisions. Its origins lay in logistics using mathematical approaches (Stein and Waldmann, 2011). It expresses a problem as a mathematical model usually including one objective function that is to be maximised or minimised and a set of constraints that need to be fulfilled. The model can then be solved by an open-source or commercial solver that determines the optimal solution for the problem with respect to the

objective. For full description of the mathematical model, see p. 4-5. The Maximum Coverage Location Problem (MCLP) by Church and ReVelle (1974) is used to model objectives and variables. IBM CPLEX Optimization Studio was used as a tool to proceed with modelling and calculations.

In the case of this study three objectives were set up and variations of possible scenarios were calculated:

- The driving time (ride time) for all patients is minimised.
- The demand covered (%covered) is maximised, or
- The maximum time patients need to drive (max ride time) is minimised.

The modelling processes producer three scenarios, each suggesting a different approach to planning the spatial distribution of GP practices in the respective rural area. Illustration of one of the scenarios is presented in Table 4.

Table 4: Scenario for spatial planning of GP practices in rural areas (minimal driving time)

# Locations	Max ride time	Avg. ride time	% Covered	Villlages
1	6	-	-	“B”
1	15	10.5	70%	“F”
1	23	14	100%	“A”
2	15	-	90%	“D”, “F”
2	18	9.6	100%	“C”, “G”
3	18	-	100%	“C”, “D”, “F”
4	15	6.5	100%	“D”, “H”, “C”, “F”

The authors of the study argue that the model based on Operational Research is applicable to different health systems, i.e. both those where patients are not set on a specific GP and those where the patient can only visit a specific GP. In this sense, the model has a high degree of applicability in cases where RUSTIK living labs choose to work on topics related to improving quality of life in rural areas and their endogenous functions and thus to address the socio-economic transition topic.

The idea of creating this model to solve a problem related to access to primary health care can probably be extrapolated to find solutions for other specific problems. What is specific in the application of the model is that it works with different types of data, quantitative, spatial and qualitative, but also that it covers data that relate to all social actors affected by the problem (physician preferences and patient preferences).

The application of the model requires specific competencies for data handling and probably not every RUSTIK living lab would be able to apply it. However, this article could inspire LLs to initially formulate specific "smaller" problems to develop as data sources and analyses that

nonetheless address a larger strategic goal like the socio-economic transition. In the case described in this article, the model of spatial localisation of general practitioners is practically relevant to improving the quality of life in rural areas while taking into account their local specificities.

The municipal councils considered the three models developed by the research teams and the mayors of the affected municipalities and the results achieved were used for policymaking at local and regional level. New and transforming GP practices were spatially distributed in a way addressing changing population needs (aging, high coverage of health services) and general practitioners' preferences (to work more and more in group practices with other professional staff and not in an 'old fashion' mode in an isolated individual practices).

3.3. An Approach to Developing Local Climate Change Environmental Public Health Indicators in a Rural District

3.3.1. Problem definition: climate change vulnerability assessment in rural area

The third article reviewed here, problematizes the link between climate change and the higher risk it poses to rural populations. The authors argue that climate change represents a significant and growing threat to population health. They perform a literature review demonstrating that rural areas face unique challenges, such as high rates of vulnerable populations; economic uncertainty due to their reliance on industries that are vulnerable to climate change; less resilient infrastructure; and lower levels of access to community and emergency services than urban areas. The analysis provided has an ambition to develop climate and health environmental public health indicators for a local public health department in a rural area. The authors adapted the US Environmental Public Health Tracking Network's framework (EPHTN) for climate and health indicators to a seven-county health department in Western Kentucky. They first identified primary climate-related environmental public health hazards for the region (extreme heat, drought, and flooding) and a suite of related exposure, health outcome, population vulnerability, and environmental vulnerability indicators. Indicators that performed more poorly at the county level than at the state and national level were defined as "high vulnerability." Six to eight high vulnerability indicators were identified for each of the studied counties. The local health department plans to use the results to enhance three key areas of existing services: epidemiology, public health preparedness, and community health assessment.

The authors first describe the situation in rural areas and rural economies in terms of general trends in the context of climate change and data availability. They found that rural economies in the USA (which could be tested and scrutinised in EU contexts) are more vulnerable to the negative effects of climate change because they rely on a combination of agriculture and heritage industries such as mining and heavy manufacturing (Hales, et al., 2014). Many agricultural products are already facing climate-related challenges, such as shifting growing seasons and changing precipitation patterns, which will increase as the climate continues to change. Agriculture and industry combined represented over 30% of US greenhouse gas (GHG) emissions in 2014, with the electric power industry (many of whose installations are located in rural areas) contributing an additional 30%. With 60% of total US GHG emissions sourced from the economic engines of rural areas, these communities are particularly vulnerable to the

negative economic consequences of GHG reduction policies. Additionally, agriculture is sensitive to changes in seasonal weather patterns (Hatfield, et al., 2011). On the other hand, mitigation activities such as reforestation and largescale renewable energy installations may reinvigorate some rural economies and hurt others (Hales et al., 2014, p. 214:340).

In terms of data availability, the authors found that in spite of comprising the large majority of the nation's landmass and a sizeable minority of the country's population, less data are available quantifying the vulnerability of rural areas to climate-related environmental hazards than for urban areas, due to the challenges of developing robust statistical models in areas with low densities of both people and environmental sensors such as weather stations for example. Local health departments are key players in protecting their communities from the negative health effects of climate change. However, to date, fewer data sources and public health intervention opportunities are available for rural local health departments than for their urban counterparts. The Third US National Climate Assessment identifies vulnerability assessments in rural areas as a key research gap. This need is particularly evident in the shortage of indicators measuring the health effects of specific climatic hazards in rural areas.

3.3.2. Data and indicators

In a first step, three broad categories of indicators of needed data were defined: 1) data of environmental hazards; 2) data on human exposure to hazards; and 3) data on health effects. To define sub indicators and to identify appropriate data relevant to the rural area in Western Kentucky the authors first reviewed the Third National Climate Assessment (P.S. The equivalent at EU level should be European Climate Assessment & Dataset and EEA data and indicators) (Melillo, et al., 2014) and the associated scientific assessment of the impacts of climate change on human health (Crimmins, et al., 2016) to develop a short list of climate-related environmental hazards with a history and/or projected future of risk to human health in the Southeastern US. Authors then gathered evidence at a more granular level to identify which hazards were associated with the most negative health outcomes and highest economic burdens in rural Western Kentucky. Finally, the authors conducted consultations with climatologists, emergency management officials, and other subject matter experts at the local and state levels to validate the selection of extreme heat, drought, and flooding as the leading climate-related hazards for the region. They used data from these consultations to defined extreme heat exposure as three or more days with maximum temperatures greater than or equal to 95 ºF degrees. Through the literature review they found that exposure to extreme heat can inhibit the body's natural ability to regulate its internal temperature. It can also exacerbate cardiovascular, respiratory, and cerebrovascular diseases. Heat combined with humidity and extended exposure to extreme heat alone can be debilitating, reducing an individual's ability to concentrate and leading to fatigue. From a mental health perspective, extreme heat has been linked to increases in aggressive behaviour and hospital admittances for psychiatric conditions. The combination of heat and humidity may also correlate with increases in suicide rates, although current findings are not conclusive.

Population vulnerability to extreme heat includes individuals on either end of the age spectrum. Both children and the elderly have a limited capacity to regulate their internal temperature. Both groups are also likely to rely on others to keep them safe during heat events. Families living in poverty are at risk, because they may not have sufficient access to heat-related adaptations such as weatherized buildings and affordable air conditioning. Non-Hispanic Black populations are often at higher risk than the general population because of a combination of health status,

socioeconomic status, and environmental justice concerns. Homeless populations may combine increased exposure to heat and cold with other risk factors such as social isolation, psychiatric illness, and multiple chronic diseases. Outdoor workers are at an increased risk of negative health outcomes during extreme heat events, due to increased exposure to elevated temperatures during the heat of the day. Pre-existing chronic health conditions can also place an individual at higher risk of negative health outcomes during an extreme heat event. For example, obese individuals are more sensitive to high ambient temperatures. Similarly, exposure to heat can exacerbate conditions such as diabetes, cardiovascular disease, asthma, and cerebrovascular disease. Thus, combining data about extreme heat at a local level, socio-economic and health status of rural population the authors defined rural social groups and their vulnerability status in the context of climate change. The same exercise was conducted with the two other climate indicators: drought and flooding. Table 5 summarise information about indicators defined and data used to define various social groups 'climate change vulnerability statuses.

Table 5: Climate Change and rural population health: vulnerability assessment indicators (h – heat indicator; d-drought indicator, f – flooding indicator)

Indicator Cateogry	Data available from EPHT Network *(notes)*	Data from external source *(source)*
Environmental exposure	Exposure to heat waves" Exposure to heavy precipitation events Exposure to air pollution°	Exposure to heat waves. *(Kentucky Climate Center)* Exposure to d rough? *(US Drought Monitor)* Exposure to air pollution° *(CDC WONDER)* Exposure to heavy precipitation events' *(Kentucky Climate Center. National Weather Service)*
Human health outcome	Heat-related mortality during summer months° *(annualized data; not available at county level)*	Heat-related morbidity and mortality during extreme heat events" *(Kentucky Cabinet for Health and Family Services. Office of Health Policy: Kentucky Department for Public Health, Cabinet for Health and Family Services)* Unintentional flooding-related mortality during flooding events *(Kentucky Department for Public Health. Cabinet for Health and Family Servitzs CDC WONDER)* Unintentional flooding-related morbidity during flooding events *(Kentucky Cabinet for Health and Family Services, Office of Health Policy; Kentucky Department for Public Health, Cabinet for Health and Family Services)*
Population vulnerability	Asthma Diabetes Heart disease *(not available at county level)*	Children . elderly' , population living in poverty' , non-Hispanic Blacks.", outdoor workers", population with limited English proficiency', ambulatory difficulty *(US Census)* Homeless"

	Obesity *(not available at county level)* Poverty *(not available at county level)*	*(Kentucky Housing Corporation, US Musing and Urban Development)* Long-term Care *(Kentucky Cabinet for Health and Family Services Office of Health Policy)* Chronic lower respiratory Disea.se° *(CDC Community Health Status Indicators)* Diabetes"' *(Kentucky Behavioral Risk Factor Surveillance System)* Heart disease", cerebrovascular disease" *(CDC Interactive Atlas of Heart Disease and Stroke)* Mental health *(Kentucky Safety and Prevention Alignment Network)* Obesity. *(CDC Behavioral Risk Factor Surveillance System)*
Environmental vulnerability	100-year floodplain' Carbon monoxide poisoning'". *(KY data currently not available via EPHT portal)*	Air conditioning access" (Energy Information Administration Residential Energy Consumption Survey) Carbon monoxide poisoning.' (Kentucky Cabinet for Health and Family Services) Stressed housing" (CDC Community Health Status Indicators)

The example described in this article could be helpful for the RUSTIK living labs to develop a cross-cutting problem, such as that of climate change and human health. LLs could also develop local systems for assessing population health risks under climate change to define social groups that should be targeted for special measures.

4. Bottom-up data collection

This section surveys initiatives and advances in using bottom-up data collection and citizen science techniques to retrieve data on socio-economic and demographic, climate-environmental, and digital transitions.

While initiatives are typically adapted to a particular local issue or shared challenge, some common techniques for gathering bottom-up data can be identified. These include:

- **Surveys and questionnaires**: either paper-based or online, to gather data on particular issues. Citizen science oriented methods recruit people and groups to help distribute surveys, collect data, or both.
- **Photo elicitation**: photo elicitation techniques are used to gather visual data. This may be to capture a user-eye view, enable real-time reporting, or document changes over time.
- **Participatory mapping**: these techniques are used to gather geo-located data at a variety of scales. They are discussed elsewhere in this report.

- **Reporting platforms**: web-based reporting platforms enable people to contribute data on particular topics. They typically make this data publicly available, and often integrate elements of surveys, photo elicitation, and/or participatory mapping.
- **Mobile apps**: many mobile apps have been developed to facilitate bottom-up data collection at a local or hyper-local scale. Some apps are custom-designed for specific initiatives, while others offer commercial or open-source solutions that can be used in multiple contexts. These may overlap with online reporting platforms.
- **Crowdsourcing**: crowdsourcing uses public volunteers to help interpret data that has already been gathered. Usually, these techniques are used to code or localise data from larger scale datasets, such as satellite imagery.
- **Sensors and in situ stations**: these methods are most often deployed to gather environmental data. They typically use low-cost technologies that can be easily purchased and used in local communities.
- **Internet of Things (IoT)**: With IoT, various devices and objects can be connected to the internet, allowing data to be collected and analysed in real-time. IoT can include sensors for monitoring environmental data, and there are also initiatives using wearable devices and devices in the home to collect data. IoT data can be used to monitor the performance of connected devices, track energy usage, and gather data on environmental factors.

4.1. Socio-economic and demographic transitions

Although participatory techniques and grounded theory approaches are widely used in research projects that address socio-economic and demographic transitions, the sorts of apps and platforms that predominate in bottom-up data collection in the natural sciences (see climate-environmental transitions, below) are much less prominent. While it is evident that a wealth of socio-economic and demographic data is regularly retrieved to inform research and policy in the social sciences, much of this data is dispersed and/or confined to discrete projects and/or publications.

Generally, four types of collection that can be defined as more bottom-up or open can be discerned:

Repositories

Although repositories do not directly undertake data collection, they provide an important resource for retrieving data from discrete projects. Many repositories are aimed at researchers, but some examples have explicitly aimed to provide data in ways that are more accessible to local communities.
Examples: UK Data Service, Finnish Social Science Data Archive, Understanding Welsh Places.

Longitudinal panels and surveys

Often deriving from the social indicators research tradition, notable examples of panel and survey data provide robust samples and publicly available data that can be compared over time.
Examples: European Social Survey (ESS), German Socio-Economic Panel (SOEP), Irish Longitudinal Study on Ageing (TILDA).

Web-scraping

Web scraping is a technique used to extract data from websites. Common forms of web-scraping that retrieve bottom-up data are social media analysis, and opinion mining or sentiment analysis. It should be noted that many people posting online will not be aware of supplying data, or intend to do so.
Examples: sentiment analysis of COVID-19 tweets in Italy, UN Global Pulse.

Participatory indicators and dashboards

These approaches enlist bottom-up participation in identifying indicators and types of data that matter most for a local area or community. Although dashboards that enable government organisations to select from available indicators have been available for some time, approaches that engage communities and stakeholders are more recent.
Examples: ESPON Territorial Quality of Life dashboards, OECD Better Life Initiative regional well-being index.

The following details some specific examples:

Understanding Welsh Places / Deall Lleoedd Cymru

Understanding Welsh Places is a bilingual website that was launched in 2019 to provide publicly accessible local-level data on over 300 towns in Wales. This represents every place in Wales with over 1,000 residents, however places with at least 2,000 residents have the most data available. The website aims to enable accessing of economic, demographic, and service provision data in an easy to use and comparative way. The project was funded by the Carnegie UK Trust and the Welsh Government, and developed by the Institute of Welsh Affairs and Wales Institute of Social and Economic Research and Data (WISERD).

Understanding Welsh Places primarily draws upon existing data from validated national sources. However, the intention of the project is to provide data that can be used to identify local economic opportunities and inform decision-making. Where extensive data is available, the website collates this into automated dashboards by category, providing a range of maps and graphs on, for example, age distribution, access to shops, and commuter flows. The website also provides suggestions on similar places and allows users to select another place from a list to compare their place with. The most recent update (February 2023) invites local communities to upload community plans or place audits. Overall, the project has aimed to:

- Provide a better understanding of the economic and social characteristics of towns in Wales, their strengths and challenges.
- Develop a classification system for Welsh towns based on their economic and social characteristics, to help policymakers and researchers to understand the different types of towns in Wales and their specific needs.
- Provide a tool for evidence-based policy-making.
- Foster collaboration and partnership working between different stakeholders in Welsh towns, such as local authorities, businesses, and community groups, by providing them with a shared understanding of the strengths and challenges of their town.

The Irish Longitudinal Study on Ageing (TILDA)

TILDA was established in 2009 with the aim of establishing a nationally representative survey about Ireland's older population that would help inform policy and public sector decision-making. It was launched amidst long-term projections of a demographic transition to an ageing population in Ireland, in the recognition that social, economic and health data on older people in

Ireland was lacking. The first wave attracted over 8,000 participants, and the study is now at wave six.

The TILDA methodology selects participants aged 50 and over from the Irish Geodirectory, an up-to-date listing of residential addresses in Ireland. Participation involves a computer-aided personal interview and a self-completed questionnaire. Some TILDA waves have also invited participants to complete a health assessment at home or at a medical centre. The instruments collect a wide range of data, ranging from the participant's childhood, to their work and income history, to their health and well-being. The research is led by Trinity College Dublin with a consortium of other Irish higher education institutions.

TILDA is designed to harmonise with the US-based Gateway to Global Aging Data, which brings together multiple longitudinal studies to provide cross-country comparisons. Unfortunately, while TILDA data is technically publicly accessible, users must complete a request form or use a dedicated physical hot desk. This means that the data is largely aimed at researchers. Some of the main outcomes from TILDA have included:

- Health outcomes: TILDA has provided insights into the health status of older adults in Ireland.
- Cognitive outcomes: TILDA has also provided insights into cognitive function and decline in older adults.
- Social outcomes: TILDA has provided insights into the social circumstances of older adults in Ireland, including their living arrangements, social networks, and participation in social activities.
- Economic outcomes: TILDA has provided insights into the economic circumstances of older adults in Ireland, including their income, wealth, and pension arrangements.
- Policy and practice outcomes: TILDA has highlighted the need for policies and interventions to address issues such as social isolation, cognitive decline, and economic vulnerability among older adults.

ESPON Territorial Quality of Life dashboards

Research on a methodology and indicators for measuring quality of life at territorial scales was commissioned by ESPON in 2019. The project aimed to produce evidence about the challenges, achievements and development trends of European regions and cities in relation to Quality of Life (QoL) as well as to deliver guidance for local, regional and national level policy makers to promote the integration of QoL in the development and implementation of territorial development strategies.[2] The project encompassed three broad spheres of quality of life: personal, socio-economic, and ecological. Indicators were developed for 9 domains and 22 sub-domains.

Significantly, the project used a deliberative approach to engage citizens, experts, and policy-makers in identifying how quality of life should be measured. The approach was therefore flexible, and aimed to avoid developing indicators on a 'one-size-fits-all' basis. The major outcome was a TQoL dashboard tool that can be applied to understand a single territorial context over time, or used to compare other regions. Data availability proved a significant limitation, however, and proxies were not always robust. Nevertheless, the project represents a step forward in using data at a more granular scale and integrating a citizen-centric to inform what data matters most in the places where people live. The project aimed to develop:

- An updated set of quality of life indicators, as well as new indicators to cover the different domains of quality of life.

- A user-friendly database and tool that will allow policymakers and researchers to access and analyse the quality of life indicators.
- Improved understanding of quality of life and the different factors that influence quality of life in European regions, as well as the regional variations in quality of life across Europe.
- Support for evidence-based policies and strategies that aim to improve the quality of life in European regions.

VERA – Virtual Ecosystem for Research Activation

VERA is an online platform developed as part of the Horizon 2020 project COESO (Collaborative Engagement on Societal Issues). COESO is led by the École des hautes études en sciences sociales in France. The project kicked off in 2021 and will conclude at the end of 2023. The project explicitly aims to address the lack of citizen science initiatives in the humanities and social sciences. VERA is intended to provide an easy to use collaboration platform for citizen science projects. It was released in an alpha version in 2021 and remains in development.

VERA is designed to connect with the OPERAS Research Infrastructure for open social science communication and eu-citizen.science platform, and to integrate with common social media tools. The platform consists of a shared hub, dashboards for registered projects, and personal workspaces. To date, much of the development activity appears to be focussed on enabling tools for project recruitment and communication[3] rather than specifically storing and retrieving data. However, the focus on citizen involvement in social science is distinctive, and the full potential of the VERA platform remains to be seen.

4.2. Climate-environmental transitions

Multiple initiatives have sought to use citizen science techniques to involve local communities and residents in monitoring and addressing environmental transitions. These initiatives have occurred at a variety of scales, but a general distinction can be drawn between **local or hyper-local initiatives** focussed on a particular location (such as a woodland, watercourse, street, or town) and **initiatives at scale** to more comprehensively collect, aggregate, or compare data. Examples of the former tend to be oriented around sustainability awareness and/or community resilience; the latter are more likely to aim to use bigger datasets to inform policy decisions.

Both types of initiatives are often associated with particular research or publicly funded projects, meaning that they are time limited and potentially creating problems with longevity. Many localised initiatives can be especially fleeting, such as one-off events to populate a database or raise public awareness about an issue *du jour*. As this suggests, validating and maintaining up-to-date data can be challenging. Similarly, the possibilities to re-use data from some initiatives can be limited. By contrast, some more popular types of initiatives are replicated across multiple disconnected platforms, posing interoperability challenges. For example, citizen scientists interested in logging biodiversity can choose from an array of platforms, including iNaturalist, Natusfera, iSpot, and Pl@ntNet.

In practice, approaches to data gathering can be adapted to suit different contexts and needs. Different tools and methods also help to engage a broader range of participants. Several common techniques can be distinguished:

Smartphone apps

App-based initiatives leverage the widespread availability of smartphones to collect data from citizens. These have often been used in monitoring and documenting data about ecosystems, enabling citizens, for example, to take photos of plants or log real-time data about pollution and allergens.
Examples: Forest Watcher, Mosquito Alert (ES & EU), iNaturalist (US & international).

Social media and crowdsourcing

These initiatives are similar to app-based projects, but use social media or other online platforms to sift information. Crowdsourcing examples are distinguished by enlisting members of the public to interact with data, such as classifying photos and assigning geo-references.
Examples: Cities at Night crowdsourced light pollution research (international), E2mC crowdsourced emergency mapping platform (EU).

Paper and web-based collection

These methods involve providing citizens with paper forms or online data sheets that they can fill out to record observations or measurements. While paper-based methods may be more time-consuming and prone to errors, they can be a useful option in areas with limited access to technology. Web-based collection typically requires users to register for an online account.
Examples: Artportalen species observation system (SE), NOSE Network for Odor SEnsitivity (IT), Chronolog photo elicitation tool (US).

Distributed lab technologies

These initiatives use low-cost tools and methods for environmental monitoring. This includes tools such as aerial mapping kits, water quality testing kits, and air quality sensors. These tools are designed to be affordable and accessible to communities who may not have access to expensive laboratory equipment.
Examples: Mini Secchi water quality monitoring, iSpex smartphone-enabled air quality monitoring, Compair urban air quality Citizen Science Labs (GR, DE, BE, BG), PULSE air monitoring and health assessment test-beds.

Community-based monitoring

In this approach, local communities are empowered to monitor their own environment using their own expertise and knowledge. This may involve working with local leaders or experts to identify key indicators of environmental health, and developing monitoring protocols that are appropriate for the local context.
Examples: Public Lab (US), Anglers' Riverfly Monitoring Initiative (UK), Hollandse Luchten (NL).

Hackathons

These are short-duration events that bring together volunteers to meet and work together to tackle a given theme. They typically use data and coding to develop practical solutions to specified concrete problems.
Examples: DxO 2022 Digital x Outdoor OpenHack (CH), Crowd4SDG (CH & international), Dubrovnik INSPIRE Hackathon (HR & international).

Participatory mapping

This approach involves working with communities to create maps that reflect their knowledge of the environment. This may include mapping resources, hazards, or areas of cultural significance. The resulting maps can be used to inform environmental planning and decision-making. *Participatory GIS is specifically described later in this report*.

The following outlines selected examples.

Mosquito Alert

The Mosquito Alert project began in 2014, and it is ongoing. Mosquito Alert is a citizen science project that aims to track the spread of mosquito-borne diseases and reduce the impact of these diseases on human health. The project is based in Spain and is a collaboration between several institutions, including the Catalan Institute of Public Health, the Spanish Ministry of Health, and the Barcelona Institute for Global Health. Since its launch, the project has also expanded its reach beyond Spain, with similar initiatives being developed in other European countries.

Mosquito Alert is designed to empower citizens to become mosquito detectives by providing them with a free mobile app that allows them to report mosquito sightings and help track the spread of disease-carrying mosquitoes. The app provides information about different types of and how to identify them, as well as guidance on how to collect and submit data. The data collected by Mosquito Alert is used to create maps that show the distribution of mosquitoes and identify areas where there is a higher risk of disease transmission. This information can be used by public health authorities to develop targeted interventions to control mosquito populations and prevent the spread of disease. To date the app has recorded over 200,000 downloads, almost 70,000 sightings, and over 15,000 reported breeding sites.
Some of the key results from the Mosquito Alert project include:

- Improved mosquito monitoring: By engaging citizens in the data collection process, the project has been able to gather more data on the distribution of mosquitoes than would be possible with traditional monitoring methods.
- Identification of disease-transmitting species: The project has also been used to monitor the expansion of the Asian tiger mosquito, which is a known carrier of several diseases.
- Targeted interventions: The information gathered by Mosquito Alert has been used to develop targeted interventions to control mosquito populations and reduce the spread of disease. For example, public health authorities have used the data to identify areas with high mosquito populations and implement targeted mosquito control measures.

COBWEB: Citizen OBservatory WEB

COBWEB was an EU Framework Seven funded project aimed at creating a web-based platform that allows citizens to monitor their local environment using a range of mobile and web-based tools. The COBWEB project aimed to provide citizens with a user-friendly and accessible way to collect and share data about their local environment, such as air quality, noise levels, and water quality. The project was launched in 2013 and ran until 2017.

The project involved the creation of “citizen observatories” based in biosphere reserves in Wales, Germany, and Greece. Pilot case studies looked at the creation and validation of data products from Earth Observation data, biological monitoring, and flooding.4 The data collected by these observatories was then integrated into a central platform. COBWEB was designed to be an open platform, meaning that anyone could access the data collected by the citizen observatories. The project also developed a customisable mobile data collection tool, called Fieldtrip GB.5 Unfortunately, COBWEB has suffered from the challenges noted above, and most data are no longer available. Some of the key results from the COBWEB project included:

- Development of a web-based platform: One of the main outcomes of the COBWEB project was the development of a user-friendly and accessible web-based platform that allowed citizens to collect and share data about their local environment.

- Improved environmental monitoring: By enabling citizens to collect and share data about their local environment, the COBWEB project helped to improve environmental monitoring and to fill gaps in existing monitoring systems.
- Increased collaboration: The COBWEB project fostered increased collaboration between different stakeholders, including citizens, NGOs, government agencies, and academic institutions.

OPAL: Open Air Laboratories

The Open Air Laboratories (OPAL) project was a UK-based initiative that aimed to engage the public in scientific research and increase awareness of environmental issues. OPAL provided resources and support for people to conduct scientific investigations in their local environments. The project focused on five areas: air quality, biodiversity, soil quality, water quality, and climate. The project was launched in 2007 by Imperial College London and ran until 2019. Over 1 million people participated, including many from disadvantaged communities, and 2,800 organisations worked with OPAL.

OPAL conducted numerous surveys and studies across the UK, involving thousands of participants, and including the creation of a soil biodiversity database and the development of an air pollution mapping tool. Some of the key results from the OPAL project included:

- Increased public awareness and engagement: OPAL successfully engaged thousands of people in scientific research, and provided opportunities for people who may not have had access to formal science education to participate in scientific investigations.
- Generation of new data and knowledge: OPAL generated a wealth of new data which has been used by scientists, policymakers, and community groups to inform environmental management and decision-making.
- Development of new tools and resources: OPAL developed a range of tools and resources to support environmental research, including survey materials, identification guides, and online data portals.

MONOCLE

The Horizon 2020 project MONOCLE (Multiscale Observation Networks for Optical monitoring of Coastal waters, Lakes and Estuaries) ran from 2018 to 2022. The project brought together 12 partners from across Europe to create sustainable in situ observation solutions for monitoring optical water quality in inland and transitional waters. A key aim was to improve water monitoring by lowering the cost of optical sensors, making them affordable and widely available, to help calibrate satellite data. This included developing low-cost devices that could be used by non-experts.

The project developed and implemented eight low-cost sensor systems, designed to integrate with the Open Geospatial Consortium. These included in situ sensor stations, devices designed to fit consumer drones, and easy to use technologies such as handheld mini Secchi disks and iSpex attachments for mobile phones. Some of the key results from MONOCLE include:

- Improving sensor and platform prototypes: MONOCLE successfully demonstrated a range of low-cost technologies for measuring water quality data.
- Integrating satellite and in situ observation: MONOCLE's tools demonstrated how simple tools for collecting hyper-local data can be integrated with environmental observation technologies at a much larger scale.
- Open source design: making tools and knowledge available open source is expected to widen access to environmental data.

4.3. Digital transitions

Bottom-up data collection has been used to understand digital transitions in Europe by collecting data directly from individuals and organisations on their digital experiences, needs, and practices. Alongside the general approaches already mentioned, the following unique foci can be identified:

Age groups

Several initiatives have focussed on understanding how digital transitions affect the members of an age group, particularly young people and older adults. Data collection has often integrated apps and digital devices.
Examples: YouCount, DigiGen.

Open Urban Data Platforms

As a part of digital transitions, cities and municipalities are increasingly making data publicly available. Open platforms provide a range of features, such as data storage and management, data visualization tools, and application programming interfaces (APIs).
Examples: Berlin Open Data, Helsinki Region Infoshare.

Skills and personal data

Digital transitions are creating both quantities of personal data and new opportunities for sharing that data. Initiatives that focus on skills and personal data are typically interested in enabling individuals to take control of the data that they generate, mitigating privacy concerns and maximising opportunities.
Examples: DS4Skills, DataVaults, Gaia-X.

Eurostat and Eurobarometers

One example of bottom-up data collection in Europe is the Eurostat survey on ICT usage and e-commerce in households and by individuals. This survey collects data on the use of information and communication technologies (ICT) in households and by individuals, including their access to the internet, use of social media, and online shopping habits. The survey is conducted annually and provides valuable insights into how individuals and households in Europe are adapting to digitalisation.

The European Commission's Special Eurobarometer 503 “Attitudes towards the impact of digitalisation on daily lives” was a survey designed to assess public attitudes towards the impact of digitalisation on daily life in the European Union. The survey was conducted in 2019 and involved interviews with 27,607 respondents across all 28 EU member states.

The survey included questions about a range of topics related to digitalisation, including the use of digital devices and services, online privacy and security, and the impact of digitalisation on work, education, and social interaction. The survey also asked respondents about their attitudes towards the potential benefits and risks associated with digitalisation, as well as their views on the role of government and industry in regulating and promoting digital technologies.

Helsinki Region Infoshare

Helsinki Region Infoshare (HRI) is an open data platform that provides access to a wide range of data related to the Helsinki region. It has been ongoing since 2010. HRI offers fast and easy access to open data sources between the cities of Helsinki, Espoo, Vantaa and Kauniainen. The HRI service is funded by the cities of Espoo, Helsinki, Vantaa and Kauniainen. The Finnish

Ministry of Finance and the Finnish Innovation Fund Sitra have also supported the service in the project planning phase.

The platform is intended to support evidence-based decision-making and innovation in the region. It aims to use the opportunity provided by digitalisaton to open up administrative data, increasing citizens' knowledge and understanding of their living area, its history and future development, and thereby their participation. Although HRI provides administrative data, the emphasis is on enabling users to interact with it. HRI hence has four operational areas:

- Producing data
- Opening data
- Sharing data
- Utilising data

DataVaults

The DataVaults project is an EU-funded research and innovation project aimed at developing a decentralized platform for personal data management. The platform will allow individuals to store their personal data in a secure and private manner, and to share that data with others as they see fit. The project's goal is to empower individuals to control their personal data and to foster a more transparent and trustworthy digital ecosystem. The project began in 2020 and will conclude in April 2023.

The project responds to the way that digital transitions generate personal data, with both business and government potentially interested in putting it to use. DataVaults aims to address concerns about privacy, ethics, and intellectual property rights, by allowing individuals to take ownership and control of their data and share them at will, through flexible data sharing and fair compensation schemes. The project operates the following data demonstrators:

- Olympiakos (GR): sports and activity data sharing.
- Municipality of Piraeus (GR): citizen and visitor data sharing.
- Andaman7 (BE): healthcare data.
- MIWenergia (ES): smarthome data.
- Commune di Prato (IT): personal data for municipal services and tourism.

DESIRA

The Horizon 2020 DESIRA project is a research and innovation project focused on understanding the economic, social, and environmental impacts of digitization in rural areas. The project aims to improve the capacity of society and political bodies to respond to the challenges that digitalisation generates in agriculture, forestry and rural areas. The project brings together researchers, policymakers, and stakeholders from across Europe to identify the opportunities and challenges associated with digital technologies in rural areas, and to develop strategies for maximizing the benefits of these technologies. DESIRA began in 2019 and concludes in 2023.

DESIRA is not a data platform, but has run multiple Living Labs focussed on stakeholders' experiences of digitalisation. The project's main objectives are to:

- Assess the impact of digitization on the economic, social, and environmental sustainability of rural areas.
- Identify the barriers to the uptake of digital technologies in rural areas and develop strategies for overcoming these barriers.

- → Develop innovative solutions to support the deployment of digital technologies in rural areas.
- → Provide evidence-based policy recommendations to support the development of a digital rural agenda at the European, national, and regional levels.

DS4Skills

DS4Skills is a one year preparatory action funded under the Digital Europe Programme. The project began in 2022 and aims to lay the groundwork for developing an open and trusted European Data Space for Skills that supports sharing and accessing skills data. Work is currently focussed on identifying relevant data sources, with the consortium categorising and assessing existing initiatives in skills and educational data. DS4Skills collaborates with the Data Spaces Support Centre. While DS4Skills has yet to deliver concrete results, the project's inventory work may be of interest to RUSTIK in future.

5. PPGIS as a method to overcome information gaps

The aim of this chapter is to review how the PPGIS method can be used to collect map-based data in rural areas and how this can fill identified data gaps in relation to the rural transitions. First, in section 6.1 we will look at the general concepts of spatial data and PPGIS, and what kind of data types can be collected using the PPGIS method. The section 6.2 discusses use of PPGIS within the transitions identified in the Rustik D1.1 document: socio-economic and demographic transitions, climate and environmental transition and digital transition. Finally, in section 6.3 we consider how PPGIS data can be analysed and utilised.

5.1. Key concepts

5.1.1. Geospatial data and Geographic Information System (GIS)

Geographic information, geospatial or spatial data refer to information that is location specific. When geographic coordinates can be attached to an entity be attached or when its location can be understood in relation to another entity, it can be defined as spatial data (Howari & Ghrefat 2021). In spatial datasets the entities often have also attribute information, data that describe the characteristics of the entity. For example, a building is located at a particular location and in addition it has its own characteristics, such as what the building looks like and what it is used for. Spatial information can be physical and fixed, such as the building. It can also be time-dependent and temporal, such as a phenomena or process taking place at a certain location. It can also be more abstract, such as experiences, opinions or ideas attached to certain locations. For example, our experience of our living environment is often linked to specific places or points, such as nice spots on a daily walking route.

Geometrically spatial data is usually saved and presented in the form of points, lines or polygons. Maps are a traditional way of presenting spatial information. Today, spatial data is processed and managed digitally using GIS, Geographic Information System, which is software developed to store, manage, analyse and produce location-related information (Ali, 2020). GIS system consists of the data, the equipment, the software, and the users.

5.1.2. Public Participation GIS (PPGIS)

Location relevant statistics and GIS data sets exist on different regional levels and scales. However, these data sets lack the human dimension, the place-based knowledge of people – i.e. how do people feel, value and experience and use their living environment. Participatory mapping is an umbrella term for the process of collecting people's experiences and knowledge of places on maps and involving people in, for example, projects and related decision-making (Tulloch, 2008; Brown & Kyttä, 2014). Public participation GIS (PPGIS) combines two components: public participation and GIS, and it refers to the utilisation of digital tools to collect and use information about people's location-based experiences. PPGIS allows complementing the hard data sets with softer data collected directly from people, and the aim is to use this information e.g. in planning projects and in decision making.

PPGIS usually refers to participation in an online environment, typically an online survey that allows participants to mark places, routes and areas on a map and answer related questions. Related term Participatory GIS (PGIS) has not been clearly distinguished from PPGIS, and the terms have been used interchangeably. However, it can be noted that PGIS is the more commonly used term in cases where the main goal of participation is social learning, empowering and building social capital, and supporting NGOs and grassroots movements (Brown & Kyttä, 2014). PGIS is also not necessarily a process implemented with a digital tool; it can also take place on a paper map. The aim of PGIS is not necessarily creation of representative map-based data sets, but rather one map produced by the key stakeholders. PPGIS, on the other hand, aims to produce representative map data usually from a larger audience, with the key objective of informing decision making. Traditionally, PGIS has been a more common approach to engage and empower communities in rural areas and in developing countries, while PPGIS has been a more usual approach in urban planning projects. Today, however, technology and mapping solutions have evolved so rapidly that good quality digital map data is available also for more remote areas, and network connectivity is better than in the past. Therefore, despite the traditions, it can be stated that PPGIS is a viable option in the RUSTIK context. If the RUSTIK pilot areas contain sites with particularly poor network connectivity, or if some of the target respondents are not able to respond to the online mapping, it will be possible to collect some of the data in paper format, and manually enter the data into PPGIS afterwards.

5.1.3. Types of data that can be collected with PPGIS

PPGIS is a method allowing both qualitative and quantitative data collection. Map-based data collected with a PPGIS tool usually consists of the places, routes or areas (point features, lines or polygons) marked on the map by the respondents. Parallel, it's possible to ask for additional quantitative and qualitative information related to these locations, e.g definitions what kind of location it is and reasoning why did the participant select that certain location, what kind of values or priorities they attach to the places. The additional information can be asked for example in the form of an open text answer, number format or a classified multiple choice selection. Moreover, image or file uploads would also be an option.

The collected locations can be fixed or static, or illustrate flows and mobility patterns. The information collected on a map has also a temporal character: it can be related to the current situation, or to the future or the past.

Examples on map-based information types that can be obtained with map-based tools:

- Activities in the living environment; e.g. which places, routes and areas people use in their everyday life.
- Opinions and values regarding the living environment: how the respondent perceive their places, routes and areas.
- Memories and experiences of places, routes and areas.
- New ideas and suggestions; e.g. ideas on how to make the place/route/area more welcoming.
- Routes and mobility patterns.
- Feedback on future plans.

In addition to map responses, PPGIS questionnaires can contain traditional question types to collect more general information on respondents, such as their socio-demographic backgrounds, general values and preferences, personal motivations and reasons, and personal well-being.

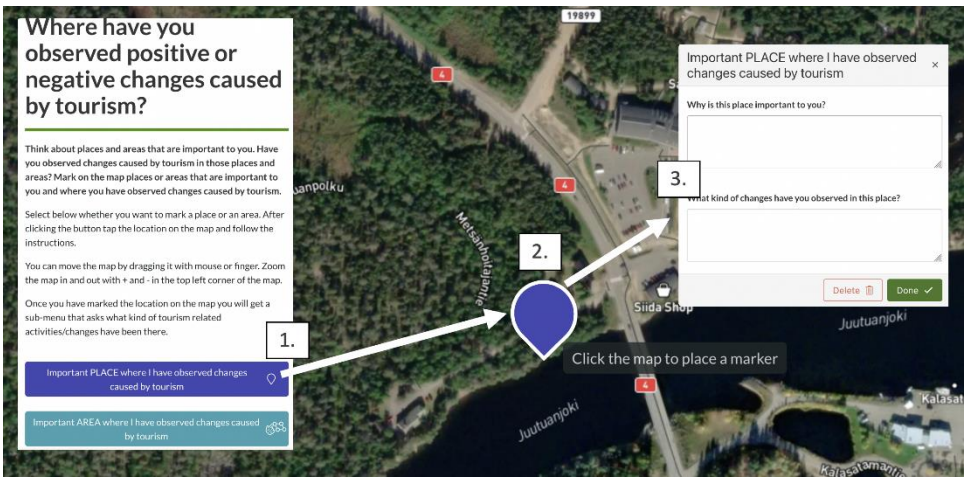

Figure 8: An example of a PPGIS survey. In the mapping section respondents are asked to mark their answers on the map as points, lines or polygons. After locating the response on the map, respondents are usually asked to elaborate on their selection.

5.1.4. PPGIS data as part of the information flow

The information flow in a participatory project runs in cycles. At different stages of the process new information and input is requested from participants (Staffans et al, 2019). Figure 8 shows how at the beginning of each phase new information flows in and at that point the views of participants are diverging. Through discussion each phase is aiming to compromise differing views and reach consensus. Each phase builds upon previous stages and datasets in the process. This approach is also useful for the RUSTIK project, as the aim is to collect data in a continuous process over a longer period of time, in many different phases, from initiation to evaluation and monitoring.

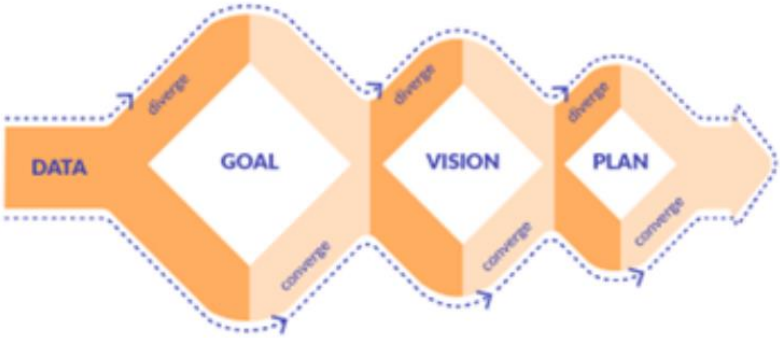

Figure 9: Double diamond model of the information flow in a participatory project (Staffans et al, 2019).

Previous data collection phases or already existing data sets can be used as the basis for the next phase. With PPGIS method this could mean e.g. building the questionnaire topics based on the previously acquired information and in the mapping sections showing map layers generated from the previous input from the stakeholders. This type of workflow also increases transparency, as participants see how their data is being used.

Loosely relying on the participation ladder by Sherry Arnstein (1969) three different ways of involving stakeholders can be distinguished, depending on the degree of the active involvement: 1) informative participation, 2) preparatory and planning participation and 3) decision making participation. Informative participation is only about sharing information with stakeholders and does not seek an active role from them. In preparatory and planning participation, both informing and participating are present: for example, the planning project is presented to stakeholders and at the same time feedback and ideas can be sought from them to support the planning process. In the case of decision-making participation, the stakeholders are also given more power to make actual decisions on the outcome of the project. Participatory budgeting is an example of this.

The use of the data collected by the PPGIS method in the subsequent stages of the process can be implemented using different tools and different methods. The information can be easily shared in digital format, but can also be used as a basis for on-site discussions. The use of PPGIS does not exclude the use of other methods: the use of multiple methods can enrich the process.

In general when planning a participation project with PPGIS, it is beneficial to plan carefully how to distribute the survey and how to find respondents in order to reach the desired level of participation. Brown & Kyttä (2014) note that as with any survey methods it is important to disseminate and market the questionnaire in order to reach respondents. Recruiting respondents to a PPGIS study can be done in the same way as disseminating any survey. An online PPGIS survey has its own link and respondents get access to the survey by receiving the link and/or a QR code. The most suitable data collection method depends on what kind of respondents, what kind of data and what kind of response rate are being aimed. As has been mentioned in the context of the RUSTIK project, the communities should be engaged in the process in the long term and in many project phases.

Data collection strategies for PPGIS:

Open data collection
The simplest and most resource-efficient way to distribute the survey is through open data collection by sharing the questionnaire link e.g. on social media and websites. However, open crowdsourcing might more easily produce a skewed respondent profile because anyone has access to the survey and can share it further in their own network (Kahila-Tani, 2019).

Random sampling
Sampling by using national registries has proven to be the most efficient way to reach higher response rate and good data quality, although at the same time the costs with this method are higher as it usually requires sending out paper mail to distribute the invitations (Fagerholm et al, 2021).

Panel companies
High response rates have been obtained by using panel companies, but the quality of the data has been observed to be worse (Brown & Kyttä, 2014).

Facilitated respondent session
For those who need more assistance, e.g. children, elderly.

5.2. Rural transitions and PPGIS

PPGIS tools have traditionally been used in community engagement projects in urban environments, such as in urban planning and transport planning. Nevertheless, PPGIS can be applied in the rural settings as well, and in fact there are various previous project examples i.e. related to tourism, resource management and mobility. As mentioned in section 3.1.5, in the rural areas the approach has often been statistical, and the RUSTIK project could take a step forward by involving communities in a more systematic collection of qualitative data. PPGIS offers a good solution to this, as it allows for the systematic collection of soft data such as people's experiences, social habits and networks. This data can be collected in a map-based format and can be accompanied by textual responses, categorized responses, images and audio files. Next, we look at past PPGIS projects through the three identified rural transitions: socio-economic and demographic change, climate and nature, and digitalisation, and how the PPGIS method can contribute to existing data gaps in these topics.

5.2.1. Collecting PPGIS data related to the socio-economic and demographic transition

To increase the attractiveness of rural areas and combat the socio-economic challenges they face, such as depopulation, demographic and regional disparities and the weakening of the service network, more empirical knowledge is needed. As mentioned in section 3.2 of this document, a key question is how to generate data for evidence-based scenarios. The local-level problems and challenges in everyday life identified in the Living Labs are part of larger socio-economic transitions and thus linked to broader strategic objectives that cross regional levels.

The PPGIS method can be applied in the RUSTIK project to capture people's perceptions of socio-economic factors in the pilot regions, especially when it comes to identifying values, activities and experiences associated with locations. In previous PPGIS literature socio-economic and demographic change have been approached through concepts of perceived

quality of life, wellbeing, lifestyle and place values (Kyttä et al, 2013; Kyttä, 2011). Kyttä et al (2013) approach perceptions of location-based wellbeing with four main themes: 1) functional possibilities, 2) social life, 3) appearance of the environment and 4) atmosphere of the environment. Functional possibilities include sub-themes such as services, hobbies, mobility and traffic safety. Social life relates to social factors such as sense of security, reputation of place, neighbourhood relations. Appearance of the environment includes factors such as price-quality ratio of living, tidiness of surroundings, presence of history, attractiveness. Atmosphere of the environment relates to the feelings evoked by the place, such as tranquillity, liveliness, child-friendliness and sense of relaxation. Although previous PPGIS studies of perceived wellbeing have mostly examined the impact of the urban environment on well-being, the themes are also relevant to the socio-economic transitions of the rural environment. By involving communities, useful local information can be gathered to help identify locally important sites that contribute to well-being, where there are development needs and what are the potential future conflict points in land use planning (Knapps et al 2022, Kyttä et al 2013, Kyttä 2011).

Accessibility of services, such as healthcare services or recreational services, can create inequalities and regional disparities and can negatively affect health and social well-being in a region. Laatikainen et al (2017) used the PPGIS method to measure travel thresholds to popular recreational environments, and used the data to construct a service area analysis that not only takes into account the spatiotemporal characteristics of the travel network, but also the preferences, experiences and needs of individuals. Accessibility of services has often been measured from the perspective of only one mode of transport, while in reality, individuals' travel behavior and perceived accessibility may differ greatly (Laatikainen et al, 2017). Walenga & Heldt also investigated modes of transport and the experiences of traveling to a tourist destination. They find that the car was clearly the dominant mode of transport in the responses, and they call for further research on the challenges of public transport and the use of electric cars. This topic is also relevant in rural areas where the car has traditionally been the most popular mode of transport. In order to move towards more sustainable transport planning in rural areas, experience-based information on mode of transportation preferences, current problems and future wishes is needed.

5.2.2. Collecting PPGIS data related to climate change and environment

Climate change poses many hazards to rural areas, and these vulnerabilities need to be studied more in detail, as stated in Chapter 3.3 of this document. In particular, more information is needed on environmental hazards in general, the threats they pose to people and the impacts on health. As stated in the RUSTIK D1.1 rural areas will face or have already faced challenges due to climate change, such as drought resulting in water management issues, crop losses and wildfires, land abandonment, loss of traditional farming landscape and cultural heritage, new production methods and multifunctionality and coexistence of activities in rural areas. Next, we will review how the PPGIS method can be used to fill in data gaps in these topics.

Resilience is the ability to respond and adapt to future changes. More understanding of the threats posed by climate change is needed for practical decision-making and planning, in particular place-based knowledge of the social, economic and physical vulnerabilities of regions (Morse et al, 2020). Participatory methods can (Raymond & Brown, 2011), for example, allow participants to mark land-scape values on a map and assess how vulnerable these places are to climate change. As a result, a better understanding of the level of vulnerability and how the area could better respond to future challenges can be obtained. The ability of areas to mitigate the

effects of natural hazards can be viewed as an ecosystem service (Brown & Montag, 2012). Ecosystem services can be defined as the benefits that the environment provides to humans, such as health benefits and quality factors of life. Brown & Montag used PPGIS to map ecosystem services, and one of the categories was natural hazard regulation, the ability of valued places to respond to impacts such as floods, droughts and wildfires. Data collection on climate and environmental hazards can be divided into two temporal categories: 1) a pre-study prior to the occurrence of hazards or 2) a post-study to assess the extent and impact of hazards that have already occurred.

Many of the previous PPGIS projects in rural areas approach climate and environment topics from the perspective of ecosystem services. In PPGIS research, ecosystem services are also often associated with the concept of multifunctional landscapes, a concept relevant to RUSTIK project as well, as several functions from food and energy production activities to recreational ecosystem services are co-existing. Plielinger et al (2019) conducted a map survey in 13 rural locations in Europe and explored synergies and trade-offs between different ecosystem services. Plielinger et al (2019) discuss that mapping ecosystem services helps to understand perceptions of multifunctional landscapes. Fagerholm et al (2019) highlight that local-level knowledge collected from people supports contextualized and socially acceptable policies for sustainable management. The study investigated locally perceived ecosystem benefits of multifunctional landscapes in rural areas, and the mapped responses identified outdoor recreation, aesthetic values and social interactions as the most important.

5.2.3. Digitalisation

Digitalisation is one of the main transitions identified in the RUSTIK project. Digital solutions and technologies provide opportunities for rural areas where the distances are long and the population is often too sparse for many services. Digital tools can help to enrich the services in rural areas and offer local people new opportunities e.g. to participate in decision making. Use of PPGIS is one example of a digital solution that can give people the chance to more easily participate in the local decision making and engagement projects. Participants can give their input even at home with their own devices. This makes the data collection more efficient for the project leaders as they don't need to travel long distances in the sparsely populated areas. At the same time, online participation also saves participants' time and efforts.

As digital tools are getting more important in land use management, planning projects and different types of engagement projects, it's important to provide everyone equal access and try to minimize the digital divide. Use of PPGIS is not an exemption of this and it's important to assure that everyone has equal right to participate and express their views (Gottwald et al, 2016). Digital divide does not only refer to the divide between old and young generations, but anyone who doesn't have the skills or resources to use digital tools. These participants are potentially disadvantaged in the processes. It is important to provide alternative ways or assistance for those who need it. In the context of PPGIS this can mean e.g. providing time slots in public places, e.g. at library or town hall, where those who want can participate with assistance. Hedge et al (2017) call for more research on how the older generations see their participation and how they would like to participate and how they see themselves using internet technologies. Minorities and participants from other language groups can be engaged by translating the questionnaires into relevant languages. User experience can be made better by adding instructions, such as small text tips, visuals and videos. Good user experience also improves data quality, when respondents don't face problems while using the tools. In PPGIS

projects for example navigating and zooming on the map are important points to instruct the respondents (Gottwald et al, 2016).

Compared to the urban environment, there are specific characteristics of rural areas that should be borne in mind when planning PPGIS data collection. Network connectivity may not be as seamless in sparsely populated areas as in urban areas. To improve the user experience, the design of the PPGIS questionnaire should be as light as possible and not contain too large files in order to optimize the loading time with a less robust network connection. In sparsely populated areas it is also crucial to consider how to preserve the anonymity of respondents, especially if the datasets are to be published as open data. When designing a survey, it is worth considering whether, for example, it is necessary to ask respondents to indicate the location of their home or precise routes.

5.2.4. Summary: PPGIS topics potentially relevant for the RUSTIK transition topics

Socioeconomic and demographic transition

Everyday life in the rural areas, perceived wellbeing, place-based values, mobility, accessibility, services, health care

Climate and environmental transition

Ecosystem services, resilience, mitigation of hazards, environmental observations, landscape values, multifunctional landscapes, coexistence of activities, traditional farming landscapes, water resources management, crop damages

Digital transition

PPGIS allows easier access to public participation in rural areas, but potential challenges with network connectivity and digital divide should be considered.

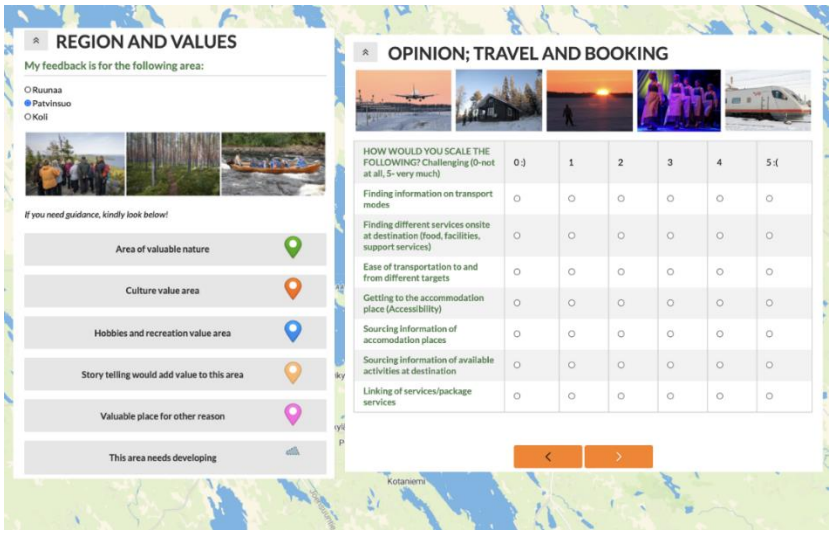

Figure 10: An example of a tourism related PPGIS survey in the rural area in the Eastern Finland. Participants could map e.g. valuable places and areas or development ideas. Furthermore, a PPGIS survey can contain background questions.

As one of RUSTIK project partners, Mapita is offering a PPGIS tool, Maptionnaire, that can be used in the project to collect, visualize and analyse map-based information. Maptionnaire (maptionnaire.com) is a SaaS service that allows anyone to create, publish and analyse map-

based questionnaires with an editor tool. The editor allows anyone to design content for their own PPGIS survey. The tool is easy to use and comes with ready-to-use background maps, so users do not need to know how to use GIS software. The results, also the map-based results, can also be studied and visualised directly in the tool on the map, so no in-depth knowledge of maps is required at this stage either. Within the RUSTIK project, it is possible to create map-based surveys on any topic where there is a need to collect spatial data.

5.3. Analysis, visualization and reporting of PPGIS data

Fagerholm et al (2021) suggest three analysis levels that can be distinguished for PPGIS data: 1) explore, 2) explain and 3) predict/model.

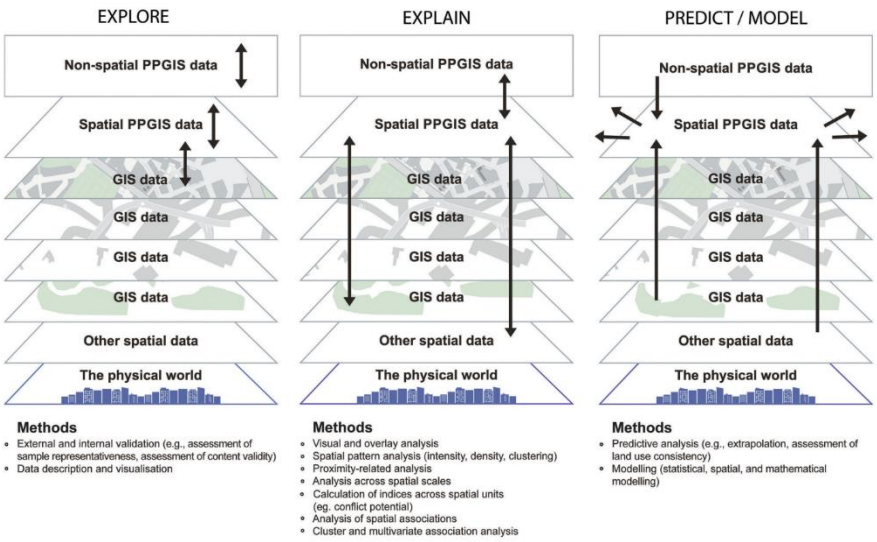

Figure 11: A methodological framework for analysis of participatory mapping data in research, planning, and management, International Journal of Geographical Information Science (Fagerholm et al, 2021).

Explore level contains descriptive and exploratory light analysis of data and it does not require deeper analytical skills. An output example would be presenting the results as visual formats, such as thematic maps and graphs. The map data could be visualized as such, showing on a background map the locations marked by respondents. The Explain level concentrates on understanding the relationships between PPGIS data and other data sets. This type of analysis requires more knowledge of analysis methods. As an output overlay analyses with other datasets, spatial pattern analyses, recognising hotspots, cold spots and clusters. The Predict/model analysis level combines data from different sources to generate predictions and models. For example, based on the collected data on walking routes and the experienced qualities a generalized model of other walking regions could be created. This type of analysis requires advanced analysis skills and capabilities to handle different types of data sets, software and usually also coding skills.

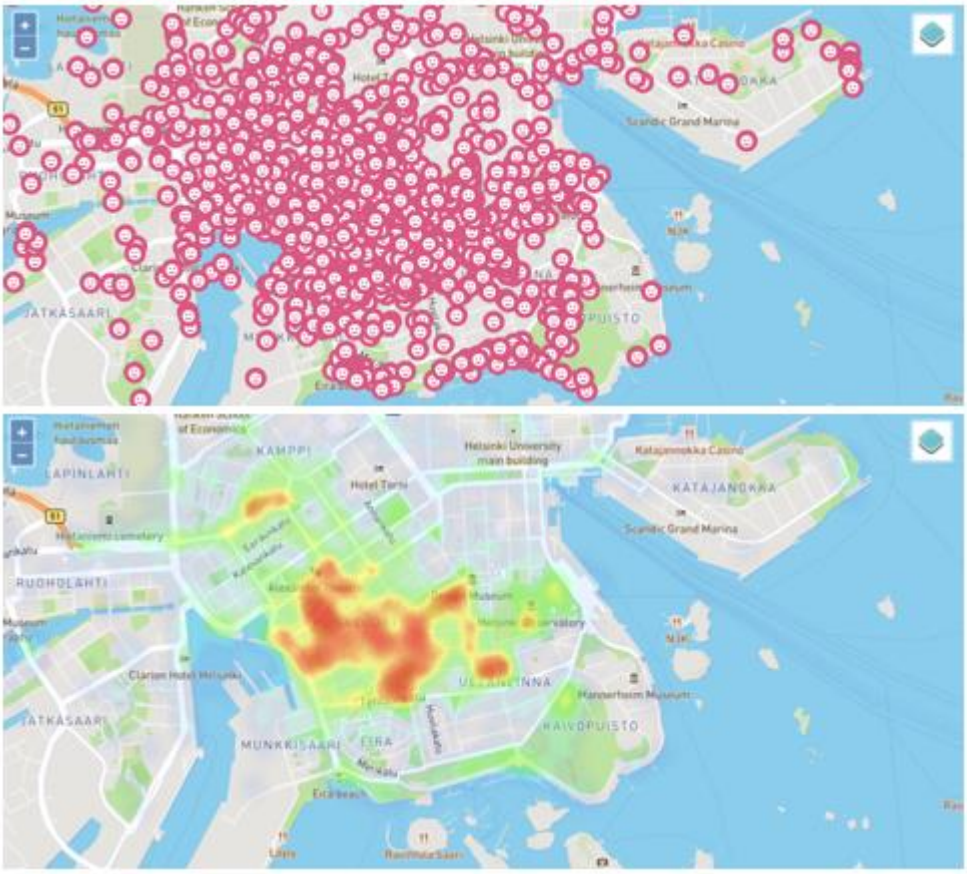

Figure 12: Captures from the Maptionnaire online analysis tool. The tool allows easy analyses and visualisations of the PPGIS data.

6. Methods and technologies used to gather relevant data and information to design and assess policy-impacts on rural areas at national and European scale

According to the FAO (FAO, 2018), the majority of rural areas definitions focus on the dimensions of density of settlement, land cover and remoteness from markets and public services. Statistical data on rural areas, where ¾ of the world's poor are estimated to live, come primarily from censuses, surveys, public and private administrative records, and increasingly from satellite imaging (e.g. the CORINE Land Cover system; Copernicus Programme, 2023) and other remote sensing technologies, as well as Big data sources such as data collected from internet service providers, social media or educators (ibid.; ESPON, n.d.). In the SHERPA project, information acquired using technology such as web crawlers applied to the CORDIS and LIFE databases, complemented by human expert fine-tuning, has been used as a basis to gather information on relevant projects reports whose contents were then collated by experts into discussion papers to be discussed by stakeholders at the local level (Espejo Garcia et al., 2020). In other cases, where reliable statistical data is lacking, other kinds of qualitative and expert knowledge may be combined.

In ecological research, on the other hand, an entirely different array of approaches is used to acquire data, such as e.g. quadrat or transect sampling (Young and Young, 1998).

For example, with regard to the categorization of areas into the rural or urban category, within the GHSL (Global Human Settlement Layer) project, the EU's Joint Research Centre (JRC) has developed a grid based on a combination of information on population size and density sourced from a combination of satellite data and census data (European Commission, n.d.a), which proposes a continuous rural-urban definition (FAO, 2018). Additional layers and geo-coded data (e.g. on access to healthcare or employment) can be added to GHSL grids to support policy analysis (ibid.).

In 2022, the European Union launched a new 'Rural observatory', an EU flagship initiative based on the European Commission's Long-Term Vision for Rural Areas (LTVRA) and developed by the JRC in coordination with DG AGRI and DG REGIO. This platform is intended to provide data about rural areas, including data and knowledge that will be produced by EU-funded projects such as GRANULAR and RUSTIK (SHERPA, 2022). It offers statistics, indicators and analyses based on data from multiple sources, such as JRC data, ESPON, Eurostat as well as Horizon Europe projects (EUROMONTANA, 2022).

A somewhat older but similarly oriented data portal is the ESPON database portal, which supplies data, indicators and tools that can be used for European territorial development and cohesion policy formulation, application and monitoring at different geographical levels (ESPON, 2023). The data are mainly acquired from European institutions such as EUROSTAT and the European environmental agency (EEA), and from all ESPON projects. Further similar collections of tools that offers specialised composite indicators are the Resilience dashboards (European Commission, n.d.b) and the indicators intended to measure digital performance (Directorate-General for Communications Networks, Content and Technology, n.d.).

6.1. Data at European scale to define the three transitions

The long-term vision for the EU's rural areas is a European Commission initiative to develop a common European vision for 2040. It identifies common challenges and opportunities in the rural territories across Europe.

The Commission created a wide-ranging vision and a comprehensive rural action plan to help rural communities and businesses reach their full potential in the coming decades. It also proposed the Rural Action Plan. It has the aim to:

- Foster territorial cohesion and create new opportunities to attract innovative businesses
- Provide access to quality jobs
- Promote new and improved skills
- Ensure better infrastructure and services
- Leverage the role of sustainable agriculture and diversified economic activities

Rural areas face a unique set of challenges, including demographic changes, high risk of poverty, and a lack of access to basic facilities. In order to secure the best of their qualities, it is essential to understand and overcome the worst of their challenges.

We need specific rural data to better understand rural diversity, provide evidence for policy making on rural areas and implement rural proofing. In this sense, the Rural Observatory, became and improvement to rural statistics.

6.1.1. The Rural Observatory

The Rural Observatory aims at centralising and analysing data, ensuring a bridge between data sources through a rural data portal. The rural observatory supports knowledge production and aims at disseminating data related to EU rural areas. It offers statistics, indicators and analyses based on data from multiple sources, covering economic, social and environmental dimensions. It was launched in December 2022.

It is set up by the European Commission and provides users with information about any given urban, intermediate and rural areas in EU countries. The observatory makes it possible to compare diverse territories to reflect the multiple dimensions and the diversity of rural areas.

The Rural Observatory lets users visualise data at different scales, including the LAU2 scale.

Mainstreaming the degree of urbanisation

It supports the Commission efforts to increase the number of indicators that are available by "degree of urbanisation", which is the typology providing the finest differentiation between urban, semi-dense and rural areas. Over 200 indicators are now available.

The tool makes it possible to select multiple indicators, typology of territory and years and to download related charts. Interestingly, the Rural Observatory also gives the possibility to compare trends between different areas in the EU, but also with EU averages.

The data used is collected from the Joint Research Centre, ESPON, Eurostat and selected Horizon Europe projects. The Rural Observatory is meant to evolve, with new features and tools to be added over time. It offers four different visualisation for its data:

Rural Focus shows how rural areas compare with those classified as urban or intermediate (towns and suburbs) owing to their degree of urbanisation. Where available, the data also takes into account also the concept of remoteness (driving time to an urban centre > 45 minutes).

My Place offers an overview of any place (from country to municipality) and allows its comparison to other places in the EU.

Trends allows the comparison of indicators at specific granularity levels, by displaying them both in a map and in charts. Trends are also provided and, for some indicators, future projections are made available.

Thematic Analyses is expected to provide analytical capabilities to the Observatory. Its aim consists in transforming data mapping into multi-dimensional analysis at various territorial levels, focusing on rural areas.

The available datasets from Country to NUTS3 level are numerous, and in diverse domains. All the data can be accessed aggregated by degree of urbanisation, and the covered topics are:

- Demography & Migration
  - Population
- Economic Development
  - GDP

- Labour Market
  - Employment and unemployment
  - Not in Education, Employment or Training
- Tourism
  - Nights spent at tourist accommodation establishments
  - Tourism capacity
- Education
  - Tertiary educational attainment
  - Early leavers from education
- Infrastructure & Accessibility
  - Access to high speed broadband
  - Average road distance to the nearest SGIs
- Living Conditions and Social Inclusion
  - Mean and median income
  - Persons at risk of poverty or social exclusion
  - Housing costs
  - Older people facing severe difficulties with personal care and/or household activities
  - Crime, violence or vandalism
  - Noise from neighbours or from the street
- Environment & Climate
  - Pollution, grime or other environmental problems
  - Agricultural land, Built up area & Forests and natural areas
- Health
  - People having a long-standing illness or health problem
  - Average distance to healthcare facilities
  - Unmet needs for medical or dental examination

At municipality (LAU2 level), the available datasets are the following:

Table 6: Available datasets at LAU2 level in the Rural Observatory.

Domain	Indicator	Data available	Temporal coverage	Source
Demography	Total Population	Population, population density and surface	1961 - 2020	EUROSTAT
Tourism	Tourism capacity	Number of available rooms at municipality level	2021	JRC
Infrastructure and accessibility	Broadband speed	Access to high speed broadband	2019 - 2022	JRC
	Access to Services	Average road distance per person to the nearest service (primary school, secondary school, cinema, train station, healthcare facilities), in kilometers.	2018	JRC-GEOSTAT, TELEATLAS, DG REGIO, ESPON PROFECY, OpenStreetMap
Environment and Climate	Land Use	Land Use (Agriculture, Buit Up Area, Forest; and detailed in 25 classes)	2018	JRC - LUISA

Despite being the cornerstone of the EU Rural Action Plan in terms of data creation and dissemination, the Rural Observatory faces at this stage some disadvantages that must be stated (on 30th March 2023):

- There is a low number of datasets available at a local scale (LAU2) compared to the ones at higher ones (e.g. NUTS2, the one with most available data).
- The data cannot be downloaded for some of the indicators (Broadband access, Land Uses…) and for the ones it can be downloaded, this cannot be done for aggregated municipalities.

Besides the Rural Observatory, the Rural Vision is supported by a wide range of datasets:

6.1.2. EUROSTAT Rural Europe

EUROSTAT is the statistical office of the European Union and its mission is to provide statistics and data on the EU. They produce statistics in partnership with National Statistical Institutes and other national authorities in the EU Member States. Eurostat provides a wide range of statistical data on the European Union and its member states, including data on demography, economy, society, environment, and more. Some of the datasets have a resolution at LAU2 level or smaller.

Since January 2023 they made available a new "Statistics explained" chapter called Rural Europe. It provides information on education and training, labour market, income and living conditions, digital society, economy, demographic developments in rural regions and areas, women and men living in rural areas, and quality of life in rural areas.

EUROSTAT is one of the main organisations feeding the Rural Observatory, and most of these datasets can be found in the Degree of Urbanisation dataset. This data is aggregated by the three typologies of degree of urbanisation and comprehends the following topics:

- Health
- Lifelong learning
- Educational attainment level and outcomes of education
- Living conditions and welfare
- Labour market
- Tourism
- Digital economy and society

In this sense, EUROSTAT has a Rural Development database aiming to measure economic, social and environmental issues related to rural areas. It provides data into the specific features of the regions at a NUTS 3 level.

- Demography statistics by other typologies (urt_demo)
  - Area of the regions by other typologies (urt_d3area)
  - Population density by other typologies (urt_d3dens)
  - Population on 1 January by five year age group, sex and other typologies (urt_pjangrp3)
  - Population on 1 January by broad age group, sex and other typologies (urt_pjanaggr3)
  - Demographic balance and crude rates by other typologies (urt_gind3)
  - Live births (total) by other typologies (urt_births)
  - Deaths (total) by other typologies (urt_deaths)
- Population projections by other typologies (urt_proj)
  - Population on 1st January by age, sex, type of projection and other typologies (urt_proj_19rp)
  - Assumptions for net migration by age, sex, type of projection and other typologies (urt_proj_19ranmig)
  - Projected deaths by age, sex, type of projection and other typologies (urt_proj_19rdth)
  - Demographic balances and indicators by type of projection and other typologies (urt_proj_19rdbi)
- Economic accounts by other typologies (ESA 2010) (urt_eco10)
  - Gross domestic product (GDP) at current market prices by other typologies (urt_10r_3gdp)
  - Average annual population to calculate regional GDP data by other typologies (urt_10r_3pgdp)
  - Employment by NACE Rev. 2 activity and other typologies (urt_10r_3emp)
  - Gross value added at basic prices by other typologies (urt_10r_3gva)
- Intellectual property rights by other typologies (urt_ipr)
  - Patent statistics by other typologies (urt_pat)
  - Community trade marks (CTM) by other typologies (urt_ipr_t)
  - Community design (CD) by other typologies (urt_ipr_d)
- Business demography by other typologies (urt_bd)
  - Business demography and high growth enterprise by NACE Rev. 2 activity and other typologies (urt_bd_hgn2)
  - Business demography by size class and other typologies (urt_bd_size)
  - Employer business demography by NACE Rev. 2 activity and other typologies (urt_bd_en2)
  - Employer business demography by size class and other typologies (urt_bd_esize)
- Transport statistics by other typologies (urt_tran)
  - National annual road freight transport by regions of loading, group of goods and other typologies (urt_road_gonl)
  - National annual road freight transport by regions of unloading, group of goods and other typologies (urt_road_gonu)
- Labour market statistics by other typologies (urt_lmk)
  - Economically active population by sex, age and other typologies (urt_lfp3pop)
  - Unemployment by sex, age and other typologies (urt_lfu3pers)
  - Unemployment rates by sex, age and other typologies (urt_lfu3rt)
  - Population by sex, age and other typologies (urt_lfsd3pop)
  - Employment by sex, age and other typologies (urt_lfe3emp)
  - Employment rates by sex, age and other typologies (urt_lfe3emprt)
  - Population aged 25-64 by educational attainment level, sex and other typologies (urt_edat_lfse4)
- Crimes recorded by the police by other typologies (urt_crim_gen)

Figure 13: Available data in the EUROSTAT Rural Development database.

Narrowing down to the LAU2 level, EUROSTAT has developed a Historical Population Dataset (1961 – 2011). This project is independent from regular Eurostat population data collection and covers EU Member States, certain Candidate Countries and EFTA countries. Data is recalculated for the 2011 local administrative boundaries and interpolated for the following dates: 1st January of 1961, 1981, 1991, 2001, 2011.

6.1.3. Census data (2021)

Census data are population-wide observations on individuals and households. Census-taking is done within enumeration units or blocks, where each unit typically contains 150-300 households. As a census is a universal enumeration, these household observations can be aggregated as desired without concern for statistical validity (FAO, 2018).

In the EU, a census typically happens every 10 years. The census counts the entire population and housing stock of a given country and collects information on its main characteristics. Population and housing censuses in the EU are based on European statistical legislation that sets out key statistical definitions and the data and metadata to be produced by EU countries. Since 2021, administrative data sources have become the backbone of the census in most EU

countries. (EUROSTAT. n.d.a). EU MS implement their censuses based on a harmonised methodology that is internationally aligned (EUROSTAT, n.d.b). However, they can adapt the specific data sources, methods and technology to the context in their country. Some carry out traditional fieldwork with census interviewers (enumerators), which may be complemented with technologies including laptops or tablets connected to the database to avoid paper questionnaires, telephone interviews or online self-enumeration. Others have developed statistical registers that they update regularly to avoid costly fieldwork. Others still use a combination of the two approaches, obtaining part of the data from registers, but still carrying out limited surveys; the overall tendency is to move away from the traditional census towards the register-based system (EUROSTAT, n.d.c.).

EU Member States are currently implementing the 2021 population and housing censuses. The key factor of censuses is that they provide information on rural areas that is not available within annual demographic statistics. The 2021 round of population and housing censuses is expected to provide by mid- 2023 detailed regional information, including data in 1 km square grids for all Member States.

Increased statistics quality and availability

Furthermore, the Commission is currently working on a new framework regulation for statistics on population which integrates census, demography and migration statistics. The proposal extends the data requirements towards their geographical detail to enhance the scope of statistics relevant to rural areas. The Commission is currently discussing with Member States data needs on rural areas.

Developing pan-European geospatial datasets

The European Commission works to establish a harmonised approach to the use of Geospatial Information Systems, developing pan-European geospatial datasets. Experimental datasets on health care services and education facilities have been published, as a pilot exercise to explore accessibility analysis to core services.

The commission is currently working on a more complete geospatial data set infrastructure including administrative units, addresses, buildings, parcels, transport networks and population distribution. Additionally, is working to improve the geospatial definition of the LAUs and NUTS based on the upcoming CENSUS 2021 results.

6.1.4. Administrative records

The Integrated Administration and Control System (IACS) may be considered such a system, although data are not acquired exclusively administratively (spatial data are also used in the Land parcel identification system) (European Commission, n.d.d). Information on budgetary expenditure on different agricultural policy measures under the EAGF (European Commission, 2021) may be considered another such source. Some databases that are worth mentioning with datasets at high resolution for the entire world are:

WorldPop

WorldPop is based at the University of Southampton and maps populations across the globe. Since 2004, they have partnered with governments, UN agencies and donors to complement traditional population datasets with dynamic, high-resolution data for mapping human population distributions. WorldPop provides open-access data with a resolution down to 100 meters. Some of its relevant datasets are:

- Population Counts, Population Density, Population Weighted Density
- Age and sex structures, Births, Dependency Ratios, Pregnancies
- Development Indicators
- Global Flight Data, Global Holiday Data
- Global Settlement Growth, Grid-cell surface areas, Urban change
- Migration Flows

Global Human Settlement Layer (GHSL)

The GHSL provides data on human settlement patterns and infrastructure at a global scale, with a resolution down to 10 meters. The data includes Europe and can be used for various purposes, including creating maps at LAU2 level or smaller.

The GHSL applies its own image analytics framework, powered by census data, crossed with satellite imagery. Their main datasets are offered for download as open and free data.

- Built-up surface grid (1975-2030, 5 years interval)
- Building height (2018)
- Built-up volume grids (1975-2030, 5 years interval)
- Settlement Characteristics (2018)
- Land fraction (2018)
- Population grid (1975-2030, 5 years interval)
- Settlement layers, application of the Degree of Urbanisation methodology (1975-2030, 5 years interval)
- Degree of Urbanisation Classification (1975-2030, 5 years interval)
- Built-up surface statistics in European LAU2 (1975-2020, 5 years interval)

6.1.5. Copernicus Land Monitoring Service (CLMS)

Copernicus is the European Union's Earth observation programme, in which data is collected by Earth observation satellites and combined with observation data from sensor networks on the earth's surface. The processed data provides reliable and up-to-date information within six thematic areas: land, marine, atmosphere, climate change, emergency management and security. All information is free and openly accessible to all users.

CLMS is part of the Copernicus Programme and provides geographical information on land cover to a broad range of users in the field of environmental terrestrial applications. This includes land use, land cover characteristics and changes, vegetation state, water cycle and earth surface energy variables. The CLMS provides high-resolution land cover and land use information for the European Union, with a resolution down to 10 meters.

The CORINE Land Cover (CLC) inventory was initiated in 1985, being updated 2000, 2006, 2012, and 2018. It consists of an inventory of land cover in 44 classes, with a Minimum Mapping Unit (MMU) of 25 hectares (ha). The time series are complemented by change layers, which highlight changes in land cover with an MMU of 5 ha.

CLC is produced mostly by visual interpretation of high resolution satellite imagery, and in some countries semi-automatic solutions are applied, using national in-situ data, satellite image processing, GIS integration and generalisation.

The European Environment Agency (EEA) has started to develop and implement a new series of products and applications known as the CLC+ system. It extends the currently existing CLMS

products to match the increasing Land Cover/Land Use (LC/LU) monitoring and reporting needs. CLC+ is a system with two components:

CLC+ Backbone (BB) A geospatial data component which produces and updates geospatial land cover datasets. It produces a detailed vector reference layer with basic thematic content (18 classes) and an 11-class, 10m spatial resolution raster product. The products can be used as input data for the CLC+ Core database.

CLC+ Core A database/web application component which provides a tool that can be used to create tailor-made 100m grid products (instances) by combining available data in new ways.

It delivers a consistent, multi-use, grid-based Land Cover/Land Use (LC/LU) hybrid data repository. By implementing a flexible data handling approach, CLC+ Core incorporates existing and future European CLMS products and various national LC/LU products using a standardized integration approach in line with the EAGLE data model. These elements are separated into:

- → Land Cover Components (LCC)
- → Land Use Attributes (LUA)
- → Further Characteristics (CH)

The main use-case for CLC+ Core is to derive tailor-made LC/LU products (instances), on a 100m grid level, based on an on-demand combination of available (EAGLE harmonized) LC/LU information. This allows for the combination of previously non-harmonized datasets in new ways—in particular, LC information coming from CLMS products with specific land use (LU) information from the countries.

Since early 2022, both the CLC+ BB raster product for the 2018 reference year, and the CLC+ Core database are available. The CLC+ BB vector product is expected to be released soon.

Pan-European High Resolution Layers (HRL) provide information on specific land cover characteristics, and are complementary to LC/LU mapping. The HRLs are produced from satellite imagery through a combination of automatic processing and interactive rule based classification. Five themes are addressed so far, corresponding with the main themes from CLC:

Level of sealed soil (imperviousness)
Imperviousness status and change for reference year 2018 in 10 meter resolution. Addition of Impervious Built-up (IBU) and its corresponding 100 meter aggregate Share of Built-up (SBU).

Tree cover density and forest type
Tree cover density, dominant leaf type and forest type products for reference year 2018 in 10 meter resolution.

Grasslands
Grassland status product for reference year 2018 in 10m resolution. 2015-2018 Grassland change in 20m resolution.

Wetness and water
Product based on 7-year time series (2012-2018) analysis, mapping temporary and permanent wet, and temporary and permanent water status for the reference year 2018 in 10 meter resolution. The update uses a "rolling-archive" approach with overlapping 7-year time periods.

Small woody features

Product based on VHR data, mapping small patchy and linear woody features, as a vector, but also available in 5m and 100m raster version. 2018 production is under validation.

All of these five products are continuing existing products, some with longer time series existing (Imperviousness and tree-cover/forest), and three products that have only one previous reference year (2015) (grassland, the water & wetness products and Small Woody Features). The HRLs can then be used, for example, as attributes for different kind of more aggregated spatial units, such as NUTS3, CLC polygons, regular grids or designated areas.

Similar to the Imperviousness HRL, the European Settlement Map is produced. It is a raster dataset that maps human settlements based on satellite imagery. The European Settlement Map 2016 represents the percentage of built-up area coverage per spatial unit (that can vary from 2.5m to 100m).

Figure 14: Screenshot comparing the HRL imperviousness product (red), capturing all sealed areas, with the Building Layer (grey), offering more detailed information on the built-up structures. Source: CLMS.

The CLMS is also offering LULC datasets at even higher resolution in what they call the Local Component. This dataset is available for certain units:

- Functional Urban Areas (FUA)
- Riparian Zones
- Natura 2000 protected areas
- Coastal Zones

Besides the already stated products, the CLMS offers other products in the Biophysical Parameters (High Resolution Vegetation Phenology and Productivity, High Resolution Snow and Ice Monitoring), the Corine Land Cover pilots in Eastern Partnership countries and the European Ground Motion Service, that fall apart of the RUSTIK project scope.

All the Copernicus Program datasets are available in real time at the Copernicus Data Space Ecosystem, which is being gradually launched this year 2023.

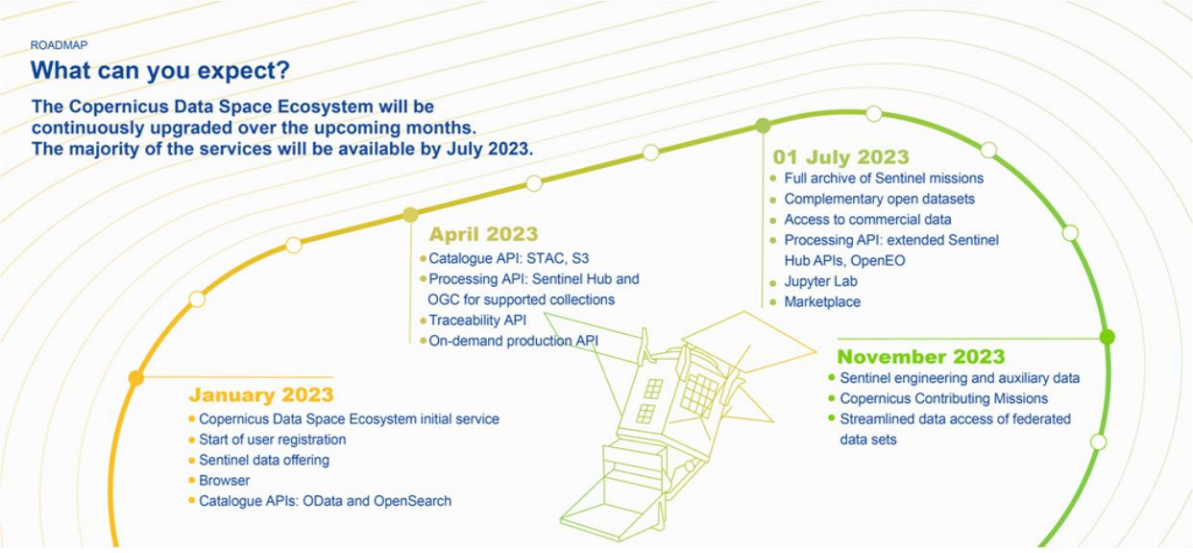

Figure 15: Roadmap for the Copernicus Data Space Ecosystem. Source: CLMS.

6.1.6. European Environment Agency (EEA)

The EEA provides environmental data and information at the European level, including data on air and water quality, climate change, biodiversity, and more, with datasets at LAU2 level or in high resolution raster.

The EEA provides geographic information system (GIS) application programming interfaces (APIs) to obtain a wide range of environmental data for Europe, and helps users create their own map services. EEA content can be integrated in many different ways by developers or by end users who wish to combine this information with their own or other public map services (mash-ups). The data covers thematic areas such as air, water, climate change, biodiversity, land and noise.

INSPIRE: Infrastructure for spatial information in Europe

The INSPIRE Directive aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment. This European Spatial Data Infrastructure will enable the sharing of environmental spatial information among public sector organisations, facilitate public access to spatial information across Europe and assist in policy-making across boundaries.

INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications.

The Directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2021.

DiscoMap: Discover Map Services

DiscoMap is a webpage property of the EEA that offers datasets for different categories of geodata. Services from Discomap are allowed to be re-used by anybody. EEA content can be integrated in many different ways by developers or by any end-user who might find an interest in combining EEA's information with their own or other public map-services.

6.1.7. Joint Research Centre (JRC)

The JRC is the European Commission's in-house science service which employs scientists to carry out research in order to provide independent scientific advice and support to EU policy. It provides a variety of datasets related to environment, agriculture, energy, and more. Some of the datasets have a resolution at LAU2 level or smaller. Its data can be retrieved from the Joint Research Centre Data Catalogue,

The JRC hosts three Copernicus Emergency Services, all of them providing key data on their specific expertise areas:

European Drought Observatory (EDO)
The EDO provides drought-related data and information for Europe. It produces precipitation forecasts. Its more numerous contributions are on the monitoring, producing data in the following fields:

- Combined Drought Indicator
- Precipitation
- Hydrology
- Temperature
- Soil Moisture
- Vegetation Response
- Disaster monitoring

European Forest Fire Information System (EFFIS)
EFFIS supports the services in charge of the protection of forests against fires in the EU and neighbour countries and provides updated information on wildfires in Europe. EFFIS is one of the components of the Emergency Management Services in the Copernicus program. A number of specific applications are available through EFFIS:

- Current Situation Viewer (Up to date information)
- Current Statistics Portal & Historic Data Request (Statistics at national level)
- Firenews (Collects, geo-locates and stores in a database published fire news)
- Long-term fire weather forecast (Expected temperature and rainfall anomalies)
- Wildfire Risk Viewer (Considers fire danger and vulnerability for people, ecological, and economic values)

European Flood Awareness System (EFAS)
The aim of the EFAS is to support preparatory measures before major flood events strike, particularly in the large trans-national river basins and throughout Europe. To provide information on upcoming flood events, EFAS relies on a hydrological forecasting chain. It provides data on:

- Flood (social media analysis)
- Flood prediction (Flow anomaly and probability of occurrence for the next six weeks)
- Flash flood (24h accumulations)
- Initial conditions (Snow, temperature, precipitation, soil moisture)
- Static river data (regions, catchments, protection levels, landslide susceptibility)

6.1.8. ESPON Database

ESPON is an EU funded programme that bridges research with policies. It provides territorial analyses, data and maps to support EU development policies –particularly Cohesion Policy; and help public authorities to benchmark their region.

All their published content is publicly available on their website for download and use. Despite not providing data at a municipality level, over 500 datasets are available in the ESPON Database at NUTS3 scale, covering the topics of: Population and Living Conditions; Environment, Climate and Energy; Economy, Finance and Trade; Territorial Structures and Land Use; Employment, Education and Skills; Science, Technology and Innovation; Transport and Accessibility; and Governance.

6.1.9. Data on specific sectors

Agriculture and agrifood

Agrifood Data Portal

It is the main source of information in the field, providing data on national and European agriculture and common agricultural policy (CAP). It is provided by the European Commission's agricultural and rural development department. The following relevant data portals are referred in this site:

Agrifood Markets

This portal provides data on national and European agriculture. It enables users to browse visualisations about imports, exports, prices, production and aid schemes. Some of the displayed data can be disaggregated at national level, and data can be displayed either by topic (Prices, Production, Trade and Quotas, Dashboards, School Schemes and Short-term outlook) or by market sector (Beef, Pig meat, Eggs and Poultry…)

CAP Indicators

A set of indicators to assess the CAP implementation. Context indicators, that can be more relevant to our project, provide information on agricultural and rural statistics as well as general economic and environmental trends. Some of this information drills down to regional level (NUTS 2-3). The addressed topics are as follows:

- Financing the CAP - CAP expenditure by main CAP instruments.
- Farming Income Support - Distribution of income support and share in farming income.
- Jobs and Growth in Rural Areas - GDP, incomes, employment in agriculture and poverty rates.
- Market Orientation - EU agri-food trade in context and elements of EU competitiveness.
- Adding Value - Focus on the value added in agriculture.
- Productivity - Indicators describing agricultural productivity, emphasis on rural development.
- Environment and Climate Action - Environment and main land use indicators.
- Climate Change and Air Quality - GHG and ammonia emissions from agriculture
- Organic Production - An overview of organic areas and producers, including specific CAP support.
- Water Quality and Availability - Pressures on water (quality and quantity)
- Soil Quality - Mapping of soil conditions

- Biodiversity - Overview on biodiversity monitoring and CAP contribution to biodiversity protection.
- Food and Health Quality Protection - Indicators on plant protection products, antimicrobials and animal welfare.

Farm Accountancy Data Network public database

The Farm Accountancy Data Network (FADN) monitors farms' income and business activities, being the only source of farm-level microeconomic data based on harmonised bookkeeping principles. It is based on national surveys and only covers EU agricultural holdings which can be considered commercial due to their size. The network monitors farms' income and business activities and is also an important source for understanding the impact of the measures taken under the common agricultural policy. Data is provided by member states, regions (NUTS2), economic size and type of farming. A large dataset is provided, with data on the following categories:

- Annual economic farming data at EU level and by country
- Economy of farms and rural areas
- Farm economy data by sector:
  - Crop farms
  - Livestock farms
  - Mixed crop and livestock farms

Farm Sustainability Data Network (to be released)

Is the initiative that will expand the scope of the current network for data collection in the EU farms to include data on their environmental and social practices. With this new data collection, it will be possible to benchmark farm performance and give farmers tailored advice and guidance.

It is shaped in the context of the EU Green Deal and aligned with the CAP and the farm to Fork Strategy. It comes after its predecessor, the Farm Accountancy Data Network.

Tourism

EU Tourism dashboard

The EU Tourism Dashboard is aimed at promoting and monitoring the green and digital transitions and socio-economic resilience factors of the European tourism ecosystem.

The dashboard offers visualisations of tourism-relevant data to allow the profiling and monitoring of the progress of EU countries towards the EU policy objectives. The indicators of the EU Tourism Dashboard are organised under three policy pillars: environmental impacts, digitalisation and socio-economic vulnerability. The dashboard currently covers all the EU27 Member States, Iceland, Norway and Switzerland. Data is disaggregated down to the NUTS3 level and the interface is the same as the Rural Observatory one.

Digitalisation

Digital Economy and Society Index (DESI)

The DESI is a composite index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU Member States, across five main dimensions: Connectivity, Human Capital, Use of Internet, Integration of Digital Technology, and Digital Public Services.

Data is provided at national level, allowing the disaggregation of the rural instances of the countries, in some of the indicators. Additionally, the specific topic of Rural in Digital is assessed, containing data on the use of internet, human capital and connectivity.

DESIRA Rural Digital Europe Dashboard

DESIRA is a H2020 project focusing on the capacity of society and political bodies to respond to the challenges that digitalisation generates in agriculture, forestry and rural areas. One of their outputs is an OpenAIRE repository that collects Publications, Research data, Research software and other research products. However, it hosts a huge volume of data from multiple sources and in multiple formats, which makes it difficult to find the intended datasets.

6.1.10. Other relevant data sources and projects

OpenStreetMap (OSM)

OpenStreetMap (OSM) is a free, open geographic database updated and maintained by a community of contributors, who collect data from surveys, trace from aerial imagery and import from other freely licensed data sources. OSM is freely licensed and is commonly used to make electronic maps, inform turn-by-turn navigation, data visualisation and assist in humanitarian aid. OSM uses its own topology to store geographical features which can then be exported into other GIS file formats. The database is hosted by the OpenStreetMap Foundation, a non-profit organisation funded mostly via donations. Its data can be retrieved by different means, as the Geofabrik or the QuickOSM QGIS pluggin.

The GDELT Project

The GDELT Project, or Global Database of Events, Language, and Tone, describes itself as "an initiative to construct a catalog of human societal-scale behavior and beliefs across all countries of the world, connecting every person, organization, location, count, theme, news source, and event across the planet into a single massive network that captures what's happening around the world, what its context is and who's involved, and how the world is feeling about it, every single day."

The GDELT Project is the largest, most comprehensive, and highest resolution open database of human society ever created. GDELT has a wealth of features in the event database which includes events reported in articles published in 65 live translated languages, measurements of 2,300 emotions and themes, relevant imagery, videos, and social media embeds, quotes, names, amounts, and more.

GDELT includes data from 1979 to the present. The data is available as zip files in tab-separated CSV files.

DECODE Project

Collecting reliable and detailed data is key to implement in full a citizen-centric approach. To address this issue, the DECODE (H2020) project developed a proof of concept tool for collecting decentralised data from citizens in a territory. This tool could help to collect data on subjective perceptions, values and opinions by means of ad hoc questions on different aspects, and behavioural and environmental data through smartphone sensors.

Common app users share personal data with App developers or distributers. Giant tech corporations own large volumes of data from users who have agreed to give it in exchange for

the services provided, with a restricted internal exploitation and use. The access to this data from the public sector or even from the civil society is difficult and costly but its possibilities are endless (potential uses of this data could be e.g. for monitoring citizen habits, personal preferences, mobility patterns, health conditions...).

DECODE has developed practical alternatives by creating and testing a distributed and open architecture for managing online identity, personal and other data, and collective governance in a citizen- and privacy-friendly way. DECODE has developed pilot tools that give people ownership of their data combining blockchain technology with attribute-based cryptography, this allows the data owners to have control over how their data is accessed and used. One of the products of DECODE was a pilot that formalised standards-based data governance agreements.

7. Novel methods and technologies. Alternative solutions for the RUSTIK System at European scale

There are many novel technologies in the field of Geographic Information Systems (GIS) that can be useful for supporting rural development and. In this review we focus on novel data processing technologies (Data Cubes, AI and Machine Learning), on data collection tools at different scales (UAVs and Small Satellites) and on remote sensing technologies and sensors (Radar, LiDAR and Hyperspectral).

Data Cubes

In recent years, earth observation satellites have generated large amounts of geospatial data freely available for society and researchers. This scenario challenges traditional spatial data infrastructures to properly store, process, disseminate and analyse these big data sets. To meet these demands, Data Cubes emerge as an interesting framework for processing large volumes of Earth Observation (EO) data.

EO data cubes are commonly defined as multidimensional arrays with dimensions for space and time, but they can handle multiple bands or data types, narrowing down to pixel level, regardless the data initial product packaging.

A Data Cube serves earth observation data as a multi-dimensional data array that can exceed the size of the memory resources of the server. The goal is to serve users with analysis ready data in order to reduce their burden in terms of data preparation and pre-processing. In particular, time series analysis are very well fitted as retrieving all the available data for a given area over a user defined time period is straightforward with a Data Cube.

AI & Machine Learning

Artificial Intelligence is a broad field that encompasses machine learning and other techniques such as deep learning, neural networks and computer vision. AI can be used to automate tasks such as image processing, data analysis, and decision making. It can also be used to improve the accuracy and efficiency of Earth observation systems, such as by reducing the number of false positives or negatives in a detection system, or by identifying patterns or trends in data that might not be immediately obvious to a human analyst.

Machine learning is a type of AI that enables a computer to learn from data, without being explicitly programmed. Machine learning algorithms can be used to process and analyse large amounts of Earth Observation data. It can be used to automatically identify specific features in an image, such as roads, buildings, or vegetation, or to detect changes in land use over time. It

can also be used to improve image classification, target detection and tracking, atmospheric correction, and cloud removal. Both machine learning and AI are being used to develop new Earth observation applications, such as predicting crop yields, monitoring deforestation, detecting oil spills and natural disasters and to improve the efficiency and cost-effectiveness of existing systems.

CubeSats: Small Satellite Technology

Small satellite refers to the use of lightweight satellites that are relatively low-cost to develop, launch, and operate. These satellites are typically less than 500 kg, and often no bigger than a shoebox. The small size and low cost of these satellites allow the deployment of large constellations of them in orbit, which can provide more frequent and higher-resolution imagery of the Earth's surface. They provide valuable data and information that can be used to improve the lives of people living in rural areas by delivering decision-making support, improving efficiency of services, and reducing costs. This technology has been used for a variety of applications, including remote sensing, weather forecasting, and telecommunications. These relate to rural development in a number of ways:

Small satellites give high-resolution images and data of rural areas, which can be used to create maps and 3D models; to identify areas for development, such as land for agriculture or infrastructure; and to plan for conservation and land use. Small satellites provide data on crop health, stress and pests, and yields, providing an improvement crop management and increase yields. In other fields, they can provide information on infrastructure to plan maintenance and repairs and to identify areas in need of development; regarding natural resources, their information can be used to plan for conservation and sustainable use of resources.

UAVs

Unmanned Aerial Vehicles (UAVs or drones) are aircrafts that can be operated without a human pilot on board. UAVs have been increasingly used in Earth Observation for a variety of applications, including mapping and monitoring. They can provide high-resolution images and can cover large areas in a relatively short amount of time. UAVs can also access remote or hard-to-reach areas, making them useful for monitoring natural disasters, wildlife, and environmental changes. The main uses of UAVs in the field of rural development can be:

Mapping and surveying: Create high-resolution maps and 3D models of rural areas. This information can be used to identify areas for development, such as land for agriculture or infrastructure, and to plan for conservation and land use.

Agriculture: Monitor crop health, detect crop stress and pests, and estimate crop yields. This information can be used to improve crop management and increase yields.

Infrastructure: Inspect and monitor infrastructure such as roads, bridges, and buildings in remote or hard-to-reach areas. This information can be used to plan maintenance and repairs and to identify areas in need of development.

Natural resources: Monitor natural resources such as forests, water, and minerals. This information can be used to plan for conservation and sustainable use of resources.

Further, drones can be used for emergency response by quickly assessing damage and identifying areas in need of assistance after natural disasters; for connectivity by delivering internet and other communication services to remote or hard-to-reach areas; and for delivery by making deliveries of goods and supplies.

SAR: Synthetic Aperture Radar

Synthetic aperture radar (SAR) imaging is a remote sensing technology that uses radar waves to produce high-resolution images of the Earth's surface. Unlike conventional optical imaging systems, SAR can penetrate cloud cover and produce images even at night. This makes it useful for a variety of applications and has become increasingly important in recent years, especially in rainy areas where monitoring with conventional multispectral satellites is not possible.

SAR can be used to monitor natural resources such as forests, water, and minerals. This information can be used for planning conservation and sustainable use of resources. Thanks to the high penetration depth, soil moisture can be monitored, which can be useful for agricultural purposes, such as detecting drought conditions and planning irrigation systems.

LiDAR

LiDAR, short for Light Detection and Ranging (SAR), is a remote sensing technology that uses laser pulses to measure the distance between a sensor and the Earth's surface. LiDAR can be used to create high-resolution 3D maps of the Earth's surface, including terrain, vegetation, and man-made structures. This technology is particularly useful for applications such as 3D mapping, measuring the height of vegetation, and modeling the Earth's surface. LiDAR has numerous functions, the most important of which are:

Mapping and surveying: creating high-resolution 3D maps. Agriculture and forestry: LiDAR is able to measure the height of vegetation, which can be used to estimate crop yields and improve management, and to estimate the structure and biomass of forests. Terrain modelling: LiDAR is capable of creating digital elevation models (DEM), which can be useful for various applications such as floodplain mapping, hydrological modelling, and landslide risk assessment.

Hyperspectral Sensors and Imagery

Hyperspectral imaging is a remote sensing technology that captures and analyses light across a wide range of wavelengths, typically in the visible and infrared portions of the electromagnetic spectrum. This technology allows to detect and identify specific materials, such as minerals, vegetation, and water bodies, by their unique "signature" of reflected light. Hyperspectral imagery can provide valuable data and information that can be used to improve the lives of people living in rural areas, by providing decision-making support, improving efficiency of services, and reducing costs. It can be used for a variety of applications, including:

Vegetation mapping: Identify different types of vegetation, including different species of crops, trees, and grasses; Soil mapping: Detect different types of soil, including their mineral content, organic matter and moisture; Land use and land cover classification: Map different land uses, such as agriculture, forest, water resources and urban areas; and Environmental monitoring: Identify and map different types of pollution and to monitor changes in land use, vegetation, and soil over time.

8. Analytical Methods for Impact Assessment

8.1. Approaches to Impact Assessment

The techniques appropriate to impact assessment necessarily depend, first, upon what the impact assessment is trying to achieve and, second, the data and other resources that can be assembled. As with most things, there is no universal and timeless “best practice”.

Since impact assessment is a policy-related activity, it operates under time and resource constraints to produce the best answer available within these constraints – not necessarily the best possible answer. As ever in policy work, if a decision has to be taken in six months, a two-year study will not answer the question. The obverse of that coin is that impact analysts could often be braver in describing – or sometimes even noticing – the limitations of their work.

8.1.1. Multicriteria Decision Making Methods (MCDM)

MCDM are a general framework for supporting complex decision-making situations with multiple and often conflicting objectives that stakeholder groups and/or decision-makers value differently (Belton and Stewart 2002). They are rooted in operational research and support for single decision-makers (Mendoza and Martins 2006), often in terms of finding an optimal solution to a decision-making problem. The emphasis in MCDM applications in environmental management and policy-making has nevertheless shifted towards multi-stakeholder processes to structure problems and to facilitate dialogue on the relative merits of alternative courses of action.

The general steps in a MCDM process are presented in Figure 15. The following phases are typically carried out in MCDM:

- → Identifying the problem (What is the decision context, who are the key stakeholders and what are their objectives and concerns?)
- → Structuring the problem (developing alternatives and determining criteria which are used to evaluate the alternatives)
- → Estimating performance (or ranks) of alternatives with respect to each criterion, usually in a form of an impact matrix, using (i) natural measures like monetary units or hectares; (ii) proxy measures, which indirectly assess the performance of the alternatives (e.g. the number of indicator species as a yardstick of biodiversity); and (iii) constructed measures, which report the achievement of the objective using a scale tailored to the decision context
- → Eliciting stakeholders' and/or decision-makers' values (e.g. ranking the criteria in preference order or assigning numerical weightings to reflect the relative importance of each criterion)
- → Synthetizing the results using a mathematical model to do evaluate trade-offs and the overall performance of the alternatives, either to suggest a solution to the decision-making problem, to illustrate different perspectives and/or to discover new solutions, and finally
- → Analysing the sensitivity of the results to changes in model parameters to assess the robustness of the analysis.

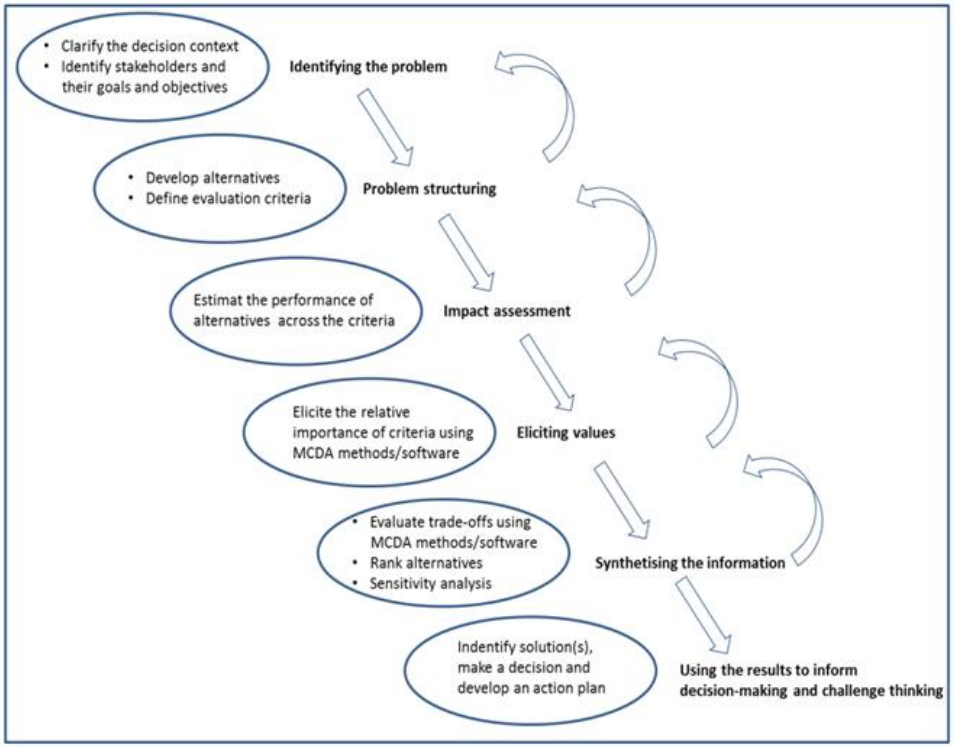

Figure 16: General steps in MCDM process. Source: Catrinu-Renström et al. (2013) and Belton and Stewart (2002).

A large number of MCDM have been developed to sort, rank or evaluate decision alternatives. They all follow at least roughly the general steps presented in Figure 15 but have different principles and procedures for eliciting and structuring information. The main differences between these methods are related to the complexity level of algorithms, the weighting methods for criteria, the way of representing preferences evaluation criteria, uncertain data possibility, and finally, and data aggregation type.

8.1.2. Territorial Impact Assessment (TIA)

Territorial impacts are considered the impacts on a given geographically defined territory resulting from the introduction or transposition of EU policy. In this context, Territorial Impact Assessment (TIA) provides the mechanism for the consideration of the territorial dimension of EU policies by contributing to the identification of their impacts at national, regional and local level and their differentiation between different places (ESPON, 2013). By this way, it aims at informing policy makers on the impacts of (EU) policies, e.g. Directive 2009/28/EC on the promotion of the use of energy from renewable sources, on different geographical areas ('territorial units'), comprising the assessment of environmental and spatial, economic, social and administrative impacts. It consists of four phases, namely screening, scoping, assessment, and evaluation, and can be performed in either ex-ante or ex-post manner.

The European Commission steadily supports this territorial dimension for the impact assessment of all policy domains (CEC, 2008) and provides clear guidelines for its integration to impact assessment studies (EC, 2013). TIA methodology is often used under the European Spatial Planning Observation Network (ESPON) Programme to support the purposes of its policy analysis, including the transport policy domain (ESPON, 2013).

The final aim of territorial impact assessment is to make a preliminary assessment or estimates in the design of various EU policies and what outcome they can get by territorial approaches and differences. These types of assessments have become more realistic to perform when there has been a considerable increase in the regional, local and spatial data available.

This approach is based in 6he Territorial Impact Assessment (TIA) and draws on the conceptualization of vulnerability developed by the Intergovernmental Panel on Climate Change (IPCC). In this case, the effects deriving from a particular policy measure (exposure) are combined with the characteristics of a region (territorial sensitivity) to produce potential territorial impacts. In the TIA the following definitions are used:

- The exposure describes the intensity by which EU directives and policies potentially affect European territory through a double logical chain. On the one hand single directives and policies may affect specific classes of regions (regional exposure), without reference to the specificity of each region; on the other hand, they may affect "fields" of the territorial realm, e.g., surface water quality, emissions, sectoral production (field exposure);
- The (territorial) sensitivity describes how single territories/regions are subject and evaluate impacts in specific exposure fields, due to their socio-economic and geographical characteristics and to the social values and priorities they are likely to show. The different conditions that affect regions in a particular way can be assessed and analysed through the framework of SWOT analysis and, more concretely, by assessing the internal factors (Strengths and Weaknesses of a territory/region).
- The territorial impact is the final, likely effect of a given EU policy or directive as a product of exposure and regional sensitivity. The impact can be direct or indirect along specific cause and-effect logical chains.

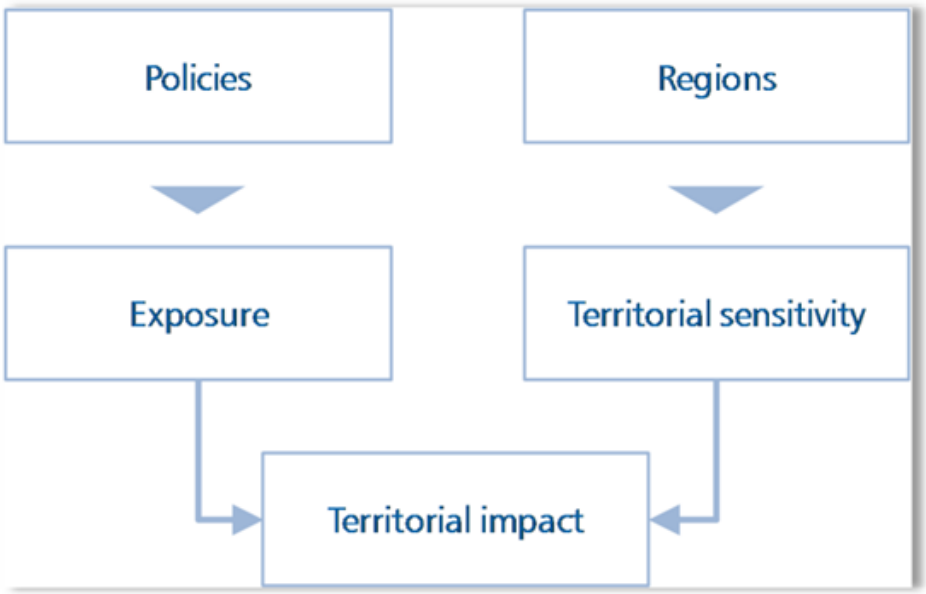

Figure 17: Territorial impact combining exposure and sensitivity. Source: ESPON, 2013.

ESPON has developed the ESPON TIA tool, which is an interactive web application that can be used to get a quick impression of possible territorial impacts of EU Legislations, Policies and Directives (LPDs) that are in the making. The tool is meant to help a moderator in a workshop setting to steer an expert discussion on possible asymmetric territorial impacts of a concrete LPD.

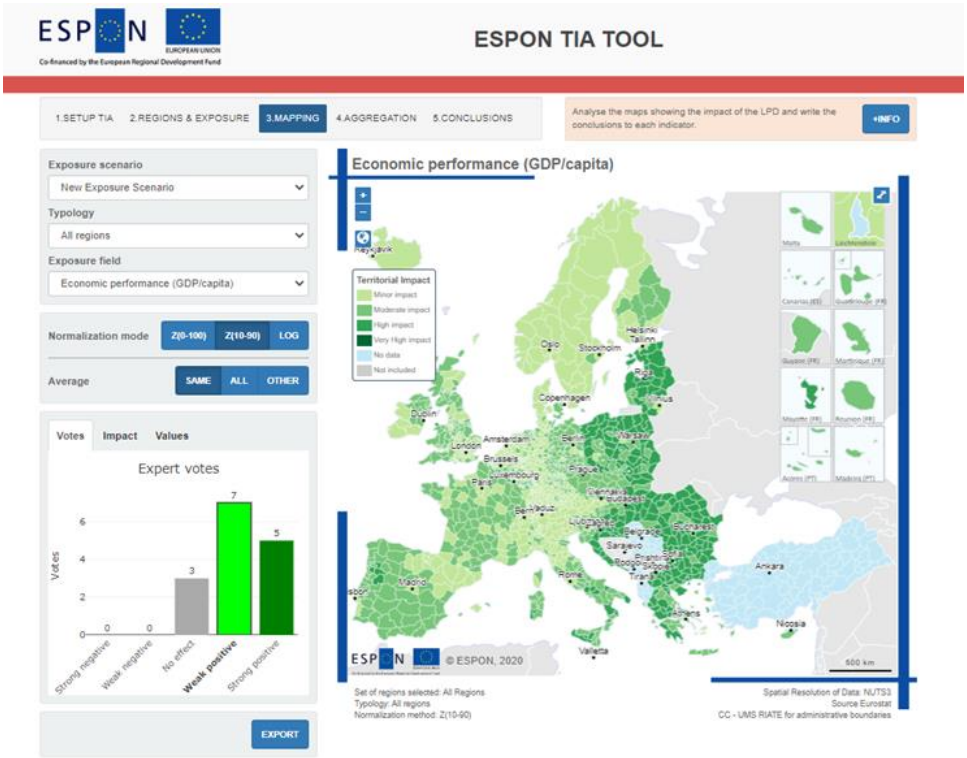

Figure 18: Capture from the ESPON TIA tool. Source: ESPON.

The participants of the workshop are guided through the different steps of an impact analysis. The policy impacts are assessed using a vulnerability approach. This approach uses three elements: a) exposure, b) sensitivity and c) impact. The tool combines expert knowledge on exposure (a) gathered in the workshop with a set of statistical data describing the sensitivity (b) of the regions. The resulting maps visualise the impacts (c) on the various territories and serve as input for discussion among the experts. The maps can serve as a starting point for further discussion of different impacts of a concrete EU policy on different regions.

The tool allows to do a TIA for Europe as a whole, but one can also focus on cross-border regions, urban areas and even on custom made areas.

8.1.3. Environmental Impact Assessment

A second approach of Impact Assessment is Environmental Impact Assessment (EIA). It represents a process of evaluating the likely environmental impacts of a proposed project or development, considering inter-related socio-economic, cultural, and human-health impacts, both beneficial and adverse.

the European Commission (2013) defines Environmental Impact Assessment (EIA) as a tool used to identify the environmental, social, and economic impacts of a project prior to decision-making. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers. By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations.

According to the European Commission (2013), and although legislation and practice vary around the world, the fundamental components of an EIA would necessarily involve the following stages:

- → Screening to determine which projects or developments require a full or partial impact assessment study.
- → Scoping to identify which potential impacts are relevant to assess (based on legislative requirements, international conventions, expert knowledge and public involvement), to identify alternative solutions that avoid, mitigate or compensate adverse impacts on biodiversity (including the option of not proceeding with the development, finding alternative designs or sites which avoid the impacts, incorporating safeguards in the design of the project, or providing compensation for adverse impacts), and finally to derive terms of reference for the impact assessment.
- → Assessment and evaluation of impacts and development of alternatives, to predict and identify the likely environmental impacts of a proposed project or development, including the detailed elaboration of alternatives.
- → Reporting the Environmental Impact Statement (EIS) or EIA report, including an environmental management plan (EMP), and a non-technical summary for the general audience.
- → Review of the Environmental Impact Statement (EIS), based on the terms of reference (scoping) and public (including authority) participation.
- → Decision-making on whether to approve the project or not, and under what conditions.
- → Monitoring, compliance, enforcement, and environmental auditing. Monitor whether the predicted impacts and proposed mitigation measures occur as defined in the EMP. Verify the compliance of proponent with the EMP, to ensure that unpredicted impacts or failed mitigation measures are identified and addressed in a timely fashion.

The EIA procedure guarantees environmental protection and transparency about the decision-making process for several public and private projects. With its wide scope and broad purpose, the EIA ensures that environmental concerns are considered from the very beginning of new building or development projects, or their changes or extensions. It allows the public to actively engage in the EIA procedure.

8.1.4. Economic Impact Assessment

Economic Impact Assessment examines the effects of a project or proposed policy change on the economy. The scope can range from something impacting a small suburban neighbourhood, to a policy that has economic ramifications on a global scale. Ultimately, Economic Impact Assessments offer a rules-based and transparent measure of the economic importance of certain operations or undertakings to an economy.

This sort of analysis is typically undertaken in instances where there is public concern about the potential impacts of a project or policy, such as the construction of a new residential development or mine, or changes to taxation policies (e.g. restricting the use of rental property losses to reduce taxable income, so-called "negative gearing"). An Economic Impact Assessment also serves to highlight the importance of a particular type of operation or project using standard measures of economic activity including Gross Domestic Product (GDP), employment, wages, and tax revenues. Decision-makers, including local councillors, mayors and members of parliament need to know how economies will be affected by certain projects or policy / regulatory changes. These economic consequences can influence decisions regarding development or environmental approvals, as an example.

The most common methodologies for compiling an Economic Impact Assessment are the following:

- Input-Output analysis (I-O)
- Input-Output Econometric modelling (IOE)
- Computable General Equilibrium modelling (GCE)

Overall, the economic effects of a project or program can be divided into direct effects (initial expenditures, persons directly employed, etc.) and secondary effects. To estimate the secondary effects of a project, most analysts employ input-output models, which quantify the linkages among sectors of the area economy. Others use employment or income multipliers derived by a variety of statistical methods.

8.1.5. Cost-Benefit Analysis (CBA)

CBA Cost-Benefit are useful methods for providing meaningful information to support decision-making processes. CBA is based on a set of predetermined project objectives, giving a monetary value to all the positive (benefits) and negative (costs) welfare effects of the intervention. These values are discounted and then totalled to calculate a net total benefit. The project overall performance is measured by indicators, namely the Economic Net Present Value (ENPV), expressed in monetary values, and the Economic Rate of Return (ERR), allowing comparability and ranking for competing projects or alternatives.

The initial Cost Benefit Analysis (CBA) concepts ("Consumer and producer surplus") were developed by the French Engineer Jules Dupuy in the 1870s to assess the "social utility" or public interest of roads, in a similar way the business interest of railway projects was assessed by their promoters. These concepts, inspired by Adam Smith's Moral Philosophy and by an emerging discipline known as Political Economy, were later theorised by several mathematicians and economists. Arthur Pigou's developed Welfare Economics in the 1920s, extending the application of the CBA to any investment or regulatory change, well beyond public works. The modern CBA was applied by IFIs, beginning by the World Bank in the 1960s. Then, the Executive Order 12,291 by President Reagan in 1981 made CBA mandatory in the American Federal Administration. Many European public administrators already applied CBA to assess the public interest of infrastructure projects, particularly transport infrastructure (e.g. the Conseil Géneral des Ponts et Chaussées in France, following Dupuy's legacy).

However, since the late nineties, the Cost-Benefit framework is being disputed from many perspectives – from ethical to operational, from the economic theory behind it as well as for its usefulness on policy decision-making. It has intrepid supporters as well as determined detractors. Academics such as Eric Posner, Matthew Adler, Amy Sinden, Douglas Kysar, David

Driesen and many other scholars began to discuss an intriguing paradox on early 2000s: the reputation of Cost-Benefit was poor among so many academics at the same time that the popularity was very high among governments, in USA as well as in EU countries like UK, The Netherlands, France, Germany or the Nordic Countries.

How project appraisal methods are actually used in public decision-making processes matters remains fundamental. In this sense, in Europe transport infrastructure projects there are very different traditions. Even Sweden and Norway have very different approaches, for instance; while Sweden has a more instrumental/rationalistic and expert driven planning processes Norway has more communicative and politically driven planning processes at different levels. In Sweden, economic viability is a determining factor in the selection of projects to be included in the national transport plan. In Norway, economic viability seems to have no significant impact on the selection of projects included in the national transport plan (Morten Welde, et al. 2013). The critical question is that project appraisal methods, as complex as they are to be scientifically sound and philosophically right, must be well understood by policy-makers and citizens to be legitimated.

The European institutions, such as the European Commission or the Investment Bank, as well as JASPERS, and agencies like The Innovation and Networks Executive Agency (INEA) systematically review Cost-benefit of projects and research on new more updated guidelines, as well as in more general impact assessment methodologies:

- EIB (2004) RAILPAG, Railway Project Appraisal Guidelines
- EC (2009) Impact Assessment Guidelines
- EIB (2013) Methodologies for Assessing Social and Economic Performance in JESSICA
- EC (2014) Guide to Cost-Benefit Analysis of Investment Projects
- EC (2014) Update of the Handbook on External Costs of Transport
- EC, DG REGIO (2014) Cost-Benefit Analysis Guidelines.

8.1.6. Stakeholder's Matrix

For the last half of the XX century, investment decisions in the rail sector were generally taken by the government entity in charge of railways (e.g. Ministry of transport), or by the national rail company holding a monopolistic position in the provision of rail services. Often the responsible Ministry dealt only with rail, leaving roads and, in many cases, ports and airports, in the hands of other ministries. This situation limited a proper multimodal vision and a harmonisation of appraisal procedures in the allocation of financial resources to the transport sector, causing quite often misallocation of resources.

Project appraisal has often been carried out mainly from a rail perspective, without considering proper scenarios which led to forecasts frequently being too optimistic. There is often a lack of control of the administration over rail companies, from which many investment proposals originate. Thus, this political preference should be supported by appropriate evaluation tools able to justify the selection of projects and the use of public funds in rail projects.

RAILPAG guidelines were developed as an answer to the need for harmonised procedures for rail project appraisal, it also suggests best practices for applying Cost-Benefit Analysis to rail projects. RAILPAG addresses the need to complement socioeconomic appraisal methods, from de point of view of the whole society, with financial Cost-Benefit Analysis, from the point of view of the different stakeholders.

In this sense, we consider the Stakeholder/Effects Matrix proposed by the RAILPAG appraisal method developed by Mateu Turró at the European Investment Bank (EIB, 2014) as a relevant reference for presenting financial and socioeconomic appraisal in an integrated and consistent manner.

An investment in the rail sector represents costs and benefits for different agents (institutions, companies, and individuals) where the distributional effects of an investment are an important component for decision makers. The Stakeholders-Effect matrix facilitates to represent the results of the CBA in a way that facilitates the understanding of the consequences of the project. The SE matrix gives an indication of the economic and financial implications for the different stakeholders and the relative weight taken by the different elements considered in the costs and benefits.

CELL CLASSIFICATION																								
SE MATRIX			STAKEHOLDERS																					
			USERS				TRANSPORT SERVICE OPERATORS					CONTRACTORS & SUPPLIERS				INFRASTRUCTURE MANAGERS				NON USERS (external)		GOVERNMENT			
			RAIL LINES		ALTERNA-TIVE MODES		RAIL									RAIL									
EFFECTS			Pax	Freight	Pax	Freight	Rail Operator 1	Rail Operator 2	;	Other modes	INSURANCE COMPANIES	Infrastructure	Superstructure	Rolling stock	Electrification & signalling	Rail manager 1	Rail manager 2	;	Other modes	LOCAL	REGIONAL	LOCAL	REGIONAL	NATIONAL	EU
USER SERVICE		Fares	●	●	●	●	●			●	●													●	
		Travel time	●	●	●	●																			
		Reliability of service	●	●	●	●																			
		Comfort	●																						
		Convenience	●	●																					
		Safety / accidents (economic / financial)	●		●						●														
		Consumer surplus (new traffic)	●	●	●																				
OPERATION	DIRECT	Fees					●									●								●	
		Vehicle operating costs					●			●															
		Operating personnel					●			●															
		Facilities operations					●																		
	INDIRECT	Overhead management -HQ					●																		
		Subsidies					●									●								●	
		Taxes					●			●														●	
ASSETS	INVESTMENT	Land value										●				●				●		●		●	
		Infrastructure					●						●			●								●	
		Superstructure					●									●									
		Stations & terminals					●									●									
		Garage & repair facilities					●							●		●									
		Rolling stock (vehicles)					●							●									●		
		Residual value					●									●									
		Taxes					●					●										●			
	MAINTAIN-ANCE (ROUTINE)	Infrastructure & Superstructure														●									
		Rolling stock					●																		
EXTERNAL EFFECTS		NETWORK EFFECTS (not included above)	●	●			●									●								●	●
	ENVIRONMENTAL	Noise & vibrations																		●					
		Air pollution																		●	●				
		Climate change																			●			●	
		Use of space																		●					
	TERRITORIAL DEVELOPMENT																			●	●				

Figure 18: Stakeholders-Effects matrix proposed by RAILPAG. Source: Rail Project Appraisal Guidelines (European Commission; EIB, 2005)

The SE Matrix feeds from the information that is usually available for the traditional CBA, and it presents it in a way that relates effects (in the rows) and stakeholders (in columns). It shows the transfers between stakeholders and the distribution of costs and benefits by stakeholder and by effect. It can also incorporate markers for effects that could not be monetised and overall indicators of the profitability of the investment.

8.1.7. Quality of Life Indicator

Quality of life indicators is an Eurostat online publication providing recent statistics on the quality of life in the European Union (EU). The publication presents a detailed analysis of 8+1 dimensions which can be measured statistically to represent the different complementary aspects of quality of life, complementing the indicator traditionally used as the measure of economic and social development, gross domestic product (GDP). Eight of these dimensions concern the functional capabilities citizens should have available to effectively pursue their self-defined well-being, according to their own values and priorities. The last dimension refers to the personal achievement of life satisfaction and well-being.

Quality of life defined the following 8+1 dimensions/domains as an overarching framework for the measurement of well-being. Ideally, they should be considered simultaneously, because of potential trade-offs between them:

- Material living conditions (income, consumption, and material conditions)
- Leisure and social interactions
- Economic security and physical safety
- Governance and basic rights
- Natural and living environment
- Overall experience of life

For each quality of life dimension, a set of selected relevant statistical indicators is presented and analysed. Trends over time and differences between countries or demographic groups are discussed. In each case the emphasis has been on highlighting interesting findings, rather than providing a complete and exhaustive presentation of all available statistical data.

8.2. RUSTIK approach to Impact Assessment

As a decision support tool intended to facilitate impact assessment integrating socioeconomic, environmental, and digital considerations into policies, plans and programs, the following framework of territorial assessment is presented. The rationale for this framework stems from the need for an approach that extends the different methods for impact assessment to cater for the interdependency of the environment with development and growth.

Table 7: RUSTIK approach to Impact Assessment

	Definition	Method	Issues at stake
Territorial Asessment	Tool to analyze the effects of physical development in relation to the objectives of the planning or the plans for the area	**SWOT**	Strengths, Weaknesses, Opportunities and Threats in relation to the demographic, digital and ecological transitions
Policy Intensity	Intensity by which EU directives and policies potentially affect European territory through a double logical chain	**TIA**	• Political integration: regulations and investments across sectors aiming demographic/digital/ecological transitions • Territorial governance issues: Mismatch between functional and administrative boundaries. Quality of government.
Territorial Sensitivity	Describes how single territories/regions are subject and evaluate impacts in specific exposure fields, due to their socio-economic and geographical characteristics and to the social values and priorities	**TIA**	• Types of rural areas • Rural functions
Territorial Impact	Final, likely effect of a given EU policy or directive as a product of exposure and regional sensitivity	**TIA**	• **Framework conditions**: governmental, technologic, sociocultural & environmental. • **Policy impacts on the management of transitions**: ○ Demographic (migration flows, aging) ○ Digital (smart economy, business cultures) ○ Ecological (land-taken, biodiversity, water cycle, circular economy, clean soil and air) • Overall impact on the **Quality of Life** in the rural area overtime

Policy assessment	Evaluation of the effectiveness of public policies and assess their impact on social welfare to determine how to improve their interventions and identify in which areas these are most effective	**CBA** **MCDM**	• General Interest of the Policy being implemented at EU, National, Regional and Local scales • Stakeholder's Interest • Spillover Effects in neighbouring and other regions

9. Relation of indicators

The following chapter aims at linking the description of the practices of information access, communication channels, and preferences of stakeholders in local development; the methods and technologies used to gather data and information, and to overcome data and information gaps; and the review of policy impact assessment options in rural areas with the identification of suitable indicator candidates for concepts defined in WP1.

The provided set of indicators is divided in four tables, corresponding with the identification of functional rural areas and the three RUSTIK transitions. These indicators have been identified and reported in two instances, being:

→ Retrieved from the deliverable D1.1
→ Added by this document beneficiaries according to the transitions definition in D1.1

9.1. Proposed indicators to define the Functional Rural Areas

9.1.1. Structural Approach

Name of indicator	Granularity	Territorial coverage	Temporal coverage	If the indicator was proposed by you, provide indicative calculation method. Otherwise, indicate source	Comments and observations	Was this indicator proposed by you, or is already available?
Population	1 sq. km GRID or LAU 2 level	EU 28+4	1950-2021	Eurostat, National Statistics	Temporal and territorial coverage depends on granularity	Already available
Population Density	From 1 sq. km GRID and LAU 2 level to NUTS 2 level	EU 28+4	1950-2021	Eurostat, National Statistics	Temporal and territorial coverage depends on granularity	Already available
Population in 0-14 age group	1 sq. km GRID or LAU 2 level	EU 28+4	1995-2021	Eurostat, National Statistics	Temporal and territorial coverage depends on granularity	Already available
Population in 0-17 age group	LAU 2	EU 28+4	1995-2021	National Statistics	Temporal and territorial coverage depends on granularity	Already available
Population in 65+ age group	LAU 2	EU 28+4	1995-2021	National Statistics	Temporal and territorial coverage depends on granularity	Already available
Population in post-productive age group	LAU 2	EU 28+4	1995-2021	National Statistics	Temporal and territorial coverage depends on granularity	Already available
Ageing ratio	1 sq. km GRID or LAU 2 level	EU 28+4	1995-2021	National Statistics	Temporal and territorial coverage depends on granularity, defined as population under 14 per 100 inhabitants 65+	Already available
Age dependency ratio	LAU 2	EU 28+4	1995-2021	National Statistics	Temporal and territorial coverage depends on granularity, defined as population in non-productive age per 100 inhabitants in productive age	Already available
Feminization rate	1 sq. km GRID or LAU 2 level	EU 28+4	1995-2021	National Statistics	Temporal and territorial coverage depends on granularity, defined as females population per 100 of male population	Already available

Feminization rate for matrimonial age group	LAU 2	EU 28+4	1995-2021	National Statistics	Temporal and territorial coverage depends on granularity, defined as females population per 100 of male population in matrimonial age group	Already available
Degree of urbanization	LAU 2	EU 28+4	2001, 2014, 2018, 2020 (provisional)	Eurostat DEGURBA	Data based on granularity of population GRID	Already available
Built-up area	1 sq. km GRID or LAU 2 level	EU 28+4	1990-2018	Share of built-up area per total area based on selected GIS land cover databases	Temporal coverage as an example based on CLC data	Already available
Land use intensity	1 sq. km GRID or LAU 2 level	EU 28+4	1990-2018	Ratio calculated as in ESPON EU-LUPA project, based on CLC		Already available

9.1.2. Approach based on multifunctionality

Name of indicator	Granularity	Territorial coverage	Temporal coverage	If the indicator was proposed by you, provide indicative calculation method. Otherwise, indicate source	Comments and observations	Was this indicator proposed by you, or is already available?
Population dynamics	1 sq. km GRID and LAU 2	EU 28+4	2000-2021	Average yearly population change in percentage, based on Eurostat and National Statistics	Temporal and territorial coverage depends on granularity, temporal coverage limited according to ESPON ESCAPE project assumptions	Already available
Share of employment in primary sector	NUTS 3 or 2	EU 28+4	1995-2021	Eurostat, National Statistics	Temporal and territorial coverage depends on granularity	Already available
Share of employment in tertiary sector	NUTS 3 or 2	EU 28+4	1995-2021	Eurostat, National Statistics	Temporal and territorial coverage depends on granularity	Already available
Share of GVA in primary sector	NUTS 3 or 2	EU 28+4	1995-2021	Eurostat, National Statistics	Temporal and territorial coverage depends on granularity	Already available
Nights spent at tourist accommodation establishments	LAU 1 or 2 level	EU 28+4	1990-2021	National Statistics		Already available for selected areas of Europe

Arrivals at tourist accommodation at tourist accommodation establishments	LAU 1 or 2 level	EU 28+4	1990-2021	National Statistics		Already available for selected areas of Europe
Number of collective tourist accommodation establishments	LAU 1 or 2 level	EU 28+4	1990-2021	National Statistics		Already available for selected areas of Europe
Number of collective tourist accommodation bedrooms	LAU 1 or 2 level	EU 28+4	1990-2021	National Statistics		Already available for selected areas of Europe
Number of collective tourist accommodation bed-places	LAU 1 or 2 level	EU 28+4	1990-2021	National Statistics		Already available for selected areas of Europe
Percentage of seasonal bed-places in collective tourist accommodation	LAU 1 or 2 level	EU 28+4	1990-2021	National Statistics		Already available for selected areas of Europe
New houses	From precise vector data to national level	EU 28+4	1995-2021	National Statistics	Territorially diversified data availability and possible inconsistence of definitions and temporal intersections	Available for selected areas of Europe
Built-up area dynamics	1 sq. km GRID or LAU 2 level	EU 28+4	1990-2018	Change of built-up area share in total area, based on selected GIS land cover databases	Temporal coverage as an example based on CLC data	Already available
Share of protected areas	NUTS 2 or 3or LAU 1	EU 28+4	1990-2021	The area under certain form of protection per sq. km		Already available
Car travel time to the next SGI point (grid)	beyond NUTS3	EU 28+4	2016	ESPON DB		Already available
Location of SGIs in Europe (primary and secondary schools)	beyond NUTS3	EU 28+4	2016	ESPON DB		Already available
Location of SGIs in Europe (pharmacies, doctors, hospitals)	beyond NUTS3	EU 28+4	2016	ESPON DB		Already available

Location of SGIs in Europe (cinemas, shops)	beyond NUTS3	EU 28+4	2016	ESPON DB		Already available
Pan-European Map of Forest Biomass Increment	beyond NUTS3	EU 28+4	2006	ESPON DB		Already available
Land use efficiency regarding Provision of Biotic Resources	1 sq. km GRID or LAU 2 level	EU 28+4	1990-2018	Ratio calculated as in ESPON EU-LUPA project, based on CLC		Already available
Land use efficiency regarding Provision of Leisure and Recreation	1 sq. km GRID or LAU 2 level	EU 28+4	1990-2018	Ratio calculated as in ESPON EU-LUPA project, based on CLC		Already available
Land use efficiency regarding Provision of Food and Energy	1 sq. km GRID or LAU 2 level	EU 28+4	1990-2018	Ratio calculated as in ESPON EU-LUPA project, based on CLC		Already available
Land use performance regarding the Nitrate directive	1 sq. km GRID or LAU 2 level	EU 28+4	1990-2018	Ratio calculated as in ESPON EU-LUPA project, based on CLC		Already available
Biodiversity index	LAU 1 or 2 level	EU 28+4		Number of species in the area per total number of individuals in the area, based on various GIS databases		Non-available
Exposure to air pollution by particulate matter	NUTS0	EU 28+4	2000-2017	Eurostat		Already available

9.1.3. Urban-rural relations within the geographical proximity

Name of indicator	Granularity	Territorial coverage	Temporal coverage	If the indicator was proposed by you, provide indicative calculation method. Otherwise, indicate source	Comments and observations	Was this indicator proposed by you, or is already available?
Standardized travel time to next regional centre	NUTS3	EU 28+4	2017	ESPON DB	The notion of regional centre to be defined	Already available

Standardized travel time to next sub-regional centre	NUTS3	EU 28+4	2017	ESPON DB	The notion of sub-regional centre to be defined	Already available
Potential accessibility by road and rail	NUTS3	EU 28+4	2014	ESPON DB		Already available
Migration ratio	LAU 2	EU 28+4	1995-2021	National statistics	A period of recent 5 or 10 years suggested, to avoid the impact of picks in particular years observed at local level	Already available
Percentage of migration to FUA of regional centre	LAU 2	EU 28+4	1995-2021	National Statistics	Matrix data needed, containing exact destination of migrants	Already available for selected areas of Europe
No. of daily commuters per 1000 inh.	LAU 2	EU 28+4	1995-2021	National Statistics	Inconsistence of temporal intersections of available data as a potential obstacle	Already available for selected areas of Europe

9.1.4. Relations based on networks

Name of indicator	Granularity	Territorial coverage	Temporal coverage	If the indicator was proposed by you, provide indicative calculation method. Otherwise, indicate source	Comments and observations	Was this indicator proposed by you, or is already available?
Standardized travel time to next airport	NUTS3	EU 28+4	2017	ESPON DB		Already available
Households with broadband access	NUTS2	EU 28+4	2012-2019	Eurostat		Already available
Individuals who accessed the internet away from home or work	NUTS2	EU 28+4	2012-2019	Eurostat		Already available
Individuals who used the internet for interaction with public authorities	NUTS2	EU 28+4	2008-2021	ESPON DB		Already available
Individuals who ordered goods or services over the internet for private use	NUTS2	EU 28+4	2006-2016	ESPON DB		Already available

FDI per capita	NUTS3	EU 28+4	2003-2015	To be calculated per capita, based on BvD Zephyr and FT databases		Already available
Remittances turnover	NUTS2	EU 28+4	2010-2018	ESPON IRiE DB	Data will be launched in 2023	Available soon
Number of EU projects in rural areas per capita	NUTS 2 or 3 or LAU 1	EU 28+4	2012-2021	National Statistics	Dispersed sources, need for comprehensive review of data sources	Already available for selected areas of Europe
Number of LAGs	NUTS 2 or 3 or LAU 1	EU 28+4	2012-2021	National Statistics	Dispersed sources, need for comprehensive review of data sources	Already available for selected areas of Europe

9.2. Proposed indicators to define the Demographic transition

9.2.1. Indicators of the demographic domain

Grouping	Indicator	Description	Granularity	Territorial coverage	Source
Total	Population	Total number of people residing in that area at a given time	NUTS2-3, LAU2		EUROSTAT; national statistics
Total	Population	Total number of people residing in that area at a given time	Grid 1x1km	EU 28+4	EUROSTAT; national statistics
Total	Population	Total number of people residing in that area at a given time	Grid 1x1km	Worldwide	Global Human Settlement Layer (GHSL)
Total	Population	Total number of people residing in that area at a given time	Grid 250x250 m and 1x1km	EU 28+4	JRC
Total	Population density	Population/km2	NUTS2-3, LAU2		EUROSTAT; national statistics
Total	Population density	Population/km2	Grid 1x1km	EU 28+4	EEA, EUROSTAT
Total	Population growth rate	Mean number of children who would be born to a woman during her lifetime	NUTS2-3, LAU2		EUROSTAT; national statistics
Gender	Gender	Distribution of the population by sex/gender	LAU2		National statistics
Age	Age distribution of the population	Age pyramid	LAU2		National statistics
Age	Young age dependency ratio (1st variant)	Population 0-14/Population 15-64	NUTS2-3, LAU2		EUROSTAT; national statistics

Age	Old age dependency ratio (1st variant)	Population 65+/Population 15-64	NUTS2-3, LAU2		EUROSTAT; national statistics
Age	Median age of population	The age that divides population in two groups numerally equal, younger and older	NUTS2-3, LAU2		EUROSTAT; national statistics
Age	Ageing index	Population 65+/Total population	NUTS2-3, LAU2		EUROSTAT; national statistics
Age	Elderly index	Population 65+/Population 0-14	NUTS2-3, LAU2		EUROSTAT; national statistics
Age	Structural dependency index	(Population65+) + (Population 0-14) /Population 15-64	NUTS2-3, LAU2		EUROSTAT; national statistics
Age	Structural dependency of young	Population 0-14/Population 15-64	NUTS2-3, LAU2		EUROSTAT; national statistics
Age	Structural dependency of elders	Population 65+/Population 15-64	NUTS2-3, LAU2		EUROSTAT; national statistics
Fertility	Total fertility rate	Births from women in fertile age	NUTS2-3, LAU2		EUROSTAT; national statistics
Fertility	Birth	Births occurring in a population (includes both live births and stillbirths)	NUTS2-3, LAU2		EUROSTAT; national statistics
Fertility	Birth	Live births by age group of the mothers	NUTS3		EUROSTAT (Rural Observatory)
Mortality	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	NUTS2-3, LAU2		EUROSTAT; national statistics
Mortality	Life expectancy	Mean additional number of years that a person of that age can expect to live, if subjected throughout the rest of his or her life to the current mortality conditions	NUTS2-3, LAU2		EUROSTAT; national statistics
Mortality	Mortality	Deaths that occur in a population	NUTS2-3, LAU2		EUROSTAT; national statistics
Mortality	Natural population change	Difference between live births minus the number of deaths	NUTS2-3, LAU2		EUROSTAT; national statistics
Migration	Migration	Number of migrants, people changing their residence to or from a given area (usually a country) during a given time period (usually one year).	NUTS2-3, LAU2		EUROSTAT; national statistics
Migration	Net migration	Difference between the number of immigrants and the number of emigrants	NUTS2-3, LAU2		EUROSTAT; national statistics
Migration	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	NUTS2-3, LAU2		EUROSTAT; national statistics

Migration	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		EUROSTAT; national statistics
Migration	Net migration	Difference between the number of immigrants and the number of emigrants (plus statistical adjustment)	NUTS2-3, LAU2		EUROSTAT; national statistics
Disability	Disability	Share of the population with different degrees of disabilities and labour dependency	LAU2		National statistics
Race and etnicity	Race and ethnicity	Racial and/or ethnic distribution of the population by self-identification	LAU2		National statistics

9.2.2. Indicators of the social domain

Grouping	Indicator	Description	Granularity	Territorial coverage	Temporal coverage	Source
Education	Participation rate in education and training		NUTS2-3, LAU 2			EUROSTAT; national statistics
Education	Educational distribution of the population	Population by highest degree of education	LAU2			National statistics
Education	Population by educational attainment level, sex		NUTS2-3, LAU 2			EUROSTAT; national statistics
Education	Early leavers from education and training by sex		NUTS2-3, LAU 2			EUROSTAT; national statistics
Education	Young people neither in employment nor in education and training by sex and NUTS 2-3 regions (NEET rates)		NUTS2-3, LAU 2			
Education	Available educational institutions by level of education	Number of educational institutions by level of education	NUTS2-3, LAU 2			National statistics
Education	Population aged 25-64 and 30-34 by educational attainment level		NUTS3	EU 28+4	2000-2016	ESPON DB
Self-reported skills	Number of foreign languages known (self-reported)		NUTS0	EU 28+4	2007, 2011, 2016	EUROSTAT
Lifelong learning	Participation rate in education and training		NUTS3	EU 28+4	2000-2016	ESPON DB
Opportunities	Participation/ enrolment in education		NUTS0	EU 28+4	1998-2012	EUROSTAT
Health	HE: Share of people with good or very good perceived health by sex		NUTS2-3, LAU 2			EUROSTAT; national statistics
Health	HE: Physicians or doctors by NUTS 2-3 regions and LAU	Number of physicians per capita	NUTS2-3, LAU 2			
Health	HE: Number of Dentists	Number of dentists per capita	NUTS2-3, LAU 2			

Health	HE: Distance to primary health services (km.)		NUTS2-3, LAU 2			Rural observatory
Life expectancy	Life expectancy		NUTS0	EU 28+4	1960-2017	EUROSTAT
Morbidity & Health status	Healthy life years (from 2004 onwards)		NUTS0	EU 28+4	2004-2016	EUROSTAT
Morbidity & Health status	Self-perceived health		NUTS0	EU 28+4	2008-2018	EUROSTAT
Morbidity & Health status	Current depressive symptoms		NUTS0	EU 28+4	2014	EUROSTAT
Healthy and unhealthy behaviours	Body mass index		NUTS0	EU 28+4	2014	EUROSTAT
Healthy and unhealthy behaviours	Daily smokers of cigarettes		NUTS3	EU 28+4	2014	EUROSTAT
Healthy and unhealthy behaviours	Frequency of heavy episodic drinking		NUTS3	EU 28+4	2014	EUROSTAT
Healthy and unhealthy behaviours	Performing (non-work-related) physical activities		NUTS0	EU 28+4	2014	EUROSTAT
Healthy and unhealthy behaviours	Time spent on health-enhancing (non-work-related) aerobic physical activity		NUTS0	EU 28+4	2014	EUROSTAT
Healthy and unhealthy behaviours	Daily consumption of fruit and vegetables		NUTS0	EU 28+4	2014	EUROSTAT
Access to healthcare	Self-reported unmet needs for medical examination		NUTS0	EU 28+4	2008-2018	EUROSTAT

9.2.3. Indicators related to the overall experience of life, leisure and social interactions

Grouping	Indicator	Description	Granularity	Territorial coverage	Temporal coverage	Source
Housing	Housing stock (type of buildings)		NUTS2-3, LAU 2			National statistics, Census data
Housing	Housing quality		NUTS2-3, LAU 2			National statistics, Census data
Housing	Housing prices		NUTS2-3, LAU 2			National statistics, Census data
Living Conditions	Dwelling conditions	People living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor	NUTS2-3, LAU 2			EUROSTAT, National Statistics
Living Conditions	Household composition	Number of children and adults per household	NUTS2-3, LAU 2			EUROSTAT, National Statistics

Living Conditions	Household size	Average number of members per household	NUTS2-3, LAU 2			EUROSTAT, National Statistics
Transport	Types of available public transport at LAU level		NUTS2-3, LAU 2			Municipality data
Transport	Frequency of available public transport connections between settlements in the pilot region		NUTS2-3, LAU 2			Municipality data
Transport	Frequency of public transport connections between the town in the pilot region and the nearest larger town		NUTS2-3, LAU 2			Municipality data
Culture	Number and type of cultural institutions available in the pilot region	Number of libraries, cinemas, museums, theatres, and community clubs	NUTS2-3, LAU 2			Municipality data, National statistics
Culture	Participation in activities of amateur groups, hobby associations, interest clubs of the population aged 25-64 by sex, age, education, employment status and place of residence		NUTS2-3, LAU 2			National statistics, Census data
Culture	Participation in cultural activities	Number of visits of live performances, cinema, cultural sights, by reading of newspapers and books	NUTS2-3, LAU 2			National statistics
Culture	Publishing activity	Number of published books and issued newspapers and magazines	NUTS2-3, LAU 2			National statistics
Culture	Broadcast and media activity NUTS3 - LAU	Number of radio and TV operators	NUTS2-3, LAU 2			National statistics
Leisure	Participation in any cultural or sport activities in the last 12 months		NUTS0	EU 28+4	2006, 2015	EUROSTAT
Leisure	Frequency of participation in cultural or sport activities in the last 12 months		NUTS0	EU 28+4	2006, 2015	EUROSTAT
Leisure	Average rating of satisfaction by domain		NUTS0	EU 28+4	2013	EUROSTAT
Leisure	Percentage of the population rating their satisfaction as high, medium or low by domain		NUTS0	EU 28+4	2013	EUROSTAT
Leisure	Reasons of non-participation in cultural or sport activities in the last 12 months		NUTS0	EU 28+4	2015	EUROSTAT

Social interactions	Frequency of getting together with family and relatives or friends		NUTS0	EU 28+4	2015	EUROSTAT
Social interactions	Frequency of contacts with family and relatives or friends		NUTS0	EU 28+4	2015	EUROSTAT
Social interactions	Participation in formal or informal voluntary activities or active citizenship		NUTS0	EU 28+4	2015	EUROSTAT
Social interactions	Reasons of non-participation in formal or informal voluntary activities, active citizenship in the last 12 months		NUTS0	EU 28+4	2015	EUROSTAT
Social interactions	Persons who have someone to ask for help		NUTS0	EU 28+4	2013, 2015	EUROSTAT
Social interactions	Persons who have someone to discuss personal matters		NUTS0	EU 28+4	2013, 2015	EUROSTAT
Social interactions	Average rating of trust by domain		NUTS0	EU 28+4	2013	EUROSTAT
Institutions	Trust in institutions: Confidence in institutions	Share of population with confidence in national and EU institutions	National - NUTS2-3, LAU 2			EUROSTAT, National
Physical and personal security	Recorded offences by offence category - police data		?	EU 28+4	2008-2016	EUROSTAT
Physical and personal security	Crime, violence or vandalism in the area		?	EU 28+4	2008-2016	EUROSTAT
Trust/satisfaction in institutions and public services	Index of Good Governance		NUTS2	EU 28+4	2009	ESPON DB
Trust/satisfaction in institutions and public services	Average rating of trust by domain		NUTS0	EU 28+4	2013	EUROSTAT
Discrimination and equal opportunities	Gender gap by age group		NUTS0	EU 28+4	2009	ESPON DB
Discrimination and equal opportunities	Typology of gender differences on the labour market		NUTS0	EU 28+4	2009	ESPON DB
Discrimination and equal opportunities	Unemployment by sex		NUTS3	EU 28+4	1999-2016	ESPON DB
Discrimination and equal opportunities	Unemployment by age		NUTS3	EU 28+4	1999-2016	ESPON DB
Discrimination and equal opportunities	Gender pay gap in unadjusted form by NACE Rev. 2 activity - structure of earnings survey methodology		NUTS0	EU 28+4	2007-2017	EUROSTAT

Discrimination and equal opportunities	Employment rates by sex, age, educational attainment level, country of birth and degree of urbanization		NUTS0	EU 28+4	2007-2017	EUROSTAT
Active citizenship	Participation in formal or informal voluntary activities or active citizenship		NUTS0	EU 28+4	2015	EUROSTAT
Life satisfaction	Average rating of satisfaction by domain		NUTS0	EU 28+4	2013	EUROSTAT
Life satisfaction	Percentage of the population rating their satisfaction as high, medium or low by domain		NUTS0	EU 28+4	2013	EUROSTAT
Affects	Frequency of being happy in the last 4 weeks		NUTS0	EU 28+4	2013	EUROSTAT
Life satisfaction	Development		1x1 km grid	Worldwide		Global Human Settlement Layer (GHSL)

9.2.4. Indicators in the domains of economy and productive activities

Grouping	Indicator	Description	Granularity	Territorial coverage	Temporal coverage	Source
Employment	Employment (thousand persons)	Number of employed persons	NUTS2-3, LAU 2			EUROSTAT; national statistics
Employment	Relative change in the share of employment in the primary sector 2012-2022	The number of people currently employed in the primary sector as a share of the total working-age population, which is the number of civilian, non-institutionalized persons, age 16 and over.	NUTS2-3, LAU 2			EUROSTAT; national statistics
Employment	Relative change in the share of employment in the secondary sector	The number of people currently employed in the secondary sector as a share of the total working-age population, which is the number of civilian, non-institutionalized persons, age 16 and over.	NUTS2-3, LAU 2			EUROSTAT; national statistics
Employment	Relative change in the share of employment in the third sector	The number of people currently employed in the third sector as a share of the total working-age population, which is the number of civilian, non-institutionalized	NUTS2-3, LAU 2			EUROSTAT; national statistics

		persons, age 16 and over.				
Employment	Relative change in the share of employment in the public sector	The number of people currently employed in the public sector as a share of the total working-age population, which is the number of civilian, non-institutionalized persons, age 16 and over.	NUTS2-3, LAU 2			EUROSTAT; national statistics
Employment	Compensation of employees	Wage/salaries of employees	NUTS2-3, LAU 2			EUROSTAT; national statistics
Employment	Unemployment rate		NUTS2-3, LAU 2			EUROSTAT; national statistics
Employment	Long-term unemployment (12 months and more)		NUTS3	EU 28+4	1999-2016	ESPON DB
Employment	People living in households with very low work intensity		NUTS3	EU 28+4	2005-2016	ESPON DB
Employment	Involuntary part-time employment as percentage of the total part-time employment		NUTS0	EU 28+4	1983-2017	EUROSTAT
Employment (Quality)	Low-wage earners as a proportion of all employees		NUTS0	EU 28+4	2006, 2010, 2014	EUROSTAT
Employment (Quality)	Part-time employment and temporary contracts		NUTS0	EU 28+4	1993-2017	EUROSTAT
Employment (Quality)	Temporary employees by main reason		NUTS0	EU 28+4	1983-2017	EUROSTAT
Employment (Quality)	Self-declared over-qualified employees		NUTS0	EU 28+4	2014	EUROSTAT
Employment (Quality)	Persons reporting an accident at work		NUTS3	EU 28+4	2007, 2013	EUROSTAT
Employment (Quality)	Persons reporting a work-related health problem		NUTS3	EU 28+4	2007, 2013	EUROSTAT
Employment (Quality)	Persons reporting exposure to risk factors that can adversely affect physical health		NUTS0	EU 28+4	2007, 2013	EUROSTAT
Employment (Quality)	Average number of usual weekly hours of work in main job		NUTS0	EU 28+4	2000-2017	EUROSTAT
Employment (Quality)	Employed persons working on Saturdays		NUTS0	EU 28+4	1992-2017	EUROSTAT
Employment (Quality)	Employed persons working on Sundays		NUTS0	EU 28+4	1992-2017	EUROSTAT

Employment (Quality)	Employed persons working in the evenings		NUTS0	EU 28+4	1992-2017	EUROSTAT
Employment (Quality)	Employed persons working at nights		NUTS0	EU 28+4	1992-2017	EUROSTAT
Employment (Quality)	Employees by flexibility of their working schedule and educational attainment		NUTS0	EU 28+4	2010	EUROSTAT
Employment (Quality)	Employed persons being able to choose their methods of work or to influence their pace of work		NUTS0	EU 28+4	2005, 2010, 2015	EUROSTAT
Employment (Quality)	Average rating of satisfaction by domain		NUTS0	EU 28+4	2013	EUROSTAT
Employment (Quality)	Percentage of the population rating their satisfaction as high, medium or low by domain		NUTS3	EU 28+4	2013	EUROSTAT
Employment (Quality)	Employees having a good relationship with their supervisor		NUTS3	EU 28+4	2005, 2010, 2015	EUROSTAT
Employment (Quality)	Employed persons having a good relationship with their colleagues		NUTS0	EU 28+4	2005, 2010, 2015	EUROSTAT
Poverty	People at risk of poverty or social exclusion		NUTS2-3, LAU 2			EUROSTAT; national statistics
Income	Disposable income of private households		NUTS3	EU 28+4	2003-2013	ESPON DB
Income	At risk of poverty rate		NUTS3	EU 28+4	2005-2016	ESPON DB
Income	People at risk of poverty or social exclusion (% of total population)		NUTS3	EU 28+4	2005-2016	ESPON DB
Income	Mean and median income by age and sex		NUTS0	EU 28+4	1995-2017	EUROSTAT
Income	At-risk-of-poverty rate anchored at a fixed moment in time		NUTS0	EU 28+4	2008-2018	EUROSTAT
Income	At-risk-of-poverty rate by poverty threshold		NUTS0	EU 28+4	2008-2018	EUROSTAT
Income	S80/S20 income quintile share ratio		NUTS0	EU 28+4	2008-2018	EUROSTAT
Income	Percentage of the population rating their satisfaction as high, medium or low by domain		NUTS0	EU 28+4	2013	EUROSTAT
Income	Average rating of satisfaction by domain, sex, age and educational attainment level		NUTS0	EU 28+4	2013	EUROSTAT
Tourism	Nights spent at tourist accommodation		NUTS2-3, LAU 2			EUROSTAT; national statistics/

						rural observatory
Tourism	Type of available accomodations		NUTS2-3, LAU 2			EUROSTAT; national statistics/ rural observatory
Economic security	Index of access to funding and financial support		NUTS2	EU 28+4	2013	ESPON DB
Economic security	Inability to face unexpected financial expenses		?	EU 28+4	2003-2018	EUROSTAT
Economic security	Arrears (mortgage or rent, utility bills or hire purchase) from 2003 onwards		?	EU 28+4	2003-2018	EUROSTAT
Economic security	Labour transitions by employment status		?	EU 28+4	2006-2018	EUROSTAT
Material conditions (deprivation, housing)	Severe material deprivation rate		NUTS3	EU 28+4	2005-2016	ESPON DB
Material conditions (deprivation, housing)	Inability to make ends meet		NUTS0	EU 28+4	2003-2018	EUROSTAT
Material conditions (deprivation, housing)	Total population living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor		NUTS0	EU 28+4	2003-2018	EUROSTAT
Material conditions (deprivation, housing)	Overcrowding rate and poverty status		NUTS0	EU 28+4	2003-2018	EUROSTAT
Material conditions (deprivation, housing)	Share of people living in under-occupied dwellings by household type and income quintile		NUTS0	EU 28+4	2003-2018	EUROSTAT
GDP	GDP per capita 2012-2022	the sum of gross value added by all resident producers in the economy plus any product taxes (less subsidies) not included in the valuation of output, divided by mid-year population.	NUTS2-3, LAU 2			EUROSTAT; national statistics
Consumption	GDP per capita 2012-2022		1x1 km grid	Worldwide		Global Human Settlement Layer (GHSL)
GDP	Gross domestic product (GDP) at current market prices	Regional Gross Domestic Product (GDP) is used to measure and compare the economic activity of the regions. This is the most important	NUTS2-3, LAU 2			EUROSTAT; national statistics

		indicator for the selection of regions eligible for support under the investment objective for growth and jobs in the country's regional policy.				
Added value	Share of GVA (gross value added) produced by the primary (NACE rev.2 sector A) in 2022 and change for the period 2012-2022	Contribution of a corporate subsidiary, company, or municipality to an economy. It is used to see how much value is added (or lost) from a particular region, state, or province.	NUTS2-3, LAU 2			EUROSTAT; national statistics
Added value	Share of GVA produced by secondary sector (NACE rev.2 sector B-F) in 2022 and change for the period 2012-2022	Contribution of a corporate subsidiary, company, or municipality to an economy. It is used to see how much value is added (or lost) from a particular region, state, or province.	NUTS2-3, LAU 2			EUROSTAT; national statistics
Added value	Share of GVA produced the service sector (NACE rev.2 sector G-N) in 2022 and change for the period 2012-2022	Contribution of a corporate subsidiary, company, or municipality to an economy. It is used to see how much value is added (or lost) from a particular region, state, or province.	NUTS2-3, LAU 2			EUROSTAT; national statistics
Added value	Share of GVA produced by the public sector (NACE rev.2 sector O-U) in 2022 and change for the period 2012-2022	Contribution of municipal, regional and state entities to an economy. It is used to see how much value is added (or lost) from a particular region, state, or province.	NUTS2-3, LAU 2			EUROSTAT; national statistics

9.3. Proposed indicators to define the Digital transition

9.3.1. Indicators of the digital infrastructures domain

Indicator	Description	Baseline	Target	Granularity	Source
Urban-rural divide in broadband coverage	Comparison of rural and urban data in coverage by technology			National	Annual Digital Economy and Society Index (DESI) report
Urban-rural divide in next generation access (NGA) broadband coverage	Comparison of rural and urban data in rural VHCN (very high capacity network) coverage			National	Annual Digital Economy and Society Index (DESI) report

Urban-rural divide in households with a fixed broadband subscription	Comparison of rural and urban data about households to have a fixed broadband subscription			National	Economy and Society Index (DESI) report
Broadband speed	The indicator measures the access to broadband and the quality of the connection in each municipality. It displays the average download speed (measured in Megabits per second) for both the fixed and mobile networks.			Local	EU Rural Observatory
Gigabit coverage*	Percentage of households covered by a network capable of gigabit speeds	0.59	All European households will be covered by a Gigabit network	Member State level	'Broadband coverage in Europe' studies by IHS Markit, Omdia and Point Topic
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	Member State level	'Broadband coverage in Europe' studies by IHS Markit, Omdia and Point Topic
Share of SMEs with at least basic level of digital intensity	The degree of penetration and speed of adoption of the different technologies by SME's			National	Economy and Society Index (DESI) report
SMEs selling online and selling online cross-border	e-commerce adaptation level			National	Economy and Society Index (DESI) report
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
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	–	–

9.3.2. Indicators of the digital skills domain

Indicator	Description	Baseline	Target	Granularity	Territorial coverage	Temporal coverage	Source
Urban-rural divide in ratio of at least basic level digital skills in population	Differences in the level of basic digital skill levels among the population of of cities, towns, suburbs and rural areas			National			Annual Digital Economy and Society Index (DESI) report
Urban-rural divide in internet use	Differences in internet use between cities, towns, suburbs and rural areas			National			Annual Digital Economy and Society Index (DESI) report
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	0.56	0.8	Member State level			Eurostat Community survey on ICT usage in households and by individuals
Self-reported skills	Individuals' level of digital skills			NUTS0	EU 28+4	2015-2017	EUROSTAT
Level of internet user skills	Since 2015, the European Commission has measured citizens' digital skills through the Digital Skills Indicator (DSI). It is a composite indicator based on selected activities related to internet or software use, which are performed by individuals aged 16-74.			National			Annual Digital Economy and Society Index (DESI) report1
Digital life	Individuals who ordered goods or services over the internet for private use			NUTS2	EU 28+4	2006-2016	ESPON DB
Digital life	Individuals who used the internet for interaction with public authorities			NUTS2	EU 28+4	2008-2016	ESPON DB
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	Member State level			Eurostat labour force survey

9.3.3. Indicators of the digital transformation of businesses domain

Indicator	Description	Baseline	Target	Granularity	Source
Number of local/regional initiatives to develop digital services/products	The number of financed applications/share of funding from total budget/project results to develop local digital services and products			Sub-national/ regional	M&E data of LAGs
SMEs with at least a basic level of digital intensity*	percentage of SMEs using at least four of 12 selected digital technologies (Late adopters) [1]	0.6	more than 90% of SMEs should reach at least a basic level of digital intensity	Member State level	Eurostat Community survey on ICT usage and e-commerce in enterprises
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	Member State level	Eurostat, IPSOS
Unicorns*	sum of realised 'unicorns' and unrealised 'unicorns' (Innovators) [2]	122	grow scale-ups and access to finance leading to double EU Unicorns	Only EU level	Dealroom

9.3.4. Indicators of the digitalisation of public services domain

Indicator	Description	Baseline	Target	Granularity	Source
Digital Identity	Use of digital ID solution	Not yet available	80% of citizens should have access to digital ID	Member State level	–
Share of e-government users among internet users	The percentage of individuals who used the Internet in the last 12 months to interact with the public authorities			National	Economy and Society Index (DESI) report
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	–
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	Member State level	e-government benchmark studies by Capgemini

Key Public Services*	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	Member State level	e-government benchmark studies by Capgemini
Level of satisfaction with local/local public e-services	The level of satisfaction with local and regional public e-services by local population			Local/regional	National dashboards, satisfaction surveys of local/regional authorities
Share/volume of public finances for digital transformation	Share/volume of finances invested by public authorities into the development of local and regional e-services and digital tools			Local/regional	Annual financial reports/budges of local/regional public authorities

9.4. Proposed indicators to define the Environmental transition

9.4.1. Indictors of the pollution domain

Indicator	Availability	Source	Granularity	Territorial coverage	Temporal coverage
Emissions of carbon oxide	*Already available*	ESPON DB	NUTS2	EU 28+4	2010
Emissions of nitrogen oxides	*Already available*	ESPON DB	NUTS0	EU 28+4	2010
Emissions of non-methane volatile organic compounds	*Already available*	ESPON DB	NUTS2	EU 28+4	2010
Emissions of sulphur oxides	*Already available*	ESPON DB	NUTS0	EU 28+4	2010
Exposure to air pollution by particulate matter	*Already available*	EUROSTAT	NUTS0	EU 28+4	2000-2017
Pollution, grime or other environmental problems	*Already available*	EUROSTAT	NUTS0	EU 28+4	2003-2018
Noise from neighbours or from the street	*Already available*	EUROSTAT	NUTS0	EU 28+4	2003-2018
Night-time light		Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	
Pollutant's emission		Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	
Pollutant’s concentration		Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	

9.4.2. Indictors of the climate change domain

Indicator	Source	Granularity	Territorial coverage	Temporal coverage
CO2 emissions from ground transport, non-transport fossil combustion and territorial fossil combustion	ESPON DB	NUTS2	EU 28+4	2000, 2008
Annual total emissions of greenhouse gases	ESPON DB	NUTS0	EU 28+4	1970-2014
Economic losses from climate-related extremes in Europe	EEA	NUTS 0	EU+	
Burnt area in European countries	EEA	NUTS 0	EEA	1992 (1980 for Mediterranean countries)
Average near-surface temperatures	EEA	Grid	EU	1958+
Water scarcity conditions	Copernicus	NUTS 0	Global	2000+
Total GHG emissions	EEA, Copernicus	NUTS0	Europe	1990+ (real and projected)
Total greenhouse gas concentration	EEA		EU27+UK	
GHG emission intensity of electricity generation	EEA	NUTS0	Global	1990+
Greenhouse gas emissions from transport	EEA	NUTS0	EU	1990+ (real and projected data)
Greenhouse gas emissions from energy use in buildings	EEA	NUTS0	EU	2005+ (real & projected)
GHG from LULUCF	EEA	NUTS0	EU	1990+
Use of renewable energy for transport	EEA	NUTS0	EU	2005-2021
Downscaled bioclimatic indicators	EEA	1x1 km	EU	1950 to 2100
Agroclimatic indicators	EEA	0.5°x0.5°	Global	1951 to 2099
Climate extreme indices and heat stress	EEA	from 0.5° x 0.5° to 2.8125° x 2.8125° depending on the model	Global	1850 to 2300 for the whole dataset. Shorter for most of the models and products.
Fire danger indicators	Copernicus	0.11° x 0.11°	Global	1970 to 2098
Sensitivity to desertification and drought	EEA	Grid 1x1km	EU 28+4	
Climate, soil and vegetation quality	EEA	Grid 1x1km	EU 28+4	
Temperature	Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	
Precipitation	Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	
Maximum magnitude of heat waves	Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	

9.4.3. Indictors in the domains of landscape, access to green areas and built environment

Indicator	Availability	Source	Granularity	Territorial coverage	Temporal coverage
Green urban areas	*Already available*	ESPON DB	NUTS3	EU 28+4	1990, 2000, 2006
Pan-European Map of Forest Biomass Increment	*Already available*	ESPON DB	beyond NUTS3		2006
Nationally designated areas	*Already available*	ESPON DB	beyond NUTS3		2018
Natura 2000 sites	*Already available*	ESPON DB	beyond NUTS3		2018
Average rating of satisfaction by domain	*Already available*	EUROSTAT	NUTS0	EU 28+4	2013
Percentage of the population rating their satisfaction as high, medium or low by domain	*Already available*	EUROSTAT	NUTS0	EU 28+4	2013
Land cover	*Already available*	EUROSTAT	NUTS2	EU+UK	2009, 2012, 2015, 2010
Land use	*Already available*	EUROSTAT	NUTS2	EU+UK	2009, 2012, 2015, 2010
Settlement area	*Already available*	EUROSTAT	NUTS0	EU+UK	2009, 2012, 2015, 2010
Vegetal land use (forest, pasture…) and imperviousness	*Already available*	EEA	Grid 1x1km	EU 28+4	
Corine land cover	*Already available*	EEA	Grid 1x1, 5x5 and 10x10km	EU 28+4	
Naturalis (land cover potential)	*Already available*	EEA	Grid 1x1km	EU 28+4	
Green potential background	*Already available*	EEA	-	EU 28+4	
Biome	*Already available*	Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	
Greenness	*Already available*	Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	
Soil sealing		EEA	Grid 100x100m	EU 28+4	
Urban morphological zones		EEA	Grid 1x1km	EU 28+4	
Degree of urbanisation		EUROSTAT	Grid 1x1km	EU 28+4	
Land cover		EUROSTAT	Grid 1x1km	EU 28+4	
Digital elevation model		EUROSTAT	Grid 1x1km	EU 28+4	
Urban-rural		JRC	Grid 1x1km	EU 28+6	
Built-up surface		Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	

Urban-rural (urban centres, urban clusters, rural settlements)		Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	
Land use efficiency		Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	
Open spaces		Global Human Settlement Layer (GHSL)	Grid 1x1km	Worldwide	

9.4.4. Indicators of the agriculture and agro-environment domain

Indicator	Source	Granularity	Territorial coverage	Temporal coverage
Agricultural area under organic farming in Europe[1]	Eurostat	NUTS 0	EU + some other countries	2012-2023
Drought impact on ecosystems in Europe	JRC	NUTS 0		
Greenhouse gas emissions from agriculture in Europe[2]	EEA	NUTS 0	EU	2005-
Eutrophication caused by atmospheric nitrogen deposition in Europe	Several data sources	NUTS 0	Most of Europe	2005+
Nutrients in freshwater in Europe	EEA	NUTS 0	EU+	1992+
Nutrients in transitional, coastal and marine waters in Europe	EEA	Grid data	Mediterranean, Baltic, Black, other regional seas	1980+
Pesticides in rivers, lakes and groundwater in Europe[3]	EEA	NUTS0	EU+	2013+
Mineral fertiliser consumption	EUROSTAT, EUROSTAT	NUTS2	EU+	2012-2021
Soil cover[4]	EUROSTAT	NUTS2	EU+	20,132,016
Farming intensity	AGRI-FOOD DATA PORTAL	NUTS0	EU28	2004-2020
Risk of land abandonment	EUROSTAT	NUTS2	EU27	2006-2008
Specialisation	EUROSTAT	NUTS2	EU+	2010,2016,2020

[1] European Green Deal initiatives, particularly the EU biodiversity strategy for 2030 and the farm to fork strategy, set the target that at least 25% of the EU's utilised agricultural area (UAA) should be under organic farming by 2030.

[2] Regulation (EU) 2018/842 — the ESR — lays down obligations for MS with respect to their minimum contributions to meeting the GHG emissions reduction target of the Union, for the period 2021-2030. The goal for Europe to become climate neutral by 2050 is enshrined in the European Climate Law, which includes the target of reducing net emissions of GHGs by at least 55% by 2030, compared with 1990 levels. This law acknowledges the need to revise the ESR to deliver the additional emissions reductions for 2030, for which the Commission made a proposal in July 2021.

[3] The Water Framework Directive (WFD) and its daughter directives on environmental quality standards in water policy, as amended in 2013, and quality standards for groundwater set quality objectives and targets for pesticides in surface waters and groundwater and should protect water quality from pesticide pollution.

[4] This article reports on soil cover during winter, i.e. to keep agricultural land with a cover of winter crops, crop residues or catch/cover crops. This is important for preventing nutrient and pesticide run-off, and soil erosion. Keeping agricultural land covered may improve soil fertility and help mitigate the effects of climate change through the preservation and increased sequestration of soil organic carbon.

9.4.5. Indicators of the ecosystem domain

Indicator	Source	Granularity	Territorial coverage	Temporal coverage
Ecosystem services: Supply, demand, use and mismatch of a number of provisioning, regulating and cultural ecosystem services, calculated in biophysical and monetary units; ecosystem extend and condition accounts	JRC, EEA	Down to NUTS 3	EAA + UK	2000+
Ecosystem condition: A variety of indicators compiled by JRC	JRC	Down to NUTS 2	Mainly EU	

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