Landscape Research

ISSN: 0142-6397 (Print) 1469-9710 (Online) Journal homepage: https://www.tandfonline.com/loi/clar20

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To cite this article: Theo van der Sluis, Bas Arts, Kasper Kok, Marion Bogers, Anne Gravsholt Busck, Kalev Sepp, Isabel Loupa-Ramos, Vangelis Pavlis, Nicoleta Geamana & Emilie Crouzat (2019) Drivers of European landscape change: stakeholders' perspectives through Fuzzy Cognitive Mapping, Landscape Research, 44:4, 458-476, DOI: 10.1080/01426397.2018.1446074

To link to this article: https://doi.org/10.1080/01426397.2018.1446074

Published online: 09 Apr 2018.

LANDSCAPE RESEARCH
2019, VOL. 44, NO. 4, 458–476
https://doi.org/10.1080/01426397.2018.1446074

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Drivers of European landscape change: stakeholders' perspectives through Fuzzy Cognitive Mapping

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ABSTRACT

Understanding complex processes of landscape change is crucial to guide the development of future landscapes and land resources. Through Fuzzy Cognitive Mapping, we studied the processes of landscape change of six different environmental zones in Europe. Results show that landscapes are complex systems, with many interactions. Except for one, all regions show a strong decline in landscape quality. Dominant drivers are EU policy and the global economy, sometimes in conjunction with environmental drivers or the governance system. The process of change differs for all cases, through urbanisation or land abandonment in some cases, and agricultural intensification in others. The (un)intended effects of policies are difficult to predict. Although some EU Policies directly improve landscape quality, their indirect effects as well as other EU policies outweigh this positive influence and jointly result in a decrease of landscape quality. To counter these negative side effects, targeted landscape policies are urgently needed.

KEYWORDS

Social-ecological systems; complex systems; landscape policy; drivers of change; land management

1. Introduction

1.1. Landscape as social-ecological system

The landscape is dynamic, and continuously changing. Following the European Landscape Convention (ELC), the landscape is 'an area perceived by people whose character is the result of the action and interaction of natural and/or human factors' (Council of Europe, 2000). People have been modifying the landscape for millennia, adjusting its properties to suit their own needs and it is therefore a product of interaction between man and its environment. Where landscapes were initially a reflection of mainly natural conditions, over time they have become more and more influenced by culture and technology (Pedroli, Pinto Correia, & Primdahl, 2016; Vos & Meekes, 1999). In most of Europe, this transition emerged

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around 1850 (Jepsen et al., 2015) with the introduction of technological innovations like the steam engine, which allowed large scale landscape modifications, including agricultural intensification, industrialisation and urbanisation (Meeus, Wijermans, & Vroom, 1990). Today, many of these landscapes lost their typical pattern and functional relations (Pedroli et al., 2016; Van Eetvelde & Antrop, 2004).

In line with the ELC, a landscape can be described as a social-ecological system (SES) (Buizer, Arts, & Kok, 2011). Key to SES is that landscapes are to be considered dynamic human-nature complexes and that they should be governed through adaptive management (Buizer et al., 2011). The dynamics of such complex SES systems are defined by their resilience, adaptability and transformability (Walker et al., 2006). Opdam (2014) and Cáceres, Tapella, Quétier, and Díaz (2015) argue that the wide ranges of spatial and temporal scales in landscape governance can only be addressed with involvement of stakeholders at different scale levels.

Landscapes provide so-called 'landscape services', and management interventions in the ecological system generate added value (Figure 1). This process takes place at the landscape scale, yet, the system is also affected by biophysical and socio-economic processes at higher scales (Opdam, 2014). Examples are the effects of globalisation, the economy, but also public preferences which stem from the social system. Components of the latter may be individuals like farmers or forest managers, but also organised groups, and institutional rules used to guide interactions with and within the ecosystem. Cultural factors like cognition, beliefs, tradition are also part and parcel of the social context. The ecological system is shaped by all these social components, particularly through land use interventions.

1.2. Drivers and processes of landscape change

Drivers of landscape change are determined by the spatial, temporal and institutional scale of the system under study (Bürgi, Hersperger, & Schneeberger, 2004). The driving forces that are propelling change are often categorised as political, economic, cultural, technological and environmental forces

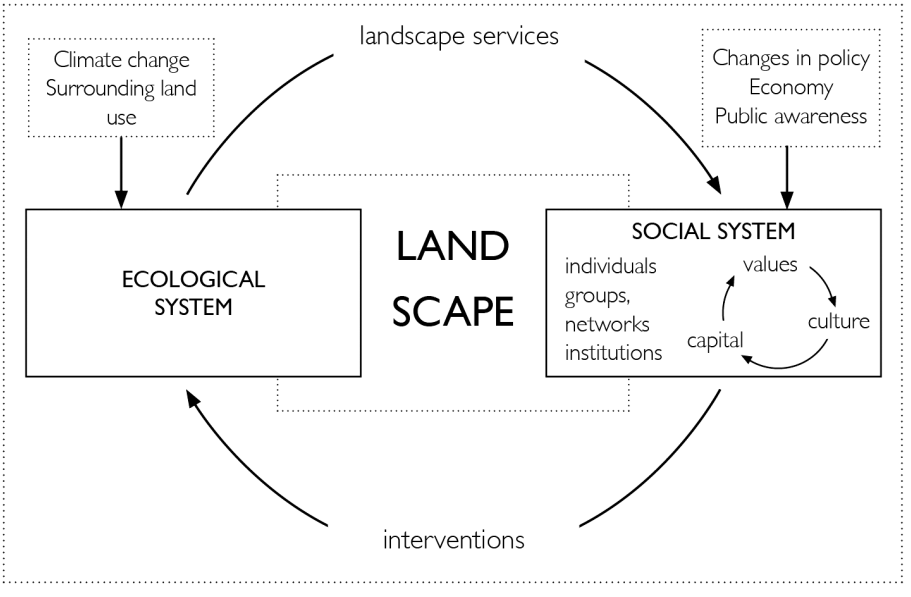

Figure 1. Conceptual framework, the landscape as a social-ecological system provides landscape services for the people (Opdam, 2014). The Social system, comprised of individuals, groups, networks and institutions (rules, regulations and procedures) intervene to obtain goods and services from the landscape. These interventions may include the harvesting of plants, vegetation, animals, management of the agricultural landscape and construction of infrastructure. The interventions directly and indirectly modify ecosystem structure and function. This takes place at the landscape scale, however, the system is affected at higher scale level by biophysical and socio-economic processes.

(Hersperger & Bürgi, 2009; Kristensen, Reenberg, & Peña, 2009). The scale at which they operate also defines the stakeholders that are relevant. Identifying drivers in a system where everything connects to everything is always somewhat artificial. Drivers in this paper are understood as those factors that are relatively unaffected by other factors in the system, and those that are of prime interest. Drivers can be changed, and the sensitivity of other factors on these forces can easily be assessed. They are not necessarily those factors that are most important for the system.

On the local scale, the landscape is often shaped by local land managers, farm managers, estate managers or foresters. The farmer is a major factor in agricultural land use change (Van Vliet, de Groot, Rietveld, & Verburg, 2015), his decisions are partly driven by economic interests but are also rooted in culture and tradition and the farmer accordingly decides for 'appropriate' management (Arts et al., 2013; Ingram, Gaskell, Mills, & Short, 2013). In response to forest policies and economic conditions the forest manager will decide on tree selection, crop rotation length, as well as mono- or multifunctional use of forests (Forest Europe, 2015). In the urbanised countryside of Europe the interaction with urban areas has become important (Kolen & Lemaire, 1999; Van Eupen et al., 2012). Urban residents settle in the countryside, and some part-time farmers also gain income from other activities (Primdahl, 2014). Large parts of the countryside have thus become dynamic areas which are not predominantly used for farming anymore (Woods, 2004). This underlines that the landscape is a complex system.

Policy, landscape governance and economics are essential phenomena to understand the processes of landscape change (Hersperger & Bürgi, 2010). In the past, land use economies and policies were defined at national levels, however, after the establishment of the European Union, with common market integration processes, national policies and economies became more and more Europeanised and affected by global trends and developments (Brussaard et al., 2010). Today, European land use and environmental policies affect all member states, and transposition of EU-law shapes national and regional land use. Also the European economy drives landscape change ever more.

1.3. Tools for landscape analysis

There have been many studies, with different methods, to assess the processes of landscape change. A review from Plieninger et al. (2016) of 144 studies on drivers of landscape change showed that most studies assessed only one case study area at one local spatial scale and they therefore recommend studies that rather do cross-site and cross-country comparisons. They found that some regions are not well covered, for example, the boreal, steppic and arctic landscapes. Plieninger advocates the use of more robust tools and methods to assess quantitatively the causalities of landscape change, which also identify and assess the role of actors (Plieninger et al., 2016). Other studies analyse the drivers of change, and proximate causes of change, but ignore the role of institutions and actors in the landscape change process. In urban development it was found that the local actors, their coalitions and financial resources typically defined the outcome of the process (Hersperger, Gennaio Franscini, & Kübler, 2014).

It is possible to deduce what change processes do occur through an integrated approach with different techniques (spatial analysis, in-depth interviews repeated over time), and occasionally such studies are done at a local or regional scale (Pedroli, Tagliasacchi, Van der Sluis, & Vos, 2013; Vos & Stortelder, 1992). However, this does not provide answers with regard to the origin of changes, and also changes with limited visibility are often not identified (small landscape elements, biodiversity). Recently, some studies focused on the drivers and not so much on the complex system that the landscape is. Van Vliet et al. (2015) in a review of 137 case studies analysed the underlying drivers of agricultural land use change, and highlighted the role of farmers' decisions in land use change. Major landscape change trajectories were related to globalisation of agricultural markets, the transition from rural to urban society, and the shift to post socialism in Eastern Europe (Van Vliet et al., 2015). This meta study however does not identify in greater depth the role of actors, or restricts this mostly to the land user (Van Vliet et al., 2015). Kristensen, Busck, van der Sluis, and Gaube (2016) approached the process of landscape change from the farmer level, based on interviews. They found that farm size and ownership of livestock are of particular importance for landscape activities. Jepsen et al. (2015) analysed the

temporal dimension of landscape change for different regions, from 1800 AD till now, to identify key periods of landscape management and the underlying drivers of change. They found strong similarities between countries, that were often related to institutional reforms and technological innovations.

What these studies did not address are the processes of change at different scale levels simultaneously, in relation to the role of stakeholders in this process as a crucial part of social-ecological systems. This requires a tool that can analyse the complexity of the landscape system as well as the dynamics of the system, that can be implemented at the landscape level, and has a focus on stakeholders (agents of change and those that perceive the landscape quality). This paper introduces Fuzzy Cognitive Mapping (FCM) for this purpose and discusses its usefulness.

1.4. Objective of the study and approach

The aim of this paper is to understand better the drivers and process of landscape change. We use FCM, a system dynamics model that takes a systemic approach. System Dynamic models differ fundamentally from agent-based models that take the agents as entry point. Through FCM we describe the landscape system as perceived by stakeholders and the role of policies and other drivers that affect the European landscape.

FCM is a participatory tool that builds upon perceptions of stakeholders in order to describe a social-ecological system and its agents of change. Since stakeholders represent the social subsystem, and are moreover knowledge holders of the ecosystem, they are assumed to be essential for analysing the landscape system as a whole. In short, FCM can help to describe the dynamics of complex systems. FCM in this case is implemented at the landscape level since landscape changes are defined by environmental conditions, multi-scale level policies and landscape governance, economic factors as well as the social fabric of land users and the population. Through FCM we studied the mechanisms of change in six different case studies in Europe, a meta-analysis of the processes and drivers of landscape change. More than in recent studies of drivers of landscape change we focus on the complex system that the landscape is: Are the driving forces of landscape change linked to technological improvements, to incentives, to policy changes, to cultural/social evolutions? At what level are these evolutions shaped (local, national, European)? What factors are affected by the drivers of change?

2. Methods

2.1. Environmental zones and case study selection

The classification of the European environment, resulting in 13 Environmental zones, formed the basis for this research (Metzger, Bunce, Jongman, Mücher, & Watkins, 2005; Mücher, Klijn, Wascher, & Schaminée, 2010). We assumed at the start of our project that environmental conditions are crucial factors or drivers of landscape change. We located six regional case studies in six selected environmental zones (Figure 2), which were based on study areas of a large FP7 project VOLANTE, with two additional cases to cover the wide range of landscapes of Europe. The environmental zones are the boreal/nemoral zone (Estonia), Atlantic/continental zone (Denmark), continental/Pannonian zone (Romania), Alpine south (French Alps), the Atlantic/Mediterranean north (Portugal) and Mediterranean south (Greece). Workshops were held in these environmental zones we consider as representative for much of the European landscapes and encompassing the environmental variation in Europe (Van der Sluis et al., 2015). For the readers' convenience reference is made to the countries, not to the environmental zones.

2.2. Fuzzy Cognitive Mapping

FCM is frequently used to describe complex systems, with many interdependencies and relations between the variables of the system (Penn et al., 2013). FCM consists of a graphical representation of the system in which the factors are described that influence a core problem. Then, the links of influence

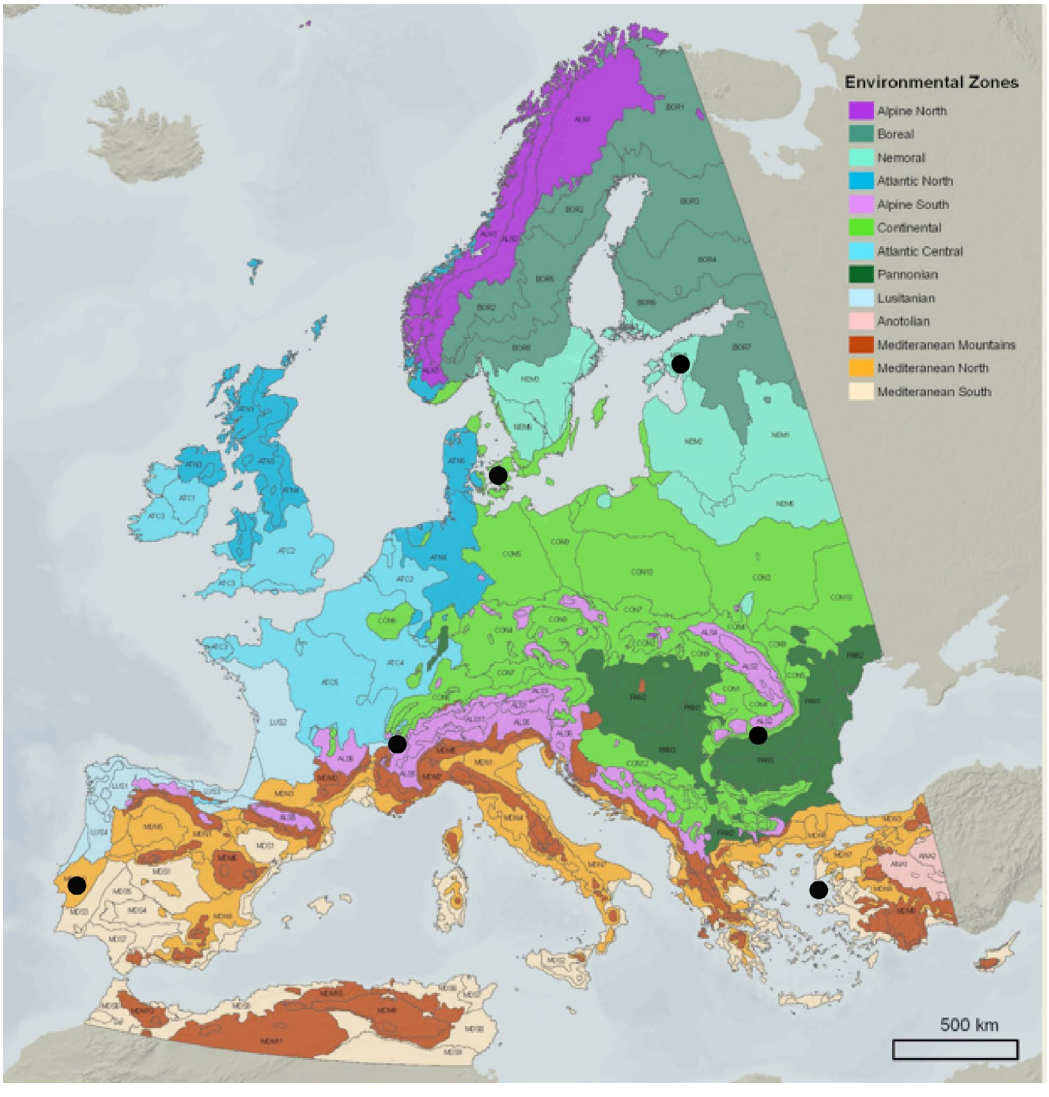

Figure 2. Environmental zones of Europe (Metzger et al., 2005). FCM-workshops were held in the boreal/nemoral, Atlantic/continental, continental/Pannonian, Alpine South and Mediterranean environmental zones. Black dots indicate the locations where workshops were held, mostly in capital cities.

between all factors and their intensity are defined. The importance of FCM lies in the possibility to define how strong political drivers are in comparison with, for example, environmental and economic drivers of change, and it allows for exploring informal knowledge on the complex processes of landscape change. Crucial in the whole method of building participatory models, is the fact that stakeholders determine the strength of all relationships. It is a carefully designed process in which it is first established whether a relationship exists (0 or 1) and which sign it has (+ or –). In a second stage, the relative strength of relationships is determined, which can either be a linguistic class ('weak' or '++') or an interval variable ('0.2'). For various reasons, the system, its components and the relative strength of relationships cannot and should not be validated. In short, they are stakeholders' opinions of a causal relationship between factors, which exist if they exist for stakeholders. FCM has been used in various types of research, for example, to analyse the dynamics of deforestation processes (Kok, 2009) in relation to securing livelihoods (Diniz, Kok, Hoogstra-Klein, & Arts, 2015), understanding the development of a

biobased economy (Penn et al., 2013), and the development of participatory environmental plans and resettlement of people (Özesmi & Özesmi, 2004). The theoretical foundations of FCM have been dealt with in detail in other publications (Jetter & Kok, 2014; Kok, 2009; Penn et al., 2013; Soler, Kok, Camara, & Veldkamp, 2011).

Using FCM, we study the relationships between driving forces and resulting landscape change. In practical terms, knowledge about the relationships between drivers of change and factors affecting the landscape is translated into simple vector algebra, and used to provide visual output in the form of graphs. We used Excel to describe and analyse the properties of the system and its internal feedbacks when iterating the multiplication of the change vector and a matrix representing all relationships (Kok, 2009).

2.3. Regional workshops

In every zone a workshop was held for which experts were invited in the field of land use and landscape change. The experts provided their insights on the drivers of change, the relationships between those drivers as well as their relative importance. By ranking the drivers of change, insight is gained in the relative importance of different drivers and regional variation in landscape change processes (Soler et al., 2011). The credibility of the results of the workshop is very much dependent on the number and 'quality' of the participants. Therefore, we aimed at a minimum of 20 experts with in-depth knowledge of land use and landscape change processes for each workshop. The participants should represent different sectors of society, from different backgrounds: ministries, decentralised government, farmers' organisations, research, hunting, tourism and conservation. Discussion among such experts with different backgrounds will ensure a comprehensive view on change processes, and should provide a reliable picture of processes of change. In Portugal the discussion focussed on land use change, which is better understood in the Portuguese context, this is however strongly related with the landscape and interpreted as such.

For each of the six cases, a meta-analysis was executed of drivers and factors that constitute the process of landscape change. Since it is too much to discuss all these cases in detail in one journal paper, we follow a 'nested approach' here: the Southern Mediterranean zone (Portugal) and the boreal zone (Estonia) are presented in more detail. These cases are contrasting from an environmental point of view, but also differ politically (EU-membership) and culturally. In addition, the Portuguese and Estonian case studies constitute regions which have not been covered well in literature thus far (Plieninger et al., 2016).

The workshops were facilitated by the researchers with the aim to reflect in the results as much as possible the knowledge and opinions of the stakeholders. A brief introduction on the FCM methodology was given to the workshop participants. For each of the six workshops the central question was: how has the landscape in the environmental zone changed over the past 25 years? All workshops followed the same procedure: in the first stage the concepts of landscape change (factors) were identified by the individual experts. The input of the experts was anonymous. Because of existing overlap, factors were organised and grouped together in a joint exercise. The final number of factors varied between 10 and 12, depending on the region. Subsequently, the participants discussed what would be drivers of the system, that is, factors that are not influenced by other factors. In the next step, participants discussed the causal relationships between the factors which play a role in the identified change processes. The stakeholders also assessed whether the relationship was 'enforcing' and they identified the relative strength of the factor at three levels. The impact on the landscape was assessed as positive or negative, based on the change in quality of the landscape and the multiple services the landscape provides to the stakeholders (Martín-López et al., 2012).

The workshops resulted in Fuzzy Cognitive Maps developed in discussion with the stakeholders. Post-processing was required, either to simplify the FCM, to make the maps more uniform and results comparable and factors being labelled in the same way, or to ensure that the model also works and provides coherent results. The workshop report with the revised map was distributed to all participants, with the request to provide feed-back, in particular whether the discussion of factors was correctly

Table 1. Factors (x) and drivers of change (●) based on 6 FCM workshops in different environmental zones.

	Cultural			Technology				Economy/market					
Environmental zone (country)	Demography	Lifestyle	Cultural values	Agriculture & agr. innovations	Agro-industry	Animal husbandry	Permanent crops	Global economy	Regional economy	Natural resource use	Land ownership	Market prices	Funds, subsidies
Mediterranean south (GR)			x			x	x						x
Mediterranean north (P)	x	x		x				●			x		
Continental & Pannonian (RO)	x	x		x						x	x	x	x
Alpine South (F)	x	●						●	x				
Atlantic (DK)	x		x	x	x			●					
Boreal & Nemoral (Est)	x	x		x					x	x			
Sum of factors and drivers		11			7					12			

	Transport & infrastructure				Policy, legislation				Environment			Sum
	Urbanisation/ sprawl	Roads/ infrastructure	Mass tourism	Small-scale tourism	National policy/ regulations	EU-policy	Governance system	Sectoral policy	Natural succession	Pollution	Climate	
Mediterranean south (GR)	x	x		x		●	●	x		x		11
Mediterranean north (P)	x	x	x			x	x	x	●			12
Continental & Pannonian (RO)		x			●						●	10
Alpine South (F)		x	x	x		x	x					9
Atlantic (DK)		x		x	x	●		x			x	11
Boreal & Nemoral (Est)	x			x	x	●						9
Sum of factors and drivers		14			15					4		

interpreted. Where necessary, corrections were made to ensure proper interpretation and processing of the data.

3. Results

3.1. Meta-analysis of landscape change

Main components of the FCMs in the six case studies are presented in Table 1. The cultural factors are usually strongly related: demography includes where people settle or whether they migrate to or from the cities, and this is also related to other cultural factors such as values and attachment to the land. Lifestyle is more related to processes of globalisation and the digital economy, but also to trends such as increased demand for healthy products or ecological food. The governance system refers here to the interactions between different government agencies and stakeholders in decision-making. The policies can be largely overlapping, since national policies are usually strongly linked to European policy, and both may include conservation policies. Usually it depended on the weight that participants attributed to certain aspects of a factor how it would be classified in the workshop. Environmental factors include pollution and climate change, but also natural succession.

Asked for the drivers and processes of landscape change over the past 25 years, the experts mentioned a variety of drivers. Policy and legislation were perceived as very important in all cases, since it recurs 15 times as a factor in the Fuzzy Cognitive Maps of which 5 times as driving factor (Table 1), and in the Mediterranean south (Greece) even both drivers reside in the policy and legislative domain. Only in the Alpine south and Mediterranean north (Portugal) economy rather than policies are perceived as the main driver. The second important driver is the 'global economy', in France, Portugal and Denmark. Economy relates on one hand to the process of globalisation, on the other hand to markets and prices for food, feed and fibres. Also transport and infrastructure is frequently mentioned as a factor of landscape change (in total 14 times), but never as a driver, mostly infrastructure was driven by policy and legislation. Technology was likewise never considered to be a driver of change. Technological drivers affecting the landscape are mostly related to technological innovations which drive changes in agriculture. Transport and infrastructure relate to all aspects of settlement, settlement patterns and roads, including recreation and tourism development. Environmental policy includes regional, national and European policies, the spatial planning system and its implementation, and farming subsidies or policies for energy supply, of which many are inspired by European policy. Environmental drivers are climate change and natural succession.

3.2. Results of the Portugal and the Estonia cases

General characteristics of the two Fuzzy Cognitive Maps are described in Table 2. The density of relationships is high in both cases, although slightly lower in Portugal, which could be related to less complex landscape change processes. The number of drivers is relatively low (2 resp. 1 for Portugal and Estonia), as is the number of receiving factors (1). The lower density of relationships might indicate that Portugal has a slightly simpler system of landscape change, despite the fact that the FCM has more factors (12) than Estonia (9), and more relationships (36 vs. 25).

3.2.1. Case study Portugal

Context: By the middle of the twentieth century the maximum territory of land was used for agricultural production and all rural life in villages and rural settlement was related to agriculture. This however has changed, and also in Portugal rural space is more and more seen as a space for living and consumption (Breman, Vihinen, Tapio-Biström, & Pinto Correia, 2010). They also note that traditional agricultural activities have been replaced by new uses, which is extensification and not land abandonment. With EU subsidies much of the land has been planted with forests, resulting in extensive management and use of land, not necessarily land abandonment (Breman et al., 2010). Since the 1990s the Portuguese rural landscape has been drastically changing as a result of the CAP, but subsidies also resulted in forest plantations, of mostly exotic species such as pine trees (Van Doorn & Bakker, 2007), a development also

Table 2. Key characteristics of the Fuzzy Cognitive Maps.

Characteristics	Portugal	Estonia
Number of factors (N)	12	9
Number of relationships (R)	36	25
Maximum of relationships (MaxR)	132	73
Density (C/MaxR) (D)	.27	.34
Positive relationships	29	20
Negative relationships	7	5
Number of receiving factors	1	1
Number of drivers	2	1

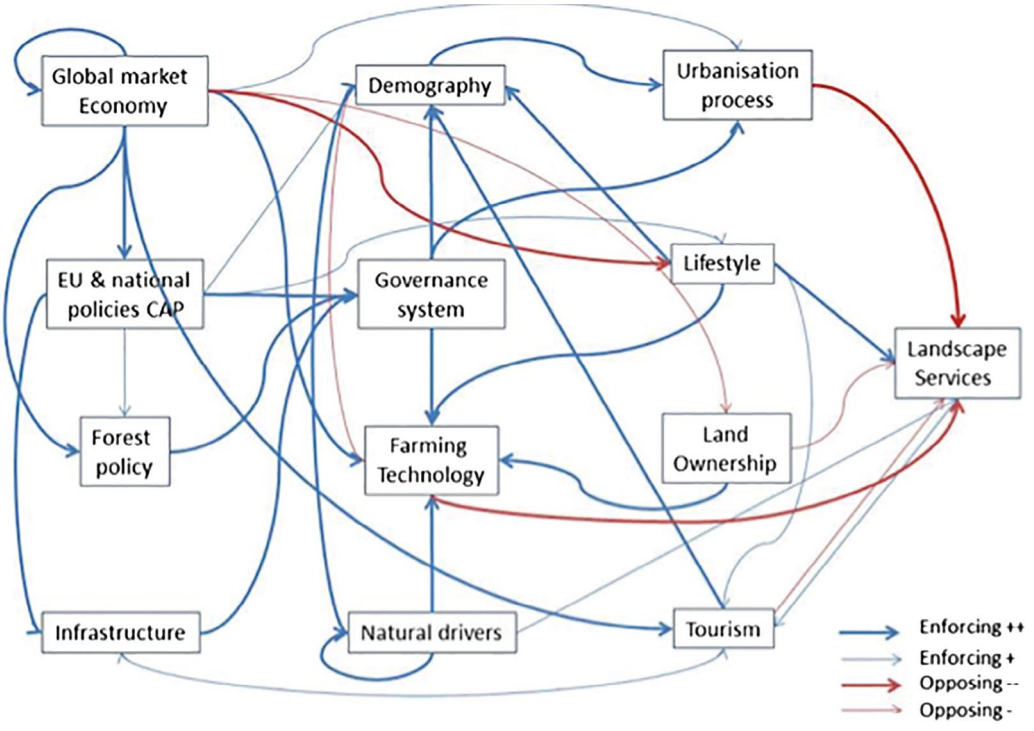

Figure 3. Resulting Fuzzy Cognitive Map for landscape change processes in the western Mediterranean as perceived by experts in Portugal.

observed in Northern Spain (Corbelle-Rico, Butsic, Enríquez-García, & Radeloff, 2015). In recent years, neo-rurals and lifestyle farmers have settled and taken over traditional farming areas, with its own dynamics and impacts on the landscape (Pinto-Correia, Almeida, & Gonzalez, 2016).

The FCM shows how stakeholders see the system. Initially, stakeholders identified 22 factors for the FCM for Portugal (Figure 3). Slight adjustments were made to the FCM afterwards: some factors were combined, few were eliminated, which reduced the FCM to a total of 12 factors and 36 relationships. The factor 'social cohesion' was more related to demographic processes, and was therefore renamed 'demography', also closely linked to the factor 'urbanisation', which has more a focus on settlement process in and around major cities.

Two drivers were identified: the 'global market economy', and 'natural drivers'. The Global market/economy is a strong driver [+1] of landscape change, and affects most 'EU policies and national policies', but also 'forest policy', which is treated as a distinct factor due to the importance of forests for the Portuguese landscape. The main spatial policies operate mostly through the governance system and result in demographic changes and urbanisation which cause a negative change of the landscape. Also

farming technology (changes in spatial arrangement of land, industrial agricultural production) exert a negative impact on the landscape. These processes have a homogenising effect on farming and other land uses which form the fabric of the landscape.

Natural drivers [+1] entail vegetation recovery after land abandonment, and climate change (here changing rainfall patterns, increased aridity and soil degradation). Also natural drivers affect the demography and farm technology, both have a negative impact on the landscape and the services it provides. Tourism is partly small-scale, heritage-oriented tourism with a positive impact and some mass tourism stimulating coastal development, where the negative impact is dominant. Tourism is the only feed-back of the system: the quality of the landscape will positively affect tourism. This is however of limited impact on the whole system.

The role of the governance system stands out as important, and all policies operate through this system. The many different institutions involved in landscape policy point towards institutional shortcomings and a lack of policy integration. Effective spatial planning is lacking and planning is not focused on containing urban boundaries, which often results in urban sprawl in rural areas, with a negative impact on the landscape.

The dynamic model shows that the 'Landscape' (i.e. landscape quality), after a short positive response, declines and after some fluctuations stabilises at a much lower level, below all other factors (Figure 4). This can be interpreted as a system whereby different factors interact, and the compounded result is a landscape which is much worse-off than it was at the beginning. In particular farm technology and the governance system are increasingly influential, whereas tourism and to some extent lifestyle are showing a decline as well. In particular small-scale tourism is affected because of the decline of landscape quality, mass-tourism is less likely to be affected. Urbanisation and farming technology have an overriding negative effect.

3.2.2. Case study Estonia

Context: In Estonia there seems to be not such a clear notion of a 'traditional landscape'. Usually the landscape which developed before the Second World War (the end of the Republic of Estonia) is considered as traditional, with small-scale farming, the average size of farms at that time being approximately 22 ha. The USSR brought tremendous changes in Estonia, with scale enlargement, the first collectivisation in the late 1940s, then large-scale amelioration and a more industrial approach to farming. During the Soviet era, arable land decreased by nearly 405,000 hectares, much becoming forest. In 1990 there were 221 collective and 117 state farms with an average of 350–400 workers each (Jullinen, Lilover, & Roosmaa, 2000). After the independence of the Republic of Estonia the 1991 land reform started: land was restituted to the former owners of 1940, the year Estonia was occupied. The

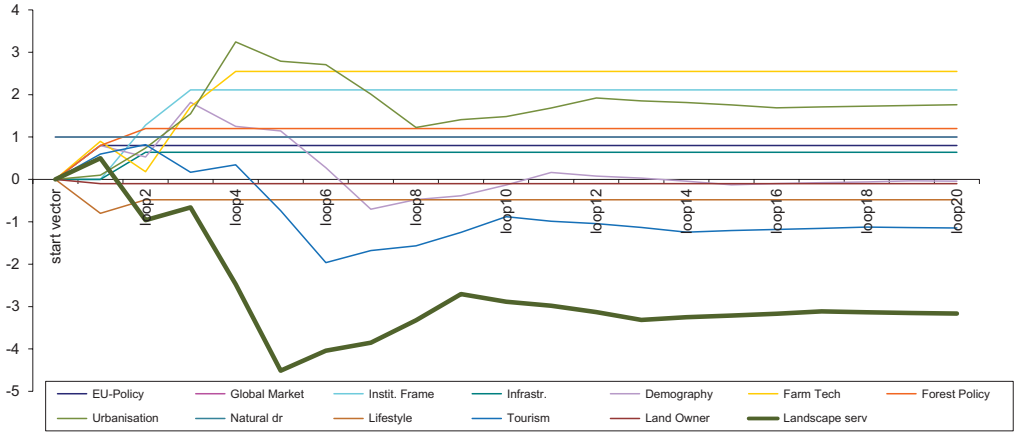

Figure 4. Graph for landscape change processes for the Northern Mediterranean (Portugal).

reform of Estonia's agricultural system began already in December 1989 with adoption of the Law on Private Farming. Despite the fact that the number of private farmers increased rapidly, land was abandoned in marginal areas (Schneeberger, Bürgi, Hersperger, & Ewald, 2007). In the 1990s there were no subsidies for famers anymore and many of them stopped farming. Only from 2001 onwards financial support is provided to land managers, for mowing and grazing of protected areas and potential Natura 2000 sites. Since Estonia joined the EU in 2004, farmlands have been cleared again due to increased land pressure, as a result of an increased demand for agricultural products and availability of subsidies. Between 2003 and 2010 the area of permanent grassland and meadows grew by 18.2%: from 250,400 to 296,060 ha (*Agricultural Census in Estonia*, 2012).

Initially the stakeholders identified 23 factors for the Fuzzy Cognitive Map for Estonia. Combination of some factors resulted in a total of 9 factors and 25 relationships (Figure 5). The participants defined several closely related factors, like 'political processes', 'disintegration of the USSR', followed by 'EU-membership' and 'introduction of EU subsidies'. All these different factors were combined in one driver, 'EU-policy', in order to reflect the current situation. Another amalgam of factors is: 'transport', 'urbanisation' and 'urban sprawl', in this context aspects of the same phenomena, that we therefore combined as 'transport & urbanisation'. 'Depopulation' and 'Abandonment & marginalisation' finally were considered two sides of the same coin and labelled 'demography'.

The only driver of the system is 'Political change & EU policy' [+1], which is narrowly linked with Estonia joining the EU and implementation of European legislation (Figure 5). EU policy steers the national and regional policies. Some European policies (N2000, Structural Funds and the LIFE programme) have a direct positive effect on the landscape: for example, payments for maintaining Natura 2000 habitats in farmland are much higher than farm subsidies. Also recreation and cultural heritage have a positive impact as a result of changes in lifestyle and appreciation of the landscape. Nonetheless, the national/regional policies all have a negative impact on the landscape, through demographical change, transport and urbanisation, agricultural intensification and unsustainable use of natural resources (Figure 6).

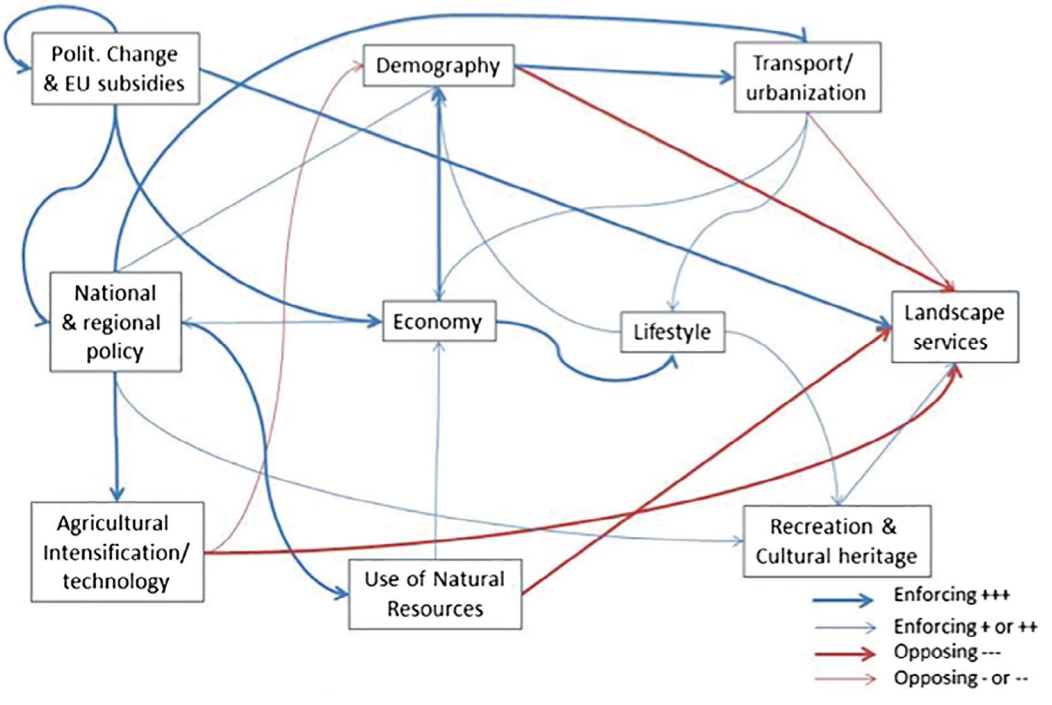

Figure 5. Resulting Fuzzy Cognitive Map for landscape change processes in the boreal and nemoral region, as perceived by experts from the Baltic states.

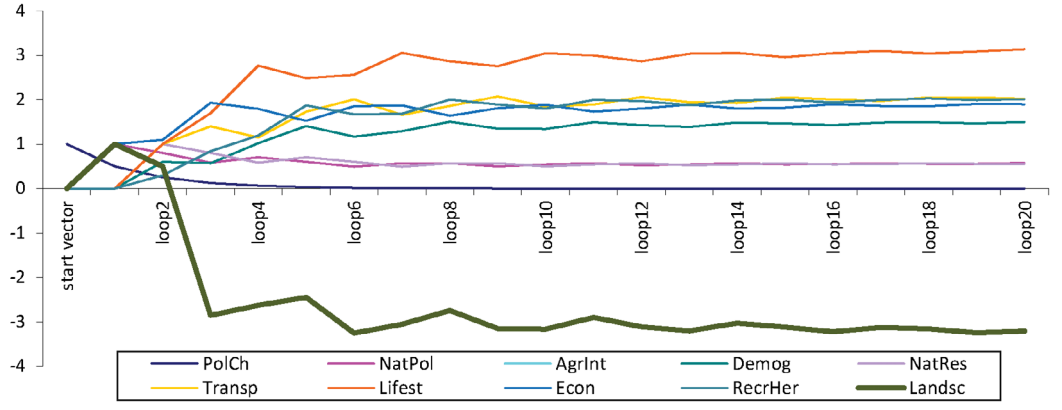

Figure 6. Graph for landscape change processes for the boreal zone (Estonia).

The economy and agricultural technology affect demographic patterns which—as a result of lack of planning control—also leads to negative impacts on the landscape. The experts identified no feedback loops from landscape quality level back into the system.

The dynamic model for Estonia shows the direct positive impact of EU policy: in the first iteration the line indicating the Landscape is positive. However, in the following loops the triple negative factors (demography, agricultural intensification and use of natural resources), with some delay, influences the landscape quality that declines and stabilises at a much lower level.

The stakeholders' representations of the landscape system show in both cases a rapid decline in landscape quality: In Portugal this is related to the farming system and institutional framework, in Estonia to lifestyle and economic changes which affect the demography. In Portugal natural drivers and the economy drive the system, in Estonia the EU-policies. Two factors (one of which is a driver) are unique for Portugal: natural drivers and the governance system (Figure 7), all other factors are comparable in the two cases.

3.3. Overall results of the six cases

Most of the other case studies also show a decline in landscape quality, predominantly through demography and urbanisation, but everywhere through a different constellation of drivers and factors. Only for Romania the landscape quality shows slight improvement as a result of policies that have a positive impact on the landscape, to the detriment of the economy. However, another study highlighted that much of the landscape changes had taken place long ago, which had resulted in a rationalised, large scale landscape (Snoeijer, 2014).

Still, there are geographical differences, in Northern Europe economic forces are perceived to be more dominant, in the south the role of the government is more pronounced. The governance system is a factor mentioned in particular in the Southern Alps and the Mediterranean. The governance system generally includes formal laws, procedure, and informal conventions, customs, and norms which, in the discussion with stakeholders, often turned out to be an obstacle for good implementation of legislation. For Portugal in the 1990s the planning system changed, which resulted in scattered urbanisation and subdivision of farm plots. This resulted in many political compromises, not 'technically supported'. Now, the spatial plan has become guiding in most cases, but still there is no shared vision of stakeholders on the role and value of landscape. There is a conflict between public and private interests and there are misconceptions of land property rights. This gives way to poor implementation of spatial plans and economic land speculation. The system results in unclear policy interpretation, thus hampering

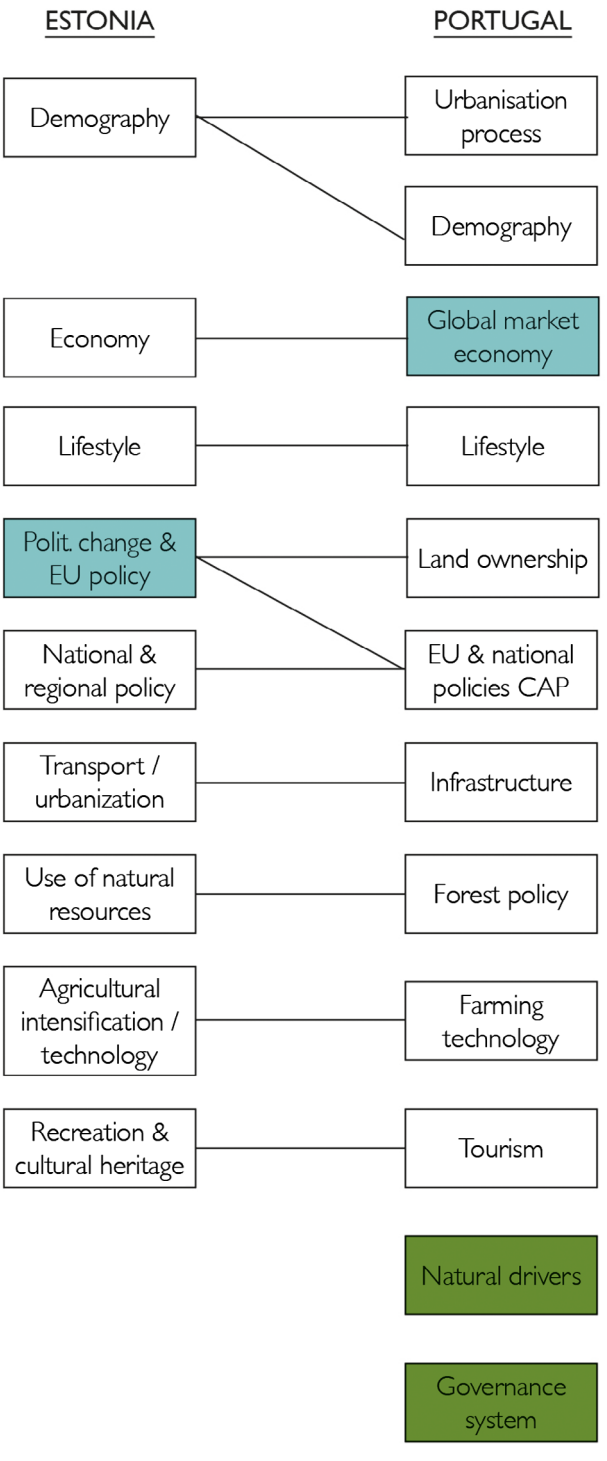

Figure 7. Comparison of factors and drivers (white and blue) for Estonia and Portugal.

implementation. Clarification of roles and responsibilities in different government layers would be a first step to overcome such institutional inhibitions.

Over the six case studies, we identified two dominant driver categories: 'policy and legislation' and 'economy and market'. Dominant drivers are EU policy, and the global economy, and in all zones at least one of these drivers is dominant. These drivers, although not negative in themselves, affect the system mostly negatively. For example, policies and economic developments result in expansion of infrastructure, demographic changes, urban sprawl, and/or fragmentation, which ultimately have a negative impact on the landscape quality. Despite some policies with clear positive impacts (e.g. in Estonia, Romania and Denmark), other sectoral policies in combination with other factors have an overriding negative impact. The factors that have a positive impact are few: mostly it is related to feed-back loops, related to (eco-) tourism development, such as in France, Denmark and Estonia. Often these factors are not so strong, or overshadowed by the impacts of, for example, mass-tourism that results in concentrated infrastructure development (roads, development of resorts).

The global economy and European policies are the most important drivers in the case studies. The global economy defines prices for agricultural products, which means, for example, that Portuguese farmers have to compete with New Zealand farmers. The global economy has a strong influence on the EU-policy, which is guiding in most territorial policies, funding and subsidy schemes and it defines the framework conditions for farming. Most important, according to the stakeholders, are CAP, LIFE and the Rural Development Programme (RDP). At the same time, various measures cause landscape change, such as urban sprawl, road infrastructure development or biofuel crops: the (un)intended effects of policies are hard to predict, and are partly a result of how the political system functions. The younger generation often has no ambition to continue farming and leaves to urban areas. An example is the Portuguese institutional system, which does not have the capability to restrict nor guide the urbanisation process due to uncontrolled demographic changes. The stakeholders described that many different institutions are involved in spatial planning, but there is no shared vision nor effective coordination among them. As a result, construction in the countryside is not contained. With available EU funds (e.g. European Regional Development Fund, Cohesion Fund), this resulted in uncontrolled development, land grabbing for speculation purposes and a strong decline in landscape quality, all effects that were not foreseen in the formulation of the RDP. The unintended effects of policies were also discussed by Pedroli et al. (2016), describing agricultural and market policies being dominant at European level. Environmental and societal concerns can thus only take place at European level, which results in the local farmer and community losing autonomy. Such complex relationships are typical for the landscape.

Indeed, all landscape systems are complex, also according to the stakeholders: They are multi-scale, often with multi-layered governance models (EU-policy, regional policies, sometimes a complex governance framework) with complicated relationships between areas (Schneeberger et al., 2007). An example is the case for the Alps, France, where people live in an appreciated landscape, buy their grocery products in cheaper stores in France and work in Switzerland for better income: 'migration d'agrément'. This results in transport infrastructure, changed land use and finally segregation in society and associated cultural changes. In Portugal and other Mediterranean countries the changes may be strongly rooted in traditional cultures and lifestyles (Pinto-Correia et al., 2016). Feed-back mechanisms are not common, these were only reported in Denmark and Portugal, where the landscape quality has a positive effect on recreation. According to stakeholders the good landscape quality also attracts newcomers settling in the countryside. An attractive landscape nearby towns and the availability of older farms and houses that are possibly abandoned, or not used, results in a reversed trend and creation of 'lifestyle farmers' in some cases.

4. Discussion

The in-depth assessment of the selected cases shows the variation in processes, and how the drivers of change affect landscape planning and landscape quality through various factors. It illustrates

how—through different pathways—the global economy affects processes like urbanisation, scale enlargement, as well as marginalisation of farming. As a result different landscapes may evolve in a same direction.

The choice of case studies was based on environmental zones variation, under the assumption that environmental factors would be dominant in landscape change. However, the analysis shows that environmental drivers play only a minor role in landscape change processes, limited to climate change (Romania, Denmark) and natural succession (Portugal). Although climate change was mentioned in discussions with stakeholders a few times, it was so far rarely considered a driver of change. This might be explained by the fact that in the workshops we looked at the processes of change over the past 25 years, and the effect of climate change is only surfacing recently. The environmental stratification of case studies turned out to be less relevant.

FCM shows that it is not just globalisation or European policy that results in a perceived decline of landscape quality, but it is often an outcome of parallel processes, that all head in a direction of landscape decline. The additional value of FCM to analyse the processes of landscape change is that it identifies this chain of factors that play a role. Studying aspects of a complex system like landscapes in isolation will not allow such in-depth understanding of the processes of change. FCM makes it possible to explore the knowledge of what local experts perceive as major drivers of change. The experts in the workshops were knowledgeable people well-versed with European policy and its impact on the landscape. Therefore, their interpretation of the impact of, for example, regulations on the landscape gives important insights in how policy translates at the regional or local level. At the same time this interpretation is subjective and may differ from what model output suggests. However, the strong points of FCM are the semi-quantitative approach and it produces storylines, which provides insight in the processes of change (Kok, 2009). More tools and mixed methods may be required to improve the assessment. Weaker points for FCM are data and literature availability to identify causal relationships, as well as semi-quantification of relationships (Soler et al., 2011): FCM provides no hard scientific answers. In that respect it differs from the traditional scientific approach, which is founded in empirical research and causal relationships. The advantage is that through informal knowledge systems we can describe the processes of change, and quantify them to some extent.

The observed, unintended landscape changes require a different approach for future landscape services. An integrated landscape approach (Sayer et al., 2013) could offer a new perspective for future development, which would suit complex SES such as we found in our study. This landscape approach gives due consideration to: (1) different stakeholders, sectors and scales in a landscape (2) adaptive and participatory management of change processes and (3) social learning and capacity building. Hence, contrary to classical policy-making, that is highly expert-driven and sectoral in nature (e.g. agriculture separate from forestry), it aspires to be an integrative, participatory and reflexive approach. Part of it is what some scholars coin 'landscape governance' (Buizer, Arts, & Westerink, 2016; Görg, 2007; Van Oosten, Gunarso, Koesoetjahjo, & Wiersum, 2014). This concept calls for considering governance processes—the steering of social change in accordance with public aims (Arts, 2014; Kooiman, 1993)—against the background of the 'bio-physical conditions of landscapes' on the one hand and 'the politics of scale' on the other. The former reminds us of the physical boundaries and limits of the landscapes we live in, the latter of the political construction of borders, areas, sectors and their qualities. It is within this paradoxical situation of 'natural determinism' and 'social voluntarism' that landscape governance needs to address the various landscape challenges, as identified by landscape scholars and stakeholders, such as in this paper. Too often, policy makers rely on sectoral engineering of landscapes, while underrating their socio-economic and ecological coherencies and feedbacks. Landscape governance should redress these shortcomings.

Opdam (2014) observes that policy tools developed for landscape management, such as the European Habitat and Water Framework Directives or LIFE-Nature, do not allow for adaptive governance at different scale levels. This is also observed in the case studies, where most policies operate at the national level, few funding tools like LIFE operate at the landscape scale (Estonia, Romania). In Denmark a complaint was the lack of nature conservation funding through, for example, the RDP or

LIFE programme, the complexity of financing systems, and bureaucracy for farmers (Van der Sluis et al., 2015). The designation of N2000 has influenced almost all landscapes, but also the spatial zoning in the various countries is very influential. Policy and legislation can balance to some extent market forces that also exert much influence on spatial development. The aspect of governance and how institutions involved in the implementation of policy function in the end will be very decisive in the effectiveness of a given policy (Frederiksen et al., 2017).

5. Conclusions

The stakeholder perspective on the process of landscape change provides important insights in similarities and differences in different regions of Europe. Through FCM and the experts involved, the changes are observed from a human perspective, which is in line with the approach of the landscape as a social-ecological system. The resulting FCMs teach us that there are fundamental differences in the change processes across Europe, that require policies that are not a 'one size fits all', but rather integrated approaches.

Still, except for Romania, we found in all case studies that the landscape quality deteriorates. EU policies such as the CAP, RDP and N2000 are very influential according to the participants in the FCM workshops. This is through indirect relationships and impact on national policies, and despite the fact that EU policies in principle aim for positive impacts on landscape and biodiversity. In Estonia we observe that EU-policy is strong with regard to implementation of the conservation agenda, with targeted funding through, for example, LIFE-nature for farmland restoration and EU structural funds, that generally exceeds the subsidies from the CAP. At the same time groundwater quality in some regions has declined due to more intensive agriculture based on subsidies. In other regions the EU-policy in particular enhances those factors that affect the landscape quality negatively. Clearly, the processes that occur in different regions of Europe require a more coherent approach. A better screening of the landscape impact of policies is required, such as the required biodiversity proofing since 2011 as part of the EU biodiversity strategy. This study underlines the need for such a 'landscape proofing' as a cross-sectoral measure.

European policies—for instance CAP—could gain in effectiveness when focusing on the identified drivers and trajectories of change. Landscape structure, biodiversity and other ecosystem services could benefit from this approach. FCM provides important complementary information on processes of landscape change, as it allows for the combination of expert-gathered data with 'hard-fact' map data.

From the six case studies we conclude that there are different processes of landscape change. Many factors have negative impact on the landscape and the services provided. Based on the FCM the following short-list of factors are identified, that generally have a positive impact which could help improving landscape quality:

- small scale recreation and tourism;
- targeted subsidies in support of landscape quality;
- support for farmland restoration and traditional management;
- lifestyles which respect traditional landscape values;
- organic farming;
- forestry policies which support autochthonous forest resources;
- policies in support of permanent crops.

To ensure an improved allocation of land resources and to safeguard that the landscape also in future will meet the societal demand for landscape services it is important that governments set proper policy strategies: a planning system which is more in control of preferred development pathways. The landscape governance approach as touched upon in the above is promising, as it opens up much more space for stakeholder involvement, policy integration and social learning, compared to current sectoral

and expert-driven policies. It promises to better meet the socio-ecological conditions of regions and countries, while being flexible enough for considering different governance scales at the same time.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by Seventh Framework Programme [grant number 265104].

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