EU-LUPA
European Land Use Patterns

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This report presents the interim results of an Applied Research Project conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

Information on the ESPON Programme and projects can be found on www.espon.eu

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This basic report exists only in an electronic version.

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1. Executive summary

Current land use patterns in Europe could be seen as an expression of centuries of human intervention on its environment. The geographical context and the availability of resources, along side the push of demographic evolution and the economic development have played an important role in driving land use changes and shaping Europe´s landscapes.

Moreover, the legacy of past decisions constitutes a crucial element to understand this changing process, where leadership, policies, planning systems and governance structures have had also a major influence.

Nowadays, the aim of territorial cohesion for the European cooperation towards sustainable development is on the core of the EU political agenda, revealing an increasing interest of policy makers in a territorial approach with deeper horizontal policy integration and cross-sector perspective, over the last decades.

The main objective of the EU LUPA project is to *provide a consistent methodology to analyse comparable information about European regions based on data from different sources and different levels […] integrating physical dimension (land cover) with social-economic (land use) and environmental, in order to understand and obtain a clear view on land use changes […] identifying main challenges […] and defining policy options to cope with those challenges.*

Following the European Spatial Development Perspective (ESDP) in 1999 -the first attempt of a cross-sector strategy for the European territory which included policy orientations, approaches and governance ideas; a number of initiatives have followed up deepening on the three fundamental goals of European policy of economic and social cohesion; conservation of natural resources and cultural heritage; and more balanced competitiveness of the European territory.

The Territorial Agenda (2007) was an important step forward by adding stronger emphasis on:

- Competitiveness of regions and cities including creation of innovative clusters,
- Climate change concerns and
- Territorial cooperation and multilevel governance.

Since then, all the political documents and process have clearly shown that there is a policy demand for a better and deeper knowledge and more scientific evidence with regard to the main challenges with territorial impact (accelerating globalisation and market integration, ageing and migration, climate change, changing energy paradigm), territorial indicators as well as improved ex-ante territorial assessment methods.

Land use specialization (urbanization, agricultural intensification and abandonment, natural afforestation) decrease of arable land and permanent crops and land artificialization (residential, economic sites and infrastructures) are major trends that could be identified in the last decades (SOER, 2010). Those trends are the result of interacting driving forces including policies.

From the environmental point of view, those trends are associated with several impacts such as:

- contribution to climate change at regional and local level through release of carbon dioxide to the atmosphere due to the disturbance of soils and natural vegetation
- increase of greenhouse gases emissions, especially methane (through surface hydrology and elimination of forest cover) and nitrous oxide (through agriculture)

- acceleration of habitat fragmentation and consequent effects on biodiversity
- increase of natural resources consumption, energy consumption, accessibility problems, impacts on social cohesion derived from conflicting land use demands
- increase of mobility needs and therefore an increase of energy consumption and associated emission of contaminants from a inappropriate/inefficient distribution of land uses in the territory

Land-use planning and management are essential to better reconcile land use with environmental concerns. It is a challenge that involves various policy levels and different sectors. Monitoring and mediating the negative environmental consequences of land use while sustaining the production of essential resources is a major priority of policy-makers around the world.

In this context, policy makers should rely on scientific evidence in order to provide the most appropriate measures and policies in line with the EU development principles and objectives,

- on one hand to resolve conflicting land use demands and to monitor land use intensity to support responsible land management,
- and on the other hand to improve regional competitiveness, to guarantee landscape quality and territorial cohesion towards sustainability.

Accounting for land cover change at the European scale in a consistent way has been made possible with CORINE Land Cover, covering the period 1990, 2000 and 2006, although their limitations are mainly related to its resolution and minimum change detection. However, land use and land use change in Europe have been mainly addressed from a thematic perspective. Given the complexity of the interacting processes that drive land uses and land uses changes, a comprehensive understanding of the interactions between the multiple uses of land, their temporal and spatial changes, requires reliable framework for integration of scales and themes which is currently lacking.

Therefore, a better and deeper knowledge of land use changes and patterns in the European territory is needed, integrating different sector views, realizing that land use characteristics are becoming increasingly multi-functional, crossing not only sectors but also administrative boundaries, and thereby becoming more demanding in relation to background information and institutional and administrative structures.

The EU-LUPA approach asses land use patterns and dynamics at regional level in the EU with a multi-sector perspective in relation to spatial development principles.

An **integrated assessment** of land use policies implies simultaneous consideration of all spatially relevant aspects of economic sectors and human activities that are linked to land (Helming et al. 2008). These include agriculture and forestry as the main traditional economic sectors, nature conservation and rural tourism as mainly land conserving activities, and settlement, transport and energy infrastructure as mainly urbanised land uses. All of these sectors and activities compete for land resources, so any policy change affecting one land use has the potential to induce changes in the others (Plummer 2009).

Sustainable land use implies a balanced consideration of the range of social, economic, and environmental goods and services provided by the land uses in a certain region/landscape (Wiggering et al., 2006; Pérez-Soba et al., 2008). It also implies a careful consideration of long term attributes of resilience and robustness that are to maintain underlying ecosystem processes. In an attempt to operationalise sustainable development for the case of land use, the concept of mutlifunctionlity was introduced (Wiggering et al., 2006).

The underlying rationale for **multifunctional land use** is to consider effects of any land use action interactively. Commodity production is analysed in the context of its negative and positive externalities in a spatial system. This interpretation of multifunctionality relates the supply of land use goods and services to the societal demands for land use goods and services and allows assessing the value that multifunctional land use has for society (Helming et al., 2008). Understanding sustainable development as a discourse based, deliberative process (WCED, 1987), this multifunctionality concept can be used as an estimate for sustainability assessment of land use (Pérez-Soba et al, 2008).

Based on sound scientific basis, the EU-LUPA project will provide

- o Awareness-raising: messages on how the land use typology and economic, social and environmental performance relate (e.g. "fast urbanizing areas face social and environmental problems")
- o Indication of potential and challenges in relation land use patterns: What should European, national, regional and local authorities do in order to face challenges and use potentials of land use patterns and dynamics?
- o Formulation of policy recommendations anchored in the EU Cohesion Policy and the Territorial Agenda policy objectives.

These *options* will then allow policy makers to make relevant *choices.*

The project takes a stepwise approach integrating the biophysical dimension with the human system. In that sense in the context of this project the following definitions are being managed:

- Land cover. Is the physical cover of the land (e.g. water, forest,…) providing one dimension for the description or characterisation of a specific area. It reflects the biophysical state of the land.
- Land use is the description on how the land is used and the related socio-economic activities. Then, at a single point there may be multiple uses. This is the core definition used in this proposal and that will be further implemented.

Hypothesis for investigation

Our approach for the characterisation of land use patterns and dynamics in the European territory is based on the land use functions, which reflect the goods and services provided by different land uses, and how those functions could explain certain territorial behaviour.

Land use patterns and dynamics are integrated in a certain typology as a mean to synthesize the information and highlight similar regions in Europe. It could be considered that each group in the typology also reflects certain pathways which will be relevant for the identification of potentialities and territorial challenges.

Land use patterns have a scale dimension. Consequently certain process will only be detected in the case studies; while at European scale will be identified as emerging patterns. This may be the case of certain type of urban sprawl occurring in small patches that will not be identified at European scale.

Land use patterns have also a time dimension. The impact of intensive process tends to be immediate while extensive process takes longer (decades or even a century). An intensive process could be described by the amount of energy involved in the process of change (either input or output –e.g. building a new infrastructure or the impact of a forest fire). This is also relevant for the interpretation of the impact of different policies on the land cover and land use.

Although the legacy of the past is an important component we will test the hypothesis that certain process tend to homogenise and converge to similar typology. This would be the case of certain type of sprawl. In that sense land use change becomes a function of economic growth and spatial localization.

Land Use Functions provide a conceptual framework to assess how changes in land use (partly driven by policies) impact on the multiple functions attached to land use, which in turn affect sustainability and stock and quality of natural resources. Therefore the approach of Land Use Function will well reflect the performance and efficiency of different regions. It is expected that the groups identified in the typology will not be homogenous in terms of land use functions and efficiency. However, this approach will help to identify hidden process and fine tune the potentialities of the regions.

Although multifunctionality is considered a paradigm, it will be explored to what extent certain monofunctionalities may be sustainable or needed to compensate inequalities between regions.

The future in the European territory brings an increase in land use conflicts (mostly in the town's surroundings). As space is a limited resource, different economic actors compete to obtain the possibly largest area for their needs. A conflict generally occurs when the system is out of equilibrium and a collision of functions takes place. The analysis of multifunctionality will help to identify to what extent certain policies have been effective in achieving sustainable development and distance to certain targets already identified for Europe 2020.

We will observe permanent changing of land use structure connected with transformation of policy paradigm.

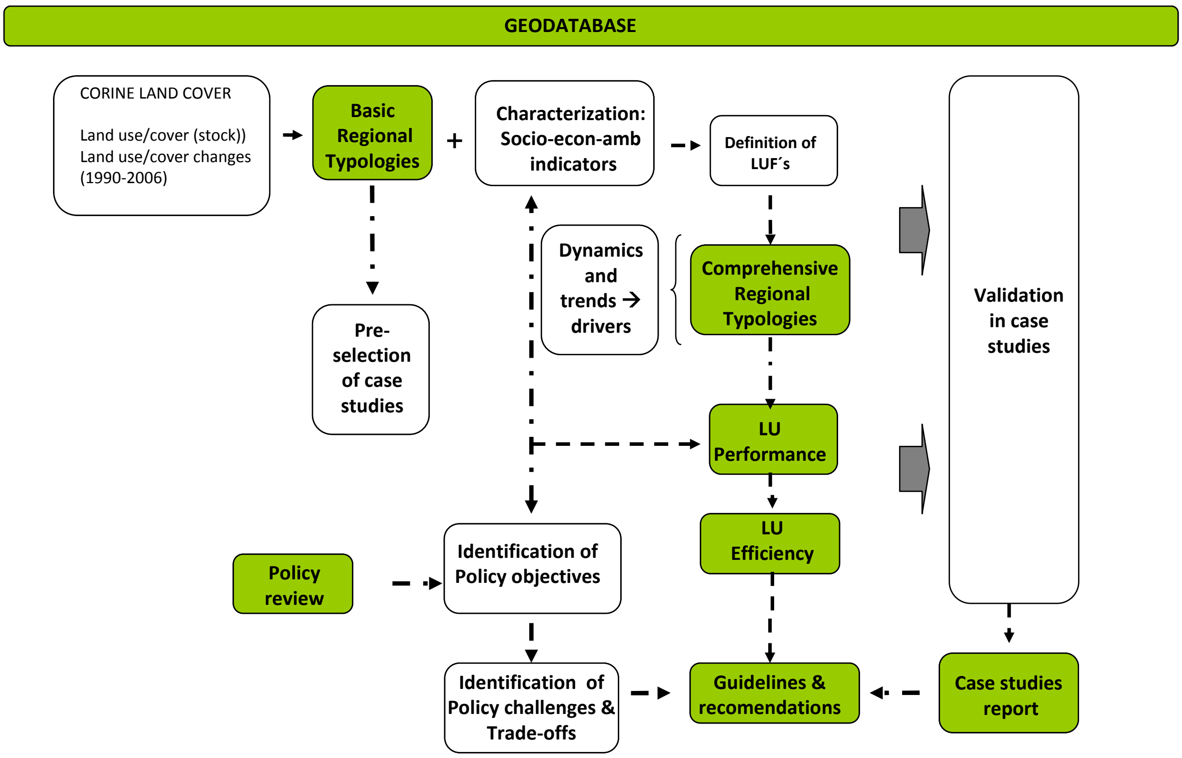
Globalisation has lead to an important shift on the geography since physical distance may be offset by connectivity (transport and IT). It will be tested to what extent well connected regions have a certain advantage in terms of balanced intensity and efficiency.

2. Outline methodology

The proposed approach is based on a stepwise process build on the following main components:

- Basic regional typologies. This is closer to the classical approach of land use typologies. It is based on CORINE Land Cover and it is intended to capture the main attributes of European regions considering stability, dominant land cover type and major changes. When analysing changes two elements are considered: internal changes between certain land cover type (very often ommitted) and land cover flows, which provide a first interpretation on all the possible changes.
- Land Use Functions express the goods and services that the use of the land provides to human society that are of economical, ecological and socio-cultural value and likely to be affected by policy changes.
- Policy review provides the framework for the analysis, including identification of drivers, targets and, finally, the guidance for recommendations.
- Case studies are used to better understand hidden process not captured at European scale and to validate/better understand the main outcomes of typologies and land use functions assessment.

Figure 1 EU-LUPA Conceptual approach



2.1. Defining urban form and urban sprawl

Although it is not the main topic of the project, it will be further developed in the project as part of the regional characterisation and an important component on land use.

A variety of urban forms have been covered by the term “urban sprawl” ranging from contiguous suburban growth, linear patterns of strip development, leapfrog and scattered development. In terms of urban form, sprawl is positioned against the ideal of the compact city, with high density, centralised development and a spatial mixture of functions, but what is considered to be sprawl ranges along a continuum of more compact to completely dispersed development. In any way it is important to recognise that urban sprawl is not merely an attribute, or **pattern**, of a city. Moreover, it should be considered as a **process of urban change** (Couch et al. 2005). Finally, urban sprawl cannot be defined by a single parameter (Kasanko et al. 2006). Galster et al (2001) defines sprawl as a pattern of land use in an urbanised area that exhibits low levels of some **combination of eight distinct dimensions**: density, continuity, concentration, clustering, centrality, nuclearity, mixed uses and proximity. These eight attributes also combine two dimensions of the compacity/sprawl characterisation: physical and functional. The physical compactness refers to the spatial configuration of land use development within the city, the functional compactness to the density and the mix of daily activity

The approach taken in the current project is to interlink two aspects: **urban form** and **urban dynamics**.

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<u>Structure of European cities: form and compacity</u>

The understanding of the city’s structure is important for the assessment of its growth. The availability of space and set up of the urban area may determine to some extent the feasibility for a city to grow and to what extent. European cities have been identified as compact cities compared to the American counterpart, and this is considered a more sustainable model. However, the complexity of the spatial organisation of cities could not be translated into simple indices that establish a threshold for what is a compact city and what is a dispersed one. More than that there is a continuum where the compact and the dispersed cities are only the extremes. Because of that, very often comparisons are taken having in mind the extremes and omitting the complexity of the full range of situations. Analysing the compacity of European cities means to apply a magnifying glass to a segment of the continuum between dispersed and compact cities

<u>How to measure urban form and compacity?</u>

The degree of compacity of a city could be described by its form, density, proximity and continuity. The assessment of these attributes in European cities poses the challenge of data availability. Given the limitations of data resolution from CORINE Land Cover a good alternative would be the land cover data from Urban Atlas. Currently it is only available for 200 cities; consequently the results will be necessarily limited to this subset of cities. Additionally, the high resolution soil sealing data (2006) has a full European coverage and provides also relevant information related to land use intensity (degree of imperviousness of the artificial areas).

Taking into account the data constraints the following indicators are considered:

- **Urban form**
  - **Compacity index**. This index shows how far a city is from a circular form with the same area (Figure 5). The circular form is the one with the lowest perimeter to area ratio. It ranges from 0 (highly irregular and less compact form), to 1. Given the high resolution of Urban Atlas, first all artificial areas were selected. Then, all small features like roads outside urban areas removed. Finally, the remaining patches less than 200 m apart were aggregated. The index was calculated for the largest patch which in most of all cases represents the core city.
  - **Mixed uses**. High land use mix diversity is considered a desirable situation in order to promote more compact cities, and also facilitate the socialisation of the communities. Ideally the land use mix should be evaluated at block level. However, since Urban Atlas is derived from satellite images it is not possible to identify mixed uses in a single block or parcel. Then, what has been measured is the mix of single uses (Figure 6). Moreover, commercial areas will only include services above certain size that are clearly identifiable with satellite images. The indicator has been developed considering three uses: residential, commercial and industrial, and other land use classes. A value of 0 for this measure means that the land is exclusively dedicated to a single use, while a value of 1 indicates perfect mixing of the three land uses.

Figure 2 Urban form and compacity index of Foggia (Italy, left) and Katowice (Poland, right). The index ranges from 0 (more irregular and less compact city) to 1. Foggia and Katowice are the most extreme cases for the available cities in Urban Atlas. Black: built-up areas; red: approximation of the urban form to a 1 km grid. Data so urce: Urban Atlas.

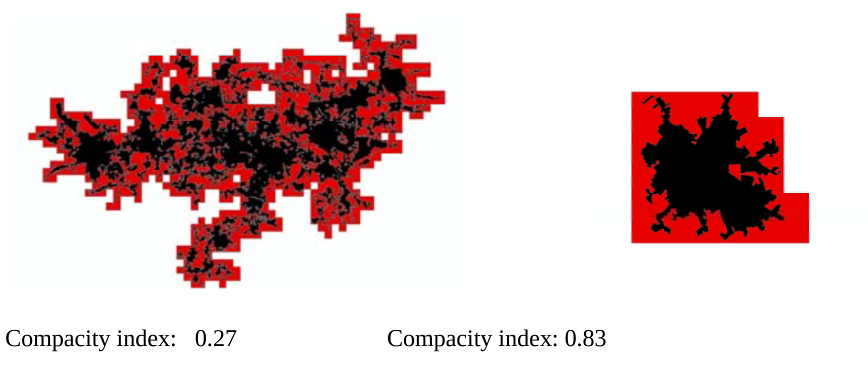


Figure 3 Land use in Cremona (Italy). This city has the highest value for the land use mix index (0.99). Data source: Urban Atlas.

- **Density**
  - o **Soil sealing per capita.** Soil sealing is the coverage of the soil by an impervious layer. It reflects the maximum intensity of use of the land. It is assumed that an efficient city will have a good performance in different areas while keeping at minimum the land consumption, in that case the soil sealed per capita.
- **Proximity**
  - o **Distance to the city centre.** Distance has been computed as the distance between all the urban patches and the city centre (the largest patch). Two factors are relevant: number of patches (that could be related to high fragmentation or sprawl) and size of the metropolitan area (LUZ). The latter one may introduce an artifact since the delineations are based on administrative boundaries resulting from different historical process and planning cultures in Europe. Then, the sum of all distances has been corrected by the total area and normalised.

<u>Measuring urban dynamics</u>

In a similar manner as it has been explained in the structure of the cities, urban sprawl is part of the complex interactions and evolution of cities and there is not a single index that would enable to classify a city as sprawling or not. Once again we should consider different trajectories of cities leading to different types of growth which in the most extreme cases could be defined as sprawl.

Conceptually different type of urban developments have been considered:

- **Redevelopment**. Changing the use of existing urban land (e.g. industrial to residential). This would fit with the idea of land reuse or recycling.
- **Infilling**. Development of new areas within the city.
- **Expansion**. Urban development in the fringe or in less dense areas

Redevelopment and infilling can be related to compact urban development, while expansion will lead to more diffuse patterns.

In order to characterise the urban development in Europe a first set of variables were selected representing the status and changes. After removing higher correlated variables and those that explained less variability in the factorial analysis, the following ones were selected.

It should be highlighted that the information on built-up areas and related changes are derived from CORINE Land Cover. Then, there is a clear limitation on the resolution of the data both on the stock (percentage of certain type of land cover) and changes. Limitations are clear on linear features (e.g. roads and rails) and also on plots below the CLC resolution that may be relevant for urban areas.
The existing CORINE Land Cover data allows to analyse changes for two periods: 1990-2000 and 2000-2006. However, data for United Kingdom and Greece is not yet available for the period 2000-20006. Consequently the basic analysis is for the period 1990-2000 and comparisons for the period 2000-2006 are done without UK and Greece.

Another important methodological aspect is that the reference years provided for CORINE Land Cover are not the same for all countries. It is particularly true for the reference year 1990 since some countries started in 1987 and the latest ones did it in 1994. Then, for the reference year 1990 there is a variability of 7 years between the first country to produce CORINE Land Cover and the last one. This gap has been reduced in 2000 and 2006 with a maximum of one year. To overcome this problem changes have been computed on basis of ha/year. However, there is an insolvable issue with that approach since it assumes that changes have been equally distributed during the period analysed.

Table 1 Variables used in the definition of typologies of urban development.

Index	Description
Ratio of built-up area	Percentage of built-up area of total land area
Degree of soil sealing	Percentage of sealed area of the total land area
Increase of built-up area	Percentage of new of built-up area over total built-up area at the beginning of the period.
Land take per capita	Increase of built-up area divided by the total population
Degree of redevelopment	Percentage of redevelopment over all new built-up areas for the period.
Destination of new urban areas	The growth rate of residential areas and industrial, commercial and transport areas. Those areas have been identified according to CORINE Land Cover nomenclature and methodology.

2.2. Defining basic regional typologies

Overview of existing typologies

Typologies can be broadly defined as the classification of entities based on shared or common characteristics, and they will be used as an analytical unit to in turn support the development of land use policy recommendations for the ESPON territory.

Within the ESPON 2013 Programme the Typology Compilation project was implemented to take stock of existing territorial typologies and to propose a set of eight consolidated and complimentary typologies to be used as a point of reference throughout the 2013 Programme (see Böhme et al., 2009). These are: urban / metropolitan regions, rural regions, sparsely populated regions, regions in industrial transition, cross-border regions, mountainous regions, islands and coastal regions. The report covers a total of 56 existing typologies that have been created by ESPON or other actors including the OECD, DG REGIO, EEA, JRC, CMPR, or AEBR. However, the project did not find any existing typology that could be proposed to define one of the eight proposed typologies. Accordingly, different elements of most of the existing typologies are combined to define the proposed typologies.

Below, the existing typologies reviewed by the ESPON Typology Compilation project team that are relevant to land use patterns addressed in the EU-LUPA project are introduced based on their connections to the formation of the eight territorial typologies used by the ESPON 2013 Programme. Within this structure, pertinent regional typologies created by other actors are also described. Preliminary comments are also provided in terms of the relevance of applying these typologies within the EU-LUPA project and the additional insight that can be drawn from an additional typology set within the LUPA project.

Urban Metropolitan Areas: Corine data indicating that growth of artificial surfaces increased the most in terms of net area and percentage change indicates that urban typologies are a crucial means for understanding drivers as well as policy responses to land use (EEA, 2010).

Mainly developed by the EEA, the Urban Audit and ESPON existing typologies indicate that delineation is a key issue to be considered. In this case, none of the existing classifications (i.e. Urban Morphological Zones (EEA), Degree of Urbanization (EEA), Functional Urban areas according to their population (ESPON), Large cities and metropolises (ESPON), Typology of functional Urban Areas (ESPON), City-types (Urban Audit), and participating Cities (Urban Audit) use NUTS 2 or 3, but have defined their own geographical levels and statistical units. (Böhme et al., 2009)

At a basic level, the approach of the final typology uses a two-tier approach to distinguish between upper tier urban centres and lower tier urban centres. Upper tier urban centres are defined initially through the Urban Audit Database and augmented with information on larger cities through the GISCO STEU geodata base. Together, upper tier urban centres consists of 592 cities identified through the urban audit and a further 103 STEU cities not identified through the urban audit, but totaling more than 100,000 inhabitants. The result is cities identified through both means – with more than 100,000 inhabitants are categorized as upper tier. Of these approximately 660 cities, a further classification enables the distinction between different types of cities – specifically, this compares the population of the large urban centres in relation to their surrounding NUTS 3 region. If the population is below, for example, one-third, the area region would not be considered urban at this stage. In turn this allows for the typologies to be scaled from LAU2 to NUTS3 for further usability. (Böhme et al., 2009)

The lower tier urban centres account for those cities from the urban audit with less than 100,000 inhabitants along with the remaining STEU cities that are outside the urban audit and have a population between 50 000 and 100 000 (820 such cities). (Böhme et al., 2009)

Within the ESPON Typology Compilation Project, it is noted that the ESPON FOCI project has also completed an urban typology on the spatial dynamics of cities based on Corine Land Cover and Urban Atlas data. The aim of these typologies is to provide a general picture of the intra-urban dynamics of cities to provide additional insight into the interactions between urban cores and their larger urban zones.

The appraisal of the FOCI typologies illustrates the value of using Corine data to analyze patterns of urban spatial form, which can be used to guide land use policy in the urban context. At the same time, its constraints – mainly in terms of geographical coverage and underestimation of key linear features such as roads and rails. In this context, it is assumed that typology formation in the EU LUPA project could lead to an improved understanding of the relations between urban areas and their less immediate hinterlands.

Rural Regions: These are simultaneously crucial to study, but difficult to characterize within the perspective of the EU-LUPA project. This is mainly to do with the fact that a rural area by definition (see for example Böhme et al., 2010) constitutes all non-urban land, therefore covering a vast majority of the European landscape. However, the numerous land covers generally attributed to “rural” areas covers a wide range of types and prospective functions, each with their own sets of corresponding land use intensities. As such, the understanding of existing regional rural typologies, both in terms of their potential application but also their limitations is necessary in order to characterize land use patterns and land use flows with the EU-LUPA project.

The Regional Typology Compilation effectively uses the starting point for rural areas as being those regions that are not classified as urban (cf. urban typology). This is not necessarily the case in the 17 other urban-rural typologies they examined (cf. within ESPON 1.1.1, 1.1.2, ESPON Atlas, OECD, DG REGIO, etc.) where urban and rural areas are not necessarily viewed in mutually exclusive terms. The most common features used to define rural typologies within the examined typologies include population density, accessibility/proximity to urban centres and land use (especially agricultural). (Bohme et al., 2009)

Accordingly, the proposed rural typology includes non-urban areas that are assessed vis-à-vis urban centres (in terms of proximity/accessibility). Secondly, gross value added of the primary sector and primary sector employment are considered to understand how important primary production chains are to the overall economy. This results in a two-dimensional rural typology with four corresponding categories:

- Rural areas close to urban centres without agrarian profile
- Rural areas close to urban centres with agrarian profile
- Remote rural areas without agrarian profile
- Remote rural areas with agrarian profile (Bohme et al., 2009)

While this typology has its obvious merits and can be utilized in the EU-LUPA project as an analytical tool, there are limitations that need to be considered within the EU-LUPA perspective. Most importantly, the typology is not based on Corine Data and is therefore not an explicit characterization relating to land cover. While land cover associated with agrarian characteristics is directly correlated with a certain group of land cover characteristics, the direct use of Corine data could provide additional insight into implied land use intensity; especially related to non-economic/non-production land uses. It can be said for the rural typology identified through Regional Typology Compilation, maintains a bias towards classification in terms of land-based industries. Considering that the EU-LUPA project is focused on analyzing land use patterns, it is essential to characterize regional rurality by including land cover data. This will provide a comprehensive understanding of the rural land use patterns, not only in terms of land cover changes between agriculture, forestry and artificial surfaces, but will also highlight important internal conversions within these general categories. This is especially important considering the extent of land cover classified as different forms of forest or semi-natural surfaces, which are envisaged as providing increasingly valuable functions – and particularly multi-functions - in lieu of the multiple pressures for improved environmental sustainability.

The EDORA project has formulated two additional rural typologies and while they are also limiting in that they don’t use land cover data in the delineation they provide additional relevant insight that can be used as a tool for analyzing patterns of land cover change in Europe. First, the Performance Typology uses the unweighted mean of the Z scores for five indicators - net migration, GDP per capita, average annual change in GDP, average annual change in total employment and unemployment rate – to identify regions on a continuum between “depleation” and “accumulation” in terms of different forms of capital (Copus et al., 2010). Second, the EDOR project has created the Structural Typology using 13 indicators to define four structural types (Agrarian, Consumption Countryside, Diversified (Strong Secondary Sector) and Diversified (Strong Private Services Sector) (Copus et al., 2010). Nevertheless it is again the case that land cover is used as an input for the EDORA typologies, therefore providing a potential additional level of analysis for the EU-LUPA project. It could be particularly interesting to investigate the Land Cover status and flows pertaining to the “Consumption Countryside” (for example, regions that reflect a shift from productivism towards new functions reflecting the importance of countryside public goods) considering the correlation between these regions and relatively high GDP productivity found in the EDORA project.

Areas of Geographic Specificity: Within the ESPON Typology Compilation project there are four regional typologies that are characterized as having geographic specificity:

- Sparsely Populated Regions: the basic feature is population density measured through the number of inhabitants per square kilometer. Due to the fact that the typology is based on a dataset used within the analysis of regional typologies in the EU-LUPA project, the typology as a tool of analysis is redundant.
- Mountainous Regions, Islands and Coastal Areas: These regional typologies share the common characteristic that they are based on physical and static regional characteristics, and are therefore fixed typologies. They will potentially be useful as analytical tools for the EU-LUPA project to understand if distinct land cover dynamics are taking place taking place in regions with distinct geographical characteristics.

Cross Border Regions: Cross-border regions provide the opportunity for valuable analysis because they involve regions in immediate proximity with each other (therefore implying similar or same climatic and geophysical characteristics) but are often exposed to very different development histories, current development pressures/drivers and policy oversight. The analysis of land cover in this connection will allude to a fuller understanding on the effect of socio-economic and political contexts on the land cover patterns and flows of proximate regions. Due to the fact that these patterns require detailed analysis for individual cases at the regional level, this is a regional activity that will be taken up by the case studies generated in the EU-LUPA project. However, the cross border typologies themselves are not useful to the EU-LUPA project because they are designed only to identify those regions with international borders. As such, they do not provide any insight into the relationships between cross-border regions.

Regions in Industrial Transition: This typology is unique within the ESPON Typology Compilation project because there is no existing European typology for regions in industrial transition (Bohme et al., 2009). The process of identifying these regions involves a two-step process where it is first decided if a region is industrial or not based on a predetermined threshold on the share of manufacturing branches’ GVA and employment as a share of total regional GVA and employment (Bohme et al., 2009). Once industrial regions are classified the annual rate of change in industrial GVA and industrial employment identifies those regions where structural changes are taking place. Land cover characteristics can be then analyzed in the EU-LUPA project to determine the dominant land cover flows taking place when these structural transitions are taking place.

Approach to typologies

In Task 2.2 the creation of preliminary land cover typologies in the EU LUPA project is generally responsible for understanding to what extent land use patterns match with socio-economic developments. By nature they also identify regions sharing similar characteristics which in turn allows for the selection of contrasting regions within the case studies in Task 2.4. To this point the typologies have only been created on a preliminary basis to test the methodology and to act as the basis for the preliminary identification of case study regions. Accordingly, the presentation of the typologies below concentrates on the methodological framework used to formulate the preliminary typologies and the initial findings of the relationships between land cover patterns and socio-economic characteristics.

There are a number of limitations that have been highlighted thus far in the composition of the regional typologies. A part of the resolution (only changes or patterns above certainthreshold are identified) it is important to reflect on the different time span for the two series of changes (1990-2000, 2000-2006). It is also important to note that reference year 1990, the first data for CORINE, in fact includes data collected during the period 1985 and 1994 depending on the country.

In looking for a basis typology based on the available data of land cover characteristics and changes, these three central questions are asked: what are the constant characteristics of land cover/land use; what characterizes the changes in land cover/land use; and how are both connected to the socio-economic development?

Among the challenges in this connection is, that the analysis of a current picture of land use characteristics and changes in Europe should provide an objective view on the situation and trends of changes.

In the visible changes happening, the land cover characteristic is the most immediate and observable indicator of changes. And there are several elements in relation to land cover that reveals these changes: vegetation intensity, the involvement of technology, structural changes in relation to production, and the intensity of human activities just to mention a few of the most important. And a keyword in this connection is the **intensity**.

Intensity is in many ways inseparable from the question of human activities. Measures of intensity is usually related to human behavior and expectations, and a more generic typology reflecting the status and changes in land cover characteristics therefore should include measures of human activities, and the identification of interactions between land cover development and general socio-economic parameters.

The land use intensity is determined by the extent to which land is used. In most cases the land use intensity cannot be determined directly. It is proposed therefore to follow a pragmatic approach in EU-LUPA, having CORINE Land Cover (CLC) as a first step. The CLC nomenclature is hierarchical and distinguishes 44 classes at the third level, 15 classes at the second level and five classes at the first level. The order of the CLC classes follow already some degree of land use intensity, starting with artificial surfaces (class1 at level 1) and ending with water bodies (class 5 at level 1). Within artificial surfaces there are 4 classes at level 2, namely starting with urban fabric (1.1) and ending with artificial non-agricultural vegetated land (1.4). It can be assumed here that the land use intensity of class 1.1 is much higher than of class 1.4. So each CLC class can get a weight for its land use intensity. Nevertheless, CLC classes only reflect land use intensity in limited way. A good example is that within the same land cover class, e.g. non-irrigated arable land (1.2.2) there is a wide range of land use intensities across Europe. The intensity of arable land is largely determined by its management which is determined by the amount of inputs and land use activities.

Consequently, an additional weight to define the LU intensity of a region will be defined by using an additional set of environmental and socio-economic indicators that reflect the intensity of land use. For example:

- for agricultural land use: amount of pesticides and nutrients applied from FADN or FSS statistics

- for artificial land use: density of transport infrastructure network population density

- for nature conservation land use: size of protected sites

As basis for the definition of land cover typologies should be simple and operational, ensuring a high explanatory power without being too complex, be built on robust and complete data, should be easy to communicate and reflecting the fact that multiple functions are becoming a question of increasing concern. While a traditional focus on land cover and land use typologies can be considered adequate in reflecting the changes at more general levels, the increasing interaction between different activities - and thereby the need of typologies reflecting multiple functionalities - has to be reflected.

Three issues are considered important in relation to the development of the EU-LUPA land cover typology:

- It should be able to show what can be characterized as the stable basis for the land use development;
- It should at the same time provide input to include and reflect on the dynamics which are characterizing the changes in land cover;
- It should finally provide the means to reflect on the changes in intensity in relation to land cover as well as economic and social performance of the landscapes.

A "three layer" approach has been applied in connection with the development of a land cover typology based on land cover data including the current land cover characteristics and changes for the period 1990 -2000 – 2006 in Europe. The methodology is illustrated on the model below:

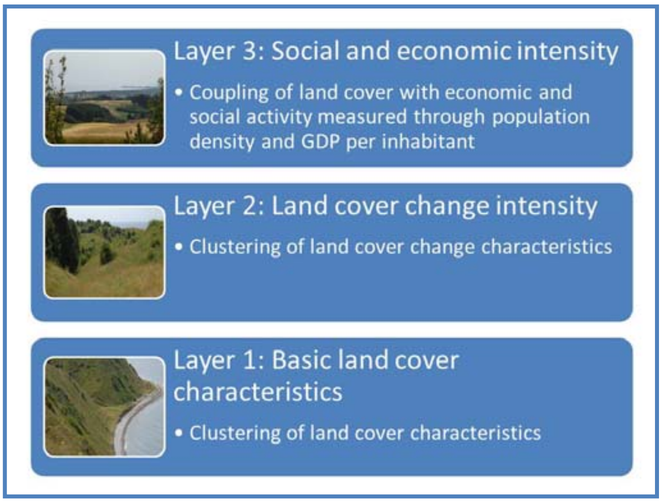


Figure 4 The three layers of analysis in relation to a typology of land cover in Europe

2.3. Land Use Functions Approach

Why using Land Use Functions in EU-LUPA?

The Land Use Functions (LUFs) conceptual framework provides a tool to analyse in a comprehensive way the multiple functions attached to land use, considering the three main dimensions of sustainability, i.e. economic, environmental and societal. The LUFs concept enables therefore the translation of a broad range of economic, environmental and societal indicators describing the performance of the land use (e.g. soil sealing, area harvested, unemployment rate) into an integrated territorial assessment.

The two main objectives of the LUFs framework in EU LUPA are:

- To assess land functionality in a comprehensive way and not based on the partial views provided by individual indicators: multi-criteria analysis;
- To support the evaluation of land use performance, considered as an integrated picture of two key territorial dimensions, i.e. land use intensity and the land functionality that results in that intensity.

These objectives respond to one of the main objectives of the EU-LUPA project that is to *provide a consistent methodology to analyse comparable information about European regions based on data from different sources and different levels […] integrating physical dimension (land cover) with social-economic (land use) and environmental, in order to understand and obtain a clear view on land use changes […] identifying main challenges […] and defining policy options to cope with those challenges.*

The LUFs concept was developed in the EU FP6 SENSOR project (Pérez-Soba et al., 2008; Paracchini et al. 2011) and it has been implemented in other projects since then (König et al., 2010; Reidsma et al., 2011).

Annex III describes in detail the adaptation of the original LUFs methodology to the specific EU- LUPA objectives and present an example of the implementation of the methodology for the Netherlands. The next sections of this chapter provide a summary of Annex III including the LUFs definition and methodology.The end of this section describes future work, i.e. the assessment of land use intensity and how this will be linked to land use functionality in a novel land use typology for the ESPON territorial dimension.

Definition of Land Use Functions

Land Use Functions (LUFs) express the goods and services that the use of the land provides to human society that are of economical, ecological and socio-cultural value and likely to be affected by policy changes.

In EU-LUPA six LUFs have been identified considering the following criteria:

- The main uses of the land in Europe are represented (i.e. agriculture, forestry, nature conservation, tourism, urban settlement, transport and energy infrastructure);
- Ensure that all three dimensions of sustainability (economic, environmental and societal) have an equal representation;
- The functions are likely to be affected by European policies.

Two key LUFs have been defined for each sustainability dimension and are listed in Table 1. They are named as mainly economic, environmental and societal because the borders between the three dimensions are not sharp, e.g. provision of work is mainly societal but can be considered as well among the economic functions; provision of housing (in terms of use of land) has mainly an economical dimension but it can be considered as well as a societal function.

Table 2 The six Land Use Functions in EU-LUPA

Sustainability dimension	LUF	Land Use Functions	Issues included
Mainly societal	LUF1	Provision of work	Employment provision for all in activities based on natural resources
	LUF2	Provision of Leisure and recreation	Recreational and cultural services, including cultural landscapes and green spaces in urban areas

Mainly economical	LUF3	Provision of food and energy	Land-dependent production of food, timber and biofuels
	LUF4	Provision of housing and transport and energy infrastructure	*Building of artificial surfaces*: settlements (residential areas, offices, industries, etc.), transport infrastructure (roads, railways, airports, harbours) and *Land-independent production*: energy infrastructure (wind and solar energy parks, etc.)
Mainly environmental	LUF5	Provision of abiotic resources	Regulation of the supply and quality of air, water and minerals
	LUF6	Provision of biotic resources	Factors affecting the capacity of the land to support biodiversity (genetic diversity of organisms and habitats)

Methodology

A summary of the LUFs methodology is described in this section. It consists of the following steps:

Step 1: Selection of suitable indicators

The goal of this step is to define a common and concise set of indicators, that enable to measure quantitatively or qualitatively the dominant functions of the land and how these functions change in time (i.e. a static and dynamic assessment). These indicators express the significance of different aspects of each LUF. For example, soil sealing is an indicator for LUF 4 (Provision of housing and transport and energy infrastructure), since it is directly linked to the use of land by artificial surfaces associated to housing transport and energy infrastructure, e.g. the higher the soil sealing, the higher the significance of LUF4 in that region.

The selection of the impact indicators is based on a number of criteria:

a) Availability: the indicators should be available at least for two time steps, being considered the first time step as the reference; in EU-LUPA the changes in land use will be mainly based on changes observed in CLC, and therefore the time period selected is 1990 - 2000 - 2006;
b) Spatial resolution: in principle preference is given to indicators available at NUTS 3 or higher spatial resolution; it should be always possible to upscale the date to a lower resolution;
c) Balance between the three sustainability dimensions: the indicators should be associated to the three dimensions of sustainability, e.g. economic, environmental and societal and their number should be approximately the same for each dimension to keep a balanced approach;
d) Relevance for the assessment of changes in LUFs in the area of study: for example, the set of environmental indicators should reflect main trends in the area of study regarding water, soil, air and biodiversity;
e) Redundancy: it should be avoided selecting key indicators that were redundant in some way, i.e. describing trends in the same issue. For example, habitat eutrophication is directly caused by deposition of NH_3 and therefore habitat eutrophication and NH_3 are redundant.

f) Spatial coverage: the indicators should be available for all EU-27 and if possible for the ESPON space countries, also on the regional level.

The results of the selection of impact indicators should be presented in an Excel sheet table. The indicators should be structured according to the sustainability dimension and *EU policies* which impact could be assessed (linked to Task 2.5).

Per indicator a fiche will be prepared including definition, spatial and temporal scales, data source and indication of the quality of the dataset used.

Step 2: Definition of the links of the indicators with the LUFs

The specific links between the selected indicators and the LUFs should be defined by a group of experts using *a generic table* similar to that shown in Table 2 that lists and quantifies the contribution of each indicator to each LUF, including the confidence of the expertise based on quality of the dataset (if possible adding a literature reference justifying it) and finally identifying potential EU policies that may have an effect on the indicator (this last column will be filled in based on the findings of WP 2.5).

Table 3 Impact indicators showing the change in performance in LUFs

Indicator code	Indicator name	Score	Justification for score	Confidence of expertise	Potential EU policies that may impact the indicator

The contribution of each indicator to each LUF has to be defined separately since the same indicator can have at the same time a positive relation to one LUF and a negative one to a different LUF, and this must be reflected in the direction the scale min-max is assigned to indicators in each LUF during the normalisation process. For example, high soil sealing related to building may have a positive impact on LUF1 Provision of Work, and negative for LUF6 Provision of Biotic Resources. Therefore the maxima are attached to high soil sealing values in the first case, to low soil sealing values in the second. It is measured as a score.

The score ranges from -1 to +1 as follows:

1 = the indicator hinders (-) or enhances (+) the land use function in a very significant way. For example, the indicator 'nights spent in touristic accommodations' has a positive link with LUF2 Provision of Leisure and recreation, because an increase in nights spent in touristic accommodations means the leisure and recreation activities will be enhanced. On the other hand, the indicator 'area harvested' has a negative link with LUF5 Provision of abiotic resources, because an increase in area harvested means that the land used for agricultural activities is larger and therefore the provision of water and minerals resources is decreased.

0 = irrelevant, i.e. the relationship between the indicator and the LUF does not allow one to infer on the consequences that a change in the indicator value could have on the LUF , i.e. no direct link is known between the indicator and the LUF or maybe there are some impacts but they counterbalance each other. For example, the indicator 'pesticide use' is irrelevant for LUF 1 Provision of work.

The summary of contributions of indicators to the six LUFs should be presented as shown in in Table 3. Detailed tables have been produced for the test case presented in section 4 of this document, and are shown in Appendix 1 of Annex III. They describe the conceptual contribution of each selected indicator to each of the six LUFs where clear links were identified. The generic tables present the scores associated to the contribution as well as the scientific justification and the confidence on the scoring.

Table 4 Summary of cross-linkages between the selected indicators and the six LUFs

Indicator code	Indicator name	LUF1	LUF2	LUF3	LUF4	LUF5	LUF6

Step 3: Assessment of the importance of each indicator for each region

The regional dimension of the assessment results from the recognition that not all indicators may be relevant in all regions, e.g. the indicator 'soil sealing' is unlikely to be relevant in a region with a very low proportion of artificial land cover. In effect, this step reflects the uncertainty and regional differences that need to be taken into account in the assessment.

This step provides the regional dimension to the framework by evaluating for each region considered in the analysis, the potential importance that each impact indicator may have on the land use functionality. The approach reflects the considerable variety of situations that exist within the ESPON space and consists of a weighting of individual indicators within each of the regions considered.

It is well accepted that changes in indicators - that is measurements of something in the economy, environment or society – may be of different importance in relation to our efforts to assess the changes in phenomena (such as land use). In other words, it means that some 'things' are more important for the phenomena we are concerned than others. Therefore, weighting of different indicators is a normal procedure in Impact Assessment. However, agreeing on the weighting is difficult. It can be imposed 'top-down' by policy makers/administrators and their advisory scientists, or generated 'bottom-up' by stakeholders. Ideally, one might have different weighting systems derived from different sources such as expert ('Delphi') panels, stakeholder valuation workshops, internet valuation, etc. and present them in final outcomes to assess the risk. We have chosen to limit ourselves to expert panels.

The description of the decision rules used by the experts is transparently done in individual fact-sheets, which include the 'importance' weighting showing how significant an issue (measured by the indicator) is in that region. The rule base determines the potential impact of change in an indicator for a particular region, and should be guided by supporting references describing the core bio-geographical (e.g. climate, altitude, relief, land use) and socio-economic (e.g. GDP, population, unemployment) characteristics of each region. The detailed description should not be exhaustive and therefore for some indicators other sources explicitly concerning the impact of the indicator have been used. For example, some indicators, particularly the economic ones, are considered of equal importance in all regions. Care should be taken to minimise co-correlation of factors determining the rule base and those from which the indicator values themselves were derived.

The regional importance scores take values between 1 and 3 as follows: 1 (not important at all, or very low importance), 2 (of some importance), 3 (of great importance). The regional importance scores should be summarized in a table as shown in Table 4 below, while full description of the rule bases and the scientific justification should be given separately.

Table 5 Example table to showing how the regional importance scores (1 to 3) are indicated for each selected indicator in the regions of analysis.

Region code	Region name	ENV 01	ENV 02	ENV 03	ECO 01	ECO 02	ECO 03	SOC 01	SOC 02

Step 4: Normalisation of the indicators and target values

One of the requirements for processing multiple indicators within an aggregation framework is that all are reduced to the same scale, with common units (Nardo et al., 2005). Thus all indicators must be normalised, preferably to a continuous numerical scale, in order to allow mathematical procedures such as linear-additive aggregation to be performed. The normalisation approaches considered in EU-LUPA for this aggregation framework is a normalisation with respect to the range of indicator values and the target.

Normalisation of indicators is required not only for result presentation but also for thematic aggregation from single indicators to LUFs. This needs to take into account the impact of a particular indicator on a Land Use Function. For example, the indicator 'soil sealing' has a positive impact on the Provision of Work Function, but a negative impact on the 'provision of biotic resources' Function. For this reason, the normalization of an indicator is conducted separately for each link of an indicator to a LUF, so that different impacts with respect to sustainability can be accommodated. Discrete, or qualitative indicators, or those with rule-based classes e.g. classes of risk, can also be normalized, using a rule-based approach which assigns discrete values within the normalization range to each class. The target is treated in the same way, where appropriate. A corollary of this method is that it is the normalized indicators which are aggregated, not the indicator values themselves. This avoids scaling issues, since indicator results are effectively translated into units of performance which are scale-independent.

Once that the indicator values are normalised, it is possible to compare the analysed quantitative and qualitative changes in indicators for the different years. When considering the territorial performance linked to multi-fucnitonality (see step 6), if the indicator value is below the target, then we will assume that the performance of the function linked to the indicator will not be affected. On the contrary, if the target has been exceeded for a specific indicator, its contribution to the function will be changed. As a result, the effect of a change on the land use performance of a region will be described by the changes caused in its LUFs, which is a comprehensive and integrated description of changes observed in each single indicator.

Step 5: Assessment of the multi-functionality of the region based on LUFs

This step consists on the aggregation of the individual normalised values of the indicators, considering the min and max values observed in the territory considered as unit for the assessment.

Step 6: Territorial land use functionality performance

The final step is the assessment of the territorial land use performance linked to multi-functionality. It is based on the relationships between the normalised land use functions and its targets.

This step includes the expert identification of regional specific (policy) 'targets' (thresholds or similar references) for each indicator. The targets are used in EU-LUPA to assess the territorial performance. If indicator values are above the targets, it is assumed that the performance of the functions linked to these indicators will be affected, which in turn will impact at the performance of the studied region.

The notion of targets in EU-LUPA

There are important differences between the environmental notion of targets (thresholds) and its socio-economic counterpart. To account for these differences, one may distinguish *thresholds* based on established threshold relationships or breakpoints, mainly applicable for the environmental dimension, and *targets* referring to political objectives or social preferences, more relevant for the social and economic pillars.

In EU-LUPA the targets will be based (in priority order) (i) on policy targets, (ii) on statistical distributions of indicator current values, or (iii) on scientific values. They can be quantitative (e.g. policy target that the European average is the optimum level – target- to achieve); or qualitative (e.g. soil sealing = Low, Medium, High). Values provided as targets are soundly based, traceable and scientifically justified.

The integrated weighing of all the indicators, which targets have been exceeded or not provides a comprehensive description for the LUFs. It is mainly based in the integrated weighing of all the indicator values and targets, described below in the aggregation scheme, as published in Paracchini et al (2009).

The aggregation scheme

Aggregation can be performed in compensatory or non-compensatory frames. In the first case the weights have the meaning of trade-offs (Jeffrey, 2004), therefore a decrease in a LUF value is considered comparable to an increase in one or more other LUF values. Due to the complexity and multiple dimensions of the impacts to be assessed, in the approach described in this paper the decision is taken to leave the analysis of trade-offs to the end user, since it would be impossible to assess *ex-ante* if conflicts between all possible targets exist. Therefore, a solution that holds some characters of non-compensation is sought. The basic aggregation framework is presented in Figure 3. Following the feed-back provided during the ESPON Workshop on Evidence on European Land Use last 24th May 2011 in Brussels, we will adapt the scheme and replace sustainability by land use performance linked to land use functionality.

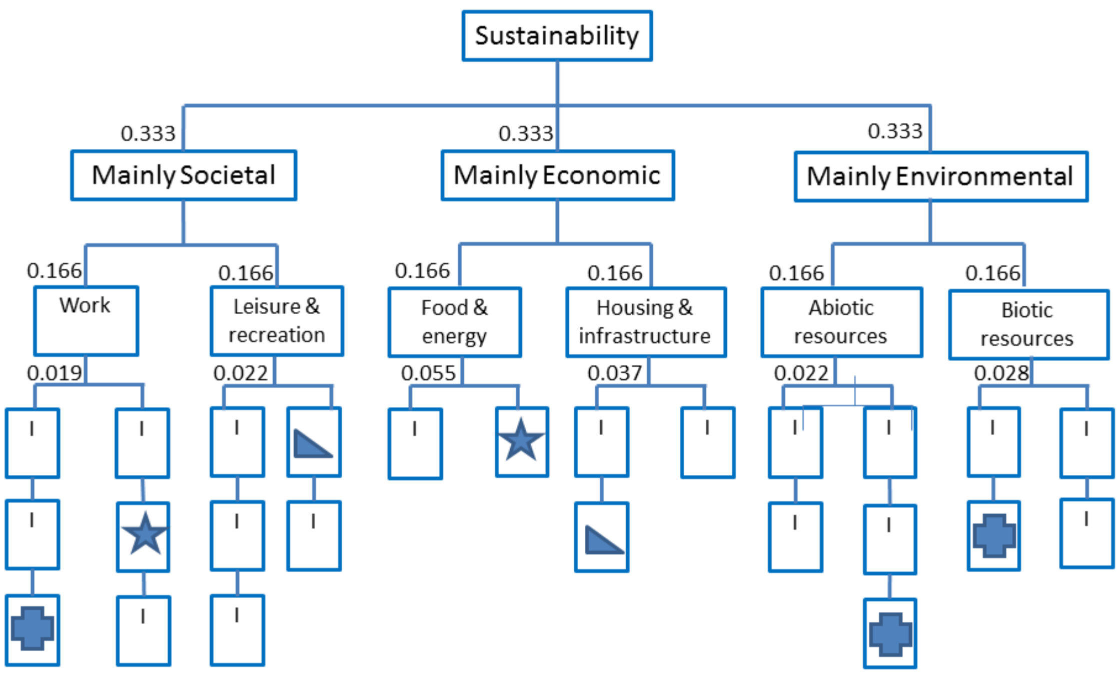


Figure 5 Basic aggregation scheme, after Paracchini et al. (2008). The symbols represent individual indicators contributing to more than one LUF

In such a hierarchical scheme the six LUFs are grouped in twos, according to the three dimensions of sustainability, and indicators are each assigned to one LUF. In order to deal with the compensability problem in linear aggregation, and with the problem of assigning weights in a context of social choice, as suggested by Munda (2004) the value of the weighs attached to each LUF is decided *a-priori* and LUFs are considered to be equally weighted. The indicator weights are then derived by dividing the LUF weight by the number of indicators concurring to it. The method therefore remains compensatory within a LUF, but not among the LUFs. It is the end-user of the system, i.e. the policy maker at the EU level, who makes the decisions on the possibility of accepting trade-offs between LUFs.
In practice, the requirements of the system are complex. The LUFs do not refer uniquely to a dimension of sustainability, but have a “prevalent” social, economic or environmental character, acknowledging that the pillars of sustainability are not isolated, but involve numerous cross-linkages (mostly social, mostly economic and mostly environmental), as shown in Figure 5.
In this aggregation framework, three additional characteristics apply:

a. Each indicator can concur to more than one LUF (as shown in Figure 5);

b. The indicator link to a LUF can be positive or negative, stronger or weaker;

c. Each indicator may perform differently according to the geographical/environmental/socio/economic context in which it is measured.

All these elements must be taken into account when building the aggregation frame, and concur in solving the open questions:

- how is spatial variability of the European environmental/socio/economic context taken into account;

- how is sustainability included in the aggregation frame.

The system uses three weighting components to achieve this multi-dimensional, regional assessment, and is organised in a way that the aggregated values of indicators produce a final LUF score on the same 0 – 10 scale. In the same way the targets are normalised and aggregated to produce an aggregate target for the LUF, against which LUF scores for a policy option are compared.

The three weights are used as follows:

w1 – Number and type of indicators contributing to each LUF
Figure 5 shows that aggregation of indicators to LUFs is performed on a compensatory basis, in which the contribution of each indicator is weighted according to the number of indicators concurring to a LUF, and the indicator inherent importance (addressing issues of redundancy between indicators) and the balance of indicators across the three sustainability pillars.

This is the first of three weighting factors: **w1**, and is calculated as follows:

w1 = intrinsic indicator weight x pillar balance weight x 1/ n_{LUF} (1)

where n_{LUF} is the number of indicators concurring to the LUF.
Intrinsic weights should be shown as in the example in Table 5 below. The importance of some individual indicators may be down-weighted to account for issues of redundancy. For example, N and P surplus where both represent impact of the agricultural sector on water quality. However, the spatial pattern varies across Europe, so rather than select just one indicator and fail to adequately capture this impact, it can

be decided to retain both, but to down-weight them equivalent to one indicator. Two sectors are represented for Value added per sector, agriculture and energy, therefore these can be also down-weighted to sum to one indicator. The second component to weight 1 takes into account the differences in number of economic, social and environmental indicators to achieve balanced representation between the three dimensions. These two components are combined to form weight 1. In the LUF framework, weight 1 is also adjusted separately for each LUF to take into account the number of indicators contributing to that LUF, ensuring LUF calculations are evenly balanced through the framework.

Table 6 Example showing how components combine to form Weight 1, balancing each indicator contribution to the LUF framework

Indicator code	Indicator	Intrinsic indicator weight (A)	Pillar balanced weight (B)	Product (A) x (B)	Balanced Weight 1
ECO_06.1	Labour productivity	1	0.25	0.25	0.3333
ECO_08.1a	Value added in agricultural sector	0.5	0.25	0.125	0.1667
ECO_08.1b	Value added in energy sector	0.5	0.25	0.125	0.1667
ECO_11.1	Growth rate or real GDP per capita	1	0.25	0.25	0.3333
	No. ECO indicators	**4**		**0.75**	**1**
SOC_01.1	Unemployment rate	1	0.2	0.2	0.2
SOC_03.1	Deviation of regional unemployment rates	1	0.2	0.2	0.2
SOC_03.2	Deviation of regional income	1	0.2	0.2	0.2
SOC_09.1	Net migration	1	0.2	0.2	0.2
SOC_11.1	Alteration in appreciated landscape heritage	1	0.2	0.2	0.2
	No. SOC indicators	**5**		**1**	**1**
ENV_01.1	Ammonia (NH3) emission from agriculture	1	0.1111	0.1111	0.1429
ENV_01.2	Nitrogen dioxide (NO2) emissions	1	0.1111	0.1111	0.1429
ENV_02.1a	Nitrogen surplus	0.5	0.1111	0.0556	0.0714
ENV_02.1b	Phosphorus surplus	0.5	0.1111	0.0556	0.0714
ENV_03.2	Soil sealing	1	0.1111	0.1111	0.1429
ENV_04.1	Carbon sequestration	1	0.1111	0.1111	0.1429
ENV_06.2	Trends in farmland birds	0.5	0.1111	0.0556	0.0714
ENV_06.6	Pesticide use	0.5	0.1111	0.0556	0.0714
ENV_09.1	Forest fire risk	1	0.1111	0.1111	0.1429
	No. ENV indicators	**9**		**0.78**	**1**

w2 – Strength and sign of indicator impact on LUF performance

Expert panels of internal and external experts can assign values to the link between each indicator and the LUFs. Such weights are attributed in close relation to the indicators' ranges. Weight 2 describes the impact on functional performance, i.e. whether it has a positive or a negative impact on that LUF. Since these indicator weights can show positive or negative relations, great attention must be paid to the meaning attached to minima and maxima per each indicator in the normalisation frame. As explained above the same indicator can have a positive relation to one LUF and a negative one to a different LUF, and this must be reflected in the direction the scale

min-max is assigned to indicators in each LUF during the normalisation process (i.e high GDP may be good for LUF provision of work and bad for LUF provision of biotic resources, therefore the maxima are attached to high GDP values in the first case, to low GDP values in the second).
This is the second of three weighting factors: **w2**, taking discrete values from -1 to +1.

<u>w3 – Regional importance of the indicator</u>

Weight 3 reflects the importance of each indicator at a regional level. Once more a panel of experts need to define a set of indicator-specific rules to determine the importance of an indicator in separate regions. Care needs to be taken to minimise co-correlation of factors determining the rule base and those from which the indicator values themselves were derived. This is the third of three weighting factors: **w3**, taking discrete values from 0 (not relevant) to +3 (strong importance).
Together, the information in these weighting scores is used in the aggregation framework to address the issues a) to c) listed above, since they represent how much a LUF is sensitive to a change in a specific indicator and how much the relevance of a LUF changes across the European regions considered.

2.4. Land Use typology linking land use functionality and land use intensity

The territorial land use performance is proposed to be assessed as an integrated picture of two key territorial performance dimensions, i.e. land use intensity and the land functionality that results in that intensity. This typology links therefore the Land Use Functions with the land use intensity described before

Finally the land use intensity and land use functionality will be integrated in a land use typology based on the classes described in the figure below. This typology will provide the framework to assess the land use performance.

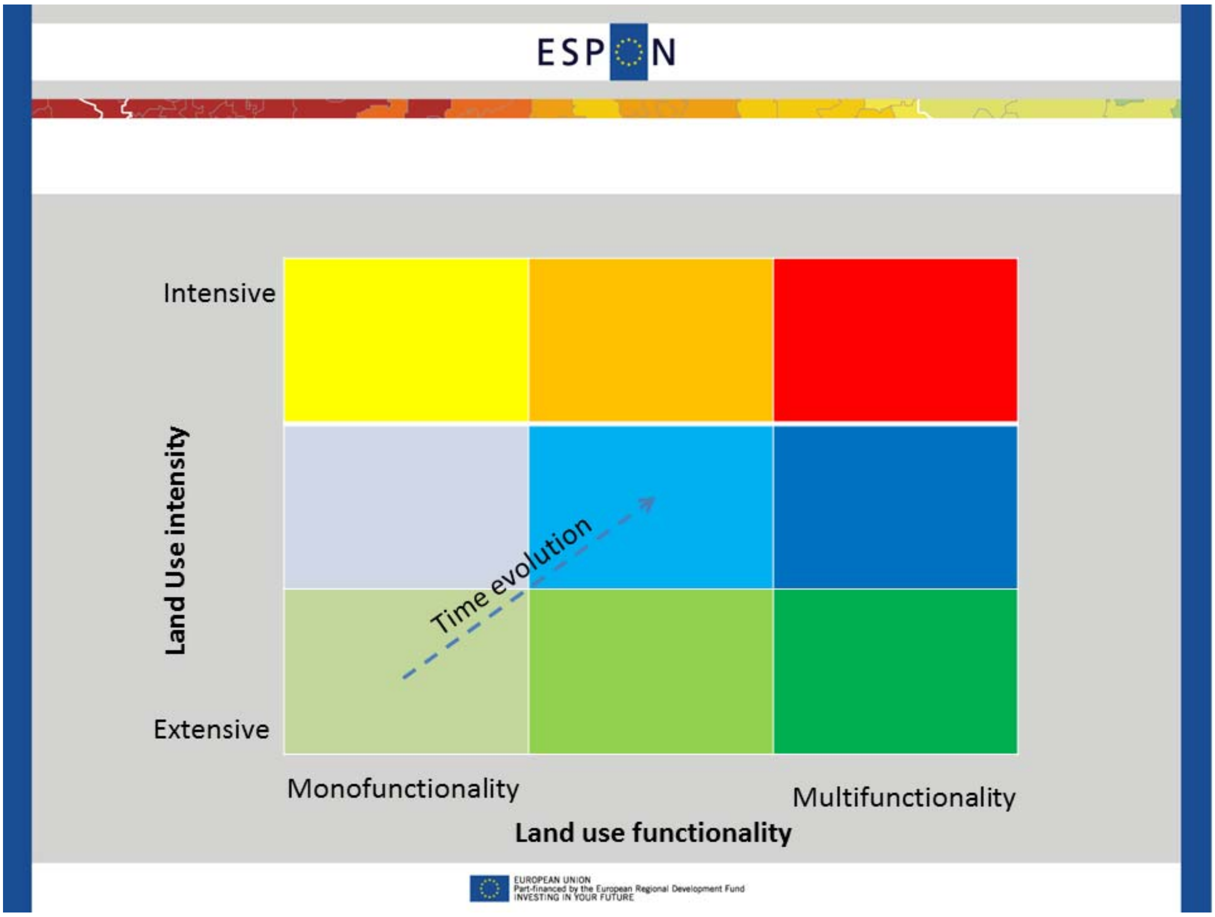


Figure 6 Classifying territorial units based on combination of Land Use functionality and Land Use intensity

3. Main results achieved so far

Results to date:

- Overview of the policy context and identification of key policy objectives and headline targets
- Preliminary regional typologies
- Land Use Functions applied in The Netherlands
- Case study preliminary selection and development strategy

3.1. Policy context

The aim of territorial cohesion for the European cooperation towards sustainable development is on the core of the EU political agenda, revealing an increasing interest of policy makers in a territorial approach with deeper horizontal policy integration and cross-sector perspective, over the last decades.

Land use implications on the compliance of the key EU policy objectives and targets is crucial due to its cross-cutting nature touching upon many different territorial challenges such us urbanization and rural-urban relationships, climate change mitigation and adaptation, natural resource management, energy, transport, regional competitiveness and cohesion.

The challenge for a European cross-sector strategy for the European territory was first voiced in 1992, and it was adopted by EU Member States that developed and approved at an Informal Ministerial Meeting in Potsdam in 1999, the **European Spatial Development Perspective (ESDP)**. This document included policy orientations, approaches and governance ideas that are still to be found in the policy thinking today. The key policy orientations of the ESDP for the entire European territory in line with the three fundamental goals of European policy of economic and social cohesion; conservation of natural resources and cultural heritage; and more balanced competitiveness of the European territory, are:

- ➢ development of a balanced and polycentric urban system and a new urban-rural relationship;
- ➢ securing parity of access to infrastructure and knowledge to regions and services ; and
- ➢ sustainable development, prudent management and protection of nature and cultural heritage, intelligent management of natural and cultural resources.

Ever since, the territorial dimension is being addressed in the EU political agenda and EU policies, also at regional level, are increasingly focused on harmonious territorial development towards sustainability.

In 2007 the enlarged EU adopted a **Territorial Agenda for the European Union** which modernized the policy orientations of the ESDP and added stronger emphasis on:

- ➢ Competitiveness of regions and cities including creation of innovative clusters,
- ➢ Climate change concerns and
- ➢ Territorial cooperation and multilevel governance.

The Territorial Agenda has been followed up by an ambitious Action Plan 1, currently under implementation. The Territorial Agenda has been recently reviewed in the first half of 2011. Some actions are related to the themes of ESPON applied research, others are being supported by ESPON targeted analyses.

The **Leipzig Charter** (2007) builds on a process of cooperation aimed at strengthening urban development in the European context. With the Leipzig Charter the Ministers agreed on common principles and strategies for an integrated approach to urban development policy and on the need for action in socially and economically deprived urban areas as well as in cities as a whole. The complementarities between the Leipzig Charter and of the Territorial Agenda are addressed in First Action Programme.

The Leipzig charter particularly stressed the need for proposals and strategies for sustainable EU cities calling for a European polycentric urban structure.

In 2008 the Commission launched a debate publishing a **Green Paper on Territorial Cohesion**. This document puts a territorial perspective on economic and social cohesion setting the objective of a more balanced and harmonious development of the European territory. It focuses on 3 key territorial development dynamics: (1) Concentration, (2) Connections and (3) Cooperation. It pays as well particular attention to regions with specific geographical features. Mountain regions, island regions and sparsely populated areas may heavily suffer from the likely impacts of climate change, demographic change, accessibility, regional integration and energy supply.

The Green Paper on Territorial Cohesion is accompanied by a Staff Working Document and poses questions for a European wide debate that will run until 28 February 2009. This has first been visible in the 4th Cohesion Report that for the first time mentioned a new concept of “territorial cohesion” which in 2009 was ratified with the Lisbon Treaty.

The Lisbon Strategy is a dynamic strategy in which sustainability has been taken on board (climate change, energy, financial and social sustainability) making sustainable development a key objective for the EU and, in 2010, the EU renewed a number of environmental Directives to ensure they comply with it.

With the adoption of the Lisbon Treaty, territorial cohesion is added to the goals of economic and social cohesion. This new element adds and underlines a number of issues.

• It emphasizes the territorial dimension of access to services of general economic interest;
• It underlines the importance of environmental sustainability;
• It underscores the importance of functional geographies, of the problems of territories with specific geographical features, of the role of city, and of local development approaches;
• It strengthens the role of territorial cooperation and highlights the potential of macro-regional strategies.

Besides, the **Gothenburg Strategy (2009)** defines a number of key environmental objectives and target dates, both political and legislative. Major priorities include climate change, sustainable transport, public health and natural resources management.

In this context, land use planning and management are essential to better reconcile land use with environmental concerns. It is a challenge that involves various policy levels and different sectors. One of the major priorities of policy makers in EU and also around the world is the monitoring and mitigating of the negative environmental impacts of land use while sustaining the production of essential resources.

Land use changes have impacts on climate, biodiversity and ecosystems services and cause degradation and pollution of water, soil and air. (EEA, 2010- Thematic Assessment State and outlook 2010).

Processes such as urbanization, agricultural intensification, a-forestation, rural abandonment, land use specialization are land use processes resulting from interacting driving forces. Policy decisions that shape land use involve trade-offs between many sectoral interests, including industry, transport, energy, mining, agriculture and forestry that represent the largest share of land use by economic sectors. (SOER, 2010).

The **Sustainable Development Strategy (reviewed in 2009)** has had an important impact on the EU political agenda as revealed by the EU's climate change and energy policies.

The EU has started to integrate the sustainability dimension in many other policy fields also. Climate change and clean energy, sustainable transport, sustainable consumption and production, conservation and management of natural resources, public health, social inclusion, demography and migration, global poverty and sustainable development challenges, education and training, research and development, financing and economic instruments.

Consequently successful management of land use is crucial in order to comply with the main goals of European sustainable development particularly in:

- Contributing to a rapid shift to a low-carbon and low-input economy, based on energy and resource-efficient technologies and sustainable transport and shifts towards sustainable consumption behaviour;
- Intensifying environmental efforts for the protection of biodiversity, water and other natural resources. Evidence shows that the destruction of biodiversity is continuing at a worrying rate. Degradation of ecosystems not only reduces the quality of our lives and the lives of future generations, it also stands in the way of sustainable, long-term economic development;

The next step in defining the future EU Cohesion Policy after 2013 is envisaged by a **5th Cohesion Report** published by the European Commission in October 2010, stressing the importance of providing more support for the less developed EU regions in line with the Union's strong commitment to solidarity and its Treaty aim of reducing regional disparities in levels of development, to foster territorial cooperation in its three dimensions (cross-border, transnational, and inter-regional) and concentration of social exclusion in urban areas.

The European Commission adopted on 17 June 2010 the **Europe 2020 Strategy t**he growth strategy for the coming decade**.** This policy document sets out a vision of Europe's economy for the 21st century. It shows how the EU can come out stronger from the crisis and how it can be turned into a smart, sustainable and inclusive economy delivering high levels of employment, productivity and social cohesion. These three mutually reinforcing priorities should help the EU and the Member States deliver high levels of employment, productivity and social cohesion. The strategy has five ambitious objectives - on employment, innovation, education, social inclusion and climate/energy.

Considering its objective on climate and energy the EU member states have committed themselves to reduce greenhouse emissions by 20%, increasing the share of renewals in the EU´s energy mix to 20% and achieving the 20% energy efficiency target by 2020.

In February 2011 the EU council reconfirmed the EU objective of reducing GHG by 80-95% by 2050 compared to 1990 in the context of necessary reductions according to the Intergovernmental panel on climate change by developed countries as a group.

Land use/ land cover change plays an important role in climate change at global, regional and local scales by increasing the release of carbon dioxide to the atmosphere and other green house gases by means of the alteration of soils and natural vegetation, the modification on the hydrology and the elimination of forest cover.

The white paper on transport, the energy efficiency plan and the communication of the EC A Roadmap for moving to a competitive low carbon economy by 2050 constitute the key deliverables under the Resource Efficiency flagship. (COM (2011)112 final)

It outlines the need for raising land use productivity sustainably: improved agricultural and forestry practices increasing the capacity of the sector to reduce GHG and preserve and sequester carbon on soils and forests. This can be achieved for instance through targeted measures to maintain grasslands, restore wetlands and peat lands, low or zero-tillage, to reduce erosion and allow for the development of forests. Agriculture and forestry are also providing the resources for bio-energy and industrial feedstock's.

Although the cohesion policy has already significantly reduced economic, social and environmental disparities within the EU it has been observed that it could be more effective and it could play a crucial role in the context of the current economic crisis and to guarantee the compliance with the EU strategy 2020.

One of the most relevant issues addressed is the need for strengthen territorial cohesion, with particular emphasis on the role of cities, local development and the macro-regional strategies.

Land-use planning and management decisions are usually made at local or regional level. However, the European Commission has a role to play in ensuring Member States take environmental concerns into account in their land-use development plans. The goals are:

- To analyse the environmental impact of proposed developments
- To improve the geographic information flow about land-use issues
- To develop and implement European urban environment strategy
- To improve the planning, management and use of Europe´s coastal zones

European economies depend on natural resources, including raw materials and space (land resources). The EU thematic strategy on the sustainable use of natural resources includes space as a resource. It applies to areas of land and maritime space that are needed for production purposes (e.g. minerals, timber, food) and for various socio-economic activities. These interests are often competing for the same territorial resource.

Efforts to modify land-use practices to reduce non-point pollution of air and water include integrated river basin management and, in particular, the Nitrates Directive. Flooding caused by the construction of impervious surfaces (e.g. buildings and roads) and provoked by extreme weather events is addressed by a new European Floods Directive. The cross-cutting nature of land use is also emphasised by the EU rural development and regional policies.

The commission intends to adopt a Common Strategic Framework delineating a comprehensive investment strategy, which translates the targets and objectives of Europe 2020 into investment priorities for Cohesion policy, covering structural funds, the cohesion fund, European fisheries fund and the European agricultural fund for rural development. Each member state would present their overall strategy for cohesion policy in line with the national reform programmes and the thematic and country specific recommendations for Europe 2020.

Scientific evidence on the land use patterns and dynamics and its correlation to land use efficiency will allow policy makers to identify those regions where land use conflicts exist and also regions where there is a potential for territorial development and define policy measures accordingly.

Policy objectives have been identified from the key relevant documents in the EU political agenda.

The Lisbon performance of regions is assessed based on a strategic set of indicators set by the European Commission and the European Council. The indicators stated below are used to measure the regions' success in relation to the Lisbon Strategy (ESPON, 2007):

Headline targets	Indicators
Average of all individual quartiles of performance of seven regionalised Lisbon short list indicators	GDP/capita
	GDP/person employed
	employment rate of 15-64 (EU 2020 range 20-64)
	employment rate of elderly
	gross expenditure on research and development
	dispersion of regional unemployment rates
	long-term unemployment rate.
Average of all individual quartiles	Regional Unemployment, 2008
	R&D Expenditure as Percentage of GDP, 2006
	Composite Economic Lisbon Performance, 2006; Change in Composit
	Tertiary Educated People in Labour Force, 2007
	Share of Renewables in Gross Final Consumption, 2005
	Wind Power Potential, 2005

Table 7 Lisbon Strategy and Gotteborg objectives: indicators and headline targets

The European Strategy for Sustainable Development also provide a set of indicators attached to headline targets some of which are already included in the Lisbon and Gotteborg objectives.

Headline targets	Indicators
Socio-economic development EU27 Average	Growth rate of real GDP per capita
Sustainable consumption and production EU27 Average	Resource productivity
Social inclusion	Population at-risk-of-poverty or exclusion
Demographic changes	Employment rate of older workers
Public health EU27 Average	Healthy life years and life expectancy at birth, by gender
Climate change and energy	Greenhouse gas emissions
	Share of renewable energy in gross final energy consumption
Sustainable transport EU27 Average	Energy consumption of transport relative to GDP
Natural resources EU27 Average	Common bird index
	Fish catches taken from stocks outside safe biological limits
Global partnership EU27 Average	Official development assistance as share of gross national income

Table 8 European Strategy of Sustainable Development headline targets and indicators

For the EU-LUPA project we have decided to focus on the EU2020 objectives for the assessment of the territorial performance at regional level.

Headline targets	Indicators
75 % of the population aged 20-64 should be employed	Employment rate by gender, age group 20-64
3% of the EU's GDP should be invested in R&D	Gross domestic expenditure on R&D (GERD)
The "20/20/20" climate/energy targets should be met (including an increase to 30% of emissions reduction if the conditions are right) EU27 target 80	Greenhouse gas emissions, base year 1990
	Share of renewables in gross final energy consumption
	Energy intensity of the economy (proxy indicator for *Energy savings* , which is under development)
The share of early school leavers should be under 10% and at least 40% of 30-34 years old should have	Early leavers from education and training by gender
	Tertiary educational attainment by gender, age group 30-34
Reduction of poverty by aiming to lift at least 20 million people out of the risk of poverty or exclusion	Population at risk of poverty or exclusion *(union of the three sub-indica*
	Persons living in households with very low work intensity
	Persons at risk of poverty after social transfers
	Severely materially deprived persons

Table 9 Indicators suggested evaluating territorial performance based on Europe 2020 headline targets and indicators

The potential correlation between the performance of regions towards those indicators and the land use changes and trends analysed could lead us to the evaluation of the land use efficiency at regional level and to provide with policy recommendations oriented to move towards a more sustainable management of land.

3.2. Data collection and assessment: from data needs to coherent data structure

The data required to provide the empirical basis for the project has been collected considering the needs identified in the different parts of the project, namelly:

- Data related to indicators based on policy targets. The policy analysis provides de framework for the
- Land use typologies including an assessment of urban sprawl
- Land use functions

It should be pointed out that it has been an iterative process in order to connect the different needs, to identify redundancies and, finally, to exclude data that was considered not highly relevant or data with limited geographic coverage.

In order to have a coherent structure three dimensions have been considered for each data set collected:

- Spatial dimension:
    - o Europe
    - o National
    - o Regional (NUTS 2/3)
    - o Local for the case studies
- Temporal dimension. The temporal dimension ranges from 1990 up to 2006 given the existing information at European level.
- Thematic scope. Data has been organised according to the 8 major themes described by the ESPON Database Project. This thematic classification is based on an exhaustive text mining of ESPON projects and other relevant European data. Consequently it provides a consistent approach being able to subdivide each theme in subthemes that perfectly fitted to the needs of the project. On the other side, taking this approach, the data collected at the end of the project will be easily integrated into the ESPON database.

Table 11 provides an overview of the compiled data according to data needs and related dimensions. The major data sources are listed in Annex I

Table 10 Comprehensive overview of existing land use data at European scale

Data	Coverage	Minimum mapping unit	Time dimension
CORINE Land Cover	EU 27	25 ha (minimum change detection 5 ha)	1990, 2000, 2006
High Resolution soil sealing	EU 27	1 ha (*resolution*)	2006
Urban Atlas	EU 27, about 250 cities (> 100 000 inhabitants)	0.25 ha urban classes 1 ha non-urban classes	2006

CORINE Land Cover is the main data source for land cover since this is the only one that provides a European wide coverage through time. IIndeed this is the only existing information harmonised at European level on land cover. The classification agreed between all the European countries is a mixture between land cover (e.g. forest and water) and land use (agriculture and artificial classes). The three time shots currently available (1990, 2000 and 2006) makes CORINE a reference source when dealing with land use and land use change in Europe. However, CORINE Land Cover has its own limitations (resolution, minimum change detection to name the more relevant ones). In general CLC tends to understimate urban classes, so one can expect that when an increase on urbanisation is observed (e.g. urban sprawl) the process is really occurring. For the forest and agricultural data there is not a clear trend on understimation or overestimation and it is very much depending on regional specificities and type of dominant processes. The table below shows the geographic coverage for the different time shots of CLC

	EU 27	Western Balkans	Iceland	Norway	Turkey
CLC 90	All (except UK)	All (except Albania, Bosnia and Hercegovina)	No	Yes	No
CLC 2000	All	All	No	Yes	Yes
CLC 2006	All (except UK and Greece)	All	Yes	Yes	Yes

Note: Western Balkans include Albania, Bosnia and Herzegovina, Croatia, Macedonia, the former Yugoslavian Republic of Montenegro, and Serbia.

In addition the following layers, derived from CLC which will be integrated:

- Dominant Land Cover Type. This layer enhances the dominant land use type considering the land at a given point and in a 5 km radius. This approach allows identifying where are dominances of certain uses and where are mixes considering not only a particular point, but also the context.

Corilis. Corilis is a methodology developed for land cover data generalization and analysis. The purpose of CORILIS is to calculate "intensities" or "potentials" of a given land cover class in each point of a territory.

High Resolution Soil sealing layer. This layer has been developed in parallel with the CLC and provides the percentage of impervious surface in Europe. This information is relevant to characterise the urban areas, however the use is not specified. It is only available for year 2006. Coverage: EU 27, Western Balkans, Turkey, Iceland.

Urban Atlas. This is a high resolution land cover for the cities included in Urban Audit. Because there is no time change for this data it will be used to assess the error associated with CLC for urban areas and to better characterise the cities and agglomerations in the urban sprawl characterisation.

Table 11 Overview of the data collected organsied according to the following dimensions: theme, spatial dimension, time coverage, Land Use Functions and policies. For time coverage 1990, 2000 and 2006 have been taken as reference years (in line with existing land cover data), therefore data has been selected if it is available for the given reference year (+/- 1).

Theme	Sub-themes	Data	Spatial dimension	Time coverage			Land Use Functions	Policies
Agriculture & Fisheries	Farm structure	Area, size, yields, net value added	Discrete (administrative)	1990	2000	2006	Food & energy	EU Sustainable Development Strategy (EU SDS) Objective Climate Change mitigation-reduction of GHG European Spatial Development Perspective (ESDP) Objective: development of a new urban-rural relationship EU2020 Objective- Reduction of GHG Rural development policy 2007-2013 Objective improving the competitiveness of the agricultural and forestry sector CAP Objective- evolution of agriculture sector
	Livestock	Animal population	Discrete (administrative)	1990	2000	2006	Food & energy	EU2020 Objective- Reduction of GHG
	Rural development	Labour force; Agriculture in less favoured areas	Discrete (administrative)		2000	2006	Work	Lisbon Treaty Objective- Employment rate EU2020 Objective- Reduction of GHG and Employment Cohesion Policy Objective- Competitiveness of less favoured areas CAP Objective- evolution of agriculture sector
Demography	Population structure		Discrete (administrative)	1990	2000	2006	Work, Housing and infrastructure	EU Sustainable Development Strategy (EU SDS) Objective- Social Cohesion Territorial Agenda Objective- Social Cohesion
	Natural changes	Migration	Discrete (administrative)	1990	2000	2006	Work, Housing and infrastructure	EU Sustainable Development Strategy (EU SDS) Objective- Social Cohesion Territorial Agenda Objective- Social Cohesion
Transport	Accessibility	Potential accessibility	Discrete (administrative)		2000	2006	Work; Leisure and recreation; Housing and insfrastructure	Cohesion and Transport policy Objective- Territorial cohesion and competitiveness Territorial Agenda Objective- Strengthen territorial cohesion
	Infrastructure	Major trasnport infrastructure	Continuous			2007	Work; Leisure and recreation; Housing and insfrastructure	Transport policy Objective- Land take by transport infrastructure and its connectivity Nature conservation and environmental protection Objective- Reduce biodiversity loss and promote habitat conservation

Energy & Environment	Energy and resources	Solar energy; Wind power installed	Discrete (administrative)			2006	Food & energy	EU Sustainable Development Strategy (EU SDS) Objective - Share of renewable energy in gross final energy consumption Lisbon Strategy, EU2020 and Climate Change policy Objectives: - Share of Renewable in Gross Final Consumption, 2005 - Wind Power Potential, 2005
	Vulnerability impacts	Vulnerability to climate chantge	Discrete (administrative)			2009		CLimate change policy Objective- adaptation strategies EU Flood Directive Objective- mitigation of flood risk
Land Use	Land use and land cover types	Land Cover, Soil sealing	Continuous	1990	2000	2006	*All land use functions*	Environmental policy: Nature conservation and environmental protection Objective- Biodiversity Loss and habitat conservation Coastal Zone Policy and EU Floods Directive Objective- Mitigation of floods Water Framework Directive Objective- avoid contamination of ground and surface water
	Urban land use attributes and changes	Urban Atlas	Continuous			2006		European Spatial Development Perspective (ESDP) and Territorial Agenda Objective- strengthen territorial cohesion by polycentric urban systems Sustainability of urban systems: energy consumption, emission of GHG
	Rural land use attributes and changes	High nature value farmland, Protected areas	Continuous			2006	Biotic resources	Environmental policy: Nature conservation and environmental protection Biodiversity Loss and habitat conservation
Social Affairs	Education	Early school leavers; Education degree	Discrete (administrative)			2008	Work; Housing and insfrastructure	EU Sustainable Development Strategy (EU SDS)/Territorial Agenda/ Lisbon Treaty/ EU2020 Objective -promoting social inclusion and territorial competitivess
	Living conditions	Hospital beds;	Discrete (administrative)				Work; Housing and insfrastructure	
Economy	Aggregated accounts	GDP; Tourists' overnight stays	Discrete (administrative)	1990	2000	2006	Work; Leisure and recreation	EU Sustainable Development Strategy (EU SDS)/ European Spatial Development Perspective (ESDP)/Territorial Agenda/ Lisbon Treaty/ EU2020 Objective - regional development, competitiveness, territorial cohesion
	Employment	Employement rates	Discrete	1990	2000	2006	Work; Food and	EU Sustainable Development Strategy (EU

			(administrative)				energy; Housing and infrastructure	SDS)/ European Spatial Development Perspective (ESDP)/Territorial Agenda/ Lisbon Treaty/ EU2020 Objective -regional development, competitiveness, territorial cohesion
	Production and costs per sector	Labour productivity per sector	Discrete (administrative)			2007	Work; Leisure and recreation; Housing and insfrastructure	EU Sustainable Development Strategy (EU SDS)/ European Spatial Development Perspective (ESDP)/Territorial Agenda/ Lisbon Treaty/ EU2020 Objective - regional development, competitiveness, territorial cohesion
	Research and innovation	Expenditure on R&D; Employement in high-technology	Discrete (administrative)			2008	Work; Housing and insfrastructure	EU Sustainable Development Strategy (EU SDS)/ European Spatial Development Perspective (ESDP)/Territorial Agenda/ Lisbon Treaty/ EU2020 Objective -regional development, territorial cohesion

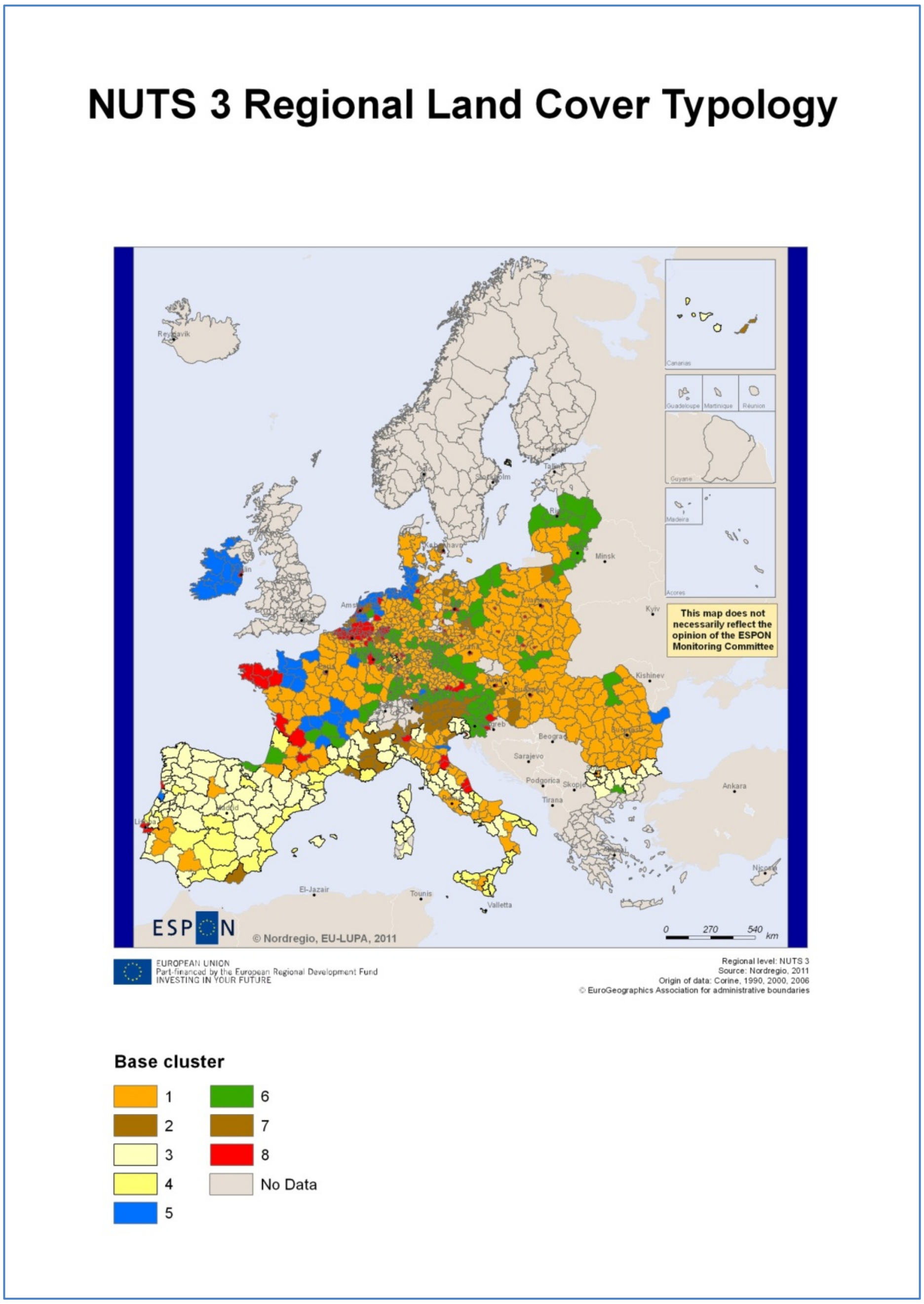
3.3. Defining regional typologies

The first step in the definition of regional typologies is the creation of preliminary land cover typologies in the EU LUPA project which is generally responsible for understanding to what extent land use patterns match with socio-economic developments. By nature they also identify regions sharing similar characteristics which in turn allows for the selection of contrasting regions within the case studies. To this point the typologies have only been created on a preliminary basis to test the methodology and to act as the basis for the preliminary identification of case study regions.
We are now presenting results from the exercises for configuration of first and second layers

First layer

The basic typology layer has been a clustering exercise based on Nuts 3 data determining both the geographical and functional characteristics of possible typologies, emphasizing what could be characterized as stable elements based on data representing land use status, i.e. what is characterising the land cover situation at three different points of time, and out of that what are the static characteristics of land cover and land use. When mentioning a clustering exercise, it has actually been a double exercise. The approach can be characterized as a two-tier clustering. For each of the three years a first level cluster analysis has been conducted, identifying regions characterized by the same land cover situations. Based on the outcome of the clustering, 15 clusters have turned out to be advantageous. The statistic characteristics of the clusters have been used in a second level cluster analysis, determining regions with similar land cover characteristics over the time period. The regional characteristics of the final clusters are shown on map1 below.

Due to limitations in data availability for some countries the analysis does not provide full coverage for Europe, and due to the existence of extreme outliers in the data material, the number of NUTS3 regions included in each cluster differs very much.
The typology shown on map 1 – the static characteristics of land cover in Europe – include the following 8 clusters:



Map 1 Static characterístics of land cover in Europe

- Cluster 1: Pan-European agriculture as the main major land cover (>75%) but also including Urban, Industrial and Infrastructure coverage (6%), and Forest (14%);
- Cluster 2: More intensive agriculture (40-50%) and substantial more urban activities (12-15%), with wetland/coastal areas as a characteristics (7-10%) as well as some forest (10-15%).
- Cluster 3: Primarily South European land use of lower intensity with major land cover including some limited Urban, Industrial and Infrastructure coverage (3-5%), while Arable land and Agriculture (40%), as well as Forest (20%) and Scrub/Herbaceous vegetation (15%);
- Cluster 4: Typical coastal mediterenian land cover characteristics with some urban activities (5%) as well as Agriculture (45%) with permanent crops, and forest (10-15%) and Scrub/Herbaceous vegetation (10-15%).
- Cluster 5: Land cover to some extend influenced by wetlands (2-5%), mainly agriculture (60-70% and some forest and herbaceous vegetation (7-10%).

- Cluster 6: Land cover characterized by forest (40-50%) in combination with agriculture (45%) of lower intensity.
- Cluster 7: Mountainous areas with forests and scrub/herbaceous vegetation as the main characteristics (75%), some minor agricultural areas (10%) and sparse urbanization (2-5%).
- Cluster 8: Dense urbanized land use, with Urban, Industrial and Infrastructure (25-30%) with Arable land and Heterogeneous Agriculture (20-30%), forests (10-15%) and minor areas of Inland waters (1-3%)

Second layer

Another element in the first step has been the analysis of data representing land use change, i.e. what is characterising the land cover and land use between the points of time when registration takes place, and thereby the dynamic characteristics of land cover and land use.

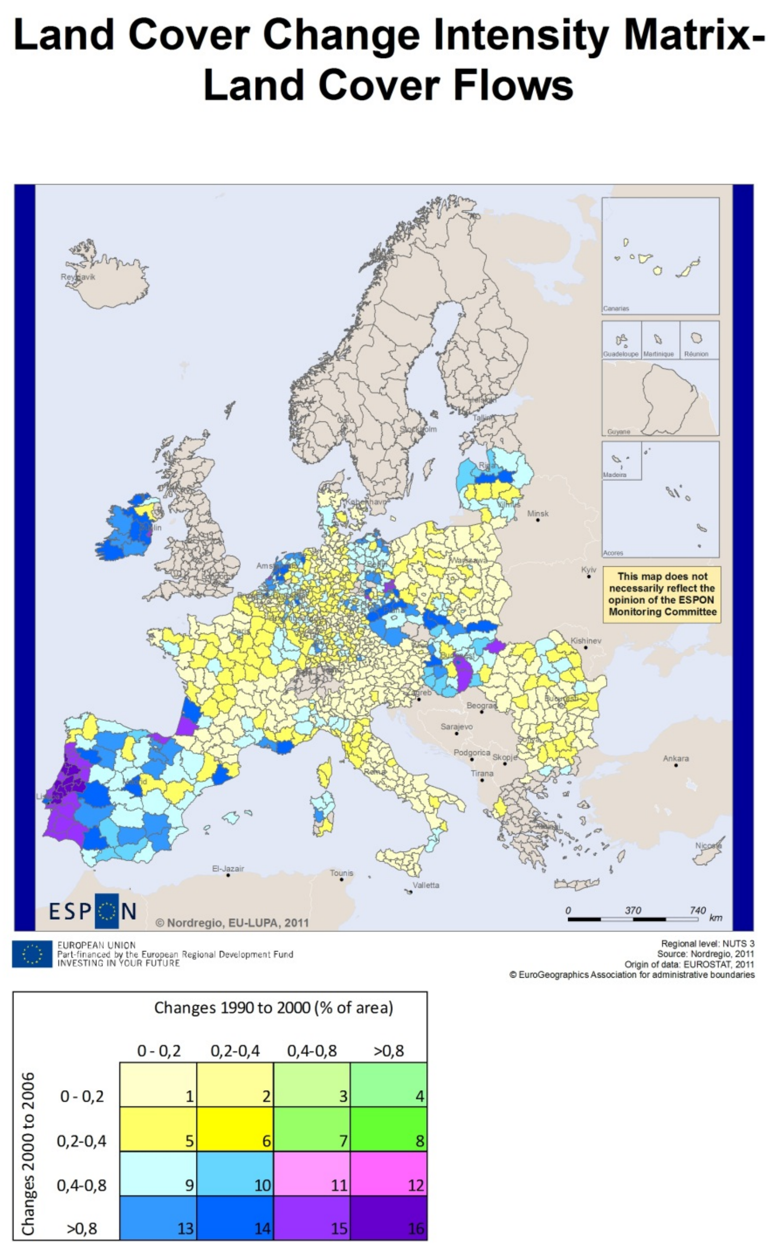
For each of the two time periods a cluster analysis has been conducted, identifying regions characterized by the same land cover changes. As there are marked differences in the process of land cover changes, an important issue has been not only to identify the changes, but also to show these time based differences. And in order to keep the analyses comparable, the focus has been on percent changes per year. Due to this, our approach has its focus on the synthesizing of typologies representing as well status (static characteristics) and change (dynamic characteristics). The main characteristics could be described here:

- **Urban Land Management;** The map shows where changes in Urban Land Management has taken place. The major part of the changes has been ongoing throughout the whole period (yellow=low intensity, purple=high intensity). In addition new activities has taken off during 2000 to 2006 (blue colors).
- **Urban Residential Sprawl:** Low intensity activities has taken place during the whole period 1990-2006 (yellow colors); The major part of the changes, however, has taken off after 2000 (blue colors); It is very much a NW European process
- **Sprawl of economic sites and infrastructures:** In most of Europe it is an ongoing phenomenon during the whole period (yellow=low intensity, purple=high intensity); There are, however, high intensity activities mostly during 1990-2000 (green colors) or 2000-2006 (blue colors).
- **Agriculture Internal Conversions:** Due to Europe as a high intensity agricultural region, substantial changes has been ongoing during the whole period, i.e. 1990-2000 (yellow) and 2000-2006 (purple); A major part of the changes, however, has taken place after 2000 (blue colors).
- **Conversion from other land cover to Agriculture:** This change has taken place in low scale throughout the whole period in both Eastern and Southern Europe; The most substantial changes, however, have been taking place in Spain, and partly also Portugal, some during the whole period (Purple), but most after 2000 (blue colors.
- **Withdrawal of Farming:** This is an activity which has taken place especially in Eastern Europe, Spain, Portugal and Eireland; It has taken place throughout the whole period (yellow and purple), but in some areas it is a more recent activity, i.e. after 2000 (blue colors); This land cover change is, however, one of the few where the intensity in a number of places has been higher in 1990-2000 than after 2000
- **Forest Creation and Management:** This is the land cover change which has been among the most dominant in Europe during the period 1990 to 2006; In several areas the changes has been ongoing throughout the whole period (yellow and purple); The major pattern, however, is an intensification of the process after 2000 (blue)
- **Water Bodies Creation and Management:** This is among the lower intensity changes which has been ongoing in most of European areas characterized by this land cover type.

- **Changes of Land Cover due to Natural and Multiple Causes:** Spain, and the Mediterranean Islands are characterized by this type of change, but other parts of Europe have seen similar situations, but in lower scale.

By combining a matrix of change 1990-2000 versus 2000-2006 it is possible to highlight the major trends for the full period. By means of colors both intensity and time period is shown on the map. Colors yellow (low intensity) and Purple (high intensity) show changes which have been ongoing through the whole period, Color green shows changes which have been mainly on going during 1990-2000. Color blue shows changes which have been mainly on going after 2000. It could be seen that for the full period East-Central Europe and Spain and Portugal are the regions where the major changes have been registered.

Map 2 Layer II in the typology – Changes in land cover characteristics during the two periods 1990-2000 (x-axis) and 2000-2006 (y-axis).



3.4. Applicability of the Land Use Functions approach in the EU-LUPA project

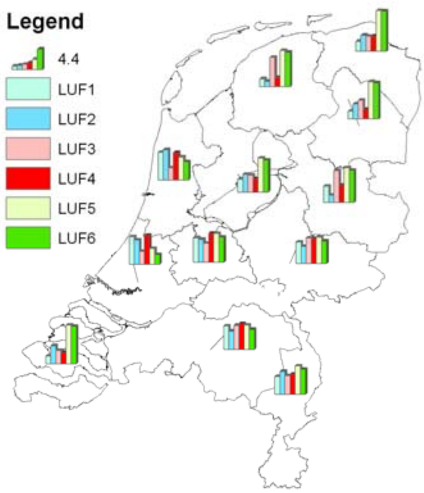
In order to test the methodology of the LUFs adapted for the EU-LUPA project, it has been applied to The Netherlands (see details in Annex III

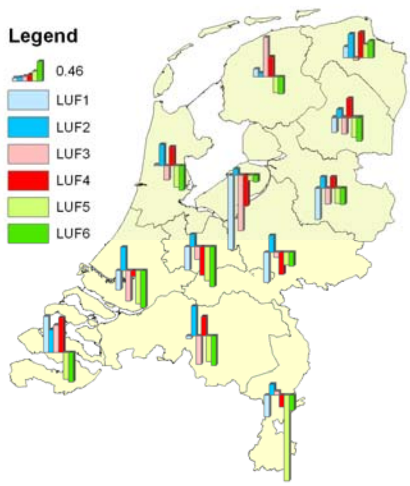
Initially it was decided to consider NUTS 3 regions as the unit of assessment. However, after revising the number of indicators available at NUTS 3 level, and having in mind that a minimum of 12 indicators should be available to apply meaningfully the LUF methodology, it was decided to use NUTS 2 level as the spatial unit for the assessment.

Map 3 shows the values of the six LUFs for each province in 2006, and changes in the period 2000-2006. In general terms, it shows how the economic functions are performing well, whereas the societal and especially the environmental have mainly negative values, which is in accordance with general trends observed in other studies.

Its shows as well how small are the differences between 2000 and 2006, which is in accordance to the small changes observed in the CLC classes between the two years for the Netherlands. Still there are important differences between the regions, e.g. the three richest regions of the NL have higher values in the economic LUFs.

Map 3 Land use functions per NUTS 2 region in Netherlands in 2000 (left) and changes in the period 2000-2006 (right). LUF1, work; LUF2, leisure and recreation; LUF3, food and energy; LUF4, housing and infrastructure; LUF5, abiotic resources; LUF6, biotic resources.





The objective of the exercise was:

- To assess the suitability of the LUFs methodology in EU-LUPA for assessing the impacts of land use change between 2000 and 2006 (suing as basis the changes in CLC) in a comprehensive way and not based on the partial views provided by individual indicators: multi-criteria analysis;
- To estimate the impact of land use changes on sustainability, measured as integration of the economic, social and environmental dimension;
- To identify the number and quality of the land use functions present in the twelve Duct provinces and therefore the degree of existing multifunctionality

The preliminary results indicate that the methodology is feasible and the results are plausible.

3.5. Case studies

The research will be complemented by case studies with the purpose to:

- Verify and confirm proposed typology and identified processes and challenges;
- Identify land use functions and undertake a "multifunctionality" assessment;
- Identify factors and drivers (natural and socio-economic) of land use changes and land use dynamics in details in different types of areas;
- Give answer about mechanisms and trends (processes) of land use changes in local scale;
- Identify challenges in those areas and defining policy recommendations to cope with those challenges on the basis of stakeholders opinion;

Case studies selection

At the first step of case study selection – pre-selection – there were identified six areas (regions) as s potential cases for analysis from each partner perspective, interesting in relation to the topic of land use but also bearing to mind the availability of data and accessibility. The major base for the preselection was Corine Land Cover Dynamic Regional Clusters (draft) worked out as an element of Land Cover Typology study by Nordregio (Task 2.2)

Figure 7 Preselected Case Studies

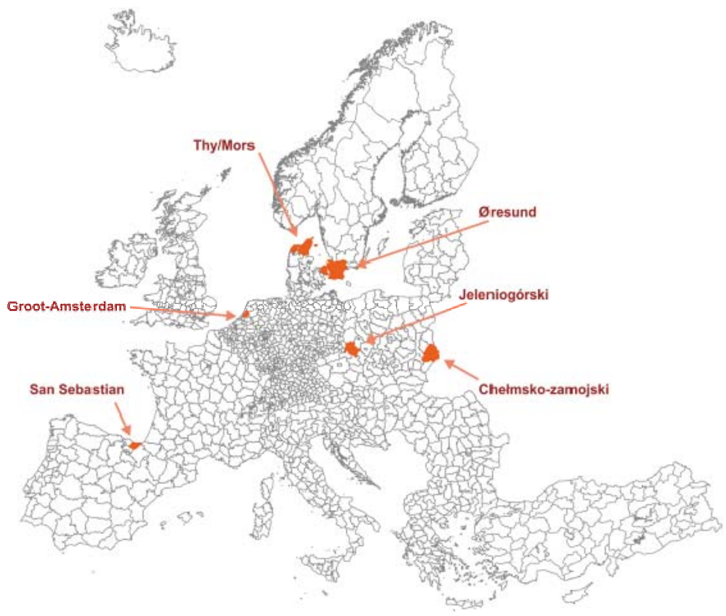


Table 12 Preselected case studies

Case studies NUTS 3	Cross border	Mountain area	Highly populated	Outermost	Urban-rural open space	Costal	Others
Öresund (Sweden/Denmark)	X		X		X	X	
Thy/Mors (Denmark)						X	X
Jeleniogórski (Poland)	X	X		X			
Chełmsko-Zamojski (Poland)	X			X			X
Amsterdam (The Netherlands)			X		X		
Eurocity DonostiSan Sebastian-Bayonne (Spain-France)	X					X	

The preselected regions represent the different land use management with different drivers of land use patterns. They represent variety of types (cross-border, mountain areas, highly populated, coastal, peripheral, etc.) located in different geographical space (West, East, South and North Europe). Preselected regional land use has also a different dynamics due to social, economic and environmental development changes.

To each chosen regions were worked out a statistical profile with the identification of the land use changes direction and the main current socio-economic processes and actors with possible impact to land management and land cover change (see example of profiles of chelmsko-zamojski regions – Annex IV).

The proper selection will reduce the number of case studies on the base of worked out typology and data availability. Very important role in the final selection will have an experience from "pilot" study in Oresund region (represent cross-border and highly populated area). The number of case studies will be 4. As far as possible, we will try to select regions within the area of influence of the TPG countries.

Scheme of research

1. Region's general overview (on the basis of literature, regional expertise, documents and other sources)

2. Collection of statistical data and statistical deep analysis of regions.

3. Collection and analysis of main policy documents, especially those related to spatial planning (law related to spatial planning, regional plans of spatial organization, regional socio-economic and investment plans); planning system assessment.

4. Field study

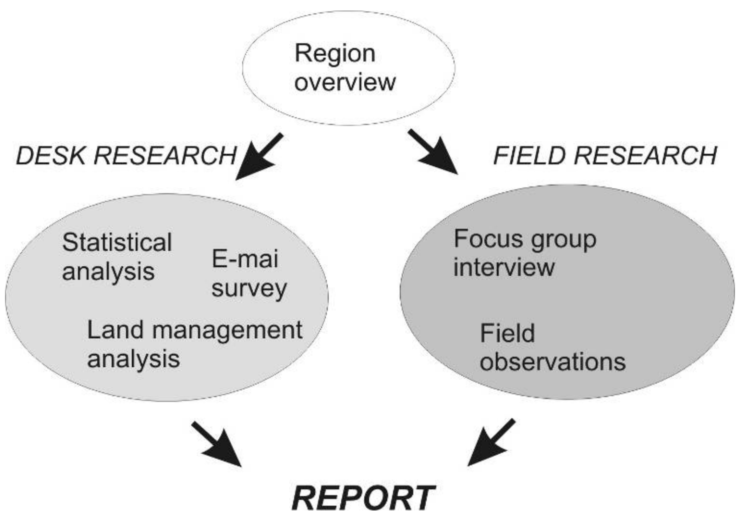
- focus group interview (3 regional experts + 2 members of TPG: one from partner responsible for the appointed region and one from IGSO). The preferred stakeholders are: (1) representative of regional authority, (2) representative of “practice” – eg. farmers, tourism, business association (depending on the main economic function of the region, influencing significantly land use changes), (3) representative of regional research organizations (university, research institutes, etc.) dealing with regional development issues. See draft version of interview questions in Annex IV.

- field observation of current condition of land use (character of settlements, structure of agricultural land, industrial areas, tourism zones, natural areas, multifunctional land use etc.).

5. E-mail survey (on-line survey): questionnaire with closed questions, addressed to wider range of stakeholders (representatives of different departments of regional administration: planning / transport/ energy/ agriculture/ environment etc.; representatives of private sector, non-profit sector, experts from different branches of university)

6. Report (see Annex IV)

Figure 8 Basic scheme of case study research



4. Description of further proceeding towards the Draft Final Report

Final report commitments

The Draft Final report will take into account feed-back on the Interim report from an ESPON seminar and by the Sounding Board. The report is supposed to include elements such as:

Main main results, trends, impacts, projections and options for policy development, including key analysis/diagnosis/findings and the most relevant indicators and maps (any additional information should be included in a scientific report). Particularly important are options for policy makers, which could provide the basis for interventions related to opportunities for improving European competitiveness and cohesion.

An executive summary, summarising the main results of the applied research that can be communicated to a wider audience of stakeholders. This summary should be based on the report mentioned above.

Scientific report documenting the scientific work undertaken in the applied research including elements such as:

- Literature, definitions and methodology/theory used.
- Methodologies, typologies and concepts developed and used.
- Data collected and indicators used, including calculation algorithms and tables with the exact values of indicators.
- Maps produced in support of the results, covering the territory of EU 27, Iceland, Liechtenstein, Norway and Switzerland.
- Tools and models used or developed.
- Future research avenues to consider, including further data requirements and ideas of territorial indicators, concepts and typologies as well as on further developments linked to the database and mapping facilities.

Expected results by project task

Task 2.1 Data assessment & management

- Geodatabase
- Literature, definitions and methodology theory used
- Data collected and indicators used, including calculation algorithms and tables with the exact values of indicators
- Maps produced in support of the results, covering the territory of EU 27, Iceland, Liechtenstein, Norway and Switzerland.
- Future research avenues to consider, including further data requirements and ideas of territorial indicators, concepts and typologies as well as on further developments linked to the database and mapping facilities

Task 2.2 Characterisation of land use in Europe: dynamics and typologies

- Characterization of land use in EU : In depth assessment of land use dynamics
- Definition of Regional typologies in Europe based on land use dynamics as a result of a clustering exercise and production of maps with European coverage
- Methodologies, typologies and concepts developed and used

Task 2.3. Land Use Performance and Efficiency

- Assessment of European territorial performance and related land use efficiency
- Methodologies and concepts developed and used.

Task 2.4. Case Studies

- Identify and analyze factors and drivers
- Give answer about mechanism and trends (processes) of land use changes in micro and macro scale;
- Verify and confirm proposed typology processes and challenges

Task 2.5. Policy Recommendations

- Guidelines for Policy Recommendations for spatial development based on land use patterns in Europe in view of regional specificities

Annexes

Annex I Collected data
Annex II Policy review: objectives and targets
Annex III Pilot case for The Netherlands
Annex IV Case studies description
Annex V Bibliography

www.espon.eu

The ESPON 2013 Programme is part-financed by the European Regional Development Fund, the EU Member States and the Partner States Iceland, Liechtenstein, Norway and Switzerland. It shall support policy development in relation to the aim of territorial cohesion and a harmonious development of the European territory.

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