HERCULES

Sustainable futures for Europe's HERitage in CULtural landscapES: Tools for understanding, managing, and protecting landscape functions and values

GA no. 603447

D1.3: Report on the three individual systematic reviews (rates and patterns, drivers and outcomes, actors)

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Executive summary

This deliverable of work package 1 is comprised of three parts which all strive for a common goal: to organise and develop a preliminary synthesis of existing knowledge on patterns, drivers and outcomes of persistence and change in Europe's cultural landscapes. The necessity for these reviews was dictated by the objectives of HERCULES and by the acknowledgment that recent progress to landscape research "can be deemed particularly useful for the highly complex research field on society-ecosystem interactions" (Plieninger et al., 2015). The Deliverable is structured in three parts: The first part consists of the findings of the literature review on the driving forces of landscape change in Europe, the second part of the findings of the literature review on rates of landscape change in Europe and the third part of the findings of the review on landscape actors.

These three parts are kept separate in order to provide as much depth in the three reviews as possible. The overall synthesis of the three reviews will be presented Deliverable 1.4. Each of these reviews has been submitted in peer-reviewed journals and here we present the draft manuscript versions that are being reviewed.

The first part, the literature review on the driving forces of landscape change in Europe, deals with the understanding of the drivers of landscape changes, which remains rather poor because of the strong variation and fragmentation of landscape research across many domains and disciplines. The review provides a first systematic synthesis of 144 studies that identify the underlying drivers and proximate causes of landscape change across Europe. Firstly, the driving forces have been addressed and categorized. – Although research on landscape drivers is diverse – most typically, medium-term time scales and local spatial scales have been studied, assessing one study area, one spatial scale, and between three and four points in time. Secondly, existing biases are analysed and it is revealed that countries with a low Gross Domestic Product; Boreal, Steppic, and Arctic landscapes; and forest land systems have been strongly underrepresented. Thirdly, the review shows that land abandonment is the most prominent (89 cases) among multiple proximate (often opposing) causes of landscape change. Fourthly, we find that combinations of political / institutional, cultural, natural / spatial and other underlying drivers are controlling landscape change, rather than single key variables.

The second part, the literature review on the rates of landscape change, provides a systematic synthesis of 48 studies with 86 different landscape changes that were used to calculate change rates and magnitude of this change across Europe. The rates and the magnitude of changes were combined to categorize the type of change within each landscape (from very slow to very fast). The cases were also correlated with 11 different processes of landscape change and five different drives of change. The cases studied area sizes varies from a few km^2 to large landscapes of thousands km^2. Rates of change were correlated with the process of change, with changes related with urbanization being on average faster than changes related with land abandonment (which made up the majority of the changes in the studies of the sample). Rates and magnitude of change were also weakly correlated with cases were the fastest changes were also important in terms of area size in the landscapes, covering typical cases of urbanization or decrease of landscape elements.

The third part, the review on actors, focuses in local initiatives which aim to sustain landscapes and the services they provide through landscape stewardship approaches. Very little is known about their situation in Europe. We provide a systematic analysis of the spectrum of these initiatives in the continent. This review consists of the collection of varied examples of initiatives all over Europe through systematic Internet key word searches and the canvassing of European umbrella organisations; followed by the invitation of the representatives of the initiatives collected to a detailed online survey. Overall, 338 initiatives were invited to participate in a self-administrated online survey. Through this survey, we collected in-depth information on each Integrated Landscape Initiative (ILI) that was generally not available on their websites. The responses to the surveys have been systematically analysed to characterize the initiatives in terms of patterns, gaps, challenges and potentials.

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Introduction

This deliverable of work package 1 comprised three parts which all strive for a common goal: to organise and develop a preliminary synthesis of existing knowledge on patterns, drivers and outcomes of persistence and change in Europe's cultural landscapes.

The necessity for these reviews was dictated by the objectives of HERCULES and by the acknowledgment that recent progress to landscape research "can be deemed particularly useful for the highly complex research field on society-ecosystem interactions" (Plieninger et al., 2015, Deliverable D1.2). This conceptual framework that we developed in the context of D1.2 highlighted six areas of landscape research deriving from the characteristics of the landscape approach (Plieninger et al., 2015, p. 2):

> *"1. Landscapes are shaped by the connections and disconnections between people and their environment;*
>
> *2. Landscapes exhibit important biophysical structures and land use intensities;*
>
> *3. Landscapes have experienced long-term histories, which have left land-use legacies that critically determine the functions and values of many contemporary landscapes;*
>
> *4. Landscapes are undergoing change at different rates, with a multiplicity of driving forces, processes, actors, and outcomes;*
>
> *5. Landscapes entail broad and diverse sets of values and meanings for people; and*
>
> *6. Landscape governance can follow a preservation or a stewardship approach, with the latter becoming increasingly influential."*

These areas are broad and overlapping, but there are some issues that seem to unite them like a thin red line: these are related with the understanding of change (and continuity) of landscapes and the values that different actors embed in these landscapes. Landscape conceptualization today mainly revolves around four distinct concepts: (1) landscape as purely natural phenomenon, i.e., a biophysical interpretation, (2) landscape as nature with human artefacts, i.e., anthropogenic interpretation, (3) landscape as cognitive representation of a space, i.e., intangible interpretation, and (4) landscape as totality including both material natural and cultural dimensions, i.e., coupled social-ecological interpretation (Angelstam et al., 2013a). Whatever concept is used though, landscapes remain at the interface of nature and society and express a tight interplay of physical features of the human environment with social structures and human ideas.

Therefore, change (and continuity) of landscapes would seem like the obvious choice to attempt a synthesis of existing knowledge. The very idea of landscape change and its understanding is linked with the investigation of the processes that change them, the actors involved, and the rates of change, both short and long term. Different names have been proposed and used for these processes, one of the most common being that of "driving forces", i.e. the forces that drive changes in and of a landscape (Bürgi et al., 2004). Initially introduced in the late 1990s as an indicator framework for environmental policy, the concept of driving forces has developed into a framework for understanding the causes, processes, and outcomes of landscape change. Other names that have

been proposed include “drivers”, “processes”, “factors”, etc., along with a glossary of “types” of driving forces “temporal and spatial levels” in which these act and interact, “direct and indirect: ones and actors that mediate between driving forces and the actual changes. In the review we conducted, we attempt to navigate through this terminology, but tend to use “driving forces” as the term that describes these processes.

Along with these “forces”, or “processes” that cause change, another important aspect for understanding this change is its rate. Landscapes are inherently dynamic objects and change continuously, but the rates of these changes can be so different that can conceal longer term changes for shorter scales, especially human temporal scales of understanding, valuing and experiencing landscapes. Making sense of these rates and linking them with “driving forces” is another aspect where a synthesis of existing knowledge is necessary.

But, what exactly constitutes landscape change? This is a far trickier question than it would seem, especially in the light of identifying research of such changes. Defining what is change is related with defining landscape. In the project, the diversity of the approaches used reflects the diversity of landscape change research in general that was described above: different spatial and temporal scales, different tools and approaches from modelling to participatory geographical information systems; from top-down change analysis with the use of satellite images to qualitative approaches of how these changes are perceived; and from seeing classifying landscapes at the European level to working at the local level. This welcome diversity, presents a challenge for determining what should qualify as landscape change. For reasons related with the fact that we only review what was done and not design our own research, we have adopted a pragmatic and practical approach: land cover changes qualify as changes ***in*** a landscape, but they are not always a change ***of*** the landscape. This duality reflects the conceptualization of landscape as a complex sum of many parts, land cover and land use prominent among them. We believe that this choice is important and can be used, as the first two reviews demonstrate, to classify landscape related research and also understand better the processes and rates involved in changes within a landscape and of “whole” landscapes.

The “actors” that are involved in landscape change is another aspect where a synthesis of available knowledge seems to be long overdue, but where there is another issue that calls for in depth investigation. These two issues are related, but are also separate: first we need to understand the role of actors as mediators between “driving forces” and landscape changes, as in reality actors change landscapes as a result of driving forces. This issue is dealt with in the reviews of driving forces. The other issue is related with who are these actors in Europe and very little research has been conducted so far in this field. Therefore, we decided that for actors, a different approach would prove more useful towards the synthesis that is the goal of WP1. This approach identified and questioned active actors around Europe in landscape change and protection (called Integrated Landscape Initiatives – ILIs) and provides a contribution to understanding these actors, how they value landscapes, how they act upon landscapes and how they interact with other actors. Although this review is different in scope and methods than the other two reviews of the Deliverable, it nevertheless gives added value to the approach, as it is novel and provides a comprehensive synopsis of the operation and success of such initiatives.

The Deliverable is structured in three parts:

The first part consists of the findings of the literature review on the driving forces of landscape change in Europe, The second part of the findings of the literature review on rates of landscape change in Europe and the third part of the findings of the review on landscape actors.

These three parts are kept separate in order to provide as much depth in the three reviews as possible. The overall synthesis of the three reviews will be presented Deliverable 1.4, where also links to other WPs of the project will be discussed. Each of these reviews has been submitted in peer-reviewed journals and here we present the draft manuscript versions that are being reviewed.

There are 4 more review literature papers linked with the project and these are presented in the Annexes of the Deliverable. The papers are:

1. van Vliet, J., de Groot, H.L.F., Rietveld, P., Verburg P.H. (2015) Manifestations and underlying drivers of agricultural land use change in Europe. Landscape and Urban Planning 01/2015, 133:24–36.

2. van Zanten B. T., Verburg, P. H., Koetse, M., van Beukering P. J. H. (2014) Preferences for European agrarian landscapes: A meta-analysis of case studies, Landscape and Urban Planning 132, 89–101.

3. Plieninger, T., Bieling, C., Fagerholm, N., Byg, A., Hartel, T., Hurley, P., López-Santiago, C. A., Nagabhatla, N., Oteros-Rozas, E., Raymond, C. M., van der Horst, D., Huntsinger, L. (2015) The role of cultural ecosystem services in landscape management and planning. Current Opinion in Environmental Sustainability, 14, 28-33.

4. Hernández-Morcillo, M., Hoberg, J., Oteros-Rozas, E., Plieninger, T., Gómez-Baggethun, E., Reyes-García, V. (2014) Traditional Ecological Knowledge in Europe: Status Quo and Insights for the Environmental Policy Agenda, environment 3, 56(1).

Part 1: The driving forces of landscape change in Europe: A systematic review of the evidence

1.1 Introduction

Landscapes have been shaped and maintained by people and their activities over millennia (Ellis, 2015; Farina, 2000) and have undergone fundamental changes, both today and in their history (Levers et al., 2015; van der Sluis et al., 2015; Verburg et al., 2010). Partly reflecting global trends, partly exhibiting regional particularities, multiple causes are influential in reshaping European landscapes, though their magnitude has not been quantified yet. Depending on prevailing social-ecological conditions, these trends find strongly varying regional expression, exhibiting diverse directions and pace (Pinto-Correia and Kristensen, 2013). For example, hotspots of land abandonment occur in Eastern Europe (Estel et al., 2015), the Mediterranean parts of Europe (Sluiter and de Jong, 2007) and many European upland areas (MacDonald et al., 2000). In contrast, agricultural intensification is most expressed in those European regions where biophysical and structural conditions for agriculture are favorable, e.g. in many areas of North-western Europe (Pinto-Correia and Kristensen, 2013).

The magnitude and rate of these changes has given rise to concerns that landscape sustainability – the capacity of a landscape to consistently provide long-term, landscape-specific ecosystem services essential for maintaining and improving human well-being (Wu, 2013) – is currently at risk (Selman, 2012). The understanding of the reasons behind landscape changes has been of concern in recent landscape research, and the "driving forces", i.e. the forces that drive changes in and of a landscape (Bürgi et al., 2004), have developed into a central concept. Initially introduced in the late 1990s as an indicator framework for environmental policy (OECD, 1999), the concept of driving forces has developed into a framework for understanding the causes, processes, and outcomes of landscape change and has become indispensable for the evaluation of policy interventions (Klijn, 2004). Knowledge on drivers of landscape change is becoming more important, as attention is moving away from traditional sectorial policies toward integrated "landscape approaches" in natural resources management (Sayer et al., 2013). In the European context, this view has been reflected in the cross-sectoral approach of the European Landscape Convention that calls for the integration of protection, planning, and management of landscapes (Jones et al., 2007).

The concept of driving forces distinguishes between proximate and underlying drivers of change. Proximate drivers refer to human activities at the local level that result in landscape change, such as agricultural expansion or extension of settlements (Geist and Lambin, 2002). Underlying drivers comprise the fundamental social and natural processes (e.g. human population dynamics, agricultural policies, markets, or culturally embedded attitudes and beliefs) that underpin the proximate drivers and either operate at the local level or have a more indirect impact from the national or global level (Geist and Lambin, 2001; Geist and Lambin, 2002). Underlying drivers can comprise political, economic, cultural, technological, and natural factors (Brandt et al., 1999; Bürgi et al., 2004).

Since the turn of the millennium, the number of case studies on driving forces of landscape change in Europe has grown (e.g., Bieling et al., 2013; Hersperger and Bürgi, 2009; Mottet et al., 2006; Serra et al., 2008), and important conceptual contributions have been made, e.g. directed towards enhancing the understanding of the interplay between driving forces and actors (Hersperger et al., 2010). However, the understanding of the drivers of landscape changes remains poor, among other reasons due to the strong variation of existing case studies over disparate spatial and temporal scales (Bürgi et al., 2004) and the current spread of landscape research across many domains and disciplines within the human, social, and natural sciences (ESF, 2010). Case study research at local scale is on the one hand needed to foster a "place-based culture" in landscape ecology (Fischer et al., 2011), because the landscape is the most relevant scale to address real-world sustainability problems (Crumley, 2012). On the other hand, local-scale studies are highly specific in contexts, actors, main processes, scale, and resolution (Bürgi et al., 2004). But despite the unique context of most local landscapes and their drivers, the application of a comparative framework can allow more generalized insight that can be transferred across places (Kinzig, 2012; Rindfuss et al., 2007). Systematic review and meta-analyses techniques are particularly promising approaches to synthesize and upscale local-scale insights on environmental changes to a more general level (Rudel, 2008). While recent years have brought significant developments in all corners of landscape research, these have hardly been synthesized, so that Pan-European perspectives on landscape change – as informed by local case studies – are under-developed (ESF, 2010).

As the number of individual case studies rises, systematic reviews and meta-analyses have become valuable tools to synthesize knowledge (Pullin and Stewart, 2006), and such meta-analyses have provided valuable insights into drivers and patterns of land-use change (Magliocca et al., 2014; Van Vliet et al., 2015b). Previous studies reviewed individual land-cover changes (e.g., deforestation, Geist and Lambin, 2002; Robinson et al., 2014; or urban land expansion, Seto et al., 2011), land-use sectors (e.g., agriculture, Keys and McConnell, 2005; van Vliet et al., 2015a), or natural ecosystems (e.g., wetlands, van Asselen et al., 2013). However, studies that synthesize broader landscape change at continental scale, including the interactions among multiple change processes, have not been carried out.

The aim of this study is to provide a synthesis of the proximate and underlying drivers of landscape change across Europe. Our systematic review of the literature on landscape change identifies and catalogues the available knowledge from a wide variety of sources. In particular, our review has the following objectives: (1) to broadly characterize how proximate and underlying drivers of landscape change have been addressed in empirical case studies; (2) to identify and classify the most important drivers of change in European landscapes, including combinations of proximate and underlying drivers; (3) to examine existing bias in the scientific literature related to particular biogeographical and land systems attributes. By this, we identify knowledge gaps that put barriers to the understanding and management of landscape change.

1.2 Methods

Our method followed established guidelines for systematic review and systematic mapping (Centre for Evidence-Based Conservation, 2010) and was inspired by previous systematic review exercises in comparable fields (Geist and Lambin, 2002; Rudel, 2008; van Asselen et al., 2013; van Vliet et al., 2012).

1.2.1 Study selection

Scoping was performed to find useful keywords and to get a first overview about the availability of landscape studies. The scoping exercise was performed in the ISI Web of Science and revealed that many landscape studies did not use terms such as “driving forces”, “drivers”, or “causes” in the abstracts, though they offered explanations on these. Therefore, we decided to perform an inclusive search based on the following search string: *“Landscape change” OR “landscape dynamics”*. To select only case studies from Europe, the search was refined by adding the names of each European country as search terms. We searched the following databases for relevant documents: ISI Web of Science, GEOBASE (Ovid), CABI: CAB Abstracts (Ovid), and Scopus. To locate grey literature, we additionally considered the first 50 pdf and word documents that were provided by the Google Scholar and Dogpile search engines. We stored titles and abstracts in a single reference database and removed all duplicates. Our review considered studies in English, French, and German language.

Building on Rudel et al. (2008) and Geist and Lambin (2002), we specified the following four inclusion criteria: A study had to (1) cover a landscape of clearly anthropogenic origin, (2) be based on in-depth field investigations, (3) provide some form of measurement of landscape change processes at regional to local scale within Europe, and (4) offer explanations about the forces driving landscape change in the study areas. In particular, we included studies focusing on landscapes in Europe at local to regional scales (1-10,000 km^2). Observations of multiple landscapes that were situated more than 200 km apart, but appear within one paper were included separately in the dataset and considered independently. We used six categories of proximate drivers of change, comprising urban and infrastructure development, agricultural expansion and intensification, expansion and intensification of forestry, extraction of nonrenewable resources, land abandonment and extensification, and nature and heritage conservation activities. We covered policy and institutional, economic, technological, cultural, or natural and spatial factors as underlying drivers. Policy and institutional factors comprise formal policies, but also the informal policy climate and property rights. Economic factors relate to markets and commercialization (e.g. of agricultural commodities), economic structures, urbanization, and industrialization. Technological factors refer to the appearance and spread of new technologies. Cultural factors represent public attitudes, values and beliefs as well as individual and household behaviour (Geist and Lambin, 2002). Natural and spatial drivers include climate, topography, natural disturbances, soil characteristics, and the spatial configuration of landscape patches.

We performed the search in August 2014 and initially obtained 4,034 papers. After removal of duplicates, 2,190 papers remained. The selection of studies relevant for this review took place in a three-stage process.

First, we selected 606 papers on the basis of study titles on the basis of the four inclusion criteria. Second, after further selecting studies on the basis of their abstracts, we retained 174 papers. The third stage, in which we assessed the content of the full papers, left 96 papers. In cases of doubt, we included studies to the next phase of the selection process. We checked the repeatability of study inclusion through a random subset of at least 10% of the references whose titles (201 studies) and abstracts (60 studies) were assessed by a second reviewer independently. Inclusion consistency was calculated through kappa statistics (Cohen, 1960). The agreement between reviewers was good in both steps (k = 0.57 in the first stage and k =0.63 in the second stage). In parallel, we asked experts on landscape change to provide additional publications that were not part of our list and that should be considered (c.f. van Vliet et al., 2012), which resulted into an additional 30 papers. The total of 125 papers comprised 144 independent case studies, which form the basis of this review (the full list of studies is included in the supplementary material).

We coded all information extracted from the studies in spreadsheets. Spreadsheet categories were pretested to assure repeatability. In the course of that process the initially intended identification of actors and their role in landscape change had to be given up, since the studies provided not systematic information and a differentiation between actors and driving forces was not possible. From the 144 studies that met the inclusion criteria, we extracted the following information (see supplementary material for all variables that were extracted from the case studies):

- What were the characteristics of the study that may influence the identification of driving forces?
- Which proximate drivers of landscape change were observed?
- What underlying drivers were considered for specific landscape outcomes?

1.2.2 Data analysis

We synthesized how the studies addressed proximate and underlying drivers of landscape change, using the classification scheme by Geist and Lambin (2002) as a starting point. We then explored the relationship between the number of case studies that were performed in a country and the country's Gross Domestic Product (GDP, reference year: 2013, source: World Bank), its membership in the European Union (EU) and the European Free Trade Association (EFTA), and its ecological footprint (reference year: 2011, source: Global Footprint Network) through Spearman correlation analyses and t-test. We used location data given in the studies (selecting a central point within each study area) to obtain parameter estimates for context variables (biogeographic regions, and land system archetypes) from the European Environment Agency (EEA, 2012) and from Levers et al. (2015). To identify bias and knowledge gaps, we compared the observed percentage of studies performed in a particular biogeographical and land systems context to the percentage that these zones and systems cover in Europe as a whole. To identify proximate and underlying drivers, we carried out frequency analysis across all case studies. Here, we analyzed both single-factor and multi-factor causations (compare van Asselen et al., 2013). Finally, we assessed the most important interactions between proximate and underlying drivers through descriptive statistics.

In addition, we performed hierarchical cluster analysis to identify typical clusters of studies identifying the presence or absence of similar proximate and underlying drivers. Monothetic divisive clustering method suggested for binary variables was applied for this purpose in R statistical package 3.2.2 (Everitt et al., 2011; Kaufman and Rousseeuw, 2008). Clustering used a single variable on which to base the split at a given stage. Hence, at each stage, clusters contained publications with a certain attribute (i.e., proximate or underlying driver) either all present or all absent. The split was based on the variable which had the maximal total association to the other variables, according to the observations in the cluster. Monothetic divisive clustering was chosen as it is effective in revealing the main structures in the data and reveals transparently which variables produce the separation of clusters. Four clusters were chosen as a meaningful interpretation to describe the data in this review.

1.3 Results

1.3.1 Study characteristics and analytical approaches

Our review resulted in 144 case studies, performed in 23 different countries (Fig. 1.1). Spain (17 studies), the Czech Republic (16 studies), Italy (16 studies), Germany (13 studies), and Greece (10 studies) were the most intensively studied countries. It was conspicuous that not a single study on landscape drivers was detected for many Eastern European countries (e.g., Belarus, Russia, Serbia, or Ukraine). Six studies were carried out across two countries.

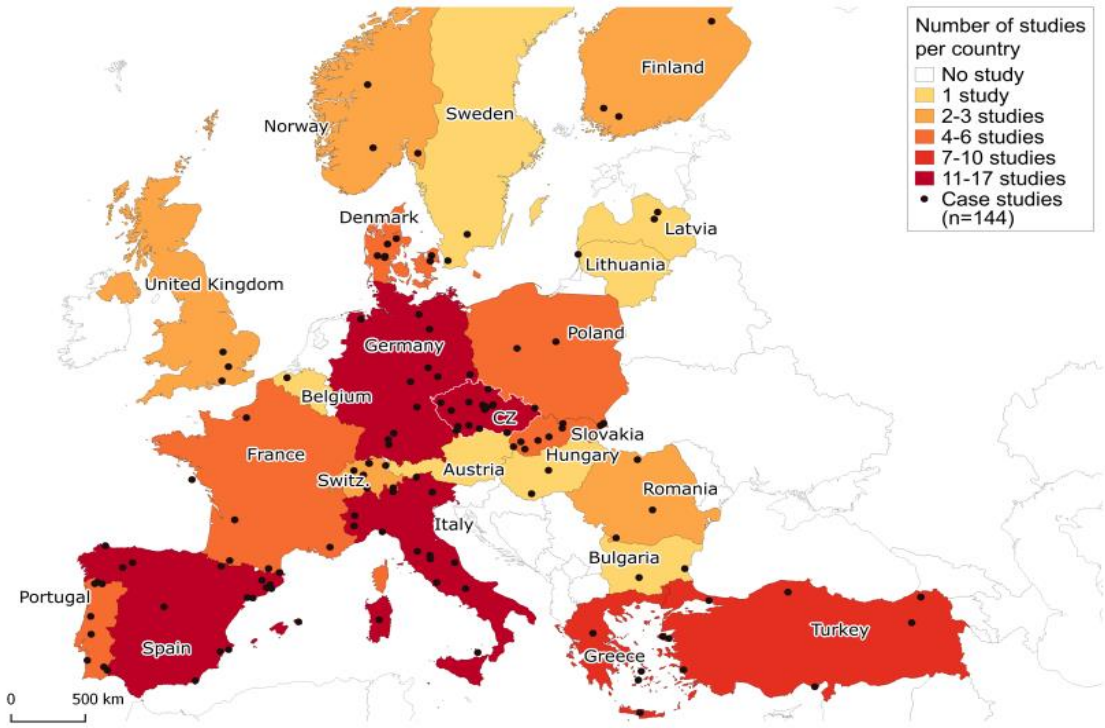


Figure 1.1: Map of case study sites and number of case studies per country

The studies included in this review were published between 1990 and 2015, but only 2 studies were published before 1995. A first wave of publications followed the release of the Dobris Assessment of the European Environment Agency (Stanners and Bourdeau, 1995), which was the first continental-scale assessment of landscape trends in Europe (10 studies from 1995-1999). The bulk of the studies was published after the adoption of the European Landscape Convention (COE, 2000) in 2000 (15 studies from 2000-2004) and after the publication of an influential concept paper on driving forces of landscape changes (Bürgi et al., 2004) in 2004 (117 studies from 2005 to 2015).

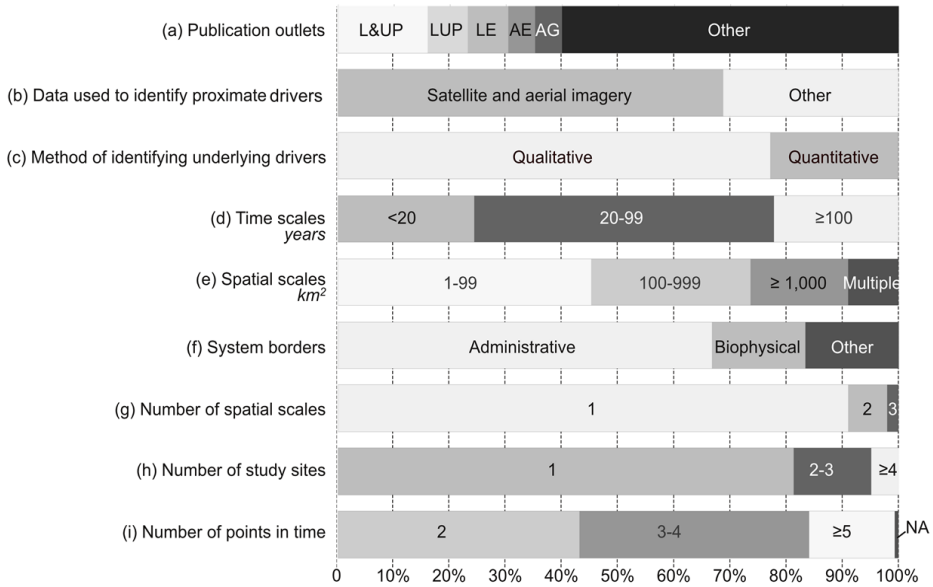


Figure 1.2: Percentage of case studies following different approaches

Percentage of case studies following different approaches: a) Publication outlets, b) Data used to identify proximate drivers, c) Method of identifying underlying drivers, d) Time scales, e) Spatial scales, f) System borders, g) Number of spatial scales considered, h) Number of study sites considered, i) Number of points in time considered. L&UP = Landscape and Urban Planning, LUP = Land Use Policy, LE = Landscape Ecology, AE = Agriculture, Ecosystems and Environment, AG = Applied Geography.

Studies of landscape drivers were published in 55 different journals and books, covering research areas such as geography, environmental sciences, ecology, agriculture, forestry, urban studies, biodiversity and conservation, engineering, and remote sensing. The most prominent outlets were Landscape and Urban Planning (16% of the papers), Land Use Policy (7%), Landscape Ecology (7%), Agriculture, Ecosystems and Environment (5%), and Applied Geography (5%), covering together 40% of all papers (Fig. 1.2a). A majority of studies (69%) used satellite and aerial imagery to determine proximate drivers of change (Fig. 1.2b). Other important data sources were maps (50% of studies), official statistics (22%), and biophysical field data (17%). Cadastral data (12%) and social surveys (10%) were less common. Only 23% of studies used quantitative methods to identify underlying drivers of change (Fig. 1.2c). The bulk of studies relied exclusively on personal interpretation (55%), while literature and archival sources (28%), statistical modelling (23%), and expert interviews (9%) were less often used. Most studies (53%) assessed drivers of mid-term landscape changes (20-99 years), while short- and long-term studies were less frequent (Fig. 1.2d). Starting dates of the landscape change analyses ranged from 1670 to 2002.

Study areas ranged from 2 km² to ca. 10,000 km², with a spatial scale of 1-99 km² being most frequent (51%, Fig. 1.2e). System borders were defined mainly by administrative units (67%) and less by biophysical units or other units, which were most often rectangular landscape sections (Fig. 1.2f). A very large portion of the studies considered only one spatial scale (81%, Fig. 1.2g) and only a single study landscape (81%, Fig. 1.2h). Landscape changes were assessed using between 2 and 14 points in time (Fig. 1.2i).

1.3.2 Biases along socio-economic, biogeographical, and land systems attributes

Our spatial exploration of the location of study areas reveals several biases in research efforts on landscape change across the different parts of Europe. Studies were significantly more frequent in EU/EFTA member countries (mean number of studies: 4.4±0.9 S.E.), compared to non-member states (mean: 0.5±0.5) ($t=3.557$, $p=0<0.001$, $n=46$). There was a significantly positive correlation between the number of landscape change studies in a country and its Gross Domestic Product (Spearman's rho $=0.661$, $p<0.001$, $n=46$). The correlation between the number of case studies and a country's ecological footprint was slightly significant (Spearman's rho $= 0.319$, $p=0.045$, $n=40$). In terms of biogeographical zones, a clear bias toward Mediterranean (30.5% of studies, but covering only 10.8% of Europe according to EEA, 2012) and Continental (30.5% / 23.4%) parts of Europe can be identified. In contrast, landscape change in the boreal (6.5% of studies, 25.7% European coverage), steppic (0.0% / 11.8%), and arctic (0.0% / 5.5%) zones were rarely or not at all investigated. A large number of studies investigated urban land systems (15.7% of studies, but covering only 1.8% of the EU surface according to Levers et al., 2015). In contrast, forest systems, in particular low-intensity forest systems (10.7% of studies, 19.3% EU coverage) received little consideration. (See supplementary material for full documentation.)

1.3.3 Proximate drivers

Fig. 1.3 displays the proximate and underlying drivers of landscape change that were extracted in the review. The most important proximate drivers included land abandonment and extensification; agricultural expansion and intensification; expansion and intensification of forestry; and urban and industrial development categories, as documented in 65%, 62%, 56%, and 53% of the case studies respectively (Table 1.1). Extraction of non-renewable resources and nature or heritage conservation activities were less frequently listed. Land abandonment, afforestation, and urban development were the three most studied individual proximate drivers. In Northern and Western Europe, intensification and expansion of agriculture was the most frequently recorded proximate driver (Fig. 1.4). In Eastern Europe, the expansion of forestry was particularly important, together with intensification of agriculture. In Southern Europe, land abandonment was by far the most frequent proximate driver, documented both in the Eastern and the Western Mediterranean countries (Table 1.1).

Table 1.1: Frequency of proximate drivers of landscape change in Europe

	All cases (n=144)		Northern Europe (n=21)		Western Europe (n=26)		Eastern Europe (n=39)		Southern Europe (n=50)		Other (n=8)	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
Urban / infrastructure development	**77**	**53%**	**4**	**19%**	**17**	**65%**	**24**	**62%**	**25**	**50%**	**7**	**88%**
Urban development	64	44%	3	14%	15	58%	19	49%	22	44%	5	63%
Tourism development	21	15%	2	10%	3	12%	4	10%	12	24%	0	0%
Construction of roads, airports, etc.	25	17%	3	14%	5	19%	6	15%	8	16%	3	38%
Dam / reservoir construction	10	7%	0	0%	0	0%	7	18%	1	2%	2	25%
Agricultural expansion	**89**	**62%**	**17**	**81%**	**20**	**77%**	**28**	**72%**	**20**	**40%**	**4**	**50%**
Intensification of agriculture	52	36%	5	24%	13	50%	16	41%	17	34%	1	13%
Expansion of arable land	37	26%	7	33%	6	23%	16	41%	5	10%	3	38%
Upscaling / consolidation of plot sizes	40	28%	11	52%	9	35%	12	31%	7	14%	1	13%
Removal of landscape elements	35	24%	12	57%	10	38%	12	31%	1	2%	0	0%
Forestry expansion / intensification	**81**	**56%**	**8**	**38%**	**9**	**35%**	**28**	**72%**	**28**	**56%**	**8**	**100%**
Afforestation / plantations	74	51%	7	33%	8	31%	26	67%	27	54%	6	75%
Intensification of forestry	20	14%	2	10%	1	4%	10	26%	2	4%	5	63%
Extraction of nonrenewable resources	**11**	**8%**	**1**	**5%**	**3**	**12%**	**5**	**13%**	**2**	**4%**	**0**	**0%**
Extraction of energy carriers	5	3%	0	0%	2	8%	3	8%	0	0%	0	0%
Extraction of minerals	5	3%	1	5%	1	4%	2	5%	1	2%	0	0%
Peat extraction	2	1%	0	0%	1	4%	1	3%	0	0%	0	0%
Water extraction	1	1%	0	0%	0	0%	0	0%	1	2%	0	0%
Land abandonment / extensification	**94**	**65%**	**6**	**29%**	**16**	**62%**	**26**	**67%**	**44**	**88%**	**2**	**25%**
Land abandonment	90	63%	6	29%	13	50%	25	64%	44	88%	2	25%
Agricultural extensification	24	17%	3	14%	6	23%	8	21%	7	14%	0	0%
Nature / heritage conservation activities	**33**	**23%**	**12**	**57%**	**7**	**27%**	**5**	**13%**	**8**	**16%**	**1**	**13%**
Expansion of protected areas	8	6%	1	5%	1	4%	3	8%	3	6%	0	0%
Agri-environmental activities	24	17%	11	52%	6	23%	2	5%	4	8%	1	13%
Rural development activities	4	3%	0	0%	1	4%	2	5%	1	2%	0	0%

Table 1.2: Frequency of underlying drivers of landscape change in Europe

	All cases (n=144)		Northern Europe (n=21)		Western Europe (n=26)		Eastern Europe (n=39)		Southern Europe (n=50)		Other (n=8)	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
Political / institutional	**108**	**75%**	**17**	**81%**	**23**	**88%**	**32**	**82%**	**31**	**62%**	**5**	**63%**
Agricultural and forestry policy	63	44%	15	71%	14	54%	11	28%	20	40%	3	38%
Nature conservation policy	34	24%	9	43%	7	27%	11	28%	4	8%	3	38%
Spatial development policy	18	13%	1	5%	5	19%	8	21%	4	8%	0	0%
Other sectorial policies	19	13%	0	0%	8	31%	8	21%	3	6%	0	0%
Property rights	32	22%	5	24%	8	31%	16	41%	2	4%	1	13%
Policy climate	26	18%	3	14%	3	12%	18	46%	2	4%	0	0%
Economic	**80**	**56%**	**10**	**48%**	**16**	**62%**	**22**	**56%**	**30**	**60%**	**2**	**25%**
Structural change in agriculture / forestry	49	34%	6	29%	8	31%	15	38%	19	38%	1	13%
Real estate market	3	2%	0	0%	1	4%	1	3%	1	2%	0	0%
Prices for agricultural / forestry products	23	16%	3	14%	4	15%	5	13%	11	22%	0	0%
Market growth and commercialization	30	21%	2	10%	10	38%	8	21%	9	18%	1	13%
Cultural	**93**	**65%**	**9**	**43%**	**16**	**62%**	**24**	**62%**	**37**	**74%**	**7**	**88%**
Population numbers / distribution / age structure	69	48%	1	5%	10	38%	21	54%	31	62%	6	75%
Public attitudes / values / beliefs	17	12%	7	33%	4	15%	1	3%	5	10%	0	0%
Individual and household behavior	37	26%	6	29%	10	38%	6	15%	10	20%	5	63%
Technological	**47**	**33%**	**10**	**48%**	**14**	**54%**	**15**	**38%**	**7**	**14%**	**1**	**13%**
Modernization of society	9	6%	0	0%	4	15%	3	8%	2	4%	0	0%
Modernization in land management	44	31%	10	48%	14	54%	13	33%	6	12%	1	13%
Natural / spatial	**94**	**65%**	**13**	**62%**	**17**	**65%**	**25**	**64%**	**34**	**68%**	**5**	**63%**
Climate	12	8%	0	0%	3	12%	2	5%	7	14%	0	0%
Disturbances	23	16%	2	10%	2	8%	4	10%	13	26%	2	25%
Soil characteristics	46	32%	8	38%	11	42%	13	33%	14	28%	0	0%
Topography and spatial configuration	74	51%	12	57%	12	46%	16	41%	31	62%	3	38%

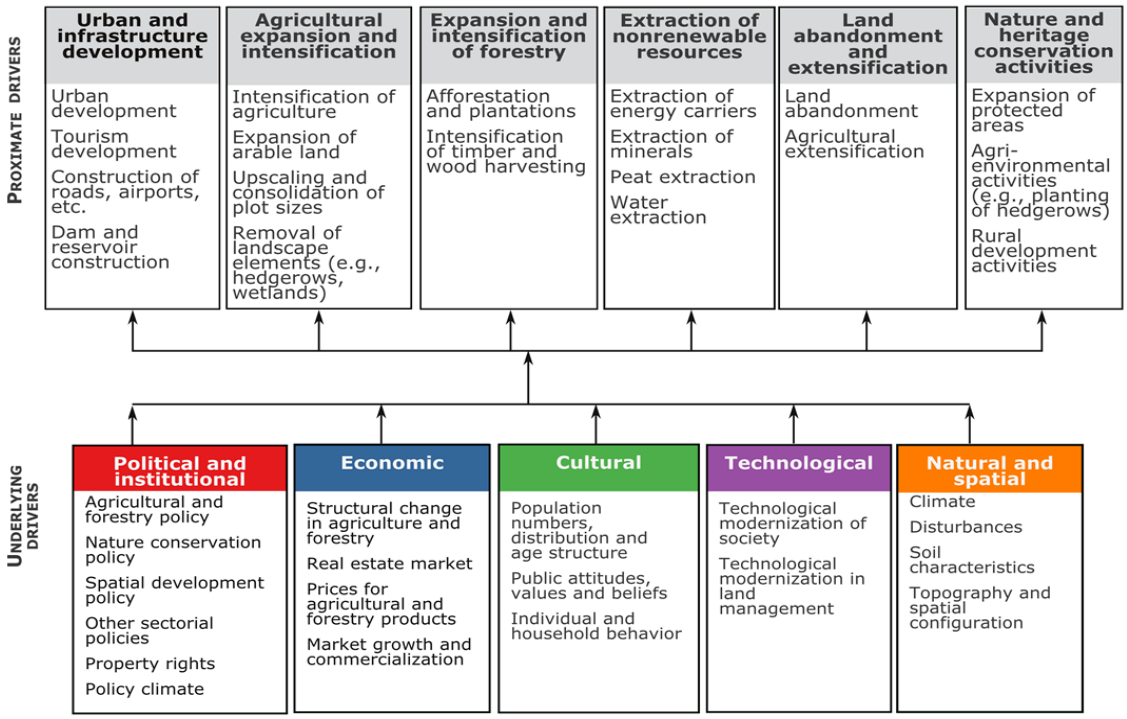


Figure 1.3: Variables used to describe proximate and underlying drivers of landscape

Most studies (83% of cases) reported a combination of proximate drivers of landscape change, most typically of two- to three-factor causations. The most frequently cited single proximate drivers of landscape change were agricultural intensification (8% of cases) and land abandonment (6% of cases). Land abandonment (56 out of 85 cases) and agricultural intensification (56 out of 85 cases) were the most frequent components in two- and three-factor causations. Land abandonment was most typically related to afforestation (35 out of 85 cases). Agricultural intensification was most frequently connected to urban and industrial development (25 out of 85 cases). However, there were also 21 cases of two- to three-factor causations where both land abandonment and agricultural intensification were reported, indicating that intensification and extensification of land uses occur in relatively close spatial proximity.

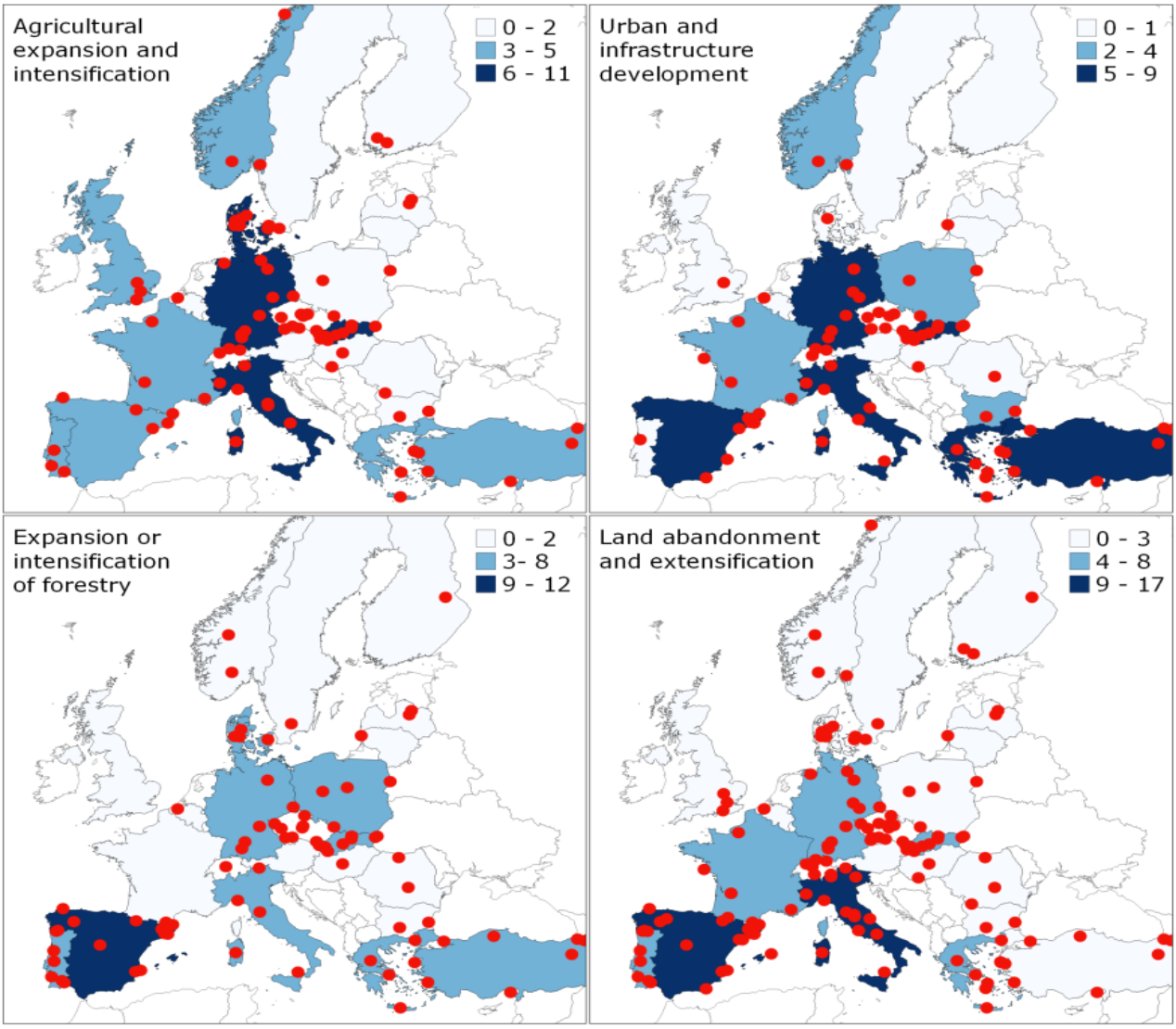


Figure 1.4: Location of case studies that identified major proximate drivers of landscape change: a) land abandonment and extensification, b) agricultural expansion, intensification, and upscaling, c) expansion and intensification of forestry, and d) urban and industrial development.

1.3.4 Underlying drivers

The dominant underlying drivers were political / institutional (75% of cases), natural / spatial (65%), and cultural (65%) factors (Table 1.2). The transition from socialist to post-socialist policy regimes in many Central and Eastern European countries was the most frequently mentioned specific underlying driver. Various types of one- to five-factor causations occurred, with two- and three-factor causations being most frequent (49% of cases). The most prominent combination of causations comprised the full range of political / institutional, economic, cultural, technological, and natural / spatial factors (20 cases). The most frequent one-factor causations were political / institutional factors (14% of cases). Political / institutional factors dominated by far in Northern (75% of cases), Western (81%), and Eastern Europe (88%); in contrast, cultural factors were most prominent in Southern Europe (74%) and Turkey (88%).

1.3.5 Interactions between proximate and underlying drivers

Only few proximate drivers of landscape change were related to one single key underlying driver (10 out of 77 cases for urban and industrial development; 10 out of 89 cases for agricultural expansion, intensification, and upscaling; 14 out of 81 cases for expansion and intensification; 1 out of 11 cases for extraction of nonrenewable resources; 10 out of 94 cases for land abandonment and extensification; 1 out of 33 cases for nature and heritage conservation activities) (Fig. 1.5). More typically, landscape change was identified as determined by a combination of underlying drivers. For urban and infrastructure development, political and institutional factors (62 out of 77 cases) as well as cultural factors (56 cases) were most frequent, whereas all other underlying drivers were much less frequently mentioned. Agricultural expansion, intensification, and upscaling was typically determined by political and institutional (62 out of 89 cases) and cultural factors (60 cases). The same was found for expansion and intensification of forestry (63 and 58 out of 81 cases). Extraction of nonrenewable resources was driven by a broader mix of political / institutional (8 cases out of 11), economic (6 cases), cultural (6 cases), and natural / spatial (6 cases) factors. For land abandonment and extensification, natural and spatial factors were slightly more important (70 out of 94 cases) than political / institutional factors (68 cases). Nature and heritage conservation activities were determined by political / institutional (31out of 33 cases) and cultural (26 cases) factors.

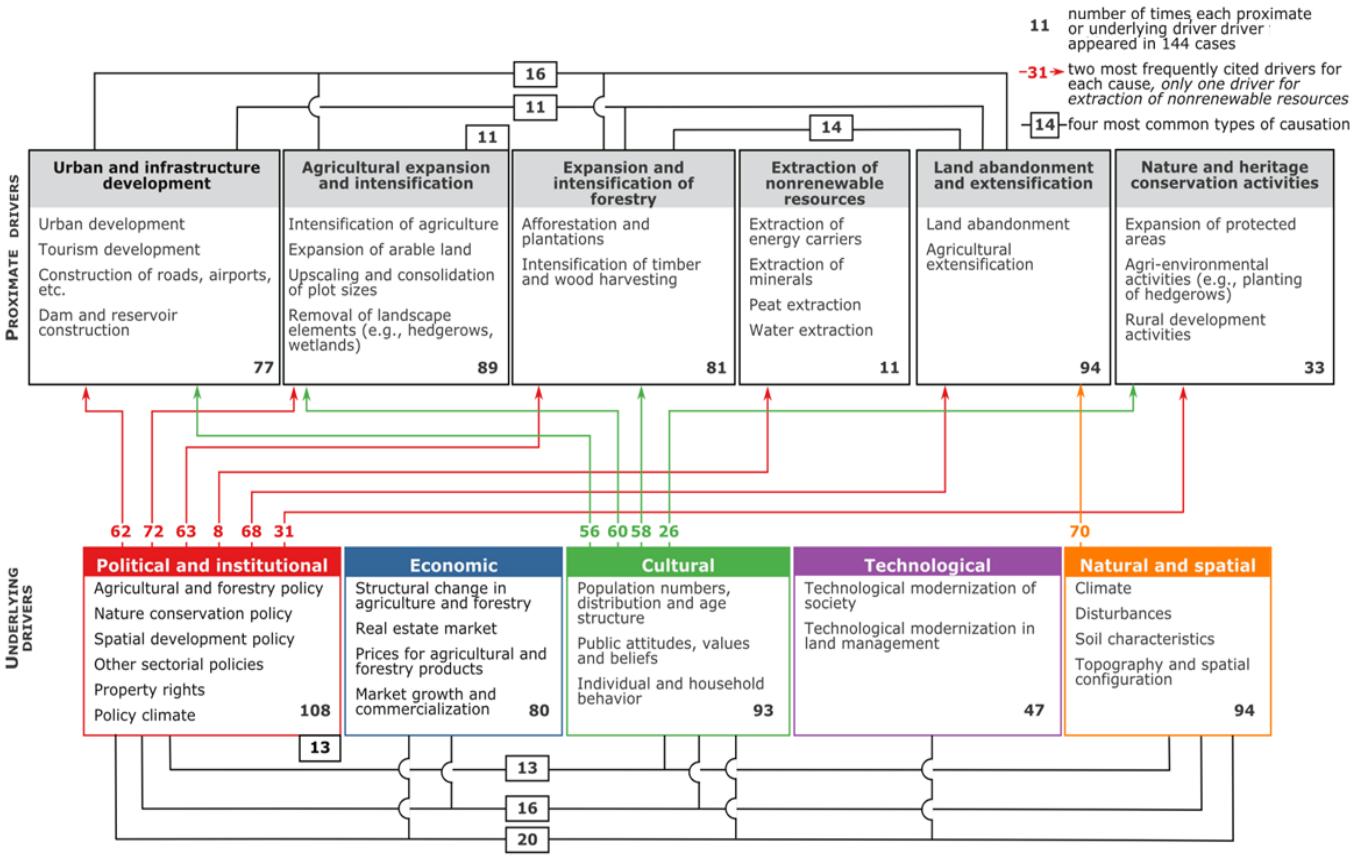


Figure 1.5: Causal patterns of landscape change in Europe (n=144)

Political and institutional underlying drivers were frequently cited for all proximate drivers of landscape change (Table 1.3). Cultural factors were likewise important, but appeared with the highest relative frequency among studies observing nature conservation and heritage activities. Economic factors were most typically related to agricultural expansion, intensification, and upscaling. Natural and spatial factors were cited most frequently among land abandonment and extensification studies. Technological factors were the category that was generally least identified as being an important underlying driver of landscape change.

Table 1.3: Frequency of underlying drivers attributed to proximate drivers of landscape change in Europe

	Political / institutional		Economic		Cultural		Technological		Natural / spatial	
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
Urban / infrastructure development (n=77)	62	81%	46	60%	56	73%	31	40%	50	65%
Agricultural expansion / intensification (n=89)	72	81%	58	65%	60	67%	43	48%	58	54%
Forestry expansion / intensification (n=81)	63	78%	47	58%	58	72%	23	28%	54	67%
Extraction of nonrenewable resources (n=11)	8	73%	6	55%	6	55%	4	36%	6	55%
Land abandonment / extensification (n=94)	68	72%	63	67%	67	71%	26	28%	70	74%
Nature / heritage conservation activities (n=33)	31	94%	23	70%	26	79%	16	52%	19	61%

The best splitting variable in the clustering of the studies was land abandonment which divides the data into 94 publications with presence of this proximate driver and 50 without (Fig. 1.6). Those 35% of publications not addressing land abandonment were in the second separation step divided into those without (group A, n=29) and those with (group B, n=21) technological factors identified as relevant underlying drivers. The majority of the publications (65%) dealing with land abandonment were then again divided based on the concomitant absence (group C, n=44) or presence (group D, n=50) of agricultural expansion / intensification. At this separation step there were four distinctive clusters, the largest one being D (35%) with the presence of land abandonment and agricultural intensification.

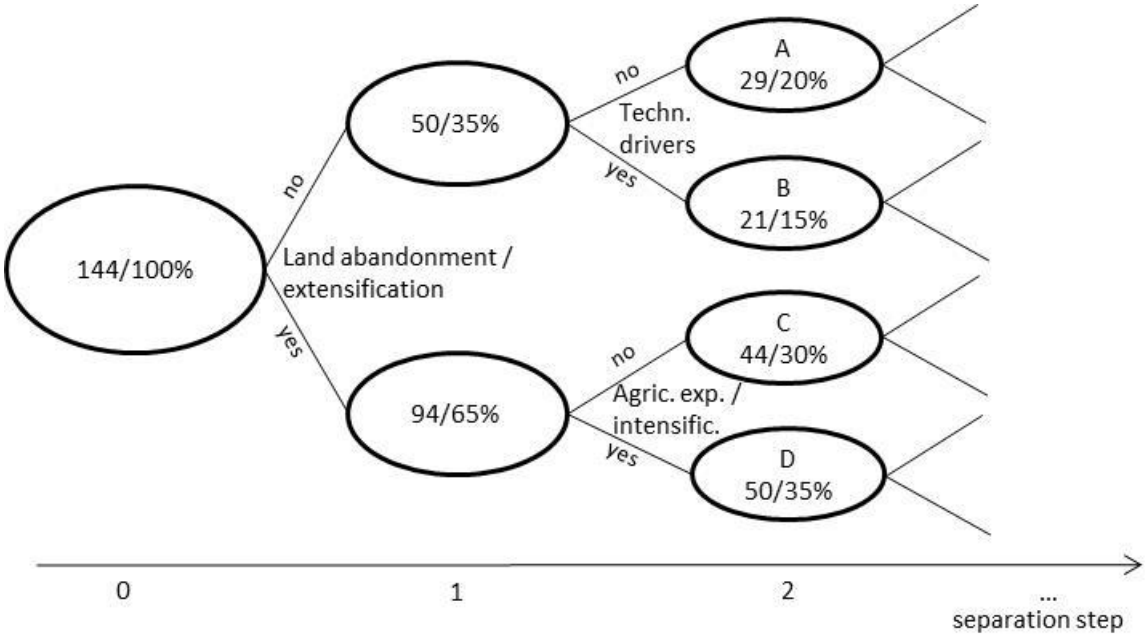


Figure 1.6: Results of applying monothetic divisive clustering to characterize typical clusters of studies (n and % of studies) on the basis of presence absence of similar proximate and underlying drivers of landscape change.

1.4 Discussion

Global and regional economic and environmental changes are increasingly influencing local landscapes, but the processes by which these act upon landscapes remain poorly understood. Our study addresses recent calls for applying synthetic and meta-study techniques to generate global and regional knowledge from local case studies of land change (Magliocca et al., 2014; Turner II et al., 2013) and presents the first comprehensive systematic review of proximate and underlying drivers of land use and landscape change in Europe. Compared to previous review of land-use changes (e.g., Keys and McConnell, 2005; Robinson et al., 2014; Seto et al., 2011; Van Vliet et al., 2015b; van Vliet et al., 2012), our study is much broader in scope, covering multiple aspects of landscape change, from agricultural intensification to urbanization to the rise of nature conservation. Our study assumes a holistic and systemic understanding of landscapes, which is particularly focused on the linkages between the interwoven change processes within a given landscape (Plieninger et al., 2015). By this, it may be less useful for the identification of individual causal event chains (Walters and Vayda, 2009).

1.4.1 Research on landscape change drivers is diverse, covering multiple disciplines, methods, as well as spatial and temporal scales

Our review indicates that research on landscape change drivers has been carried out in all parts of Europe, using a broad range of disciplinary approaches, data sources, spatial and temporal scales, methods, and publication outlets. Most of the reviewed studies quantified the proximate drivers of landscape change with great rigor, often based on satellite and aerial imagery. In contrast, the underlying drivers of landscape change were in most studies simply identified through a qualitative

interpretation by the authors. The role of actors and how they relate to driving forces is typically not considered in a systematic way. Most prominently, time scales between 20 and 100 years and spatial scales between 1 and 100 km² were studied, typically assessing one study area only, one spatial scale, and between three and four points in time. The latter indicates a move from bi-temporal detection of landscape change to the analysis of multitemporal trajectory analysis and rates of change, as advocated by Bürgi et al. (2004) and Gillanders et al. (2008). As most studies put more interest on political, institutional, economic and cultural drivers than on natural underlying drivers and probably due to better data availability, administrative units were more prominently used as system borders than biophysical ones (e.g., watersheds). The diversity of approaches that we found is certainly a consequence of landscape being an ambiguous term that carries a plurality of meanings (Aronson, 2011). Although landscape studies are fragmented into many isolated communities (ESF, 2010), the conceptual openness makes landscape a useful boundary object with great potential to inform sustainability sciences, similar to the likewise ambiguous concept of ecosystem services (Abson et al., 2014).

1.4.2 Major research biases are revealed related to biogeographic regions and land systems

Research on landscape change drivers has not been carried out with the same intensity for all areas of Europe, confirming the findings from a global review of the landscape literature (Conrad et al., 2011). Our analysis showed that countries that are not EU/EEA members and that have a low GDP are underrepresented. We also found a neglect of remote and economically marginal areas, such as the arctic, boreal, and steppe regions of Europe. Much research focused on urban and peri-urban landscapes, indicating that research has followed the intentions of the European Landscape Convention to put more emphasis on those landscapes that people experience in their everyday life and that are directly relevant for individual and social well-being (Déjeant-Pons, 2006; Luginbühl, 2006). Few studies focused on landscapes that remained stable, which may be an expression of a “publication bias” (Leimu and Koricheva, 2005) for studies finding significant changes or differences compared to studies reporting a null result (but see recent studies of landscape continuity, e.g. Levers et al., 2015; Pătru-Stupariu et al., 2015; Skalos and Kasparova, 2012).

1.4.3 Land abandonment is the most prominent among multiple proximate drivers of landscape change in Europe

Agricultural extensification and land abandonment was the most prominently identified proximate driver of landscape change, in particular in the Mediterranean (Sluiter and de Jong, 2007), but also in the Eastern part of Europe (Estel et al., 2015). Land abandonment is a global phenomenon (Cramer et al., 2008; Munroe et al., 2013), but has frequently been overlooked by science and policy in the face of the dominating trends of worldwide expansion of land management activities (Foley et al., 2005) and accelerating competition for land (Smith et al., 2010). Land abandonment can have both positive and negative effects on biodiversity, ecosystem services, and human well-being (Höchtl et al., 2005; Plieninger et al., 2014; Queiroz et al., 2014), requiring locally-adapted management strategies either towards purposeful rewilding (Navarro and Pereira, 2012) or towards conservation and development of valuable cultural landscapes (Plieninger and Bieling, 2013).

Our review also revealed that opposing causes of landscape change often act within the same study area, for the spatial extend of the areas we have used in the selection of our sample. Specifically, land abandonment / extensification causes and agricultural expansion / intensification causes were concurrently identified in 35% of the studies. On the one hand, co-occurrence of multiple causes of change is common in multifunctional landscapes that are dedicated to different (and often contrasting) land uses (Wiggering et al., 2006). On the other hand, overlapping causes of change provide evidence of a polarization of land-use that has been described as an overall change pattern in European landscapes (Antrop, 2004, 2006; Primdahl et al., 2013). Such polarization of land uses may occur within local, regional, national, and continental scales; on short-term and long-term temporal scales; and both within the same broad land-use category (e.g., pasture abandonment on some sites, grazing intensification on other sites) and between different land-use sectors (e.g., abandonment of crop cultivation, intensification of livestock husbandry).

1.4.4 Combinations of underlying drivers are determining landscape change, rather than single key variables

Political / institutional, cultural, and natural / spatial factors were frequently identified as underlying drivers of landscape change. But similar to other recent work (van Vliet et al., 2015a), the studies included in our review typically related combinations of factors to landscape change, rather than singling out individual factors. Actually, the most common type of causation was a combination of all five categories of underlying drivers. Studies identified an average of 4.4 factors within the 19 categories in our driving forces framework, but there was distinct variation among the driving forces of different landscape change processes and geographical regions (Table 1.3). For example, natural and spatial drivers were described as being more influential on land abandonment than on other change processes. Our analysis showed that cases cluster in groups of a small number of shared characteristics, with land abandonment, agricultural expansion / intensification and technological drivers being most relevant for separating clusters. While the major clustering reflects the dominance of land abandonment, further subdivision of clusters indicates the importance of agricultural intensification and technological driving forces.

1.4.5 Limitations

When interpreting the results of our systematic review, several caveats need to be taken into account. Although systematic review is acknowledged as a straightforward method that yields robust results (Pullin and Stewart, 2006), relevant information reported in the empirical studies used may be lost, and some relevant studies may be missed in the selection process. Landscape as a concept has different meanings to different disciplines (Angelstam et al., 2013). We selected only papers that described themselves to study “landscape change” or “landscape dynamics” and that were written in English, French, or German. Other papers (for example, those that focused on more isolated land change processes or those that were published in other languages) remained unconsidered. Therefore, we feel that our review includes a broad sample of internationally published landscape research, but may neglect studies of more regional relevance as well as studies that investigate individual change processes without a landscape perspective.

1.5. The way forward

Bürgi et al. (2004) defined a set of “new directions” to tackle the challenges of landscape change studies. Here, we build on these directions with a series of key lessons that we derive from our review and that should be of relevance for the advancement of landscape change research both in Europe and beyond. We propose that the way forward for the analysis of proximate and underlying drivers of landscape change needs to comprise:

An expansion of the scope of studies to include underrepresented countries, biogeographic regions, and land-use systems;

An improvement of conceptual clarity with regard to the role and identification of actors vs. driving forces of landscape change (cf. Hersperger et al., 2010);

The deployment of more robust tools and methods to quantitatively assess the causalities of landscape change, while maintaining the holistic character of landscape studies;

Long-term studies that go beyond the use of satellite imagery, considering diverse types of data on landscape change (cf. Fuchs et al., 2015);

A strengthening of standardized cross-site and cross-country comparisons of landscape change drivers to foster generalizability of insights;

The design of multi-scale studies that consider distal relations between actors, drivers, and patterns of landscape change (Eakin et al., 2014); and

Stronger consideration of subtle (e.g. land management intensity, Bürgi et al., 2015) and/or novel (e.g. emergence of "energy landscapes", Nadaï and van der Horst, 2010) processes of landscape change.

Part 2: Rates of landscape change in Europe: A systematic review of the evidence

2.1. Introduction

The landscapes of Europe have been shaped by nature and societies for centuries (Emanuelsson, 2009). These landscapes were never static, but the 19th and 20th centuries marked increased change rates that affected many European landscapes (Antrop, 2004). Recent estimates found as much as 700,000 km^2 land-cover change in Europe in a 60-year time span (1950-2010), corresponding to 15.5% of its total area (Fuchs et al., 2015). These changes reflect a variety of causes, from global trends (e.g. market liberalization, technological change, etc.) to local particularities (e.g. land ownership patterns, economic structure of areas, etc.), which are not always discernible, but are nested and interlinked (Hersperger and Bürgi, 2009). The configuration of these causes for a specific landscape is again very diverse, as similar causes may be responsible for different outcomes on the landscape level (e.g. urbanization patterns present very important differences from south to north and from western to eastern Europe, Antrop, 2004), while very different drivers can have similar effects (e.g. land abandonment has been the outcome of a number of different causes, including markets, social change, etc., Sluiter and de Jong, 2007; Baumann et al., 2011).

Understanding, measuring and planning for landscape change has been practised at different spatial levels and with widely different methods of analysis around Europe in the last decades Antrop, 2000). From fine grain, local landscapes studied with historical spatial and non-spatial data (e.g. Kizos et al., 2010; Hersperger and Bürgi, 2009; Plieninger et al., 2012; Bieling et al., 2013), to the national – regional landscape scale with spatial data (e.g. Alcantara et al., 2013; Griffiths et al, 2013); and the European - global scale (e.g. Van Vliet et al., 2012). Research has also addressed the challenges that landscape change poses on environmental and social aspects (Verburg et al., 2009), such as habitat loss and fragmentation (Paudel & Yuan, 2012), biodiversity loss (Moser et al., 2002), soil degradation and carbon storage decrease (Eaton et al., 2008), decline of ecosystem services (Newton et al., 2009) and flood event frequency (Solin et al., 2011).

The availability of spatial data and new tools for managing these data has allowed rapid comparisons (in the sense that the analyses can take place shortly after the events, but also rapid in the sense that they are relatively fast to implement) of land cover and land use change and from there landscape changes (Newton et al, 2009), which typically involve processes such as deforestation, afforestation, farmland abandonment, agricultural and urban land expansion (e.g. Tomaz et al., 2013; Alcantara et al., 2013; Li et al., 2013; Griffiths et al., 2013; Seto et al., 2011; Romano and Zullo, 2014; Baumann et al., 2012). Spatial modelling is another by-product of this great expansion of data availability and processing speed and the efficiency, which has allowed new approaches that go beyond the comparison of separate moments in time and provided important insights into the dynamics and future of landscape change (Verburg et al., 2006). Another concern, again facilitated by the quantification of spatial data, is the rate and magnitude of landscape changes.

Rates of change can be calculated by comparing the total area of a specific land cover for multiple time points (usually annual or per decade), revealing patterns of acceleration or deceleration (Puyravaud, 2003). These rates are affected by many factors – driving forces, including environmental changes and social, economic and political transitions (Munteanu et al., 2014; Sklenicka et al., 2014; Alcantara et al., 2013; Biró et al., 2013).

Recently, the number of studies into landscape change rates has increased. The diversity in terms of causes, rates and magnitude of landscape change, has made the understanding of overall patterns fragmented at best for specific processes or types of change and in general poorly understood (van Vliet et al., 2015a). Systematic reviews and meta-analyses that seek to investigate patterns and arrive at broader insights into large areas of research, have become popular in environmental sciences (Pullin and Stewart, 2006), especially since in landscape change studies, place-based approaches are dominant, but –to our knowledge– such systematic approaches on landscape change rates and magnitude in Europe have so far not been carried out. In this paper, we perform a Pan-European systematic review of the literature and meta-analysis to map, analyse and quantify landscape change rates and their patterns at multiple scales. More specifically, this literature review will consider aims to: (a) provide estimations and measurements when possible of land-cover and landscape change across Europe, (b) provide measurements of landscape change rates across multiple spatial scales, (c) link landscape changes to driving forces and (d) examine existing biases in the scientific literature related towards particular scales, rates, drivers and processes. The outcome of the study is expected to reveal current trends in landscape change in Europe and provide evidence to improve policy-making at a landscape level.

2.2 Methods

2.2.1 Selection of the case studies

Our method followed established guidelines for systematic review and systematic mapping (Centre for Evidence-Based Conservation, 2010) and was oriented along previous systematic review exercises in comparable fields (Geist and Lambin, 2002; Rudel, 2008; van Asselen et al., 2013; van Vliet et al., 2012; van Vliet et al., 2015a). Optimal keywords for the review were obtained after initial scoping in the Scopus online library. It revealed that many landscape studies did not use terms such as “rates”, or this term was used in other contexts, although they included the calculation of such rates in their analysis. Moreover, scoping revealed that quantitative calculations for rates of landscape change were relatively few. In the end, we used the keywords “land-cover change rate”, “land cover change rate”, “land change rate”, “landscape change rate”. To select only case studies from Europe, the search was refined by adding the names of each European country as search terms. The databases we searched were ISI Web of Knowledge, Scopus and Google Scholar. The starting point was 1945 (Antrop, 2005) and we considered studies in English language. To locate grey literature, we additionally considered the first 50 pdf and word documents that were provided by Google Scholar. We modified search strings to the customs of each database and search engine. We stored titles and abstracts in a single Endnote/Zotero database and removed all duplicates.

The criteria for including a study in our sample were (Rudel, 2008; Geist and Lambin, 2002): (i) cover a landscape of clearly anthropogenic origin; (ii) be based on in-depth field investigations; (iii) provide some form of measurement of landscape change processes at regional to local scale within Europe; (iv) offer quantified measurements of land- use/cover change and landscape change (either in absolute numbers directly or in percentages from which absolute numbers could be calculated), (v) offer quantified measurements of land-cover and landscape change rates at regional to local scale (where these were not available directly, we calculated annual rates for each process and each distinct process was considered as a separate case, and (vi) provide explanations about the forces driving landscape change in the study areas (Rudel, 2008).

We performed the search in September - October 2014 and initially obtained 2,346, reduced to 1,575 after removal of duplicates. The selection of the studies followed a three stage process: First, the titles of the papers were considered (resulting in 531). In the second stage of the screening process, the selection of studies was based on the relevance of the abstract (344 papers), while in the final stage the whole text was considered. The screening process yielded 49 papers with 89 case studies to be included in the review. Data extracted from the papers were stored in spreadsheets, where for every study the following information was stored: the coordinates, area size, population (where available), journal the study was published, type of data (satellite images, aerial photos, CORINE land-cover classification and historical maps, multiple types were allowed), and methodological choices for the analysis of data (statistical analysis, time-series mapping, landscape metrics, again multiple analysis methods were allowed).

Following van Vliet et al. (2015) we also recorded the process of landscape change, first separated into intensification and disintensification broader processes and then into 11 processes of change: five reflecting intensification processes (increase in agricultural land area, decrease in landscape elements, increase in management intensity, change in agricultural land use activities and specialization/monoculture), five reflecting disintensification processes (land abandonment, increase in landscape elements, decrease in management activities, change in agricultural land use, on farm diversification) and one reflecting urbanization, allowing for multiple processes. Classification of the changes reported in the selected papers were straightforward in some cases (e.g. “increase in agricultural area”, “increase in management intensity”). For other intensification processes, such as the “decrease in landscape elements” cases were deforestation or loss of landscape elements such as hedgerows or small plots was reported. For disintensification processes, in “land abandonment” cases in which agricultural land was not cultivated anymore and changed into shrubs or forest areas, or forests, while the “increase in landscape elements” category was used in cases were physical elements of the landscape were reported to increase (e.g. individual trees) or added in the landscape. The distinction was problematic in some cases due to differences in reporting the processes or differences in the rate of changes that result after abandonment of agricultural land. “Urbanization” was used for cases were increase in urban cover was reported, either as urban sprawl or as compact settlements. Finally, information on drivers of landscape change were also documented following the categories suggested by Hersperger and Bürgi (2009): economic, demographic, technological, institutional, socio-cultural drivers.

2.2.2 Data analysis

The 89 case studies were stored into another spreadsheet into which the process of change was again recorded, but this time only one process was related with each case. The calculation of the annual rate of change between land cover classes follows the formula proposed by Puyravaud (2003): Annual Change = $(A2/A1)^{1/(t2-t1)}$ -1, where A1 and A2 represent the area of the land cover of interest in time point 1 and 2 respectively. When multiple rates are found in one period, weighted averages were used. According to the distribution of the values of the rates four types were used: "very slow" change refers to rates less than 0.7% of change per year (the lower quartile of the values of the variable); "slow" change to rates from 0.7-1.2 % per year (to the median value of the variable), "fast" change to rates 1.2-2% per year (the upper quartile); and "very fast" change with rates higher than 2% per year. Another variable that was calculated from the data of the case studies was the "magnitude of changes", which reflects the percentage of the total area affected by any type of change. We calculated magnitude from the data provided in each study, if these were not provided in the text. Two different types of magnitude are used: "small" and "large", with the value that distinguishes the two classes being the lower quartile (2% of the total area).

We synthesized rates and magnitude of change to arrive at the type of change for the landscape, using four types: "very slow", "slow", "fast" and "very fast" landscape change (Figure 2.1). We then explored the geography of the case studies and their size through descriptive statistics. We then correlated annual rates and magnitude of change and checked for mean differences of each variable for the other and for processes of landscape change and landscape change rate through ANOVA.

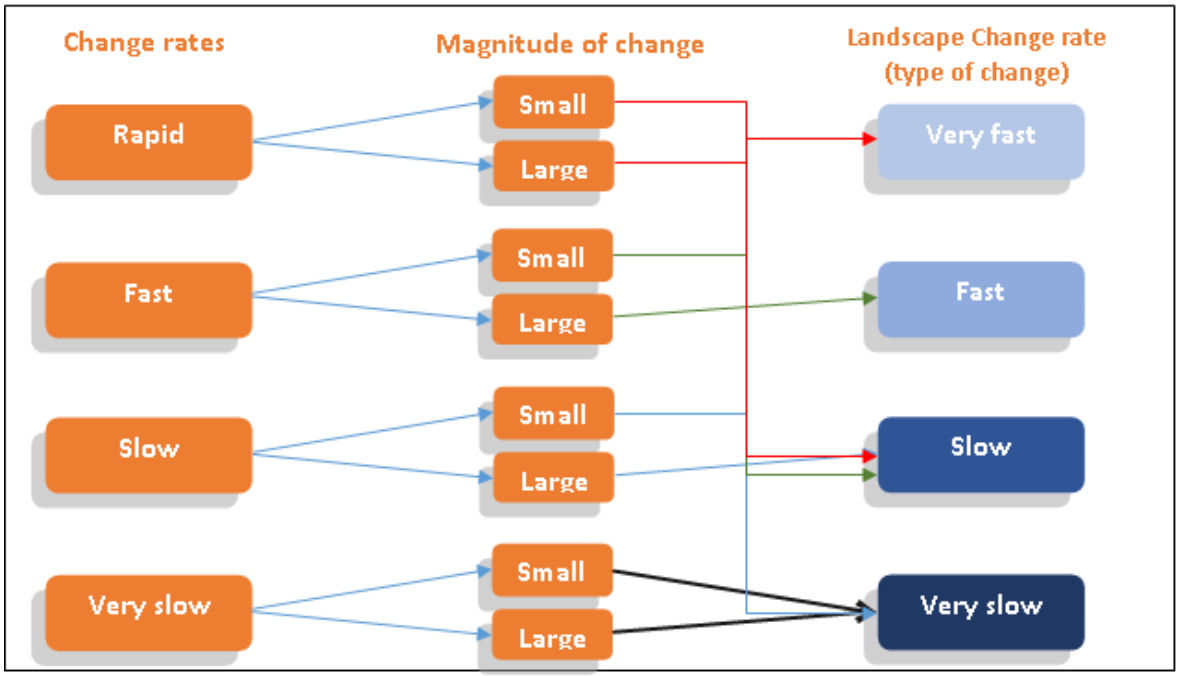


Figure 2.1: Landscape change rates from magnitude and rate of change

2.3 Results

2.3.1 Analytical approaches

The case studies in our review were in 49 papers, with 86 cases, performed in 16 different countries (Fig. 2.2). It seems that research on rates of landscape change has not been performed with the same frequency across Europe. The Mediterranean part of Europe is overrepresented in the sample (30 of the 49 papers), with studies on Spain being by far the more frequent (15 papers), followed by Italy (seven papers), Portugal and Greece (four papers each) were the most intensively studied countries. Two studies referred to three different countries (Figure 2.3A). Eastern European countries were underrepresented in the sample.

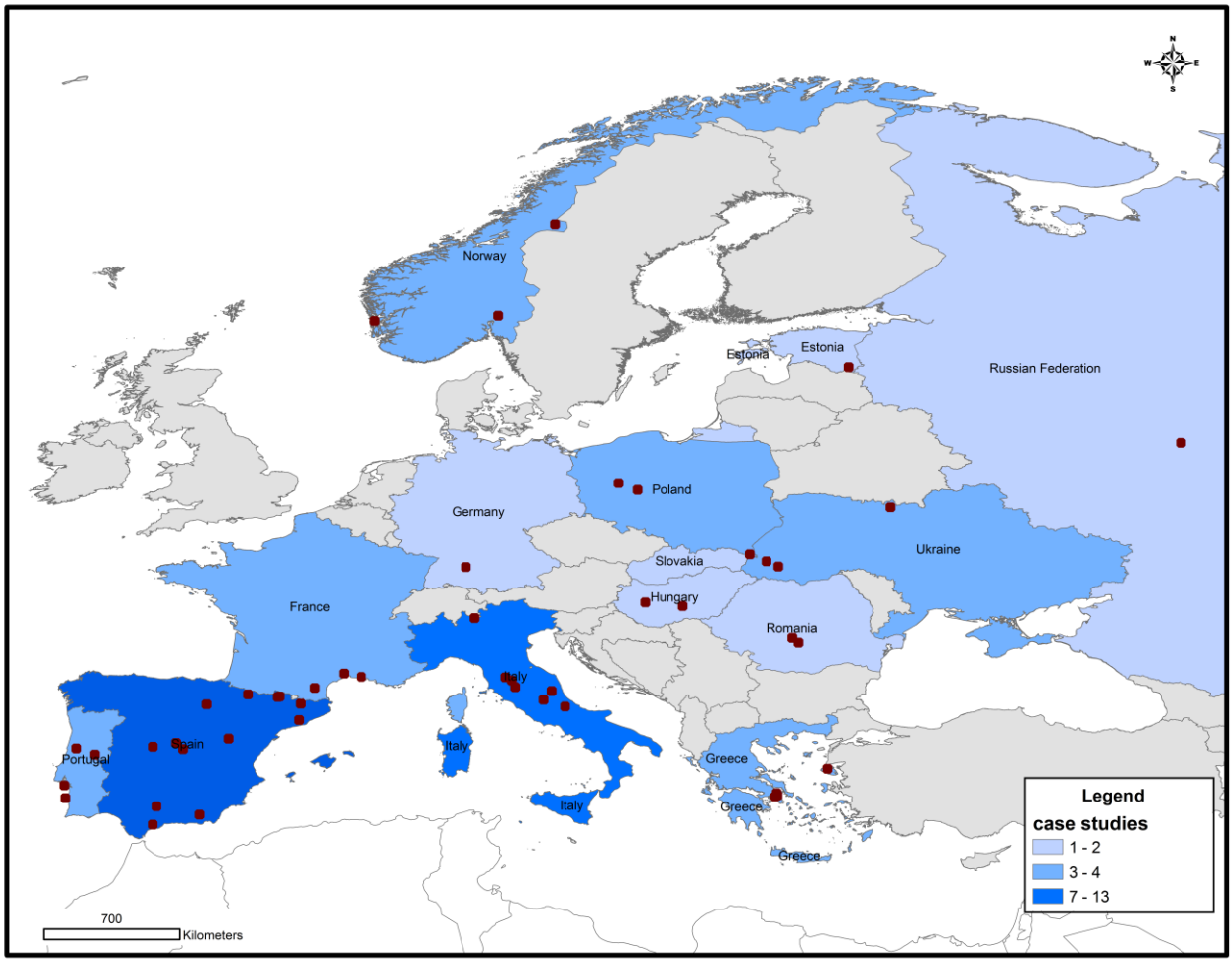
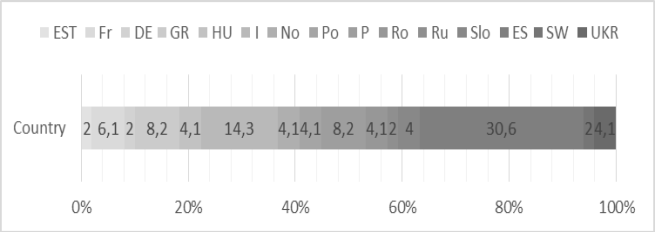


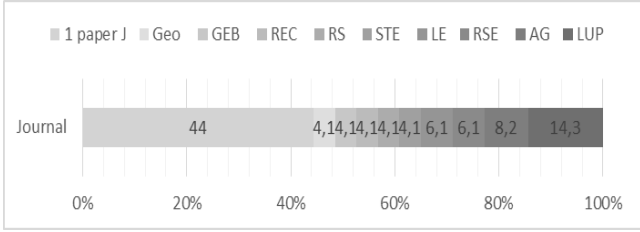
Figure 2.2: Location on the case studies

Studies of rates of landscape change were published in 31 different journals, from research areas very diverse, including geography, environmental sciences, ecology, agriculture, forestry, urban studies, biodiversity and conservation and remote sensing.

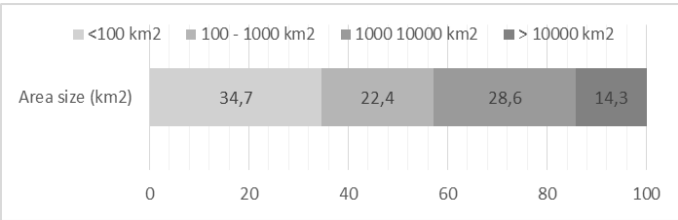
The most prominent outlets were (Figure 2.3B) Landscape and Urban Planning (seven papers or 14.3% of the total), Applied Geography (four papers), Landscape Ecology and Remote Sensing of the Environment (three papers for each), five more journals with two papers (Remote Sensing, Science of the Total Environment, Regional Environmental Change, Geomorphology and Global Ecology and Biogeography), while there were 22 different journals with one paper each.



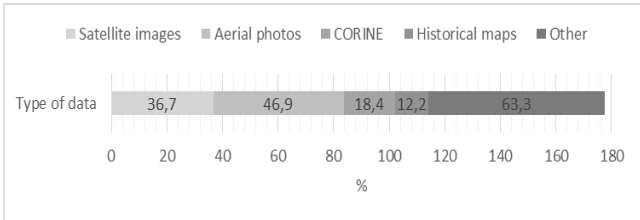
A: Location of the case studies (countries) % of total



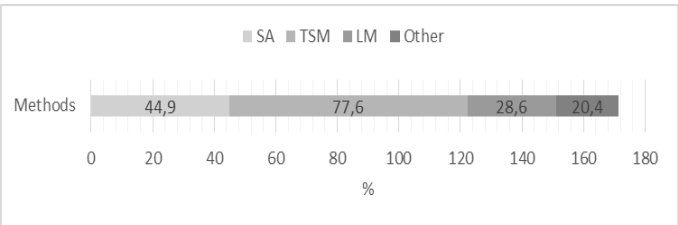
B: Journals % of total



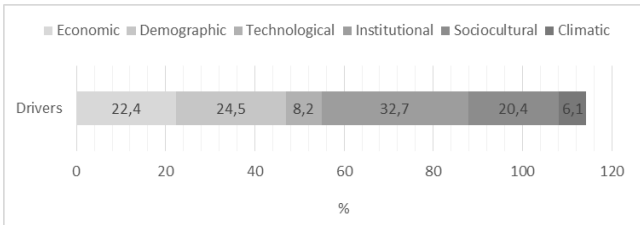
C: Area size of case studies % of total



D: Type of data % of total



E: Methods used % of total



F: Drivers of landscape change % of total

Figure 2.3: Descriptive statistics of the case study papers

A: Location of the case studies: EST: Estonia, FR: France, DE: Germany, GR: Greece, HU: Hungary, I: Italy, NO: Norway, PO: Poland, P: Portugal, RO: Romania, RU: Russia, SLO: Slovakia, ES: Spain, SW: Switzerland, UKR: Ukraine;B: Journals % of total: 1 paper J: Journals with one paper in sample, Geo: Geomorphology, GEB: Global Ecology and Biogeography, REC: Regional Environmental Change, RS: Remote Sensing, STE: Science of the Total Environment, LE: Landscape Ecology, RSE: Remote Sensing of Environment, AG: Applied Geography, LUP: Landscape and Urban Planning C: Area size of case studies;D: Type of Data;E: Methods used: SA: Statistical Analysis, TSM: Time Series Mapping, LM: Landscape Metrics;F: Drivers of landscape change

Aerial photos were used by 23 papers to determine landscape changes (46.9% of the total), satellite images were used by 18 papers, while official statistics and other data were used by 31 papers (63.3% of the total), CORINE data from nine papers and historical maps by six papers (Figure 2.3C).

Time-series mapping (TSM) was the dominant method of analysis of 38 papers (77.6% of the total), complimented usually with statistical analysis (SA) for 22 papers, while Landscape Metrics (LM) were also used from 14 papers (Figure 2.3D). Ten papers used other methods as well, typically related with socioeconomic indicators or field work. Qualitative methods were not considered in this review, as the objective was to arrive at quantitative assessments.

Study areas ranged from 0.6 km² to ca. 87,000 km². Most sizes (17 or 34.7% of the sample, Figure 2.3E) were from 1-99 km², followed by those between 1,000 and 10,000 km^2 (14 papers), while 11 areas were 100 – 1,000 km^2. System borders were defined mainly by administrative units.

The drivers mentioned in the papers were mostly institutional (16 papers, or 32.7% of the total, Figure 2.3), followed by demographic (12 papers), economic (11 papers) and sociocultural (10 papers) drivers, while climatic and technological were less often mentioned. Few papers mentioned only one type of driver, these being mostly of the institutional type, while common combinations included institutional and demographic drivers.

Finally, the most common type of change for the cases (the 86 cases) was “increase in landscape elements” with 28 cases (32.6% of the total, Figure 2.4D), followed by “land abandonment” with 25 cases (29.1% of total) and “urbanization” (18 cases), while the rest of the types are mentioned less frequently, with “decrease in landscape elements” (9 cases), “increase in agricultural land area” with 5 cases and “decrease in management activities“ with only one case.

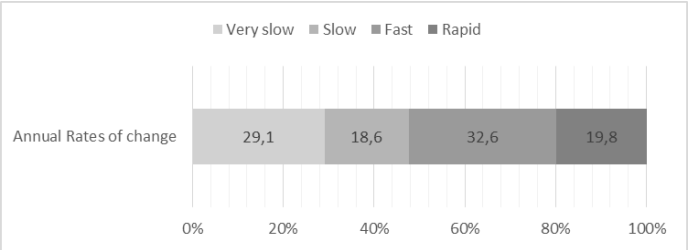
2.3.2 Annual rates of landscape change

The calculated annual rates of landscape change range from 0.02% up to roughly 7%, with an average value of 1.64% (median at 1.2%, standard deviation 1.77). These values were classified as “very slow” (less than 0.7%) for 25 cases (29.1% of the total, Figure 2.4), “slow” for 16 cases, fast for 28 cases and rapid for 17 cases (Figure 2.4A). We compared the average values of these rates for the types of change of each case (Table 2.1). The average values differ and the difference is statistically significant (ANOVA F= 3.3, s=0.014, N=86), with the highest average at urbanization processes (2.29%) and the lowest at increase in agricultural land area processes (0.63%). Between groups, urbanization is the class of processes that has statistically significant differences on average from all other processes.

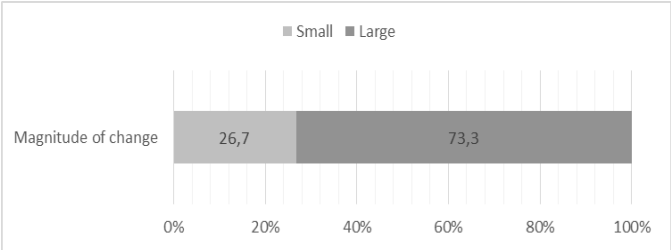
2.3.3 Magnitude of change

The values for magnitude of change are also diverse, with a minimum of 0.02% and a maximum of 44% (average 7.38%, median 3.86%). These values were classified as “small” magnitude for 23 cases (less than 2% of the landscape) and “large” for 63 cases (Figure 2.4B). Magnitude of change values are weakly and positively correlated with the values of annual rate of change (Pearson’s rh0= 0.406, s=0.000, N=86), demonstrated by the statistically significant differences of mean values of magnitude of change for the annual rates classes (ANOVA F= 5.8, s=0.000, N=86): the lowest rates were recorded for “very slow” annual rates (4.53% of the landscape changed), with 7.5% for “slow” annual rates, 5.4% for “fast” and 14.5% for “rapid” rates. Between groups, “rapid” rates is the class with significant statistical differences with all other classes. Likewise, mean value differences for

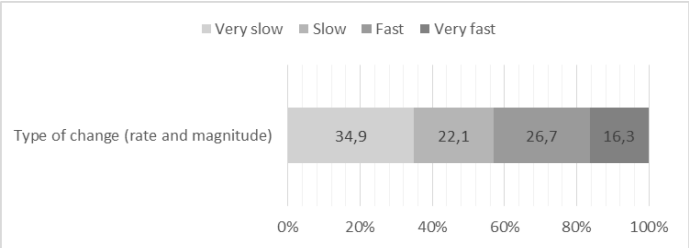
the different processes of change are not statistically significant, with the highest average value recorded for “increase in landscape elements” at 8.79% change and “land abandonment” at 8.61%, while the lowest values were recorded for “increase in agricultural land area” process at 2.71% (Table 2.1).



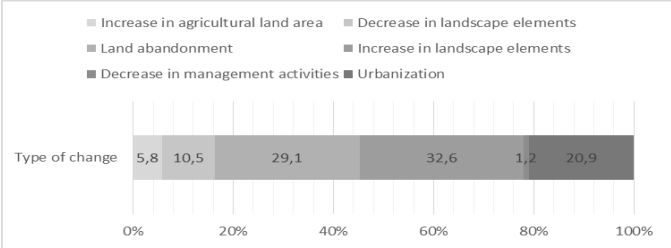
A: Annual rates of change % of total



B: Magnitude of change % total



C: Type of landscape change (Rate and Magnitude) % of total



D: Type of change % of total

Figure 2.4: Descriptive statistics of the case studies

A: Annual rates of change % of total;B: Magnitude of change % total;C: Type of landscape change (Rate and Magnitude) % of total;D: Type of change % of total;

Table 2.1: Descriptive statistics for annual rates of landscape change and magnitude of changes for processes of landscape change

		Annual rate of change %		**Magnitude of change (% of total area)**	
	N	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
Increase in agricultural land area	5	0.63	0.40	2.71	3.40
Decrease in landscape elements	9	0.87	0.58	5.91	8.36
Land abandonment	25	1.63	1.54	8.61	11.42
Increase in landscape elements	28	1.26	0.94	8.79	8.15
Decrease in management activities	1	12.6	-	12.6	-
Urbanization	18	2.29	1.51	4.75	5.82
Total	**86**	**1.51**	**1.31**	**7.22**	**8.76**

2.3.4 Landscape change rates

Landscape change rates were produced from the values of the annual rates and the magnitude of change for each case study (Figure 2.1). The outcome is a majority of "very slow" landscape changes (34.9% of the total, Figure 2.4C), with 22.1% of changes characterized as "slow", 26.7% as "fast" and 16.2% as "very fast". The average values of the annual rates and the magnitude of change increase across these classes (Table 2.2, as expected the differences of the mean values are statistically significant for both variables), with the exception of the "slow" and "fast" classes, where the heterogeneity of the values and the variety of trajectories for classifying a case in these classes makes the averages very similar. What come out of the cross tabulation of the magnitude of changes and the landscape change rates is that "fast" and "very fast" change rates are the result of only "large" changes (Figure 2.5), i.e. changes that affect a large proportion of the total landscape area.

Table 2.2: Landscape change type from annual rates and magnitude of change

		Annual rate of change %		**Magnitude of change (% of total area)**	
	N	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
Very slow	30	0.48	0.27	3.88	4.69
Slow	19	1.68	1.44	6.63	8.75
Fast	23	1.55	0.28	6.53	5.66
Very fast	14	4.20	2.67	17.32	12.85
Total	**86**	**1.64**	**1.76**	**7.38**	**8.84**

Table 2.3: Processes of change and Landscape change rates

Landscape change rate (%)	**Process of change (%)**						
	Increase in agricultural land area (N=5)	**Decrease in landscape elements (N=9)**	**Land abandonment (N=25)**	**Increase in landscape elements (N=28)**	**Decrease in management activities (N=1)**	**Urbanization (N=18)**	**Total (N=86)**
Very slow (N=30)	*13.3*	*16.7*	*33.3*	*30.0*		*6.7*	***100.0***
	80.0	55.6	40.0	32.1		11.1	**34.9**
Slow (N=19)		*15.8*	*26.3*	*36.8*		*21.1*	***100.0***
		33.3	20.0	25.0		22.2	**22.1**
Fast (N=23)	*4.4*	*4.4*	*21.7*	*39.1*		*30.4*	***100.0***
	20.0	11.1	20.0	32.1		38.9	**26.7**
Very fast (N=14)			*35.7*	*21.4*	*7.1*	*35.7*	***100.0***
			20.0	10.7	100.0	27.8	**16.3**
Total (N=86)	***5.8***	***10.5***	***29.1***	***32.6***	***1.2***	***20.9***	***100.0***
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Cross-tabulation of the overall landscape change rate with the processes of change indicates that although there is no statistically significant relationship between the values of the variables, urbanization tends to be associated with "fast" and "very fast" changes (67% of the total urbanization cases and 35% and 30% of the "very fast" and "fast" classes respectively, Table 2.3). But, there are some cases of urbanization that are categorized as "very slow" (they refer to cases of relatively smaller areas in relation to the total landscape size). Land abandonment processes appear to be slower on a whole, as 60% of the total number of cases are categorized as "very slow" and "slow". The cases that are categorized as "very fast" (5 cases or 35% of the "very fast" category), refer to large areas and relatively slow rates. Processes that refer to increase of landscape elements are more evenly encountered in all landscape change rates (Table 2.3), while processes of increase in agricultural land area and decrease in landscape elements are mostly "very slow" and never "very fast", since they typically refer to smaller areas and relatively slow annual rates.

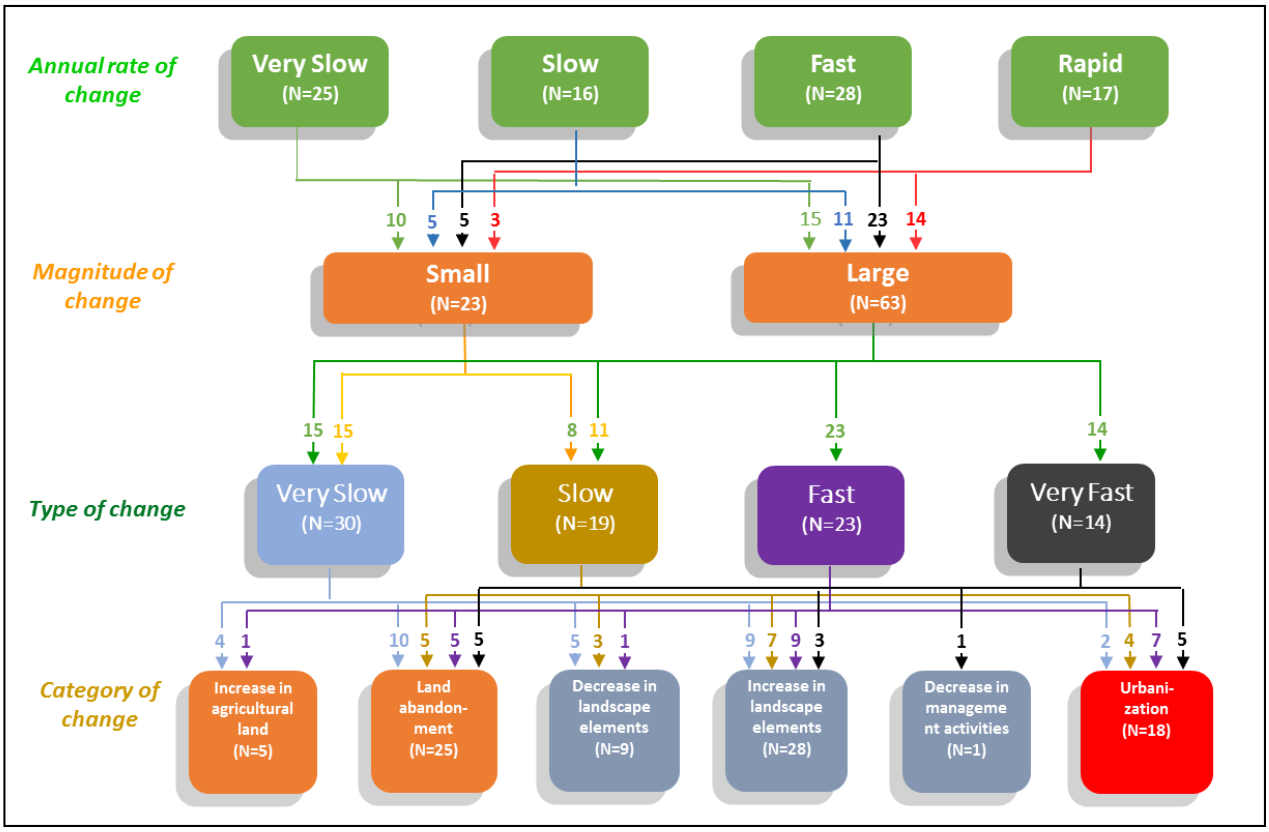


Figure 2.5: Annual rates, magnitude and type of change analyzed in the review

2.4 Discussion

Although the literature on landscape change is growing rapidly (see some recent reviews with related literature Geist and Lambin, 2002; Seto et al., 2011; van Vliet et al., 2015a; van Vliet et al., 2015b; van Asselen et al., 2013), the understanding of the complexity of landscape changes rates and the processes these are associated with remain incomplete. In our study, we reviewed empirical case studies that cover Europe with a variety of spatial scales and multiple aspects of landscape change. We also propose a conceptual frame for estimating and depicting the change of the landscape from the annual rates and the magnitude of changes within this landscape, since one of the findings of the review was the inherent complexity of landscape change and the often very different rates and magnitudes of different changes within the same landscape. The relatively limited number of papers and case studies included in the review from this rich literature is a result of the need to calculate annual rates of change from the total numbers of the preselected papers (742 papers). Other possible sources of omissions and errors in the papers considered for analysis are related with the selection process of the papers and how they defined their analysis and "landscape" itself, since it carries different meanings and is defined in different ways by different disciplines. Therefore, cases that used different terms for defining landscape or cases that were not described as "landscape change" or "land cover change" were not considered.

2.4.1 Diversity of research on landscape change rates

Our review indicates that although research on landscape change rates has been carried out in all parts of Europe, there is a bias towards the Mediterranean parts, at least for case studies that could be quantified. Satellite images and aerial pictures have been used in most of the case studies that we reviewed, indicating that the availability of these data for the past decades allows the application of approaches that are related with time series mapping (TSM) and landscape metrics (LM). TSM has been by far the most common approach used, which allows the quantification of landscape changes and the extraction of different rates for different processes within the same landscape and for the landscape as a whole. Typically, 2-4 points in time were used and the temporal scale involved decades. These approaches seem to be leading to the next step pf landscape change related research, modelling (Magliocca et al., 2015;), although for this step TSM approaches requires the calculation of rates of change and the identification of drivers for these processes of change for addressing the issues of the Anthropocene (Verburg et al., 2015).

The spatial scales used from the case studies of our review indicate that the "landscape" has been considered at a variety of scales. Although smaller geographical extents are the relative majority of the case studies (less than 100 km^2), larger scales are also being considered by researchers as suitable for conceptualizing landscape and its changes. The scale issue is not unrelated with the research approach and the data used in the case studies, as satellite images and aerial pictures are linked with specific spatial scales and objects of analysis (land cover classes and how these change) and metrics (typically how the areas and edges of these classes are placed in space and how they change).

Landscape and land use change "processes and impacts are scale dependent, [therefore] the comparison of case studies conducted at different scales may become troublesome". These "differences might lead to bias due to aggregation issues and misinterpreted scale effects" van Vliet et al. (2015b, p. 2).

Another aspect of landscape change research was the drivers associated with landscape change. Unlike the quantitative analysis of land cover change, the reported drivers were identified through qualitative approaches with the use of official statistics and personal interpretation of the authors. Although conceptual approaches for the drivers of change tend to follow the categories suggested by Bürgi et al. (2004), there were also very loose approaches or studies that simply reported changes without offering drivers. The type of data used and the temporal scale that these data imply, since satellite images and in general maps are available for the last decades, lead to identification of human induced drivers (institutional, demographic, economic and sociocultural) than natural ones. This leads to the use of administrative units for delimiting landscapes rather than biophysical ones.

Concerning the most common type of change, again in many cases the types that were used in our analysis were not very well fitted to the approaches used. Even obvious cases such as urbanization presented significant diversity in different countries with cases of loose urban sprawl, planned expansion of urban areas and linear growth. Other processes such as "increase in landscape elements" where even more diverse in content. As in other reviews (Plieninger et al., 2014; van Vliet et al., 2015b), land abandonment was very important. Classifying a case as abandonment was though not always straightforward, as it dependent from the focus of the analysis in the cases considered for both the final outcome of abandonment and the temporal scale considered: in some cases natural vegetation encroachment was considered as abandonment and in other cases as "reforestation", but the only actual difference may be the years between the original state and the period the change was measured. This is particularly the case in Mediterranean Europe case studies, where abandonment may change vegetation with slower rates rather than wetter and more continental climatic zones (see also Lasanta et al., 2015; Sluiter and de Jong, 2007; Baumann et al., 2011). The issue of "abandonment" and "re-wilding" are hot topics today in Europe (Haddaway et al., 2013; Plieninger et al., 2014) and need to be defined either as processes (stopping of land management practices) and/or as final outcomes in the landscape (as a land cover class: shrubland, forest, maquis). Different bioclimatic zones and local conditions will obviously yield different rates of the process and this adds to the complexity of unraveling this important process in Europe today. Land abandonment involves both positive and negative effects on a number of landscape services (Benayas et al., 2007), including biodiversity, ecosystem services, and human well-being (Plieninger et al., 2014) and its perceived effects on the landscape may also vary.

2.4.2. Rates of landscape change

How fast do landscapes change? This has been a central question of landscape studies for years in planning, ecological and cultural approaches (Marcucci, 2000; Haines-Young, 2000; Termorshuizen and Opdam, 2009). Answers to this seemingly simple question are very ambiguous as we need first to define what constitutes change and the temporal scale of this change. In this review, we have focused on case studies that are recent (the last 5-6 decades) and that changes that are mostly anthropogenic in origin, although some cases are rather ambiguous, e.g. abandonment and

subsequent re-wilding: in abandonment, human management of land stops completely in many cases, so the actual changes could be considered as “natural” in origin and not “anthropogenic”. Although this is simply a matter of definition, conceptualizing the drivers of change and linking these with rates depends very much on these definitions (Hersperger and Bürgi, 2009) making broad categorizations and comparisons of different cases not always straightforward. In this sense, the findings of the review should be treated as a first approach towards systematizing existing research on landscape change.

Aside from this, the actual rates were also problematic, as rates that were calculated in this review are to an extent artificial. Landscapes change as a sum of many smaller changes that accumulate in the landscape matrix (Verburg et al., 2015). These changes are driven by specific drivers, but their realization in the matrix is random in the sense that the actors that realize them act randomly and in an uncoordinated manner. In this review we have followed the approach that assumes an average rate of change for each of the land cover classes that make the landscape and then with the use of the magnitude of change of this class in the landscape, we propose a classification system that estimates the change of the landscape as a whole. This approach is very well suited to the dominant data use on landscape change research today, satellite images and/or aerial pictures, and to modelling approaches that are more and more used at different scales to quantify land cover and landscape change (Verburg et al., 2015; van Vliet et al., 2015b). But, a landscape is more than the sum of its parts (see the discussion in Plieninger et al., 2015) and the change of the landscape as a whole is not the sum of different land cover changes. This is an issue that was highlighted as well in the first review (part 1 of the Deliverable). Issues of scale and “landscape character”, but also of the perception of landscape change (Fagerholm et al., 2013) are pertinent here. The diversity of the size of the case studies is large.

Although many issues remain open, the findings of this review seem to corroborate (van Vliet et al., 2015a) that specific processes of change are responsible for “faster” landscape changes, with urbanization being prominent, while “abandonment” refers to “slower” but “larger” changes in European landscapes, although there are surely many different “types” of abandonment, some faster than others. There are biases and omissions in the cases considered here: the Mediterranean parts are overrepresented, abandonment and urbanization processes are dominant and landscapes that have not changed much so not seem to be considered for analysis by researchers in Europe. But, in the end, the categorization offered here seems to correspond with other reviews on similar aspects in Europe and the world (e.g. van Vliet et al., 2015a; 2015b; Lasanta et al., 2015; Sluiter and de Jong, 2007; Baumann et al., 2011; Haddaway et al., 2013; Plieninger et al., 2014).

2.5. Conclusions and a way forward

Landscapes change continuously from a variety of drivers and at different rates. The interplay between continuity and change of landscapes has been very much in the forefront of landscape related research. In this paper, we have attempted to review this literature and explore quantitatively the rates and the magnitude of landscape change in relation with processes and drivers of change. The quantitative approach has shrunk the pool of case studies, but has allowed an exploration of the rates of landscape change in Europe.

As van Vliet et al. (2015b) note, meta-studies synthesize empirical, case-based, research, but this synthesis is often not straightforward as "land use changes and their impacts are usually studied from real-world observations rather than experiments in a controlled environment… [and] these differences in local conditions can cause confusion between correlation and causation, and restrict the comparability of case-study findings" (p. 2), while drivers and processes of change are often reported only qualitatively and/or in a narrative format. At the same time, the different disciplines involved in collecting empirical evidence for landscape change processes and rates including ecology, geography, social sciences, land use science, among others. "Consequently, only few studies include a comprehensive coverage of socioeconomic and biophysical drivers" (van Vliet et al., 2015b, p. 2).

The findings seem to re-confirm the qualitative estimations of Antrop (2004) about the importance of processes of urbanization in landscape change. The overall landscape change rates for these processes is impressive in many cases, especially if the qualitative aspects of the particular process is considered, namely that it is an irreversible process for human time scales that alters landscape character, values and services. Abandonment is another aspect that has emerged from the cases studies, although definitions and outcomes in relation with its rates need to be further investigated.

To conclude, the findings of the review bring forward some key issues for the analysis of landscape change rates:

(a) More approaches that relate individual changes with drivers or processes of change are required;

(b) An expansion of the scope of studies to include underrepresented countries and processes of change would improve comparability and width of the available cases;

(c) The performance of long-term and multi-scale studies that will consider diverse types of data sources and other aspects of landscape change would improve conceptual, geographical and thematic aspects of landscape change.

Part 3: Integrated Landscape Initiatives in Europe: multi-sectorial collaboration in multi-functional landscapes

3.1 Introduction

Landscapes have been stamped by sometimes gradual, sometimes rapid reorganisations in order to adapt their uses to changing societal demands throughout history (Antrop, 2005; Dannebeck et al., 2009). However, the speed, scale and magnitude of current landscape change are unprecedented in most world regions (Jansen et al., 2009; Millennium Ecosystem Assessment, 2005). Landscapes face the challenges of globalisation and its associated increasing flows of technology, investment and trade; intensification and homogenisation; urbanisation and proliferation of built infrastructure; marginalisation and abandonment; and renewable power provision (Antrop, 2008; Plieninger and Bieling, 2012). In response to these challenges, there is a growing movement among civil society throughout Europe that demands local products, is interested in local traditional knowledge and culture as connected to landscapes, is concerned about the conservation of biodiversity, longs for unique touristic destinations, demands eco-products, or (if living in the big cities) is willing to start a new life in a rural area (Penker, 2009; Plieninger et al., 2015a; Termorshuizen and Opdam, 2009). Such initiatives typically build on collaboration among different sectors and actor groups at many levels (Prager, 2012; Prager et al., 2012; Scherr et al., 2012).

Such collaborative action has been termed “Integrated Landscape Initiatives (ILIs)” (Estrada-Carmona et al., 2014; Milder et al., 2013). Here, we understand Integrated Landscape Initiatives in Europe as projects, programs, platforms, initiatives, or sets of activities that foster the provision of a broad range of landscape services (Termorshuizen and Opdam, 2009) and contribute to the personal and social fulfilment and well-being of people. Integrated Landscape Initiatives are characterised by the following criteria: they act at a landscape scale, involve inter-sectorial coordination, develop or support multi-stakeholder processes, are highly participatory, and work mainly on a non-profit basis. Integrated Landscape Initiatives include bottom-up local initiatives and grassroots movements, civil society associations, local governments organisations, agrarian or environmental platforms and cooperatives, but also initiatives fostered by regional and central governments, by international funds or by national and international umbrella organisations; all working at a place-based level and involving multi-sectorial coordination.

Several authors have analysed different aspects of ILIs, often also called landscape stewardship initiatives in Europe (Plieninger et al., 2015b). Motivated by the importance of these new management approaches for the conservation of the values of landscape, for understanding the incentives that encourage actor groups to take part on them and for finding new ways of landscape governance and stewardship; many authors are studying different aspects of this phenomenon: Schultz et al. (2007) developed a social-ecological inventory of local stewardship groups in Sweden; Axelsson et al. (2011) disaggregated the concepts laying behind the landscape approaches that proliferate to give answer to the problems the Earth faces; Ode Sang and Tveit (2013) studied the perception of landscape stewardship in agricultural areas of Norway as related to landscape preferences; Penker et al. (2014) defined a typology of organisations where voluntary forces are

involved in the protection of landscapes; and Enengel et al. (2014) studied the "efforts, benefits and risks" perceived by the members of such initiatives. Continental-level reviews have been performed for Africa (Milder et al., 2013) as well as for Latin America and the Caribbean (Estrada-Carmona et al., 2014); and Reed et al. (2015) developed a protocol to create a systematic map of integrated landscape approaches in the tropics. But until now, there is no synthesis of the full spectrum of integrated landscape approaches in Europe.

The aim of this study is to fill this gap by providing an overview of Integrated Landscape Initiatives (ILIs) across Europe. This is achieved by a systematic review of the available online information and of expert knowledge within major organizations and networks in the field as well as by an online survey of ILI representatives. Specifically, we raised the following research questions:

1. In which landscape and land use context are European ILIs taking place?
2. Which motivations and aims do ILIs typically have?
3. Who participants and stakeholders are involved in ILIs and what structure and functions do ILIs have?
4. Which activities do ILIs practice and how can they be related to landscape-level outcomes achieved in five domains?
5. What successes and problems are ILIs facing?
6. How do ILIs contribute to landscape stewardship?

We aim at providing insights on the functioning, potentials and constraints for ILIs in a Pan-European perspective. This may inform current landscape-related policy processes, for example the EU Common Agricultural Policy as well as national policies and regional planning. It will be particularly helpful in the context of achieving a transition towards sustainability, where ILIs play a crucial role as change agents preparing and guiding change processes and disseminating knowledge on how to pursue desired pathways into a sustainable future.

3.2 Method

3.2.1 Identification of ILIs

A systematic search for ILIs was performed all over Europe. Our intention of this process was not to collect all the existing ILIs in Europe, but to obtain a varied and representative sample. The greater part of initiatives was collected through internet keyword searches by introducing the expressions and operators previously selected through a scoping exercise (e.g. agricultural landscape, landscape heritage, landscape dynamics and a list of all of the countries targeted). Initiatives were also collected by canvassing European landscape researchers and representatives of European umbrella organisations (e.g. Landscape Europe, Council of Europe, European Landscape Network, and CIVILSCAPE). In addition, respondents to our survey were asked to propose other ILIs. We applied the inclusion criteria for ILIs as defined in the introductions (see examples in Table A.1).

An initial sample of 507 organizations (84% collected from keyword searches, 10% suggested by experts and umbrella organisations, and 6% recommended by survey respondents) was compiled; for which we recorded basic information on each initiative (e.g., name, duration, criteria they abide with from the ones mentioned in the introduction, and contact details) in a database in order to make a selection. Out of the 507 initial initiatives, we kept 338 initiatives from 33 Pan-European countries for our final collection. The best represented countries were United Kingdom, Belgium, Germany, Italy, Spain, the Netherlands, France, Sweden, Austria, Estonia and Romania, comprising 75% of all initiatives in this initial collection.

3.2.2 Survey

The 338 initiatives collected were invited to participate in a self-administrated online survey. Through this survey, we collected in-depth information on each ILI that was generally not available on their websites. We used Questback's EFS platform (2014) for our survey. This platform allows creating personalized and complex surveys, handling big amounts of data, inviting many participants at the same time, sending emails directly from the platform and exporting the results in Excel-compatible formats. Predefined answer categories were given for most of the questions asked, but respondents could always add an open response if the list of given options did not match their reality. In addition, some open questions were asked. The survey was structured in 10 sections including information on: the landscape characteristics and spatial context, the initiative's origin, structure and financial resources, stakeholders and sectors taking part, aims (in terms of the landscape services they addressed), activities developed and outcomes achieved within five domains (nature conservation, farming and agriculture, culture, livelihoods, and multi-sectorial coordination), problems and successful aspects. To increase the response rate, we approached respondents by their names and mentioned the name of the initiative they are part of in the invitation. Contact details were provided to encourage respondents to consult the research team if help was needed. The invitation process started in October 2014 and finished in February 2015. Within this period, one invitation and two reminders were sent. The highest answer rate was achieved right after the first reminder and on the days previous to the deadline provided. A total of 136 respondents opened the survey, and 86 completed it. The resulting response rate of 25% can be considered high, taking into account that the survey is time demanding, requires specific knowledge on the initiative and was only distributed in English. Fifteen responses had to be excluded because they did not describe an ILI as defined in the context of this study. Therefore, 71 ILIs within 23 countries (Fig. 3.1) form the sample of our analysis.

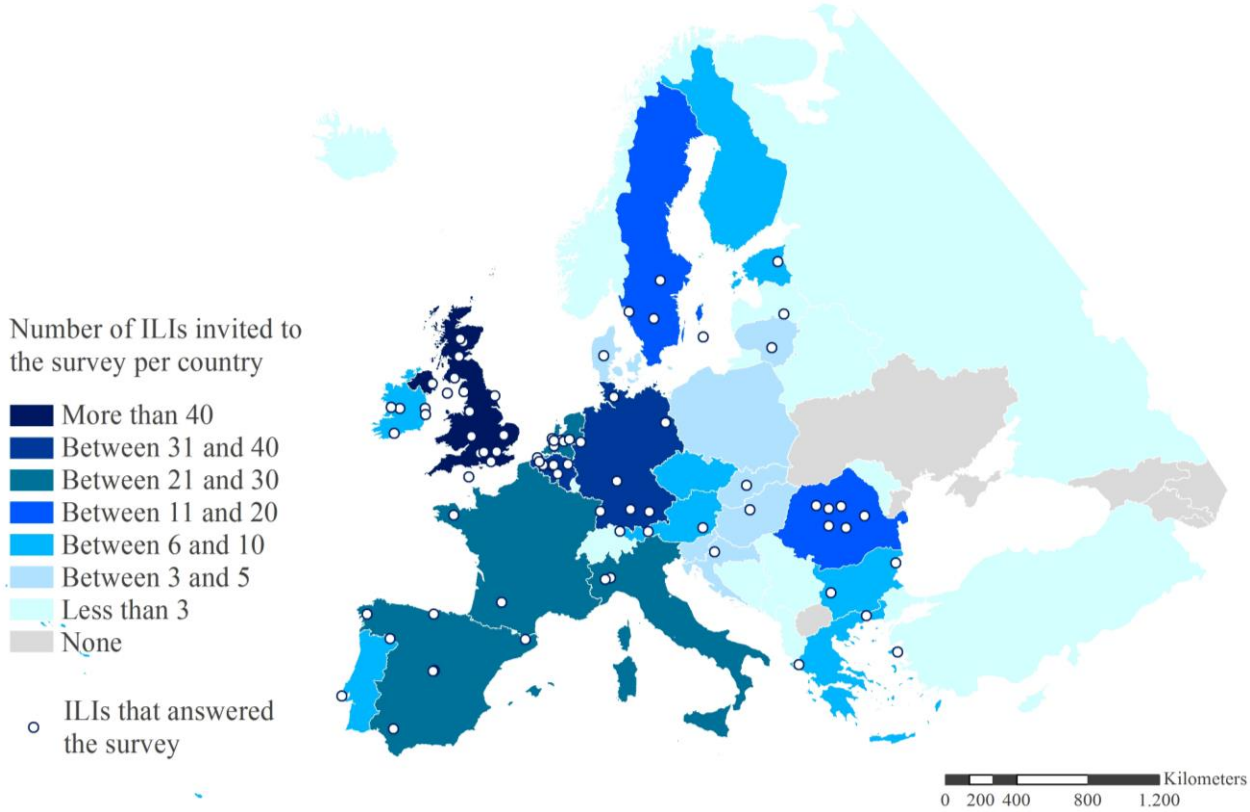


Figure 3.1: Location of the ILIs that form the sample of this study and number of responses per country

3.2.3 Data analysis

We performed frequency analyses and measures of association between variables to identify common characteristics within the ILIs and relations between their attributes. For nominal variables (the majority of our data) we used contingency tables for the assessment of relations between them. Further, we used chi-square test of association and phi and Cramer's V to examine the statistical significance of these relationships. We built a success index (or outcomes per activity index) by measuring how many activities developed by each ILI have shown successful results, as assessed by the ILIs themselves. Therefore, the list of the 40 activities and the list of the 33 outcomes provided as tick options in the survey were clustered in subgroups where activities and outcomes are directly related (resulting in a list of 17 subgroups (see Tables B.1 to B.5). For each subgroup we tested whether the initiative has had outcomes for the activities developed within that subgroup. Then we summed up the number of subgroups where the initiative has been successful and normalised the results dividing this number by the number of subgroups where the ILI has developed activities. By this we got the proportion of successful activities for each ILI. The results of the success index have been combined with other variables to identify possible reasons of success and constraints. Finally, the open-ended answers were gathered and combined in order to identify recurrent issues and new topics that were not included in the close ended options of the questions.

3.3 Results

3.3.1 Starting years and continuity of the ILIs

The oldest initiative collected started in 1926 and afterwards there is a gap till 1973; since that year there is not a continuous trend but some ups and downs. Since 1985 at least one of the ILIs had been founded every year. Most of the ILIs that have answered the survey were permanent (76%), i.e. initiatives that were not limited to a specific time frame. Non-permanent ILIs had a duration that ranged between 1 and 8 years, being 3 years the most common duration.

3.3.2 Landscape and land use contexts

The ILIs included in our survey act at a landscape scale by definition. Accordingly, most of them were regional or local initiatives (86%), but there was a tiny proportion of national (10%) and international (4%) ones as well. The size of the ILIs (in terms of members taking active part on a regular basis in the decision making and implementation of the initiatives' activities) ranged from 1 to 2000 members, but once deleted the five extreme values (100 persons involved or more), the median was 12 members.

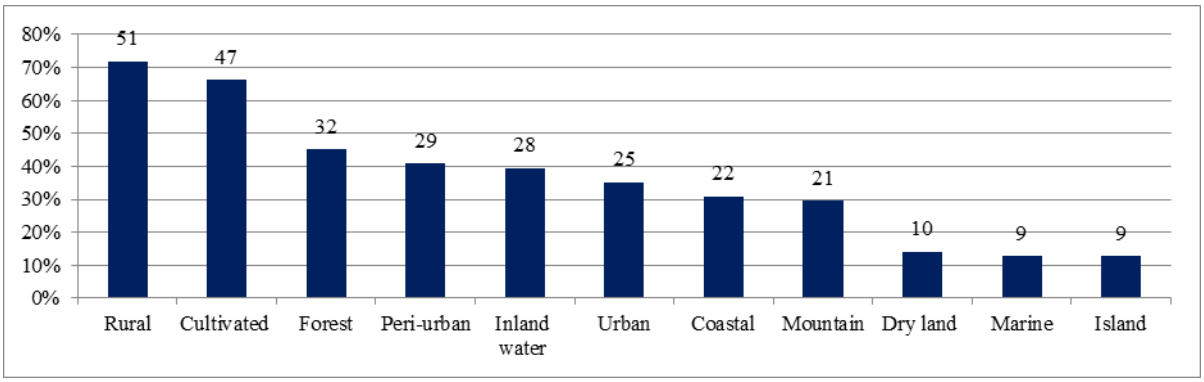


Figure 3.2: Share and number of ILIs that were dedicated to particular landscape features

To define the target area, most of the ILIs used administrative boundaries (72%). When other types of boundaries were used (ethnic and historical features / physical features / natural reserves) they were in most of the cases combined from multiple variables. Many ILIs defined their scope along boundaries that were different from those suggested by us in the survey (23%), such as: roads, landscape designations and landscape character areas, farm boundaries, land uses, land held in common and property boundaries. The target areas of the ILIs present heterogeneous landscapes that in most cases were composed by at least three landscape features, with rural and cultivated landscapes being most frequent (Fig. 3.2). The land uses addressed by the ILIs were much more varied, with each ILI specifying a median of 8 different land uses. Arable land, grazing and forestry were the most dominant land uses mentioned; arboriculture, viticulture, industry and mining appeared frequently as minor land uses (Fig. 3.3).

Land uses that were not included in the survey categories but were suggested by respondents were turf cutting and recreational uses such as golf and leisure activities.

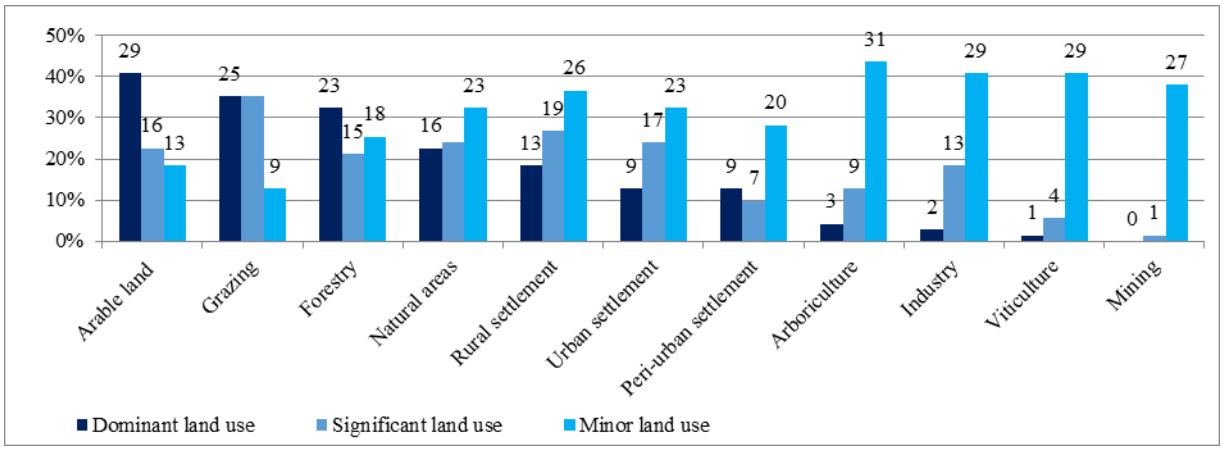


Figure 3.3: Share and number of ILIs that addressed particular land uses

3.3.3 Impetus and aims

The origin of the ILI was in most of the cases (57%) endogenous, i.e. based on the initiative of local people. In 24% of the cases the ILI had been established due to an exogenous incentive, e.g. through law, regulation or subsidy. There were also some initiatives whose origin was both endogenous and exogenous (4%). Very important aims for the ILIs were nature conservation (72%), cultural heritage, history and local memory enhancement and protection (63%) and the enhancement of landscape beauty enhancement (63%) (Fig. 3.4). The promotion of tourism (42%) and the production of localised and organic food (34%) were mainly secondary goals. The supply of localised renewable energy was not an important aim for most ILIs. ILIs that have as a very important aim the enhancement and protection of the cultural heritage, history and local memory have in most of the cases also as very important aims: the strengthening of sense of place, local identity and personal fulfilment (76%, x^2 (1) = 21.11, p=.000), the strengthening of social well-being and sense of community (69%, x^2 (1) = 13.85, p=.000), and in about half of the cases the promotion of tourism (49%, x^2 (1) = 10.07, p=.002). There were clear differences in aims depending on the participation of different stakeholders: Initiatives where civil and cultural associations were involved very often had within their most important aims: strengthening of the sense of place, local identity, personal fulfilment (72% (x^2 (1) = 8.4, p=.004)), social well-being and sense of community (70% (x^2 (1) = 6, p=.014)), and protection of cultural heritage, history and local memory (67% (x^2 (1) = 5.32, p=.021)). Initiatives where landowners were involved frequently found the protection of the regulation and maintenance services (53% (x^2 (1) = 4.98, p=.026)) very important.

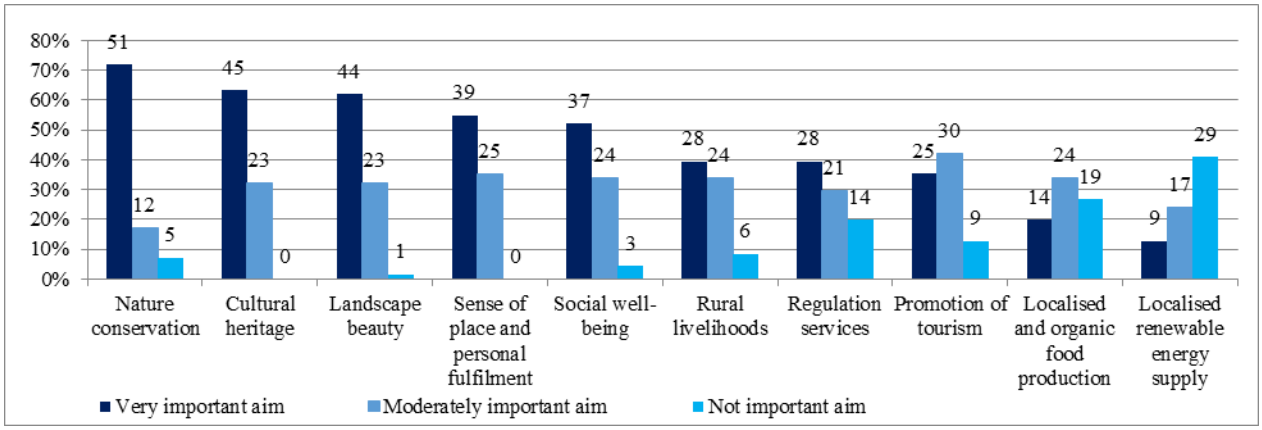


Figure 3.4: Share and number of ILIs that have selected very important, moderately important and not important aims

3.3.4 Participants and stakeholders

One of the criteria initiatives selected for the survey had to meet is the inter-sectorial coordination; hence, we asked respondents to indicate which sectors have been directly involved in the initiative (for example by providing funding or staff resources, carrying out activities on the ground or providing extension or capacity building services). Most ILIs (84%) involved more than two different sectors, with a median of three sectors involved. The most common sectors were natural resources, conservation or environment (75%), agriculture (58%) and tourism (51%) (Fig. 3.5). The design and implementation of the initiatives was characterised by multiple stakeholders in more than 90% of the cases (Fig. 3.6), with a median of six different stakeholder groups. Most frequent stakeholder groups were: independent experts or professionals, local NGOs, civil associations, governments (national, regional and local) and universities. Participation of independent experts or professional and local NGOs was larger in the implementation phase compared to the design phase.

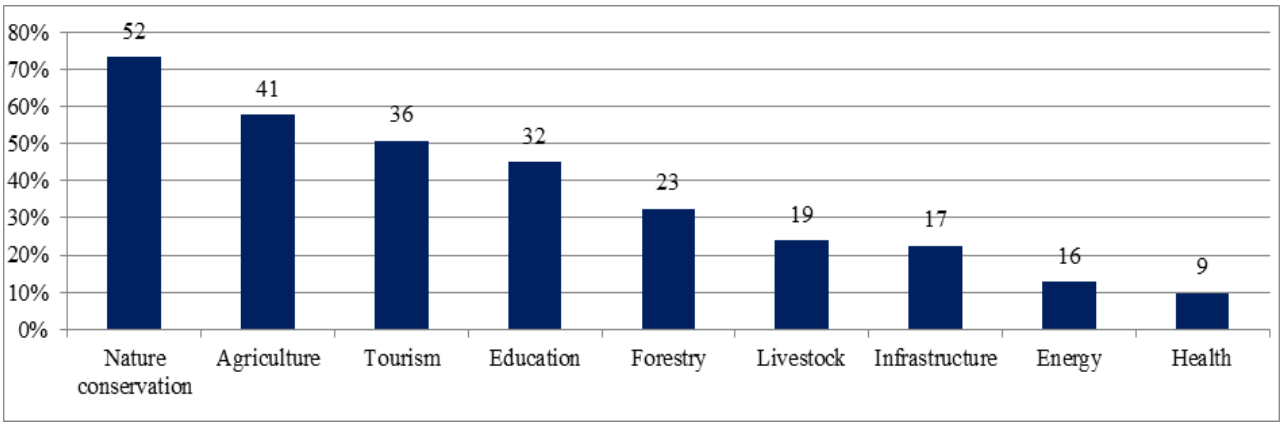


Figure 3.5: Share and number of ILIs in which the different sectors are involved

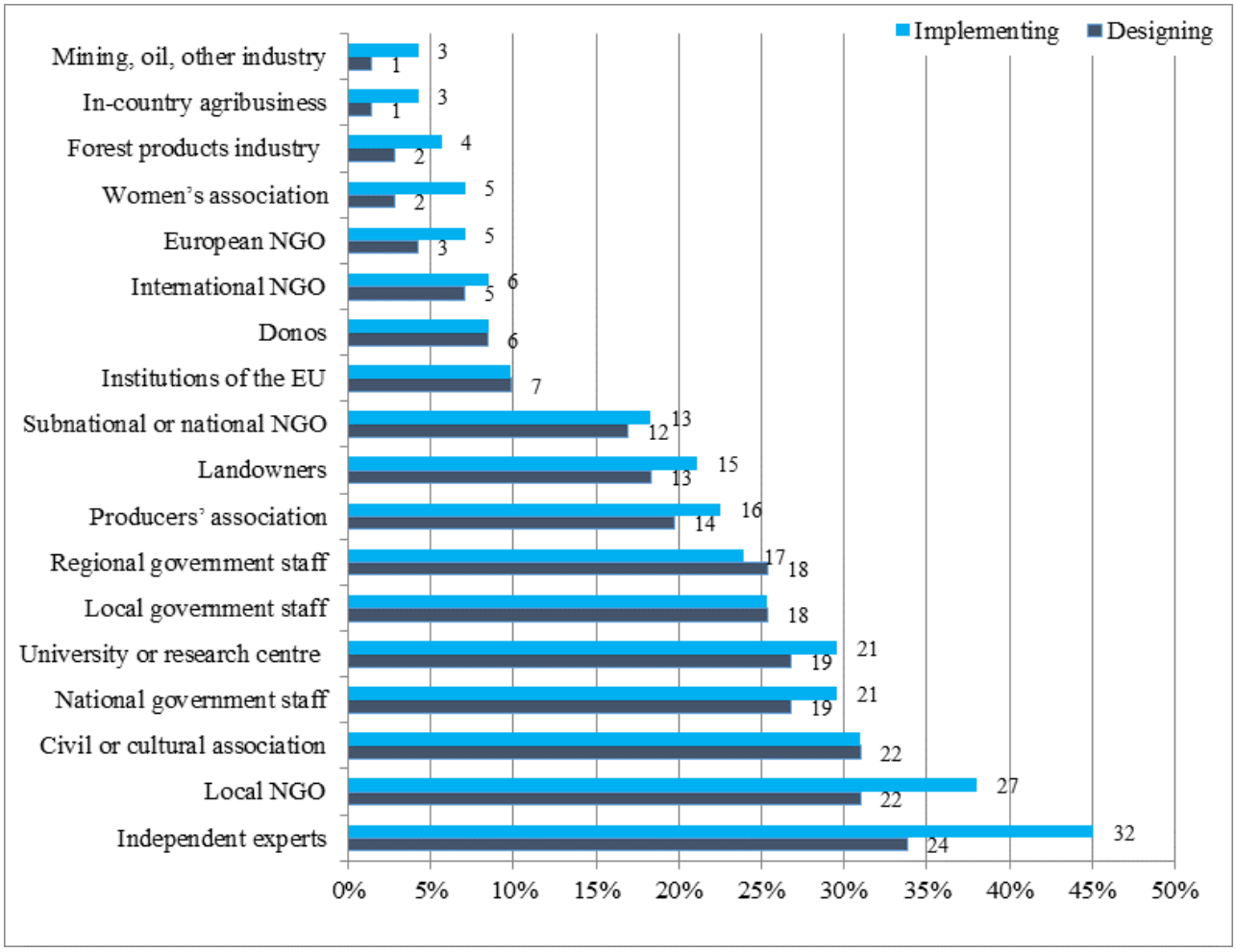


Figure 3.6: Share and number of ILIs in which the different actor groups take part

3.3.5 Structure and functioning

As for their organisation, 49% of the ILIs were civil society organisations, such as non-governmental organisations (NGO) or community-based organizations (CBO). Hybrid organisations were also very common (30%) and were typically partnerships between: public and private sectors, civic and local authorities, and local associations and universities. Initiatives formed only by public (18%) or private (7%) bodies were not common. The great majority of the initiatives (92%) was led by or collaborated with other organisations, which in most of the cases were local (82%). Initiatives also collaborated with broader organisations (56%) and with both local and broader ones (46%). Regarding financial resources, national funds were the most common (61%) source, followed by European Union funds (42%), private donors (34%), and financial support through activities –e.g. festivals, exhibitions and excursions with entry price, selling their production and organising courses (31%) (Fig. 3.7).

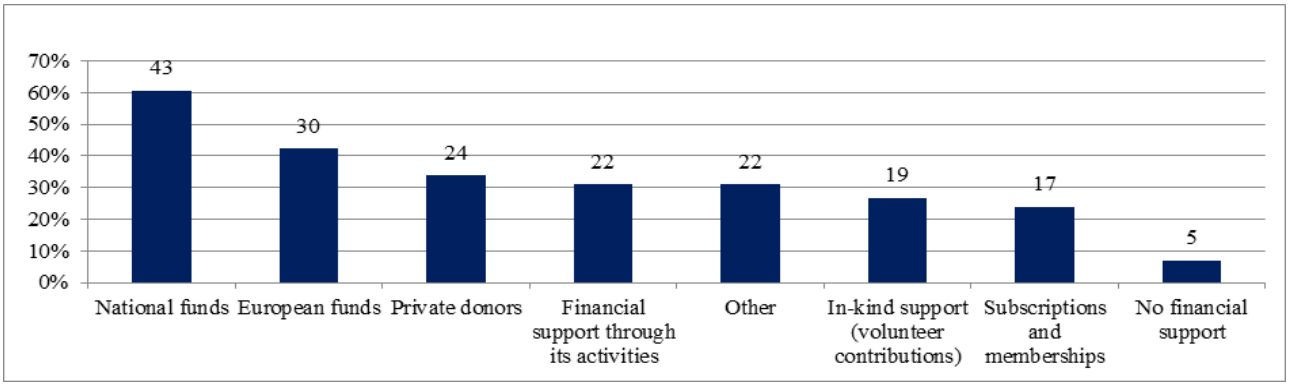


Figure 3.7: Share and number of ILIs that receive financial support from the different sources

There were more short-term exogenous ILIs than endogenous ones (V=.32, x^2 (6) = 15.00, p=.02). Most of the endogenous ILIs were civic (60%) and many hybrid (22%), and more than half of the exogenous ILIs were hybrid (53%) (V=.40, x^2 (12) = 34.91, p=.000). Most of the ILIs that received financial support from subscriptions and memberships were civic (65% (x^2 (4) = 10.4, p=.034)). Public ILIs did not receive in-kind support –i.e. in goods or services (x^2 (4) = 7.96, p=.034). There was a tendency of European Union funds being linked to ILIs where the tourism (67%, (x^2 (1) = 5.29, p=.021)) and education (60%, (x^2 (1) = 4.67 p=.03)) sectors were involved, whereas national funds and donors were associated with agriculture (65%, (x^2 (1) = 4.2 p=.04) and 75%, (x^2 (1) = 4.42 p=.035) respectively).

3.3.6 Activities

The activities ILIs develop were clustered in 5 domains: i) farming and agriculture, ii) conservation and natural resource management, iii) heritage, culture and traditions protection, iv) livelihoods and human well-being, and v) multi-sectorial coordination and planning (to foster the accurate management of the landscape specially in terms of cooperation among sectors and stakeholders, enhancing the role of local communities, and building of social capital) (Fig. 3.8). Most of the ILIs developed activities in all the five domains (66%), many in two to three different domains (29%) and only 5% in one domain. The number of activities developed per ILI varied between 0 and 34 (out of a maximum of 40), with a median of 13, being the number of possible activities 40. By far the most common activity was communication, education and awareness raising regarding issues affecting the landscape (85%). Other very common activities were efforts to protect and promote the cultural and historical physical heritage (76%), efforts to strengthen the local sense of community (63%) and actions to preserve the traditional knowledge and culture (62%). Within the domain of farming and agriculture, more than half of the ILIs specified efforts to reduce the environmental negative impacts of agriculture (54%). Most of the ILIs that have as an aim the protection of the regulation and maintenance services, are associated with activities in the field of farming and agriculture (86% (x^2 (1) = 6.14, p<.05). Within the domain of livelihoods and human well-being, the increase of recreation possibilities for local people was selected most often (48%).

The share of ILIs that carried out activities within the conservation and natural resource management domain was relatively low, with training or capacity building programs to support natural resource management (42%) being the most frequent activity.

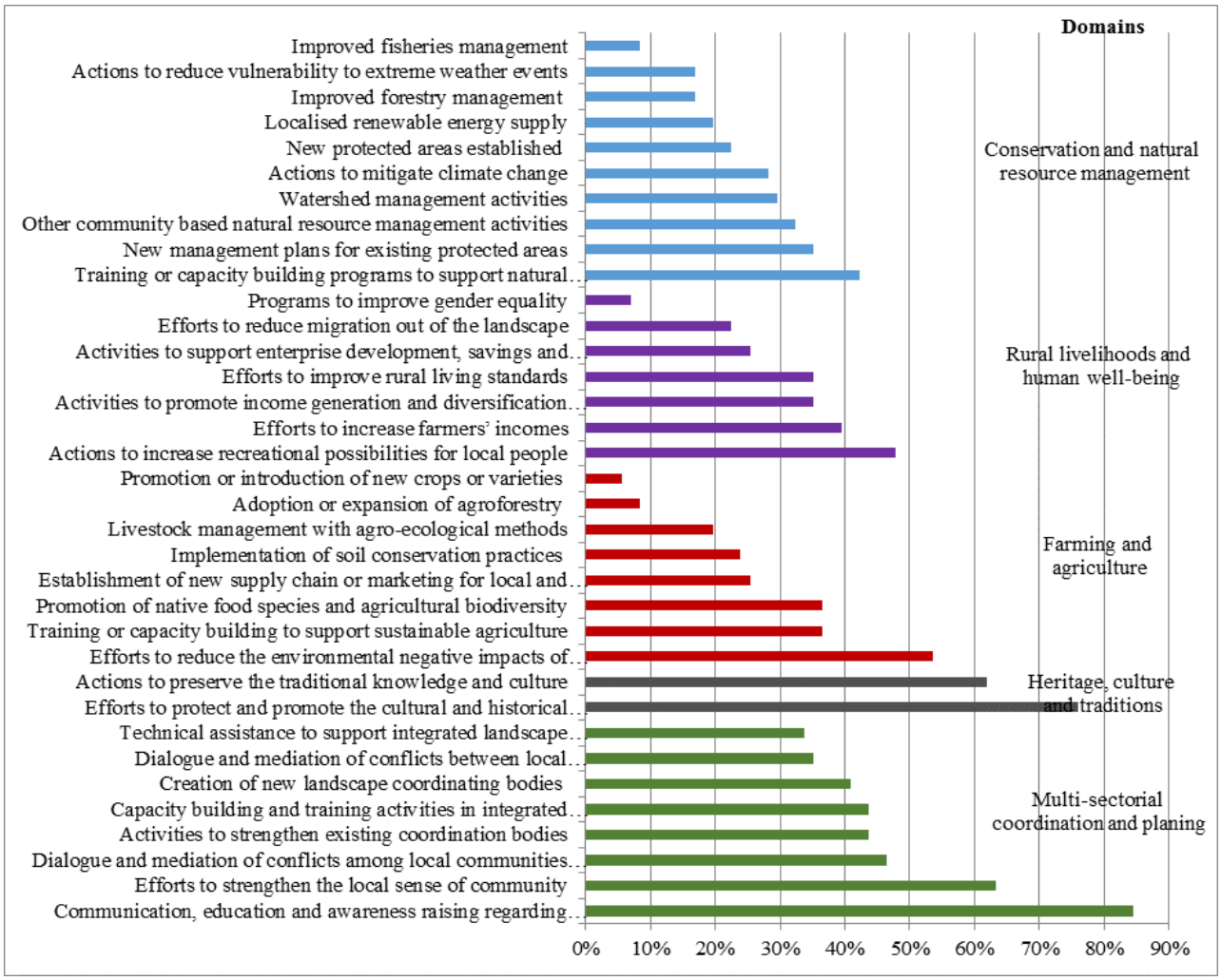


Figure 3.8: Share of ILIs that develop each activity organized by domains

3.3.7 Outcomes

The ILIs reached a median of 10 different outcomes (out of a total of 33 potential outcomes) from their activities (Fig. 3.9). The most frequently mentioned outcomes were in the multi-sectorial coordination and planning domain: improvement of the coordination and cooperation among stakeholders (68%) and increase of the local ecological knowledge (65%). In the domain promotion and protection of culture and heritage, the most frequent outcomes were: the material heritage of the area was protected, promoted and / or made accessible for the public (59%) and activities and events to share and enhance traditional knowledge and culture of the area were developed (59%). In the conservation and natural resource management domain, generation of support for ecosystem management among the members of the initiative and the general public (58%) and better protection of the overall biodiversity of the region (46%) appeared prominently as outcomes.

The livelihoods and human well-being and the farming and agriculture domain included less than 15% of all outcomes each. Here, the most frequent outcomes were: recreational and tourism infrastructures were built (45%) and agricultural biodiversity was protected or enhanced (41%).

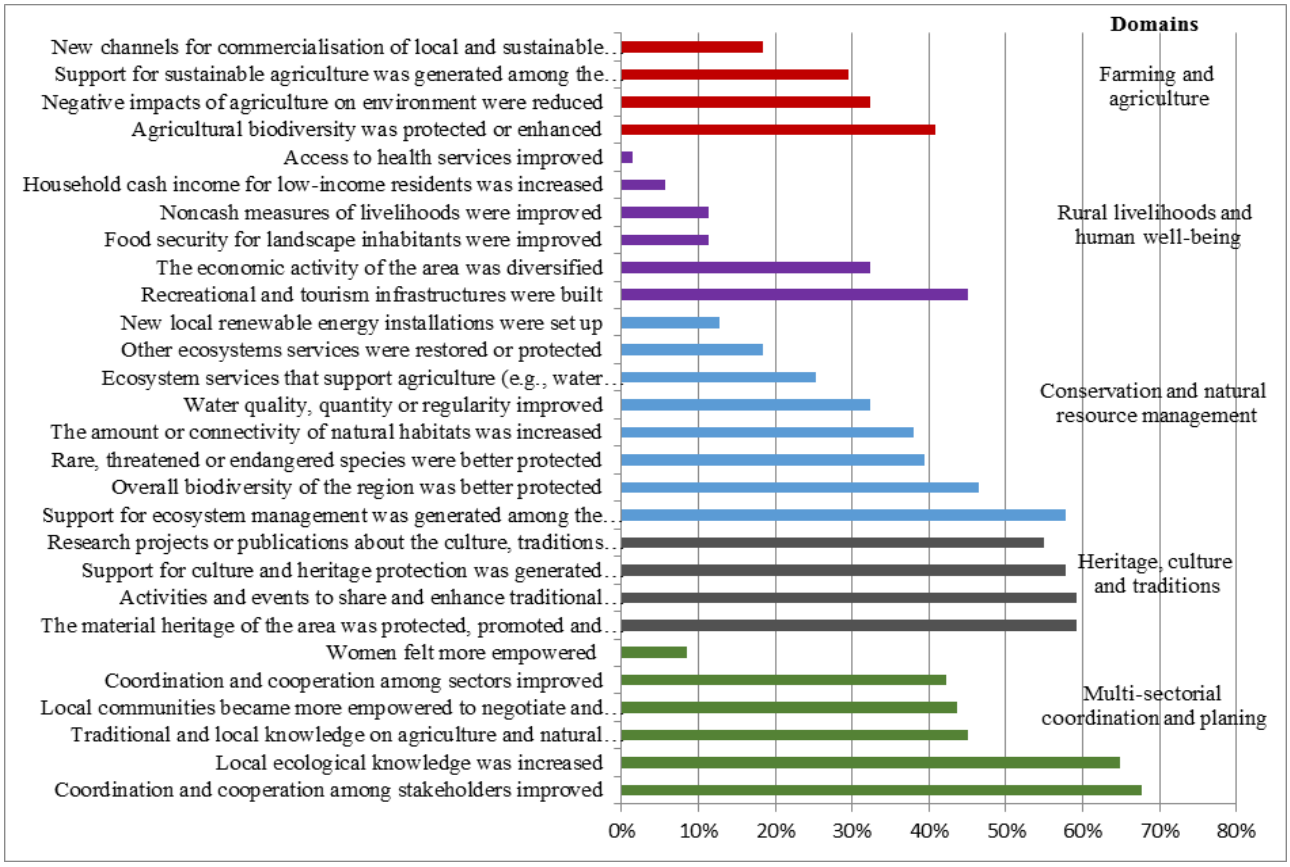


Figure 3.9: Share of ILIs that obtain each outcome organized by domains

3.3.8 Problems

Among potential problems that ILIs face, lack of funding (56%), political shifts that threaten the permanency of the initiative's achievements (40%), narrow-minded and tight policies that block the development of the initiative (35%) and lack of broader institutional support (28%) were most frequently mentioned (Fig. 3.10). The proportion of exogenous ILIs that did not report any problem was more than four times higher than that of the endogenous ILIs (V=.35, x^2 (6) = 17.1, p=.009). In addition to that, exogenous ILIs expressed less financial and support problems than endogenous ILIs. The initiatives with the problem of lack of broader institutional support were mainly endogenous (60%, x^2 (3) = 9.98, p=.019).

Within the initiatives that reported support from national funds, the problem of low level of public support was rare (7% have the problem, (x^2 (1) = 6, p=.014)). The problem of lack of social capital was inexistent in ILIs that received financial support through their activities (x^2 (1) = 4, p=.044). Surprisingly ILIs that received European funds reported problems of lack of funding more frequently (70% (x^2 (1) = 3.94, p=.047)).

In more than half of the ILIs that specified the problem of lack of funding the tourism sector was involved (62% (x^2 (1) = 5.1, p=.024)); and in most of the ILIs that reported the problem of lack of broader institutional support the tourism (70% (x^2 (1) = 4.14, p=.042)) and education (65% (x^2 (1) = 4.46, p=.035)) sectors were involved. Almost all of the ILIs that had the problem of narrow-minded and tight policies developed activities in the domains of farming and agriculture (92% (x^2 (1) = 9.53, p=.002)) and livelihoods and human well-being (92%, (x^2 (1) = 6.92, p=.008)).

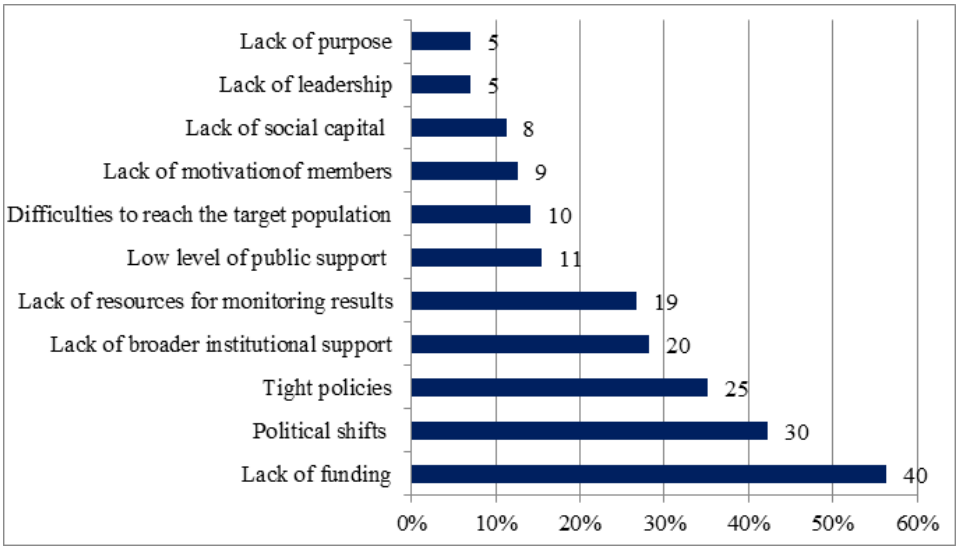


Figure 3.10: Share and number of ILIs that face different problems

3.3.9 Success

The domain with the highest proportion of activities that have generated outcomes were multi-sectorial coordination and planning (median: 100% of activities) and heritage, culture and traditions (median: 100%). The livelihoods and human well-being (median: 50%), conservation and natural resource management (median: 33%) and farming and agriculture (median: 0%) domains were clearly less successful. A more detailed analysis, focusing on the subgroups (cluster of activities and outcomes that are directly related, see Tables B.1 to B.5) reveals that the efforts towards the support of integrated landscape management among the initiative's members and the general public, the improvement of cooperation in issues related to landscape among different stakeholders and sectors, the support for traditional knowledge, local culture and history protection among the members of the initiative and the general public, and the protection and promotion of the cultural and historical physical heritage have a median success index of 100% (all belonging to domains multi-sectorial coordination and planning, and heritage, culture and traditions). Within the rest of domains the most successful subgroups are (median success index of 0%): the improvement of recreational possibilities for local people (rural livelihoods improvement domain), the reduction of the negative impacts of agriculture on the environment (farming and agriculture domain) and the protection of the natural areas and biodiversity of the region (nature conservation domain).

3.3.10 Most and least successful aspects

Respondent were asked in an open-ended question about the most and least successful aspects of the initiative. The most successful aspects were related to: awareness raising, involvement of local community and knowledge exchange. Also common was the success in making different interests, stakeholders and sectors cooperate. Less common were physical achievements on landscape linked to the preservation and promotion of cultural or natural heritage. The least successful aspects were found in the structure of the ILIs, such as: lack of funding, professional skills, and social sustainability due to missing social capital, poverty and community cohesion. In relation to that, many ILIs mentioned the considerable time and efforts that had to be devoted to fundraising and that it was challenging to achieve long-term sustainability of funding. Other unsuccessful aspects were: lacking commitment of the business sector, change in mentalities to achieve a more sustainable development, and cooperation at all levels. Recurrent problems were also: lack of political and legal support (such as regulations and management plans to protect landscape, and including missing enforcement of existing laws by the government) and of the capacity of local governments to address the challenges of landscape management.

3.4 Discussion

The objective of this review was to provide a realistic and nuanced overview of the spectrum of Integrated Landscape Initiatives (ILIs) in Europe. We particularly aimed at exploring the role, motivations, tendencies, potentials and constrains of ILIs, which are wide-spread and emerging in Europe. Our survey also revealed some differential patterns within the initiatives that help to better understand the phenomenon of ILIs. Our survey thus provides a “reality check” about the potential and outcomes of landscape approaches that have recently been promoted (Sayer et al., 2013; Takeuchi, 2010).

3.4.1 Integrated Landscape Initiatives: a world phenomenon of multi-layered collaboration in landscape management

Notwithstanding the different continental contexts, ILIs in Europe share fundamental similarities with those in Africa and Latin America and the Caribbean. In the three regions ILIs represent innovative forms of multi-layered collaboration towards the management of landscape: they act in heterogeneous landscapes, they have various objectives and develop activities in different domains, they involve different sectors and stakeholders, and collaborate with institutions at different levels. In fact, the most common outcomes obtained by the ILIs in the three continents are linked to multi-sectorial coordination and planning (cooperation among sectors and stakeholders, enhancement of the role of local communities and social capital building) (Estrada-Carmona et al., 2014; Milder et al., 2013).

However, in the European context the protection and promotion of the cultural heritage are among the main aims of the ILIs and the ones that obtain more outcomes, whereas in Africa and Latin America and the Caribbean its importance in the context of landscape action is so limited that this has not being included in the survey. Further research could analyse how ILIs from the different continents understand the concept of landscape and the role of cultural heritage in the management of the land.

In all regional contexts, nature conservation and agriculture are the most common sectors involved in the ILIs, followed by tourism and education in Europe and by forestry and rural livelihoods in the other continents (Estrada-Carmona et al., 2014; Milder et al., 2013), revealing different continental contexts and priorities. This is reflected in the stakeholders taking part in the ILIs; in the non-European context, governments and producer groups are by far the most important ones, whereas in Europe, independent experts, local NGOs and civic and cultural associations are the predominant groups. ILIs in the three regions have in common that the main problems they face are the lack of funding and participants. The lack of government support is a recurrent problem only in Latin America and the Caribbean and in Europe (Estrada-Carmona et al., 2014; Milder et al., 2013); a possible explanation is that in Africa the expectations of having the support of the government are very low and therefore this is not perceived as a lack.

3.4.2 Traditional aims, new approaches

European ILIs pursue a wide range of aims, and within this variety, nature conservation and cultural heritage protection prevail as main aims. These objectives are traditional targets of many existing organisms, laws and regulations, but whereas conventionally the approach has been rigid and hermetic, the way ILIs address the protection of nature and cultural heritage is more flexible and coherent with other land uses and sectors (especially related to the involvement of local communities). In fact, even when ILIs specify nature conservation as one of the most common main aims, they do not necessarily develop many practical conservation activities. Rather, they would consider other aspects of landscape, revealing a new and more holistic, “social-ecological” approach to the protection of nature (cf. Palomo et al., 2014 for similar observations on protected area management). This is in line with findings from Latin America and the Caribbean where “a shift of major conservation organisations toward prioritizing conservation strategies that also support economic development and human well-being” (Estrada-Carmona et al., 2014, p. 9) has been observed.

Nonetheless, the aims of nature conservation and cultural heritage protection remain largely separated across different types of initiatives. In fact, the protection of the cultural heritage is accompanied by goals of aesthetics, tourism, and personal and social fulfilment and well-being; while it is not related to the conservation of nature. This dichotomy between nature and culture is also noticeable in the stakeholders groups that take active part in the initiatives: civil and cultural associations are usually involved in the ILIs whose aims are related to cultural heritage, tourism, aesthetics and well-being; whereas landowners and agri-business are more common in ILIs with aims linked to nature conservation.

3.4.3 The importance of multi-sectorial coordination: multi-functional landscapes and the pressure on farming

An obvious difference between the Integrated Landscape Initiatives and other organisations that act on the land is the holistic understanding of landscape of the former. ILIs do not focus on a land use or landscape feature, but on the landscape as a whole. This becomes evident in the large number of land uses and landscape features mentioned by each ILI in the survey.

Such holistic approach and the multifunctionality that most European landscapes have (Mander et al., 2007) correspond to the variety of aims they pursue; in fact, most ILIs achieved outcomes in all five domains (nature, culture, farming, multi-sectorial planning and rural livelihoods) in parallel.

Farming activities are fundamental for other sectors and societal goals, such as the protection of ecosystem services and the enhancement of landscape beauty. Hart et al. (2015) argue that farmers and producer movements play a very important role to succeed in the integrated management of landscapes, not only by performing sustainable farming activities but also by contributing to the protection of nature and to the collaborative management of the land. The authors also claim that this role has not yet been acknowledged and that efforts should be made to encourage farmer participation in landscape stewardship movements and to highlight the importance of political support to achieve this. Supporting this claim, farmers and producers associations are present in less than 25% of the ILIs, even though more than 60% have cultivated land within the landscape features in their target area and arable land and grazing are the most common dominant land uses. Publicly supported land care groups may be one way to strengthen the role of farmers in ILIs (Prager and Vanclay, 2010).

From the analysis of the relation between the aims, the sectors involved, the problems and the activities developed by the ILIs, we might hypothesize that multi-sectorial, multi-aims and multi-stakeholder coordination is crucial to achieve landscape-level outcomes and successes.

3.4.4 The role of civic motivation, local initiative and upper tier collaboration

Penker et al. (2014, p. 25) claim that “civil society organisations emerge to satisfy the demand for public goods … that is not covered by market or state mechanisms”. Another typical property is that such initiatives “transcend traditional management boundaries” (Reed et al., 2015, p. 2). The significant share of civic ILIs in our survey underlines their importance to generate new and integrative approaches to a land management that responds to the personal and social-wellbeing at a landscape level. Addressing the complexity of the demands on the functions landscape provide requires forms of governance that include complex, multiple and redundant institutions and a mix of different institutional types (Dietz et al., 2003). The low proportion of only public or private governance forms shows that ILIs may be considered models for such institutional diversity. Kozar et al. (2014, p. x) highlight the importance of bridging the public and private and civic sectors to “create ‘generative forms’ of power that pull actors together through collective action (…) that can support landscape policy and practice through the actions of key individuals and champions, while helping to overcome divergent values and interests, institutional hurdles and resource limitations”. In this sense, ILIs play an important role as bridging organisations –mediating between different knowledge systems, actors and institutions at all levels; building trust and fostering social learning (Berkes, 2009; Crona and Parker, 2012; Kowalski and Jenkins, 2015; Olsson et al., 2007; Prager, 2010; Prager, 2015).

Local ingenuity and collaboration are fundamental characteristics for the ILIs. In fact, the majority of the long-term initiatives are endogenous; revealing the importance of the involvement of the local community to achieve long-lasting impulses. Nonetheless, many authors argue that an effective and sensitive management of the landscape requires the involvement of stakeholders at many levels (Axelsson et al., 2011; Enengel et al., 2014; Reed et al., 2015).

An initiative integrated only by local stakeholders might encounter problems of institutional, political and financial support. In fact, endogenous ILIs have more problems than exogenous ILIs, especially regarding lack of funding, lack of broader institutional support, political shifts and tight policies. This tendency might be accentuated by the fact that endogenous ILIs are mainly civic organisations, whereas exogenous ILIs (initiatives created due to an exogenous incentive) are mainly hybrid and hence, have access to a wider range of possibilities. In the same line, whereas exogenous ILIs are supported by more stable sources (e.g. national and European funds) endogenous ILIs have to diversify their financial. On the other hand, endogenous ILIs receive more in-kind support and financial resources from their activities, i.e. from bottom-up sources.

3.4.5 Most successful aspects of ILIs and their contribution to landscape stewardship

The aspects where ILIs are most successful are those linked to their role as agents of awareness raising and multi-sectorial and stakeholders' coordination. The success index and the open-ended questions coincide in appointing at achievements in: involving the local community in landscape management activities, increasing the coordination and communication between communities, stakeholders, sectors, and private and public institutions; obtaining legal and institutional support for the protection of landscape values and increasing the support for integrated landscape management among the public.

Our survey demonstrates that ILIs are hubs of collaborative and place-based management. Scherr et al. (2012, p. 29) highlight the role of ILIs to help land users to take "collaborative action (towards more sustainable practices) to address challenges and opportunities that cannot be addressed by any one group acting alone". In this sense, ILIs match the definition of adaptive collaborative management systems as "flexible community-based systems of resource management tailored to specific places and situations and supported by, and working with, various organisations (and stakeholders) at different levels" (Olsson et al., 2004, p. 75).

Our survey also shows that lack of social capital is not reported in ILIs that generate financial support through their activities. Obviously, ILIs play an important role in fostering landscape stewardship by bringing people in direct contact with the land – increasing their capacity and commitment by learning from their experiences (e.g., through guided walks and open air activities) – and establishing collaborative networks, thus enhancing the support for integrated landscape management strategies and creating social capital (Axelsson et al., 2011; Folke et al., 2005; Olsson et al., 2004).

Many authors appoint at the importance of social capital to integrate and apply different knowledge systems, and ILIs provide the adequate "learning environment" (Axelsson et al., 2011; Folke, Hahn, Olsson, & Norberg, 2005, p. 445; Schultz et al., 2007). In fact, the second most common outcome within the ILIs is the increase of the local ecological knowledge (65%). Axelsson et al. (2011) recognise the role of landscape approaches as learning hubs, where the different parts collaborate to produce explicit and transdisciplinary knowledge and experiences that might inform national and higher instances.

3.4.6 Need for long-term approaches in cross-cutting issues

The ILIs that we surveyed are also strong in promoting and protecting cultural heritage, both the tangible and the intangible (knowledge, traditions and culture). In contrast, their success in the fields of nature conservation, rural livelihoods improvement and sustainable farming and agriculture, is more limited. The success in the domain of cultural heritage protection might be related to the fact that this is the only domain in which problems of narrow-minded and tight policies that block the initiative's development are not common. Obviously, cultural heritage protection is already well embraced in laws, regulations and policies. It also seems to be a less controversial domain in terms of interests and land use conflicts in Europe. Another explanation might be that outcomes are achieved at different time scales. Heritage can be fostered immediately, while it may take much more time before outcomes in terms of biodiversity or rural livelihoods can be stated (Estrada-Carmona et al., 2014). For the latter more cross-cutting issues, the effects of the ILIs' activities might not be visible at a physical landscape scale, but have to be searched in the actions of the different actors involved in the process. The importance of long-term efforts was included by Scherr et al. (2013, p. 2) in their definition of Integrated Landscape Management, which refers to "long-term collaboration among different groups of land managers and stakeholders to achieve the multiple objectives required from the landscape". In the face of this, it is a serious limitation that many ILIs mentioned an increasing problem of getting long-term support.

3.4.7 How to foster the success of ILIs through political action?

Despite the benefits of the ILIs' collective approaches to "reduce institutional hurdles and resource limitations" (Kozar et al., 2014, p. x), the lack of resources and of institutional and political support are recurrent problems. This reveals that the political discourse on the preservation of landscape values has two speeds: one at an international level where landscape approaches are becoming important, through initiatives such as the European Landscape Convention (Council of Europe, 2000), a future Global Landscape Convention (IFLA, 2010) and the Florence Declaration on Landscape (UNESCO 2012); and one at a national and lower levels where it is still a vague concept more than practice and mainly linked to the protection of physical heritage (natural and cultural) (De Montis, 2014). The limited involvement of local and regional authorities in the ILIs can also be understood as an expression of this problem. Nonetheless, our results do not provide evidence that stronger participation of public agencies could solve these problems, as there is no link between higher public agency participation and better institutional or political support. Therefore, further research is needed on the role of the agencies in the ILIs and why their participation does not lead to positive effects. Also important is to study different political and legal contexts from a sample of successful and not successful ILIs, to generate insights that might allow solving problems linked to narrow-minded and tight policies that impede the development of the ILIs.

Olsson et al. (2004, p. 84) wrote about the importance of "framed creativity", to allow local stakeholders and communities to be innovative in the management of their resources, while providing a legal frame or authority that assures that they act in a sustainable manner. In the case of the ILIs, this legal frame should be provided to make sure that the political shifts do not threaten the permanency of the initiatives' achievements, and that ILIs do not lack of broader institutional support. Furthermore, Scherr et al. (2012, p. 17) state that, "policymakers, businesses, donors and

other leaders must embrace a whole landscape approach, aligning and coordinating sectorial policies to support whole landscape initiatives, mobilizing investment, and building public-private landscape partnerships". To this aim, the European Landscape Convention provides a good framework, but needs the commitment of the countries to encourage regional and local governments to implement its principles. These regional and local legal frameworks should provide enough space for ILIs to proliferate, innovate and succeed in the sensitive management of landscape, while protecting them from conflicting interests.

3.4.8 Limitations of our method

The analysis of the surveys revealed great internal consistency between answers, e.g. the tourism sector was involved in most of the ILIs whose main goal was the promotion of tourism (80%, $X2(1)=13.24$, $p<.001$), ILIs that had specified the conservation of nature, as a very important aim develop activities in the field of conservation and natural resources management (86%, $X2(1)=12.93$, $p<.001$). Despite such general consistence, the results from the association between variables are more exploratory, due to the restricted sample size and the high diversity of cases. Self-evaluation of outcomes, problems, and successes is an established method for evaluating projects (Stockmann and Meyer, 2010), but our survey did not provide detailed and customised information about every ILI. Also our outcome and success variables were very simple ones (Estrada-Carmona et al., 2014). Finally, although the collection of the initiatives has been performed in a systematic way to avoid bias, the language of the searches (English), the approach, and the different realities of internet access limited the collection of ILIs to certain areas of Europe.

3.4.9 Research and Policy recommendations

From our analysis, we derive a set of recommendations that could contribute to take advantage of the potential of Integrated Landscape Initiatives and to mitigate their constraints. We feel that it is both up to formal public policies and to civil society to provide a supportive framework for ILIs.

To support ILIs' activities, governments should:

1. provide long-term and on-going financial support to integrated landscape management;
2. simplify the paths to obtain funding and offer more stable financial resources to ILIs;
3. provide a flexible legal framework based on the knowledge and experiences generated by ILIs in order to protect the interests of collaborative managed landscapes form conflicting interests; and
4. tackle the lack of enforcement of existing laws that contribute to an integrated and sensitive management of landscapes.

The support from the governments must be reinforced by the civil society in a way that:

5. markets recognise the importance of the overlooked aspects of landscape and are ready to pay for them (e.g. added value of products that foster the landscape beauty, organic agriculture, rural livelihoods improvement and climate change mitigation);
6. the role of farmers and producers as stewards of the land is recognised and supported more strongly;
7. more resources should be devoted to educate and train society about the importance of the integrated and collaborative management of landscapes, and about the importance of individual daily activities for the protection of the values of landscape.

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Conclusion

This deliverable of work package 1 is comprised of three parts with a common goal: to organise and develop a preliminary synthesis of existing knowledge on patterns, drivers and outcomes of persistence and change in Europe's cultural landscapes. The three reviews highlight many different aspects of this knowledge.

The review of driving forces builds on previous research and pinpoint research gaps:

- underrepresented countries, biogeographic regions, and land-use systems;
- improve conceptual clarity with regard to the role and identification of actors vs. driving forces of landscape change;
- deploy more robust tools and methods to quantitatively assess the causalities of landscape change, while maintaining the holistic character of landscape studies;
- design multi-scale studies that consider distal relations between actors, drivers, and patterns of landscape change and

The review of rates landscape change explored quantitatively the rates and the magnitude of landscape change in relation with processes and drivers of change. It also pinpoints gaps:

- More quantitative approaches of the rate and magnitude of individual changes in relation with drivers or processes of change are required;
- An expansion of the scope of studies to include underrepresented countries and processes of change would improve comparability and width of the available cases;
- The performance of long-term and multi-scale studies that go beyond the use of satellite imagery, considering diverse types of data sources and other aspects of landscape change would improve conceptual, geographical and thematic aspects of landscape change.

The review on Integrated Landscape Initiatives (ILIs) highlighted policy oriented gaps and directions for intervention:

- provide long-term and on-going financial support to integrated landscape management and simplify funding paths;
- provide a flexible legal framework based on the knowledge and experiences generated by ILIs in order to protect the interests of collaborative managed landscapes form conflicting interests; and
- tackle the lack of enforcement of existing laws that contribute to an integrated and sensitive management of landscapes.
- more resources should be devoted to educate and train society about the importance of the integrated and collaborative management of landscapes, and about the importance of individual daily activities for the protection of the values of landscape.

In Deliverable 1.4 a more complete synthesis of the findings will be presented along with a detailed analysis of the research gaps highlighted by the three reviews.

References

Abson, D.J., von Wehrden, H., Baumgärtner, S., Fischer, J., Hanspach, J., Härdtle, W., Heinrichs, H., Klein, A.M., Lang, D.J., Martens, P., Walmsley, D. (2014) Ecosystem services as a boundary object for sustainability. Ecological Economics 103, 29-37.

Alcantara, C., Kuemmerle, T., Baumann, M., Bragina, E.V., Griffiths, P., Hostert, P., Knorn, J., Muller, D., Prishchepov, A.V., Schierhorn, F., Sieber, A., Radeloff, V.C. (2013) Mapping the extent of abandoned farmland in Central and Eastern Europe using MODIS time series satellite data. Environmental Research Letters 8, 1-9.

Angelstam, P., Grodzynskyi, M., Andersson, K., Axelsson, R., Elbakidze, M., Khoroshev, A., Kruhlov, I., Naumov, V. (2013) Measurement, collaborative learning and research for sustainable use of ecosystem services: Landscape concepts and Europe as laboratory. AMBIO 42, 129-145.

Antrop, M. (2000) Background concepts for integrated landscape analysis. Agriculture, Ecosystem and Environment 77 (1–2), 17–28.

Antrop, M. (2005) Why landscapes of the past are important for the future. Landscape and Urban Planning 70, 21 – 34.

Antrop, M. (2004) Landscape change and the urbanization process in Europe. Landscape and Urban Planning 67, 9-26.

Antrop, M. (2006) Sustainable landscapes: contradiction, fiction or utopia?. Landscape and Urban Planning 75, 187-197.

Antrop, M.(2008) From holistic landscape synthesis to transdisciplinary landscape management, in: Tress, B., Tress, G., Fry, G., Opdam, P. (Eds.), From landscape research to landscape planning: aspects of integration, education and application. Springer, Dordrecht, The Netherlands. pp 27-50.

Aronson, J. (2011) Sustainability science demands that we define our terms across diverse disciplines. Landscape Ecology 26, 457-460.

Axelsson, R., Angelstam, P., Myhrman, L., Sädbom, S., Ivarsson, M., Elbakidze, M., Andersson, K., Cupa, P., Diry, C., Doyon, F., Drotz, M.K., Hjorth, A., Hermansson, J.O., Kullberg, T., Lickers, F.H., McTaggart, J., Olsson, A., Pautov, Y., Svensson, L., Törnblom, J.(2011) Evaluation of Multi-level Social Learning for Sustainable Landscapes: Perspective of a Development Initiative in Bergslagen, Sweden.AMBIO 42, 241-253.

Baumann, M., Kuemmerle, T., Elbakidze, M., Ozdogan, M., Radeloff, V.C., Keuler, N.S., Prishchepov, A.V., Kruhlov, I., Hostert, P. (2011) Patterns and drivers of post-socialist farmland abandonment in Western Ukraine. Land Use Policy 28, 552-562.

Baumann, M., Ozdogan, M., Kuemmerle, T.,Wendland, K.J. (2012) Using Landsat record to detect forest-cover changes during and after the collapse of the Soviet Union in the temperate zone of European Russia. Remote Sensing of Environment 124, 174-184.

Benayas, J.M.R., Martins, A., Nicolau, J.M., Schulz, J.J. (2007) Abandonment of agricultural land: an overview of drivers and consequences. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 2(57),1-14.

Berkes, F. (2009)Evolution of co-management: role of knowledge generation, bridging organizations and social learning. Journal of Environmental Management 90, 1692-1702.

Bieling, C., Plieninger, T., Schaich, H. (2013) Patterns and causes of land change: Empirical results and conceptual considerations derived from a case study in the Swabian Alb, Germany. Land Use Policy 35, 192-203.

Biró, M., Czucz, B., Horvath, F., Revesz, A., Csatari, B., Molnar, Z. (2013) Drivers of grassland loss in Hungary during the post-socialist transformation (1987-1999). Landscape Ecology 28,789-803.

Brandt, J., Primdahl, J., Reenberg, A., (1999) Rural land-use and landscape dynamics - analysis of'driving forces' in space and time, in: Krönert, R., Baudry, J., Bowler, I.R., Reenberg, A. (Eds.), Land-Use Changes in Europe and their Environmental Impact in Rural Areas in Europe. UNESCO, Paris, New York,pp 81-102.

Bürgi, M., Hersperger, A.M., Schneeberger, N. (2004) Driving forces of landscape change - current and new directions. Landscape Ecology 19, 857-868.

Bürgi, M., Li, L., Kizos, T. (2015) Exploring links between culture and biodiversity: studying land use intensity from the plot to the landscape level. Biodiversity and Conservation.

Centre for Evidence-Based Conservation.2010. Guidelines for Systematic Review in Environmental Management. Version 4.0. Environmental Evidence: www.environmentalevidence.org/Authors.thm.

Cohen, J. (1960) A coefficient of agreement for nominal scales. Educational and Psychological Measurement 20, 37-46.

Conrad, E., Christie, M., Fazey, I. (2011) Is research keeping up with changes in landscape policy? A review of the literature. Journal of Environmental Management 92, 2097-2108.

Council of Europe, (2000) The European Landscape Convention. Florence.

Cramer, V.A., Hobbs, R.J., Standish, R.J. (2008) What's new about old fields? Land abandonment and ecosystem assembly. Trends in Ecology & Evolution 23, 104-112.

Crona, B.I., Parker, J.N. (2012) Learning in support of governance: theories, methods, and a framework to assess how bridging organizations contribute to adaptive resource governance. Ecology and Society 17.

Crumley, C.L. (2012) A heterarchy of knowledges: Tools for the study of landscape histories and futures, in: Plieninger, T., Bieling, C. (Eds.), Resilience and the Cultural Landscape: Understanding and Managing Change in Human-Shaped Environments. Cambridge University Press, Cambridge, pp 303-314.

Dannebeck, S., Hoppe, A., Küster, H., McCracken, D. (2009) Factors affecting cultural landscapes: an overview, in: Krzywinski, K., O'Connell, M., Küster, H. (Eds.), Cultural Landscapes of Europe. Fields of Demeter, Haunts of Pan. Aschenbeck Media, Bremen,pp 47-54.

De Montis, A. (2014). Impacts of the European Landscape Convention on national planning systems: A comparative investigation of six case studies. Landscape and Urban Planning 124, 53-65.

Déjeant-Pons, M. (2006) The European Landscape Convention. Landscape Research 31, 363-384.

Dietz, T., Ostrom, E., Stern, P.C. (2003) The struggle to govern the commons. Science 302, 1907-1912.

Eakin, H., Defries, R., Kerr, S., Lambin, E.F., Liu, J., Marcotullio, P.J., Messerli, P., Reenberg, A., Rueda, X., Swaffield, S.R., (2014) Significance of telecoupling for exploration of land-use change, Rethinking Global Land Use in an Urban Era. MIT Press, Cambridge, MA, pp 141-162.

Eaton, J.M., McGoff, N.M., Byrne, K.A., Leahy, P. and Kiely G. (2008) Land cover change and soil organic carbon stocks in the Republic of Ireland 1851-2000. Climatic Change 91, 317-334.

European Environment Agency (2012) Biogeographic regions in Europe. Available at: <http://www.eea.europa.eu/data-and-maps/figures/ds_resolveuid/e001d623865845e3ba8f6bd2f28a5ed3>.

Ellis, E.C. (2015) Ecology in an anthropogenic biosphere. Ecological Monographs 85, 287-331.

Emanuelsson, U. (2009) The Rural Landscapes of Europe: How Man has Shaped European Nature. Formas, Stockholm.

Enengel, B., Penker, M., Muhar, A. (2014) Landscape co-management in Austria: The stakeholder's perspective on efforts, benefits and risks. Journal of Rural Studies 34, 223-234.

European Science Foundation (2010) Landscape in a Changing World. Bridging Divides, Integrating Disciplines, Serving Society. Science Policy Briefing 41.

Estel, S., Kuemmerle, T., Alcántara, C., Levers, C., Prishchepov, A., Hostert, P. (2015) Mapping farmland abandonment and recultivation across Europe using MODIS NDVI time series. Remote Sensing of Environment 163, 312-325.

Estrada-Carmona, N., Hart, A.K., De Clerck, F.A.J., Harvey, C.A., Milder, J.C.(2014) Integrated landscape management for agriculture, rural livelihoods, and ecosystem conservation: An assessment of experience from Latin America and the Caribbean. Landscape and Urban Planning 129, 1-11.

Everitt, B.S., Landau, S., Leese, M., Stahl, D. (2011) Hierarchical clustering. Cluster Analysis. John Wiley & Sons, Ltd 71-110.

Fagerholm, N., Käyhkö, N., Van Eetvelde, V. (2013) Landscape Characterization Integrating Expert and Local Spatial Knowledge of Land and Forest Resources. Environmental Management 52(3), 660-682.

Farina, A. (2000) The cultural landscape as a model for the integration of ecology and economics. BioScience 50, 313-320.

Fischer, J., Hanspach, J., Hartel, T. (2011) Continental-scale ecology versus landscape-scale case studies. Frontiers in Ecology and the Environment 9, 430-430.

Foley, J.A., DeFries, R., Asner, G.P., Barford, C., Bonan, G., Carpenter, S.R., Chapin, F.S., Coe, M.T., Daily, G.C., Gibbs, H.K., Helkowski, J.H., Holloway, T., Howard, E.A., Kucharik, C.J., Monfreda, C., Patz, J.A., Prentice, I.C., Ramankutty, N., Snyder, P.K. (2005) Global consequences of land use. Science 309, 570-574.

Folke, C., Hahn, T., Olsson, P., Norberg, J. (2005) Adaptive Governance of Social-Ecological Systems. Annual Review of Environment and Resources 30, 441-473.

Fuchs, R., Herold, M., Verburg, P. H., Clevers, J. G.P.W. and Eberle, J. (2015) Gross changes in reconstructions of historic land cover/use for Europe between 1900 and 2010. Glob Change Biol 21, 299–313.

Fuchs, R., Verburg, P.H., Clevers, J.G.P.W., Herold, M. (2015) The potential of old maps and encyclopaedias for reconstructing historic European land cover/use change. Applied Geography 59, 43-55.

Geist, H.J., Lambin, E.F. (2001) What Drives Tropical Deforestation? A Meta-analysis of Proximate and Underlying Causes of Deforestation Based on Subnational Case Study Evidence? LUCC Report Series 4. LUCC International Project Office, Louvain-la-Neuve.

Geist, H.J., Lambin, E.F. (2002) Proximate causes and underlying driving forces of tropical deforestation. BioScience 52, 143-150.

Gillanders, S.N., Coops, N.C., Wulder, M.A., Gergel, S.E., Nelson, T. (2008) Multitemporal remote sensing of landscape dynamics and pattern change: describing natural and anthropogenic trends. Progress in Physical Geography 32, 503-528.

Griffiths, P., D. Muller, T. Kuemmerle, and P. Hostert. (2013) Agricultural land change in the Carpathian ecoregion after the breakdown of socialism and expansion of the European Union. Environmental Research Letters 8,1-13.

Haddaway, N.R., Styles, D., Pullin, A.S. (2013) What are the environmental impacts of farm land abandonment in high altitude/mountain regions: a systematic map of the evidence. Environmental Evidence 2,18.

Haines-Young, R.(2000) Sustainable development and sustainable landscapes: defining a new paradigm for landscape ecology. Fennia 178 (1), 7-14.

Hart, A.K., McMichael, P., Milder, J.C., Scherr, S.J. (2015) Multi-functional landscapes from the grassroots? The role of rural producer movements. Agriculture, Food, and Human Values Society 32.

Hersperger, A.M., Bürgi, M. (2009) Going beyond landscape change description: Quantifying the importance of driving forces of landscape change in a Central Europe case study. Land Use Policy 26, 640-648.

Hersperger, A.M., Gennaio, M., Verburg, P.H., Bürgi, M. (2010) Linking land change with driving forces and actors: four conceptual models. Ecology and Society 15, 1.

Höchtl, F., Lehringer, S., Konold, W. (2005) “Wilderness”: What it means when it becomes a reality—a case study from the southwestern Alps. Landscape and Urban Planning 70, 85-95.

IFLA, 2010. Proposal to further enhance the recognition and conservation of landscapes globally (Global Landscape Convention). 47th World Congress, Suzhou, China.

Jansen, J., Losvik, M., Roche, P.(2009) Vulnerability and resilience of cultural landscapes, in: Krzywinski, K., O'Connell, M., Küster, H. (Eds.), Cultural Landscapes of Europe: Fields of Demeter, Haunts of Pan. Aschenbeck Media, Bremen,pp 55-66.

Jones, M., Howard, P., Olwig, K.R., Primdahl, J., Herlin, I.S. (2007) Multiple interfaces of the European landscape convention. Norsk Geografisk Tidsskrift-Norwegian Journal of Geography 61, 207-215.

Kaufman, L., Rousseeuw, P.J. (2008) Monothetic analysis (Program MONA), in: Kaufman, L., Rousseeuw, P.J. (Eds.), Finding Groups in Data. John Wiley & Sons, Inc., pp. 280-311.

Keys, E., McConnell, W.J. (2005) Global change and the intensification of agriculture in the tropics. Global Environmental Change 15, 320-337.

Kinzig, A.P. (2012) Towards a deeper understanding of the social in resilience: the contributions of cultural landscapes, in: Plieninger, T., Bieling, C. (Eds.), Resilience and the Cultural Landscape. Understanding and Managing Change in Human-Shaped Environments. Cambridge University Press, Cambridge, pp. 315-327.

Kizos, T., Dalaka, A., Petanidou, T. (2010) Farmers' practices and landscape change: Evidence from the abandonment of terraced cultivations on Lesvos, Greece. Agriculture and Human Values 27, 199–212.

Klijn, J.A. (2004) Driving forces behind landscape transformation in Europe, from a conceptual approach to policy options, in: Jongman, R.H.G. (Ed.), The New Dimensions of the European Landscape. Springer, Dordrecht, pp. 201-218.

Kowalski, A.A., Jenkins, L.D.(2015) The role of bridging organizations in environmental management: examining social networks in working groups. Ecology and Society 20.

Kozar, R., Buck, L.E., Barrow, E.G., Sunderland, T.C.H., Catacutan, D.E., Planicka, C., Hart, A., Willemen, L. (2014). Toward Viable Landscape Governance Systems. What Works? , in: Partners, E. (Ed.), Landscapes for People Food and Nature. EcoAgriculture Partners. Landscapes for People Food and Nature.

Lasanta, T., Nadal-Romero, E., Arnáez, J. (2015) Managing abandoned farmland to control the impact of re-vegetation on the environment. The state of the art in Europe, Environmental Science and Policy 52(99), 109.Leimu, R., Koricheva, J. (2005) What determines the citation frequency of ecological papers?. Trends in Ecology & Evolution 20, 28-32.

Levers, C., Müller, D., Erb, K., Haberl, H., Rudbeck Jepsen, M., Metzger, M.J., Meyfroidt, P., Plieninger, T., Plutzar, C., Stürck, J., Verburg, P.H., Verkerk, P.J., Kuemmerle, T. (2015) Archetypical patterns and trajectories of land systems in Europe. In review.

Li, B.B., Jansson, U., Ye, Y., Widgren, M. (2013) The spatial and temporal change of cropland in the Scandinavian Peninsula during 1875-1999. Regional Environmental Change 13, 1325-1336.

Luginbühl, Y. (2006) Landscape and Individual and Social Wellbeing. Challenges of the European Landscape Convention. Council of Europe Publishing, Strasbourg.

MacDonald, D., Crabtree, J.R., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., Lazpita, J.G., Gibon, A. (2000) Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response. Journal of Environmental Management 59, 47-69.

Magliocca, N. R., van Vliet, J., Brown, C., Evans, T. P., Houet, T., Messerli, P., Messina, J. P., Nicholas, K. A., Ornetsmüller, K., Sagebiel, J., Schweizer, V., Verburg, P. H., Yu, Q., (2015) From meta-studies to modeling: Using synthesis knowledge to build broadly applicable process-based land change models, Environmental Modelling & Software, 72, pp. 10-20.

Magliocca, N., Rudel, T., Verburg, P., McConnell, W., Mertz, O., Gerstner, K., Heinimann, A., Ellis, E. (2014) Synthesis in land change science: methodological patterns, challenges, and guidelines. Regional Environmental Change, 1-16.

Mander, Ü., Helming, K., Wiggering, H. (2007) Multifunctional Land Use: Meeting Future Demands for Landscape Goods and Services. Springer, Heidelberg.

Marcucci, D.J. (2000) Landscape history as a planning tool. Landscape and Urban Planning 49, 67-81.

Milder, J.C., Hart, A.K., Dobie, P., Minai, J., Zaleski, C.(2013) Integrated Landscape Initiatives for African Agriculture, Development, and Conservation: A Region-Wide Assessment. World Development 54, 68-80.

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: Synthesis. Island Press, Washington D.C.

Moser, D., Zechmeister, H.G., Plutzar, C., Sauberer, N., Wrbka, T., Grabherr, G. (2002) Landscape patch shape complexity as an effective measure for plant species richness in rural landscapes. Landscape. Ecol. 17,657-669.

Mottet, A., Ladet, S., Coque, N., Gibon, A. (2006) Agricultural land-use change and its drivers in mountain landscapes: A case study in the Pyrenees. Agriculture Ecosystems & Environment 114, 296-310.

Munroe, D.K., van Berkel, D.B., Verburg, P.H., Olson, J.L. (2013) Alternative trajectories of land abandonment: causes, consequences and research challenges. Current Opinion in Environmental Sustainability 5, 471-476.

Munteanu, C., Kuemmerle, T., Boltiziar, M., Butsic, V., Gimmi, U., Halada, L., Kaim, D., Kiraly, G., Konkoly-Gyuro, E., Kozak, J., Lieskovsky, J., Mojses, M., Muller, D., Ostafin, K., Ostapowicz, K., Shandra, O., Stych, P., Walker, S.,Radeloff, V.C. (2014). Forest and agricultural land change in the Carpathian region – A meta-analysis of long-term patterns and drivers of change. Land Use Policy.

Nadaï, A., van der Horst, D. (2010) Landscapes of energies. Landscape Research 35, 143-155.

Navarro, L.M., Pereira, H.M. (2012) Rewilding abandoned landscapes in Europe. Ecosystems 15, 900-912.

Newton, A.C., R.A. Hill, C. Echeverria, D. Golicher, J. M. R. Benayas, L. Cayuela, Hinsley, S.A. (2009) Remote sensing and the future of landscape ecology. Progress in Physical Geography 33, 528-546.

Ode Sang, Å., Tveit, M.S. (2013) Perceptions of stewardship in Norwegian agricultural landscapes. Land Use Policy 31, 557-564.

OECD (1999) Environmental Indicators for Agriculture. Concepts and Frameworks. Volume 1.

Olsson, P., Folke, C., Berkes, F. (2004) Adaptive comanagement for building resilience in social-ecological systems. Environmental Manage 34, 75-90.

Olsson, P., Folke, C., Galaz, V., Hahn, T., and Schultz, L.(2007) Enhancing the fit through adaptive co-management: creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere Reserve Sweden. Ecology and Society 12(1), 28.

Palomo, I., Montes, C., Martín-López, B., González, J.A., García-Llorente, M., Alcorlo, P., Mora, M.R.G. (2014) Incorporating the social–ecological approach in protected areas in the Anthropocene. BioScience 64, 181-191.

Pătru-Stupariu, I., Tudor, C.A., Stupariu, M.S., Buttler, A., Peringer, A. (2015) Landscape persistence and stakeholder perspectives: The case of Romania's Carpathians. Applied Geography.

Paudel, S., and F. Yuan. (2012) Assessing landscape changes and dynamics using patch analysis and GIS modelling. International Journal of Applied Earth Observation and Geoinformation 16,66-76.

Penker, M.(2009) Landscape governance for or by the local population? A property rights analysis in Austria. Land Use Policy 26, 947-953.

Penker, M., Mühlman, P., Muhar, A.(2014) Volunteering for land care –A typology of civil society organisations in Austria, Germany and Switzerland as the basis for establishing new initiatives. Journal on Protected Mountain Areas Research 6.

Pinto-Correia, T., Kristensen, L. (2013) Linking research to practice: The landscape as the basis for integrating social and ecological perspectives of the rural. Landscape and Urban Planning 120, 248-256.

Plieninger, T., Bieling, C. (2013) Resilience-based perspectives to guiding high nature value farmland through socio-economic change. Ecology and Society 18(4), art. 20.

Plieninger, T., Bieling, C. (2012) Connecting cultural landscapes to resilience, in: Plieninger, T., Bieling, C. (Eds.), Resilience and the Cultural Landscape. Understanding and Managing Change in Human-Shaped Environments. Cambridge University Press, Cambridge,3-26.

Plieninger, T., Bieling, C., Fagerholm, N., Byg, A., Hartel, T., Hurley, P., López-Santiago, C.A., Nagabhatla, N., Oteros-Rozas, E., Raymond, C.M., van der Horst, D., Huntsinger, L. (2015). The role of cultural ecosystem services in landscape management and planning. Current Opinion in Environmental Sustainability 14, 28-33.

Plieninger, T., Hui, C., Gaertner, M., Huntsinger. L. (2014) The Impact of Land Abandonment on Species Richness and Abundance in the Mediterranean Basin: A Meta-Analysis, PLoS ONE 05/2014; 9(5):e98355.

Plieninger, T., Schleyer, C., Mantel, M. Hostert, P. (2012) Is there a forest transition outside forests? Trajectories of farm trees and effects on ecosystem services in an agricultural landscape in Eastern Germany. Land Use Policy 01/2012; 29(1),233-243.

Plieninger, T., T. Kizos, C. Bieling, L. Le Dû-Blayo, M.-A. Budniok, M. Bürgi, C. L. Crumley, G. Girod, P. Howard, J. Kolen, T. Kuemmerle, G. Milcinski, H. Palang, K. Trommler, and P. H. Verburg (2015) Exploring ecosystem-change and society through a landscape lens: recent progress in European landscape research. Ecology and Society 20(2), 5.Prager, K. (2015) Agri-environmental collaboratives for landscape management in Europe. Current Opinion in Environmental Sustainability12, 59-66.

Prager, K.(2010) Local and regional partnerships in natural resource management: the challenge of bridging institutional levels. Environmental Manage 46, 711-724.

Prager, K.(2012) Collective efforts to manage cultural landscapes for resilience, in: Plieninger, T., Bieling, C. (Eds.), Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments. Cambridge University Press, Cambridge, pp. 205-223.

Prager, K., Reed, M., Scott, A. (2012) Encouraging collaboration for the provision of ecosystem services at a landscape scale—rethinking agri-environmental payments. Land Use Policy 29, 244-249.

Prager, K., Vanclay, F. (2010) Landcare in Australia and Germany: comparing structures and policies for community engagement in natural resource management. Ecological Management & Restoration 11, 187-193.

Primdahl, J., Andersen, E., Swaffield, S., Kristensen, L. (2013) Intersecting dynamics of agricultural structural change and urbanisation within European rural landscapes: Change patterns and policy implications. Landscape Research 38, 799-817.

Pullin, A.S., Stewart, G.B. (2006) Guidelines for systematic review in conservation and environmental management. Conservation Biology 20, 1647-1656.

Puyravaud J.P. (2003) Standardizing the calculation of the annual rate of deforestation. Forest Ecology and Management 177,593–596

Queiroz, C., Beilin, R., Folke, C., Lindborg, R. (2014) Farmland abandonment: threat or opportunity for biodiversity conservation? A global review. Frontiers in Ecology and the Environment 12, 288-296.

Questback (2014) Enterprise Feedback Suite

Reed, J., Deakin, L., Sunderland, T. (2015) What are ‘Integrated Landscape Approaches’ and how effectively have they been implemented in the tropics: a systematic map protocol. Environmental Evidence 4.

Rindfuss, R.R., Entwisle, B., Walsh, S.J., Mena, C.F., Erlien, C.M., Gray, C.L. (2007) Frontier land use change: synthesis, challenges, and next steps. Annals of the Association of American Geographers 97, 739-754.

Robinson, B.E., Holland, M.B., Naughton-Treves, L. (2014) Does secure land tenure save forests? A meta-analysis of the relationship between land tenure and tropical deforestation. Global Environmental Change 29, 281-293.

Romano, B., Zullo., F. (2014) The urban transformation of Italy's Adriatic coastal strip: Fifty years of unsustainability. Land Use Policy 38,26-36.

Rudel, T.K. (2008) Meta-analyses of case studies: A method for studying regional and global environmental change. Global Environmental Change-Human and Policy Dimensions 18, 18-25.

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.L., Sheil, D., Meijaard, E., Venter, M., Boedhihartono, A.K., Day, M., Garcia, C., van Oosten, C., Buck, L.E. (2013) Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proceedings of the National Academy of Sciences of the United States of America 110, 8349-8356.

Scherr, S.J., Milder, J., Buck, L.(2012) Landscapes for People, Food and Nature. The Vision, the Evidence, and Next Steps, EcoAgriculture Partners, Landscapes for People Food and Nature Initiative.

Scherr, S.J., Shames, S.A., Friedman, R.(2013) Defining Integrated Landscape Management for Policy Makers, Ecoagriculture Policy Focus. EcoAgriculture Partners.

Schultz, L., Folke, C., Olsson, P.(2007) Enhancing ecosystem management through social-ecological inventories: Lessons from Kristianstads Vattenrike, Sweden. Environmental Conservation 34, 140-152.

Selman, P.H. (2012) Sustainable Landscape Planning: The Reconnection Agenda. Routledge, Milton Park, New York.

Serra, P., Pons, X., Sauri, D. (2008) Land-cover and land-use change in a Mediterranean landscape: A spatial analysis of driving forces integrating biophysical and human factors. Applied Geography 28, 189-209.

Seto, K.C., Fragkias, M., Güneralp, B., Reilly, M.K. (2011) A meta-analysis of global urban land expansion. PloS One 6, e23777.

Skalos, J., Kasparova, I. (2012) Landscape memory and landscape change in relation to mining. Ecological Engineering 43, 60-69.

Sklenicka, P., Simova, P., Hrdinova, K., Salek, M. (2014) Changing rural landscapes along the border of Austria and the Czech Republic between 1952 and 2009: Roles of political, socioeconomic and environmental factors. Applied Geography 47,89-98.

Sluiter, R., de Jong, S.M. (2007) Spatial patterns of Mediterranean land abandonment and related land cover transitions. Landscape Ecology 22, 559-576.

Smith, P., Gregory, P.J., van Vuuren, D., Obersteiner, M., Havlik, P., Rounsevell, M., Woods, J., Stehfest, E., Bellarby, J. (2010) Competition for land. Philosophical Transactions of the Royal Society B-Biological Sciences 365, 2941-2957.

Solin, L., Feranec, J., Novacek, J. (2011) Land cover changes in small catchments in Slovakia during 1990 – 2006 and their effects on frequency of flood events. Natural Hazards. 56,195-214.

Stanners, D., Bourdeau, P. (1995) Europe's Environment: The Dobris Assessment. European Environmental Agency, Copenhagen.

Stockmann, R., Meyer, W.(2010) Evaluation. Eine Einführung. Verlag Barbara Budrich, Opladen.

Takeuchi, K.(2010) Rebuilding the relationship between people and nature: the Satoyama Initiative. Ecological Research 25, 891-897.

Termorshuizen, J. W., Opdam, P. (2009) Landscape services as a bridge between landscape ecology and sustainable development, Landscape Ecology 24(8),1037-1052.

Tomaz, C., Alegria, C., Monteiro, J.M.Teixeira, M.C. (2013) Land cover change and afforestation of marginal and abandoned agricultural land: A 10 year analysis in a Mediterranean region. Forest Ecology and Management 308, 40-49.

Turner II, B.L., Janetos, A.C., Verburg, P.H., Murray, A.T. (2013) Land system architecture: Using land systems to adapt and mitigate global environmental change. Global Environmental Change 23, 395-397.

UNESCO, 2012. Florence Declaration on Landscape. 40th Anniversary of the World Heritage Convention, Florence, September 2012.

van Asselen, S., Verburg, P.H., Vermaat, J.E., Janse, J.H. (2013) Drivers of wetland conversion: a global meta-analysis. PloS One 8, e81292.

van der Sluis, T., Pedroli, B., Kristensen, S.B.P., Lavinia Cosor, G., Pavlis, E. (2015) Changing land use intensity in Europe – Recent processes in selected case studies. Land Use Policy.

van Vliet J., Magliocca, N. R., Büchner, B., Cook, E., Rey Benayas, J. R., Ellis E. E., Heinimann A., Keys, E., Lee, T. M., Liu, J., Mertz, O., Meyfroidt, P., Moritz, M., Poeplau, C., Robinson, B. E., Seppelt, R., Seto, K. C., Verburg, P. H. (2015b) Meta-studies in land use science: Current coverage and prospects. AMBIO.

van Vliet, J., de Groot, H.L.F., Rietveld, P., Verburg P.H. (2015a) Manifestations and underlying drivers of agricultural land use change in Europe, Landscape and Urban Planning 01/2015, 13336.

van Vliet, J., Verburg, P.H., Magliocca, N., Ellis, E.C., Buchner, B., Cook, E., Rey Benayas, J., Heinimann, A., Keys, E., Lee, T., Liu, J., Mertz, O., Meyfroidt, P., Moritz, M., Robinson, B., Seppelt, R. (2015b) Meta-studies in land use science: current coverage and prospects. AMBIO.

van Vliet, N., Mertz, O., Heinimann, A., Langanke, T., Pascual, U., Schmook, B., Adams, C., Schmidt-Vogt, D., Messerli, P., Leisz, S., Castella, J.C., Jorgensen, L., Birch-Thomsen, T., Hett, C., Bruun, T.B., Ickowitz, A., Vu, K.C., Yasuyuki, K., Fox, J., Padoch, C., Dressler, W., Ziegler, A.D. (2012) Trends, drivers and impacts of changes in swidden cultivation in tropical forest-agriculture frontiers: A global assessment. Global Environmental Change-Human and Policy Dimensions 22, 418-429.

Verburg, P. H., Dearing, J. A., Dyke, J. D., van der Leeuw, S., Seitzinger, S., Steffen, W., Syvitski, J. (2015) Methods and approaches to modelling the Anthropocene, Global Environmental Change.

Verburg, P.H., J. van de Steeg, A. Veldkamp, Willemen, L. (2009) From land cover change to land function dynamics: A major challenge to improve land characterization. Journal of Environmental Management 90, 1327-1335.

Verburg, P.H., Schulp, C.J.E., Witte, N. Veldkamp, A. (2006) Downscaling of land use change scenarios to assess the dynamics of European landscapes. Agriculture, Ecosystems and Environment 114, 39-56.

Verburg, P.H., van Berkel, D.B., van Doorn, A.M., van Eupen, M., van den Heiligenberg, H.A.R.M. (2010) Trajectories of land use change in Europe: a model-based exploration of rural futures. Landscape Ecology 25, 217-232.

Walters, B.B., Vayda, A.P. (2009) Event ecology, causal historical analysis, and human–environment research. Annals of the Association of American Geographers 99, 534-553.

Wiggering, H., Dalchow, C., Glemnitz, M., Helming, K., Müller, K., Schultz, A., Stachow, U., Zander, P. (2006) Indicators for multifunctional land use - Linking socio-economic requirements with landscape potentials. Ecological Indicators 6, 238-249.

Wu, J.G. (2013) Landscape sustainability science: ecosystem services and human well-being in changing landscapes. Landscape Ecology 28, 999-1023.

Annexes

Annexes are separated in four parts:

- Supplementary material from the review on driving forces of landscape change
- Supplementary material from the review on rates of landscape change
- Supplementary material from the review on actors of landscape change
- Other literature reviews linked with the project

Supplementary material from the Review on driving forces of landscape change

S 1: 125 publications (containing 144 cases) that were included in the systematic review:

1. Alados, C.L., Pueyo, Y., Barrantes, O., Escos, J., Giner, L., Robles, A.B. (2004) Variations in landscape patterns and vegetation cover between 1957 and 1994 in a semiarid Mediterranean ecosystem. Landscape Ecology 19, 543-559.

2. Alphan, H. (2013) Bi-temporal analysis of landscape changes in the Easternmost Mediterranean deltas using binary and classified change information. Environmental Management 51, 541-554.

3. Álvarez Martínez, J.M., Suárez-Seoane, S., Calabuig, E.D. (2011) Modelling the risk of land cover change from environmental and socio-economic drivers in heterogeneous and changing landscapes: The role of uncertainty. Landscape and Urban Planning 101, 108-119.

4. Aretano, R., Petrosillo, I., Zaccarelli, N., Semeraro, T., Zurlini, G. (2013) People perception of landscape change effects on ecosystem services in small Mediterranean islands: A combination of subjective and objective assessments. Landscape and Urban Planning 112, 63-73.

5. Attorre, F., Rossetti, A., Sbrega, B., Bruno, F. (1998) Landscape changes in Rome, Italy. Coenoses 13, 57-64.

6. Attorre, F., Bruno, M., Francesconi, F., Valenti, R., Bruno, F. (2000) Landscape changes of Rome through tree-lined roads. Landscape and Urban Planning 49, 115-128.

7. Baessler, C., Klotz, S. (2006) Effects of changes in agricultural land-use on landscape structure and arable weed vegetation over the last 50 years. Agriculture Ecosystems & Environment 115, 43-50.

8. Bajocco, S., De Angelis, A., Perini, L., Ferrara, A., Salvati, L. (2012) The impact of land use/land cover changes on land degradation dynamics: A Mediterranean case study. Environmental Management 49, 980-989.

9.Bender, O., Boehmer, H.J., Jens, D., Schumacher, K.P. (2005) Analysis of land-use change in a sector of Upper Franconia (Bavaria, Germany) since 1850 using land register records. Landscape Ecology 20, 149-163.

10. Bender, O., Boehmer, H.J., Jens, D., Schumacher, K.P. (2005) Using GIS to analyse long-term cultural landscape change in Southern Germany. Landscape and Urban Planning 70, 111-125.

11. Bezák, P., Mitchley, J. (2014) Drivers of change in mountain farming in Slovakia: from socialist collectivisation to the Common Agricultural Policy. Regional Environmental Change 14, 1343-1356.

12. Bezák, P., Halada, L., Petrovič, F., Boltižiar, M.A., Oszlányi, J., (2007) Bukovské vrchy in the Slovak Carpathian Mountains - Landscape changes and trends, in: Mander, Ü., Wiggering, H., Helming, K. (Eds.), Multifunctional Land Use: Meeting Future Demands for Landscape Goods and Services. Springer, Heidelberg, pp. 355-367.

13. Bieling, C., Plieninger, T., Schaich, H. (2013) Patterns and causes of land change: Empirical results and conceptual considerations derived from a case study in the Swabian Alb, Germany. Land Use Policy 35, 192-203.

14. Bielsa, I., Pons, X., Bunce, B. (2005) Agricultural abandonment in the North Eastern Iberian Peninsula: the use of basic landscape metrics to support planning. Journal of Environmental Planning and Management.

15. Biro, M., Czucz, B., Horvath, F., Revesz, A., Csatari, B., Molnar, Z. (2013) Drivers of grassland loss in Hungary during the post-socialist transformation (1987-1999). Landscape Ecology 28, 789-803.

16. Bodesmo, M., Romano, B., Pacicco, L., Cagiotti, M.R., Ranfa, A. (2010) Changes in land use in an historical area of central Italy over twenty years: The use of environmental indicators. Polish Journal of Ecology 58, 429-438.

17. Bodesmo, M., Pacicco, L., Romano, B., Ranfa, A. (2012) The role of environmental and socio-demographic indicators in the analysis of land use changes in a protected area of the Natura 2000 Network: the case study of Lake Trasimeno, Umbria, Central Italy. Environmental Monitoring and Assessment 184, 831-843.

18. Bonet, A., Peña, J., Bellot, J., Cremades, M., Sánchez, J.R. (2001) Changing vegetation and landscape patterns in semi-arid Spain. Transactions on Ecology and the Environment 10, 377-385.

19.Bork, H.-R., Dalchow, C., Kächele, H., Kersebaum, K.-C., Piorr, H.-P. (1995) Landschaftswandel in Nordost-Deutschland seit der Vereinigung. Geoökodynamik 16, 211-242.

20. Bracchetti, L., Carotenuto, L., Catorci, A. (2012) Land-cover changes in a remote area of central Apennines (Italy) and management directions. Landscape and Urban Planning 104, 157-170.

21. Brandt, J. (2003) Multifunctional landscapes - perspectives for the future. Journal of Environmental Sciences 15, 187-192.

22. Breuer, T., Kolejka, J., Marek, D., Werner, E. (2010) Convergence of cultural landscape on the Czech-bavarian border in Šumava Mts. Geografie-Sbornik CGS 115, 308-329.

23. Bürgi, M., Straub, A., Gimmi, U., Salzmann, D. (2010) The recent landscape history of Limpach valley, Switzerland: Considering three empirical hypotheses on driving forces of landscape change. Landscape Ecology 25, 287-297.

24. Burnside, N.G., Smith, R.F., Waite, S. (2003) Recent historical land use change on the South Downs, United Kingdom. Environmental Conservation 30, 52-60.

25.Busck, A.G., Kristensen, S.B.P. (2014) From agriculture to nature - a study of drivers of land use change in a peri-urban landscape. Geografisk Tidsskrift-Danish Journal of Geography 114, 41-58.

26.Cakir, G., Un, C., Baskent, E.Z., Kose, S., Sivrikaya, F., Keles, S. (2008) Evaluating urbanization,fragmentation and land use/land cover change pattern in Istanbul City, Turkey from 1971 to 2002.Land Degradation & Development 19, 663-675.

27.Calvo-Iglesias, M.S., Fra-Paleo, U., Diaz-Varela, R.A. (2009) Changes in farming system and population as drivers of land cover and landscape dynamics: The case of enclosed and semi-openfield systems in Northern Galicia (Spain). Landscape and Urban Planning 90, 168-177.

28.Carranza, M.L., Acosta, A., Ricotta, C. (2007) Analyzing landscape diversity in time: The use of Renyi's generalized entropy function. Ecological Indicators 7, 505-510.

29.Cebecauerova, M., Cebecauer, T. (2008) Spatio-temporal trends of landscape development in southwest part of Slovakia: Analysis of major landscape change types. Ekologia Bratislava 27, 212-228.

30.Celio, E., Koellner, T., Gret-Regarney, A. (2014) Modeling land use decisions with Bayesian networks: Spatially explicit analysis of driving forces on land use change. Environmenta l Modelling & Software 52, 222-233.

31.Chust, G., Ducrot, D., Riera, J.L.L., Pretus, J.L.L. (1999) Characterizing human-modelled landscapes at a stationary state: a case study of Minorca, Spain. Environmental Conservation 26, 322-331.

32.Cocca, G., Sturaro, E., Gallo, L., Ramanzin, M. (2012) Is the abandonment of traditional livestock farming systems the main driver of mountain landscape change in Alpine areas? Land Use Policy 29, 878-886.

33.Cohen, M., Varga, D., Vila, J., Barrassaud, E. (2011) A multi-scale and multi-disciplinary approach to monitor landscape dynamics: a case study in the Catalan pre-Pyrenees (Spain). Geographical Journal 177, 79-91.

34.Costa, A., Madeira, M., Santos, J.L., Oliveira, A. (2011) Change and dynamics in Mediterranean evergreen oak woodlands landscapes of Southwestern Iberian Peninsula. Landscape and Urban Planning 102, 164-176.

35.Demková, K., Lipský, Z. (2013) Changes in the extent of non-forest woody vegetation in the Novodvorsko and Žehušlcko region (Central Bohemia, Czech Republic). Acta Universitatis Carolinae, Geographica 48, 5-13.

36.Detsis, V., Ntasiopoulou, G., Chalkias, C., Efthimiou, G. (2010) Recent insular Mediterranean landscape evolution: A case study on Syros, Greece. Landscape Research 35, 361-381.

37.Dikou, A., Papapanagiotou, E., Troumbis, A. (2011) Integrating landscape ecology and geoinformatics to decipher landscape dynamics for regional planning. Environmental Management 48, 523-538.

38.Van Eetvelde, V., Antrop, M. (2009) Indicators for assessing changing landscape character of cultural landscapes in Flanders (Belgium). Land Use Policy 26, 901-910.

39.Esbah, H., Deniz, B., Kara, B., Kesgin, B. (2010) Analyzing landscape changes in the Bafa Lake Nature Park of Turkey using remote sensing and landscape structure metrics. Environmental Monitoring and Assessment 165, 617-632.

40.Feranec, J., Kopecka, M., Vatseva, R., Stoimenov, A., Otahel, J., Betak, J., Husar, K. (2009) Landscape change analysis and assessment (case studies in Slovakia and Bulgaria). Central European Journal of Geosciences 1, 106-119.

41.Fjellstad, W.J., Dramstad, W.E. (1999) Patterns of change in two contrasting Norwegian agricultural landscapes. Landscape and Urban Planning 45, 177-191.

42.Garbarino, M., Lingua, E., Weisberg, P.J., Bottero, A., Meloni, F., Motta, R. (2013) Land-use history and topographic gradients as driving factors of subalpine Larix decidua forests. Landscape Ecology 28, 805-817.

43.Geri, F., Rocchini, D., Chiarucci, A. (2010) Landscape metrics and topographical determinants of large-scale forest dynamics in a Mediterranean landscape. Landscape and Urban Planning 95, 46-53.

44.Gonzalez-Puente, M., Campos, M., McCall, M.K., Munoz-Rojas, J. (2014) Places beyond maps; integrating spatial map analysis and perception studies to unravel landscape change in a Mediterranean mountain area (NE Spain). Applied Geography 52, 182-190.

45.Hamre, L.N., Domaas, S.T., Austad, I., Rydgren, K. (2007) Land-cover and structural changes in a western Norwegian cultural landscape since 1865, based on an old cadastral map and a field survey. Landscape Ecology 22, 1563-1574.

46.Hersperger, A.M., Bürgi, M., (2007) Driving forces of landscape change in the urbanizing Limmat Valley, Switzerland, in: Koomen, E., Stillwell, J., Bakema, A., Scholten, H. (Eds.), Modelling Land-Use Change. Springer Netherlands, pp. 45-60.

47.Hersperger, A.M., Bürgi, M. (2009) Going beyond landscape change description: Quantifying the importance of driving forces of landscape change in a Central Europe case study. Land Use Policy 26, 640-648.

48.Herzog, F., Lausch, A., Muller, E., Thulke, H.H., Steinhardt, U., Lehmann, S. (2001) Landscape metrics for assessment of landscape destruction and rehabilitation. Environmental Management 27, 91-107.

49.Hietala-Koivu, R. (1999) Agricultural landscape change: a case study in Ylane, southwest Finland. Landscape and Urban Planning 46, 103-108.

50.Isaia, M., Siniscalco, C., Badino, G. (2014) From rural to urban: Landscape changes in north-west Italy over two centuries. Landscape History 35, 73-76.

51.Ispikoudis, I., Lyrintzis, G., Kyriakakis, S. (1993) Impact of human activities on Mediterranean landscapes in Western Crete. Landscape and Urban Planning 24, 259-271.

52.Jackova, K., Chuman, T., Romportl, D. (2011) Comparison of land cover changes in protected and unprotected sites on the outskirts of Prague metropolis (the Czech Republic), 1990-2006. Acta Universitatis Carolinae, Geographica 46, 67-79.

53.Kadiogullari, A.I. (2013) Assessing implications of land use and land cover changes in forest ecosystems of NE Turkey. Environmental Monitoring and Assessment 185, 2095-2106.

54.Kadioullari, A.I., Keles, S., Baskent, E.Z., Gunlu, A. (2008) Spatiotemporal changes in landscape pattern in response to afforestation in Northeastern Turkey: A case study of Torul. Scottish Geographical Journal 124, 259-273.

55.Kadlecova, V., Dramstad, W.E., Semancikova, E., Edwards, K.R. (2012) Landscape changes and their influence on the heterogeneity of landscape of the South Bohemian Region, the Czech Republic. International Journal of Sustainable Development and World Ecology 19, 546-556.

56.Kanianska, R., Kizekova, M., Novacek, J., Zeman, M. (2014) Land-use and land-cover changes in rural areas during different political systems: A case study of Slovakia from 1782 to 2006. Land Use Policy 36, 554-566.

57.Keken, Z., Panagiotidis, D., Skalos, J. (2015) The influence of damming on landscape structure change in the vicinity of flooded areas: Case studies in Greece and the Czech Republic. Ecological Engineering 74, 448-457.

58.Keles, S., Sivrikaya, F., Cakir, G., Baskent, E.Z., Kose, S. (2008) Spatial and temporal changes in forest cover in Turkey's Artvin Forest, 1972-2002. Polish Journal of Environmental Studies 17, 491-501.

59.Kizos, T., Koulouri, M. (2010) Same land cover, same land use at the large scale, different landscapes at the small scale: Landscape change in olive plantations on Lesvos Island, Greece. Landscape Research 35, 449-467.

60.Klapka, P., Křemenová, G., Martinát, S. (2005) Selected socio-economic factors affecting landscape structure in the Vrchlabí and Vimperk regions: Analysis, consequences, sustainability. Moravian Geographical Reports 13, 49-61.

61.Klich, D., Gielarek, S., Antosiewicz, M. (2013) Land cover dynamics in western Bieszczady Mts between 19th and 20th century. Ekologia Bratislava 32, 95-103.

62.Kristensen, L.S., Thenail, C., Kristensen, S.P. (2004) Landscape changes in agrarian landscapes in the 1990s: the interaction between farmers and the farmed landscape. A case study from Jutland, Denmark. Journal of Environmental Management 71, 231-244.

63.Kristensen, S.B.P., Reenberg, A., Pena, J.J.D. (2009) Exploring local rural landscape changes in Denmark: A human-environmental timeline perspective. Geografisk Tidsskrift-Danish Journal of Geography 109, 47-67.

64.Kristensen, S.P., Caspersen, O.H. (2002) Analysis of changes in a shelterbelt network landscape in central Jutland, Denmark. Journal of Environmental Management 66, 171-183.

65.Kristensen, S.P., Thenail, C., Kristensen, L. (2001) Farmers' involvement in landscape activities: An analysis of the relationship between farm location, farm characteristics and landscape changes in two study areas in Jutland, Denmark. Journal of Environmental Management 61, 301-318.

66.Lasanta-Martinez, T., Vicente-Serrano, S.M., Cuadrat-Prats, J.M. (2005) Mountain Mediterranean landscape evolution caused by the abandonment of traditional primary activities: a study of the Spanish Central Pyrenees. Applied Geography 25, 47-65.

67.Lehotský, M., Novotný, J., Grešková, A. (2008) Complexity and landscape. Geograficky Casopis 60, 95-112.

68.Levin, G.P. (2006) Farm size and landscape composition in relation to landscape changes in Denmark. Geografisk Tidsskrift-Danish Journal of Geography 106, 45-59.

69.Lipsky, Z. (2001) Present land use changes in the Czech cultural landscape: Driving forces and environmental consequences. Moravian Geographical Reports 9, 2-14.

70.Loczy, D., Gyenizse, P. (2010) Human impact on topography in an urbanised mining area Pecs, Southwest Hungary. Geomorphologie-Relief Processus Environnement, 287-300.

71.Lofman, S. (2007) Long-term changes in two boreal landscapes with different management histories. Scandinavian Journal of Forest Research 22, 22-32.

72.Lowicki, D. (2008) Land use changes in Poland during transformation Case study of Wielkopolska region. Landscape and Urban Planning 87, 279-288.

73.Luoto, M., Rekolainen, S., Aakkula, J., Pykala, J. (2003) Loss of plant species richness and habitat connectivity in grasslands associated with agricultural change in Finland. Ambio 32, 447-452.

74.Mailander, S., Eberle, J., Blumel, W.D. (2004) Human-induced landscape changes on the eastern Swabian Alb (south-western Germany) since the beginning of the 19th century: Dimensions, causes and effects Kulturlandschaftswandel auf der ostlichen Schwabischen Alb seit beginn des 19. Jahrhunderts: Ausma, ursachen und auswirkungen. Erde 135, 175-204.

75.Mallinis, G., Koutsias, N., Arianoutsou, M. (2014) Monitoring land use/land cover transformations from 1945 to 2007 in two peri-urban mountainous areas of Athens metropolitan area, Greece. Science of the Total Environment 490, 262-278.

76.Marull, J., Pino, J., Tello, E., Cordobilla, M.J. (2010) Social metabolism, landscape change and land-use planning in the Barcelona Metropolitan Region. Land Use Policy 27, 497-510.

77.Mihai, B., Savulescu, I., Sandric, I. (2007) Change detection analysis (1986-2002) of vegetation cover in Romania: A study of alpine, subalpine, and forest landscapes in the Lezer mountains, Southern Carpathians. Mountain Research and Development 27, 250-258.

78.Miklin, J., Smolkova, V. (2011) Land use/land cover changes of the Palava Pla and the proposed Soutok Pla (Czech Republic) in 1841-2006. Moravian Geographical Reports 19, 15-28.

79.Mikusinska, A., Zawadzka, B., Samojlik, T., Jedrzejewska, B., Mikusinski, G. (2013) Quantifying landscape change during the last two centuries in Bialowieza Primeval Forest. Applied Vegetation Science 16, 217-226.

80.Millington, J.D.A., Perry, G.L.W., Romero-Calcerrada, R. (2007) Regression techniques for examining land use/cover change: A case study of a mediterranean landscape. Ecosystems 10, 562-578.

81.Monteiro, A.T., Fava, F., Hiltbrunner, E., Della Marianna, G., Bocchi, S. (2011) Assessment of land cover changes and spatial drivers behind loss of permanent meadows in the lowlands of Italian Alps. Landscape and Urban Planning 100, 287-294.

82.Moran-Ordonez, A., Suarez-Seoane, S., Calvo, L., de Luis, E. (2011) Using predictive models as a spatially explicit support tool for managing cultural landscapes. Applied Geography 31, 839-848.

83.Mottet, A., Ladet, S., Coque, N., Gibon, A. (2006) Agricultural land-use change and its drivers in mountain landscapes: A case study in the Pyrenees. Agriculture Ecosystems & Environment 114, 296-310.

84.Mulková, M., Popelka, P., Popelková, R. (2012) Landscape changes in the central part of the Karviná region from the first half of the 19th century to the beginning of the 21st century. Ekologia Bratislava 31, 75-91.

85.Nikodemus, O., Bell, S., Grine, I., Liepins, I. (2005) The impact of economic, social and political factors on the landscape structure of the Vidzeme Uplands in Latvia. Landscape and Urban Planning 70, 57-67.

86.Oguz, H., Zengin, M. (2011) Analyzing land use/land cover change using remote sensing data and landscape structure metrics: Acase study of Erzurum, Turkey. Fresenius Environmental Bulletin 20, 3258-3269.

87.Parcerisas, L., Marull, J., Pino, J., Tello, E., Coll, F., Basnou, C. (2012) Land use changes, landscape ecology and their socioeconomic driving forces in the Spanish Mediterranean coast (El Maresme County, 1850-2005). Environmental Science & Policy 23, 120-132.

88.Patru-Stupariu, I., Stupariu, M.S., Cuculici, R., Huzui, A. (2011) Understanding landscape change using historical maps. Case study Sinaia, Romania. Journal of Maps, 206-220.

89.Peccol, E., Bird, A.C., Brewer, T.R. (1996) GIS as a tool for assessing the influence of countryside designations and planning policies on landscape change. Journal of Environmental Management 47, 355-367.

90.Peña, J., Bonet, A., Bellot, J., Sánchez, J.R., Eisenhuth, D., Hallett, S., Aledo, A., (2007) Driving forces of land-use change in a cultural landscape of Spain, in: Koomen, E., Stillwell, J., Bakema, A., Scholten, H. (Eds.), Modelling Land-Use Change. Springer Netherlands, pp. 97-116.

91.Plieninger, T. (2012) Monitoring directions and rates of change in trees outside forests through multitemporal analysis of map sequences. Applied Geography 32, 566-576.

92.Plieninger, T., Schleyer, C., Mantel, M., Hostert, P. (2012) Is there a forest transition outside forests? Trajectories of farm trees and effects on ecosystem services in an agricultural landscape in Eastern Germany. Land Use Policy 29, 233-243.

93.Pocas, I., Cunha, M., Marcal, A.R.S., Pereira, L.S. (2011) An evaluation of changes in a mountainous rural landscape of Northeast Portugal using remotely sensed data. Landscape and Urban Planning 101, 253-261.

94.Pottier, P., Robin, M. (1997) L'Île d'yeu, un espace convoité: Développement et aménagement. Mappemonde, 18-23.

95. Poudevigne, I., vanRooij, S., Morin, P., Alard, D. (1997) Dynamics of rural landscapes and their main driving factors: A case study in the Seine Valley, Normandy, France. Landscape and Urban Planning 38, 93-103.

96. Poyatos, R., Latron, J., Llorens, P. (2003) Land use and land cover change after agricultural abandonment - The case of a Mediterranean Mountain Area (Catalan Pre-Pyrenees). Mountain Research and Development 23, 362-368.

97. Prăvălie, R. (2013) Considerations about the reduction of marshes in southern Oltenia. Geographia Technica 18, 71-79.

98. Raska, P., Kirchner, K. (2011) Assessing landscape changes in a region affected by military activity and uranium mining (Prameny municipality area, Western Bohemia, Czech Republic): A multi-scale approach. Moravian Geographical Reports 19, 29-37.

99. Regos, A., Ninyerola, M., More, G., Pons, X. (2015) Linking land cover dynamics with driving forces in mountain landscape of the Northwestern Iberian Peninsula. International Journal of Applied Earth Observation and Geoinformation 38, 1-14.

100. Roura-Pascual, N., Pons, P., Etienne, M., Lambert, B. (2005) Transformation of a rural landscape in the Eastern Pyrenees between 1953 and 2000. Mountain Research and Development 25, 252-261.

101.Schaich, H., Kizos, T., Schneider, S., Plieninger, T. (2015) Land change in Eastern Mediterranean wood-pasture landscapes: The case of deciduous oak woodlands in Lesvos (Greece). Environmental Management 56, 110-126.

102.Schaller, N., Lazrak, E.G., Martin, P., Mari, J.F., Aubry, C., Benoit, M. (2012) Combining farmers' decision rules and landscape stochastic regularities for landscape modelling. Landscape Ecology 27, 433-446.

103. Schneeberger, N., Burgi, M., Hersperger, A.M., Ewald, K.C. (2007) Driving forces and rates of landscape change as a promising combination for landscape change research - An application on the northern fringe of the Swiss Alps. Land Use Policy 24, 349-361.

104. Schwefel, D., Glässer, C., Glässer, W. (2012) Dynamic of anthropogenically induced landscape changes of the former mining landscape Teutschenthal-Bahnhof (Saxony-Anhalt). Hercynia 45, 9-31.

105. Serra, P., Pons, X., Sauri, D. (2008) Land-cover and land-use change in a Mediterranean landscape: A spatial analysis of driving forces integrating biophysical and human factors. Applied Geography 28, 189-209.

106. Sivrikaya, F., Cakir, G., Kadiogullari, A.I., Keles, S., Baskent, E.Z., Terzioglu, S. (2007) Evaluating land use/land cover changes and fragmentation in the camili forest planning unit of northeastern Turkey from 1972 to 2005. Land Degradation & Development 18, 383-396.

107. Skaloš, J. (2006) Patterns and changes of intensively utilised agricultural landscape in the Czech Republic between 1937 and 2002: Aerial photography analysis. Ekologia Bratislava 25, 232-248.

108. Skalos, J., Kasparova, I. (2012) Landscape memory and landscape change in relation to mining. Ecological Engineering 43, 60-69.

109. Skanes, H.M., Bunce, R.G.H. (1997) Directions of landscape change (1741-1993) in Virestad, Sweden - characterised by multivariate analysis. Landscape and Urban Planning 38, 61-75.

110. Sklenicka, P., Molnarova, K., Brabec, E., Kumble, P., Pittnerova, B., Pixova, K., Salek, M. (2009) Remnants of medieval field patterns in the Czech Republic: Analysis of driving forces behind their disappearance with special attention to the role of hedgerows. Agriculture Ecosystems & Environment 129, 465-473.

111. Sklenicka, P., Simova, P., Hrdinova, K., Salek, M. (2014) Changing rural landscapes along the border of Austria and the Czech Republic between 1952 and 2009: Roles of political, socioeconomic and environmental factors. Applied Geography 47, 89-98.

112. Solon, J., Lechnio, J. (2013) Land cover as a factor affecting the structure and modifying the dynamics of a landscape system. Miscellanea Geographica 17, 34-41.

113. Szabo, P. (2010) Driving forces of stability and change in woodland structure: A case-study from the Czech lowlands. Forest Ecology and Management 259, 650-656.

114. Tasser, E., Walde, J., Tappeiner, U., Teutsch, A., Noggler, W. (2007) Land-use changes and natural reforestation in the Eastern Central Alps. Agriculture Ecosystems & Environment 118, 115-129.

115. Teixeira, Z., Teixeira, H., Marques, J.C. (2014) Systematic processes of land use/land cover change to identify relevant driving forces: Implications on water quality. Science of the Total Environment 470, 1320-1335.

116. Triantakonstantis, D.P., Kollias, V.J., Kalivas, D.P. (2006) Forest re-growth since 1945 in the Dadia forest nature reserve in northern Greece. New Forests 32, 51-69.

117. Tzanopoulos, J., Vogiatzakis, I.N. (2011) Processes and patterns of landscape change on a small Aegean island: The case of Sifnos, Greece. Landscape and Urban Planning 99, 58-64.

118. Van Der Sluis, T., Kizos, T., Pedroli, B., (2014) Landscape Change in Mediterranean Farmlands: Impacts of Land Abandonment on Cultivation Terraces in Portofino (Italy) and Lesvos (Greece), Journal of Landscape Ecology, p. 23.

119. Van Doorn, A.M., Bakker, M.M. (2007) The destination of arable land in a marginal agricultural landscape in South Portugal: an exploration of land use change determinants. Landscape Ecology 22, 1073-1087.

120. Van Eetvelde, V., Antrop, M. (2004) Analyzing structural and functional changes of traditional landscapes - two examples from Southern France. Landscape and Urban Planning 67, 79-95.

121. Vanwambeke, S.O., Meyfroidt, P., Nikodemus, O. (2012) From USSR to EU: 20 years of rural landscape changes in Vidzeme, Latvia. Landscape and Urban Planning 105, 241-249.

122. Veteikis, D., Sabanovas, S., Jankauskaite, M. (2011) Landscape structure changes on the coastal plain of Lithuania during 1998-2009. Baltica 24, 107-116.

123. Ward, N., Marsden, T., Munton, R. (1990) Farm landscape change. Trends in upland and lowland England. Land Use Policy 7, 291-302.

124. Wehn, S. (2009) A map-based method for exploring responses to different levels of grazing pressure at the landscape scale. Agriculture Ecosystems & Environment 129, 177-181.

125. Wulf, M., Sommer, M., Schmidt, R. (2010) Forest cover changes in the Prignitz region (NE Germany) between 1790 and 1960 in relation to soils and other driving forces. Landscape Ecology 25, 299-313.

Supplementary material:

Coverage of a) biogeographical regions, b) land system archetypes, and c) archetypical change trajectories of land systems in the evaluated study areas, as compared to their coverage in Europe / the European Union (in %). Data sources: EEA, Levers et al. (under review)

Biogeographical region	Study areas (n=144) (%)	Europe (%)
Alpine	12.5	8.6
Anatolian	1.4	3.9
Arctic	0.0	5.5
Atlantic	11.1	7.8
Black Sea	2.8	1.3
Boreal	6.3	25.7
Continental	30.5	23.4
Macaronesia	0.0	0.1
Mediterranean	30.5	10.8
Pannonian	4.9	1.1
Steppic	0.0	11.8

Land system archetype	Study areas (%) (n=121[1])	European Union (%)
High-intensity cropland	2.5	1.3
Large-scale permanent cropland	5.0	3.8
High-intensity arable cropland	11.6	7.5
Medium-intensity arable cropland	6.6	11.9
Low-intensity arable cropland	3.3	6.2
Fallow farmland	2.5	3.9
High-intensity livestock farming	0.0	0.9
Medium-intensity livestock farming	0.8	4.0
Low-intensity livestock farming	9.9	5.9
Low-intensity grassland area	9.1	9.2
High-intensity forest	5.0	8.3
Low-intensity forest	10.7	19.3
High-intensity agricultural mosaic	7.4	4.5
Low-intensity mosaic	9.9	11.5
Urban built up	15.7	1.8

[1] Only 121 studies are included in the analysis as the land system archetype and archetypical change trajectories data does not cover the whole Europe (e.g. Norway, Switzerland, Turkey, and off coast small islands)

Supplementary material from the review on rates of landscape change

1. Améztegui, A., Brotons, L. and Coll, L. (2010) Land-use changes as major drivers of mountain pine (*Pinus uncinata Ram.*) expansion in the Pyrenees. Global Ecology and Biogeography 19, 632-641.
2. Araya, Y.H. and Cabral, P. (2010) Analysis and modelling of urban land cover change in Setúbal and Sesimbra, Portugal. Remote Sensing 2, 1549-1563.
3. Arnaez, J., Lasanta, T., Errea, M.P. and Ortigosa, L. (2011) Land abandonment, landscape evolution, and soil erosion in a Spanish Mediterranean mountain region: The case of Camero Viejo. Land Degradation and Development 22, 537-550.
4. Begueria, S. (2006) Changes in land cover and shallow landslide activity: A case study in the Spanish Pyrenees. Geomorphology 74, 196-206.
5. Biró, M., Czúcz, B., Horváth, F., Révész, A., Csatári, B. and Molnár, Z. (2013) Drivers of grassland loss in Hungary during the post-socialist transformation (1987-1999). Landscape Ecology 28, 789-803.
6. Bracchetti, L., Carotenuto, L. and Catorci, A. (2012) Land-cover changes in a remote area of central Apennines (Italy) and management directions. Landscapae and Urban Planning 104, 157-170.
7. Cabral, P., Geroyannis, H., Gilg, J.P. and Painho, M. (2005) Analysis and modeling of land-use and land-cover change in Sintra-Cascais area. 8th AGILE Conference on Geographic Information Science, 51-60.
8. Castaldi, F. and Chiocchini, U. (2012) Effects of land use changes on badland erosion in clayey drainage basins, Radicofani, Central Italy. Geomorphology 169, 98-108.
9. Chrysoulakis, N., Mitraka, Z., Stathopoulou, M. and Cartalis, K. (2013) A comparative analysis of the urban web of the greater Athens agglomeration for the last 20-years period on the basis of Landsat imagery. Fresenius Environmental Bulletin 22, 2139-2144.
10. Díaz-Pacheco, J. and García-Palomares, J.C. (2014) A highly detailed land-use vector map for Madrid region based on photo-interpretation. Journal of Maps 10, 424-433.
11. Dupuy, D., Barbe, E. and Balestrat, M. (2012) An Object-Based Image Analysis Method for Monitoring Land Conversion by Artificial Sprawl Use of RapidEye and IRS Data. Remote Sensing 4, 404-423.
12. Dzieszko, P. (2014) Land-cover modelling using corine land cover data and multi-layer perceptron. Quaestiones Geographicae 33, 5-22.
13. Ernoul, L., Sandoz, A. and Fellague, A. (2012) The evolution of two great Mediterranean Deltas: Remote sensing to visualize the evolution of habitats and land use in the Gediz and Rhone Deltas. Ocean & Coastal Management 69, 111-117.
14. Geri, F., Amici, V. and Rocchini, D. (2010) Human activity impact on the heterogeneity of a Mediterranean landscape. Applied Geography 30, 370-379.

15. Gomez, C., Wulder, M.A., White, J.C., Montes, F. and Delgado, J.A. (2012) Characterizing 25 years of change in the area, distribution, and carbon stock of Mediterranean pines in Central Spain. International Journal of Remote Sensing 33, 5546-5573.

16. Hostert, P., Kuemmerle, T., Prishchepov, A., Sieber, A., Lambin, E.F. and Radeloff, V.C. (2011) Rapid land use change after socio-economic disturbances: the collapse of the Soviet Union versus Chernobyl. Environmental Research Letters 6.

17. Kuemmerle, T., Olofsson, P., Chaskovskyy, O., Baumann, M., Ostapowicz, K., Woodcock, C.E., Houghton, R.A., Hostert, P., Keeton, W.S. and Radeloff, V.C. (2011) Post-Soviet farmland abandonment, forest recovery, and carbon sequestration in western Ukraine. Global Change Biology 17, 1335-1349.

18. Kuemmerle, T., Chaskovskyy, O., Knorn, J., Radeloff, V.C., Kruhlov, I., Keeton, W.S. and Hostert, P. (2009) Forest cover change and illegal logging in the Ukrainian Carpathians in the transition period from 1988 to 2007. Remote Sensing of Environment 113, 1194-1207.

19. Kuemmerle, T., Müller, D., Griffiths, P. and Rusu, M. (2009) Land use change in Southern Romania after the collapse of socialism. Regional Environmental Change 9, 1-12.

20. Kuemmerle, T., Hostert, P., Radeloff, V.C., Perzanowski, K. and Kruhlov, I. (2007). Post-socialist forest disturbance in the Carpathian border region of Poland, Slovakia, and Ukraine. Ecological Applications 17, 1279-1295.

21. Lakes, T., Mueller, D. and Krueger, C. (2009). Cropland change in southern Romania: a comparison of logistic regressions and artificial neural networks. Landscape Ecology 24, 1195- 1206.

22. Lasanta, T. and Vicente-Serrano, S.M. (2012) Complex land cover change processes in semiarid Mediterranean regions: An approach using Landsat images in northeast Spain. Remote Sensing of Environment: 124, 1-14.

23. Lasanta, T., Vicente-Serrano, S.M. and Cuadrat-Prats, J.M. (2005) Mountain Mediterranean landscape evolution caused by the abandonment of traditional primary activities: a study of the Spanish Central Pyrenees. Applied Geography 25, 47-65.

24. Łowicki, D. (2008) Land use changes in Poland during transformation. Case study of Wielkopolska region. Landscape and Urban Planning 87, 279-288.

25. Lundberg, A. (2011) Climate and land-use change as driving forces in lowland semi-natural vegetation dynamics. Erdkunde 65, 335-353.

26. Mallinis, G., Koutsias, N. and Arianoutsou, M.(2014) Monitoring land use/land cover transformations from 1945 to 2007 in two peri-urban mountainous areas of Athens metropolitan area, Greece. Science of the Total Environment 490, 262-278.

27. Marignani, M., Rocchini, D., Torri, D., Chiarucci, A. and Maccherini, S. (2008) Planning restoration in a cultural landscape in Italy using an object-based approach and historical analysis. Landscape and Urban Planning 84, 28-37.

28. Martinez-Casasnovas, J.A., Concepcion Ramos, M. and Garcia-Hernandez, D. (2009) Effects of land-use changes in vegetation cover and sidewall erosion in a gully head of the Penedes region (northeast Spain). Earth Surface Processes and Landforms 34, 1927-1937.

29. Monteiro, A.T., Fava, F., Hiltbrunner, E., Della Marianna, G. and Bocchi, S. (2011) Assessment of land cover changes and spatial drivers behind loss of permanent meadows in the lowlands of Italian Alps. Landscape and Urban Planning 100, 287-294.

30. Muñoz-Rojas, M., De la Rosa, D., Zavala, L.M., Jordán, A. and Anaya-Romero, M. (2011) Changes in land cover and vegetation carbon stocks in Andalusia, Southern Spain (1956-2007). Science of the Total Environment 409, 2796-2806.

31. Padilla, F.M., Vidal, B., Sanchez, J. and Pugnaire, F.I. (2010) Land-use changes and carbon sequestration through the twentieth century in a Mediterranean mountain ecosystem: Implications for land management. Journal of Environmental Management 91, 2688-2695.

32. Pelorosso, R., Della Chiesa, S., Tappeiner, U., Leone, A. and Rocchini, D. (2011) Stability analysis for defining management strategies in abandoned mountain landscapes of the Mediterranean basin. Landscape and Urban Planning 103, 335-346.

33. Plieninger, T. (2012) Monitoring directions and rates of change in trees outside forests through multitemporal analysis of map sequences. Applied Geography 32, 566-576.

34. Plieninger, T., Schaich, H. and Kizos, T. (2011). Land-use legacies in the forest structure of silvopastoral oak woodlands in the Eastern Mediterranean. Regional Environmental Change 11, 603-615.

35. Pueyo, Y. and Begueria, S. (2007) Modelling the rate of secondary succession after farmland abandonment in a Mediterranean mountain area. Landscape and Urban Planning 83, 245-254.

36. Raet, J., Sepp. K. and Kaasik, A.(2008) Assessment of changes in forest coverage based on historical maps. Forestry Studies 48: 67-78.

37. Ruiz Benito, P., Cuevas, J.A., Bravo de la Parra, R., Prieto, F., García del Barrio, J.M. and Zavala, M.A. (2010) Land use change in a Mediterranean metropolitan region and its periphery: Assessment of conservation policies through CORINE land cover data and Markov models. Forest Systems 19: 315-328.

38. Salvati, L., Sateriano, A. and Bajocco, S. (2013) To grow or to sprawl? Land Cover Relationships in a Mediterranean City Region and implications for land use management. Cities 30, 113-121.

39. Sieber, A., Kuemmerle, T., Prishchepov, A.V., Wendland, K.J., Baumann, M., Radeloff, V.C., Baskin, L.M. and Hostert, P. (2013) Landsat-based mapping of post-Soviet land-use change to assess the effectiveness of the Oksky and Mordovsky protected areas in European Russia. Remote Sensing of Environment 133, 38-51.

40. Sirami, C., Brotons, L. and Martin, J.L. (2007) Vegetation and songbird response to land abandonment: from landscape to census plot. Diversity and Distributions 13, 42-52.

41. Staaland, H., Holand, O., Nellemann, C. and Smith, M. (1998(Time scale for forest regrowth: Abandoned grazing and agricultural areas in southern Norway. Ambio 27, 456-460.

42. Tavares, A.O., Pato, R.L. and Magalhdes, M.C. (2012) Spatial and temporal land use change and occupation over the last half century in a pen-urban area. Applied Geography 34, 432-444.

43. Thingstad, P.G., Skjeggedal, T. and Markhus, G. (2003) Human-induced alteration of two boreal forest landscapes in central Norway, and some possible consequences for avian fauna. Journal for Nature Conservation 11, 157- 170.

44. Tomaz, C., Alegria, C., Monteiro, J.M. and Teixeira, M.C. (2013) Land cover change and afforestation of marginal and abandoned agricultural land: A 10year analysis in a Mediterranean region. Forest Ecology and Management 308, 40-49.

45. van Dessel, W., van Rompaey, A., Poelmans, L. and Szilassi, P. (2008) Predicting land cover changes and their impact on the sediment influx in the Lake Balaton catchment. Landscape Ecology 23, 645-656.

46. van Gils, H., Batsukh, O., Rossiter, D., Munthali, W. and Liberatoscioli, E.(2008) Forecasting the pattern and pace of Fagus forest expansion in Majella National Park, Italy. Applied Vegetation Science 11, 539-546.

47. Viedma, O., Moreno, J.M. and Rieiro, I. (2006) Interactions between land use/land cover change, forest fires and landscape structure in Sierra de Gredos (Central Spain). Environmental Conservation 33, 212-222.

Supplementary material from the review on actors of landscape change

APPENDIX A

Table A.1. Examples of initiatives that can or cannot be considered ILIs (those which, in sum, qualify as ILIs are highlighted).

Initiative	Foster the provision of a broad range of landscape services	Work at a landscape scale	Involve inter-sectorial coordination	Support multi-stakeholder processes	Are highly participatory	Work mainly on a non-profit basis
Land-schafts-pflege-verband Harz (Germany)	YES. Nature conservation, localised food production, rural livelihoods, outdoor recreation for local people, etc.	YES. Involve different land uses: Mines, grassland, meadows, pastures and moorland	YES. Farming, local products promotion, and nature conservation	YES. Individuals, farmers, companies, associations, and the rural district and municipality of Harz	YES. Cooperation processes, partnerships, participatory events (guided walks) and publications	YES
The Farmer Network (UK)	NO. Localised food production	NO. Focuses on farming business	NO. Farming	NO. Farmers	YES. But only for the farming community	YES
Falkland Centre for Steward-ship (UK)	YES. Nature conservation, localised food production, rural livelihoods, tourism, outdoor recreation, cultural heritage, local identity, fulfilment, and other	YES. Involve different land uses	YES. Land promotion, conservation, farming, food production, heritage management, awareness raising, etc.	YES. Local community, volunteers, visitors, and farmers	YES. Volunteering, active involvement of the local community through different events (guided walks, picnics, storytelling, etc.) and invitations (courses, farming plots renting, etc.)	YES
Friends of the Lake District (UK)	YES. Nature conservation, tourism, outdoor recreation, cultural heritage, local identity, fulfilment, and other	YES. Involve different land uses	YES. Sustainable landscape development, conservation, awareness raising, and land promotion	YES. Local community, volunteers, visitors, landowners, and farmers	YES. Volunteering, becoming a member, public consultation, and education activities	YES
Czech UNESCO Heritage (Czech Republic)	NO. Cultural tourism and heritage	NO. Focuses on monuments	NO. Touristic promotion	NO. Visitors	NO	YES
The Land-scape Architects Associa-tion of Romania (Romania)	NO. Cultural and aesthetic values	NO. Punctual interventions on parks and urban spaces	NO. Landscape architecture	NO. Landscape architects	NO	YES

APPENDIX B

Tables B.1 to B.5. Activities and outcomes clustered in subgroups within the 5 domains and index of success

FARMING AND AGRICULTURE

Activities	Outcomes	Subgroups	Success index	
			Median	Mean
Promotion of native food species and agricultural biodiversity Promotion or introduction of new crops or varieties	Agricultural biodiversity was protected or enhanced	Protection or enhancement of agricultural biodiversity	0%	17%
Reduce the environmental negative impacts of agriculture Expansion of agroforestry Soil conservation practices Livestock management with agro-ecological methods	Negative impacts of agriculture on environment were reduced	Reduction of the negative impacts of agriculture on environment	0%	32%
New supply chain or marketing for local and sustainable products	New channels for commercialisation of local and sustainable products were created	Creation of new channels for commercialisation of local and sustainable products	0%	11%
Capacity building to support sustainable agriculture	Support for sustainable agriculture was generated among the members of the initiative and the general public, by strengthening interest in local and organic products	Support for sustainable agriculture among the members of the initiative and the general public	0%	20%

CONSERVATION AND NATURAL RESOURCE MANAGEMENT

Activities	Outcomes	Subgroups	Success index	
			Median	Mean
New protected areas established New management plans for existing protected areas	Rare or endangered species were better protected Connectivity of natural habitats was increased Overall biodiversity of the region was better protected	Protection of the natural areas and biodiversity of the region	0%	31%
Capacity building programs to support natural resource management	Support for ecosystem management was generated among the members of the initiative and the general public, by strengthening interest in and a sense of nature	Support for ecosystem management among the members of the initiative and the general public	0%	30%
Watershed management activities	Water quality, quantity or regularity improved	Accurate watershed management	0%	23%
Localised renewable energy supply	New local renewable energy installations were set up	Installation of new local renewable energy	0%	8%
Mitigate climate change Reduce vulnerability to extreme weather events Community based natural resource management activities Improved fisheries management Improved forestry management	Ecosystem services that support agriculture were restored or protected Other ecosystems services were restored or protected	Protection and restoration of the ecosystem's regulation and maintenance services	0%	23%

MULTI-SECTORIAL COORDINATION AND PLANNING

Activities	Outcomes	Subgroups	Success index	
			Median	Mean
Strengthen existing coordination bodies Creation of new landscape coordinating Dialogue and mediation of conflicts among local communities or resource users Strengthen the local sense of community	Coordination and cooperation among stakeholders improved Coordination and cooperation among sectors improved	Improvement of the cooperation in issues related to landscape among stakeholders and sectors	100%	66%
Dialogue and mediation of conflicts between local communities and external stakeholders	Local communities became more empowered to negotiate and participate in political decision making			
Capacity building activities in integrated landscape management Technical assistance to support integrated landscape management Communication, education and awareness raising regarding issues affecting the landscape	Local ecological knowledge was increased. Local communities better able to sustainably manage agriculture, cultural heritage and natural resources Traditional and local knowledge on agriculture and natural resources has been preserved and used	Support of integrated landscape management, including traditional local knowledge among the initiative's members and the general public	100%	76%

HERITAGE, CULTURE AND TRADITIONS PROTECTION

Activities	Outcomes	Subgroups	Success index	
			Median	Mean
Promote the cultural and historical physical heritage	The material heritage of the area was protected, promoted and / or made accessible for the public	Protection and promotion of the cultural and historical physical heritage	100%	52%
Preserve the traditional knowledge and culture	Research about the culture, traditions and history of the area was developed Activities to enhance traditional knowledge and culture of the area were created Support for culture and heritage protection was generated amongst the members of the initiative and the general public, by strengthening interest in traditional knowledge, local culture and history	Support for traditional knowledge, local culture and history protection among the members of the initiative and the general public	100%	56%

Other literature reviews linked with the project

1. van Vliet, J., de Groot, H.L.F., Rietveld, P., Verburg P.H. (2015) Manifestations and underlying drivers of agricultural land use change in Europe, Landscape and Urban Planning 01/2015; 133:24–36.
2. van Zanten B. T., Verburg, P. H., Koetse, M., van Beukering P. J. H. (2014) Preferences for European agrarian landscapes: A meta-analysis of case studies, Landscape and Urban Planning 132, 89–101.
3. Plieninger, T., Bieling, C., Fagerholm, N., Byg, A., Hartel, T., Hurley, P., López-Santiago, C. A., Nagabhatla, N., Oteros-Rozas, E., Raymond, C. M., van der Horst, D., Huntsinger, L. (2015) The role of cultural ecosystem services in landscape management and planning, Current Opinion in Environmental Sustainability, Volume 14, Pages 28-33.
4. Hernández- Morcillo, M., Hoberg, J., Oteros-Rozas, E., Plieninger, T., Gómez-Baggethun, E., Reyes-García, V. (2014) Traditional Ecological Knowledge in Europe: Status Quo and Insights for the Environmental Policy Agenda, January/February 2014 3, 56(1).