EU-LUPA

European Land Use Pattern

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1 Introduction

1.1 Europe: need to understand the path of changes

Land represents the biophysical unit determined by its natural components (geological and geomorphologic structure, soil, water, climate, flora and vegetation, fauna). Land is understood as a reference place where multiple interests coincide. Sometimes these interests are linked to the land functions which may be complementary, but very often, particularly in the densest areas, conflict of uses occur that require information and complex set of tools to manage. This is not limited to the development of artificial surfaces for housing versus transport and economic activities; intensification or extensification of agriculture practices; conversion of natural land to agriculture or farmland abandonment; afforestation or deforestation, etc. The imprint of human activities on the land is strongly related to the amount of energy invested for its use and transformation. As a consequence the more intensive changes in shortest period of time tend to be the most irreversible.

The shape and patterns of current European land is an expression of centuries of human intervention on its environment. The geographical context and the availability of resources, alongside 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 has also had a major influence. Those differences in land use decision processes due to different pattern of legal, constitutional and administrative framework represent an aspect, which macro-regionally shape Europe. There is also a scale dimension in relation to governance, from local planning to European institutions.

Although the European Union does not have any competence to regulate land use and land planning, there are several policies that have a strong impact on the territory (e.g. Habitats Directive or CAP). 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

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.

Policy decisions that shape land-use involve trade-offs between sectoral interests, including industry, transport, energy, mining, agriculture, forestry (SOER, 2010) as well as protection/

conservation and recreation activities. There is a lack of a comprehensive and integrated approach that takes those trade-offs between many sectoral, social and environmental issues into consideration.

In particular- **A Resource Efficient Europe 2011:** Flagship initiative under the Europe 2020 Strategy, sets the goal of no net land-take by 2050. Yet this mandate will mostly likely work against the goals of a number of regions; particularly those seeking to ascend the socio-economic ranks toward the most established European nations.

Even more, globalisation and new communication tools open the space for new geographies sometimes disconnected from the physical source.

It is strikingly clear that we have double-sided relationship between land and growth. We are dependent on land to provide the resources we need to grow (particularly in the short term), yet our ability to grow (particularly in the long term, which is often referred to as development) is inseparable from our need to conserve and protect land.

Two European initiatives have been developed in order to gain an understanding on these process and also to provide evidence/warning on more unsustainable process. Each one has its advantages and constrains:

- Corine Land Cover. The information is derived from satellite images and available for three time shots in most of the European countries: 1990-2000-2006. In fact the nomenclature reflects a mixture of land cover (biophysical component of the land –e.g. water) and land use (e.g. built-up areas are differentiated by its use). The main limitation is on the resolution of the data both on the stock (percentage of certain type of land cover) and changes. Limitations are also clear on linear features (e.g. roads and rails) and also on plots below the CLC resolution. On the other side each portion of land has one single attribute or class, not allowing assessing the degree of multifunctionality.

- LUCAS. This is an initiative of Eurostat (started in 2001) is based on in situ monitoring and focussed on pure land use. In fact this approach recognises all land uses in a certain place. In parallel a soil monitoring has been developed. The downside of LUCAS is that its statistical significance is only relevant at NUTS 2 level (Kleeschulte et al.,2011).

These two initiatives illustrate to a certain extent the interchangebility of “land cover” and ”land use” as terms describing overlapping or even identical perspectives to the way land exists or is consumed in time and space. Nevertheless, the distinction between the two can be made very simply. Land cover is a term that reflects the bio-physical nature of the land surface. To determine the land cover is simply to ask one’s self what they see when they look to the ground. Therefore, in its absolute sense it is void of human perception and be placed in zero-sum terms. Examples of land cover could be given in relational terms (i.e. natural or non-natural) or in absolute terms (i.e. grassland or bare rock).

In contrast, a land use is an adjective that is used to describe the manner in which the land is perceived or consumed by humans. For example, ’recreational’, ’preserved’ or ’waste’ land uses are often legal entities but also speak to the describing the nature of human activities

that use, exploit and consume land. For example, agriculture, industrial land, transport areas, pastures, agro-forestry, plantations and irrigated land all relate directly to the use of land in space. Here, human intervention does not operate in zero-sum terms and allows for the inclusion of multiple functions on a given piece of land. For instance, we often hear the term mixed land use within planning policy as a way of describing the conditions and benefits of over-lapping land uses.

Land use and land use change in Europe have been mainly addressed from a thematic perspective (e.g. environment, agriculture, urban areas). There is a need to integrate all these different sector views in order to provide a better understanding on key questions even more relevant on the current time of general economic crisis, and at the same time 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.

With this in mind, the task of LUPA is to provide evidence on land use and its changes that can support policy; which in turn can support an improvement of land use performance and thus land use efficiency. In other words to analyse comparable information about European regions based on data from different sources and different levels integrating physical dimension (land cover) with socioeconomic (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.

But the tangibility, dependence and interconnectedness we share with land itself (in this case relating to the bio-physical perspective of what covers the land) puts emphasis on the importance of accounting for land patterns and attributing these patterns to the general conditions of socio-economic development. Accordingly, the focus of the project is on the development of a land use characterization for Europe - one which perceives land in relation to the drivers, effects, challenges, or put more plainly, the general conditions of regional development in Europe. This characterization is to take place primarily by the classification of patterns of land and the processes of land change through regional typologies with a European coverage.

Within this context, it is increasingly understood that a more integrated, comprehensive and up-to-date policy approach is needed; one that can bolster sustainability through increased efficiency and a multi-functional approach.

As such, this project seeks to provide evidence to support such a policy initiative by providing a new and insightful way of characterizing land use patterns and their dynamic relationship with socio-economic growth. For example, it emphasizes that we need land to grow, but our growth puts pressure on the social, economic and environmental services we can obtain from it. But it also shows that the drivers, the enablers and the ingredients of what we require for development are the very things pressuring the over-consumption of land. This pressure cannot continue to escalate as we continue to develop and it means that a growth model that is blind to the host of thresholds related to land and its resources cannot continue sustainably.

An **integrated assessment** of land use 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.

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).

1.2 Hypothesis for investigation

Land use patterns and dynamics are integrated in a certain typology as a means 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.

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 processes tend to homogenise and converge to similar typology. 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 reflects 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.

It is expected that the diversity between the regional realities within the European territory could be also reflected in their land use dynamics which in principle would obligate the analysis of each reality independently in order to be able to define meaningful policy recommendations.

However, it is out of the EU-LUPA project scope to provide a place-based approach to policy making unless for the case studies.

2 Research approach

2.1 Overview

Land use and land cover changes in Europe have been extensively addressed by the use of Corine Land Cover data which currently is available for three time shots: 1990, 2000, and 2006. Its use has been very much focussed on environmental aspects. However, its potentiality has not yet been fully exploited by relating the observed patterns to on-going socioeconomic process. EU-LUPA's innovative approach is focussed on two aspects: intensity, which relates to the interaction of human activities with observed patterns of land use, and multifunctionality. The concept of multi-functional land use (Knickel et al., 2004) recognises that it is often desirable to maximise the benefits obtained from a given parcel of land, and that a more equitable balance of the competing economic, environmental and social demands on land is more sustainable in the long-term than an unbalanced system.

In order to achieve these objectives the approach taken by Eu-LUPA is based on several building-blocks that provide a complementary view and understanding of the land use patterns:

- The first component is a simple observation of prevailing characteristics of the land.
- A second component tries to understand where the hot spots are. Hot spots are defined by characterising the amount of change and its intensity.
- In order to understand hot spots it is also necessary characterise the type of changes which derives the change typology.
- The last building stone is the development of land use functions.

All these elements are described in more detail in next sections.

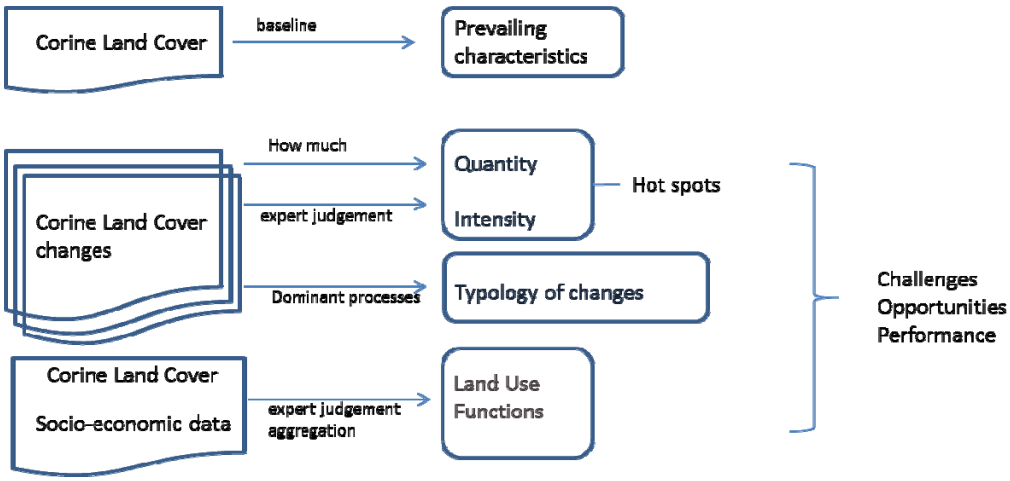


Figure 1. Overview of the methodological approach to the land use patterns taken by EU_LUPA. The first pillar (on the left) provides the needed data. The second pillar can also be analysed from the top to the bottom, starting with a simple characterisation of the baseline, then identification of hot spots and typologies of changes, and finally the characterisation of land use functions. All these elements together assist in the identification of challenges, opportunities and performance.

2.2 Analysing land use patterns using typologies

Typologies are defined as the classification of entities into types based on shared or common characteristics. In the context of the EU LUPA, their general role is to serve as an analytical tool to support the development of land use policy recommendations for Europe. More specifically, through the use of CLC data, they are used to characterize land use and land use change in Europe.

In looking to develop typologies the answers to three central questions are sought:

1. What are the general characteristics of land use in Europe?
2. What characterizes land use changes?
3. How are both of these connected to the socio-economic development?

Ultimately, it is the objective of the project to show that by responding to the first two questions the EU LUPA typologies provide an optimal characterization of land use patterns that reflect socio-economic dynamics. This in turn reveals additional insight into the nature of land use patterns and their relationships with socio-economic development.

It is also understood that concern during the typology formulation is that they should be simple, operational and easy to communicate, have a high explanatory power and be built on robust and complete data. The most immediate impact of these demands is that an individual typology cannot sufficiently characterize each of the dimensions required. Instead, one typology is necessary to interpret the prevailing characteristics of land use in Europe and another is needed to account for land use changes.

In generating typologies that seek to have a high explanatory power, it is advantageous to make them available for mapping at both the grid and regional formats. This relates to the need to integrate two different dimensions of territorial structures; on one hand represented by land cover data that is "independent" independent of administrative bonds; and on the other hand by socio-economic data that is constructed by explicit administrative bonds – in this case, the NUTS2 and NUTS3 levels. At the same time, it is also important to point out that a gridded output is needed to acknowledge land functions that take place in overlapping or close proximity and for pursuing intra-regional analyses in the case studies.

Given the complexity of patterns and processes driving land use and land use change, as well as the nature of the data that is needed to account for both land cover and socio-economic dimensions, it is not possible to aggregate all of the relevant and interesting information into a single typology. Accordingly, a complete understanding requires consistent framework for integration of scales and themes. The result is that this task uses CLC data in three general ways to create typologies of land use patterns in Europe:

1. In relation to the prevailing characteristics of land use: answering the question, based on the distribution to CLC data, what characterizes the land use in Europe? The results are typologies of prevailing characteristics of land use provided at both a 1km^2 grid level and a regionalized NUTS2/3 level.

2. In relation to the intensity of land use change. Intensity is understood as the degree of human intervention on the land caused by socio-economic activities. It is included in the analysis based on an inferred intensity hierarchy that is inherent in the CLC classification. This allows for the production of a basic typology showing **Hotspots of Land Use Change**, which typifies regions based on the levels of physical change (by area) and intensity change that takes place.

3. In relation to land use change: this is the cornerstone of the EU LUPA land use characterization and it answers the question, based on the regional clustering of all CLC flows, and changes in land use intensity, what characterizes land use changes in Europe? The results are typologies of Land Use Change provided at a regionalized NUTS2/3 level.

2.3 Understanding human activities: Land use intensity

The concept of land use intensity is introduced in EU-LUPA project to acknowledge and respond to the understanding that while socio-economic development is less and less attributed to land-based production; it is an ever increasing driver of land changes. Seen from this perspective, it is not only important to know how much land is changing, but it is crucial to know if land changes reflect minor changes (which usually reflect on-going socio-economic processes) or if they reflect major shifts in land cover (which are often part and parcel with structural socio-economic changes or environmental impacts). Furthermore, it is important to consider that increased human landscape intervention is among the strongest pressures on biodiversity (Environment Council, 2010), and potentiating land use efficiency is a direct means of improving the sustainability of land use in general.

This aim is in direct relation to a key question of the project; namely, how and to what extent land cover changes interact with ongoing changes in the ways the land is used for socio-economic purposes. This in turn raises questions of how the typologies in EU-LUPA can reflect on both the physical characteristics of land patterns and the socio-economic dynamics of land use that are behind these changes.

In light of this, land use intensity is defined as: the degree of human intervention caused by activities taking place on a given parcel of land - activities that, in most cases, do not have a direct and one-to-one implication on the characteristics of land cover. Therefore, the intensity is not related to the amount of input used – a driver that usually leads to an increase of production from a piece of land (cf. Gabrielsen, 2005). Such a characterization would be reminiscent of what we are trying to avoid – land use characterization that is preferential the inputs and outputs of land-based production. But at the same time, land use intensity is not only related to the per capita use of artificial surfaces, for this is also too narrow a concept which tells more about the efficiency of land use than is doe about intensity (cf. Prokop et al. 2011).

In contrast, the quantitative assessment of land use intensity is created based on the inference that the ordering of the CLC classes – from CLC 34 – Glaciers and Perpetual Snow to CLC 1 – Continuous urban fabric – are representative of has an increasing level of land use intensity. This ordering is based on a conservative set of guidelines and assumptions that are used to reinforce the plausibility of scoring land use intensity through the CLC classification hierarchy in lieu of additional validation. Wetlands and Water bodies and have not been considered in the analysis due to uncertainty over the associated socio-economic activities that may take place on them.

We are aware that this relatively simplified approach may be critiqued for being too simplistic. However, the structure of the CLC at an overall scale obviously shows tendencies towards the interpretation as indicated above. Thus, it is clear that when looking into details there are limitations to how much characterization and distinction can be incorporated into the scale of intensity reflected by the CLC classification.

Nevertheless, preliminary validation of the land use intensity concept uses indicators that can infer the value of land in relation to the range of socio-economic activities it provides (again, especially those which are not related to land-based production). Two indicators that best serve this purpose are population density and gross domestic product (GDP). In terms of the former, the presence of greater concentrations of people is quite clearly indicative of higher land use intensity. This impacts land especially through the development of artificial surfaces in order for people to establish their everyday lives and routines in space. As mentioned, the desire for increased living and recreation space reiterates that increased population in a given area creates more intensive land use – which through the creation of impervious surfaces reflects the complete manipulation of landscapes.

GDP is also a good indication of land use intensity because of the safe assumption that increasing economic output is equal to situations of greater land intervention. This is not only placed in terms of land-based production but also incorporates the role of urban areas as areas of relatively high economic output. However, one of the problems in relation to

GDP being a perfect indicator of intensity is that economic outcome of the land use activities may not always be registered where the economic activity takes place. For instance, the registration of the economic outcome of production from a factory may depend on the accounting system, i.e. whether it is registered where the production takes place, where the workforce is living, or where the central office of the factory is situated. Similarly the energy outcome of a windmill may be registered where it is situated or where the owner of the mill is residing. But even with these constraints in mind, both population density and GDP are presumed as robust indicators of land use intensity.

Thus, the general causality of land use intensity is similar to that of physical land take; that as the development of society and economy take place both the amount of land changes and the invasiveness with which we change it increases. We can then take things a step further toward by saying that situations where population and economy grow vis-à-vis relatively low levels of land use intensification and land take will imply greater land performance and efficiency.

In total, seven intensity scales have been generated – three levels in the Artificial surfaces class and two classes in both the Agricultural areas and Forest and Semi Natural Areas classes. In terms of the Artificial surfaces class, Continuous urban fabric is considers as the most intensive land cover type because it represents urban cores and centres of sub-urban areas where over 80% of the land is impervious (Bossard et al. 2000). Likewise, these are areas that are known to support a majority of economic activity in Europe, as well as being the home to a high share of the European population.

The utility of ranking CLC classes according to intensity allows for the possibility to assess land changes in terms of intensification or extensification of land use. To achieve this, all land changes are accounted based on the consumption intensity score (what the land changes from) and the formation intensity score (what the land changes to). The intensity score of each land change thus amounts to the difference between the two scores. For example:

- A change from Natural Grassland (CLC class: 26, intensity score: 7) to an Airport (CLC class 6, intensity score 2) is an intensification of 5.
- A change from Pastures (CLC class 18, intensity score: 5) to Natural Grassland (CLC class 26, intensity score 7) is and extensification of -2.

Table 1 Ranking of CLC classes based on Land Use Intensity

GRID CODE	CLC CODE	LABEL1	LABEL2	LABEL3	Intensity Code
1	111	Artificial surfaces	Urban fabric	Continuous urban fabric	1
2	112	Artificial surfaces	Urban fabric	Discontinuous urban fabric	3
3	121	Artificial surfaces	Industrial, commercial and transport units	Industrial or commercial units	2
4	122	Artificial surfaces	Industrial, commercial and transport units	Road and rail networks and associated land	2
5	123	Artificial surfaces	Industrial, commercial and transport units	Port areas	2
6	124	Artificial surfaces	Industrial, commercial and transport units	Airports	2
7	125	Artificial surfaces	Mine, dump and construction sites	Mineral extraction sites	2
8	126	Artificial surfaces	Mine, dump and construction sites	Dump sites	2
9	127	Artificial surfaces	Mine, dump and construction sites	Construction sites	2
10	141	Artificial surfaces	Artificial, non-agricultural vegetated areas	Green urban areas	3
11	142	Artificial surfaces	Artificial, non-agricultural vegetated areas	Sport and leisure facilities	3
12	211	Agricultural areas	Arable land	Non-irrigated arable land	4
13	212	Agricultural areas	Arable land	Permanently irrigated land	4
14	213	Agricultural areas	Arable land	Rice fields	4
15	221	Agricultural areas	Permanent crops	Vineyards	4
16	222	Agricultural areas	Permanent crops	Fruit trees and berry plantations	4
17	223	Agricultural areas	Permanent crops	Olive groves	4
18	231	Agricultural areas	Pastures	Pastures	5
19	241	Agricultural areas	Heterogeneous agricultural areas	Annual crops associated with permanent crops	5
20	242	Agricultural areas	Heterogeneous agricultural areas	Complex cultivation patterns	5
21	243	Agricultural areas	Heterogeneous agricultural areas	Land principally occupied by agriculture, with significant areas of natural vegetation	5
22	244	Agricultural areas	Heterogeneous agricultural areas	Agro-forestry areas	5
23	311	Forest and semi natural areas	Forests	Broad-leaved forest	6
24	312	Forest and semi natural areas	Forests	Coniferous forest	6
25	313	Forest and semi natural areas	Forests	Mixed forest	6
26	321	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Natural grasslands	7
27	322	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Moors and heathland	7
28	323	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Sclerophyllous vegetation	7
29	324	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Transitional woodland-shrub	6
30	331	Forest and semi natural areas	Open spaces with little or no vegetation	Beaches, dunes, sands	7
31	332	Forest and semi natural areas	Open spaces with little or no vegetation	Bare rocks	7
32	333	Forest and semi natural areas	Open spaces with little or no vegetation	Sparsely vegetated areas	7
33	334	Forest and semi natural areas	Open spaces with little or no vegetation	Burnt areas	7
34	335	Forest and semi natural areas	Open spaces with little or no vegetation	Glaciers and perpetual snow	7
35	411	Wetlands	Inland wetlands	Inland marshes	N/A
36	412	Wetlands	Inland wetlands	Peat bogs	N/A
37	421	Wetlands	Maritime wetlands	Salt marshes	N/A
38	422	Wetlands	Maritime wetlands	Salines	N/A
39	423	Wetlands	Maritime wetlands	Intertidal flats	N/A
40	511	Water bodies	Inland waters	Water courses	N/A
41	512	Water bodies	Inland waters	Water bodies	N/A
42	521	Water bodies	Marine waters	Coastal lagoons	N/A
43	522	Water bodies	Marine waters	Estuaries	N/A
44	523	Water bodies	Marine waters	Sea and ocean	N/A

The sum of these scores for all of the land changes in a region is then divided by the number of land changes (regardless of the size of the change) to infer the intensity of land use change at a regional level for Europe. This also allows for the analysis of land use change hotspots, which combines the total area of land change with the average change in land intensity for each region to identify hotspots showing where extreme land cover changes have taken place due to large changes in terms of land area and/or substantial changes in land intensity.

2.4 Multifunctionality

Mankind uses land for a multitude of purposes, obtaining many functions (economic, environmental and social) from any particular form of land use. The concept of multi-functional land use (Knickel et al., 2004) recognises that it is often desirable to maximise the benefits obtained from a given parcel of land, and that a more equitable balance of the competing economic, environmental and social demands on land is more sustainable in the

long-term than an unbalanced system. To this end, there is a need for evaluation tools which allow a more sensible approach to the assessment of whether competing demands in a multifunctional land use system are sustainable or not. In particular, there is a need to integrate information and data from a wide variety of sources into a single evaluation framework.

The approach to "land use" should be seen not only from the land cover perspective but from "functionality", where there is a linkage with other transversal issues. "Functionality" could be a motivating approach in the integration of land cover, land use management, socio-economics, transportation, energy conservation, water management and climate change. While the concept of "land use" traditionally has been considered to some extend being binary, i.e. one land use activity would exclude other activities, the situation in Europe is that the functionality has been in a process of diversification: on one hand towards exclusiveness with mono-functional large scale production, and on the other hand towards inclusiveness, stressing the fact that different activities co-exists, and that the policy and planning issue is the development of methods where the question of harmonious and disharmonious functionalities could be a way of improving the planning process.

It is now clear that even though a CLC-prescribed notion of land cover can be used to infer land use such an approach leaves room for improvement for meeting the multiple elements of a comprehensive and up-to-date definition of land use. This would be a notion that simultaneously reflects direct and indirect uses, mono- and multi-functional uses, and especially, its contribution to socio-economic production which is not explicitly related to the consumption of land.

In fact, one may argue in line with Verburg et al (2008) that the term land functions would be a more suitable concept when referring to the goods and services provided by the land systems. Their view is that land functions "not only include the provision of goods and services related to the intended land use (e.g. production services such as food and wood production), but also include goods and services such as the provision of esthetic beauty, cultural heritage and preservation of biodiversity that are often unintended by the owner of the land.

Based on the need to approach these multiple perspectives of land use, EU-LUPA has introduced the notion of Land Use Functions and has completed a comprehensive analysis of changing performance in relation to six individual land use functions:

1. LUF1: Provision of work
2. LUF2: Provision of leisure and recreation
3. LUF3: Provision of primary products
4. LUF4: Provision of housing and infrastructure
5. LUF5: Provision of abiotic resources
6. LUF6: Provision of biotic resources

Synthesis of these functions also allows for the summaries of land use functions relating to:

1. Provision of economical functions
2. Provision of environmental functions
3. Provision of societal functions
4. Provision of total functions

Land Use Functions (LUFs) express the goods and services that the use of the land provides to human society, which are of economical, ecological and socio-cultural value and are 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 (agriculture and forestry as the main production sectors, nature conservation and rural tourism as land conserving activities, and settlement, transport and energy infrastructure as urbanised land uses);
- Ensure that relevant economic, environmental and societal key issues in land use have an equal representation;
- The functions are likely to be affected by European policies.

The six functions were reviewed by an expert panel during the ESPON seminar on 'Evidence on European Land Use' that was held on 24 May 2011 in Brussels. The panel found that the six LUFs provided a good compromise between the number of functions and the topics covered, i.e. the six LUFs considered key functions of land use, they could be assessed by the set of indicators currently available at a NUTS 2/3 level, and they were easy to communicate main messages to policy and decision makers. It was also concluded that many different classification of the functions could be made, if needed, since the approach is flexible. The LUFs have been defined considering main links to the economic, environmental and social dimensions, and are listed in Table 2. It should be noted that 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. Consequently 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 is considered economical (building areas are strongly linked with economic development), but it can be considered as well as social 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 land-based products	Land-dependent production of food, timber and biofuels
	LUF4	Provision of housing and infrastructure	Building of artificial surfaces: settlements (residential areas, offices, industries, etc.), transport infrastructure (roads, railways, airports and harbours)
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)

The methodology for developing the six Land Use Functions is summarised in these steps:

- Selection of indicators. In this step indicators are selected from an extensive survey of harmonised European datasets. Following this selection an indicator set is built that enables to measure quantitatively temporal changes in the performance of the six Land Use Functions.

- Definition of the links between indicators and the LUFs. The specific links between the selected indicators and the LUFs should be defined by a group of experts using a generic table which lists and quantifies the contribution of each indicator to each LUF, and justifies the scores.

- Assessment of the specific importance of each indicator for the economic, environmental and social dimensions of the 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 'area harvested' is unlikely to be relevant in a region with small agricultural area. In effect, this step reflects the uncertainty and regional differences that need to be taken into account in the assessment. 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. It is an expert-based value judgment on what impact it would have on sustainability in the region if that indicator was to have an unacceptable value based on the current knowledge.

- Normalization and equalizing of indicators values. 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. Within this aggregation framework it is considered to normalize the values towards a nominal scale of 0 (low performance) to 10 (high performance).

- Integrated assessment of the land use functionality. The final step is the integrated assessment in order to derive a final functionality score. The integrated weighing of all the indicators contributing to a LUF, provides a comprehensive description of changes observed in the indicators, which in turn shows the overall consequences (stimulating, hindering or none) for the LUFs performance.

2.5 Land use performance and efficiency

How to measure if the ongoing trends of land use change in the European regions are sustainable or whether they are compromising future development has been one of the key challenges of the EU-LUPA project research. These questions have been approached by analysing performance and efficiency.

Land Use performance is defined in EU-LUPA as the degree in which the land used to deliver a specific function complies with a related policy target. The policy goals should be clearly defined and could be simple (e.g. job provision, air quality, soil quality) or combined (e.g. job-to-housing ratio). The policy goals should be ideally available at national or regional level. However, many policy targets are disconnected to the direct land use or data is not enough relevant. In particular, only two policies specifically refer to land use targests- **A Resource Efficient Europe 2011:** Flagship initiative under the Europe 2020 Strategy, sets the goal of no net land-take by 2050 and the Nitrates Directive.

As an alternative, the EU or national averages could be used as reference. Consequently the performance of a region will be in relation to the national or European average.

Efficiency has a wide variation in meaning for different disciplines. In general terms, efficiency describes the extent to which time or effort is well used for the intended task or purpose. In the case of land use science, this definition could be translated as the extent to which land is well used for the intended function considered.

The term "efficient" is very much confused and misused with the term "effective". In general, efficiency is a measurable concept, quantitatively determined by the ratio of output to input. "Effectiveness", is a non-quantitative concept, mainly concerned with achieving objectives. IN EU-LUPA effectiveness is clearly related with the Land use performance definition, i.e. achieving policy objectives.

Three different approaches have been taken in EU LUPA:

- **Connecting typologies with land use functions**. First exercise has been to assess the connection of Land Use Change typologies to Land Use Functions. The idea is showing regions where changing land use functions are taking place. From a socio-economic perspective – where the Land use change typology has incorporated the notion of land use intensity – it is particularly interesting to compare the typology results to the LUF analysis of land use for provision of work. This seeks to further extend the analysis of the drivers of land use change by analyzing land use changes vis-à-vis changing socio-economic and activities taking place within European regions.

  A cornerstone in the LUF categorization is the connection between the performance of European regions in relation to the functions under consideration. Furthermore, the ability to measure the performance across the same time series as the most recent CLC data allows us to analyze changes in land use functions in relation to changes in land cover - as presented by the land change typology. This is an opportunity that allows us to significantly expand the manner in which socio-economic and environmental activities are analyzed in relation to land cover data.

  With a numerical distribution of the performance for all outputs of the LUF analysis it becomes possible to compare the distribution of the LUF analysis (based on the matrix of performance values for each LUF) with the Land use change types for each region.

- **Land taken in relation to certain socioeconomic indicators**. A broad evaluation of the potential relationship between certain socioeconomic indicators particularly those set in the EU2020 Strategy and Cohesion Policy and the land take at NUTS2 level, based on CLC data, and by means of a scatter plot exercise, has been undertaken. EU2020 Strategy is the one for the EU's growth for the coming decade for a smart, sustainable and inclusive economy. These three mutually reinforcing priorities should help the EU and the Member States deliver high levels of employment, productivity and social cohesion. Five ambitious objectives - on employment, innovation, education, social inclusion and climate/energy have been established.

  Ideally we should have been able to assess the potential relationship between those objectives and land use patterns observed in Europe but we have identified two major handicaps:

  - Data availability. Most of the indicators set by the EU2020 strategy are available at NUTS2 level and even at national level for certain indicators on Climate and Energy.
  - On the other hand, from the 5 objectives set by the EU2020 it is very difficult to find a coherent link with land use patterns, particularly those on education and social inclusion

That is why we have selected a set of indicators to be analysed where we could identify some kind of policy relevance directly or indirectly to land use: Population growth; Employment rates 15-64; Long term unemployment rates; Gross Domestic Product at current market prices; Share of renewal energy in final energy consumption; RTD expenditure (as percentage of GDP). Then, two kind of analysis have been carried out:

- **Static analysis** comparing the state of the indicators in 2006 and land in take in the same year at NUTS2 level. Land take assumes changes, therefore we have two options: a) Compare built-up area 2006 with state indicators; b) Land take in the immediately previous period and the static indicator.

- **Dynamic analysis** comparing the average progress of those indicators for the period 2000-2006 and the average annual growth rate of land take (Land take 2000-06. LCF2 Changes 00-06: Urban residential sprawl +LCF3 Changes 00-06: Sprawl of economic sites and infrastructures)

Although statistically speaking there is a weak correlation between the variables analysed there are several outliers that could provide relevant insights on how land consumption in certain regions explain socioeconomic behaviour and viceversa.

- **Efficiency per land use function**. In this case, it is suggested to use a slightly broader model of efficiency, i.e. efficiency corresponds to the ratio

$$\text{Land Use efficiency} = O/I$$

of the amount 'O' (output) of some valuable resource/revenue produced by the use of the land, per amount 'I' (input) of land used. In this case land use efficiency is defined per land use function, and therefore this ratio should be calculated for each of the six Land Use Functions. For example, LUF1 Provision of Work, efficiency will be defined as the nr of jobs per sector related to the use of the land for that specific sector. The definition of efficiency is therefore linked to the specific functionality of the land used and does not always correspond to a percentage when the resource/revenue produced and the areal (amount of land) used are not compatible units, or if they are transformed into products. For example, in the analysis of the efficiency for the LUF 3 Provision of food, the product P may be the revenues obtained by the production of food, timber and bioenergy, while the consumable C is the amount of land used as input.

Table 3 Link of land use functions to efficiency. Efficiency is measured as the output obtained per unit of input.

Land Use Function	Output (O)	Input (I)	Definition
Provision of work	Nr of jobs per sector	Area used by each sector	Base on NACE data on jobs per sector; consider the agricultural sector and al the other sectors: Nr of agri-jobs / km2 agriculture (CLC 21 + 22 + 24) Nr of jobs outside agriculture / km2 built-up area (CLC 11)
Provision of leisure and recreation	Nr of tourists (proxi: Nights spent in tourist accommodations)	Urban areas	Nr of nights spend in tourist accommodations / km2 urban areas (CLC 11 + 14)
Provision of food and energy (only for agricultural production)/ check with EFI for forestry	Area harvested	Agricultural area	Area harvested (km2) / agricultural area (CLC 21 + 22 + 24). Three options: (equal, less area harvested than total and multiannual crops)
Provision of housing and transport and transport infrastructure	Population nr	Built-up area and roads longitude	- Population nr / km2 built-up area CLC 11) - Population nr / km roads
Provision of abiotic resources	All the soil that is not sealed is consider as potential source of abiotic resources	Area of the region	Un-sealed area (km2) / Total area region (km2)
Provision of biotic resources	Area covered by N2000 and CDDA in 2006	Area of the region	Protected area (km2) / Total area (km2)

2.6 Strategy for policy messages and recommendations

A review of the most relevant EU policies, strategies and institutional reports has been undertaken in order to set the policy framework regarding Land Use in Europe

This review helps us in the contextualization of the land use change and land use dynamics as a policy driven processes

A qualitative DPSIR exercise was later carried out to better understand the processes behind land use changes, the impacts derived from those process, trade-off and conflicts among different interest of land use and the key responses to reverse the undesirable trends.

Based on sound scientific basis, the EU-LUPA project is providing key policy messages:

- Awareness-raising in form of key messages on how the land use dynamics and economic, social and environmental performance relate (e.g. “fast urbanizing areas face social and environmental problems”)
- Indication of potential and challenges in the regions in relation to the land use patterns found
- Formulation of policy measures and recommendations for European, national, regional (and local when appropriate-mainly as case study level) authorities to face the challenges and take advantage of the potentials, anchored in the EU Cohesion Policy and the Territorial Agenda policy objectives.

The EU-LUPA policy messages have been structured:

By kind of action: Policy responses are needed to:

- support responsible land management
- resolve conflicting land use demands affecting the economic, social and environmental performance of a region
- improve regional competitiveness and territorial cohesion towards sustainability based on the region potentials

by means of:

- Integrated programmes for land-use planning/ regional development and management (territorial agenda, regional policy and Water framework directive(integrated river basin management plans e.g))
- Sectoral policies that focus on economic drivers for certain land use types
- Targeted policy instruments that focus on specific locations or land-use types

By level of implementation: Territorial dimension on land use competences: within this group we will consider administrative boundaries for decision-making on "European, state and regional", to the three-level spatial classification adopted by ESPON (macro, meso and micro-scales). In the EU, land use planning depends on different administrative levels. Thus, in some countries land use policy is the sole competence of central government (state-level) while in other cases decision making is divided between state, regional and local agents. EU-LUPA is considering the governance structures and planning systems in place in each territorial reality in order to define the most appropriate level of implementation of each of the suggested policy messages and recommendations.

By regional land use change typologies: Having in mind the assumption that regions with similar characteristics may be addressed by a common set of recommendations and general awareness, the policy recommendations will be primarily associated to the different profiles of land use patterns obtained in Task 2.2 Regional Typologies.

2.7 Case studies

Four case studies have been analyzed in the EU-LUPA project. The pre-selection of the case studies was made based on the ESPON typologies with regard to represent specific and different geographical regions. The final selection reduced the number of case studies on the base of worked out typology and data availability.

At the first step the case study area was focused on the statistical profile of each region with the identification of the main current socio-economic processes and actors with possible impact to land management and land cover change.

Secondly the changes of the land use and land cover structure and they dynamics have been characterized. In each region major effect of the land use change (deforestation, desertification, soil degradation, biodiversity changes, urban sprawl, floods etc.) and dynamics of these changes identified.

There were analyzed regional development strategies and others regional and state documents according to land use policies and influences to land use changes. Other sources with influences to land use changes surveyed too, including interviews with local authorities and other important player.

Field studies were carried out in each o f the case studies, in which 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.) was done.

Besides personal in-depth interviews with preferred stakeholders - representative of regional authority, representative of regional research organizations (university, research institutes, etc.) dealing with regional development issues, were undertaken.

The case studies provide two key results:

- the identification of the drivers and dynamics of land use changes. They make possibility the answer about mechanism and trends of land use changes as well as interrelation between different functions and factors in those changes.
- and verification of proposed typologies of land use change. To date the verification has been made on the Land cover flow typologies. The next step in the assessment of the case studies will be the

3 Main results, trends, impacts

3.1 The prevailing characteristics of land use in Europe

In order to understand land use patterns in Europe, and related changes, there is a need to establish a baseline, a starting point that provides a common reference. One can argue that any baseline is an arbitrary selection, fitted to certain purpose, and consequently provide a biased perspective. In case of EU-LUPA the baseline has been constructed by the prevailing characteristics of the land for the full period 1990-2006 (Figure 4). According to that, 14 typologies have been identified, ranging from the more intensively urbanised areas to those areas characterised by natural components:

1. ***Urban cores and metropolitan areas*** – 29 regions – show a situation where almost 60% of regions have land characterized as urban cores and metropolitan areas in the grid-level typology. As such, their spatial distributions are quite similar. At the same time, when grid data are summarized at the administrative level, it becomes very evident that urban cores in larger regions are becoming overshadowed by more dominant (rural) land types. As a consequence regions in this type are generally smaller regions which can be characterized as regional city-states, where peri-urban areas and rural hinterland is accounted for in neighbouring regions. Thus, the urban land features in this type are influential not only for the social, economic and environmental performance of regions within this type but also those regions within near proximity.

2. ***Suburban areas*** – 32 regions – Urban land types have the dominating influence in these regions and that there is a clear connection to the gridded type “Suburban residential and economic land extending into peri-urban areas”. Urban and infrastructural related land typically consumes 15-20% of the region and as a result,

activities related to urban and infrastructural settings are highly influential in characterizing overall land use in the region. The distribution of regions in this type – for instance, most of Belgium – reiterates a noteworthy characteristic when regionalizing grid level results.

The results of the cluster analysis emphasize the vast difference in the size of NUTS regions throughout Europe. Even though the NUTS 2/3 hybrid helps overcome some of the problems with disproportionate regional sizes it is quite clear that heterogeneity is an unavoidable factor influencing the cluster results. For example, relatively small regions (in terms of area), such as those around Brussels and especially city-states have proportionally shares of urban land covers compared to relatively large regions that may be endowed by larger cities as well; such as Regions in Spain, France, Italy and the Nordic countries. As a result even though a city such as Madrid has an extensive urban area and a huge regional (and even national) influence, it can only be characterized as a "suburban or peri-urban" region because rural land covers still dominate in a physical perspective.

3. ***Suburban or peri-urban areas*** – 21 regions – Regions in this cluster are either situated in near proximity to large urban centres – such as London or Paris – or are similar to the previous land type in the sense that they have a higher urban land component because of the relatively small area of the region. The urban and infrastructural component typically covers around 15% (and up to 20%) of the land. Relatively high levels of artificial surfaces are also evident in certain regions where large urban areas are situated in relatively large regions (by physical size). For example, regions in Spain or those adjacent to city-states such as London fall into this group. Other examples include larger industrial areas, for instance in southern Poland, or further north in the UK where the region between Liverpool and Manchester serves as a densely populated hinterland for the city activities.

4. ***Arable land in peri-urban and rural areas*** is dominated by the very high content of arable land defined through CLC classes 12 to 15. These categories cover more than 70% of the land in the 41 regions characterized by this type. The historic role of the agricultural production potential of this land use type for Northern Europe, Central Europe and the Balkans is clearly indicated through its distribution as the immediate hinterland around the major urban centers in the Central-North, and the matrix which constitutes the core population areas along the rivers in the Balkan area.

   In addition to what is indicated through the three previous land use types, it is also notable that this land use type is becoming swallowed up by the sprawl of urban and residential related activities; especially in Central Europe. Being among some of the more fertile areas in Europe, the high intensities of crop growth has demanded a process where intensification is supported through increasing land prices. This, in conjunction with better loaning opportunities has limited the options for more traditional land use approaches. As such, these regions are an object of continued speculation in relation to future development and policy related to non-agrarian production and reproduction land uses.

5. ***Arable land and pastures in predominantly rural areas*** includes 97 regions that share many similarities to the "Arable land in peri-urban and rural areas" type discussed above. Both types are structured by combinations of the two grid typologies of "Arable land in predominantly rural areas" and "Pastures and agricultural mosaics in peri-urban or rural community areas". They show a clear dominance of arable land in combination with permanent crops and some forest land. Both types also have CLC classes 1-3 covering over 4% of the regional area. The main difference however, is that while arable land covered more than 70% in the previous land use type it is down to 50% while pastures, permanent crops and forested areas make up for the remaining differential.

   In a von Thünean perspective of concentric farming types around urban areas it is likely that, compared to the previous land use type, we are moving to the next intensity level of concentric circles around the major cities. It seems common that regions in this type could still be highly influenced by the major cities and their constant expansion, though.

   Also, compared to the previous prevailing regional land use type, we are clearly moving into a situation where the land use mix is slightly more diverse and has a slightly lower production potential than strictly arable land. While this is a predominant characteristic of more peripheral areas in Northern Europe, it at the same time has occasional appearance in Southern Europe, for instance with coverage in Spain, Italy, Turkey and Greece, but especially in the Balkan region where it constitutes a natural continuum from the more fertile lowland towards toward the more mountainous parts of the countries. Nevertheless, it is clear that agricultural activity is still quite prevalent in these regions, but the relatively arid climate for many of the regions means that agriculture is often dominated by less intensive permanent crops.

6. ***Rural arable land with permanent crops and some forest*** is characterized by a mix of arable land, pastures, mosaics and some forest in the 81 regions covered by this regional type. Even with the risk of stretching the von Thünen analogy too long, these regions seem to add a further step in the von Thünen intensity ladder as it is very much a continuation of the trend noted in the previous types (where the dominance of agriculture is waning toward increased presence of agricultural mosaics, often associated with permanent crops, pastures and dispersed forest areas). Compared to the previous regional type, this one shows an increased reduction in arable land, 40%, followed by forest areas above 30% while permanent crops are around 20%.

   This prevailing regional type has a very diverse extent in Europe; stretching from southern Sweden and Finland through eastern, central and western Europe, while also playing an important role in the south. Its coverage is notable throughout Spain, in central as well as in northern Italy, Romania, Greece and Turkey.

This type of diverse spatial coverage adds credence to the notion of it being a very diverse land structure, both in terms of rural land covers, but especially in relation to the mixed role of urban and rural landscapes.

7. ***Rural mix dominated by pastures with some arable land*** show a diverse land cover throughout its 52 regions. Again, this is a continuation of the trend in the previous three types where arable land, pastures, agricultural mosaics and sporadic forest are being replaced by first and foremost the permanent crops and forest land covers. However, given that no land type accounts for more than 43% of the areas in these regions it is safe to assume a quite diverse land mix in these regions.

   Spatially, regions in this type are situated together with the following regional type in the border zone between northern and southern land production types. This seems to indicate a production zone where on-going changes in climate could result in important changes both positively and negatively.

   What is even more interesting is the connection to the land situated in coastal areas stretching from Ireland through south-western England, Normandy, northwest coastal areas in The Netherlands and Germany, as well as down to the Spanish isles in the Mediterranean. It also appears to have relations to inland water and watercourses in central Europe. In both cases the interaction between land and water are important as they generate challenges as well as new opportunities. For example, opportunities exist in relation to tourism and possibilities for different types of renewable energy production.

8. ***Rural pastures and complex cultivation patterns*** is a relatively small but distinct type which to some extent covering 18 regions. It resembles the previous regional type by having a very high component of permanent crops in combination with some arable land as well as pastures, some agricultural mosaics and mixed forest. Its absolute dominance in south-central France and more occasional appearance in Latvia, Northern Ireland, Romania as well as in a few regions in central Balkan show that land is dominated by pastures, agricultural mosaics and mixed forest, while the presence of arable land is significantly diminished compared to the previous regional land types. This seems to point toward a few conditions that could be influencing the rural consumption of land. It is quite clear that pasturing is likely the dominant form of rural land use and the presence of forest may not be as high as compared to Estonia, Latvia or Romania where mix between forest and pasture activities is evident.

9. ***Diverse land use in rural areas*** is among the three major types encompassing a total of 97 regions, but actually represented through two distinctly different types – a northern and a southern type. These show similar overall coverage characteristics, but representing very different landscapes. Being one of the major categories represented in southern Europe and Turkey, it depicts what best can be characterized as typical Mediterranean landscapes. There is a diverse mix of land cover types with statistically significant levels of arable land (25-30%), permanent crops (15-20%) and forests (40-50%).

Similar characteristics account for the distribution of this type in the Balkans, primarily in Romania and Bulgaria. The northern landscape encompassing this type is characterized by the same mix of land cover, but with arable and grazing land being the dominant characteristic compared to forest and scrub coverage in the southern regions. Furthermore, from southern Scotland, across Norway, Sweden, and Finland, as well as into the Baltic States this type is connected to the expansion of more urban activities into former rural areas previously dominated by forestry.

10. ***Diverse rural forest coverage with dispersed areas of permanent crops, pastures and arable land*** is by far the largest type represented by a total of 171 regions in Europe, and mainly related to mountainous regions dominated by forest. More than 50% of the land is forested, but substantial input of permanent crops (25-30%) and arable land (10-15%) provide a basis for other economic input. However, such a large number of regions in a single clustering with such large variation in terms of landscapes and accessibility make it difficult for further generalization.

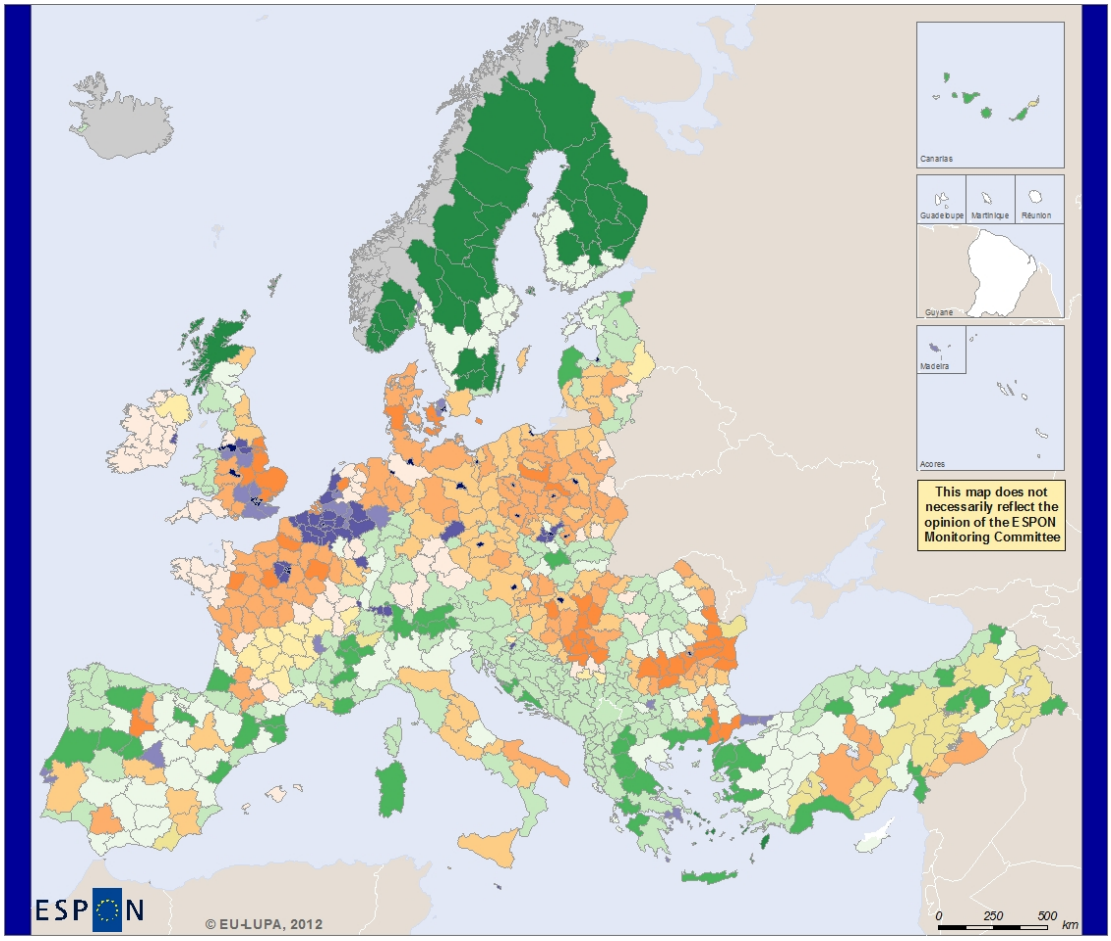
11. ***Arid mixed forest*** - represented through 56 regions, this type is in many ways a continuation of the southern type of the diverse land use in rural areas, but with a higher percentage of forest (50-60%) and it is situated in areas with more mountainous characteristics. It stretches across the whole Mediterranean area from Portugal in west to the most eastern regions in Turkey.

12. ***Sparse vegetation with some forests and pastures*** has been identified throughout mountainous parts of Europe, and with a major part of the 56 regions situated in Turkey, while the others are dispersed over most of Europe. The regions are characterized by a mixture of forests (30-35%) in combination with sparse vegetation (25-30%) and with scattered areas of arable land (15-20%) and permanent crops (15-20%). It seems safe to assume the land-based production potential could be quite low in terms of traditional rural activities.

13. ***Rural forest*** is typifies 30 regions with a clear northern orientation and where forest covers more than 75% of the areas, while water and sparsely vegetated areas constitutes the rest. In a Nordic setting these areas are responsible for a major part of forestry in the north stretching from Scotland through Norway, Sweden and Finland.

14. ***Sparsely vegetated areas*** constitute a total of 27 regions, mainly situated in Norway and Iceland, being characterized by a split between sparse vegetation and forest.

Prevailing Characteristics of Land Use 1990 - 2006



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Regional level: NUTS 2/3,X
Source: Nordregio, 2012
Origin of data: EEA, 2011
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Regional land use types

- Urban cores and metropolitan areas
- Suburban areas
- Suburban or peri-urban areas
- Arable land in peri-urban and rural areas
- Arable land and pastures in predominantly rural areas
- Rural arable land with permanent crops and some forest
- Rural mix dominated by pastures with some arable land
- Rural pastures and complex cultivation paaterns
- Diverse land use in rural areas
- Diverse rural forest coverage with dispersed areas of permanent crops, pastures and arable land
- Arid mixed forest
- Rural forest
- Sparse vegetation with some forest and pasture
- Sparsely vegetated areas
- No Data

Figure 4. Prevailing characteristics of land use in Europe (1990-2006).

In addition to the specific patterns of each typology one can observe an important bio geographic component, which determines a N-S gradient. In Northern and Baltic countries the homogenous rural forest is dominant. Moving to South the rural land dominanted by arable land becomes a common pattern, only altered by urban areas. Finally on the Mediterranean region one can see the high diversity of rural landscapes.

3.2 Where are the hotspots of land use change?

During the period 1990 -2006 Europe has undergone large amount of changes, even in some cases almost 30% of an individual region has reported some form of change. Here, the spatial distribution of these changes is also quite territorialized, where vast changes are especially evident in areas such as Spain, Portugal, the Czech Republic, The Netherlands and Ireland.

Some of the most significant changes between 1990 and 2000 takes place on the Iberian Peninsula. In part, this is likely due to the ascension of Spain and Portugal to the EU in 1986, which resulted in a process where the former agricultural structure was broken up and in many places turned into more intensive forms of production. Also the land ownership reforms in Eastern Central Europe during the 1990s resulted in marked changes, a process which was further fuelled by the expectations regarding future membership of EU in the period up to and after the membership in 2004. These are important observations because they highlight the types of changes that can be expected by current or future candidate countries. Similar changes are not yet observed regarding the Balkan countries as discussions and uncertainties regarding membership in 2007 did not provide the same expectations. Therefore more limited changes during the 2000-2006 period are noted –it should also be noted that different time lap compared to 10 years span of the 1990-2000 period may explain the results observed.

Yet all things considered, the most dramatic land change processes taking place in Europe continue to be predominantly driven by Europe's path of socio-economic development, which is taking place due to the effects of globalization and its effect on the global division of labour. The result has been a two-fold dynamic; on one hand, the continued decline of land-based economic production – i.e. agriculture, forestry, mining and quarrying, etc. – in favour of knowledge-intensive, innovation-driven and service-based economies on the other hand.

The former process has led to processes of extensification that result from the abandonment of former production areas when natural conditions or other constraints limit competitiveness. In terms of agricultural withdrawal, abandonment processes have been most pronounced in the central-south and north-east regions of Hungary (between 2000 and 2006), on the Italian island of Sardinia (between 1990-2000), and in Ireland southern Portugal to differing degrees throughout the 1990-2006 period.

The latter process has led to the incredible intensification of land use, toward increased property values and growth of urban areas (artificial surfaces). This is reflected in the fact that in 1990, 4.1 % of the EU territory was classified as artificial surface – share that increased to 4.4 % (an 8.8 % increase) by 2006. Even more telling is that the European

population grew by only 5 % in the same time period (Prokop et al. 2011). This 3.8% differential represents an increased per capita land take as a result of the demand for newer and bigger housing, more roads, and growth of business locations; each of which a represents the effect of development on the European landscape.

However, national or regional performance for limiting the extent of artificial surfaces cannot simply be judged based on total area or percentage of growth, especially over such a short window of time as 1990-2006. One issue is that the development of sealed surfaces is path dependent on socio-economic positioning and comparing rapidly developing regions against already established ones would be short-sighted and unfair to those regions that are "catching-up". Established regions have already undergone this process, it's just that they have done so in the decades or centuries prior to 1990.

In order to have a deeper insight on these changes and understand the hot spots two components have been combined: percentage of change and intensity of change (Figure 3). For each component 5 levels have beend efined resulting in a 5x5 matrix. Using this matrix, regions in white are considered to have relatively stable land use characteristics while increasingly darker shades of green or purple identify "hotspots" of change where high intensifications or extensifications are coupled with increasing levels of overall land change. The scales of intensification and physical change were selected based on the wish to have a simple and consistent classification.

One can observe a clear east-west dimension. Large volumes of land use extensification are almost exclusively found in Eastern European member states; particularly in Poland, The Czech Republic and Hungary.

High volumes of land use intensification are especially notable in countries such as The Netherlands, Brussels, Spain, Portugal and Croatia. In Spain, this is especially evident for regions along the south and east coast as well as the island regions. On regional/territorial level it is evident that intensification is associated with the growth (sprawl) of urban areas and their associated artificial surfaces. Intensification is also appears to take place in a greater degree for coastal regions (cf. in Spain, France, Croatia), likely related to the growth of the coastal tourism in these regions. In other words, European tourism is an activity requiring still larger areas, and the development of the Spanish coastline illustrates that it is not only a question of short term changes, but seems to have been a consistent development process throughout the whole period from 1990 to 2006.

All regions in Portugal are identified as hotspots, mainly due to the fact that all regions show very high levels of overall change. This is due to the high levels of ongoing changes related to forest management**.** In Lisbon, the intensification is predominantly related to residential sprawl between 1990-2000; a process that has slowed considerably since then (EEA, 2011). In Alentejo, relatively high land change is characterized as an extensification process. This is due to the fact that land abandonment due to the withdrawal of farming activities (EEA, 2011).

The immediate effects of the inclusion of East-Central European countries - previously part of the "East Block" mostly characterized by state and cooperative ownerships - are

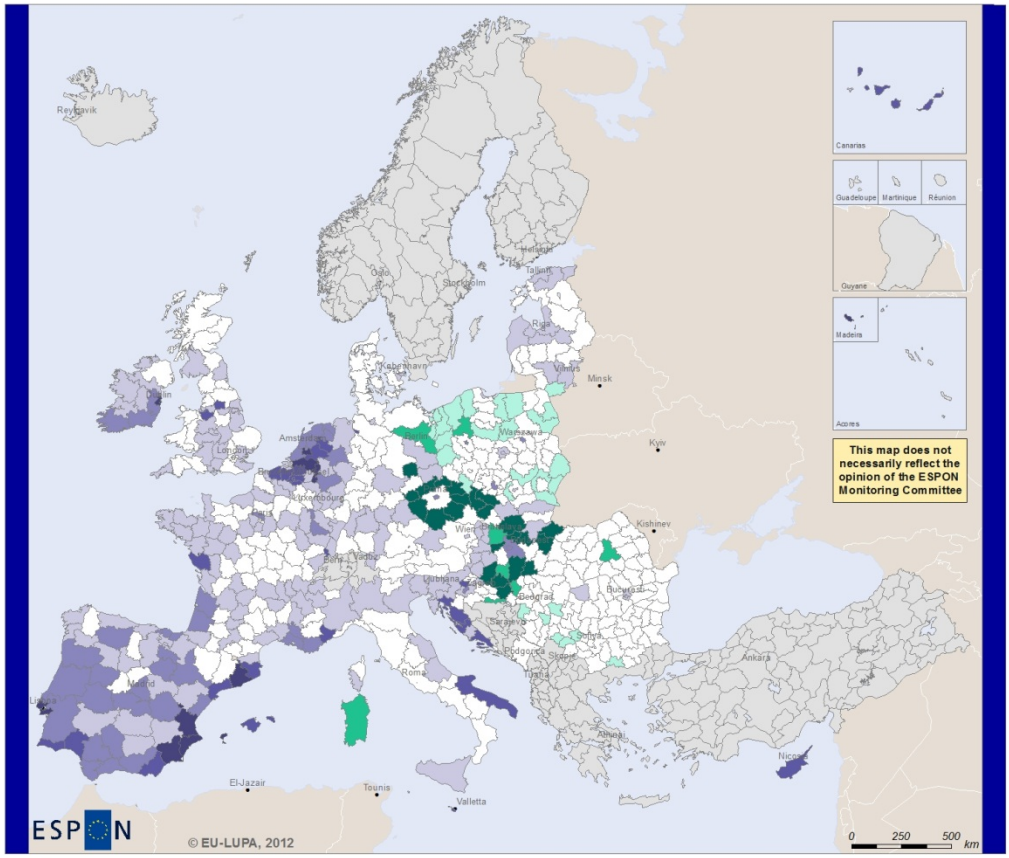
immediately reflected through a drastic decline in intensity over substantial areas in the period from 1990 to 2000. The reforms in ownership from the former state and cooperative ownerships forms has had some immediate consequences in relation to intensity due to that the new private farms did not have the necessary means to ensure a high intensity in land use. The situation in Poland being different in this respect because of a dominance of private land use activities, and as a consequence effects as described above only relating to the relatively smaller areas owned by cooperatives and a few state holdings as well.

The situation in Poland was, however also affected through the lack of funding for investments in many of the small farms functioning more as subsistence bases for a still older population, and several of the regions where this has been the dominating characteristic have continued being regions of decreasing intensity through the 2000-2006 period as well. One important element in this connection has been the small size of a substantial part of the already private farms. The advantage in other parts of East-central Europe has been that in the aftermath of the first round of extensification the new private farms were able to establish themselves not as subsistence activities but as professional and capital intensive farms on previous state or cooperative owned large scale farms. And similar situations have appeared in relation to other types of land use.

Ireland being a “hotspot” for IT development during the 1990’s had some spin-off in relation to increased intensification of activities related to land use. Partly because the attraction of labour force away from direct land use to industrial activities required adjustment in land related activities requiring technology to replace the missing workforce. With a partly collapse of the IT-adventure after 2000 the process described above came to a halt, and the shift is apparent when comparing the 1990-2000 and the 2000-2006 situations.

While missing data for Sweden, Finland and Norway for the period 1990-2000 does not allow a comparison between the two periods, an important issue of the effects of increasing activities related to resource extraction, especially in relation to oil and gas development, is very apparent for the 2000-2006 period shown for Norway. While fisheries used to be a mainstay for coastal communities in Norway the picture today is a high degree of dependency on the sea, but in relation to energy resource extraction. This leads to the inclusion of large areas for on-shore production facilities, but requires at the same time related economic activities – processing, investigation, planning, education etc., which shows through inclusion of still larger areas for housing.

1990 - 2006 Land Change Hotspots



EUROPEAN UNION
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Regional level: NUTS 2/3,X
Source: Nordregio, 2012
Origin of data: EEA, 2011
© EuroGeographics Association for administrative boundaries

Matrix of land change hotspots

The x-axis shows the percentage of land that has undergone change between the given years, while the y-axis indicates the intensity of those changes. Therefore, regions in white represent regions with relatively stable land cover characteristics wile increaslingly darker shades of green or purple identify "hotspots" of change where high intensifications or extensifications are coupled with increasing levels of overall land change.

No Data

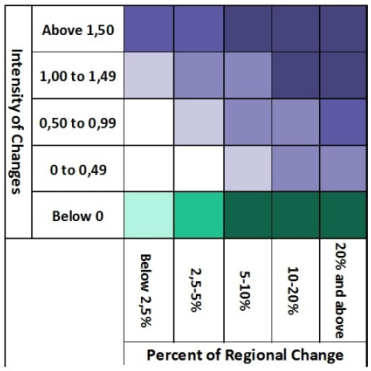


Figure 5. Land change hot spots (1990-2006).

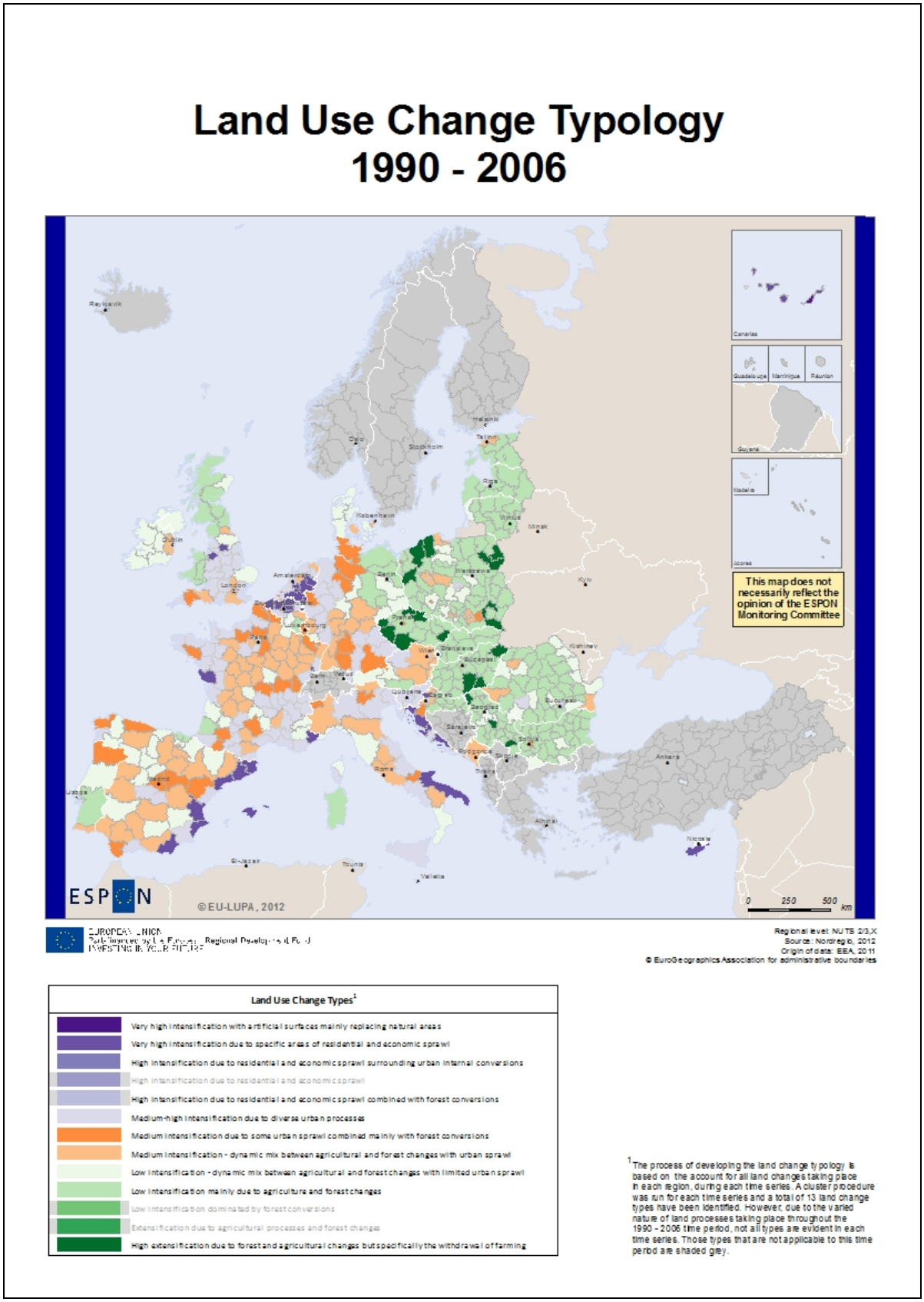


Figure 6. Land use change typologies.

While the hotspots enables us to identify places in Europe where marked changes have been taking place during the last 16 years, the development of a typology which is able to capture these changes and provide a connection between types and processes of change, an important planning instrument will be at hand. So the next step is to turn the focus on such a typology (figure 6):

- **Very high intensification with artificial surfaces mainly replacing natural areas**. Regions in this cluster are very unique. In each time series, both the area and the total number of land change are very small. However, the changes that are taking place relate exclusively to urban land management and residential, economic and infrastructure development. The very high level of intensification indicates the formation of these land uses results from the consumption of very low intensity land covers; most likely natural landscapes. Presence of this Land Use Change Type is limited to the Canary Islands (touristic infrastructure) and northern Norway (urban infrastructure supporting natural resource-based development).

- **Very high intensification due to specific areas of residential and economic sprawl**. Regions in this type are experiencing land use changes that are dominated by urbanization process. The term "specific" is used because, like the previous type, the level of change by area is low (for example, the average amount of land change for the 1990-2006 period was only 1.1%). The reason for such a low level of changes is that these regions are exclusive to the existing large urban centres in Europe; in particular, NUTS3 city-states. Urban form in these regions is already well-established and changes tend to further to the amount of urbanized area.

- **High intensification due to residential and economic sprawl**. This group encompasses three sub-categories with small variations: each type reflects the high level of economic and residential sprawl, but each type is somewhat distinct based on the land use change processes that accompany the sprawl. For this particular type urban sprawl is coupled with relatively high levels of internal urban change. Regions in this typology are predominantly located in western European countries where many regions in each country appear to be undergoing the same urbanization processes. Many of the regions are either located along the coast or in close proximity to large urban centres. For example, inland regions surrounding Madrid, Geneva, Zurich, Paris and Brussels are a part of this type, along with coastal regions in Spain, France, Italy and Croatia.

- **Medium-high intensification due to diverse urbaan processes**. This type characterizes over 100 regions that are undergoing very typical types of land change – moderate levels of urbanization processes are coupled with diverse forest and agricultural changes. Like each of the high and very high intensification types above there is a very strong western dimension to this type.

- **Medium intensification due to some urban sprawl combined mainly with forest conversions.** Regions in this type are undergoing relatively stable land processes with comparatively low levels of regional change (by area) in the sequence 1990-

2000-2006. While there is still a Western orientation to the regions in this type, the appearance of regions in Eastern Europe (for instance Poland in the 1990-2000 time series) is evident. This trend extends to regions in Romania and Serbia in the 2000-2006 time period.

- **Medium intensification - dynamic mix between agricultural and forest changes with urban sprawl**. The land use change characteristics in this type are similar to the previous type except the rural land processes increase in their role of defining regional changes. The same east west pattern is evident as in the previous type, but additional regions in selected Eastern European member states are notable, especially in the 2000-2006 time period (e.g. Romania, Serbia and especially Turkey).

- **Low intensification - dynamic mix between agricultural and forest changes with limited urban sprawl**. Regions in this group are characterized by land changes that have resulted in a neutral level of intensification (between 0.00 and 0.40). Rural land changes dominate in these regions with an increased level of change related sprawl of economic sites and infrastructures.

- **Extensification due to to agriculture and forest changes**. Regions in this group are unique in that they show regions where cumulative land changes in each of the time series' have resulted in an extensification of socio-economic activities taking place on the landscape. For a majority of the regions a dominant trend has been the replacement of agricultural activities in favour of pastures or forest land covers. As such, land use changes seem to reveal a socio-economic trend of rural stagnation; as rural land-based activities are being replaced by growth that is concentrated in urban areas. Regions in this type are exclusive to Eastern European and new member states, with notable distributions in Poland and the Czech Republic; particularly in the 1990-2000 time series.

3.3 What functions are supporting the different regions?

So far we have seen the changing faces of Europe related to different pathways. Next step is to understand what are the functionalities of a particular region underlying these changes.

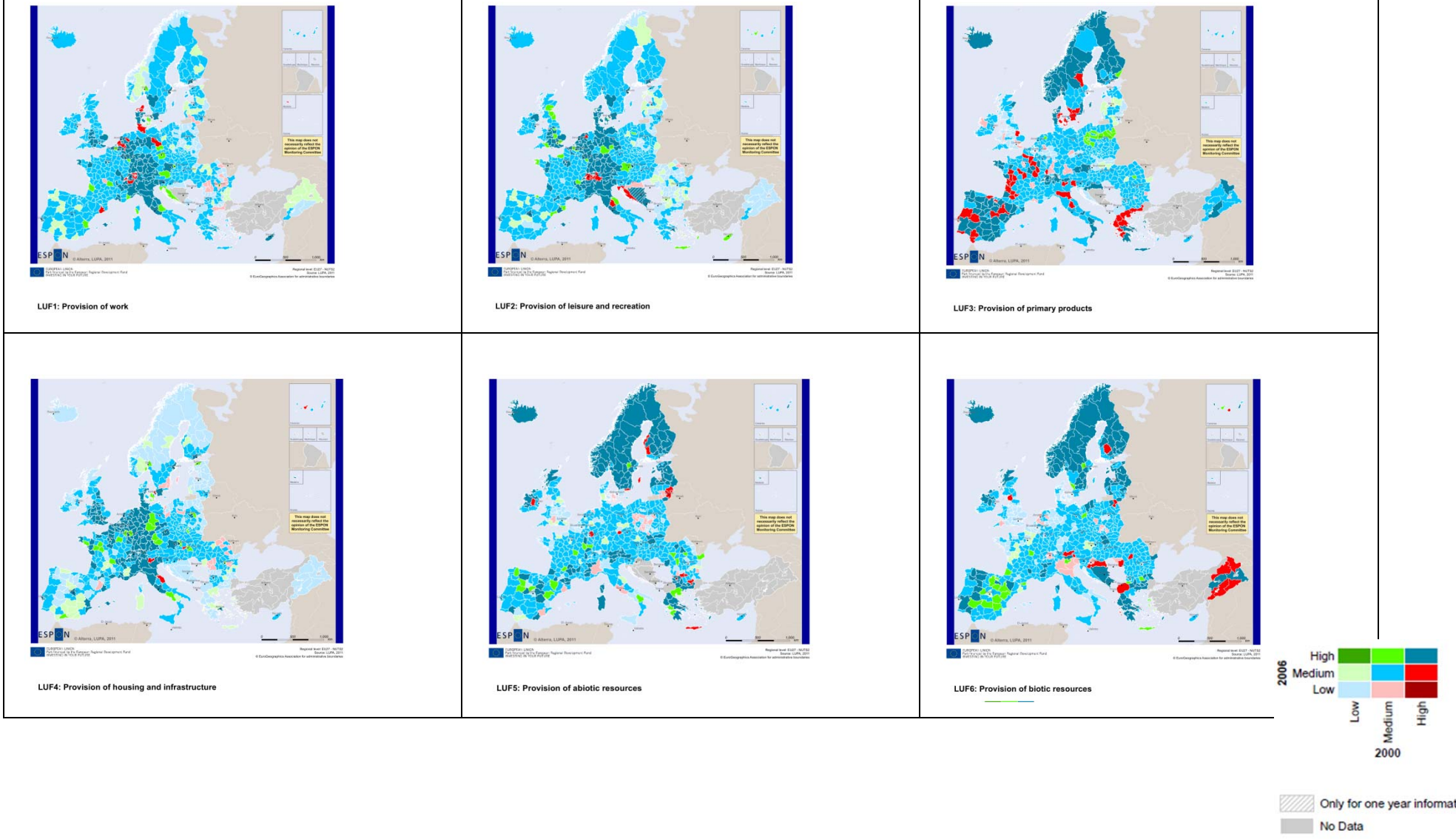
The spatial assessment of the changes in functionality between 2000 and 2006 starts with a general overview of the performance of economic, environmental and social dimensions. As it can be seen in Figure 7, the performance of the three dimensions remained quite stable (i.e. dominance of the blue colours). This mainly reflects the short time period, covering only six years. Few changes are observed, mainly in the economic and environmental aspects, and these changes are moderated – never from high to low or low to high. They do not follow apparently any geographical specific pattern. The social performance is high in the *Blue Banana* corridor. Interestingly, the regions where changes in economic performance are found do not coincide with those regions showing changes in environmental or social performance. Interestingly, this indicates that the three dimensions are not following the same development patterns. The economic aspects show a decrease in performance in

Southern Finland, Northern Denmark, North France, Cataluña (North-eastern Spain) and central Italy, and increases in southern Norway and Levante (eastern Spain).

The assessment of the changes in the six LUFs provides a more detailed insight at functional level. The analysis of the LUFs maps show that:

- Extreme changes do not occur and the overall pattern shows stability in the six years studied. Overall Scandinavia shows the highest stability, being central and southern Europe more unstable with mixed patterns.
- The two mainly economic LUFs (LUF1 Provision of work and LUF2 Leisure and recreation) show a high stable performance in the *Blue Banana* corridor, as it could be expected, although some negative changes in LUF 1 are observed in the fringes, e.g. in the Netherlands and East Germany, Eastern France and Barcelona. Positive changes are scattered except in Scandinavia and the Baltic countries. Other countries showing positive development are eastern Turkey, western Spain and central Europe.
- LUF2 Leisure and recreation shows a more general trend to increase the performance than to decrease. In general, coastal areas and the Canarias islands improve. Romania and Bulgaria increase from low to medium, showing developments in the tourist sector in the years previous to their entrance in the EU (2007).
- In contrast with the economic LUFS, LUF3 Provision of food, timber and biofuels shows negative developments in several regions, especially in the Mediterranean countries, which could be associated to land abandonment and decrease in area harvested (mainly conversion of rural areas into urban). In contrast, there are positive changes in Scotland and central Europe. It is interesting to see the different geographical patterns in Sweden, with a high and stable performance in the North (associated to forestry), and a negative performance in the south (linked to agricultural production).
- LUF4 Housing and infrastructure shows a high stable performance in the Blue Banana, similarly to the economic LUFs, indicating significant urban and infrastructure developments in the European Megalopolis. Coastal areas in the Mediterranean show as well a high stable performance and even an increase in some regions. Increases are also observed in southern Spain, southern Italy and eastern Germany, as well in main cities in central Europe (Budapest, Bratislava and surroundings). Decrease is found in few rural areas of Romania, Poland, South Sweden and Lleida (Spain).
- LUF5 abiotic resources shows scattered changes as it describes broad environmental issues linked to air, water and soil quality. Therefore variations are difficult to explain without assessing the changes in the indicators affecting the LUF.
- LUF6 biotic resources shows significant improvement in central Spain and north-western France. There are more negative developments than in the other environmental LUF. For example, in some regions of the Ducth ‘randstad’ (industrial and metropolitan conurbation occupying west-central Netherlands) where significant infrastructure and urban development has taken place. This trend appears as well in southern Alps including the densely populated Po valley.

Figure 7: Changes in the performance of the six LUFs: LUF1 Provision of Work, LUF2 Provision of leisure and recreation, LUF3 Provision of food and bioenergy, LUF 4 Provision of housing and infrastructure, LUF5 Provision of abiotic resources and LUF6 Provision of biotic resources, for the period 2000-2006.

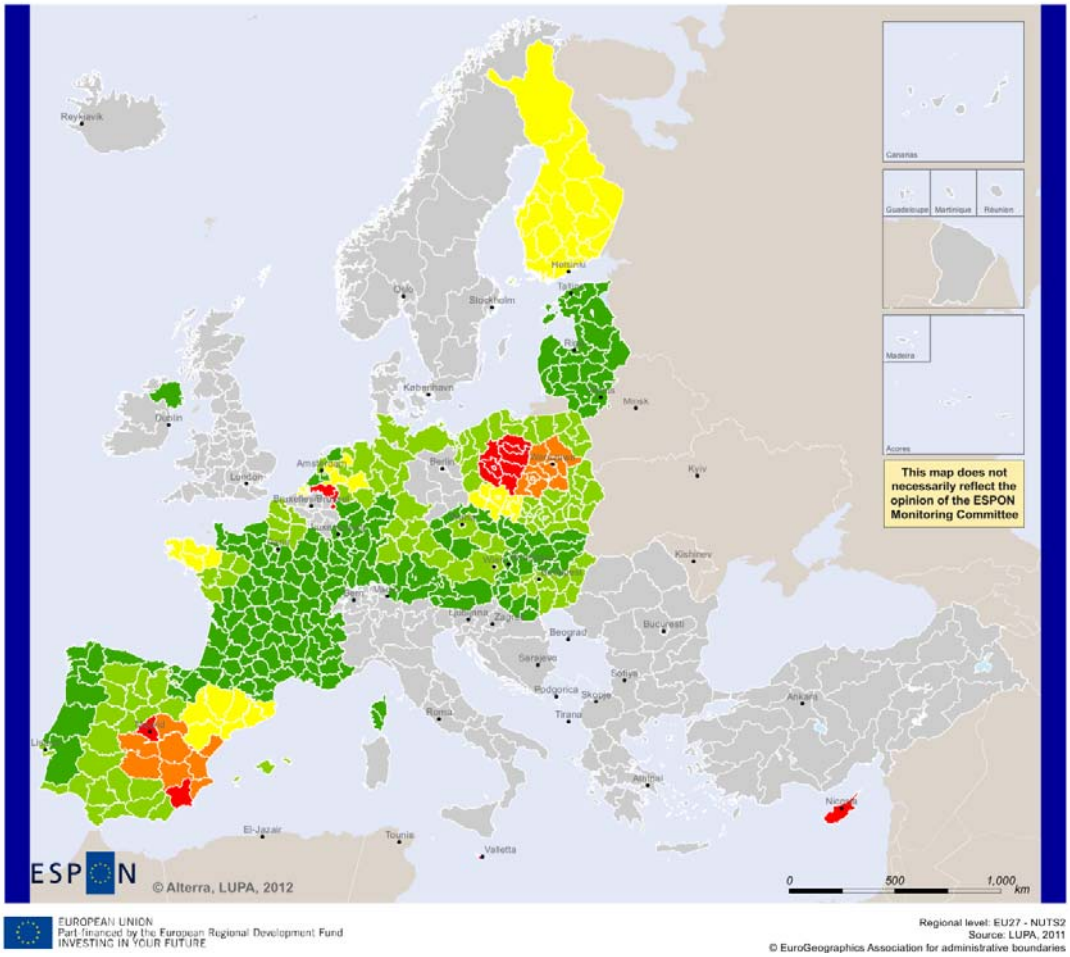


3.4 Analysing the performance and efficiency

One of the difficulties to understand the performance of European territories in relation to land use is that most of the policy targets do not have a direct translation on land use. Even that polices that have a more direct relationship with the land (e.g. Biodiversity, CAP) there are no specific targets on percentage of land that should fulfil certain requirements. This is strongly related to the fact that Europe has not any legal mandate on land planning. On the other side, the relevance of cities and the phenomena of sprawl have raised many concerns and the recommendation to limit urban sprawl appears in many documents. Moreover, land reclamation is strongly promoted by different means of funding and even a potential threshold in soil sealing is currently proposed in the EU2020 Strategy.

In EU-LUPA a test has been done with the Nitrate Directive in order to show the potentiality when a clear threshold is available. The Nitrates Directive requires MS to monitor surface waters and groundwater for nitrate pollution against a maximum limit of 50 mg nitrate/l (Directive 91/676/EEC on pollution caused by nitrates from agricultural sources). *The Directive seeks to reduce or prevent the pollution of water caused by the application and storage of inorganic fertiliser and manure on farmland. It is designed both to safeguard drinking water supplies and to prevent wider ecological damage in the form of the eutrophication of freshwater and marine waters generally*. Therefore this policy target clearly refers to the agricultural function considered under *LUF3 Provision of food, timber and biofuels*. One of the indicators considered underpinning this function is the Nitrogen surplus, for which values are available at NUTS 3 level.

The results in Figure 8 show that regions in eastern and central Spain, Bretagne in France, south of the Netherlands, Belgium, some regions in the western part of Germany, Finland and some regions in Poland do not comply with the nitrate directive and therefore their environmental land use performance regarding the agricultural land use is negative. Moreover, it is possible to differentiate the case of Poland where it is strongly linked to changes in agricultural areas, while in the rest of the countries the process is more complex and probably related to decrease in agricultural area or even displacement of agriculture to less productive areas by urban sprawl like in the case of the Mediterranean coast (EEA, 2006).



Option 1. Land use performance regarding the Nitrate directive
Policy target is below 50 mg Nitrate / litre - year 2000

- 67 - 140 % above threshold
- 34 - 66 % above threshold
- 1 - 33 % above threshold
- 1 - 50 % below threshold
- 50 - 99 % below threshold
- Only for one year information available
- No Data

Figure 8. Land use performance regarding the Nitrate Directive policy target.

Efficiency can be understood as the amount of resource needed to obtain certain output (benefit). In the case of EU-LUPA the resource is the land and it involve an understanding of the quantity and quality.

The approach taken by EU-LUPA has been based on linking certain socio-economic benefits with the land needed to produce these benefits. One of the main difficulties that have been found is the degree of aggregation of socioeconomic data. There are two types of aggregations that need to be considered: one is related to the administrative unit at which the data is provided; the other type of aggregation relates to the typology of the data itself. For example employment by sector can be disaggregated down to several sectors and subsectors. However, to link the level of employment to certain land uses one would require a level of detail of sectors which is not available at European level.

Another problem refers to the scale and the complexity of issues analysed. There are different drivers that act at different scale; consequently there is a need to identify the appropriate level for analysis. This is also connected to different resolution of original data sources.

To date, an analysis of the different typologies in each of the LUF´s has been undertaken. However, it has been very difficult to extract any relevant conclusion to this exercise. It could be rather interesting to do the analysis in the other way round. There is analyse the different LUFs within each of the land use change typologies.

3.5 Interpretation of the case studies

The case study regions of the EU-LUPA project are: Øresund (Denamark), Basque Eurocity (Spain/ France), Chełmsko-Zamojski & Jeleniogórski (Poland). All analysed regions are strongly diverse in the land use structure and land use changes respectively. According to the land use change typologies within the examined regions it is possible to separate some specific territories representing different clusters. The case studies investigated four of them:

- Low intensification mainly due to agriculture and forest changes,
- Extensification of rural activities,
- Dynamic rural and peri-urban changes,
- High extensification in rural and sparsely populated region and Stable rural and peri-urban activities.

The main process identified in these regions are described in further detail.

Urban residential sprawl represents intensification of multiple land uses (conversion of agricultural land into built-up areas). The main factors of those changes are: localisation close to road or railway infrastructure, good connection to core towns, access to social

infrastructure. This process is characteristic of **dynamic rural and peri-urban changes**. In these regions the development of non-land based economic activities occurs. The highest pressure on peri-urban areas is observed around big cities, which will certainly become a challenge for regional green structure plans like the Fingerplan in Denmark or sectorial planning in Basque Country. Urban sprawl is less chaotic in ountries with standardised spatial planning, and therefore the land use is very patchy (there are a lot of single houses scattered over a large territory, between the forest and agricultural areas). In the Polish cases there are also difficulties with lack of development in technical and social infrastructure in the suburban area.

Sprawl of economic sites and infrastructures Dynamics and directions of land use as well as the land cover changes are high or very high and are connected with the localisation and pressure derived from the new investors. Dynamic rural and peri-urban changes are represented in each of the case study regions, but underlying differences are noted. For instance, in Lomma (Sweden) the nature reserve is located on one side of the road and new services are situated on the other. There was a significant pressure on this nature reserve which resulted in building a protection fence. In Øresund Region, mostly on the coast, conflicts between building of second houses, leisure activities area and wind power plants are appearing. Also in Polish cases the highest level of development of infrastructure is to be seen in the most attractive places (e.g. development of tourism infrastructure in mountain areas). Very common type of infrastructure is the leisure-designated areas, such as golf clubs and horseback riding paths, especially in the vicinity of cities, but in an attractive landscape.

Agriculture internal conversions characterise extensification or stabilisation and differentiated dynamics of land use changes (from high to low) depending on the region. Some of the territories represent high natural environment values and consequently they are protected by law. The investigated areas represent wide range of trends (- extensification of rural activities, - high extensification in rural and sparsely populated regions and - stable rural and peri-urban activities), what is confirmed by relatively diverse directions and dynamics of land use changes. Agriculture areas were gradually transformed into more peripheral ones, where the building pressure and land price are lower (e.g. in Denmark, farmers moved to Jutland and the new EU member-states). The internal conversions are mostly observable in the neighbourhood of big cities: there are more ecological farms, which produce healthy food and sell it on a local market. One of the most considerable changes in land use is related to the migration from peripheral areas to the coastal and urban ones. People living in rural areas resign from cultivation of land, moving to towns and changing the way of production to a more environment-friendly. In the Basque Country rural tourism is more popular (to foreign visitors) in comparison to the most typical coastal tourism. Internal conversions in Chełmsko-Zamojski region derive from the economic transformation. Changes in the structure of land use are related to the profitability of production: high extensification of region's agriculture results in the increase of cereals cultivation and the abandoning of sugar beetroots, tobacco, flax, hemp and potatoes cultivation.

Forests creation and management represents stabilisation and low dynamics of the land use changes. The major reason for the stabilisation is poor quality of land in relation to other economic activities and land protection. The investigated areas represent - extensification of rural activities and - stable rural and peri-urban activities). On the example of Basque Country the shifting function of forest is observable. There are a lot of areas, classified as forests, which in reality turn out to be tree plantations. There are no visible changes in the landscape or in CLC data, but only as the environmental issue. In Chełmsko-Zamojski case in the last decades, forest invasion on meadows and pastures is observed and therefore resulting in the reduction of their areas. This process of renaturalisation is strongly linked with concentration and intensification of cattle breeding within the region, abandoning meadows and pastures as a fodder source. Small farms do not uphold animal production due to macroeconomic changes in agriculture and their meadows and pastures areas are often under renaturalisation. The processes taking place in forest areas (extensification and stability) have no major impact on land use change, such as intensification. The changes often appear as a point, invisible to the Corine Land Cover, but having a very strong influence on the functional and economic structures.

Table 4 Identification of the factors and processes in the case studies regions according to Land Cover Flows Characteristic

Land Cover Flows Typology	**Case study region and Name of investigated area**	**Identified processes**	**Factors** *++ - most important; + - less important*
Urban land management			
Urban residential sprawl	1. Jeleniogórski / Jeżów Sudecki 2. Basque Eurocity / Urban sprawl In Kalitxo 3. Legutio – Urban residential sprawl 4. Chełmsko-Zamojski / Werbkowice	Changes of agricultural land into the build-up areas. New houses are surrounded by the agricultural land – big mixture of land use. When the investors are private people - lack of development of technical and social infrastructure (eg. roads). When there is one investor - complex development of the new settlement.	++ natural process of suburbanization – better quality of life ++ location in a very favorable place ++ access to social infrastructure: schools, health care, kindergarten, shops.
Sprawl of economic sites and infrastructures	1. Jeleniogórski / Hotel building in Karpacz 2. Basque Eurocity / Lanbarren Industrial Zone 3.Basque Eurocity / Derio – technological park	Intensive development of tourism infrastructure in the most attractive places. Very good location of new investments – close to the main transport corridors and close to the main cities. Transformation of	++ big increase of popularity of skiing in Poland, lack of luxury hotels in that subregion ++ very good location – near the motorway and harbor, increase of international exchange ++ increasing demand of leisure activities sites

	4. Basque Eurocity / Bidart – sprawl of economic sites and infrastructure 5. Øresund / Hedeland	industrial sites in direction of leisure activities functions development.	surrounding agglomeration + transformation of industry in developed countries
Agriculture internal conversions	1. Basque Eurocity / Getaria - port city and agricultural land 2. Chełmsko-Zamojski / Huczwa river near Malice village 3. Øresund / Lomma	Internal changes in town and agriculture. Conversion of wet arable land into meadows and pastures due to worse natural conditions for plant cultivation and collapsing of food processing industry. Environmental protection on small valuable areas in neighborhood of attractive investment areas	+ region located on the coast, without good connection to big cities + worse environmental conditions for plant cultivation + collapsing of food processing industry in the region + pressure of investments and entrepreneurship in attractive localizations
Conversion from forested & natural land to agriculture			
Withdrawal of farming			
Forests creation and management	1. Basque Country / Geldo – forest changes 2. Chełmsko-Zamojski / Polanówka 3. Øresund / Forest near Svedala 4.Jelenioórski / Izerskie Mountain	Forests are characterize by the very extensive land use. Some of the forests are under of economic cultivations – they are plantations. Due to economic circumstances, trees in forests are cut or not. In some places the forest is recultivated due to ecological reasons	+ poor quality of land for other activities, extensive land use, plantations cultivated in terms of economic profits + enlarging demand for services connected to leisure activities ++ reconstruction of forest after the ecological catastrophe
Water bodies creation and management	1. Jeleniogórski / Sosnówka Lake	The artificial lake was created at the beginning of XXI century. It is very intensive change of land use – the wetland were transformed into the anti-flood and reservoir of the drinking water for Jelenia Góra citizens.	++ Anti-flood protection ++ Reservoir of drinking water
Changes of Land Cover due to natural and multiple causes			

3.6 Key messages and lessons learnt for policy development (3 pages)

It is important to bear in mind the context of the EU-LUPA project research. The project assess the 16 year period from 1990 to 2006 just a couple of years before the global economic and financial crisis which reached Europe in the year 2008. This is important because trends in land use at the moment of entering the crisis may help to identify risks and potentialities.

Risks: Hot spots related to urban development. How was the changes in related LUFS e..g provision of work?

Potentialities: Basis for interventions related to development opportunities for improving European competitiveness and cohesion.

3.6.1 Identification of the challenges of land use change in case studies areas and proposed recommendations

Oresund

Challenges:

- Green energy production, from wind power plants for bio-fuel cultivation. It is necessary challenge due to predicted future energy prices rising.

Recommendations:

- Concentration of urban sprawl in isochrones from railway stations. It helps to develop more effective railway transport and modal shifting among daily commuting people.
- Converting rural areas should be conducted dual. In the first direction relatively good connected with agglomeration parts of the region should be transformed into leisure activities for citizens or summer houses areas. In the case of rest of such areas should be introduced function of green energy production, from wind power plants or plant for bio-fuel cultivation.

Basque Eurocity

Challenges:

- Coordination among the different levels of responsibility and competences of spatial planning and land use management among the 3 provinces which configure the Basque Country
- Connection and cooperation between the three main cities is important – thanks to such situation there can be stronger functional specialization of each of the city and cooperation between them. Thanks to that level of development of each of the functions can be much higher and much more competitive on national and EU level
- The development of the Basque Country should be based on criteria of interconnection (spatial and sectoral) and fulfil the main objectives as: reinforce and rebalance urban system, improve urban areas and stimulate creation of medium cities network

Recommendations:

- Holistic development of the region needs a very good planning system which will be complex on the horizontal and vertical level – these means that sectoral plans should be created in cooperation with territorial ones (cohesion in spatial planning);
- Very detailed planning on the municipality level – thanks to that there will not be many conflicts of functions;
- Cooperation between different parts of the regions and division of functions within the territory – development of stronger functions of some particular towns has an important influence on the whole region. There should be regional competitiveness and not competitiveness within region.

Chelmsko-zamojski

Challenges:

- co-existing agricultural activity and environmental and landscape values protection
- introducing of services sector on rural areas, which will help to limit young people outflow
- exploitation of the energy sources with co-existing regional unique character

Recommendations:

- Key of financial support for farmers should stronger motivate to conducting really traditional agricultural activity, which could substitute potential profits from crops in intensive farming. Support for traditional farms for diversified forms of co-existing agricultural activities and services for agrotourism and leisure activities based on regional heritage.
- Different forms of support for selfemployment in rural areas in third sector. Dispersing of offices and regional institutions from the biggest towns to smaller ones and to rural areas. Special funds deducted from wind power plants owners dedicated for really local societies. Rules for investors exploiting slate gas resources regarding minimal share of employment in non-specialized professions among local societies.
- On regional level strictly planned zones of the highest landscape values, which are excluded from energy production function, but especially supported in conducting of traditional agriculture and developing services connected to leisure activities and agro-tourism.

Jeleniogórski

Challenges:

- Complex and holistic planning – connection of sectoral planning (socio-economic) with territorial one
- Conducted the permanent, annual monitoring of spatial organization in such spheres as: environment protection, industry investments, housing, cultural landscape and infrastructure
- There should be obligatory in establish the local plans of spatial organization for each settlement
- Higher activity of local institutions – local self-government has to have the initiative.

Recommendations:

- Holistic development of the region needs a very good planning system which will be complex on the horizontal and vertical level – these means that sectoral plans should be created in cooperation with territorial ones (cohesion in spatial planning);
- Equal importance of sectoral and territorial planning;
- Very detailed planning on the municipality level – thanks to that there will not be many conflicts of functions;
- Cooperation between different parts of the regions and division of functions within the territory – development of stronger functions of some particular towns has an important influence on the whole region. There should be regional competitiveness and not competitiveness within region;
- Permanent monitoring of socio-economic and spatial changes in the region and its communes;
- Coherent visions of development of communes, counties and region – there should be some hierarchical way of planning of strategies of development, because thanks to that will be "added value" of bigger scale of development;
- Engaging many institutions, local actors, representatives of main institutions important for spatial planning and creation of socio-economic development – thanks to that social consultancy the whole process of planning will be more coherent, transparent and complex;
- Good management – giving priority to public needs and public goods over the private benefit.

Some preliminary messages are suggesting in the present Draft Final Report.

3.6.2 General policy messages in support to responsible land management towards a more sustainable territorial development

- Good governance to enhance integration of sectoral policies
- Strengthening co-operation on particular topics in the field of spatial development through crossborder and transnational networks.
- Integrated spatial planning instruments and integrated programmes for land-use planning/ regional development and management (Spatial planning policies and strategies)
- Integration of sector policies with land use planning processes to resolve conflicts of land use demand
- Landscape approach and integration in spatial planning
- Securing sustainable agriculture, application of environmental measures and diversification of agrarian land utilisation.
- Introduction of territorial impact assessment as an instrument for spatial assessment of large infrastructure projects (especially in the transport sector).
- Improvement of co-operation between transport policies at EU, national and regional level.

- Better co-ordination of spatial development policy and land use planning with transport and telecommunications planning.
- Co-ordinated and integrated infrastructure planning and management for avoiding inefficient investments (for example superfluous parallel development of transport infrastructure) and securing the most efficient use of existing transport infrastructure.

3.6.3 Environmental protection and risk prevention

- Integration of land-use planning & environmental policy:
- Environmental objectives in spatial planning policy
- Strenghen of EIA/ EEA procedures
- 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.
- The new European Floods Directive addresses the risk of flooding caused by the construction of impervious surfaces (e.g. buildings and roads) and provoked by extreme weather events.
- The EU rural development and regional policies also emphasised the cross-cutting nature of land use.
- Future directions on the EU CAP and implementation of renewable energy targets will have a significant impact on forest and agricultural land use and its intensity.
- The role of green infrastructure and site protection under Natura 2000 as well as the re-use of land are also important aspects of land resource management.
- Land use policy to reduce impacts on agriculture and forestry
    - Forest management (private – Finland/ public owner)
    - Suitability of agriculture production (selection of species vs productivity)
- Continued development of European ecological networks, as proposed by Natura 2000, including the necessary links between nature sites and protected areas of regional, national, transnational and EU-wide importance.
- Integration of biodiversity considerations into sectoral policies (agriculture, regional policies, transport, fisheries, etc) as included in the Community
- Biodiversity Strategy.
- Preparation of integrated spatial development strategies for protected areas, environmentally sensitive areas and areas of high biodiversity such as coastal areas, mountain areas and wetlands balancing protection and development on the basis of territorial and environmental impact assessments and involving the partners concerned.
- Greater use of economic instruments to recognise the ecological significance of protected and environmentally sensitive areas.
- Protection of the soil as the basis of life for human beings, fauna and flora, through the reduction of erosion, soil destruction and overuse of open spaces.
- Strengthening of regional responsibility in water resource management.
- Application of environmental and territorial impact assessments for all large-scale water management projects

3.6.4 Land use policy towards adaptation to climate change impacts

- Reinforce the role of spatial planning and development and the importance of adopting a territorially-based approach when addressing the issue of adaptation to climate change, one of the challenges mentioned in the Territorial Agenda.
- The UNFCCC Kyoto Protocol promotes among others practices that reduce emissions of methane and nitrous oxide from agricultural land.
- EU policies on climate change adaptation are directly relevant to current and future land-use practices and economic sectors depending on this.
- Climate change adaptation strategies and plans
    - Adaptation strategies include banning new construction in vulnerable areas with high risk of flooding, minimizing flashy runoff from impervious surfaces, changing the requirements for stormwater retention structures in new developments, and protection of wetlands that buffer runoff from heavy rainstorms.
    - Land use planning to reduce urban heat effects, through maintenance of green areas, use of different building materials.
    - Land use policies discouraging shoreline building allowing communities to be more flexible to deal with sea level rise.

3.6.5 Policies to promote sustainable use of land and improving regional competitiveness.

- Promoting integrated spatial development strategies for city clusters in individual Member States, within the framework of transnational and crossborder co-operation, including corresponding rural areas and their small cities and towns.
- Promoting better accessibility in cities and metropolitan regions through an appropriate location policy and land use planning that will stimulate mixing of urban functions and the use of public transport.
- Strengthening small and medium-sized towns in rural areas as focal points for regional development and promotion of their networking.
- Use of the potential for renewable energy in urban and rural areas, taking into account local and regional conditions, in particular the cultural and natural heritage.
- Integrating the countryside surrounding large cities in spatial development strategies for urban regions, aiming at more efficient land use planning, paying special attention to the quality of life in the urban surroundings.

3.6.6 Urban phenomena and land take

- Promotion of integrated urban development strategies sensitive to social and functional diversity. Particular attention should be given to fighting social exclusion and the recycling and/or restructuring of underused or derelict urban sites and areas.
- Support for effective methods of reducing uncontrolled urban expansion; reduction of excessive settlement pressure, particularly in coastal regions.

- Demand for new urban areas may be partly satisfied by brown-field remediation relieving pressure on rural areas and green-field sites, reducing pollution costs, and more efficient energy use and natural resource consumption, facilitating economic diversification and emerging habitat (housing) requirements (The OECD Territorial Outlook 2001). Recycling of artificial surfaces in several countries in Europe reach 30 % or more if compared to total area of land take (CORINE LC 2006 results).
- Establish urban planning principles for regeneration of abandoned sites
- Stronger links between EU urban and soil policies are needed (e.g. following up respective 6th EAP Thematic strategies).
- Promotion of a wise management of the urban ecosystem: Implement Urban Metabolism procedures
- Green infrastructure and land use planning

3.6.7 Economic instruments for land use planning

Instruments with effect on the peri-urban land uses, e.g intergovernmental financial transfers, public subsidies, taxation tools, service pricing, tools for regulate development processes could be included.

These instruments are of key importance to:

a) Indirectly influence the functioning of the functional urban area, i.e. the mobility of people, investments, services between urban and peri-urban areas and

b) Directly regulate the change towards more intensive land use, e.g. residential, commercial, industrial, office through re-zoning regulations; and influencing the level of development in already established areas through regulating the conditions of building permissions.

4 Further analytical work and research within ESPON framework

An important of the last decades of land use development in Europe has been – as noted in the report above – a withering away of many of the differences in land use characteristics determined by national borders and replaced by land use characteristics still more determined by land use potentials in combination with the general economic development.

The land use systems in Europe used to be characterised by varying, historically developed governing and planning systems in in relation to both landscape and spatial planning, resulting in national differences in land use decision processes due to different patterns of legal, constitutional and administrative frameworks, showing obvious impacts on the concept of landscape and practices in relation to landscape management and planning.

Common policies, however, especially in relation to territorial cohesion, are in the process of limiting or even eliminating these differences! And in this context it is clear that the landscape and its potentials has become a key territorial value where analyses and assessments as well as integrating into the governing and planning systems is becoming still more important. This, however, is not a simple task, because knowledge about differences in land use decision processes due to different patterns of legal, constitutional and administrative frameworks are obviously impacting the practices of landscape management and planning.

A crucial issue in this connection is the fact that – as emphasized in the report above – there are marked differences in connection with land use development relating to two major questions: On one hand the question of development relating to mono-functionalities versus multi-functionalities, and on the other hand the question of development relating to intensification versus extensification in land use. And when working with both questions it becomes apparent that there are limitations to accessible tools that allow the necessary analyses in order to understand both background and consequences of the processes. The landscapes of the future will have to serve, simultaneously and in integrated ways, a number of different functions (Haber 1973). These include for instance:

- ecological (as an area for living organisms and natural environments),
- economic (as an area for production and reproduction),
- socio-cultural (as an area for cultural actions and identification),
- historical (as an area for settlement, memory and identity),
- and aesthetic (as an area for shaping and experiencing).

The expression “multifunctional landscapes” refers to areas serving different functions and combining a variety of qualities, i.e. that different material, mental, and social processes in nature and society take place simultaneously in any given landscape and interact accordingly. Multifunctionality in landscape, therefore, means the co-existence of ecological, economic, cultural, historical, and aesthetic functions.

Thus, landscape multifunctionality is not necessarily synonymous with multiple land uses. Different land uses can be a criterion for multifunctionality in landscapes, but even a single

land use can involve numerous functions. Different land uses can result in different functions, but not all functions can be expressed as land uses. The problem in this connection, however, is that the concept “land use” often – as emphasized in the report - is only related to the physical characteristics of the land cover identified through for instance the Corine land cover characteristics and the economic activities related to its use.

An important tool for the analyses of changes in land use during the last decades has been the registration of land cover characteristics through the Corine system, and throughout the report this characterization has been a key input to the analyses, base for both the determination of land use and land use change typologies. Due to the ongoing changes in land use characteristics in Europe, however, important limitations in relation to identifying for instance mono versus multi functionalities are apparent. In many cases the previous secondary activities have become dominant, for instance when aesthetic or recreational functions are defining what kind of land cover would be acceptable. Such considerations have become key questions in the ongoing discussions of how the future CAP should be structured.

There is obviously a need of developing tools which enables the inclusion of differences in relation to both intensity and diversity of the use of landscapes in order to become an asset in regional development towards sustainability. Such tools – both quantitative (intensity) and qualitative (functionality) - are needed in order to for instance enable the analysis of questions relating to balances between landscape protection and social welfare combined with different types of economic development.

Additional research activities must be done towards the Final Report in order to finalize the project expectations:

- Further exercises would be undertaken in order to better measure the sustainability of the ongoing land use trends by means of the performance and efficiency evaluations.
- There are several challenges and questions that remain unresolved or in need for further explanation and rationalization: Data availability at NUTS3 in order to evaluate the potential correlation between land use dynamics observed in the Land Cover Characterization and typologies and the land use functions exercise and distance to the policy targets
- To complete the assessment of the case studies in relation to the Land use change typologies.
- Policy recommendations: Policy guidance and recommendations document, to be delivered in the Final report after workshop with stakeholders in Warsow September 2012.

Glossary

Land. Land represents the biophysical unit determined by its natural components (geological and geomorphologic structure, soil, water, climate, flora and vegetation, fauna). Land is understood as a reference place where multiple interests could coincide. Sometimes these interests are linked to the land functions which may be complementary, but very often, particularly in the densest areas, conflict of uses occur requiring information and complex set of tools to manage it. (e.g. agriculture vs. nature protection).

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.

Landscape. According to the European Landscape Convention the landscape adds to the previous elements the cultural element and people's perception. This aspect will not be addressed since it is beyond the objective of this project.

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