

Chapter 2

Landscape Change in Europe



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Abstract The study of the evolution and change of landscapes' ecological conditions through history has fascinated professional and amateur scientists for centuries. However, the understanding of why these changes happen and what these changes fully entail is still an emerging field of research, which nowadays broadly covers the study of the evolution of landscapes as complex social-ecological systems. This field has become particularly relevant in the current context of rapid global change, widespread environmental degradation and increasing land use conflicts, as an important source of information to facilitate sustainable landscape management. In this chapter, we provide an overview of the current state of landscape change research in Europe and of the main findings and methodological challenges therein. These methodological challenges are bound up with the complex, dynamic and interlinked nature of landscapes, which require co-designed approaches that combine different perspectives, such as quantitative analysis with participatory approaches, and that capture diverse spatial and temporal scales. Together, these make it possible to achieve a comprehensive understanding of past changes and future trajectories.

Keywords Land use and land cover change · Intensification · Abandonment · Drivers of change · Transdisciplinary approaches

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T. Weith et al. (eds.), *Sustainable Land Management in a European Context*, Human-Environment Interactions 8, https://doi.org/10.1007/978-3-030-50841-8_2

2.1 Introduction

Landscapes are dynamic; the use of the land is in constant change as societal aspirations and natural conditions evolve. The ever-growing human capacity to modify landscapes raises concerns about the consequences these changes will bring for humans' and nature's well-being. Knowing more about land use patterns, rates of land use change and the drivers behind them are all important in preventing and reducing tensions between conflicting land uses, predicting future scenarios, developing strategies to achieve more desirable futures and designing adequate policies. In Europe, the study of landscape changes is currently developing rather vividly, in part driven by initiatives by the Council of Europe and the European Union. Here, we refer to "landscape change" as an umbrella concept for the different forms of land use change and land cover change.

In this chapter, we present an overview of landscape change research developed in Europe, focusing on meta-studies, case-study research and cross-site comparison studies of European landscapes that identify processes and trajectories in land use changes and the driving forces behind them. This chapter is organised into five sections: Sect. 2.2 an introduction to the current state of landscape change research in Europe, where we also present the studies included in this overview; Sects. 2.3, 2.4 and 2.5 a review of the main findings of these studies on the trends, drivers and future scenarios of landscape change; and Sect. 2.6 a summary of research gaps and possible ways forward for landscape research towards sustainable land management.

2.2 Landscape Change Research in Europe

In Europe, landscape research dates back to the nineteenth century, when Alexander von Humboldt (1769–1859) and Carl Ritter (1779–1859) introduced the term "landscape" (*Landschaft* in German) as a scientific concept (Kirchhoff et al. 2013). Since then it has developed as a vibrant field of study, particularly after the beginning of the twenty-first century, when the German geographer Carl Troll (1899–1975) coined the term "landscape ecology" to examine the reciprocal interactions between social and ecological processes (Turner 2005). At a political level, landscape research has received increasing attention since the 1970s. It was at this time that environmental sustainability concerns gained momentum and became a target of United Nations development programmes, and scholars and policymakers realised the need to overcome the shortcomings of single-sector policies and management strategies, which prompted the adoption of the "landscape approach" (Sayer et al. 2013). One of the milestones in the inclusion of the landscape approach in the political agenda was the European Landscape Convention, in which landscapes were defined as the result of the interaction of natural and human factors (Council of Europe 2000).

Overall, there have been concerns that landscape changes are of such magnitude that societies can no longer accept them without putting landscape sustainability

at risk (Antrop 2005; Bürgi et al. 2017; Plieninger et al. 2016). According to this perspective, understanding the causes, processes and outcomes of landscape change is becoming absolutely crucial (Plieninger et al. 2016). For this reason, landscape change research has become an emerging field, in which quantitative approaches to measure the expansion or decline of different land covers and changes in land use intensity have coevolved with more qualitative studies that have tried to understand what is driving such changes. More specifically, landscape researchers argue that being aware of and understanding the rates and patterns of change, as well as the driving forces behind them is necessary for context-specific and effective policy-making and for taking action towards more sustainable land management (Jepsen et al. 2015; Kuemmerle et al. 2016; Levers et al. 2015). Here, we understand “sustainable land management” as a multidimensional and evolving concept, in which a diverse range of stakeholders are involved and where ecological, economic and social aspects need to be integrated; this means that no single definition is explanatory enough (Weith et al. 2013). Such knowledge on the trends and drivers of landscape change contributes to exploring and mitigating trade-offs and impacts on biodiversity and ecosystem services. These trade-offs result from land management practices (Kuemmerle et al. 2016; Levers et al. 2015) in the context of increasing competition for land for multiple and sometimes incompatible uses (Levers et al. 2016; Pérez-Soba et al. 2015; Verkerk et al. 2018). Finally, a comprehensive understanding of how and why landscapes have changed facilitates the anticipation and projection of possible future scenarios, which in turn may be used to develop land management strategies and policy decisions to avoid undesirable futures (van Vliet et al. 2015; Verkerk et al. 2018).

The study of landscape change can be broadly divided into: (1) land cover change and (2) land use and management intensity change (Erb 2012; Levers et al. 2015). Land cover change is understood as the “alterations of biophysical characteristics of the Earth’s surface”, such as the spreading of forests or the reduction of agricultural land; while land use and management intensity change are defined as the “changes in the levels of socioeconomic inputs (e.g., labour, resources, water, energy or capital) and/or altered outputs (value or quantity) per unit area and time” (Erb 2012, p. 8). Erb (2012) and Verburg et al. (2013a) suggested that the former has been more commonly studied due to the availability of land cover datasets and the methodological challenge of quantifying and understanding land use intensity and intensification processes. However, in the past decade, the study of intensification processes has become a significant topic (e.g. Levers et al. 2014, 2016). In addition to that, substantial research has focused on identifying drivers of change to understand why landscapes change or remain unchanged, why they evolve faster or slower and to identify the causal mechanisms of regime shifts (Kizos et al. 2018). Studies typically differentiate between proximate drivers—i.e. the human actions that have a direct effect on the landscape changes; and underlying drivers—i.e. the social and ecological factors that trigger those human actions (van Vliet et al. 2015). In recent years, the study of landscape change has further broadened to identify patterns of landscape stability (i.e. land cover types that remain unchanged over a certain period; Lieskovský and Bürgi 2018) and their related stabilising factors.

This knowledge can help to protect and manage valuable landscapes in a rapidly changing world and regulate undesirable land use changes (Lieskovský and Bürgi 2018). Finally, there has been a focus on analysing how current trends would evolve in the future under different political, environmental and socioeconomic scenarios (Verburg et al. 2013a; Stürck et al. 2018; Verkerk et al. 2018). In this sense, the implementation of transdisciplinary projects has been discussed as a promising approach in land use science in order to address complex multifaceted “real-world problems” and to design strategies and solutions for sustainable development (Zscheischler et al. 2017). Transdisciplinary approaches are defined as a collaborative process of knowledge production that involves scientists from different disciplines and societal actors to address highly complex, real-world problems (e.g. Pohl 2008; Wickson et al. 2006). Transdisciplinary research has become a widespread research approach in sustainability science and is increasingly promoted by research programmes and agencies (e.g. Future Earth). It can develop collaborative research approaches in land use science to bring promising means of initiating change in the current course of action (Zscheischler et al. 2017).

The study of agricultural and forestry changes has become particularly exhaustive, not only because agriculture and forestry are the most extensive land cover types in Europe, but also because they have significant impacts on the provision of a wide range of services (regulating, provisioning and cultural) (van Vliet et al. 2015) and on the environment at large (Levers et al. 2016). The study of agricultural and forestry intensification has gained attention (Levers et al. 2014, 2016; van der Sluis et al. 2016) under the assumption that knowledge on the processes and trade-offs of intensification is necessary to mitigate its negative impacts in a context of rapidly changing resource demand (Erb 2012; van der Sluis et al. 2016). While some areas face processes of intensification, land use disintensification and abandonment are also important landscape change processes occurring in Europe (Plieninger et al. 2016). “Disintensification” refers to changes to reduce the intensity of land management and the contraction of agricultural land, including abandonment (see van Vliet et al. 2015); while “abandonment” describes the abandonment of any area previously used for agricultural purposes, including croplands and grazing areas (see Benayas et al. 2007). Both intensification and its counterpart have important social and ecological consequences, and have become equally important in sustainable landscape management research (Alcantara et al. 2012; Levers et al. 2016; Plieninger et al. 2014).

Considering the different objectives and questions addressed, Bürgi et al. (2017) identified three main approaches to landscape change research:

- *Local case studies* to grasp the specifics of a place and its development, which is essential for the systematic understanding of local changes. Research usually takes place via oral history interviews, local texts and historical maps (e.g. Bürgi et al. 2017; Lieskovský and Bürgi 2018).
- *Large-scale analyses* to search for the main trends and processes over large areas using European spatial and statistical data analysis (e.g. Kuemmerle et al. 2016) and broad-scale narratives (e.g. Jepsen et al. 2015).

- *Meta-analyses* and overview publications to identify general patterns within the case studies on how specific landscape characteristics and socioeconomic circumstances in combination with potential driving forces can lead to predictable change (e.g. van Vliet et al. 2015).

In the next section, we present an overview of the findings of 18 studies on recent major landscape change trends and driving forces at the European level (from a few decades to 200 years). These studies have been carried out taking a pan-European approach, including both European large-scale analysis studies and meta-analysis of case studies (see Table 2.1). These studies were performed within two collaborative projects sponsored by the EU—HERCULES (Sustainable Futures for Europe’s Heritage in Cultural Landscapes) and VOLANTE (Visions of land use transitions in Europe). Both projects share many features with the BMBF’s Programme on Sustainable Land Management, such as in taking a systems perspective on landscapes, in investigating the links between land management and ecosystem services and in creating actionable knowledge for land use policy and practice.

2.3 Trends in Land Use and Land Cover Change

A recent large-scale analysis of land use changes in Europe between 1990 and 2006 undertaken by Kuemmerle et al. (2016) serves as an appropriate starting point to introduce this section. The current composition of land cover types in Europe is dominated by agricultural land (representing 41.1% of the territory, mainly dedicated to arable land, permanent crops and grassland), followed by forest land (32.6%) and unused or abandoned land (15.8%), leaving the remaining land to urban and industrial areas and infrastructure (Eurostat 2017). The main land cover change in recent decades identified in this study is a decrease in croplands, followed by an expansion of areas covered by pastures and forests (partly due to the aforementioned decrease in crop production) and, to a lesser extent, by an increase in urban land (Fig. 2.1; Kuemmerle et al. 2016). The most dramatic declines in croplands were found in the east of Europe and the Mediterranean, while some hotspots for their expansion were found in areas of the Netherlands, Germany, France and Ireland (Kuemmerle et al. 2016). The expansion of urban land happened mainly around capital cities and along the Mediterranean coast (Kuemmerle et al. 2016; Levers et al. 2015).

Interestingly, in contrast to the widespread perception that landscapes have been undergoing intense transformation in Europe, Levers et al. (2015) and Kuemmerle et al. (2016) identified stability in land cover as one of the most common recent trajectories, particularly in Central, Western and Northern Europe. Lieskovský and Bürgi (2018) carried out a study of the persistence of the land cover across Europe since 1900 (Fig. 2.2) and found that the most persistent land covers were forests and settlements (about 80% of the 1900-era forest cover and settlement areas were persistent), while grasslands and croplands were the most dynamic and least persistent ones.

Table 2.1 Studies synthesised in this chapter

Study	Approach	Major contribution to landscape change research in Europe
Alcantara et al. (2012)	Large-scale analysis (Eastern Europe)	Advanced research methods for mapping abandoned agricultural land at broad scales by using coarse-resolution satellite imagery and plant phenology data. It also provided some insights into agricultural abandonment trends in Eastern Europe
Prishchepov et al. (2012)	Large-scale analysis (Eastern Europe)	Used the case of the collapse of socialism in Eastern Europe and the former Soviet Union as a natural experiment to investigate whether the rates of agricultural land abandonment responded to different types of institutional changes, based on multi-seasonal Landsat TM/ETMC satellite images
Griffith et al. (2013)	Large-scale analysis	Assessed agricultural land change in the Carpathian ecoregion from 1985 to 2010, using Landsat imagery
Verburg et al. (2013b)	Review	Provided an overview of current research practices in landscape assessments and advocated a land use change research approach that would not only focus on dominant land covers, but also on the landscape structure and composition, and its importance for the functioning of the landscape
Levers et al. (2014)	Large-scale analysis	Compiled time series of sub-national forest harvesting intensity patterns in Europe from 2000 to 2010 and quantified the influence of a wide set of biophysical, infrastructure-related and socioeconomic variables in shaping these patterns

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Table 2.1 (continued)

Study	Approach	Major contribution to landscape change research in Europe
Munteanu et al. (2014)	Meta-analysis	Analysed broad landscape change configurations and processes over the past 250 years as well as the underlying drivers. This meta-analysis covered the Carpathian region, using 102 case studies from 66 publications
Plieninger et al. (2014)	Meta-analysis (Mediterranean Basin)	Examined the consequences of land use abandonment on biodiversity in the Mediterranean Basin and found that the directions and intensities of response in species richness and abundance to land abandonment were heterogeneous and context-dependent throughout the Mediterranean region
Estel et al. (2015)	Large-scale analysis (Europe)	Developed a new methodology to map the extent and spatial patterns of active and fallow farmland annually at a continental scale based on MODIS satellite data
Jepsen et al. (2015)	Large-scale analysis (Europe)	Went back 200 years to identify broad management regimes and the institutional, social and technical forces within each regime that drove land use changes in Europe. The study combined narratives of change compiled by land use experts with quantitative data
Levers et al. (2015)	Large-scale analysis	Identified and mapped landscape archetypes as well as archetypical change trajectories of landscapes between 1990 and 2006 using a clustering approach based on self-organising maps and 12 land use indicators

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Table 2.1 (continued)

Study	Approach	Major contribution to landscape change research in Europe
van Vliet et al. (2015)	Meta-analysis	Systematically analysed case studies on land use change to provide a review of the manifestations and underlying drivers of agricultural land change in Europe in recent decades
Kuemmerle et al. (2016)	Large-scale analysis	Studied spatial patterns in the distribution of hotspots and cold spots of land cover and land use intensity changes across Europe between 1990 and 2006. The study made use of European statistical data to compile a database of high-resolution land use change indicators
Levers et al. (2016)	Large-scale analysis	Provided insights into broad-scale agricultural intensity patterns in Europe between 1990 and 2007 by focusing on yields and fertiliser application for six major crop-type groups
Plieninger et al. (2016)	Meta-analysis	Systematically reviewed 144 studies to provide insights into the driving forces of landscape change in Europe
van der Sluis et al. (2016)	Cross-site comparison	Analysed 437 landowner interviews in relation to changes in land use intensity and agricultural production in six case studies in Europe between 2001 and 2011
Bürgi et al. (2017)	Cross-site comparison	Analysed landscape changes in the last 150 years, their drivers and the perception of these changes by locals in six European municipalities. The study combined land use and land cover analysis based on historical maps with oral history interviews

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Table 2.1 (continued)

Study	Approach	Major contribution to landscape change research in Europe
Lieskovský and Bürgi (2018)	Cross-site comparison and large-scale analysis	Presented an innovative approach to studying patterns of landscape stability and the corresponding stabilising factors. The paper developed a persistence index, and combined different scales of analysis using historical land cover and topographic maps
Verkerk et al. (2018)	Large-scale analysis	Built on existing participatory scenarios of desired land use configuration in Europe and plausible future projections based on current conditions to identify potential policy pathways to link the two

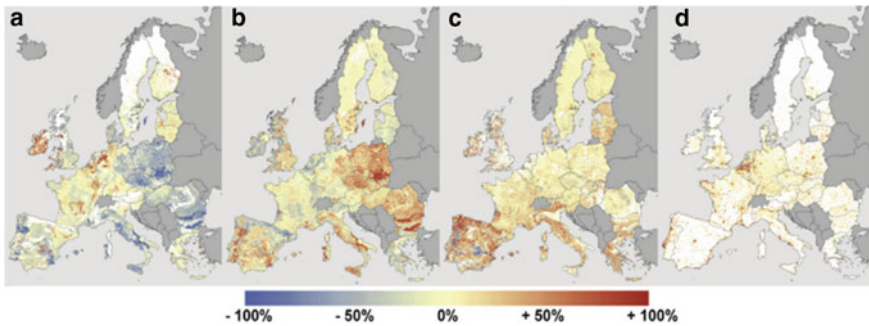


Fig. 2.1 Relative area changes in the extent of: **a** cropland, **b** pasture, **c** forestland and **d** urban land in Europe between 1990 and 2006. *Source* Kuemmerle et al. (2016) (images C and D in the original figure have not been included here)

Some crops, such as vineyards, agriculture mosaics and orchards, displayed a larger degree of persistence than others. For example, olive groves persist in a landscape over long timelines even after being abandoned. Hotspots of persistence were found in remote areas where conversion into intensive agriculture would not be viable, but also in areas particularly suitable for agriculture that have remained stable. Hotspots of change were also found in areas of major political instability, such as in the Baltic area or in areas in the south of Europe.

While land cover in Europe has remained relatively stable, the level of intensity in which the land has been used and managed has not. In fact, in the past few decades, European land use has predominantly changed along intensification gradients (Kuemmerle et al. 2016). In light of these changes, land use intensity as

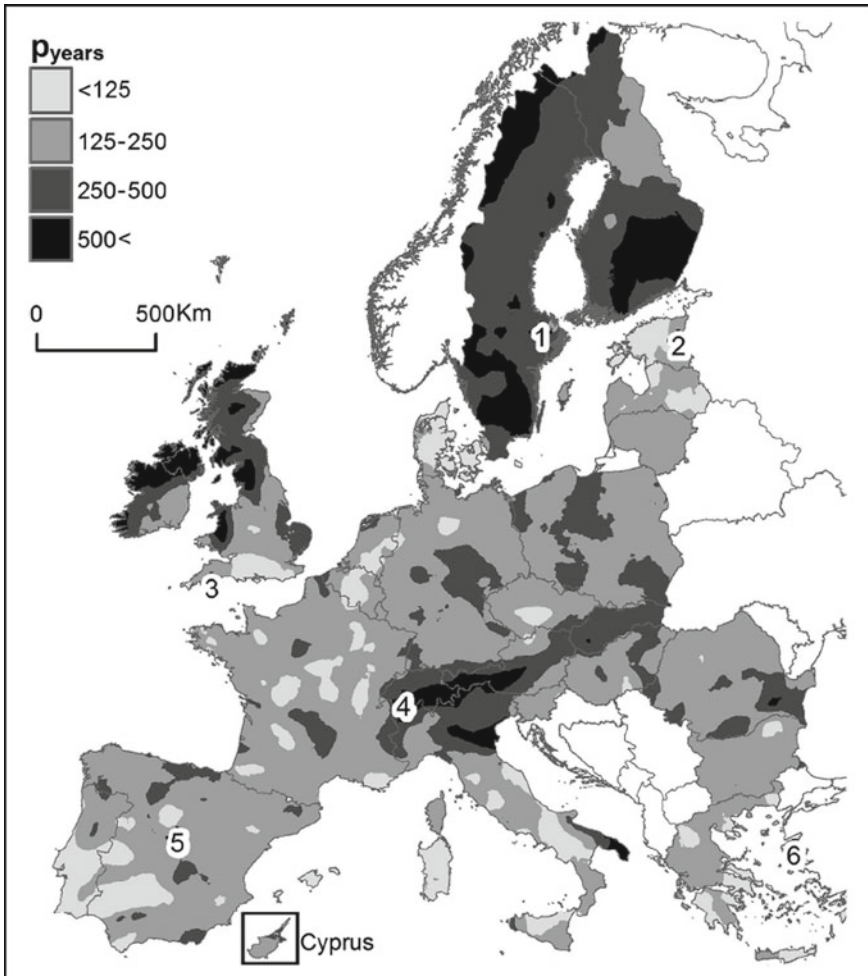


Fig. 2.2 Persistence index for Europe (years needed for the transformation of land cover if it would occur at the same speed as it occurred in the time period 1900–2010). *Source* Lieskovský and Bürgi (2018)

such has become a key area of study. Comparing these levels of intensity provides a comprehensive picture of how European landscapes have evolved (e.g. croplands may present very different characteristics depending on the intensity of how agricultural production is carried out).

There are two main processes of intensity changes: disintensification and intensification (Plieninger et al. 2016) of agriculture and of forestry. van Vliet et al. (2015, p. 28) reviewed 218 case study research articles on agricultural land use change, and defined these processes in the following way:

- “Intensification of agricultural land primarily manifests itself as an increase in land management intensity, for example through increase in livestock density or mechanization. In addition, intensification was observed as an expansion of agricultural land, a decrease in landscape elements, changes toward more intensive agricultural activities and specialization of land use activities”
- “Disintensification of agricultural land is primarily manifested as contraction, partly caused by farmers abandoning their land, but also partly caused by conversion to urban land and natural areas. To a lesser extent, disintensification is manifested as a decrease in land management intensity, as a change to a less intensive agricultural activity, as on-farm diversification and as an increase in landscape elements.”

The most prominent process, as highlighted by several authors, is the disintensification of land use (Kuemmerle et al. 2016; Plieninger et al. 2016). Kuemmerle et al. (2016) found this process in approximately 30% of Europe’s coverage, while intensification processes were present only in about 11%. Expansion and contraction of the agricultural land area and agricultural abandonment has always occurred (Alcantara et al. 2012); however, agricultural land abandonment in Europe became the most prominent change after 1990 (Estel et al. 2015; Levers et al. 2016; Plieninger et al. 2016). This is partly due to the drastic institutional and socioeconomic reorganisation that occurred after 1990 in former socialist countries, where land abandonment has been particularly prominent (Griffiths et al. 2013; Levers et al. 2015; Prishchepov et al. 2012). For instance, cropland abandonment was the most common land use change in the Carpathians (Griffiths et al. 2013; Munteanu et al. 2014). Land abandonment has also been particularly intense in remote mountain areas, less productive soils and areas where urbanisation processes have been intense, such as on the Mediterranean coast (Levers et al. 2015). Notwithstanding the magnitude of this process, some authors have claimed that land abandonment has not yet received enough attention, in part due to general attention to the worldwide expansion of land management activities and accelerating competition for land (Estel et al. 2015; Plieninger et al. 2016).

Land use intensification was most pronounced between 1960 and 1980, and since that decade, intensity levels have remained stable (Fig. 2.3; Kuemmerle et al. 2016; van der Sluis et al. 2016). When looking at crop yields and the amounts of nitrogen and pesticide application as indicators of land use intensity in recent decades, crop yields have stabilised, while nitrogen and pesticide use has generally decreased thanks to increased farming efficiency, greater environmental awareness and more restrictive regulations (van der Sluis et al. 2016). These increasing yields were most pronounced in Western Europe (Kuemmerle et al. 2016). It is also in Western Europe where nitrogen application rates were higher, although the use of nitrogen has decreased since the 1990s. As for the use of fertilisers, declines were observed in Southeastern Europe (e.g. in Romania) and in some countries from Central and Western Europe (e.g. in Germany and France), while there were increases in some Eastern countries (e.g. in Poland) (Kuemmerle et al. 2016).

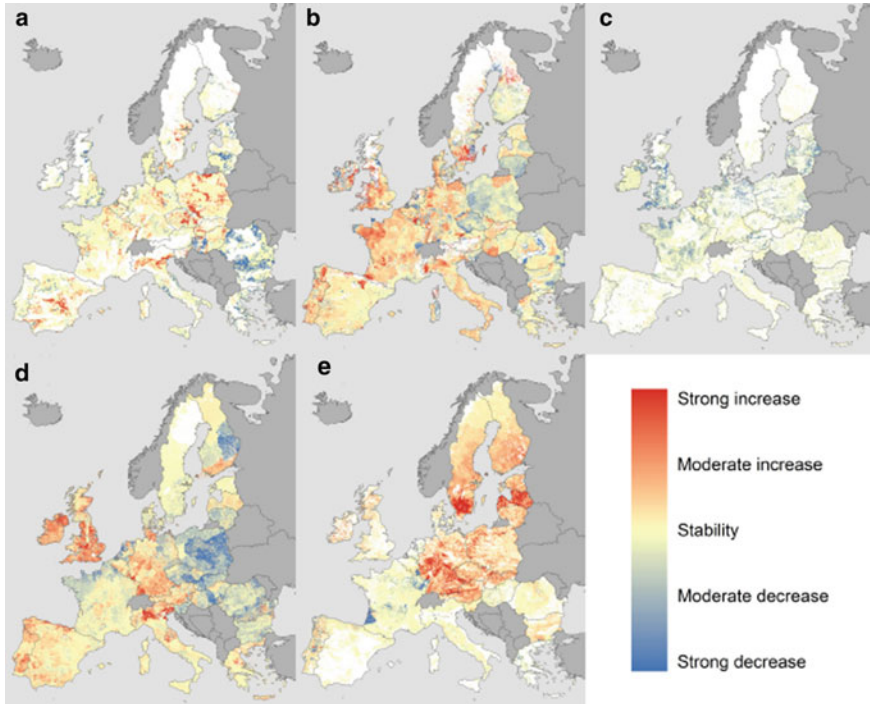


Fig. 2.3 Spatial patterns of changes in intensity: **a** fertiliser use on cropland, **b** crop yields, **c** livestock density, **d** biomass removal from grazing land and **e** roundwood production within broad land use classes in Europe between 1990 and 2006. *Source* Kuemmerle et al. (2016)

Summing up, in line with the geographic patterns of land cover change, since the 1990s intensification of agriculture has mainly taken place in Northern and Western Europe, while land abandonment and disintensification has prevailed in Eastern and Southern Europe (Kuemmerle et al. 2016; Levers et al. 2015; Plieninger et al. 2016).

However, when narrowing down the scale of analysis, land use intensification and abandonment often appear together within the same landscape (Plieninger et al. 2016). van Vliet et al. (2015) identified this mutual occurrence as a major trajectory of land use change in Europe as a result of the globalisation of agricultural markets. This polarising trend leads to a homogenisation of the landscape, where more productive areas are immersed in specialisation and intensification processes, concentrating most of the production, while marginal areas are abandoned as its use as agricultural land turns unprofitable (Levers et al. 2015), with the loss of traditional agricultural landscapes as one of the consequences (Kuemmerle et al. 2016). In the same vein, due to differences in the productivity of regions, the intensification of forestry did not necessarily happen in areas where forest land cover was expanding (Levers et al. 2015). In fact, forest cover expanded in areas that had been abandoned (Kuemmerle et al. 2016; Levers et al. 2015).

2.4 Drivers of Landscape Change

Plieninger et al. (2016) identified five groups of underlying drivers of landscape change: political/institutional (e.g. agricultural and forest policy, spatial development policy and property rights); economic (e.g. structural changes in agriculture, prices for agricultural products, market growth and commercialisation); technological (e.g. modernisation of society and land management, such as introduction of mineral fertiliser and tractors; Jepsen et al. 2015); cultural (e.g. demography, attitudes and behaviour); and natural/spatial (e.g. climate, topography and spatial configuration). It is important to note that these different types of drivers are usually combined (Plieninger et al. 2016). Here, we describe some of the most frequently mentioned ones.

2.4.1 *Political and Institutional Drivers*

Political and institutional factors, such as policies that regulate agriculture, forestry and spatial development, land reforms and property rights, appear as the dominant drivers of change in various studies (e.g. Jepsen et al. 2015; Munteanu et al. 2014; Prishchepov et al. 2012).

On a broad political and institutional scale, Jepsen et al. (2015) reviewed narratives on the drivers of land use change to provide a broad storyline of the succession of the main land management regimes in Europe in the last two centuries. They described two main regimes after World War II that were to have an important impact on land use across Europe. These two regimes help scholars understand the frequently mentioned East–West dichotomy (Kuemmerle et al. 2016; Levers et al. 2015; van Vliet et al. 2015): in Western Europe, the industrialisation regime; in Eastern Europe, the establishment and subsequent collapse of the collectivisation regime (Jepsen et al. 2015). The industrialisation regime in Western Europe was characterised by the introduction of new technologies and the adoption of commercial farming specialised in crop or livestock production oriented towards the global market (Jepsen et al. 2015). In the Eastern European countries, there were two distinct phases. The first phase was the collectivisation regime between 1945 and 1991, characterised by major land reform and the establishment of large collective and state farms and centrally planned intensification of agriculture (Jepsen et al. 2015). The second phase was characterised by the collapse of these collectivisation regimes and the consequent dismantling of the collective farm structure, as well as the state-supported, capital-intensive socialist farming model. Here, the intensity of farming practices persisted, but according to commercial premises. Since then, two trends have been observed in Central and Eastern Europe: on the one hand, the acquisition of former state and collective farms by large agro-businesses and, on the other hand, the orientation towards subsistence farming or the abandonment of the most marginal land (Jepsen et al. 2015).

This East–West dichotomy is particularly recognisable in changes to cropland systems, with fairly constant cropland area but stable or increasing land management intensity in the West, partly due to the strategic support from the EU’s Common Agricultural Policy (CAP) (Kuemmerle et al. 2016); and abandonment in the East (Kuemmerle et al. 2016; Plieninger et al. 2016; Prishchepov et al. 2012). However, there are also regional differences on how institutional and political drivers have affected landscape change patterns. For example, national policies during Soviet times led to agricultural expansion in some areas (e.g. Hungary) and to abandonment of agriculture in others (e.g. Romania) (Munteanu et al. 2014). Prishchepov et al. (2012) observed higher abandonment rates in countries with changing or inadequately established institutions designed to regulate land use changes (e.g. Latvia, Lithuania and Russia).

Since the entry of Eastern countries into the EU starting in 2004, the situation has changed. Jepsen et al. (2015) identified a new regime beginning in the 1990s all over Europe driven by environmental awareness of the impact of agricultural production, triggering agro-environmental policies that have subsequently had an impact on land use and land cover across Europe.

Political and institutional drivers are also important explanatory factors of the prevalent land cover stability observed especially in Western Europe. Land use policies frequently hinder drastic changes in landscapes across the EU, for example by providing economic support to farmers in less favoured areas (Levers et al. 2015). The CAP plays a crucial role in this stability, with the decoupling of CAP payments regarded to be an important element for preserving extensive grazing systems that otherwise would be abandoned (Levers et al. 2015). However, the CAP has also had the opposite effect in some places, leading to land abandonment (Bürgi et al. 2017) and changes in land use when the EU implemented eligibility criteria for payments based on a quota system.

2.4.2 Economic, Technological and Cultural Drivers of Change

Of the driving factors that shape society as a whole, urbanisation in particular appears to be a prominent factor triggering landscape change (Bürgi et al. 2017). In Europe, almost 75% of the population nowadays live in urban areas (Eurostat 2016), which typically have expanded at the expense of agricultural land. The rural exodus due to diminishing income opportunities in marginal areas in contrast to increasing opportunities in urban areas is one of the most recurrent sociocultural drivers explaining land abandonment (Levers et al. 2015). Moreover, with an increasingly urban society, new uses such as recreation activities have emerged around urban areas that can compete with agriculture and forestry activities (van Vliet et al. 2015). Urbanisation is typically accompanied by an increased purchasing power and higher demand for

commodities. This in turn translates into increasing pressure on ecosystems and a specialisation of the service supply of many landscapes (Verburg et al. 2013b).

Globalisation and other related economic drivers have also brought about important changes in land use. The global agriculture market has pushed farmers to intensify their production methods in order to remain competitive, while those that do not succeed have had to find their livelihood outside agriculture. This has often led to the abandonment of areas with less favourable conditions (van Vliet et al. 2015). Another consequence of globalisation is the specialisation of farm production, with the expansion of monocultures and the “outsourcing” of, for example, fodder production not only outside of livestock farms, but even outside Europe. This decreases the need to intensification of production in Europe and contributes to the abandonment of those areas that are less suitable for agriculture (Levers et al. 2015). The technological innovations associated with globalisation have also brought about important changes in farming systems (Bürgi et al. 2017). Mineral nitrogen application is one of the most mentioned technological innovations when studying the intensification of agriculture. This has important effects on landscape configuration, with the disappearance of traditional features and a loss of biodiversity (van Vliet et al. 2015).

Apart from these commonly mentioned drivers of change, growing environmental, social and political awareness is reflected in land use policies and subsidies, with an increasing focus on environmental management, nature preservation and landscape restoration, rather than on agricultural production (van Vliet et al. 2015). But beyond these institutional levels, farmers’ decisions are also an important factor that can ultimately lead to diverging land use trajectories (van Vliet et al. 2015). Most of these decisions are the result of the behaviour of land owners and land managers responding to market prices and policy incentives in varying ways (Verburg et al. 2013b). While farmers’ attitudes (e.g. productivist or environmentalist) may not be an important driver of land cover changes, they do influence the intensity of management practices (van Vliet et al. 2015).

2.4.3 Spatial and Natural Factors

In the context of urbanisation and globalisation, accessibility is another important factor when explaining the geographic distribution of more intensively or less intensively managed areas. In areas with good accessibility, land use management is often more intensive; in more remote areas, land abandonment is more frequent (Levers et al. 2015). Bürgi et al. (2017) analysed narratives on the driving forces of landscape change, using oral history interviews with local residents in six case studies. They found that access and infrastructure (e.g. railways and highways) were important drivers in most of the cases (Bürgi et al. 2017). With respect to agricultural and forestry production, this means that local products can be exported and therefore, production patterns might change. However, at the same time farmers reported that they needed to become more competitive against products that came from the outside. The flow of people also increases with better accessibility and can bring

about significant changes in the landscape if, for instance, the surrounding areas of a big city turn into commuter cities or second-home areas.

Finally, as Levers et al. (2015) observed, notwithstanding technical improvements and the increasing capacity of humans to modify the land, agro-climatic conditions still constitute an important factor to take into consideration. Intensified crop production prevails in areas with favourable conditions; forest and grasslands dominate in areas with disadvantageous edaphic and climatic conditions, although institutional and socioeconomic factors can alter this pattern to a certain extent. Nevertheless, climate change as a driver of landscape change has still not played a very evident role in the studies considered in this chapter, except for the melting of the glaciers in the Alps (Bürgi et al. 2017).

2.5 Operationalising Current Trends and Drivers of Change Towards Developing Future Scenarios of Landscape Change

In an effort to hinder the tendency towards polarisation of the landscape (intensification or abandonment) and the landscape homogenisation and loss of multifunctionality that results from it, some authors have worked together with stakeholders in the visualisation of future landscape change trajectories. Pérez-Soba et al. (2015) worked with stakeholders representing the main land use sectors in Europe to develop three overarching visions of the desired futures envisaged for Europe. These three visions shared a common ambition: to generate multifunctional land uses in Europe that would integrate multiple social, ecological, economic and cultural demands. Recently, Verkerk et al. (2018) studied potential pathways and policies required to achieve these visions of multifunctionality. These pathways would vary in the specific mechanisms involved, but all of them would entail major interventions across Europe, depending on the environmental and socioeconomic context. In general, the space dedicated to agricultural land would need to be severely restricted in favour of larger, interconnected natural areas. These studies highlighted the challenge of identifying a pathway toward reaching landscape multifunctionality at the local level. This was mostly due to methodological constraints; models still cannot capture many of the complexities associated with multifunctionality at a local-scale resolution. However, Verkerk et al. (2018) pointed out that the policy interventions that were needed to navigate that pathway would necessarily require the strengthening and maintenance of Europe's existing traditional multifunctional landscapes, most of which have been subject to long-term trends of decline.

2.6 Research Gaps and Ways Forward Towards Landscape Sustainability

Without fundamental social and economic changes, the demand for natural resources will multiply in the next few decades. The effects of this growing demand will intensify current land use trends, increasing the impacts described in the previous sections. Therefore, one of the greatest sustainability challenges in landscape change research is to identify strategies that will meet society's demands without further threatening and degrading European landscapes and their functioning. In light of this, a broad array of literature has identified pathways towards tackling the challenges of landscape change research in Europe and beyond (e.g. Bürgi et al. 2004; Plieninger et al. 2016). Here, we use our review to summarise the major contributions and derive key opportunities to make advancements in landscape change science:

- **Research for more context-specific, regionalised policymaking** (Kuemmerle et al. 2016). A deeper understanding of the outcomes of land use change for ecosystem service flows and biodiversity can contribute to mitigating the trade-offs among different land uses. In that regard, one interesting arena for future research would be to derive typologies of typical land use changes and the effects of policy interventions that characterise Europe (e.g. Levers et al. 2015; Kuemmerle et al. 2016). There is also a need for research that advances the study of landscape stability patterns and the drivers behind these patterns (Plieninger et al. 2016) in the local context, which could be very relevant for landscape management and policy.
- **Uncovering the complexity behind the drivers.** Comprehension of the underlying drivers of landscape change remains partial (Jepsen et al. 2015). Landscape research has traditionally considered the spatial determinants of land use changes (e.g. topography, soil quality, market access) and land use decisions as separate items. Future research should incorporate joint analysis that favours an understanding of complex behaviour and the linkages behind the various drivers. In addition, future studies should acknowledge that the landscape change effects of different underlying drivers reveal themselves at different time intervals, making attribution difficult if only short time spans are considered in the analysis (Jepsen et al. 2015).
- **Avoiding oversimplification of the complex realities of the land.** Verburg et al. (2013a) criticised global and supra-regional assessments for oversimplifying the complex reality of landscapes. In that regard, performing cross-site comparison studies based on place-based research (e.g. Bürgi et al. 2017) could help scholars grasp these complex realities behind landscapes. Beyond the spatial scale, another important gap in landscape change studies is the identification and comprehension of the diversity of actors and their role in landscape changes (Plieninger et al. 2016; Kizos et al. 2018). Understanding the inherent complexities of landscape change imply the incorporation of a plurality of research approaches and of underlying

conceptualisations of human–environment interactions that can encompass the full complexity of land use developments.

- **Jointly analysing changes in the extent and intensity of land use and disparate linkages.** In an increasingly connected world, the already ongoing trend of spatial disconnection between production and consumption landscapes will only increase. This entails considerable challenges to sustainability understood as imbalances in environmental degradation. Therefore, it is important to analyse how spatial patterns in changes in the extent and intensity of land use relate to changes in distant places (Kuemmerle et al. 2016).
- **Incorporating innovative approaches to evaluating landscape change, and promoting the co-design of research to address societal problems.** The importance of producing actionable knowledge in collaboration with stakeholders is gaining significance across landscape research (Verburg et al. 2013a). For this, a more participatory approach, in which local knowledge and perceptions are taken into account, is needed. In that regard, previous authors have discussed the importance of combining information on land use changes derived from field and GIS procedures with perceptions of the local population. This facilitated the development of mixed-method approaches and takes advantage of the complementarity and the specific strengths of the inclusion of a variety of types of data sources (e.g. Bürgi et al. 2017).

2.7 Conclusions

Land cover in Europe in the past few decades has remained relatively stable. In those areas where it changed, it has predominately been towards the diminishing of cropland area in favour of grasslands, and a general increase in urban areas. A more nuanced perspective emerges when looking at how the intensity of landscape management has changed. Here, two opposing but co-occurring processes can be seen: the intensification of agriculture on the one hand, and the abandonment of farming activities on the other. Both of these processes generally involve the loss of biodiversity, an erosion of cultural heritage and a diminishing of landscape multifunctionality. These trends have pushed European social-ecological systems beyond the boundaries of environmental and societal well-being. In order to change these trajectories, it is crucial to identify and understand the factors that drive them. Political and institutional drivers seem to be the most prominent ones, but economic, technological, cultural and natural aspects also play a very important role, and need to be considered as well. In this sense, although European-scale studies provide extremely relevant information to identify broad trends and drivers of land cover and land use change, more place-based analyses are needed where different sources of information are combined (by engaging with local stakeholders), various approaches and disciplines are brought together and several temporal and spatial scales are taken into account. This is necessary for a comprehensive understanding of how and why landscapes are changing, and what the consequences of these changes will be.

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