ESPON

EU-LUPA

European Land Use Patterns

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

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Preface

The EU-LUPA project constitutes a first attempt within ESPON framework to assess land use changes in Europe at regional level.

The present report sets out the outcomes of the project and it is structured in ten chapters. An introductory chapter explains the policy framework relevant for the EU-LUPA project. It is followed by Chapter 2 introducing the hypothesis for investigation. The subsequent 5 Chapters are devoted to the methodologies used in the research, the description of the analysis undertaken and the interpretation of the key findings. This is followed by Chapter 8 which gives an overview of the EU-LUPA project case studies.

Policy options and recommendations for policy development based on project outcomes are enclosed in Chapter 9.

The report ends with the identification of the further analytical work required for improvement of project results and advices for future projects to be developed under ESPON framework in Chapter 10.

1 Europe needs to understand the path of changes

The shape and patterns of current European land are 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 have 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.

Although the European Union does not have any competence to regulate land use and land planning because land-use planning and management decisions are usually made at local or regional level, there are several policies that have a strong impact on the territory (e.g. Habitats Directive or CAP). Therefore, the European Commission has a role to play in ensuring Member States take environmental concerns into account in their land-use development plans. The Commission's goals[1] 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.

With this premises in mind, the aim of EU-LUPA is to provide and analyse comparable information about European regions based on data from different sources and different

[1] Land use environmental concerns http://ec.europa.eu/environment/archives/land_use/index_en.htm Last update 02/03/2012

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.

In other words, to provide evidence on land use and its changes that could support policy development towards responsible and sustainable land use management.

It is important to highlight that the analysis done in EU-LUPA project is for the period 1990-2006, which is just before the economic and financial crisis that hit Europe in 2008. However, the outcomes of such analysis provides powerful information about the situation in which the regions enter the crisis and this is considered very useful since offer lessons learned that should help policy makers at regional level to identify their challenges and opportunities to exit the crisis.

1.1 EU-LUPA Policy framework

While the first decades of planning in the EU were related to the economic development and the economic, social and cultural integration of the member states, other issues, such as a harmonious territorial development towards sustainability have appeared on the agenda during the last three decades. This resulted in the evolution of planning from land use development by means of economic incentives, towards a more equal concern with economic development, environmental justice, and social and economic equity[2].

Back in 1999 the European Spatial Development Perspective (ESDP), a non-binding framework aiming at coordinate various European regional policy impacts, already advocated the development of a sustainable, polycentric urban system and balanced territorial development in Europe. The ESDP resulted in European policy orientations for territorial balance and cohesion, improved competitiveness, urban system with compact cities and strengthening of the partnerships between urban and rural areas; parity of access to markets and knowledge, as well as wiser management of natural and cultural resources.

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

In 2007 the enlarged EU adopted a Territorial Agenda for the European Union which modernized the policy orientations of the ESDP and added stronger emphasis on: competitiveness of regions and cities including creation of innovative clusters, climate change concerns, territorial cooperation and multilevel governance.

The Territorial Agenda has been followed up by an ambitious Action Plan 1, currently under implementation. The Territorial Agenda has been recently reviewed in the first half of 2011. Some actions are related to the themes of ESPON applied research, others are being supported by ESPON targeted analyses. Besides, shifting EU Presidencies are keeping up the momentum of the Territorial Agenda and the development of territorial thinking and approaches.

The **Leipzig Charter (2007)** built on a process of cooperation aimed at strengthening urban development in the European context. With the Leipzig Charter the Ministers agreed on common principles and the need for proposals and strategies for sustainable EU cities calling for a European polycentric urban structure.

[2] For instance the Aarhus convention: Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, adopted in Aarhus in 1998.

The Lisbon Strategy (2000) also includes the new aim of territorial cohesion. This dynamic strategy places sustainability has been taken on board (climate change, energy, financial and social sustainability) making sustainable development a key objective for the EU and, in 2010, the EU renewed a number of Environmental Directives to ensure they comply with it.

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

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

The Commission published a Green Paper on Territorial Cohesion in order to launch a debate that can support a better understanding of this policy aim. This document puts a territorial perspective on economic and social cohesion setting the objective of a more balanced and harmonious development of the European territory, a debate that during the next years will nourish the concept of future EU Cohesion Policy.

The Commission also published in November 2010 the 5th Cohesion Report with further policy orientations, stressing the importance of providing more support for the less developed EU regions in line with the Union's strong commitment to solidarity and its Treaty aim of reducing regional disparities in levels of development, to foster territorial cooperation in its three dimensions (cross-border, transnational, and inter-regional) and concentration of social exclusion in urban areas. At the same time, the main challenges with territorial impacts (accelerating globalisation and market integration, ageing and migration, climate change, changing energy paradigm) as well as the need for ex-ante territorial impact assessment of EU Policies are all increasingly taken seriously by policy makers.

On 17 June 2010, the European Commission adopted the Europe 2020 Strategy as the EU' s growth strategy for the coming decade. This policy document sets out a vision of Europe's economy for the 21st century. It shows how the EU can come out stronger from the crisis and how it can be turned into a smart, sustainable and inclusive economy, thus delivering high levels of employment, productivity and social cohesion for the EU and its member States. The strategy has five ambitious objectives - on employment, innovation, education, social inclusion and climate/energy. As highlighted by the ESPON SIESTA report on Spatial Indicators for a "Europe 2020 Strategy" Territorial Analysis[3], the spatial dimension of the strategy is not obvious. Indeed, the report reiterated how scholars such as Böhme *et al.* (2011)[4] have recently stated that the spatial derivative of the EU2020S is territorially blind.

All these processes stress the need for better and deeper knowledge, more evidence, territorial indicators as well as assessment methods for territorial impacts. The applied research themes of the ESPON 2013 Programme are chosen by policymakers involved to respond the best possible to this policy demand.

However, it must be argued that 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.

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[3] ESPON SIESTA Spatial Indicators for a "Europe 2020 Strategy" Territorial Analysis. Draft Final Report 10/08/12.

[4] Böhme, K. et al (2011): How to Strenghthen the Territorial Dimension of Europe 2020 and the EU cohesion policy. Warsaw. Ministry of Regional development.

Within the EU policy framework we could find many specific responses to land use and land take. For instance there are specific references in the following documents: 'Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development' (COM (2001)264); the Commission Communication 'Towards a Thematic Strategy on the Urban Environment' (COM(2004)60); as well as the 'European Social Fund and the Cohesion Fund Council Regulation' (EC) (No 1083/2006). It is also acknowledged within the concept of territorial cohesion in the 'Territorial Agenda 2020', where it is noted that changes in land use (urbanisation, mass tourism, etc.) threaten landscapes and lead to fragmentation of natural habitats and ecological corridors. Likewise, the 'Territorial Agenda Action Plan' – notes specific actions relevant in the field of 'Land', in particular are action 2.1d: 'Urban sprawl' and action 2.2 'Territorial impact of EU policies'. Cohesion Policy (2014-2020) – includes the thematic objective: environmental protection and resource efficiency. Funds flow to infrastructure developments (e.g. in the 2000-2006 period 5100 km of road were built and8400 km of rail was constructed). Additional references are made in: 'Cohesion Policy and cities: the urban contribution to growth and jobs in the regions' (COM(2006)385), the 'Europe 2020 Strategy' (COM(2010)2020); and the general provisions on the European Regional Development Fund; the 'Rural Development Policy' (towards 2020) - where priorities include restoring, preserving, and enhancing ecosystems (e.g. N2000, landscapes, soil management, etc.); and the 'Common Transport Policy' – where development of transport services must take account of their possible effects on the environment´. Even further still, the White Paper on transport, the energy efficiency plan and the communication of the Commission 'A Roadmap for moving to a competitive low carbon economy by 2050' constitutes the key deliverables under the Resource Efficiency flagship. (COM (2011)112 final), while 'The European Landscape Convention' (Council of Europe, 2000) deals with the protection, management and planning of all landscapes in Europe.

But perhaps most notably, the 'Roadmap on Resource Efficient Europe' includes the bold milestone of no net land-take by 2050. Yet EU-LUPA perceives that implementing this mandate would 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. The fact that the magnitude of land change has been more or less maintained throughout the period from 1990 to 2006, and prospective new members of EU appear ready to make use of land change as a vehicle for economic progress, it seems that measures of compensating any limitations in this respect would be needed. Therefore, it is both an unlikely and unrealistic goal for a number of European regions.

Existing European policy regarding land use lacks a comprehensive and integrated approach that takes the inherently broad number of trade-offs between many sector, social and environmental issues. In particular, this includes activities relating to: industry, transport, energy, mining, forestry, agriculture (EEA, 2010), as well as recreation and environmental protection/conservation. According, to the EEA, "these trade-offs can be tackled through integrated planning for land use and territorial planning, sector policies, as well as targeted policy instruments, such as protected area networks." (EEA, 2010: 5). Similarly it is expected that the integration of the European Landscape Convention as a tool in territorial planning would become an important contribution to the planning process. Along these lines, institutional arrangements dictating land use policy in Europe include the EU objective for Territorial Cohesion – with which this project is closely connected to – the Water Framework Directive, Common Agricultural Policy (CAP), Natura 2000, and with an increasing importance, Energy 2020. Important tools for informing, monitoring and evaluating these policies and programmes are Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), and most importantly, the advent of the CORINE Land Cover inventory (EEA, 2010).

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.

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 in terms of 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. Additionally, 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), which 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, “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.

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.

2 Hypothesis for investigation

The hypothesis for investigation has the following assumptions:

- Similar patterns of land use and land use change in EU could be observed at NUTS3 level and analyzed in line with socio-economic development. In that sense land use change becomes a function of economic growth and spatial localization.
- The integrated analysis of land use patterns and socio-economic development could be translated into regional typologies.
- Regions under certain typology of land use change could also reflect certain pathways which will be relevant for the identification of its territorial challenges and potentialities,
- Policy responses could be defined in line with the obtained typologies to cope with the challenges and strengthen potentialities

Similar patterns of land use and land use change in EU could be observed at NUTS3 level and analyzed in line with socio-economic development.

EU-LUPA has found an innovative way of accounting for land use and land use change patterns and dynamics through the use of land cover data. As such, this project delivered evidence on the relation of land use patterns and their dynamic relationship with socio-economic growth. As discussion will show, while land cover and land use are two terms that often get misused in place of each other, we have approached a means of investigating land use through CORINE Land Cover data by means of the "intensity" concept. (See Chapter 3.2.2)

The integrated analysis of land use patterns and socio-economic development could be translated into regional typologies.

Although the legacy of the past is an important component, is has been tested that land use patterns and dynamics are integrated in a certain typologies as a means to synthesize the information and highlight similar regions in Europe. (See Chapter 3.2.4)

Regions under certain typology of land use change could also reflect certain pathways which will be relevant for the identification of its territorial challenges and potentialities

EU-LUPA project tested that regional typologies do not directly integrate data reflecting regional socio-economic conditions in Europe, although throughout the intensity concept it is possible to see a clear correlation between the presence of land cover types and the characteristics of socio-economic development that takes place as a result.

Land use patterns have a scale dimension. Thus certain processes 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 an intensive process tends to be immediate while an 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.

Besides that, a land use functions (LUF)conceptual framework has been used in EU-LUPA project in order to assess how changes in land use (partly driven by policies) impact the multiple functions attached to land use, which in turn affect sustainability and stock and quality of natural resources.

The project sought to answer the question: Is Europe's preliminary Resource Efficient Strategy promoting legitimate goals? 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 there is a double-sided relationship between land and growth. The land use paradox is that 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. 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. 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.

The LUF approach should have been able to identify hidden process and fine tune the potentialities of the regions although unfortunately this has been only partly achieved in the project. (See Chapter 4)

Policy responses could be defined in line with the obtained typologies to cope with the challenges and strengthen potentialities

The project observed that diversity between the regional realities within the European territory are 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.

General messages for awareness rising and future policy development are addressed in Chapter 9. However, it is out of the EU-LUPA project scope to provide a place-based approach to policy making, other than for the case studies. (See Chapter 9.1)

3 Analysing land use patterns in Europe using typologies

Land changes in Europe have been extensively addressed by the use of Corine Land Cover (CLC) data that is currently available for three time shots: 1990, 2000, and 2006. Its use has been very much focused on environmental aspects, which is reflected in its classification nomenclature. With that being said, its potentiality has not been fully exploited for relating it to observed patterns of socioeconomic trends, trends that could be drivers or responses to land changes. In this context, EU-LUPA's innovative approach to characterizing land use patterns is separated into two first level research components:

First, the analysis of land use patterns using typologies provides an integrated set of outputs, which applies the notion of intensity to CLC data as a basis for analyzing land use and land use changes. As introduced below, the concept of intensity relates to the magnitude of human activities taking place on a given area of land; and therefore, on the intensity with which land is manipulated. Second, the notion of land use functions and multi-functionality is taken up by the work on land use functions (LUFS). The concept of multi-functional land

use (Knickel et al., 2004) recognizes that it is often desirable to maximize the benefits obtained from a given parcel of land, and the ability to provide a more equitable balance of often competing economic, environmental and social demands on land is more sustainable.

The outputs from these two components form the research basis of the EU-LUPA project. Beyond their roles for showing Europe-wide patterns and trends, they are validated and supported through case studies. Both levels of analysis are combined with dedicated research tasks for assessing land use performance and efficiency to form the input for key messages and policy recommendations relating to the governance of land use issues in Europe.

EU-LUPA's approach to analyzing land use patterns through typologies is both an incremental and complimentary process – one that appreciates that it is not possible to cover the multiple important dimensions of land use patterns in a single map. As such, the outputs generated in the scientific report (Volume I) seek to answer the following questions through presentation of spatial data, including in typologies:

- What are the general characteristics of land use in Europe?
- What characterizes land use changes?
- How are both of the previous connected/related to trends of socio-economic development?

In answering these questions, regional typologies are defined as the classification of entities – in this case European NUTS2/3 regions - into types based on shared or common characteristics. For EU-LUPA, they aim to be simple, operational, explanatory and communicable tools to evaluate regional land use patterns, and to support the development of land use policy recommendations. To achieve these aims, the research process is broken into six components, of which four typologies are produced: two that account for the current status of land use and two that account for land use changes.

1. In relation to the **prevailing characteristics of land use**: answering the question, based on the distribution to CLC data 1990-2000-2006 what characterizes the land use in Europe? The results are two typologies:
    - The prevailing characteristics of land use at a $1km^2$ grid level
    - The prevailing characteristics of land use at a NUTS2/3 level.
2. In relation to the **amount of land use change**, as a percentage of the total areas of NUTS2/3 regions. To simple answer the question, how much land is changing, and where?
3. In relation to the **intensity of land use change** in NUTS2/3 regions, to answer the question, what is the degree of human intervention on the land in order to meet the needs of our socio-economic activities?
4. In relation to the two previous outputs, a basic typology showing **Hotspots of land use change**. It generalizes regions based on a matrix of absolute change (by area) and intensity of change. This provides a generalized picture of which regions stick out in terms of high levels of physical land change, in terms of the degree of human intervention on the land, or both.
5. In relation to a **Land use change typology**: this is the cornerstone of the EU-LUPA land use characterization and it answers the question, what characterizes land use changes for NUTS2/3 regions in Europe?

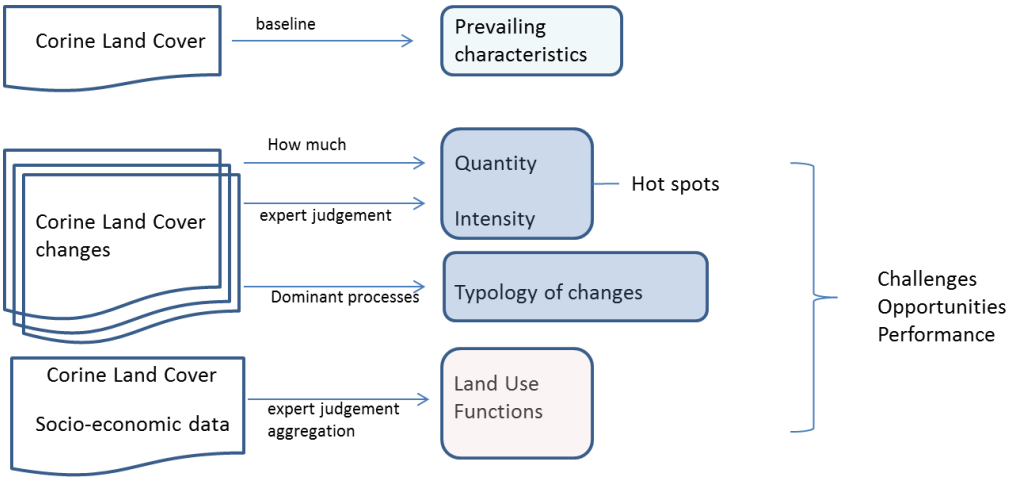


Figure 1 Overview of the methodological approach to the land use patterns taken by EU-LUPA

3.1 Prevailing characteristics of the land use

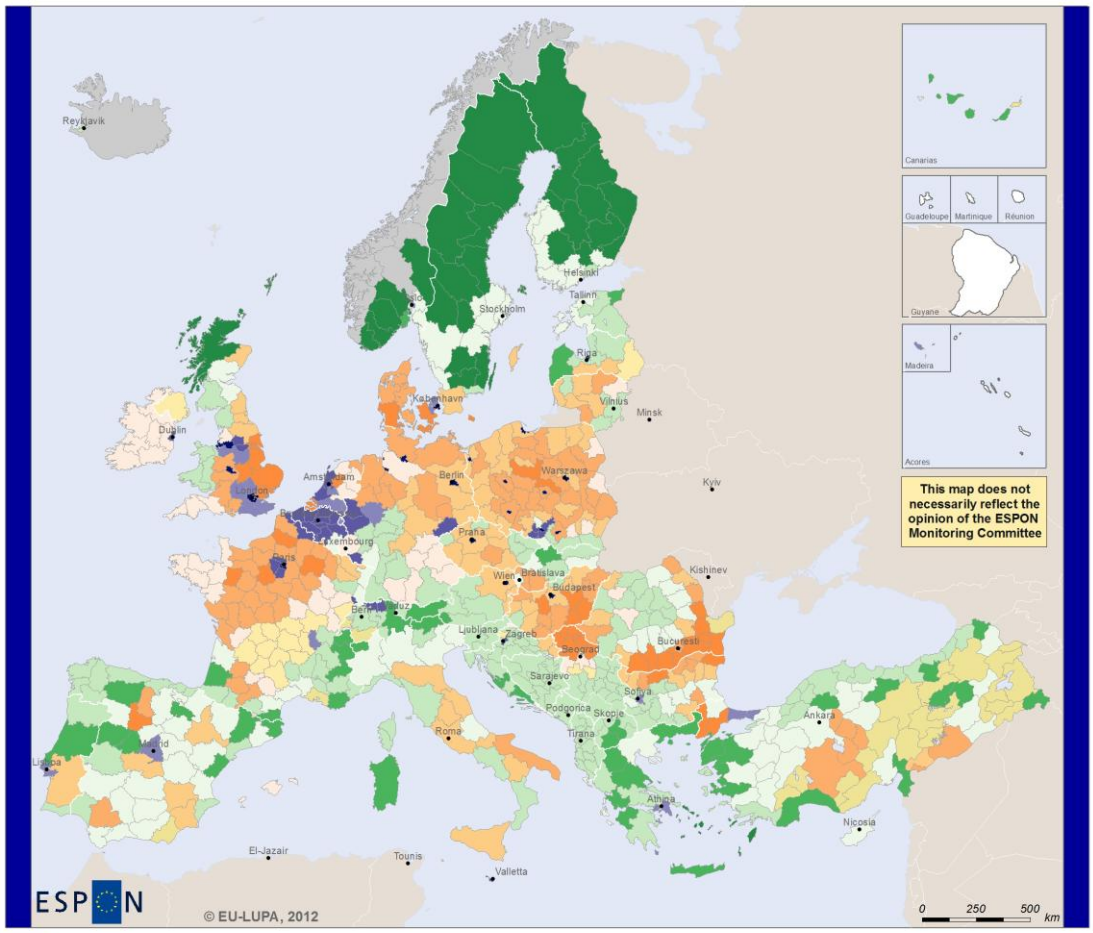
The Prevailing Characteristics of land use typologies seek to answer the question: Based on the distribution to CLC data 1990-2000-2006, what characterizes the land use in Europe? Yet, to provide a high explanatory power it must be provided in both a grid and regional format. On one hand, we know that land does not operate exclusively within administrative bonds and for the purpose of the case studies it is very important to know what patterns characterize the land within (rather than among) regions. On the other hand, however, generalizations to the regional level allow for regions in Europe to be compared to one another and for interregional patterns to be identified. The regionalization also acknowledges that socio-economic data is constructed and distributed within an administrative, regional framework.

A detailed description of the method for creating the typology is provided in the Scientific Report Volume I (Section 2.1 and 2.2). In total there are five steps to the process – the first four producing the gridded typology and a fifth step to regionalize the results. Briefly, the steps include a process of aggregating CLC data from a 100m grid to a 1km grid; an algorithm to identify differences between multiple aggregation techniques; two clustering procedures to group land cover data from the multiple aggregation procedures, and for each of the three time periods; and lastly for the gridded typology, a naming of 13 clusters produced by the results. For the regional typology, a fifth step involves an additional cluster analysis to determine which regions share similar land characteristics based on the per cent distribution of the gridded land use types in each NUTS2/3 region.

The result is 14 clusters, which have been subjectively named and transformed in to regional land use types. The naming is based on the composition of CLC classes in each cluster, which is shown for the CLC 2006 data in Table 1 on page 16.

Results provided at the gridded level contribute to sub-regional analysis of land use and land use changes in taken up in the case studies.

Prevailing Characteristics of Land Use 1990 - 2006



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Regional level: NUTS 2/3
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

Map 1 Regional typology of the prevailing characteristics of land use

	CLC classes		Cluster Numbers													
			CL15	CL16	cl20	CL02	CL07	CL03	CL-05	CL09	CL04	CL6	CL12	CL11	CL01	CL10
1	Artificial surfaces	Continuous Urban Fabric	52,41	18,15	13,38	4,78	4,23	3,99	4,05	2,51	3,15	3,07	1,94	1,17	0,63	0,32
2	Artificial surfaces	Discontinuous urban fabric														
3	Artificial surfaces	Industrial or commercial units														
4	Artificial surfaces	Roads and rail networks and associated land	11,05	2,65	3,36	0,82	0,58	0,60	0,57	0,34	0,50	0,41	0,40	0,20	0,16	0,13
5	Artificial surfaces	Port areas														
6	Artificial surfaces	Airports														
7	Artificial surfaces	Mineral extraction sites														
8	Artificial surfaces	Dump sites														
9	Artificial surfaces	Construction sites														
10	Artificial surfaces	Green urban areas														
11	Artificial surfaces	Port and leisure facilities														
12	Agricultural areas	Non-irrigated arable land	11,75	32,98	27,53	71,61	52,66	40,29	24,94	6,99	28,23	12,32	15,40	16,97	2,36	0,71
13	Agricultural areas	Permanently irrigated land														
14	Agricultural areas	Rice fields														
15	Agricultural areas	Vineyards														
16	Agricultural areas	Fruit trees and berry plantations	9,97	23,81	27,99	10,22	20,17	19,54	41,85	55,77	17,22	26,95	18,59	16,78	2,65	3,29
17	Agricultural areas	Olive groves														
18	Agricultural areas	Pastures														
19	Agricultural areas	Annual crops ass. With permanent crops														
20	Agricultural areas	Complex cultivation														
21	Agricultural areas	Agriculture with sign. Areas of natural vegetation														
22	Agricultural areas	Agro-forestry areas														
23	Forest and semi natural areas	Broad leaved forests	9,57	18,74	25,36	9,26	18,69	33,14	22,19	32,36	44,46	53,53	54,31	31,67	75,34	42,78
24	Forest and semi natural areas	Coniferous forests														
25	Forest and semi natural areas	Mixed forests														
26	Forest and semi natural areas	Natural grasslands														
27	Forest and semi natural areas	Moors and heathland														
28	Forest and semi natural areas	Sclerophyllous vegetation														
29	Forest and semi natural areas	Transitional woodland shrub														
30	Forest and semi natural areas	Beaches, dunes, sands	0,10	0,10	0,25	0,09	1,32	0,50	0,23	0,03	3,47	2,24	7,94	28,73	3,42	42,66
31	Forest and semi natural areas	Bare rocks														
32	Forest and semi natural areas	Sparsely vegetated areas														
33	Forest and semi natural areas	Burnt areas														
34	Forest and semi natural areas	Glaciers and perpetual snow														
35	Wetlands	Inland marshes	4,94	3,54	2,00	3,02	2,28	1,87	6,05	1,99	2,88	1,40	1,35	4,48	15,35	9,78
36	Wetlands	Peat bogs														
37	Wetlands	Salt marshes														
38	Wetlands	Salines														
39	Wetlands	Intertidal flats														
40	Water bodies	Water courses														
41	Water bodies	Water bodies														
42	Water bodies	Coastal lagoons														
43	Water bodies	Estuaries														
44	Water bodies	Sea and ocean	0,21	0,03	0,12	0,19	0,06	0,05	0,12	0,01	0,09	0,07	0,08	0,01	0,09	0,33
		Number of regions	29	32	21	41	97	81	52	18	97	171	56	56	30	27
		Percent of Europe	0,22	1,38	1,20	3,57	11,89	10,82	5,48	2,05	15,24	17,75	7,09	4,60	12,89	5,81
			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	Sparse vegetation with some forest and pasture	Rural forest	Sparsely vegetated areas

Table 1 **The distribution of CLC 2006 classes within each regional cluster (noted in the top row), leading to the formation (naming) of regional land use types (noted in the bottom row). The purple - orange colour scale shows the share of each CLC class group for each cluster and regional land use type.**

1. ***Urban cores and metropolitan areas*** – 29 regions – show a situation where almost 60% of regions can be generally 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.

   Differential distribution in some Eastern countries is identified: capitals and administrative cities act as attracting pole. Strong contrast urban-rural (polarisation)

2. ***Suburban areas*** – 32 regions – Urban land types have the dominating influence in these regions. 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.

3. ***Suburban or peri-urban areas*** – 21 regions – Regions in this cluster are situated in near proximity to large urban centres – such as London or Paris –. 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. 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.

   This land use type is becoming swallowed up by the **sprawl of industrial and commercial activities, and residential land to a lesser extent; especially in Central Europe**

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. 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 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. Compared to the previous regional type, this one shows an increased reduction in arable land - even though it is still dominant with a percentage of around 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.

3.2 Land Use Changes

As is immediately noticeable in **Error! Reference source not found.**2, the production of spatial data of land changes is more complex than spatial data of the prevailing land use characteristics. There are four regionalized outputs regarding land changes that, when put together, provide an understanding of how different patterns of land change are distributed throughout Europe. These are:

1. Amount of land change
2. Intensity of land changes, including a validation of the intensity concept
3. Land change hotspots
4. Land use change typology

3.2.1 The amount of land change

All CLC changes are summed at the NUTS2/3 level. These totals are then divided by the area of the region to determine percentage of each region undergoing land change. A particular focus of this is placed on regions where changes are above the European median. The results of this exercise are presented in the Scientific Report Volume I (Section 3.1).

When scrutinizing the maps it is important to keep in mind that not all countries and regions are represented throughout the 16-year time span from 1990 to 2006. This limits the opportunities for general interpretations regarding changing patterns between the 1990-2000 and 2000-2006 time series.

Nevertheless, within the entire 16-year time period it is notable that some very significant levels of land change have taken place - in some regions almost 30% of the total area has reported change. 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. What will be very interesting is to determine the socio-economic and environmental contexts of changes in these different national and regional contexts. This will be drawn out by investigating the intensity and types of changes that define these volumes.

Some of the most significant changes between 1990 and 2000 took place on the Iberian Peninsula. Starting with the agrarian reforms taking off during the 1970's and culminating in the late 1980's, the changes are, in part, likely due to the ascension of Spain and Portugal to the EU in 1986. This 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.

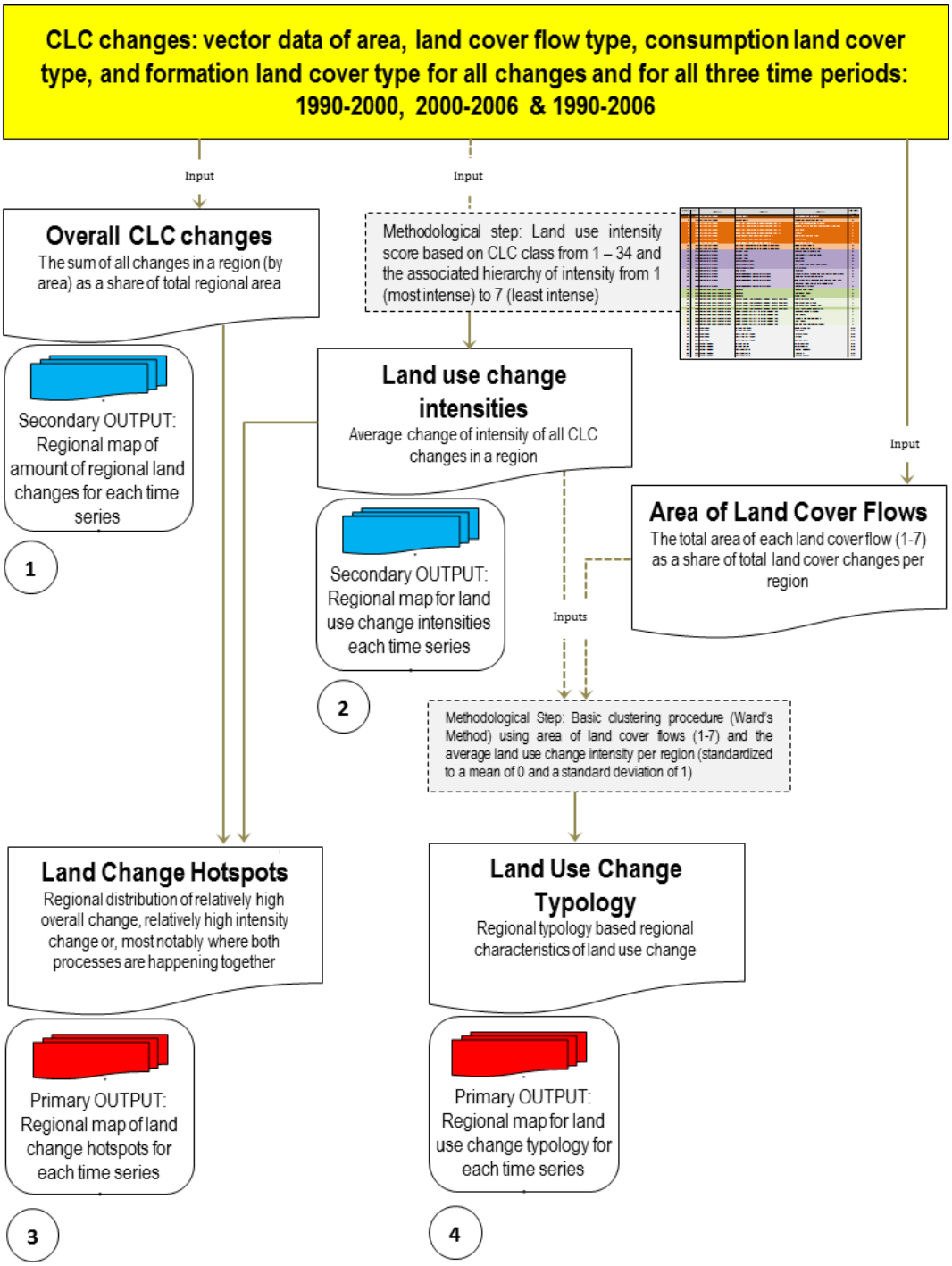


Figure 2 Methodological flow to analyse land changes in the EU-LUPA project

3.2.2 The Land use change intensity

As mentioned, the notion of intensity has been applied in the EU-LUPA project as basis for analysing the connection between land use and land use changes, and socio-economic development. The concept is a response 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.

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 to 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 it does about intensity (cf. Prokop et al. 2011).

The results of this exercise are presented in the Scientific Report Volume I (Section 3.2).

As shown in the Table 2, this quantitative assessment of land use intensity is a classification of the CLC classes (from CLC 34 – Glaciers and Perpetual Snow to CLC 1 – Continuous urban fabric), based on the relative level of land use intensity inferred by each CLC class. The subsequent classification of seven scales of intensity is based on internal expertise, which uses a number of underlying general rules to create the intensity hierarchy. The Intensity ranking has been scrutinized through a detailed validation exercise provided in volume I of the scientific report, Section 3.1. This exercise is a correlation analysis based on the percentage distribution of the CLC classes in the regionalized Prevailing land use typology versus regional GDP and population density statistics.

The presence of greater concentrations of people (population density) 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 land. GDP is considered to be 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. The results show that intensities of land use reflected through the Land use types are clearly correlated to both population density and to GDP. This does not consider the size (area) of the change, only the change of intensity.

In terms of the Artificial surfaces class, there are three classes: CLC class 1 (Continuous urban fabric) is the ranked 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. CLC classes 3-9 (Industrial, Commercial and Transport Units or Mine, Dump and Construction Sites) are ranked second because they classify land that is highly manipulated and related directly to meeting the needs of socio-economic production. CLC classes 2 and 10-11 represent the third most intensive urban type. Class 2 – Discontinuous urban fabric – accounts for land where vegetated areas that cover between 20-70% of the land surface (Bossard et al. 2000). It therefore represents transitional, suburban areas between cities and the rural hinterland where the intensity of human intervention is reduced relative to Continuous urban fabric. Green urban areas and Sports and leisure facilities are also included in this group. These are areas of increased protection compared to more intensive urban classes, but are still more intensive than agricultural or forest land due to their proximity to urban areas, and thus heightened contribution to social functions.

Agricultural classes are, for the most part, grouped together because it is very difficult to differentiate agricultural intensities due to regional topographical, territorial, cadastral and economic (land value) conditions, (see Gabrielsen, 2005). The only distinction that has been made within the 11 agricultural classes is where Arable land and Permanent crops (CLC classes 12-17) are allocated an intensity score of 4 and Pastures and Heterogeneous Agricultural areas (CLC classes 18-22) are given a score of 5. The rationale behind this distinction is that the former group is indicative of agricultural areas that are strictly dedicated to food production through cropping. In agricultural terms this is characterized as an intensive activity demanding high inputs, especially fertilizer, water, labour and management (Gabrielsen, 2005). In contrast, the latter group is representative of a mosaic of agricultural activity with a generally lower level of intensity. For instance, by area, Pastures is a dominant CLC class in this group, and is an activity characterized as being relatively low-input (Gabrielsen, 2005).

The 11 Forest and Semi-natural Areas classes are broken down into two groups because of the certain CLC groups that represent an economic production dynamic in the forest sector; where harvested forest areas are next classified as Transitional Woodland-shrub. By area, this is by far the most prevalent land cover transition that takes place in Europe. The remaining classes encompass landscapes either covered by vegetation without a specific production potential or by little or no vegetation as all. In turn, they are essentially natural landscapes with minimal prospects for substantial human intervention.

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. 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). By subtracting the intensity score in the latter year from the intensity score from the former year the intensity score of each land change is determined. For example, a change from Natural Grassland (intensity score: 7) to an Airport (intensity score 2) is an intensification of five. The average intensity score for all changes in each NUTS2/3 regions then provides the regionalized land use change.

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

Table 2 Ranking of CLC classes based on Land Use Intensity

Some of the highlights noticeable in the analysis include:

- There is a clear east-west dimension in each of the maps. Large volumes of land use extensification are almost exclusively found in Eastern European member states; particularly in Poland, The Czech Republic and Hungary. This pattern is very dominant in the 1990-2000 period but continues in 2000-2006 as well.
- 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. But furthermore – and in a very high degree in, for instance in Portugal, Spain and other Mediterranean areas, the issue of ownership reforms and characteristics of land tenure are a driver of intensification. This issue will be dealt with in more detail in relation to the identification of land change hotspots. Intensification also appears to take place in a greater degree for coastal regions (cf. in Spain, France, Croatia). It is possible that this pattern is related to the growth of the coastal tourism in these regions, but additional validation is necessary.
- In the Czech situation it is interesting to point out the seemingly high degree of rural extensification being countered by urban-related intensification in the capital region of Prague. Further, when comparing the 1990-2000 and the 2000-2006 results (Map 8 and Map 9 of Scientific Report Volume I), even while taking into account the much larger time span in the former time period) it appears that extensification processes have slowed for the country as a whole. EEA country analyses show that the main driver of extensification has been the conversion of different crop areas into land for pasture. This is a process which has been driven by national policy that uses subsidies to encourage the grassing of arable and extensive grassland management.

  The shift from 1990-2000 to 2000-2006 also relates to changes in mobility, where halted subsidies for dwellings and an increase of suburbanization have been influential on the slowing down and decline in extensification (Vobecká 2010), an issue which is dealt with further in connection with the Land Change Hotspots. In the 2000-2006 (Map 9 of Scientific Report Volume I) time series from very significant intensification is especially notable in particular regions of Norway. These are regions that we know have undergone relatively little amounts of land change (by area) based on Maps 1-3 of Scientific Report Volume I) ; however the changes that have taken place were very intensive. This is due to the development on intensive mining, hydrocarbon extraction and other heavy industrial activities in rural and remote locations. Interestingly, these intensifications are not taking place in parallel with extensification of other land covers in these areas, which indicate that these are “new” economic activities that are taking place on previously stable and unchanged land.
- Quite high rates intensification is notable for many regions in Spain in all three time series. The highest levels of intensification have taken place for coastal regions along the Mediterranean and for the island regions. This is clearly related to the growth of artificial surfaces in urban areas. CLC flow data and EEA land cover analysis (EEA, 2011) indicates that much of this intensification is due to the sprawl of economic sites and infrastructures (which both construction areas and transport infrastructure are grouped).
- For 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 (in between 1990-2000), and in Ireland southern Portugal to differing degrees throughout the 1990-2006 period.

3.2.3 The Hotspots of land change

By combining the outputs of component 2 (amount of land change) and component 3 (land change intensity) we can provide a map showing land change hotspots (see map 2). In this context, hotspot regions are those that are either characterized by relatively high intensification or extensification, where higher than average amounts land change are taking place, or where both phenomenon are happening together. The method used to determine the hotspots was to create a 5x5 matrix where land use intensity change is classed in five groups on the y-axis and the amount of regional change is classed in 5 groups on the x-axis. Using this matrix, we can effectively combine – and therefore generalize – these change phenomena in order to identify regions where extreme land cover changes have taken place.

The question of land ownership and land tenure has been extremely important in in relation to the registered changes in Southern Europe, and especially on the Iberian Peninsula. Both Spain and especially Portugal land ownership was until the late 1970s and 1980s characterized by latifundias, i.e. extremely large private estates with the owner usually living in the larger cities. Even providing job opportunities to workers and to some extent leasing out land to tenants, this type of land use has mostly been characterized by very low land use intensity. In Portugal the Agrarian Reform in 1975 being an important part of the "Carnation Revolution" laid down the principles for the expropriation of land from the latifundias and distributing ownership to former workers or tenants. Even some intensification took place the attempts to establishing cooperatives had limited effect, and a break-through in relation to market based economy followed by the reformed Agrarian law enacted by the parliament in late 1988. This enabled the new ownerships to move towards more intense production structures. At the time of EEC membership in 1986, low land and labor productivities were the most striking features of Portuguese agriculture, reaching before entry only 46% and 13% of EU-10 average, respectively (Mykolenko, Raymond, & Henry, 1987). Especially in areas close to urban centres were the first places to take advantage of the opportunities connected to the CAP (Diogo and Koomen, 2010).

As an important consequence all regions in Portugal are identified as hotspots – albeit to differing degrees – in all of the time series'. Consultation with the maps showing total land change by area (Scientific Report Volume I Appendix 5.1) shows that – as indicated above - this is mainly due to the fact that all regions show very high levels of overall change. This is by the high levels of ongoing changes related to forest management. Conversely, the intensity maps show more stable patterns with the exception of two regions. Lisbon and Alentejo. In the former, intensification is predominantly related to residential sprawl between 1990 and 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).

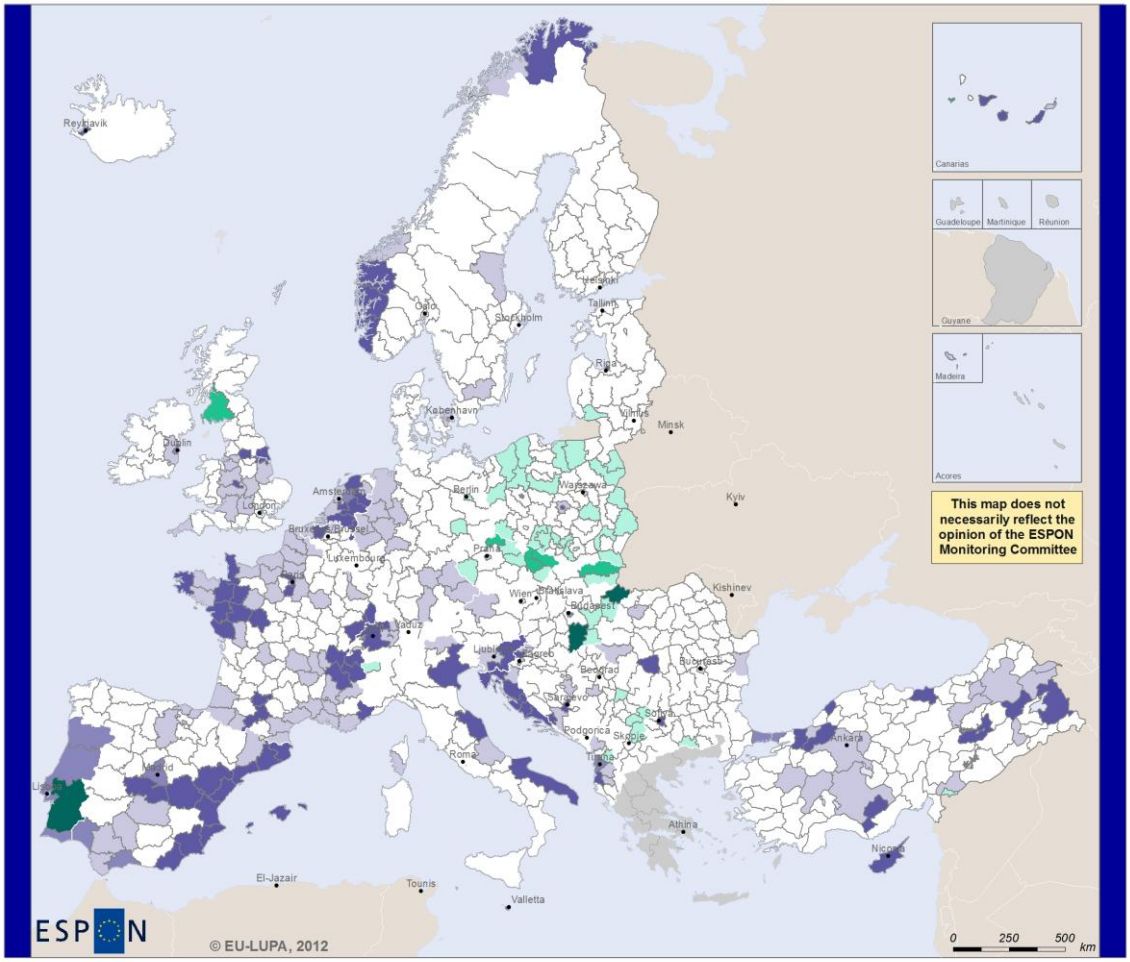
Besides processes similar to the above described, where a clear divide between latifundios (dominating in the south) and minifundios (dominating in the north) both have been characterized by low productivity the membership of EU has had some of the same land use consequences as in Portugal. Intensification due to structural changes in land ownership has been an important factor, and this combined with the CAP accounts for much of the intensification taking place in rural areas. As emphasized by Molina (2002, p2), however, "Land tenure is, after decentralization, the second most important supporting/impeding factor for National/Regional Forest Programmes in the Mediterranean regions". In the case

of rural Spain the changes can be illustrated through the example of the dehesas, a traditional, low-input, extensive agroforestry system (Meeus 1995, here from Plieninger and Schaar, 2008) combining forestry with extensive livestock grazing and farming. Low productivity and low intensity has been an easy target for intensification where the most influential force being the Common Agricultural Policy, which supported the production of cereals and cattle, sheep, and goat husbandry in the dehesas. Again, this is an important process adding to explaining the changes in intensification.

On the Iberian Peninsula, but definitely also in other parts of Southern Europe, a starting point characterized by very low land use intensities in rural areas and farming practices more related to subsistence and local markets than to European and World Market conditions have been an obvious starting point for a process of land use intensification in rural areas that took off before 1990, peaked in the period 1990 to 2000, and now being more or less "normalized" except for regions in Portugal where intensification of rural areas are still ongoing. And instead of rural intensification related to rural activities many of former rural areas – especially in coastal areas – are exposed to a new category of intensification related to urban sprawl.

In contrast to the situation on the Iberian Peninsula, 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 reflected through a drastic decline in intensity over substantial areas in the period from 1990 to 2000. In contrary to the situation in Spain and Portugal the basic land reforms distributing former estate land to small and medium scale farming had taken place pre Second World War, and in many cases during the 19th century. The structural changes connected to the post WW2 reforms in ownership instead resulted in the establishing of state farms and cooperatives. It had some immediate consequences in relation to both intensity and productivity, and was paralleled by regional policies in relation to rural areas due to the state interests in maintain a high level of production to serve the requests from the Soviet Union through COMECON. And as a consequence transfer payments and subsidies enabled intensities and productivities that were unrelated to market conditions. So the development from 1990 and onwards abandoning the former state and cooperative ownerships forms has had some immediate consequences in relation to intensity. On one hand that many of the new private farms were small and did not have the necessary means to ensure a high intensity in land use. And on the other hand that the larger farms with intensification potentials in many cases involved foreign investments which did not necessarily lead to intensifications. 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.

2000 - 2006 Land Change Hotspots



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Regional level: NUTS 2/3
Source: Nordregio, 2012
Origin of data: EEA, 2011
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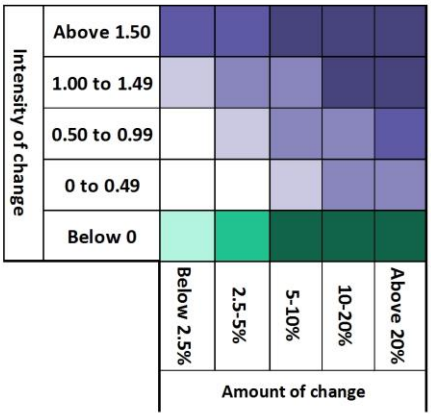
Matrix of land change hotspots

The x-axis shows the amount of land that has undergone change between the given years (in percent) while the y-axis indicates the change in intensity as a result of those changes. Therefore, regions in white represent those with relatively stable land cover characteristics while 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 are evident.



No Data

Map 2 Hotspots of land change- 2000-2006

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 – a situation that can be found in rural areas, not the least in regions remote to the capital regions or in mountainous areas in most of the former "East Block". And several of the regions where this has been the dominating characteristic has continued being regions of decreasing intensity through the 2000-2006 period as well. One important element in this connection has in Poland 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.

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.

As a conclusion it could be argued that the map of "hotspots" represents a generalization of land changes which are based on absolute changes in land use. This is advantageous because there is no chance that it "misrepresents" certain land change phenomenon taking place in the regions. At the same time, it lacks in terms of characterizing the underlying processes that are actually the result of these intensifications, extensifications and/or high amounts of overall land change (i.e. the changing social and economic activities that take place as a result of such changes).

3.2.4 The Regional typology of land use change

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.

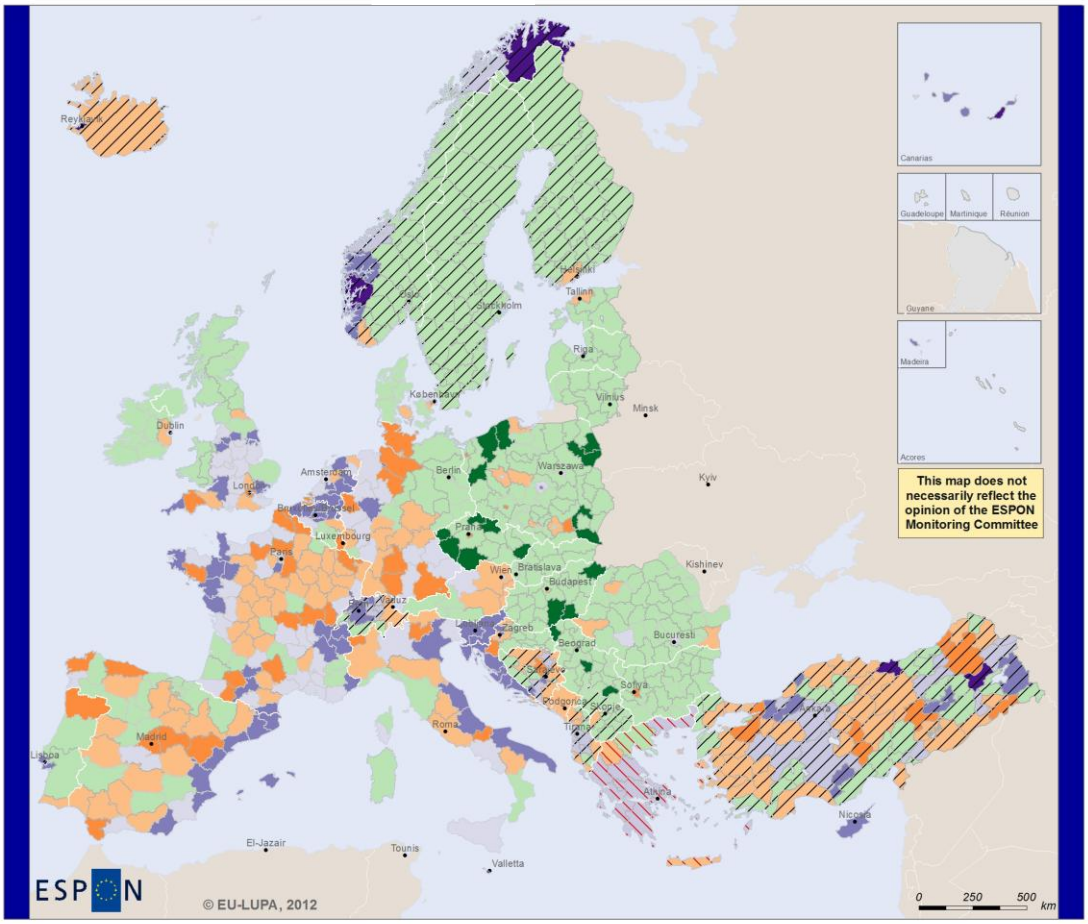
In relation to land use change this is the cornerstone of the EU-LUPA land use characterization and it answers the question, based on the regional clustering of all CLC flows, and changes in land use intensity, what characterizes land use changes in Europe? The

results are typologies of Land Use Change provided at a regionalized NUTS2/3 level in the Scientific Report Volume I Section 3.5).

As an attempt to account for this void, the intention of the Land use change typology is also to generalize land changes in terms of intensity of changes and the underlying usage characteristics of the land changes. This is achieved by trading the measure of amount of land change in the hotspots typology and replacing it with a characterization of changing land uses. Regionalized land use change intensity is therefore combined with the distribution of the most telling groups of land cover changes (LCF's) in a cluster analysis, and then grouping the results into descriptive Land use change types. In this connection, the main benefit of the Land use change typology is that it is able to reflect a limited number of dominant characteristics of land use changes; especially, urbanization from natural areas, intensive urbanization, maintenance of rural functions, and agricultural withdrawal. In terms of urbanization for instance, it adds another dimension where population or employment data is often used to reflect the urban development of regions. Complementing this, we can now see a regional dimension to these processes as they take place, literally, on the ground. In this connection, a direction of further work could be to make a closer comparison to land changes resulting in new or maintained urban areas, and to compare this data with regional – or even municipal – population data. This could give an interesting insight into places that are either maintaining or growing their population (labour force) and what the implications re in terms of land take and urbanization.

Map 3 shows the distribution of Land use change types among NUTS2/3 regions for the 1990-2006 time series. However, only 561 of the 772 NUTS2/3 regions have CLC data for all three time periods. Regions missing data for one of the periods are filled using data from either the 1990-2000 (Greece) or the 2000-2006 (all black cross-hatched regions) time series.

Land Use Change Typology
1990 - 2006



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Regional level: NUTS 2/3
Source: Nordregio, 2012
Origin of data: EEA, 2011
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No.	Land Use Change Types
1	Very high intensification - land take, often from natural areas
2	High intensification - continued urban land take from rural land
3	Moderate/high intensification - urbanizing areas while maintaining rural functions
4	Moderate intensification - rural conversions combined with notable land take
5	Moderate/low intensification - mainly rural conversions with low levels of land take
6	Low intensification - rural conversions with negligible land take. Some agricultural withdrawal
7	Extensification - rural conversions with significant levels of farm withdrawal

Only 1990-2000 data
Only 2000-2006 data
No Data

Map 3 Land use change typology- 1990-2006

Number of regions	5
Average Percent Urban Change	99%
Average change of intensity	4,17

Table 3 Type 1 Very high intensification - land take, often from natural areas

Table 3 shows that the five regions in this cluster are very unique. The land changes that have taken place are almost exclusively related to development of artificial surfaces, and especially the extension of these surfaces on previously natural land (only 12% of the changes are changes from one form of urban surface to another, while 87% relate to sprawl into previously unsealed surfaces). 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, Malta and northern coastal regions in Norway, also in two other regions in Turkey.

Table 3 also shows that the area of the change is very small, thus indicating very concentrated developments. This is substantiated when looking at the regions in this type. In the case of the Spanish regions and Malta it is clear that sprawl of touristic infrastructure into natural landscapes is taking place. In Norway, it is clear that the typology reflects the continued development of infrastructure needed to support the growing oil and gas development as well as the mining sectors. These activities are expected to expand further in sparsely populated areas of most of the Nordic countries in the next decades.

Number of regions	71
Average Percent Urban Change	51 - 67%
Average change of intensity	1,40 - 2,45

Table 4 Type 2 High intensification- continued urban land take from rural land

This type includes regions where more than 50% of the land changes resulted in a further urbanization. This is also reflected by the high intensity scores, which together show that the dominating process taking place is land take and thus urbanization. Interpreted through Map 3 we see that this type reflects at least two types of regions: first, those regions encompassing national capital or large urban centres (or in daily commuting distances). This reflects the reality of growth of urban regions in Europe and is especially evident in the U.K., The Netherlands, Belgium, Switzerland and France. In this context, the term “continued” is used in the naming of the type to reflect that many of these regions could already be defined as containing dominant “urban functions” prior to the 1990. The fact that very few “rural” land changes (forest conversions or agricultural changes) appear to be taking place also insinuates that these are already established urban areas.

In this context it is also interesting to point out that large, global cities (which are NUTS2/3 regions in and of them) are not characterized through these Land use change types reflecting intensive, urbanizing land changes. In contrast it is the surrounding, functional region where the most intensive land changes are occurring, which reflects the process of sprawl associated with growing urban regions.

In addition to these existing urban centres, and like the regions in the previous type, this type also includes regions where land change processes are clearly dominated by a growing tourist economy. For example, almost all of the regions accounting for the Spanish

Mediterranean coast and the Balearic Island are included, while the same holds true for coastal Italy, throughout Croatia and in Cyprus. This is substantiated by a recent report on best practices for limiting soil sealing (Prokop et al. 2011) where the main driver of high soil sealing per capita is the experience economy (second homes, touristic infrastructures, etc.). Not underestimated as a driver of land use change in these regions is the development of large infrastructure projects, such as highways, which we know to be responsible for land take in Spain and Croatia among other countries.

Number of regions	72
Average Percent Urban Change	44%
Average change of intensity	1,09

Table 5 Type 3 Moderate/high intensification- urbanizing areas while maintaining rural functions

In addition to the Blue Banana with land changes reflected in the previous two types, we also see this type extending through southern half of the U.K., through The Netherlands and Western Germany, southern France, in two "peri-urban" regions surrounding Madrid, throughout Greece (in the 1990-2000 data) and, notably, in selected urban regions in city-state regions (or those directly surrounding them) in Poland (ie. Warsaw, Ludz and Poznan) and extending to the large NUTS3 region where Milan is situate. In general we also see that this land use type is predominantly located in Western European regions.

The statistical information from Table 5 shows that a relatively high percentage of the changes 7.4%, relates to urban land management. This insinuates that these regions have established urban activities, likely in contrast to very recent processes of urbanization, and that the sprawl of housing, economic sites and infrastructures is taking place around established centres of socio-economic activity. Yet while this 44% of changes are attributed to urban processes, it is notable that rates of both agricultural formation and withdrawal of farming are very low (under 4% of total changes for each). Coupled with moderate levels of agricultural internal conversions (19%) and forest creation and management (22%) we can conclude that these rural land functions are still important contributors to socio-economic development, and that these processes appear to be quite stable.

Number of regions	42
Average Percent Urban Change	36%
Average change of intensity	0,85

Table 6 Type 4 Moderate intensification- rural conversions combined with notable land take

Unlike the previous clusters, a threshold has been crossed where the average level of land use intensity change is now less than 1. Similarly, the share of "urban" land changes is reduced to 36%, but is still a notable impact of land change. As such, regions in this type appear to have *mainly* rural land functions but urban changes are perhaps increasing in number and are important for meeting development goals. Further, it seems that this type, along with the next type as well, indicate regions with very diverse constellations of land changes taking place.

The statistical characteristics of this type were found in the 1990-2006 and the 2000-2006 data, but not in the 1990-2000 time series. This could be indicative of a further "mainstreaming" of urbanization throughout a wider share of previously rural regions in Europe compared to the 1990-2000 period.

However, we also see that many of the regions in this group are relatively large area-wise. As such this could indicate an unavoidable constraint of the typology classification for

relatively large regions: where rural land changes take place over broad areas trump urban land change processes that are very intensive but take place on a comparatively smaller scale. This reiterates a key challenge of the project: to attempt to merge spatial phenomenon which operates relatively independent from administrative/political spatial structures with administrative boundaries that are hugely disproportionate in size.

For example, we know that regions with large cities in their borders, such as Madrid, are regions where a vast majority of people live in the urban centre, and where urban sprawl is taking place. Yet due to the large surrounding areas within the administrative border the region appears with non-urban land changes as dominant.

Number of regions	87
Average Percent Urban Change	18%
Average change of intensity	0,62

Table 7 Type 5 Moderate/low intensification-mainly rural conversions with low levels of land take

The land use change characteristics in this type are similar to the previous type except the rural land change process increase in their role of defining regional changes ("urban" land changes in LCF's 1-3 decrease by 50% from the previous type and are mostly replaced by agricultural conversions and forest creation and management). This appears to emphasize a transition toward regions that are understood as mainly rural from a socio-economic perspective.

Similar to the each of the previous types there is quite a clear east-west dimension to this type as well. However, it is interesting to note that while this type is dominant in Western Europe (it is the most common type in continental Western Europe) it characterizes the land use changes in selected regions in selected Eastern European Member States as well. For example, we know that Poland has continued to shift toward the socio-economic standards defining regions in Western Europe – and has done so to a greater degree than other New member States such as Romania, Latvia Estonia, Bulgaria, Slovakia, etc. Consequently, we see more orange regions - with at least a medium level of relative intensification toward urban land uses - in Poland (compared to the green regions in the other Member States, which show that rural land changes still dominate).

This adds credence to a type of processional shift in land use that could be an almost unavoidable impact of socio-economic development toward a modern economic economy. If this holds true we could expect that future regional land use changes types in Poland (which became a Member State in 2004) could reflect those shown for inland Spain (which joined the EU in 1986).

Number of regions	264
Average Percent Urban Change	4 - 12%
Average change of intensity	0,05 - 0,35

Table 8 Type 6 Low intensification- rural conversions with negligible land take. Some agricultural withdrawal

Table 8 shows that regions in this type are characterized by land changes that put together, results in a very neutral level of intensification. However, based on the discussion above rural land changes trumping urbanization in relatively large regions, we know that this low intensification could be the result of two different trends. For example, the Skåne region in southern Sweden is in this type, but as reflected in the case study on the Øresund region (see Volume VI of the Scientific Report) we know that quite high urban development took place around the City of Malmö during and following the construction of the Øresund Bridge. However, the large amount of agricultural conversion in the rural parts of the region appears to mask this development in the typology results. Again, this reflects the difficulty of attempting to formulate a typology that can overcome both the scale factor (differing size of regions), the time factor (results of rapid changes take time to be registered!) as well as the underlying reality that a diverse set of land uses and changes (which are often completely isolated from one another in space) are occurring in the same region.

Nevertheless, the more common representation is of regions that are rural and with urbanization land changes accounting for only 4-12% are, for the most part, are staying that way. The changes that do take place predominantly relate to forest and agricultural conversions (mainly forest in the Baltic Sea Region and mainly agricultural in most of continental Europe. However, we do begin to see a slight rise in LCF6 – withdrawal of farming, which implies that certain regions in this type are being exposed to pressures of changing socio-economic realties, not least population loss due to the increasing supply of jobs in urban centres.

Number of regions	19
Average Percent Urban Change	2%
Average change of intensity	-0,29

Table 9 Type 7 Extensification- rural conversions with significant levels of farm withdrawals

Regions in this “extensification” type are unique and important to acknowledge because they highlight regions where cumulative land changes in have resulted in an extensification of socio-economic activities taking place on the landscape. For a vast majority of the regions, if not all, the dominant driver is the reduction of agricultural activities. On average, 9% of the land change in these regions is related to agricultural withdrawal – a significant share indeed. Not surprisingly, this trend is driven by urbanization, particularly of younger people to urban centres in search of higher quality jobs but to some extend also through withdrawal of activities which have been kept “alive” through different supporting mechanisms. Consequently, traditional jobs in rural areas suffer from low replacement rates of an aging labour force. As such, land use changes seem to reveal a socio-economic trend of rural stagnation and decline 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. What is important to consider however, is that the processes of urban development (the purples and oranges in the typology) and the

processes of rural stagnation or decline (the greens in the typology) do only reflect independent drivers. From a theoretical perspective of Growth Poles, a clear example of this is in Poland where urbanization processes in selected regions appears stronger than in other New Member States. However, to meet this growth urban centres are plucking their labour force from rural regions, therefore leading to extensification of rural area.

As such, a common challenge of land use change reflects the polarization of economic activity: rural areas could continue to experience significant agricultural withdrawal while urban centres will continue to expand as population growth and economic activities continue to be concentrated in them. Another important challenge is related to future situations where policy measures in relation to for instance re-organization of the CAP, change in regional supporting mechanisms from block grants to targeted issues such as poverty, environmental protection, or change in perceptions of what are "liveable landscapes" etc. may have on the direction of land use change. In this context, typologies where measures of intensities combined with basic socio-economic accounts such as population density and GDP seem to be very useful.

While the descriptions of the Land use change types highlighted a number of very interesting trends – trends which were largely validated in the case studies - the reality is that they represent a further generalization of land change processes. And while it was shown to be beneficial to generalize land change trends it is also potentially misleading; not least due to the fact that any changes deviating from the "average changes" or dominant changes are not well reflected. Consequently, the results of the Land use change types can have a tendency to over generalize land changes - and the processes behind those changes – for some region, especially relatively large ones.

4 Land Use Functions assessment

The approach to "land use" should therefore not only be seen from the land cover perspective but also from the perspective of "functionality", which provides 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) to be binary, i.e. one land use activity would exclude other activities, the situation in Europe is that the functionality of land areas has been increasingly diversified: on one hand towards exclusiveness with mono-functional large scale production, and on the other hand towards inclusiveness, which stresses the fact that different activities co-exists. In regards to the latter, policy and planning should develop methods where the question of harmonious and disharmonious functionalities could be a way of improving the planning process.

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.

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.

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 10. 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.

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 make them comparable and 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 ratio 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.

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)

Table 10 The six Land Use Functions in EU-LUPA project

4.1 What functions are supporting the different regions?

So far we have seen the changing faces of Europe related to land uses. Next step is to understand: which 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 3, 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).

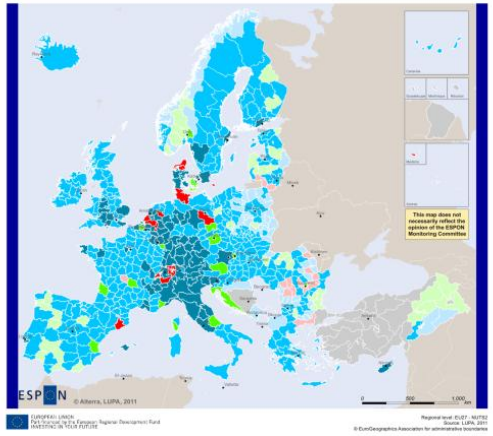
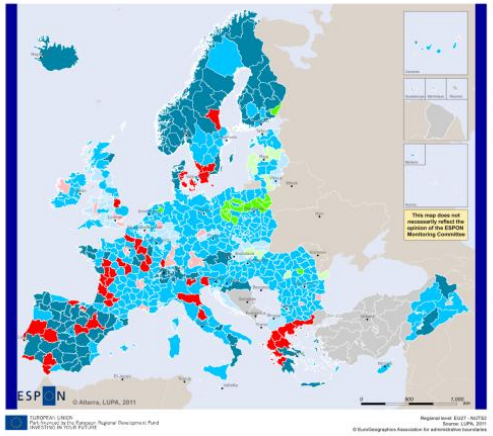
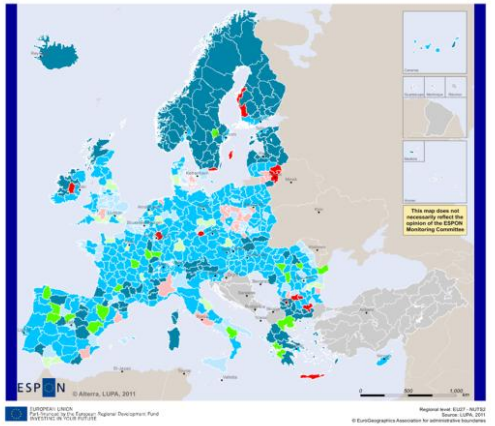
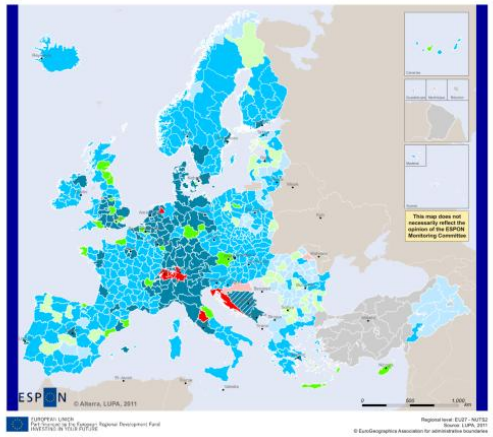
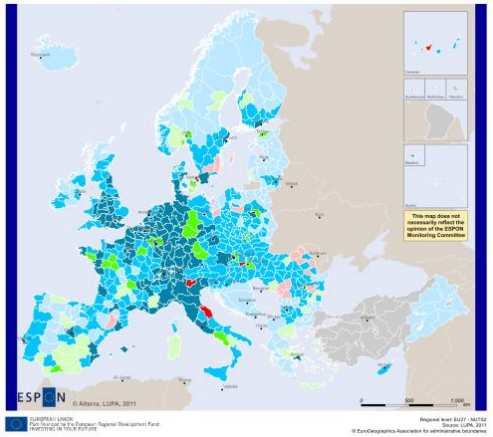
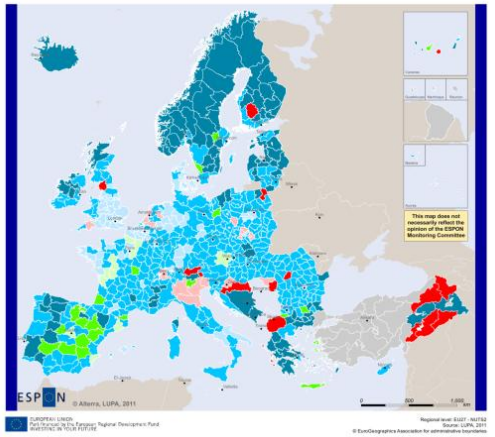
The assessment of the changes in the six LUFs provides a more detailed insight at functional level. The analysis of the LUFs maps show that:

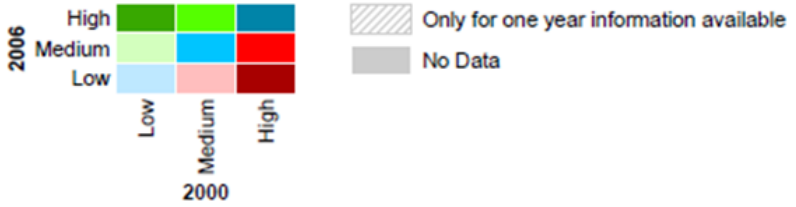
- Extreme changes do not occur and the overall pattern shows stability in the six years studied. Overall Scandinavia shows the highest stability, being central and southern Europe more unstable with mixed patterns.
- The two mainly economic LUFs (LUF1 Provision of work and LUF2 Leisure and recreation) 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 Dutch '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 (Italy).
- More intensive changes tend to occur in shorter lapse of time, while reversing their potential negative impact would take much more time -if not irreversible. This is well exemplified on the LUF ecological functions that needs longer period of time (> 6 years in our project) to see changes (changes at general ecosystem level, not single factors). On the other side economic components are much more flexible and change over very short period of time. The risk is when rapid changes in socioeconomic components are based on intensive use of large areas. In those cases an exhaustive analysis would be required to avoid a serious compromise for the future.

On the maps composing figure 3 bellow please note that the Northern part of Cyprus is indicated as "no data" since EUROSTAT statistical data is not available for areas outside governmental control.

Figure 3 Changes in the performance of the six LUFs for the period 2000-2006

Mainly societal	Mainly economical	Mainly environmental
LUF1 Provision of Work	**LUF3 Provision of food and bioenergy**	**LUF5 Provision of abiotic resources**
		
LUF2 Provision of leisure and recreation	**LUF4 Provision of housing and infrastructure**	**LUF6 Provision of biotic resources**
		



5 Analysing Land Use performance and efficiency

How to measure if the on-going 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*** *was defined within EU-LUPA as the degree in which the land is used to comply with a specific policy target.*
>
> ***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. Efficiency can be understood as the amount of resource needed to obtain certain output (benefit). In the case of EU-LUPA the resources is the land and it involves an understanding of both the quantity and quality.*

To date, several analyses have been undertaken in EU-LUPA project to assess Land Use Performance (LU Performance) and Land Use Efficiency (LU Efficiency) at regional level in Europe. However, from the results achieved so far it has been very difficult to extract any clear conclusions due to several constraints and conceptual limitations.

The first exercise for the evaluation of LU Performance and LU Efficiency at regional level is fully explained in chapter 6 of Volume II of the Scientific Report. The concept of Land Use Functions (LUFs) is further applied to define LU Performance and LU Efficiency. By assessing the individual performance and efficiency of the six LUFs, a deeper insight is reached in the depiction of the multi-functionality of a region. LU performance was defined here as the degree in which the land that is used for a specific function complies with a related policy target.

The second attempt to assess LU Performance and evaluate the LU Efficiency in EU-LUPA project concluded in the connection of Land Use Change Typologies (see Volume I) to changing LUFs (see Volume II of the Scientific Report). The idea is showing regions where changing LUFs 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 analysing land use changes vis-à-vis changing socio-economic and activities taking place within European regions. A cornerstone in the LUFs categorization is the connection between the performances 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 Corine Land Cover data allows us to analyse changes in LUFs in relation to changes in land cover. This is an opportunity to significantly expand the manner in which socio-economic and environmental activities are analysed in relation to land cover data. It becomes possible to compare the numerical distribution of the performance for all outputs of the distribution of the LUF analysis with the Land use change types for each region.

Finally, 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, was undertaken. 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 vice versa.

5.1 Are the trends sustainable?

A test has been done with the Nitrate Directive in order to show the potentiality when a clear threshold is available. The Nitrate 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.

Two options were considered:

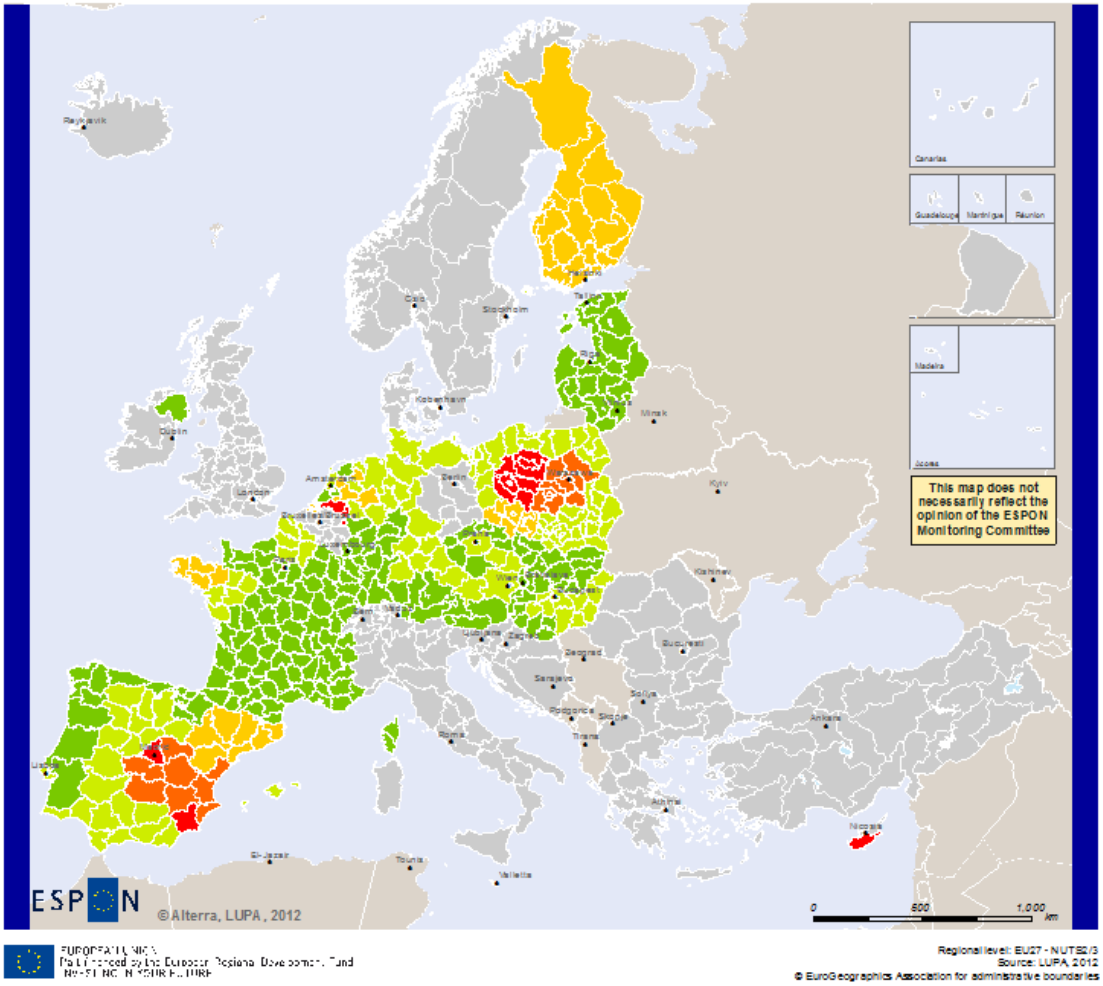
Option 1: Showing the level of compliance above and below the policy target. See Map 4.

- If nitrate concentration in the NUTS 3 region is > 50 mg Nitrate / litre (policy target) (which is considered as 100%), then the LUF5 and LUF6 performances are negative and it is expressed as a proportion below the 100%;
- If nitrate concentration is < 50 mg Nitrate/l, then the LUF5 and LUF6 performances are positive as it is expressed as a proportion above the 100%.

Option 2: Showing only the level of compliance when the values are above the policy target and considering all values below the threshold as 100% compliance. See Map 5

The results are shown in Maps 4 and 5, respectively for Options 1 and 2. The 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 LUF5 and LUF6 environmental land use performance regarding the agricultural land use is negative.

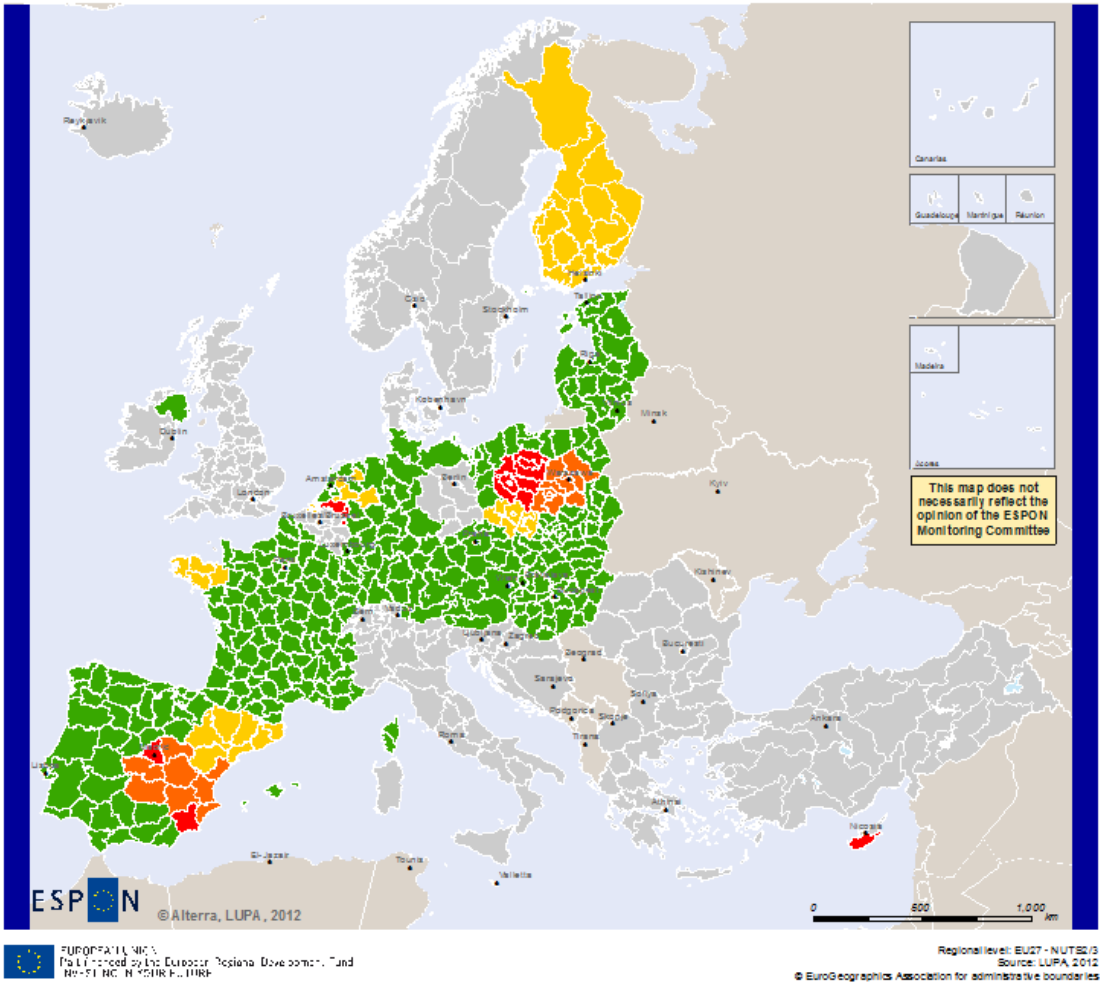
Moreover, it is possible to differentiate the case of Poland where it is strongly linked to changes in agricultural areas, while in the rest of the countries the process is more complex and probably related to decrease in agricultural area or even displacement of agriculture to less productive areas 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 % above threshold
- 34 - 66 % above threshold
- 1 - 33 % above threshold
- 0 - 50 % below threshold
- 51 - 100 % below threshold
- > 100 % below threshold
- Only for one year information available
- No Data

Map 4 Option 1. Land use performance regarding the Nitrate Directive policy target



Option 2. Land use performance regarding the Nitrate directive
Policy target is below 50 mg Nitrate / litre - year 2000

- > 67 % above threshold
- 34 - 66 % above threshold
- 1 - 33 % above threshold
- Complying policy target
- Only for one year information available
- No Data

Map 5 Option 2 Land use performance regarding the Nitrate Directive policy target

When comparing the Land Use Functions to the Land Use Change typologies a majority of land changes (calculated by area of change) are taking place in regions where extensification is taking place due to agricultural and forest change. And where this is taking place, a vast majority of the regions are characterized as having a neutral performance in terms of provision of work in both 2000 and 2006.

However, the most interesting element of comparing the LUFs to the typology is to see where changes in relation to each LUF (either increases or decreases) match up against the land use change types.

Our research has shown that decreasing functionality in terms of provision of work is most likely to take place in regions that falling under the typology "extensification due to agricultural processes and forest changes". In fact this supports the notion of both the typologies and the LUFs (where extensification can often lead to a loss of job opportunities), which is a very common trend for instance in the rural and sparsely populated parts of the Nordic countries. This seems to show that land use patterns are indicative of the economic processes taking place in these regions.

Besides, high intensification due to residential and economic sprawl combined with forest conversions, and Medium-high intensification due to diverse urban processes are characteristic of regions undergoing an increase in provision of work.

The correlation between population growth rates and land take (2000-2006) shows that in most regions the pattern has been that the increase in average population growth has gone together with an increase in the average annual growth rate of land take. Land take is growing faster than population. However, in certain regions mainly of Spain, The Netherlands and Ireland, the urban development has been a fast phenomenon particularly during the analysed period with irrelevant population growth At the European level, housing, services and recreation made up a third of the overall increase in urban and other artificial area between 2000 and 2006. (LEAC Database, based on Corine Land Cover 2000-2006 changes, version 13, 02/2010, ETC/LUSI, EEA, Land Take GDI 5 March 2012).

In western European countries but in particular in Spain, Ireland, Portugal suffered an unsustainable rise in the price of real state from the 1990s to 2008, commonly known as property bubble. This has had an enormous impact on the urban development in these countries. For instance, house ownership in Spain is above 80%. The desire to own one's own home was encouraged by governments in the 60s and 70s, and has thus become part of the Spanish psyche. In addition, tax regulation encourages ownership: 15% of mortgage payments are deductible from personal income taxes.

Certain parallelisms between increase in employment rates and land artificialization could be seen in several Spanish, Irish and Portuguese regions. Again this could be explained due to those countries dependency on construction/building sector.

5.2 Challenges analysing sustainability of the land use trends

There are several challenges and questions that remain unresolved or in need for further explanation and rationalization.

Most policy targets are territorially blind

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.

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 at NUTS3 in order to evaluate the potential correlation between land use dynamics observed in the Land Cover Characterization and typologies and the distance to the headline targets set in the EU2020 Strategy and Cohesion Policy at NUTS2/3 level. 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

Besides as previously highlighted the ESPON SIESTA Spatial Indicators for a "Europe 2020 Strategy" Territorial Analysis[5] has emphasized that the spatial dimension of the strategy is not that obvious. Indeed, the report pointed out that, scholars such as Böhme et al. (2011)[6] recently stated that the spatial derivative of the EU2020S is territorially blind.

Narrow timeframe

The consideration of only 6 years to measure land, environmental, social and economic changes is not enough timeframe to extract a conclusion on performance and efficiency.

Land Use functions approach to assess LU efficiency is in principle quite coarse.

However the approach helps in showing how relatively efficient multi-functionality works out in each region. For example, the land of a region can be used very efficiently to provide food, while at the same time being inefficient in providing housing and abiotic resources

[5] ESPON SIESTA Spatial Indicators for a "Europe 2020 Strategy" Territorial Analysis. Draft Final Report 10/08/12.

[6] Böhme, K. et al (2011): How to Strenghthen the Territorial Dimension of Europe 2020 and the EU cohesion policy. Warsaw. Ministry of Regional development.

(e.g. some North provinces of the Netherlands). The LU efficiency approach also helps to find out the degree of current use regarding the maximum (e.g. provision of food and bioenergy) or the potential use (e.g. in provision of abiotic resources).

Limitations in the results visualization

Visualisation of the LU performance results with maps and spider diagrams brings complementary information. The maps show the spatial distribution of the calculated values and help to identify hot spots, however it is difficult to get the full picture (i.e. addition of all the LUFS and indicator maps) for one region. The spider diagrams provide this by visualising at once all the indicators or the LUFs for a single region, displaying their distance to the EU average. Being able to analyse simultaneously the spider diagrams of the indicators and the LUFs, also helps to understand the role that the indicators play in underpinning the values of the LUFs. The spider diagrams show as well the large differences between the Nuts 2/3 regions and highlight their main functional specificities.

Working with aggregated data

In the attempt to link 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.

Scale and complexity of the 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.

6 Urban sprawl

The urban dimension of the EU-LUPA project and in particular the analysis of the urban sprawl phenomena is included in Volume IV of the Scientific Report.

The city types and urban processes have been analysed with regard to the **Prevailing Land Use Types** defined at NUTS2/3 level (see Volume I on Land Use Characterisation in Europe). It has been assumed that the regional/administrative level integrates socio-economic factors, connected to certain policies at that administrative level, which may influence the evolution of the cities. Therefore, it has been interesting to explore to what extent typologies developed at different scales for different entities, but connected by the geographical and socio-economic context, are complementary to understand the land use patterns. As presented in chapter 3.1, the analysis of the prevailing characteristics of land use at regional level resulted in 10 classes, from which 3 included most of the analysed cities. These typologies are: Urban cores and metropolitan areas; Suburban or peri-urban areas; Arable land in peri-urban and rural areas.

Considering size and form, urban development and destination of new urban areas, EU-LUPA project has settled a typology of urban development resulting in 4 categories:

Type 1. Slowly growing cities: diffuse and compact.
Type 2. Rapid growing cities. This group represent almost half of the European cities.
Type 3. Very rapid growing cities with diffuse urban development.

Please go to chapter 2.2 of Volume IV of the Scientific Report to see details on the definition of this typology.

Figure 4 shows the distribution of typology of cities in each of the regional land use type. It could be observed that slow developing cities are more common in urban cores and metropolitan areas. It reflects to a certain extent the limits of growth of current metropolitan areas because of physical constraints (i.e. no more space to growth), but often also related to more strict planning and development of green infrastructures which delineates new boundaries. This is complemented with the lowest percentage of very rapid growing cities. The rapid growing cities are found on the suburban areas and arable land in peri-urban. This reflects the current trend of new developments close to existing poles either in the periphery (suburban areas) or in regions that used to have a more compact distribution of cities in a rural context. In general rapid growing cities are very common in all regional types and are not distinctive.

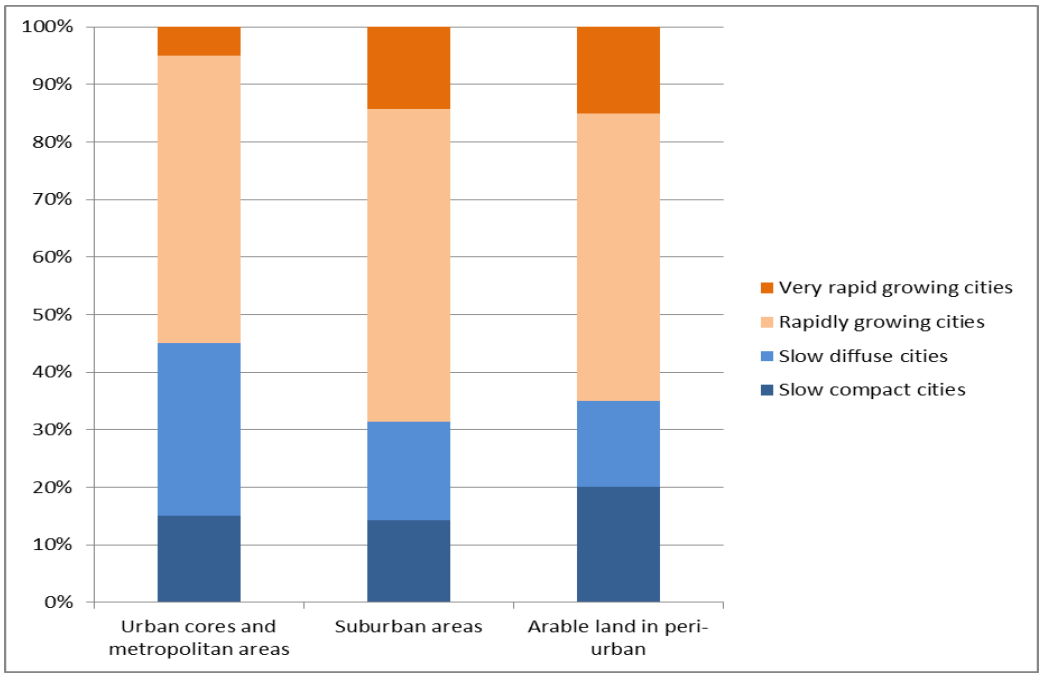


Figure 4 Distribution of typology of cities in three regional land use types

6.1 What is the impact of urban sprawl?

Urban growth comes at the expense of other land uses. In the core cities there is a clear dominance of new building development on previous agricultural land (Figure 5). This is due to several factors: Firstly most of the available land for urban growth is agricultural. Secondly, agricultural land is in most cases technically more suitable for construction than forest areas both topographically and in economic terms. Thirdly, natural areas are often considered as valuable recreational areas and hence cities have protected them from building activities. Grouping cities by regions highlights some specificity like in Eastern countries about 30% is developed on previous forests. In the large urban zones the agricultural land is still the primary source. However, in Eastern cities most of the land is developed on forests.

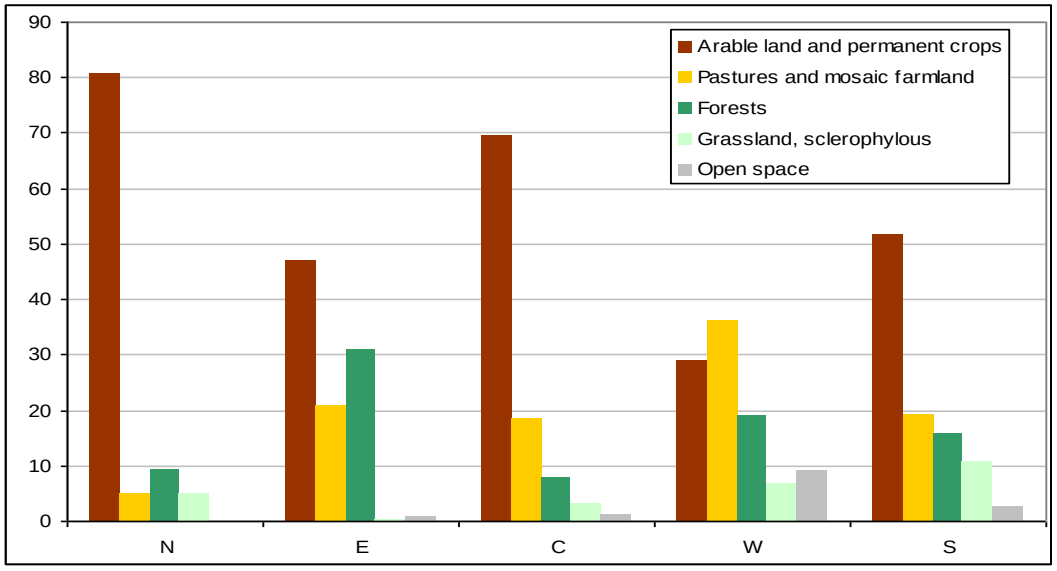


Figure 5 Natural and agricultural land lost due to urban development in the cities (2000-2006)

Percentage indicates the previous land uses in the total developed land. Cities have been grouped by countries: Northern, Eastern, Central, Western and Southern Europe[7]. Source: CORINE Land Cover.

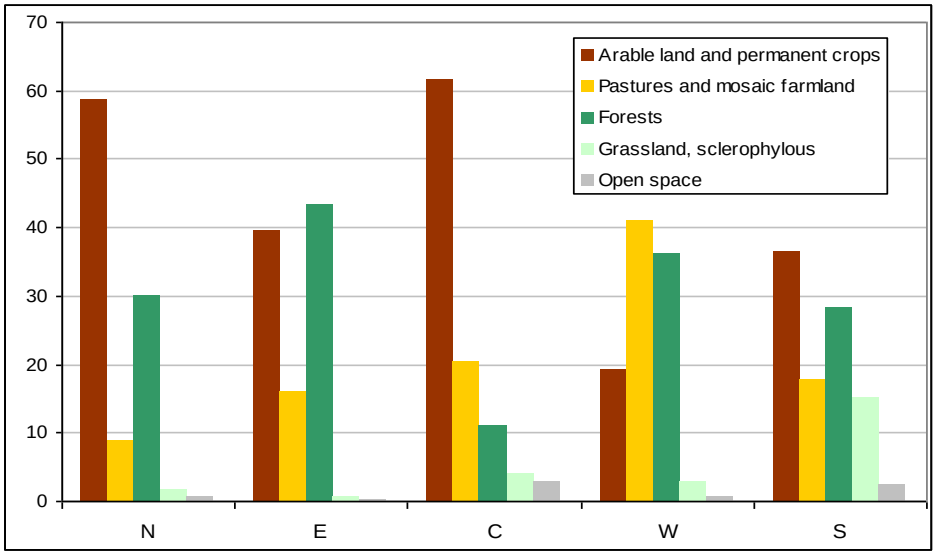


Figure 6 Natural and agricultural land lost due to urban development in large urban zone (2000-2006). Percentage indicates the previous land uses in the total developed land. Cities have been grouped by countries: Northern, Eastern, Central, Western and Southern Europe (Source: CORINE Land Cover)

[7] Northern countries: DK, FI, SE, NO. Eastern: HU, BG, CZ, EE, HR, LT, LV, PL, SK, SI, RO. Central: AT, BE, DE, LU. Western: FR, IE, NL, UK. Southern: CY, ES, GR, IT, MT, PT.

6.2 Future perspectives

Urban development in the last 20 years tended to homogenise and reduce the distance between different development paces. Generally speaking, stable cities or the ones with slow development in the 90s have experienced a relatively rapid increase while the cities that were very rapidly growing at that time have slowed down at the turn of the century.

Reuse of previous urban land has significantly increased in both core city and LUZ. The development of new residential areas has been reduced, while industrial and commercial areas are still increasing and becoming the main source of urban expansion. This is a general trend observed in the last 20 years where urban sprawl is less and less associated to development of residential areas and more to other economic developments. However, there are some exceptions like the Mediterranean coast, and specifically in Spain where second homes and speculation have been driving forces for urban development still in the period 2000-2006. Many Eastern mid-size to small cities also show a differential trend being the development of new residential areas dominant over new industrial and commercial ones.

City form and city compacity is the result of the history and evolution of urban areas including geographic and cultural factors. The available information indicates that several factors confluence in the more compact cities:

- Higher proximity of urban patches to the city centre or core city
- Mixed uses of land

However, more dynamic indicators like soil sealing per capita reveals that urban morphology and compacity alone does not explain the complexity of the system. Moreover, urban development in the last decade shows that intermediate cities are the most dynamic ones at the risk of being less efficient on use of land resources (soil sealing per capita).

From the transport perspective, compacity relates to increased use of public transport to work. However, more data is required to have a complete overview on all traffic in European cities. Current efforts done by the EC in this sense are very relevant.

All these factors are reflected in air quality, which indicates better conditions in more compact cities. In order to overcome the negative aspects there is a need for local energy generation, more efficient management of energy use and readjustment of living patterns.

7 Border effects

Borders are almost synonymous with political, demographic and economic remoteness, the meeting place of different competences, structures, legal and social affairs and they also behave as functional and territorial discontinuities (ULYSSES Final Report).

From the reading of the EU-LUPA maps there are very clear disparities between neighboring countries, but also high differences between many neighboring regions. For instance, for France vis-à-vis Spain we know that large amounts of building, infrastructure development and agricultural changes have taken place in Spain while, apart from selected regions in France land use has been very stable. Similarly we see marked differences in the volume of land change in between old East and West Germany since the fall of the Berlin Wall.

Visualization of these differences only reaffirms the importance of considering land use implications in the border regions when assessing the feasibility or appropriateness of policy.

Key messages on border effects (See Volume XIII chapter 4.1)

- The internal EU 15 borders are, from a structural point of view, still more favorable for cross-border governance than, for example, external EU borders.
- The borders seem to keep functioning as a limit for the diffusion effects of development poles. This essentially indicates that, besides the European effort in promoting territorial cohesion, the national level maintains a prime role in regional development.
- Spatial planning cultures and traditions play a key role in the border effect.
- **Pyrennees Spain-France** With regard to territorial development and spatial planning, the two systems of France and Spain are quite different. From an institutional point of view, France has a much more centralised system, while Spain is much more focused on the Autonomous Communities. On the content side, France has traditionally focused on the comprehensive approach of aménagement du territoire whilst Spain is following to some extent a land use regulation approach without an excessive degree of regulation.
- **Upper Rhin metropolitan region (France- Germany)** The economic situation of the rural areas concerning agriculture is in comparison to other European regions strong and has a relatively solid added value. This is due to concentration on winery and arable crops. The area used for agricultural use however is shrinking on an average level. The available data does not allow getting an insight in conflicts of land use. Due to topographical circumstances agglomeration takes place in the plain Rhine valley. Urban development and agriculture have to share the most valuable soil, so there are conflicts which cannot be described with the data.
- **Oresund region (Denmark- Sweden)** Strongly developed zone of summer houses along sea coast during many decades. Now landscape conflict with needs of wind power plant on the sea and spatial conflict about needs of access to sea coast and recreation, which is a barrier for further residential zone enlarging and intensifying. Urban sprawl according spatial plans (controlled by law). Transformation of regional industry and economy appearing in deconcentration of high-tech economy and R&D sector activities connected with demanding of clean environment, improving conditions of work and spatial accessibility, lowering costs and decreasing role of agglomeration profits.

- **Poland- Ukrania.** Chełmsko-Zamojski region is located in the south-eastern borderland of Poland in Lubelskie voivodeship by the Ukrainian border. Both, geographical and historical context have a significant impact on the current economic structure. Localization of the region is one of the most important factors of its economic structure. From one side it used to be a peripheral region for over two centuries, among the others, in the industrialisation period in 19th century it was a borderland of the Russian Empire. From the other side, there are very favorable conditions for the development of agriculture in the region. Currently the region remains fully peripheral in the European and country scale as it is located relatively far from Lublin, the core of Lubelskie voivodeship. On the other hand, there are three Polish-Ukrainian border crossing points and three main routes are passing across the region. They are attained mainly by vehicular traffic and are forming the main axis of development in the region. The local cores of development are Chełm and Zamość. However, their influence on the surrounding rural areas is rather weak and of a narrow range. Considering the economic activation of the region issue, its localization is a strong barrier for further development. This is reflected by an insignificant foreign investment dynamics, tourism development etc.
- While many border regions used to be characterised by differences in land use due to the influence of differences in national land use policies, Common Agricultural Policy (CAP) has reduced these differences. Nowadays differences are much less dependent on national policies and they tend to reflect combinations of natural potentials, settlement patterns and infrastructural characteristics. As a small scale example, one could mention the border between Denmark and Germany, which was previously marked with very different land uses according to CORINE 1990 data. However, with the incentive of EU membership for Denmark, a marked intensification in cattle and milk production in the border region of Southern Jutland developed, while the land use south of the border continued to be characterized by extensive land use. As a result, the differences in land use characteristics have been considerably reduced. As a large scale example, the above mentioned East-West divide in land use characteristics due to previous differences in economic systems could be emphasized. A general characteristic in this connection is the process of de-population and retracting/extensification of agricultural activities from mountainous and sparsely populated areas, and replacing it with tourism – often in combination with agriculture and other traditional land uses.(See Volume I Chapter 3.2)
- In the need for strengthen territorial cohesion particular emphasis should be placed on the role of cities, local development and the macro-regional strategies.

8 Case studies

The following case studies were implemented

1) Öresund – as a cross-border region with highly a differentiated and multifunctional land use structure (from urban core, semi-urban to arable) (See Volume VI of the Scientific Report)
2) Eurocity Basque Bayonne- San Sebastián - a cross-border region, with high share of urban areas in a multifunctional rural setting which is still dominated by agricultural activities; (See Volume VII of the Scientific Report)
3) Chelmsko-Zamojski – which is located on periphery (EU border) and characterised as a monofunctional agricultural region; (See Volume VIII of the Scientific Report)
4) Jeleniogórski – located on the Poland-Germany-Czech Republic borderland with multifunctional land uses reflecting the economic transition taking place there. (See Volume IX of the Scientific Report)

The first step of the case studies 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 their dynamics have been characterized. In each region the major effect of the land use change (deforestation, desertification, soil degradation, biodiversity changes, urban sprawl, floods etc.) and dynamics of these changes were identified.

In a third stage, regional development strategies and other regional and state documents according to land use policies and influences to land use changes were then analyzed. Other sources with influences to land use changes were also investigated, including interviews with local authorities and other important stakeholders.

The final stage was devoted to field work studies which were carried out in each of the case studies in order to observe of current condition of land use (character of settlements, structure of agricultural land, industrial areas, tourism zones, natural areas, multifunctional land use etc.).

Complementing the field studies, personal in-depth interviews were undertaken addressing preferred stakeholders - representatives of regional authorities, regional research organizations (universities, research institutes, etc.) dealing with regional development issues.

The case studies aimed at the identification of the drivers and dynamics of land use changes, which makes it possible to the answer about mechanisms and trends of land use changes, as well as the interrelation between different functions and factors in those changes and the verification of proposed typologies of land use change.

During the stakeholder's workshop held in Warsaw on the 10th of September 2012 a validation of the drivers in each of the project case study region alongside the identification of the key policy responses to their challenges was undertaken. The results are now included. (See also Volume XII).

At the EU level, generally speaking, stakeholders confirmed the classification of their region in the Land Change Hotspots and Land Use Change Typology maps.

Jeleniogorski region (Poland)	
Key drivers	**Policy responses**
• Demography (out-migration, decrease of natural increase); • Industrialisation at the beginning of the 1900s. and a decline from the 1950s.; • Historical heritage- period of the People's Republic of Poland and a transformation of the political system; • Tourism attractiveness; Local drivers: • mountainous area, good quality of soils, landscape, • poor accessibility, • co-existence of numerous functions. • No strategic policy for the region; • Lack of vertical cooperation; • No land use plans; • Natural & environmental conflicts.	• Regional plan already exists, but it is a very weak formal document with no significant influence; • Subregional programs related to certain problems and conflicts but these are informal planning thematic strategies; • Policy based on social trust rather than legal framework; • Efficient governance needed; • Bottom- up planning system approach rather than top-down required; • Vertical cooperation needed; • Real local consultancy; • Horizontal cooperation among municipalities; • Strong monitoring: both socio-economic and land use; • Regional umbrella needed.
Final discussion	• Stronger regulation and strategic perspective; • Multilevel distribution of competences; • Bottom-up is not enough, top-down regional is needed; • Participation at local level in the definition of regional planning is crucial; • New policy fields: integrated approach, landscape, clean technologies etc.
Oresund Region	
Key drivers	**Policy responses**
Regional competitiveness: accessibility and leading certain economic sectors; Housing and land prices: promotes the importance of multi-functionality. Decrease in the value of the agricultural land has driven the people to sell the land for housing. Also wind energy production; Increasing wealth lead to greater number of second houses, a lot of pressure to limit farming activities and develop second houses and leisure activities.	Strength and increasing accessibility; Focus on clean technology as an economic sector with a long term perspective (renewable energy mainly but not solely); Significant exporting of the clean tech strategy even out of the country: • Infrastructure development for connection with Hamburg, Copenhagen and Malmo and biodiversity offsets protecting landscape or land use somewhere else in the region. CAP is not able to include notion of multifunctional and additional land functions out of farming; Transport corridor in the EU from Oslo to Oresund and Berlin or even Warsaw for example.
Discussion: Most of the policies emphasized the continuation of the ongoing strategies: increasing accessibility and focus on clean tech; Improving the planning particularly in	Tax system: is problematic since some people are working in one place and living in another. The system should be addressed to them individually and somehow improved; Suburbs around Malmo and Copenhagen concentrating immigration which causes some conflicts, leading to spatial segregation- how to

Denmark with innovative instruments related to landscape and natural resources, this is already taking place in case of National Parks and landscape plans;	manage the growth from a social perspective; For instance in the Basque country around 20% of the new urban development should be social housing supporting housing.
Basque Government- San Sebastian- Bayonne	
Drivers	**Policy responses**
• Good performance indicators compared to the EU average; • Non-aggressive urban processes; • Strong spatial planning systems, controlling the urban development; • Investment on public infrastructure; • CAP is not influencing the Basque country since it is not receiving subsidies but is developing the organic farming with quality labels for traditional products and production; • Forest management - pines and eucalyptus; • Traditional industrial settlements located in rural areas, helping in maintaining economic activities. Linked with the steel sector located in the vicinity of to mining activities; • Social phenomena: cooperatives; • Successful urban regeneration; • An above average social and economic performance comparing to other Spanish regions could explain why the income from urban taxes was not the key element for municipality income.	• Common agricultural strategy is needed to coordinate rural activities and reinforce agricultural production related to quality products certification; • Primary sector is about 1% of the GDP and the government wants to reinforce this; • Forestry policies needed; • Improvement of the coherence among policy sector and spatial planning; • Improvement of coherence and the level of competence; • Innovative planning instruments: landscape, sustainable transport plans, climate change adaptation; • Strengthen the land use restrictions: delimitation of urban perimeters focused on regeneration and non-artificiality.
Discussion	Ageing should be included as a general driver with significant consequences.
Chełmsko-Zamojski Region	
Drivers	**Policy responses**
• Administrative division; • Food processing industry; • EU agricultural policy; • Strengthen of external border; • Competition of foreign food; • Urban sprawl; • Outmigration of young and educated people; • Ageing of rural societies; • Collapsing of state farms.	• Strengthen the sub-regional function of Chełm and Zamość (culture, education, tourism); • Special economic zone (bio-energy); • Support for alternative energy production (e.g., rape as a biofuel source); • Support for traffic services; • Promotion of organic farms, concentration of land ownership; • Strengthen of spatial planning; • Social policy of state; • Supporting of enlarging medium sized farms.
Discussion	More general ideas that could be applied in all cases • Financial bubble particularly in wealthy countries, after the crisis those regions have societies of the highest debt; • Public debts and financial bubble.

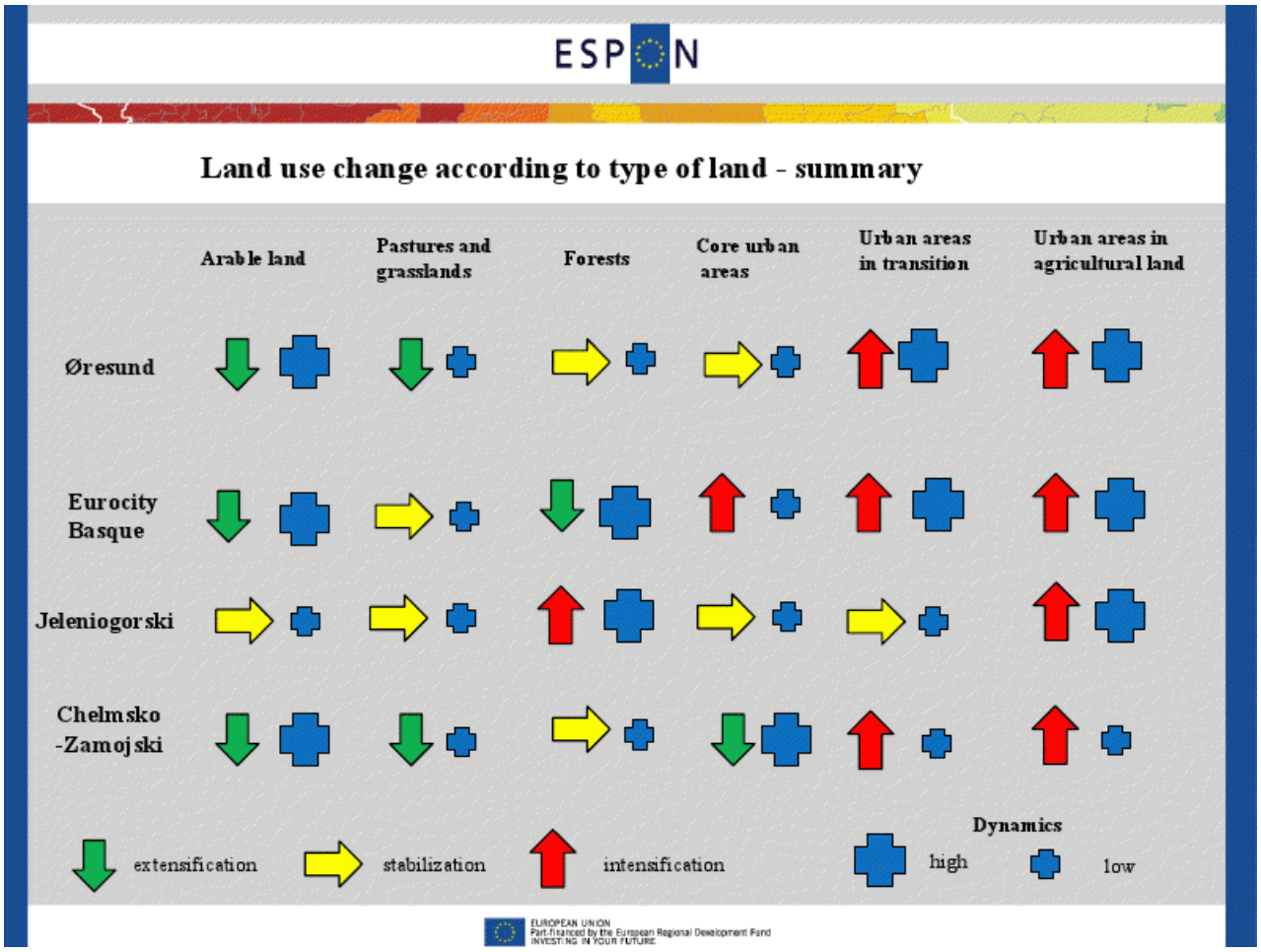


Figure 7 Land use change according to type of land – summary (Source: IGSO)

9 Lessons learned for policy development

EU-LUPA provides a battery of policy messages for awareness-rising that should be considered for future policy development. Policy makers should rely on research evidences in order to define the most appropriate measures and policies responses in line with the EU development principles and objectives (mainly under the EU Cohesion Policy, EU2020 Strategy and the Territorial Agenda),

- to support **responsible land management,** monitoring land use intensity,
- to resolve **conflicting land use demands** affecting the economic, social and environmental performance of a region,
- and to **identify the potentials for improving regional competitiveness and territorial cohesion towards sustainability.**

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 2008. This is important because trends in land use at the moment of entering the crisis may help to identify risks and potentialities.

In the EU-LUPA project, land use changes and dynamics in Europe have been approached as a policy driven processes in the context of the European Spatial Development, although the evaluation of the policy impacts is definitely out of its scope.

The land use characterization in the European territory undertaken in the project (See Volumes I and II) offers very valuable information with regard to the potentials and challenges of the regions, and it allowed us to identify the key policy areas to focus on when elaborating the policy recommendations. The key policy messages provided by EU-LUPA are far from being *ad hoc* regional policy recommendations. **They are general messages for awareness rising regarding land use changes in EU.** (See Volume XIII of the Scientific Report)

- **The enlargement of the EU to 27 Member States presents an unprecedented challenge for the competitiveness and internal cohesion of the Union.**

The assessment of the intensity of Land Use Change (see Volume I chapter 3.2) revealed that there is a clear east-west dimension that could be partly explained due to the enlargement of the European Union in the nineties. A couple of examples are provided which illustrate such phenomena. Large volumes of land use extensification are almost exclusively found in Eastern European member states, particularly in Poland, The Czech Republic and Hungary. This pattern is very dominant in the period 1990-2000 but continues in 2000-2006 as well. 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.

Besides, it also revealed that some of the most significant changes between 1990 and 2000 took place on the Iberian Peninsula. Considering that the agrarian reforms in such regions began during the 1970's and ended in the late 1980's, the changes could be partly explained likely due to the ascension of Spain and Portugal to the EU in 1986.

These are important observations because they highlight the types of changes that can be expected by current or future candidate countries.

- **The integration of the EU in global economic competition is accelerating, offering regions and larger territories more options to decide their development path, as development is no longer a zero sum game for Europe.**

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. 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).

In the analysis of Land Use Functions, the two mainly economic LUFs (LUF1 Provision of work, and LUF2 Leisure) show a high and stable performance in the Blue Banana corridor, as it could be expected, although some negative changes in LUF1 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 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 previous years to their entrance in the EU (2007).

- **Interaction is growing within the EU territory and between the surrounding neighbor countries and other parts of the world.**

This is apparent through e.g. migration pressure on more developed countries, which are themselves confronted with population decline, and by access to and investment in new markets. Borders are almost synonymous with political, demographic and economic remoteness, the meeting place of different competences, structures, legal and social affairs and they also behave as functional and territorial discontinuities (ULYSSES Final Report).

From the reading of the EU-LUPA maps there are very clear disparities between neighboring countries, but also high differences between many neighboring regions. For instance, for France vis-à-vis Spain we know that large amounts of building, infrastructure development and agricultural changes have taken place in Spain while, apart from selected regions in France land use has been very stable. Similarly we see marked differences in the volume of land change in between old East and West Germany since the fall of the Berlin Wall.

Thus, on one hand, visualization of these differences only reaffirms the importance of considering land use implications in the border regions when assessing the feasibility or appropriateness of policy. And therefore how can these developments, e.g. through cooperation initiatives, be coordinated and create a development potential?". See section 4.3 of Volume XIII

- **Interactive mega-drivers at pan-European scale provoke territorial processes at regional and local scale**

Changes in land use and land cover date to prehistory and are the direct and indirect consequence of human actions to secure essential resources. This may first have occurred with the burning of areas to enhance the availability of wild game and accelerated dramatically with the birth of agriculture, resulting in the extensive clearing (deforestation) and management of Earth's terrestrial surface that continues today. More recently, industrialization has encouraged the concentration of human populations within urban areas (urbanization) and the depopulation of rural areas, accompanied by the intensification of agriculture in the most productive lands and the abandonment of marginal lands. All of these causes and their consequences are observable simultaneously around the world today.

- **Processes such as urbanization, agricultural intensification, a-forestation, rural abandonment, land use specialization are land use processes resulting from interacting driving forces**

The assessment of the prevailing characteristics of land use in Europe at grid level highlights that with an average coverage of 32.4% of Europe, "Rural forest" is the most extensive land type, follow by "Arable land in predominantly rural areas" accounting for an average of 22.36% and "Pastures, agricultural mosaics and mixed forest" in predominantly rural areas covering an average of 21.61% of Europe.

The production cycle of many decades or even centuries related to forestry is responsible for a substantial part of the major changes registered in for instance Sweden and Finland, but also in Latvia, Estonia, Portugal, Spain and southwest France. It is also very interesting to see the different stages of the felling-afforestation-re-felling transformation cycle the four regions appear to be situated. While a relative dominance of afforestation appears to be taking place on the Iberian Peninsula and in southern Finland, recent felling appears as dominant in southern Sweden and especially in Latvia. It is clear that situations with continued felling without a balance of afforestation are an unsustainable land cover trend.

For 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 and 2000), and in Ireland southern Portugal to differing degrees throughout the 1990-2006 period.

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 due to 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 production), and a negative performance in the south (linked to agricultural production).

The ongoing mega trends are to some extent linked to the implementation of certain policies. Certain EU policies are affecting land use changes and will do so in the future in different ways: some of them tend to homogenize the European territory and others, as the Common Agricultural Policy, provoke regional inequities as is the case of eastern Poland in the Ukraine frontier or border Germany-Denmark reflecting different approaches to such policy, as derived for the assessment of the project case studies.

- **There is a need for a more integrated policy approach towards sustainable land use**

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

It is increasingly understood that a more integrated, comprehensive and up-to-date policy approach is needed, able to boost European territorial development towards sustainability through increased efficiency and multi-functionality.

There are a number of trade-offs between many sector policies that try to manage economic, social and environmental processes and dynamics. In particular, this includes activities relating to: industry, transport, energy, mining, forestry, agriculture (EEA, 2010), as well as recreation and environmental protection/conservation. Policy decisions that shape land-use involve trade-offs between sector 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 sector, social and environmental issues into consideration.

We could suggest many examples of trade-offs between different land uses and territorial conflicts. For instance, the territorial conflicts between hydropower generation and goals of the Water Framework Directive, the indirect land-use effects of bioenergy production, the wind power generation and landscape or and impacts on bird life, and at a large scale the urban sprawl phenomena and the goal of polycentrism.

One of the main failures to effectively control urban sprawl is the lack of horizontal (space) and vertical (institutional) integration of policies (EEA, 2006). City boundaries are becoming diffuse increasing the complexity of levels of governance (e.g. intermediate metropolitan administrations).

- **There is still a double-sided relationship between land and growth in most of the regions in the European territory**

We need land to grow, but our growth puts pressure on the social, economic and environmental services we can obtain from it. 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.

European economies depend on natural resources, including raw materials and space. Land is a limited resource. Different sector interests are often competing for the same territorial resource.

Europe's Resource Efficient Strategy sets the goal of no additional land consumption after 2020, 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. The fact that the magnitude of land change has been more or less maintained throughout the period from 1990 to 2006, and prospective new members of EU appear ready to make use of land change as a vehicle for economic progress, it seems that measures of compensating any limitations in this respect would be needed. Therefore, it is both an unlikely and unrealistic goal for a number of European regions.

- **Economic growth matters**

The behaviour of macro-economic sectors such as tourism, industry development, agriculture, energy (production, supply, distribution and consumption) and transport is translated into land use changes in EU.

Considering the amount of change, within the entire 16-year time period analyzed in the EU-LUPA project it is notable that some very significant levels of land change have taken place - in some regions almost 30% of the total area has reported change. 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.

In terms of per capita urban land take, the main influences are the existence of second homes, large touristic infrastructures and a dispersed settlement structure. Relatively large shares of second homes are notable to varying degrees in the Mediterranean regions, as well as in Finland, Estonia, Denmark and Sweden, often tied to coastal or mountainous areas where former small scale primary sector activities (fisheries, farming, forestry) have been or are in decline. Meanwhile, extensive touristic infrastructure coupled with a very high

average population density is the driver of such a high degree of urban land take in Malta and coastal zones especially around the Mediterranean Sea.

The shift from 1990-2000 to 2000-2006 also relates to changes in mobility, where halted subsidies for dwellings and an increase of suburbanization have been influential on the slowing down and decline in extensification (Vobecká 2010), an issue which is dealt with further in connection with the Land Change Hotspots. In the 2000-2006 time series from very significant intensification is especially notable in particular regions of Norway. These are regions that, we know have undergone relatively little amounts of land change (by area); however the changes that have taken place were very intensive. This is due to the development on intensive mining, hydrocarbon extraction and other heavy industrial activities in rural and remote locations. Interestingly, these intensifications are not taking place in parallel with extensification of other land covers in these areas, which indicate that these are "new" economic activities that are taking place on previously stable and unchanged land.

Quite high rates intensification is notable for many regions in Spain in all three time series. The highest levels of intensification have taken place for coastal regions along the Mediterranean and for the island regions. This is clearly related to the growth of artificial surfaces in urban areas. CLC flow data and EEA land cover analysis (EEA, 2011) indicates that much of this intensification is due to the sprawl of economic sites and infrastructures (which both construction areas and transport infrastructure are grouped).

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.

- **Geographical intrinsic features and physical conditions matters**

And this is particularly relevant in border regions for instance. The geographical features and conditions of a region determine the availability of resources, including existing land for the development of certain activities which are highly dependent on the demand of specific locations (including land productivity) such as agriculture, aquiculture, forestry, tourism, energy production (particularly renewal), and associated industrial sectors (row material depending industries- iron and steel industries, mining activities). Most of these categories are included in the Corine Land Cover classification. The use of land is seen here as a means of production.

- **Land price matters**

One of the lessons learned: land is still too cheap for new development, while redevelopment is too expensive (e.g. regeneration of brownfields). However, at long term redevelopment of urbanized areas and containing new development is the only sustainable approach.

Real estate market is an important player from the supply side. According to Bertaud land price profile follows approximately the population density profile in market economies. This promotes the urbanisation of the less dense areas within a certain time distance of the main centre.

The differential price between agricultural land and already urbanised land discourages the revitalisation or recycling of built space generating derelict land. It also has a strong impact in fertile flat areas where accessibility generates a conflict of uses leading to a marginalisation of agriculture.

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. But furthermore – and in a very high degree in, for instance in Portugal, Spain and other Mediterranean areas, the issue of ownership reforms and characteristics of land tenure are a driver of intensification. This issue will be dealt with in more detail in relation to the identification of land change hotspots. Intensification also appears to take place in a greater degree for coastal regions (cf. in Spain, France, Croatia). It is possible that this pattern is related to the growth of the coastal tourism in these regions, but additional validation is necessary.

A change in the price of agricultural and forest products and also in the prices of land for housing or industrial site location, can affect landowners' decisions whether to keep the land in those uses.

- **Technology push and market pull matter**

Market forces and the evolution of society in general support a geographical concentration of activities.

The on-going demographic changes with an ageing European population, in addition to migration, affect regions differently and increase the competition for skilled labour.

Yet all things considered, the most dramatic land change process taking place in Europe is predominantly driven by Europe's path of socio-economic development, which is taking place due to globalization and its effect on the global division of labour. The result has been 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. And this is where the notion of intensity adds to the understanding of processes and mechanisms behind land changes.

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.

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.

- **Population dynamics and future scenarios including visions and strategies matters**

Population growth or decline, due to both natural and migratory processes, implies changes in the need for housing, services, employment, resources including energy, food, goods and services. It is also important to bear in mind that the demand of housing units is also determined by the average number of people living in a household which is a changing variable.

As has been seen in the previous sections population growth is not the only determinant the outward expansion of built-up areas. There are other elements related to cultural aspects and individual decisions modulated by the supply side and other external conditions (price, transport, and cost).

The feedback between drivers and urban process can be seen in the case of population dynamics:

- Population change is an important consequence of urban conditions, especially the availability of economic opportunities (Green and Owen, 1995; Champion and Fisher, 2004; Storper and Manville, 2006). Migration is a response to differences in employment or the quality of life between places, even if the process of adjustment is inefficient. The bigger the differences, the more worthwhile it may be to move, subject to barriers such as distance, legal restrictions, housing constraints and information on the opportunities available. The propensity of people to move is affected by their age, qualifications, financial resources and sense of attachment.
- Population change is also an important influence on urban economic conditions (Glaeser et al., 2001; Glaeser, 2005; Florida, 2004; Krugman, 2005). There is evidence that sheer population size and deep labour pools increase agglomeration economies and productivity (Rosenthal and Strange, 2004; Rice et al., 2006). Loss of population has certainly caused wider economic and environmental problems for cities (Cheshire and Hay, 1989; Begg et al., 1986). Shifts in the level of population affect local jobs through demand for consumer goods and services, housing, schools, etc. Changes in working age residents also affect the supply of skills, which may influence mobile investment decisions. The composition of the new population is bound to have an important bearing on the scale and nature of the economic impact.

➢ **Urban growth matters**

Urban growth is at expenses of other land uses. In the core cities there is a clear dominance of new building development on previous agricultural land This is due to several factors. Firstly most of the available land for urban growth is agricultural. Secondly, agricultural land is in most cases technically more suitable for construction than forest areas both topographically and in economic terms. Thirdly, natural areas are often considered as valuable recreational areas and hence cities have protected them from building activities. Grouping cities by regions highlights some specificities like in Eastern countries about 30% is developed on previous forests. In the large urban zones the agricultural land is still the primary source. However, in Eastern cities most of the land is developed on forests. (See Volume IV chapter 3)

➢ **Subsidies, funding and investment matter**

In the Czech situation it is interesting to point out the seemingly high degree of rural extensification being countered by urban-related intensification in the capital region of Prague. Further, when comparing the 1990-2000 and the 2000-2006 results, even while taking into account the much larger time span in the former time period it appears that extensification processes have slowed for the country as a whole. EEA country analyses show that the main driver of extensification has been the conversion of different crop areas into land for pasture. This is a process which has been driven by national policy that uses subsidies to encourage the grassing of arable and extensive grassland management.

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 – a situation that can be found in rural areas, not the least in regions

remote to the capital regions or in mountainous areas in most of the former "East Block". And several of the regions where this has been the dominating characteristic has continued being regions of decreasing intensity through the 2000-2006 period as well. One important element in this connection has in Poland 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.

- **Land ownership and land tenure matter**

The question of land ownership and land tenure has been extremely important in relation to the registered changes in Southern Europe, and especially on the Iberian Peninsula. Both Spain and especially Portugal land ownership was until the late 1970s and 1980s characterized by Latifundias, i.e. extremely large private estates with the owner usually living in the larger cities. Even providing job opportunities to workers and to some extent leasing out land to tenants, this type of land use has mostly been characterized by very low land use intensity. In Portugal the Agrarian Reform in 1975 being an important part of the "Carnation Revolution" laid down the principles for the expropriation of land from the Latifundias and distributing ownership to former workers or tenants. Even some intensification took place the attempts to establishing cooperatives had limited effect, and a break-through in relation to market based economy followed by the reformed Agrarian law enacted by the parliament in late 1988. This enabled the new ownerships to move towards more intense production structures. At the time of EEC membership in 1986, low land and labor productivities were the most striking features of Portuguese agriculture, reaching before entry only 46% and 13% of EU-10 average, respectively (Mykolenko, Raymond, & Henry, 1987). Especially in areas close to urban centres were the first places to take advantage of the opportunities connected to the CAP (Diogo and Koomen, 2010).

As an important consequence all regions in Portugal are identified as hotspots – albeit to differing degrees – in all of the time series'. Consultation with the maps showing total land change by area shows that this is mainly due to the fact that all regions show very high levels of overall change. This is by the high levels of ongoing changes related to forest management. Conversely, the intensity maps above show more stable patterns with the exception of two regions. Lisbon and Alentejo. In the former, intensification is predominantly related to residential sprawl between 1990 and 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).

Besides processes similar to the above described, where a clear divide between latifundios (dominating in the south) and minifundios (dominating in the north) both have been characterized by low productivity the membership of EU has had some of the same land use consequences as in Portugal. Intensification due to structural changes in land ownership has been an important factor, and this combined with the CAP accounts for much of the intensification taking place in rural areas. As emphasized by Molina (2002, p2), however, "Land tenure is, after decentralization, the second most important supporting/impeding factor for National/Regional Forest Programmes in the Mediterranean regions". In the case of rural Spain the changes can be illustrated through the example of the Dehesas, a traditional, low-input, extensive agroforestry system (Meeus 1995, here from Plieninger and Schaar, 2008) combining forestry with extensive livestock grazing and farming. Low productivity and low intensity has been an easy target for intensification where the most influential force being the Common Agricultural Policy, which supported the production of

cereals and cattle, sheep, and goat husbandry in the dehesas. Again, this is an important process to explain the changes in intensification.

On the Iberian Peninsula, but definitely also in other parts of Southern Europe, a starting point characterized by very low land use intensities in rural areas and farming practices more related to subsistence and local markets than to European and World Market conditions have been an obvious starting point for a process of land use intensification in rural areas that took off before 1990, peaked in the period 1990 to 2000, and now being more or less "normalized" except for regions in Portugal where intensification of rural areas are still ongoing. And instead of rural intensification related to rural activities many of former rural areas – especially in coastal areas – are exposed to a new category of intensification related to urban sprawl.

In contrast to the situation on the Iberian Peninsula, 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 reflected through a drastic decline in intensity over substantial areas in the period from 1990 to 2000. In contrary to the situation in Spain and Portugal the basic land reforms distributing former estate land to small and medium scale farming had taken place pre Second World War, and in many cases during the 19th century. The structural changes connected to the post WW2 reforms in ownership instead resulted in the establishing of state farms and cooperatives. It had some immediate consequences in relation to both intensity and productivity, and was paralleled by regional policies in relation to rural areas due to the state interests in maintain a high level of production to serve the requests from the Soviet Union through COMECON. And as a consequence transfer payments and subsidies enabled intensities and productivities that were unrelated to market conditions. So the development from 1990 and onwards abandoning the former state and cooperative ownerships forms has had some immediate consequences in relation to intensity. On one hand that many of the new private farms were small and did not have the necessary means to ensure a high intensity in land use. And on the other hand that the larger farms with intensification potentials in many cases involved foreign investments which did not necessarily lead to intensifications. 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.

- **Artificialisation and sprawl intensification patters in regions with foreseen urban climate risks could increase their vulnerability.**

Forest and agriculture land use changes (extensification or intensification) in regions with foreseen changes in agricultural productivity or ecological niche due to climate should explore the potentials or define how to reduce vulnerability (soil degradation, hydrological cycle regulation, economic activities).

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

At global scale, land use change is responsible for releasing greenhouse gases to the atmosphere, thereby driving global warming. Land use change can increase the release of carbon dioxide to the atmosphere by disturbance of terrestrial soils and vegetation, and the major driver of this change is deforestation, especially when followed by agriculture, which causes the further release of soil carbon in response to disturbance by tillage. Changes in land use and land cover are also behind major changes in terrestrial emissions of other greenhouse gases, especially methane (altered surface hydrology: wetland drainage and rice

paddies; cattle grazing), and nitrous oxide (agriculture: input of inorganic nitrogen fertilizers; irrigation; cultivation of nitrogen fixing plants; biomass combustion).

Though land use changes certainly plays a critical role in greenhouse gas emissions, the complexity and dynamic interplay of land use processes favouring net accumulation versus net release of carbon dioxide and other greenhouse gases makes it a poorly constrained component of our global budgets for these gases; an active area of current research. A further source of uncertainty in estimating the climate changes caused by land use change is the release of sulphur dioxide and particulates by biomass combustion associated with agriculture, land clearing and human settlements. These emissions are believed to cause regional and global cooling by the reflection of sunlight from particulates and aerosols, and by their effects on cloud cover.

Land cover changes that alter the reflection of sunlight from land surfaces (albedo) are another major driver of global climate change. The precise contribution of this effect to global climate change remains a controversial but growing concern. The impact of albedo changes on regional and local climates is also an active area of research, especially changes in climate in response to changes in cover by dense vegetation and built structures. These changes alter surface heat balance not only by changing surface albedo, but also by altering evaporative heat transfer caused by evapotranspiration from vegetation (highest in closed canopy forest), and by changes in surface roughness, which alter heat transfer between the relatively stagnant layer of air at Earth's surface (the boundary layer) and the troposphere. An example of this is the warmer temperatures observed within urban areas versus rural areas, known as the urban heat island effect. Apart from comfort, there are other health problems that could derived from climate change and influenced by changes on land use, and those are the as the shift in the distribution of ticks, vectors of the Lyme disease and tick-borne encephalitis. Other examples include the extended range in Europe of the Asian tiger mosquito, a vector of several viruses, with a potential for further transmission and dispersion under the changing climate conditions.

Land use practices and development planning could have a major impact on hydro-morphological alterations and therefore on water scarcity and adverse ecological consequences and social impacts. The issues of water quantity and quality, irrigation water demand, water-use conflicts, environmental and socioeconomic aspects and risk management aspects can be better integrated in the institutional and political systems.

- **There are development opportunities for the production of renewal energy sources**

Increasing energy prices and the emergence of a new energy paradigm have significant territorial impacts, some regions being more affected than others. This presents particular development opportunities for the production of renewable energy sources.

ReRisk project on the implications of energy poverty in EU regions for economic competitiveness and social cohesion.

The original indicators used to measure economic and social vulnerability, as well as dependence on (motorized) transport have been completed with data on the climate characteristics in the regions (important for heating and cooling demand), and the potential to develop renewable energy resources (PV and wind).

- **The way land is used has impacts on biodiversity and ecosystem services, land degradation, and pollution on water, soil and air**

The way land is used is one of the principal drivers of environmental change, having impacts on climate, biodiversity and ecosystems services and cause degradation and pollution of water, soil and air. (EEA, 2010a) and in turn, environmental change, particularly climate

change, will increasingly influence the way we use land as communities strive to adapt to and mitigate the effects of a changing climate (EEA, 2010b).

Changes in land use could be seen as a driving force and also as an impact, to the environment, biodiversity, climate change, natural resources. For instance, a change in the land use resulting from urbanization or from converting forest into agriculture may have an impact on ecosystems, biodiversity and also on the climate (affecting carbon balance).

- **Growth is possible without major new land in take**

The correlation between population growth rates and land take (2000-2006) shows that in most regions the pattern has been that the increase in the average population growth has gone together with an increase in the average annual growth rate of land take. Land take is growing faster than population. However in certain regions mainly of Spain, The Netherlands and Ireland, the urban development has been a fast phenomenon particularly during the analysed period with irrelevant population growth At the European level, housing, services and recreation made up a third of the overall increase in urban and other artificial area between 2000 and 2006. (LEAC Database (based on Corine Land Cover 2000-2006 changes, version 13, 02/2010), ETC/LUSI, (EEA, Land Take GDI 5 March 2012) In western European countries but in particular in Spain, Ireland, Portugal suffered an unsustainable rise in the price of real state from the 1990s to 2008, commonly known as property bubble.

House ownership in Spain is above 80%. The desire to own one's own home was encouraged by governments in the 60s and 70s, and has thus become part of the Spanish psyche. In addition, tax regulation encourages ownership: 15% of mortgage payments are deductible from personal income taxes. Certain parallelisms between increase in employment rates and land artificialization could be seen in several Spanish, Irish and Portuguese regions. Again this could be explained due to those countries dependency on construction/building sector.

- **Urbanization and urban sprawl matters**

Urban sprawl is identified with some of the most critical and negative impacts of current model of territorial development including increasing greenhouse gas emissions, social exclusion and biodiversity loss. Key political concerns with climate change and uncontrolled urban sprawl are all fundamentally related in the interconnected land-use - transport - environment nexus of urban development.

The analysis of the prevailing characteristics of land use at regional resulted in 10 classes, from which 3 included most of the analysed cities. These typologies are shortly described below as a recapitulation:

- Urban cores and metropolitan areas – 29 regions – 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.
- Suburban or peri-urban areas – 53 regions –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).

- Arable land in peri-urban and rural areas 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 centres in the Central-North, and the matrix which constitutes the core population areas along the rivers in the Balkan area.

When analysing the evolution of urban areas in EU for the period 2000-2006, at first look at the overall changes in the European cities indicates an increase in the land that has undergone some urban development (See Volume IV chapter 2.4) However, the areas under redevelopment have significantly increased in both core city and large urban zone during the period 2000-2006. The development of new residential areas has been reduced, while industrial and commercial areas are still increasing and becoming the main source of urban expansion. This is a general trend observed in the last 20 years where urban sprawl is less and less associated to increase of residential areas and more to other economic developments. However, there are some exceptions like the Mediterranean coast, and specifically in Spain where second homes and speculation have been driving factors for urban sprawl still in the period 2000-2006. Many Eastern cities also show a differential trend being the development of new residential areas dominant over new industrial and commercial ones.

All in all, the densification process (redevelopment + infilling) is slightly increasing in the overall balance.

Coming to the question to what extent compacity is relevant for the different typologies the conclusion is that the existing structure can modulate future evolution, but not to the extent to overcome other driving forces like land price, people's preferences and style of life. However, from the policy and planning perspective it is always desirable to keep as much as possible this compact structure to avoid impacts that can last long. One of those legacies of the past are: brownfields, lands and buildings in urban areas which have lost their original use and have the ecological costs. Very often they are associated with abandoned industrial areas with potential problems of contamination. Their extension is quite variable depending on the country. For example in Belgium (Flanders) were estimated to represent around 0.5 % of the total area of the country, while in Romania reached the 4%. The redevelopment of brownfields is often marginally or not economically viable as compared to greenfield development. To increase its competitiveness, there is a need for the implementation of a complete package of measures, including economic, legal and fiscal incentives. In the period 2000-2006, the Structural funds expended for the EU25 were of 2.25 billion EUR for the rehabilitation of industrial sites and about 2 billion EUR for the rehabilitation of urban areas.

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 and 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).

LUF6 biotic resources show 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 Dutch 'randstad' (industrial and metropolitan conurbation occupying west-central Netherlands) significant infrastructure and urban development has taken place. This trend appears as well in the Southern Alps including the densely populated Po valley.

The assessment of the urban phenomena in the EU-LUPA project (see Volume IV) reveal that city form, and city compacity, is the result of the history and evolution of urban areas including geographic and cultural factors. The available information indicates that several factors confluence in the more compact cities:

- Higher proximity of urban patches to the city centre or core city
- Mixed uses of land

However, more dynamic indicators like soil sealing per capita reveals that urban morphology and compacity alone does not explain the complexity of the system. Moreover, urban development in the last decade shows that intermediate cities are the most dynamic ones at the risk of being less efficient on use of land resources (soil sealing per capita).

➢ **Urbanization in central and eastern countries**

Political changes occurred at the end of the 1980s and 1990s in the former socialist countries represent a special case because the factors that shaped cities in the previous period were very different from the rest of Europe. The centralised planning and the non-existence of land markets resulted in more compact cities compared to the western counterpart. By 2000 most of the cities were still below 100 000 inhabitants (25% between 100 000 and half a million, 6 between half a million an one million; and only 3 with more than one million -Budapest, Warsaw, Prague).

Although regional differences exist and the process has taken different pace depending on the cities, some commonalities have been found:

- General decline in population in the last decade except in Poland, Slovakia and Slovenia.
- Privatisation of the housing stock. After the transformation, a large number of the dwellings were sold to the inhabitants at low prices. As a consequence the new member states show the highest number of owner-occupied dwellings in Europe (96.7% in Lithuania in 2001). The exception is the Czech Republic (47% in 2001) that has never introduced such privatisation plans (vanKempen et al., 2005).
- Gradual deterioration of housing blocs as consequence of low income of many new owners, unable to repair and maintain the dwellings (Murie et al., 2005).
- Progressive deterioration of city centres. Increase of pollution because inadequate transport policies.
- Changes in the economic basis in the cities, increasing the opportunities in the service sector. However, the workers required for the service sector are not always those who have lost their job in another sector.
- Commercial development constitutes and important force that has substantially contributed to a massive reorganisation of land use patterns. Such development has been recognised as a tool of local economic regeneration and growth, often supported by government policies.
- Revitalisation of city centre has raised the prices in the inner city, becoming too expensive (e.g. Lithuania).
- Disparity in prices between capitals, more expensive than regional cities.

All these elements have led to the current situation:

- Increased suburbanisation and sprawl, although most of the cities are still more compact than in the Western Europe. The acceleration of city sprawl is evident in Hungary, as well as in Poland and the Czech Republic.
- The situation is more dramatic in cities where sprawl has been combined with decline implying a strong environmental impact (e.g. Budapest).
- Social, and sometimes ethnic, polarisation.

Policy responses are needed to respond to the major constrains to further improve the situation in these countries.

- **Land use characteristics are becoming increasingly multi-functional, crossing not only sectors but also administrative borders**

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. Multi-functionality in landscape, therefore, means the co-existence of ecological, economic, cultural, historical, and aesthetic functions. Thus, landscape multi-functionality 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.

Different land uses can be a criterion for multi-functionality in landscapes, but even a single land use can involve numerous functions. Paracchini et al. (2011)[8] therefore emphasizes that the concept of multifunctional land use provides a favourable approach based on the recognition of that in order to maximize the benefits obtained from a given parcel of land, 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 based on individual sector based rationale. In such a context there is, however, also 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, recognizing that different land uses can result in different functions, but not all functions can be expressed as land uses.

The approach to "land use" should therefore not only be seen from the land cover perspective but also from the perspective of "functionality", which provides 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) to be binary, i.e. one land use activity would exclude other activities, the situation in Europe is that the functionality of land areas has been increasingly diversified: on one hand towards exclusiveness with mono-functional large scale

[8] Paracchini, M.L., Pacini, C., Laurence, M., Jones, M., Pérez-Soba, M. (2011): An aggregation framework to link indicators associated with multifunctional land use to the stakeholder evaluation of policy options. Ecological Indicators. Vol. 11, Issue 1, January 2011. P 71-80. Elsevier

production, and on the other hand towards inclusiveness, which stresses the fact that different activities co-exists.

Our key recommendation is that each region should undertake a regional assessment following the strategy defined for the assessment of the case studies which would allow a proper contextualization of the land use patterns and dynamics and support the identification of the policy options that better respond to the challenges and opportunities in each territorial reality.

Volume XIII of the Scientific Report addressed the above mentioned general messages for awareness rising extensively. EU-LUPA provides a battery of policy messages developed at case study level in Volumes VI to IX of the Scientific Report that should be considered for future policy development.

9.1 Policy recommendations at the case study level

The difference in the size of the administrative regions being analysed is remarkably important when interpreting the results e.g., in the Oresund region with small administrative regions in Denmark and a bigger one in Sweden; the same situation is also occurring in the Basque Country (Spanish and French border).

In the regions characterised by domination of mono-functional land use, the Land Use Change Typology matches land use changes observed at case study level. In the regions characterised by multifunctional land use the Land Use Change Typology partially identifies the types of changes observed at case study level. In general, current changes in land use show an increased diversification of land use functions and land use intensity.

Land use changes reflect a process of spatial polarisation. Land use change reflects the polarization of economic activity: rural areas could continue to experience significant agricultural withdrawal while urban centres will continue to expand as population growth and economic activities continue to be concentrated in them. Another important challenge is related to future situations where policy measures in relation to for instance re-organization of the CAP, change in regional supporting mechanisms from block grants to targeted issues such as poverty, environmental protection, or change in perceptions of what are “liveable landscapes” etc. may have on the direction of land use change. In this context typologies where measures of intensities are combined with basic socio-economic accounts such as population density and GDP seem to be very useful.

While the descriptions of the Land use change types highlighted a number of very interesting trends – trends which were largely validated in the case studies - the reality is that they represent a further generalization of land change processes. And while it was shown to be beneficial to generalize land change trends it is also potentially misleading; not least due to the fact that any changes deviating from the “average changes” or dominant changes are not well reflected. Consequently, the results of the Land use change types can have a tendency to over generalize land changes - and the processes behind those changes – for some region, especially relatively large ones.

Results of the LUFs assessment at regional level (NUTS2/3) do not always match with the results at case study level. However, it should be said that case study analysis not only relies on the LUFs assessment itself and the synthesis of the Land Use Functions evaluation, but also on a more detailed assessment of each of the indicators used in the LUF approach, going deeper into the data.

It is very important to be cautious when elaborating policy recommendations based on EU level results because dynamics at case study level cannot be revealed by average results at EU level and remain covered.

Scale of the analysis and quality of the data are crucial: Better resolution at regional scale is required.

For the analysis at the case study level, other kinds of indicator beyond the LUFs approach might be needed. In fact, different regions have developed different data sets depending on their own geographical characteristics. For example, Northern regions might require the analysis of some data that could not make sense for the Mediterranean countries.

Spatial planning traditions, planning systems, past policies and territorial strategies in the European regions, on top obviously on the geographic features of each region and its relative location within the continent, must be taking into account when interpreting the results.

10 Further analytical work and research within ESPON framework

EU-LUPA project was a highly complex and extensive project which has generally made a big step towards a better understanding of land use performance and land use changes in the European space. At the same time it provides a good basis for further research on the investigated topic.

Having said that it is also evident that some issues have been encountered during the project development which caused difficulties and, if solved, could lead to improved results.

Data requirements

There is a need for more frequent data updates and better resolution and further improvement of the data coverage at regional scale.

The use of CORINE Land Cover 2010 and updated socioeconomic data at NUT3 level would allow the identification of what has happened during the economic crisis. Besides, the spatial coverage in EU-LUPA is not entirely consistent for each time series in CORINE Land Cover. This prevents full European coverage of the typologies for the entire 1990-2006 time series.

The methods developed by EU-LUPA are flexible enough to accept more detailed data whenever available.

Analytical tools

Indicators developed and/or used at EU level, should be adjusted for a more precise analysis and understanding of land use dynamics at case study level. Different regions have developed different data sets depending on their own geographical characteristics. Northern regions might require the analysis of some data that could not make sense for the Mediterranean countries. This is particularly evident for example when addressing climate change issues.

Due to the on-going changes in land use characteristics in Europe, difficulties in accurate identification of mono versus multi functionalities are apparent. Considerations on criteria for such identification have become key questions in, for instance, the current discussions on the future CAP structure.

The development of quantitative and qualitative tools is needed in order to better analyse the sustainability of diverse land uses in the European context. The development of a system of indicators monitoring prevailing characteristics of land use and land use changes in relation to socio-economic trends is suggested here. Further analytical work in that direction would enable the response to remaining unresolved questions on how to balance landscape protection and social welfare in the context of regional development. This has been already partly covered in the on-going ESPON Priority 2 Project: Liveland.

To date, several analyses have been undertaken in EU-LUPA to assess Land Use Performance (LU Performance) and Land Use Efficiency (LU Efficiency) at regional level in Europe. However, from the results achieved so far it has been very difficult to extract any clear conclusions due to several constraints and conceptual limitations, which are the following:

- The question has been approached by **analysing performance and efficiency**. Land Use Performance was defined within EU-LUPA as the degree in which the land is used to comply with a specific policy target. 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. Efficiency can be understood as the amount of resources needed

to obtain certain output (benefit). In the case of EU-LUPA the resource is the land and it involves an understanding of both the quantity and quality.

- How to measure if on-going 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, but 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 distance to the headline policy targets.
- **Most policy targets are territorially blind:** 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.
- **Narrow time-frame:** The consideration of only 6 years to measure land, environmental, social and economic changes is not enough timeframe to extract conclusions on performance and efficiency.
- The Land Use Functions approach to assess land use efficiency is in principle quite coarse due to the degree of aggregation of the socioeconomic data - one related to the administrative unit at which the data is provided; the other to the typology of the data itself.

Regional complementary potentials

Detecting territories with complementary potentials which can join forces and explore their comparative advantages together has been identified as a key issue for future analytical research. Defining synergic development potential is seen crucial for regional cooperation and cohesion. From the reading of the EU-LUPA maps there are very clear disparities and also complementary potentials between neighboring countries, but also between many neighboring regions. ESPON project ULYSSESS has done a significant step in that respect.

Policy development and implementation

Further research is required for the elaboration of a set criteria for the selection of policy interventions and criteria for the implementation with regard to sustainable, responsible,effient land use and land use management. This could be materialized in a targeted analysis, under priority 2 in the next ESPON programme.

Deeper analysis of urban phenomena

A closer comparison to land changes resulting in new or maintained urban areas could be undertaken and to compare this data with regional – or even municipal – population data. This could give an interesting insight into places that are either maintaining or growing their population (labour force) and what the implications are in terms of land take and urbanization.

The future efforts, therefore, should be targeted further in the harmonisation of indicators and data sets among the EU member states, which would enable the research into the European space and its structures at lower levels also. Particularly, the initiatives of National Contact Points (Capitalisation of ESPON results) should be further encouraged.

Glossary

(in alphabetical order)

Driving forces: Driving forces of land use could include almost any factor that influences human activity, including local culture (food preference, etc.), economics (demand for specific products, financial incentives), environmental conditions (soil quality, terrain, moisture availability), land policy & development programs (agricultural programs, road building, zoning), and feedbacks between these factors, including past human activity on the land (land degradation, irrigation and roads).

Efficiency: This term 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.

Hotspots of land use change: are areas where extreme land cover changes have taken place due to large changes in terms of land area and/or substantial changes in the intensity of land use.

Intensity of land use: 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.

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).

Landscape. The European Landscape Convention provides a useful definition by calling a landscape an "**area as perceived by people**"; this definition is reminiscent of the old saying that 'landscape' refers to the "total character of an area of Earth"(allegedly but unconfirmed by Alexander von Humboldt). However, science and humanities have increasingly split 'landscape' up into a number of different areas of expertise and some of these respond to rather narrow fields of interests. The sum of findings from diverse and thematically specific research is not equal to gaining knowledge about landscape as a whole.

'Landscape as institution' refers to interactions of society with space and territory. Institutions is the term used here to describe how space/territory is socially ordered and organized, for example by protecting some areas and developing others, by allowing free access to some areas while closing off others, etc. A useful term in analysing landscape as an institution is that of 'cultural landscape'. For analytical purposes the concept of cultural landscape leads to questions such as: What is the history of a landscape, which traditions are related to this landscape, etc?

'Landscape as a resource' refers to everything that is "real" and relates to a materiality found in physical space. The measuring for pertinent criteria might include the amount of

oxygen found in water samples taken from a river or the total number of trees counted in a suburb.

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 cover flows: Land Cover Accounts summarize and interpret the 44x43=1892 possible one-to-one changes between the 44 CORINE land cover classes. The changes are grouped to so call **flows of land cover** and are classified according to major land use processes. The classification of land cover flows, results from the feasibility studies and subsequent revisions after discussion with experts in agri-environment and forestry. Basically, the classification of land cover flows distinguishes change between broad land cover classes and changes internal to these classes. Analysis of land cover flows supplies a rapid vision of processes taking place

Land take: the amount of land occupied by artificial/ man-made structures for housing, industry, health care, education, retailing, recreation and transport

Land use is an adjective that is used to describe the manner in which the land is perceived or consumed 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.

Land use change: is the conversion of land for a particular use into a different one.

Land Use Functions: 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.

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.

Macro-regional strategy is an integrated framework endorsed by the European Council, which may be supported by the European Structural and Investment Funds among others, to address common challenges faced by a defined geographical area relating to Member States and third countries located in the same geographical area which thereby benefit from strengthened cooperation contributing to achievement of economic, social and territorial cohesion. For example, EU Strategy for the Baltic Sea Region.

Mixed land use is—in a broad sense—any area that blends a combination of different land uses, which associated functions are physically and functionally integrated. See Multifunctional land use.

Multifunctional land use: multiple land uses that take place in the same territory, or area, simultaneously as well as asynchronous over certain periods of time.

Multifunctional landscape: The general concept of Multifunctional Landscapes[9] is closely related to other specific concepts like the Landscape Services Concept[10] that, in turn, was

[9] Mander, Wiggering and Helming (2007)

derived from the Ecosystem Services Concept[11]. A multifunctional landscape is characterized by multiple uses that take place in the same territory, or area, simultaneously as well as asynchronous over certain periods of time.

Sustainable land use: means using and manage land assets in a way that benefits the local and regional economy, without compromising biodiversity and ecosystem services, working to sustain the land for future generations. **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.

[10] Groot and Hein (2007); Groot, Wilson and Boumans (2002)

[11] Reid (2005); Haber (1971)

References

Böhme, K. et al (2011): How to Strengthen the Territorial Dimension of Europe 2020 and the EU cohesion policy. Warsaw. Ministry of Regional development.

Bossard, M., Feranec, J. and Otahel, J. 2000. CORINE land cover technical guide. Technical report No. 40, European Environment Agency. Copenhagen, Denmark.

Diogo, V. and Koomen, E. (2010): Explaining land-use change in Portugal 1990-2000. 13th AGILE International Conference on Geographic Information Science 2010 (pp. 1-11). Guimarães, Portugal

Dovring, F. (1960): Land and labour in Europe, 1900-1950. M. Nijhoff

EEA, 2010. The European environment — state and outlook 2010: synthesis. European Environment Agency, Copenhagen.

EEAC (2010). EEAC conference 2010 on sustainable land use.

European Commission (1999). European Spatial Development Perspective (ESDP).

European Commission (2007b). Common Agricultural Policy (CAP) 2008-2013.

European Commission (2008). Green Paper on Territorial Cohesion. Turning territorial diversity into strength.

European Commission (2009b). Review of the European Union Strategy for Sustainable Development.

European Commission (2010b). Cohesion Policy 2007-2013.

European Commission (2010c). Europe 2020 Strategy.

European Commission (2010d). Fifth Report on Economic, Social and Territorial Cohesion.

European Commission (2011). A Roadmap for moving to a competitive low carbon economy in 2050.

European Council (2001). The Gothenburg Strategy.

European Council (2007). The Lisbon Treaty.

Environment Council. 2010. Council conclusions on biodiversity post-2010 – EU and global vision and targets and international access and burden sharing regime – 3002nd Environment Council meeting Brussels, Belgium, 15 March 2010. (Online) Available at: www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/envir/113346.pdf (accessed 2012-04-10).

ESPON SIESTA Spatial Indicators for a “Europe 2020 Strategy” Territorial Analysis. Draft Final Report 10/08/12.

European Environment Agency (EEA) 2011. Land cover country analyses. (Online) Available at: http://www.eea.europa.eu/highlights/land-cover-country-analyses (accessed: 2012-04-15).

European Environment Agency (EEA), (2010). The European environment: state and Outlook 2010. Land use- SOER thematic assessment.

Gabrielsen, P. 2005. IRENA Indicator Fact Sheet – Intensification/Extensification. EEA/IRENA Forum Archives (Online) Available at: http://archives.eionet.europa.eu/irena/library/development_irena/irena_indicator/intensification-extensif (accessed: 2012-04-20).

Groot, Rudolf de, and Lars Hein. 2007. "Concept and valuation of landscape functions at different scales". In Ülo Mander, Hubert Wiggering and Katharina Helming, eds. Multifunctional Land Use. Meeting Future Demands for landscape Goods and Services. Berlin Heidelberg: Springer, 15–36.

Informal Ministerial Meeting on Urban Development and Territorial Cohesion (2007). Territorial Agenda of the European Union (TAEU).

Informal Ministerial Meeting on Urban Development and Territorial Cohesion (2007b). Action programme for the implementation of the Territorial Agenda of the European Union.

Informal Ministerial Meeting on Urban Development and Territorial Cohesion (2007c). Leipzig Charter for an integrated sustainable urban development.

Janin Rivolin, U. & Faludi, A. (2005): Regional perspectives on European spatial planning, The Future of the ESDP in the framework of Territorial Cohesion, disP 161. 2/2005 19.

Knickel, K., Renting, H., Van der Ploeg, J.D., 2004. Multifunctionality in European agriculture. In: Brouwer, F. (Ed.), Sustaining Agriculture and the Rural Environment: Governance, Policy and Multifunctionality. Edward Elgar, Cheltenham

Kleeschulte, S. 2011. Integrating nature & biodiversity and land use data – Final Report. Output of the project: INBALUD - Integrating Nature & biodiversity and land use data. GeoVille Environmental Services, Luxembourg.

Lambin EF, Geist H, Lepers E. 2003. Dynamics of land use and cover change in tropical regions. Annual Review of Environment and Resources 28: 205–241.

Lambin, E. (2010) Land-use and Land-cover changes. Springer-Verlag Berlin.

Lepers, Lambin, Janetos, Dfries, Archard, Ramankutty and Scholes (2010) A Synthesis of Information on Rapid Land-cover Change for the Period 1981–2000

Mander, Ülo, Hubert Wiggering, and Katharina Helming, eds. 2007. Multifunctional Land Use. Meeting Future Demands for landscape Goods and Services. Berlin Heidelberg: Springer.

Montiel Molina, C. (2002). Land tenure as an influence factor on National/Regional forest programmes in Spain. COST E-19: National Forest Programmes in a European Context. Sopron, 28-29 June 2002.

Mykolenko, L., Raymond, T., & Henry, P. (1987). Agriculture and the regions: The situation and developments in the enlarged community. The regional impact of the Common Agricultural Policy in Spain and Portugal, SEDES e Société d'Étude pour le dévelopement economique et social. Luxembourg: EC Official publications

Paracchini, M.L., Pacini, C., Jones, L., Pérez-Soba, M., 2011, An aggregation framework to link indicators associated with multifunctional land use to the stakeholder evaluation of policy options, Journal Ecological Indicators, Volume 11, Issue 1, , Pages 71-80.

Pérez-Soba, M., Petit, S., Jones, L., Bertrand, N., Briquel, V., Omodei-Zorini, L., Contini, C., Helming, K., Farrington, J. H., Tinacci Mossello, M., Wascher, D., Kienast, F., De Groot, R., 2008, Land use functions: a multifunctionality approach to assess the impact of land use changes on land use sustainability. In: Helming K., Pérez-Soba M., Tabbush P. (Eds) Sustainability impact assessment of land use changes: Pages 375-404; Berlin (Springer).

Plieninger, T., and M. Schaar. (2008). Modification of land cover in a traditional agroforestry system in Spain: processes of tree expansion and regression. Ecology and Society 13(2): 25. [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art25/

Prokop, G., Jobstmann, H. and Schönbauer, A. (2011) Overview of best practices for limiting soil sealing or mitigating its effects in EU-27. European Commission – DG Environment.

Reenberg, A. (2009). Land system science: Handling complex series of natural and socio-economic processes. Journal of Land Use Science 4(1-2):1-4.

Reid, Walter V., ed. 2005. Ecosystems and human well-being. Washington, DC: Island Press.

Reidsma, P., König, H., Feng, S. et al., 2011, Methods and tools for integrated assessment of land use policies on sustainable development in developing countries. Land Use Policy. Doi: 10.1016/j.landusepol.2010.11.009.

Renetzeder, C., van Eupen, M., Mücher, S., Wrbka, T. A Spatial Regional Reference Framework for Sustainability Assessment in Europe. 2008. In: Helming K, Pérez-Soba M, Tabbush P (Eds) Sustainability impact assessment of land use changes: 249-268; Berlin (Springer).

Turner II, B.L., Lambin, E.F., Reenberg, A., 2007. The Emergence of Land Change Science for Global Environmental Change and Sustainability. PNAS 104(52):20666-20671.

UNECE (1998): Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention).

Velthof, G.L., D. Oudendag, H.P. Witzke, W.A.H. Asman, Z. Klimont & O. Oenema. 2009. Integrated Assessment of Nitrogen Losses from Agriculture in EU-27 using MITERRA-EUROPE. J Environ Qual 38 (2), 402-417.

Verburg, van de Steeg, Veldkamp and Willemen (2008): From land cover change to land function dynamics: A major challenge to improve land characterization. Journal of Environmental Management, Volume 90, Issue 3, March 2009, Pages 1327-1335

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