HERCULES

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

GA no. 603447

D5.1 Documentation of the multi-scale scenario framework

Main authors:
Nynke Schulp, Peter Verburg

Reviewers: Matthias Bürgi, Thanasis Kizos

Work package	WP 5 Fine- and broad-scale modelling of future landscapes			
Deliverable nature	Report			
Dissemination level (Confidentiality)	Public			
Estimated indicated person-months	10			
Date of delivery	Contractual	30/09/2014	Actual	30/09/2014
Version	1.0			
Total number of pages	32			
Keywords	driving forces, land use, landscape dynamics, stakeholder participation, scenarios			

Executive summary

HERCULES Work Package (WP) 5 makes a model-based assessment of processes of change in cultural landscapes. To inform such model-based assessments, scenarios are a very commonly used tool. Scenarios are defined as: “plausible descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about key relationships and driving forces”.

Scenario analysis will be performed at multiple levels, connecting EU level dynamics with local decision-making by land owners and managers. For the EU level, a wide range of scenarios already exist. These scenarios evaluate the rate of land use change over the coming few decades and evaluate the consequences of these changes on e.g. fragmentation. The outcomes of these existing EU scale scenarios can be used to analyse hotspots of change in cultural landscapes. Shortcoming of these scenarios are that they (1) do not include all drivers relevant to cultural landscapes, thus potentially missing important future developments, and (2) do not always provide sufficient detail to analyse changes in cultural landscape character and functioning.

To make EU scale scenarios better suited to analyse cultural landscape change, an inventory of drivers of landscape change can be expanded based on the work done in WP1. This inventory can inform the elaboration of scenarios specific to cultural landscapes.

For analysing the local-scale impacts of drivers of change on character and functioning of cultural landscapes, scenarios will be defined for two case studies. For defining case study scenarios, an approach is proposed where stakeholders will be involved in scenario specification. Stakeholders will be consulted on their knowledge on drivers of landscape change in their study landscape. Based on this knowledge, preliminary scenarios will be defined for the study landscapes. As a final step, preliminary scenario outputs will be discussed with stakeholders to explore consistency between the scenario outputs and stakeholders’ visions on future landscape developments. Based on this consistency check, the scenarios will be refined by exploring management options necessary to achieve the stakeholder visions.

Table of contents

1. Introduction

Changes in cultural landscapes are an inherent property of these landscapes. Past changes have been decisive for the appearance of the landscape today following long term driving forces (Dearing et al. 2010, van der Leeuw et al. 2011), while European cultural landscapes are changing at present as result of changes in society, technology and global trade. Current changes in cultural landscapes range from land abandonment in some parts of the landscape and agricultural intensification elsewhere. These two processes together cause a "polarization of land use" (Gellrich and Zimmermann 2007, Kuemmerle et al. 2008, Verburg et al. 2010, Navarro and Pereira 2012). Further threats and opportunities for cultural landscapes include tourism and urban sprawl (Vos and Meekes 1999). The future of cultural landscapes will build upon past changes that have led to the current state, but may entail different trajectories depending on the drivers, processes and cultural landscapes in question (Zimmermann 2006).

HERCULES WP5 studies future changes in cultural landscapes, both at the EU scale and in a few case studies. In order to assess the future of cultural landscapes, the use of scenarios of possible changes is necessary, because scenarios allow plausible futures of complex systems with uncertain outcomes to be addressed (Zurek and Henrichs 2007). This deliverable describes the approach for scenario development to be used in HERCULES. We first provide background on scenarios (section 2). Next, we evaluate the range of expected changes of drivers of land use change at EU scale and the expected land use changes in existing scenario studies (section 3). Different approaches for scenario development will be followed for EU scale and case study scale. Section 4 describes nesting case study scale scenarios within the EU scale framework. Section 5 gives an overview of drivers of change more specific to cultural landscapes and section 6 concludes with providing a framework for further scenario specification.

2. Background on scenarios

2.1. Developing scenarios

Analysing future changes in socio-ecological systems involves high levels of uncertainties from different sources. These include inherent uncertainty about future developments and variations in interpretation of future storylines; uncertainties in input data; uncertainties in model structure and parameters and resulting error propagation, and uncertainty in knowledge of the system and consequently our judgement of both inputs and outputs (Verburg et al. 2013a). To deal with these uncertainties, several methods exist. Data and model uncertainties can be quantified using e.g. Monte Carlo simulation techniques. To capture the uncertainties in socio-economic developments, scenarios are a commonly used tool. Scenarios have been defined as: "plausible descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about key relationships and driving forces" (IPCC 2012). Scenarios can help to work with stakeholders and managers to better understand the driving forces in landscape change (e.g. within a participatory approach, (Plieninger et al. 2013b) and can help to improve the adaptive capacity in anticipating and responding to landscape changes (Rounsevell and Metzger 2010, Metzger et al. 2010, Plieninger et al. 2013b).

Being the most frequently used tool for assessing options and characterizing possible futures (Seppelt et al. 2013), there are multiple types, definitions, typologies, classifications and applications of scenarios. Börjeson et al. (2006) distinguish three main types of scenarios, based on the principal questions they believe a user wants to have addressed about the future.

1. **Predictive** scenarios answer the question *"What will happen?"*. This can relate to the future when likely development unfolds or under the condition of specified events. An often used predictive scenario type is the **Extrapolatory** scenario that is an extrapolation of current trends, thus, answering what will happen under unchanged conditions.
2. **Explorative** scenarios answer the question *"What can happen?"*. The aim of explorative scenarios is to explore situations or developments that are regarded as plausible to happen. Often, a variety of perspectives is explored in a set of scenarios the cover a wide range of possible scenarios. They are commonly elaborated with a longer time horizon than predictive scenarios.
3. **Normative** scenarios address *How a specific target can be reached.* In a normative approach to scenario development, there is a specific future target, and the scenario aims to find out how this target can be met in the most efficient way. This can be elaborated using optimization approaches (as e.g. proposed by Seppelt et al. (2013)) that focus on adjusting the current situation, or through backcasting from the normative target with assuming a set of trend breaks or shocks (Börjeson et al. 2006).

A particularly well-known and commonly applied set of scenarios is the Special Report on Emissions Scenarios (SRES) by the Intergovernmental Panel on Climate Change (IPCC). This is a set of explorative scenarios that explores what can happen under a globalization vs. regionalization and an environmental vs. economic orientation (*Figure 1*).

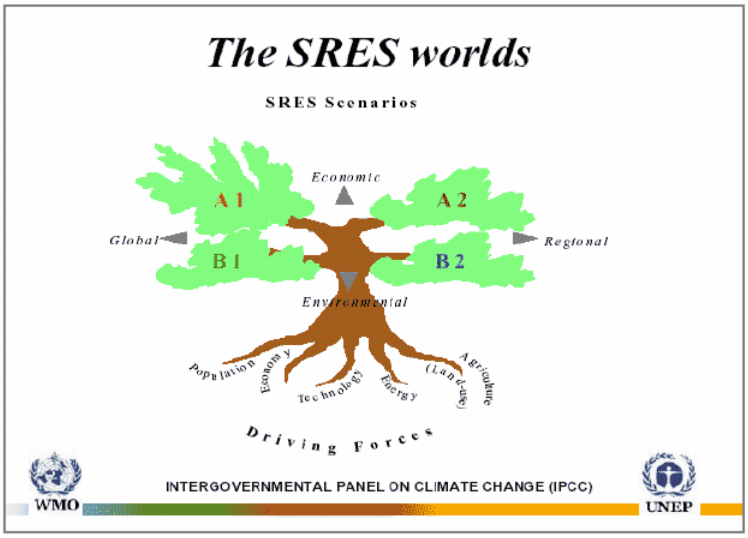
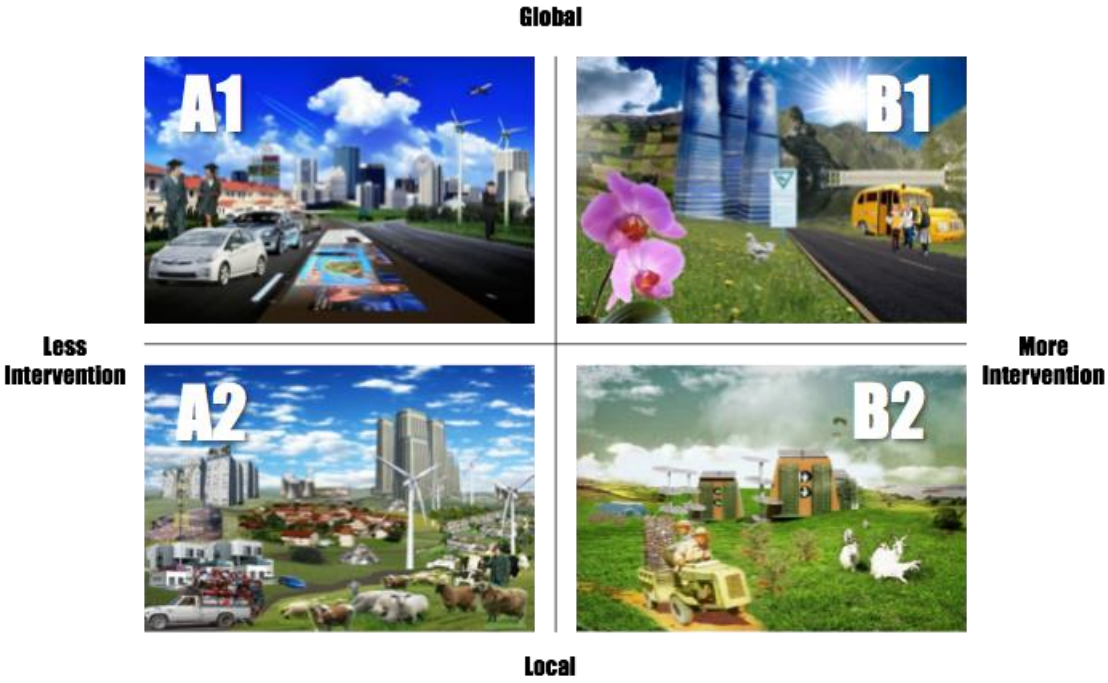


Figure 1: The IPCC SRES scenario framework

A common approach to developing such scenarios is by making an inventory of the most important and most uncertain future drivers of change for the issue that is studied. From the inventory, the two most important and most uncertain drivers are chosen and are used to specify two axes, resulting in a matrix of four scenarios. Another example of a large-scale study that has built scenarios around two main uncertainties comes from the Millennium Ecosystem Assessment (MEA). The MEA based a set of four scenarios on a survey under decision-makers and leaders, in which key concerns with respect to future changes in ecosystem services were identified. This survey identified a set of key concerns whose uncertainties have large implications for future ecosystem services. The main uncertainties identified were globalization versus regionalization, and futures that emphasise economic growth versus futures that emphasise proactive management of ecosystems and their services (Millennium Ecosystem Assessment 2005).

Many further developed scenarios are based on the SRES scenarios as they cover a broad scope which can easily be further adapted to specific settings. This includes the scenarios developed in the VOLANTE, ATEAM, ALARM and EURURALIS projects (Ewert et al. 2005, Rounsevell et al. 2006, Settele et al. 2010, Westhoek et al. 2006). These EU scale projects elaborate scenarios in much more detail for EU specific issues. Most importantly, scenarios replace the environmental vs. economic axis by a high regulation vs. low regulation axis, as this is assumed a more important driver at European scale and because environmental and economic orientation do not necessarily exclude each other (Nakicenovic et al. 2000, Westhoek et al. 2006, Paterson et al. 2012). Secondly, a nested approach to scenario specification is relevant to sub-global assessments. Scenario sets that capture global scale trends are downscaled to world regions with models that use finer scale specifications. In that way, both large scale constraints such as land availability and EU scale specifications like EU policies can be included.

The three scenario types described here are not necessarily separated from each other. The current trends can for example be used to inform on a plausible range of alternative futures. This is done within VOLANTE where an exploratory scenario approach was combined with normative visions. VOLANTE uses a set of explorative scenarios based on SRES as reference scenarios (*Figure 2*) and additionally explores a range of policy options. The policy options are developed by reviewing and inventorying documented visions from literature and through stakeholder consultation that relate to land use at local to EU scale in Europe. These are grouped into different clusters with similar key characteristics and mapped as “policy options” within the scenario framework. Such visions include, e.g. goals like stimulating a continuation of current agricultural land management in areas with a high supply of ecosystem services, or to limit urban sprawl and create and maintain compact urban settlements and cities. Next, land use trajectories for the policy options within the scenarios were analysed and linked to the normative visions to explore to what extent policy options help reaching the normative targets.



Figure

Figure 2: VOLANTE Scenario setup

The scenarios in development for the 5th Assessment Report (AR5) of the IPCC are another example of a hybrid approach for scenario development. Four possible levels of radiative forcing in 2100 were identified based on literature reviews, including pathways towards these levels (representative concentration pathways, RCPs). Using integrated assessment modelling and climate modelling, sets of technological, socio-economical and policy futures are identified that could lead to a certain RCP and magnitude of climate change. Also, climate change scenarios are specified based on climate modelling experiments. The specification of RCPs and analysing what is needed to get there is a normative approach, while the specification of the integrated assessment modelling scenarios is structured in an exploratory way.

For local case studies, sometimes similar approaches are followed, accounting for the main future uncertainties playing a role in the future dynamics of the case studies. However, often, a more participatory approach is followed, either to identify these main uncertainties or to completely build the scenario storylines. Engaging stakeholders in scenario development can empower those involved and can ensure the inclusion of a wide range of perspectives in the scenarios. Stakeholder involvement can provide relevant local knowledge that is otherwise difficult to include in scenarios, but participatory scenario development has also some pitfalls. This are discussed in section 4. Many approaches to participatory scenario development have been developed and applied. Examples of this include the sub-global assessments by MEA, which are further elaborated in section 4.

To summarize, a wide range of scenario studies and approaches to scenario development is available, both at EU scale and at local scale. Approaches in elaboration are commonly different for EU and local scale. Therefore, HERCULES will use different scenario approaches at both scales. For all scenario work, stock will be taken of existing scenario work.

3. Review of EU-scale scenarios

3.1. Drivers of pressures on land resources

Change processes that occur in cultural landscapes are among others demographic changes, changes in tourist pressure, and changes in resource use. Many of these changes in cultural landscapes will become visible as land use or land management change. These changes in land use appear as changes in:

- The area occupied by different land cover types (e.g. urban expansion, cropland expansion or contraction/abandonment)
- Land management intensity (e.g. changes in the level of inputs or extraction of goods and services)
- The configuration of different land uses in the landscape (e.g. field size, fragmentation or urban sprawl patterns)
- Changes in cultural elements: hedges, stone rows, monuments, land cover structure, buildings, etc.
- Changes in functionality: potential provision of ecosystem services; match between potential provision and demand.

Most of the available literature investigating drivers of change in land use that lead to pressures on the services provided by the land focus on changes in land cover. Recent studies have synthesized the case studies worldwide on the drivers of urbanization, deforestation, wetland conversion and degradation (Lambin et al. 2001, Geist et al. 2006, Seto et al. 2011, Van Asselen et al. 2013). The drivers of changes in agricultural management, including intensification and abandonment are less frequently investigated (MacDonald et al. 2000, Poyatos et al. 2003, Munroe et al. 2013), while land management actions directly impact the functioning of land resources, including the capacity to provide many ecosystem services and biodiversity. Land management refers to the amount / intensity of inputs and outputs. Spatial patterns of cropland intensity, grazing pressure and forest management are largely unknown or highly uncertain. Detailed data on the evolvement of land use intensity in the EU are scarce (Kuemmerle et al. 2013a, Temme and Verburg 2011, Overmars et al. 2014). Land management intensity can refer to the frequency of cultivation (crop-fallow cycles), the amount of inputs like irrigation, fertilizer or mechanization, or the quantity of outputs produced (yield). Van Vliet et al. (in review) present a meta-analysis of case studies on agricultural intensification and extensification. Kuemmerle et al (2013b) also included an analysis of intensity changes. Compared to the information on land cover change however, these analyses remain rather qualitative.

Also less frequently addressed in future modelling are the drivers of changes in configuration of land uses in the landscape. Evidence of drivers of changes in land use configuration and developing is e.g. found in scale enlargement of agricultural firms for management efficiency reasons, the removal of landscape elements and hedgerows as a result of losing their original functions as fencing and firewood provisioning, or the fragmentation of agricultural areas after the post-socialist land redistribution (Müller et al. 2009). Loss of tree alleys is closely associated with infrastructure development like road enlargement and straightening, while for alleys as well as other small landscape elements like scattered trees and hedgerows changing demands resulted in lack of conservation efforts (Plieninger 2012).

Both the extent of land cover and the spatial patterns of intensity are strongly controlled by the demand for products that are produced on land, most importantly food products. This demand is expected to grow, influenced by global population growth and economic development (Erb et al. 2013). To fulfil this demand, the supply can be increased by e.g. increasing yields through improved technology (see section 3.3.4), expansion of agricultural land, or conversion towards more intensive farming systems (Van Asselen and Verburg 2013).

Drivers for land use change can be subdivided in drivers for the demand for land-based products and drivers that affect the way in which these products are supplied (production system). The most important drivers are in listed in *Figure 2*.

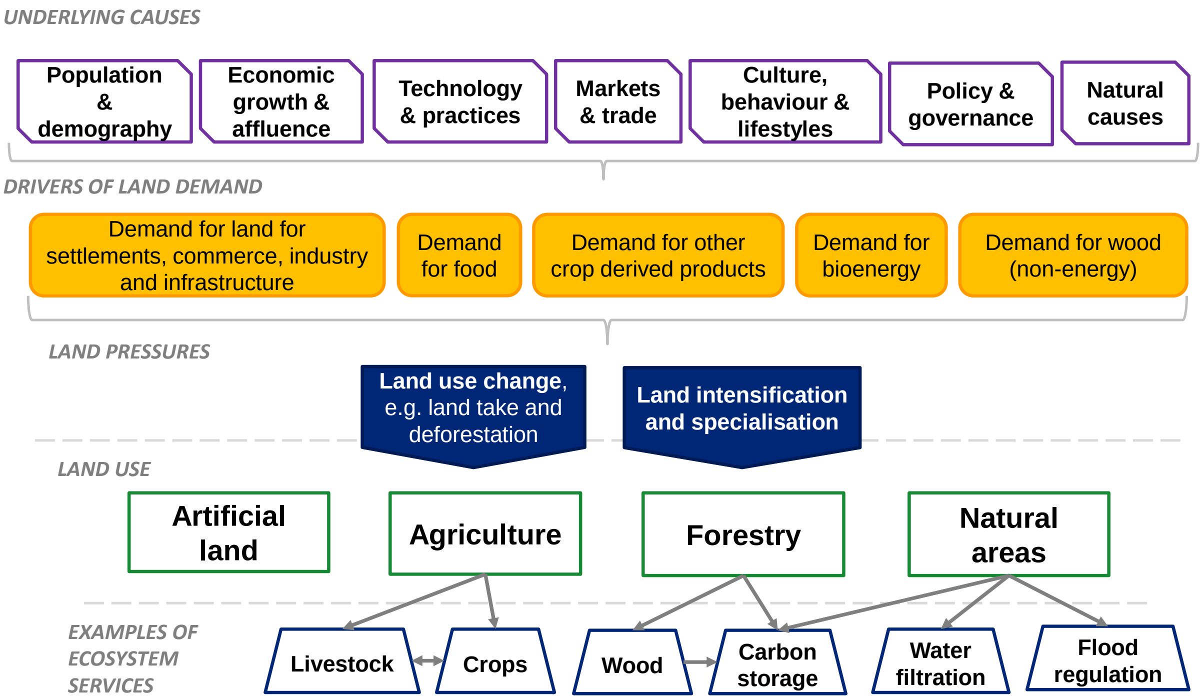


Figure 2: Drivers of land use change (from Van Vliet et al. 2014)

3.2. Overview of EU land use scenarios

Several land use change projections for the EU have been made recently, focusing mainly on land use and its consequences and less on land management. In a review on scenario studies for the European Commission, Directorate-General (DG) Environment (ENV), a range of EU scale scenario studies were assessed to get an idea of the range of expected changes in the EU. The studies reviewed for the preparation of this report are:

- Scenarios for policy support (ex-ante assessments): No Net Loss (Tucker et al. 2014), DG Climate Action study on resource efficiency (BIO et al. 2014); DEFRA study (Renwick et al. 2013)

- Scenarios aiming at scientific advancement or triggering the debate: VOLANTE (Lotze-Campen et al. 2013), EURURALIS (Eickhout and Prins 2008)
- Scenarios with combined aims: Kuhlmann et al. 2006, SCENAR2020 (Nowicki et al. 2006), DG ENV Land use modelling (Perez-Soba et al. 2010)

These studies put an emphasis on the agricultural sector. Additionally, sectoral scenario studies for the forestry sector were performed, e.g. EFORWOOD, but as these link less strongly to cultural landscapes, they were disregarded here. VOLANTE does include simulations of forest management change but does not include demand for forest products in simulation of forest area dynamics. These scenarios are not exclusive to cultural landscapes in Europe, but do address changes in landscapes, which include and affect cultural landscapes. Although these scenarios need to be specified towards their relevance for change in cultural landscapes across relevant time scales, they can give useful insight into the threats to cultural landscapes. All scenario studies describe the drivers used to simulate land use patterns and elaborate how these drivers change. All scenario studies described here either explore the impact of a specific set of policies, or provide likely, but contrasting scenarios based on a set of main drivers of change. Such scenarios aim to capture the range of uncertainty in future developments, including e.g. a wide range of gross domestic product (GDP) change estimates and contrasting levels of regionalization in which regional independence could be likely. Nevertheless, sudden extreme shocks are inherently difficult to predict, e.g. political conflicts or pests or diseases, and can consequently not be included in these scenarios.

In this section, we first describe the expected future developments of the main drivers for land use changes according to the abovementioned scenarios. Second, we describe the impact of the drivers on past and expected future land use changes.

3.3. Future trends of drivers

3.3.1. Demographic changes

All state-of-the-art land use change models translate population size into demand for residential area using a scenario-specific change of the required residential area per capita. The required residential area per capita is modelled as a function of GDP changes (this point is further discussed in the next section on economic development). The global population size and distribution influences the land demand in models through a scenario-specific, region-specific food demand per capita.

The JRC Baseline uses the Eurostat long-term population projections that assume an EU-28 population of 525.7 million in 2040 (Lavalle et al 2013). Eurostat projects increasing population in both EU-15 and EU-12. Compared to population projections used in other studies, this estimate is on the high side. Recent scenario studies apply population projections from IPCC SRES (EURURALIS, VOLANTE) or UN (BIO et al. 2014). Population projections for the EU range between a decrease of -0.2% annually (EURURALIS B2 scenario) (Eickhout and Prins 2008) and an increase of 4% annually (Perez-Soba et al. 2010). The low estimate of the EURURALIS B2 scenario is based on the IPCC SRES B2 estimate. It assumes a low migration overall with even a migration surplus out of the EU-12 countries, due to the assumption of a closed world. Given the lower increase in wealth, life expectancy and fertility rates are low. In the highest estimate, the global economic growth and the assumption of an open world leads to higher life expectancy, convergence of fertility rates throughout Europe and high migration. All scenarios assume a decreasing rural population and an increasing urban population in Europe. Regional differences mainly indicate increasing population in the EU-15, first due to immigration, and decreases are more often seen in the EU-12 due to emigration.

The medium fertility scenario of the UN, as used in the baseline scenario defined by BIO et al. (2014), assumes a continuous population decrease in Europe, with increases in some northern and western European countries and decreases elsewhere.

3.3.2. Economic growth

European-scale land use change modelling systems impose an exogenous GDP change and model economic developments using an equilibrium approach, towards meeting the GDP target given labour, capital, natural resources, and population.

The JRC Baseline follows Eurostat EPC/ECFIN long-term projections on economic development and assumes a GDP increase between 1.5 and 2% per year (EC DG Energy 2010). Other recent scenario studies use GDP projections ranging between annual increase of 1.5% (Tucker et al. 2014) and 3.48% (VOLANTE, A1 scenario) (Lotze-Campen et al. 2013) while BIO et al. (2014) assume a 1.84% annual increase. In the EU, studies that provide regional specification assume higher growth rates in the EU-12 than in the EU-15. GDP growth in the EU-12 is generally 1.5 times higher than in the EU-15 and is typically 3-4%. GDP increases in EU-12 are typically 1-2.5%. The European Commission estimate is 1.6% average annual growth up to 2030.

These scenario studies use GDP projections that were made before the financial crisis. GDP projections from recent scenarios are, consequently, high compared to actual recent changes. This might have led to overestimation of changes in built-up expansion and consumption.

3.3.3. Food composition and quantities

To simulate the impact of GDP on land use demand, land use change models define a demand for residential area per capita and a food demand per capita. Both the per capita demand for residential area and the food demand change proportionally to the GDP. Additionally, the GDP-based demand per capita for calories and livestock products can be adapted based on food preferences. An expert-based estimate is used, that reflects the assumptions and the difference between the scenarios. In the “vision oriented” studies, a range of settings is used. For example, in EURURALIS and VOLANTE, the scenarios focusing on regionalization assume a preference for regionally produced products, and consequently higher prices for non-local products. This is simulated through shifting production to within the EU. The scenarios with a higher level of regionalization assume a stronger focus on sustainability and more attention to health considerations and animal welfare issues. This is included in models by decreasing changes of the food demand or livestock product demands by an expert based percentage.

Several recent scenarios assume increasing demand for crop and livestock food products. This applies for the baseline scenario used by Tucker et al. (2014) where the demand follows GDP changes and for the scenario used by BIO et al. (2014) that assumes a demand increase of crop products of 0.5% per year in the EU-27 and increases up to 2.6% per year in Sub-Saharan Africa. For feed, the estimate is +0.4% in EU-27 and for other world regions up to 2.4% (Sub-Saharan Africa). Perez-Soba et al. (2010) assume that international food safety standards are raised. New mechanisms to ensure high social and environmental production standards are developed and developing regions also comply with these standards. Animal welfare and health considerations are assumed to decrease meat consumption.

3.3.4. Technological advances (yields)

Recent scenario studies closely follow yield estimates by agricultural outlooks from the OECD (see *Table 1*) and the United States Department of Agriculture. They assume increases in yield in the EU. Only the Scenar2020 study assumes decreases in yield in southern Europe due to water scarcity. For example, VOLANTE assumes productivity increases of 8-22% over 30 years (+0.27-0.73% per year).

It is doubtful that these yield increases could actually be achieved; cereal yields at EU level have been decreasing by 1.2% annually in the EU (European Commission 2014). Several EU-13 countries still show increases of cereal yields, but especially in the EU-15 countries yield decreases are widespread. Root crops show very small yield increases throughout the EU while for oil crops decreasing yields have been observed over the past decade (European Commission 2014). A simulation of future technology changes with an endogenous approach also showed decreasing future yields in Europe while, outside the OECD countries, stronger yield increases are expected and are more likely (Dietrich et al. 2014).

Table 1: Yield changes and projected yields for OECD countries (OECD 2013).

Commodity	Average yield (t/ha) 2002-04	2014	Annual growth (%) 1995-2004	2005-14	Average yield (t/ha) 2020
Wheat	3.2	3.5	0.92	0.96	3.7
Coarse grains	5.3	6.2	1.60	1.34	6.6
Rice	4.9	5.3	0.69	0.56	5.1
Oil seeds	2.4	2.7	0.84	1.02	2.8

3.3.5. International trade and markets

Recent baseline scenarios assume that the current tariff walls, import tariffs and export subsidies remain intact. This applies for the baselines from SENSOR (Kuhlman et al. 2006), JRC (Lavalle et al. 2013), No Net Loss (Tucker et al. 2014) and BIO et al. (2014). Perez-Soba et al. (2010) assume phasing out of export subsidies and import tariffs. Non-tariff barriers are expected to increase slightly.

The VOLANTE and EURURALIS projects simulate multiple plausible pathways of international relations. In both studies, two scenarios assume an opening up of global markets, while two other scenarios assume keeping current import and export restrictions (Lotze-Campen et al. 2013, Eickhout and Prins 2008).

3.3.6. Climate change

Recent scenario studies on future land use in Europe (Perez-Soba et al. 2010, BIO et al. 2014, Lavalle et al. 2013) generally assume moderate changes in the climate but do not consider any effects of climate change on land use. Within the relatively short timeframe of the studies considered (up to 30 years), no significant impacts are expected. Also, the impact of other factors (most importantly land use change) is assumed to be much stronger than the impact of climate change. The reviewed scenario studies do not include changes in the frequency of extreme events. It is likely that in parts of Europe the frequency or probability of droughts or floods will change to such an extent that changes in land use might be expected.

3.3.7. Policy drivers

Policies that have been implemented in the EU so far, as described in the policy context, contribute to shaping current and future landscapes by promoting one or several land functions. Several recent changes in the EU policy context demonstrate the increasing attention paid on the land issues. This is particularly remarkable in the energy and agricultural sectors, which have increasingly included greening measures in the last few years and are still expected to evolve in this sense (e.g. expected amendments to the Renewable Energy Directive; proposals from the CAP reform). The better integration of land use change issues into climate policies is also a relatively untapped potential likely to be developed in the near future. Further impacts on land use trends are also expected from the recent Green Infrastructure Strategy and from the 2013 European Commission’s proposal for a Directive on Maritime Spatial Planning and Integrated Coastal Management. *Table 2* provides an overview of the expected impacts of these policies on different land use types.

Table 2: Evaluation of expected land use impact of policies implemented in the EU

Relevant policies		Land use types					Comments	
		Built-up	Agriculture			Nature & forest	Pros	Cons
			General	Arable	Pasture			
Planning policies	EIA and SEA Directives	√			√	√	Binding instrument. Prevention, mitigation or compensation of impacts on land associated with the development of projects or programmes Could lead to more pasture and nature on areas sensitive to several forms of soil and land degradation	Limited implementation in MS (nature of screening and timing of assessment procedure)
	2013 European Commission's Directive proposal / Initiative on Maritime Spatial Planning and Integrated Coastal Management	√	√			√	Might set restrictions on urban sprawl and infrastructure expansion on specific coastal areas Might result in additional protected areas in coastal regions (against flooding and erosion)	Proposal stage – yet to be implemented
Nature and resource policies	EC Roadmap to a Resource Efficient Europe	√				√	Promotion of a multifaceted efficient land use	Guidance only
	Thematic Strategy on Soil Protection	√					Prevention of further degradation, the preservation of soil function and the restoration of degraded soils	Guidance only
	Water Framework Directive	√					Binding instrument. Can place restrictions on land take or specific land use conversions at specific locations Mitigate soil erosion and contamination	
	Habitat and Birds Directives and Natura 2000 network				√	√	Binding instrument Land protection through the protection of designated wild fauna, flora and habitats Restriction of activities that would go against these objectives and restoration of abandoned land	
	EU Biodiversity Strategy, Aichi Biodiversity Targets, Strategic Plan for Biodiversity 2011-2020				√	√	Less land use conversions and land take in protected areas Protection of permanent grasslands and a target to the restoration of degraded ecosystems Global approach through the Aichi targets aimed at better considering biodiversity worldwide and manage it more sustainably	Guidance only Increased nature protection may reduce land availability for other land use types and increase conflicts and global impacts (against Aichi targets but these remain relatively non-binding
	Green Infrastructure Strategy		√			√	Could set restrictions on land use conversions in areas that provide multiple benefits, or in areas with a high density of green infrastructure Aims at development of green infrastructure, i.e. nature expansion and especially establishment of nature networks and small patches Integration into many EU binding policies and coordination of existing instruments at MS level	Recent instrument, which efficiency regarding land degradation remains to be demonstrated Could lead to displacement of impacts and with that to increase, also of global impacts
	Ramsar Convention					√	Framework for national action and international cooperation for the conservation of wetlands. Impact not modelled yet	
	Rural Development Policies		√				Could stimulate the occurrence of varied landscapes or set disincentives to land use change in specific regions with currently	

Relevant policies		Land use types					Comments	
		Built-up	Agriculture			Nature & forest	Pros	Cons
			General	Arable	Pasture			
							a high level of multi-functionality	
	Transport policies: TEN-T (Trans-European Transport Networks)	√	√			√	Reliance on EIA and SEA Directives for the prevention, mitigation or compensation of its impacts	Driver of land take and fragmentation. Uncertainty of the proper implementation of EIA and SEA Directives in MS, which cannot in any case stop the expansion of transport completely
	EU trade policy		√			√		Increased imports of highly land embodied products
Agriculture policies	CAP Health Check 2008, GAEC, measures for improving the environment and the countryside, sustainable use of forestry land			√	√	√	Contribution of cross compliance to establishing a common reference level for sustainable soil management across the EU GAEC and AEM: assistance in farmers' transition to higher levels of soil quality and more sustainable agricultural land management Promotion of multifunctionality	Reliance of the implementation of measures beyond legal basis on individual behaviours Assessments of actual benefits?
	Common Agricultural Policy 2013 reform; greening measures			√	√	√	Will increase the amount of land dedicated to greening measures. Could trigger expansion of organic agriculture. These two factors could trigger expansion of arable land Protection of permanent grassland could result in less gross grassland conversion	Reliance of the implementation of measures beyond legal basis on individual behaviours
	EU Forest Strategy and Forest Action Plan 2007-2011					√	Aims to support and enhance sustainable forest management and the multifunctional role of forests	Low integration of environmental, social and economic aspects Low implementation and coordination
Climate and energy policies	REDD+		√				Might limit forest loss outside Europe. That might decrease the availability of land for agricultural production, increase prices, make agriculture within Europe financially more attractive, and reduce the decrease of agricultural land in Europe	Controversial in practice, especially because of the difficulty to measure and verify carbon offsets and control their permanence
	Renewable Energy Directive Policy			√		√	Promotion of biofuels with a comparatively low land footprint, progressive integration of sustainability criteria, and revision of objectives to mitigate the impacts on land consumption	Driver of land demand in the EU and elsewhere, resulting in conflicting land uses, intensification and deforestation. Impacts are mitigated, not removed
	2003 Emission Trading Directive						Recommendation for the assessment by 2020 of the appropriate modalities for including emissions and removals related to this sector	Land use, land use change and forestry emissions are not accounted for
	Roadmap for moving to a competitive low-carbon economy in 2050	√	√			√	Could result in less conversion of nature in peat areas, more forest expansion, and less land take by agriculture Reiterates the need to push progress towards in 2nd and 3rd generation biofuels and to proceed with the ongoing work on indirect land use change and sustainability	No clearly elaborated measures are defined

3.4. Future trends of land use quantities and patterns

This section describes the current status and future trends of land use change quantities and patterns. The drivers for land use change influence first the demand for land, and secondly, together with local conditions, land allocation patterns. This in turn has impacts on biodiversity and the provision of ecosystem services.

3.4.1. Future trends of land take

Built-up area: Recent scenario studies project an increase of built-up area ranging between 0.09 and 0.85% per year. Land demand is often a function of population and GDP, with a scenario-dependent fixed increase of built-up area per capita. For baseline scenarios, this ranges between a fixed increase of 0.75 m2 urban area per capita (BIO 2014) and 1.18 m2 per capita (Perez-Soba et al. 2010). Over the past decades, an increase of 1.18 m^2 urban area per capita was observed (BIO 2014). The low increase of urban area per capita in the scenario used by BIO (2014) is assumed to properly reflect the impact of the financial crisis on urban area expansion.

Urban sprawl: A wide range of settings with respect to urban sprawl is assumed in the different scenarios. The baseline scenarios (BIO 2014, Tucker et al. 2014, Nowicki et al. 2006, Kuhlmann et al. 2006, Lavalle et al. 2013) assume no policies to control urban sprawl because there are currently no EU-level measures on this topic. Some other reference scenarios (including Perez-Soba et al. 2010) assume that restricted urban sprawl leads to relatively compact urban growth, while spatial development in rural areas is allowed. This is driven by the assumption that, altough there are no EU-scale policies, several Member States do have policies to control urban sprawl.

All scenarios considered project some expansion of major cities, both in western Europe (e.g. London, Dutch Randstad, Berlin) and in eastern Europe (e.g. Budapest, Prague, major cities in Poland). Sprawl of built-up into rural areas is only expected in areas with a continuous increase in population, like northwestern Europe, or in a few scenarios that deliberately allow or stimulate built-up sprawl in rural areas.

Within the VOLANTE FP7 project, a policy scenario that includes such policies was evaluated. Also in Tucker et al. (2014), a scenario was evaluated that included measures aiming at reducing urban growth and urban sprawl, and that included offsetting the residual impacts of urban growth and urban sprawl. The VOLANTE Compact Cities scenario suggests that such policies are especially effective in already highly urbanized areas of the southern UK and Benelux. In the EU-12, the policies were expected to concentrate urban expansion in the vicinity of large cities. This decreases urban sprawl in rural areas but is likely to cause more impacts on the surroundings of large cities (Verburg et al. 2013b) (see *Figure 3*). Similar effects are seen in the analysis by Tucker et al. (2014) who also analysed the impacts of offsetting policies. This analysis suggested that strict offsetting requirements significantly increased the area of semi-natural vegetation in the vicinity of urban areas and with that also offset significant amounts of fragmentation.

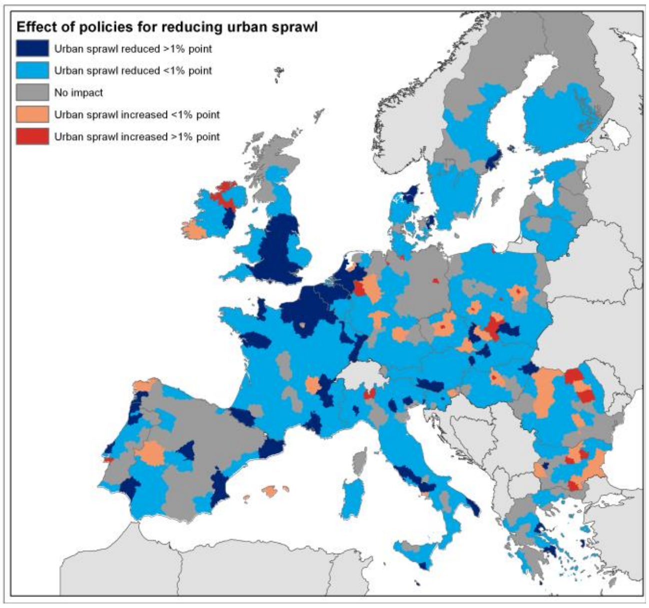


Figure 3: Difference in urban expansion between a baseline scenario and a policy option aiming at reducing urban sprawl (based on Verburg et al. 2013b)

Arable land: All scenario studies project a decrease of arable land area. The smallest decrease is expected in the SENSOR Baseline scenario (-0.01%) (Kuhlmann et al. 2006) and the strongest decrease in the VOLANTE policy scenario aiming at a high level of nature protection (-2.19%) (Lotze-Campen et al. 2013).

Many scenarios expect a loss of arable land due to urban expansion, but almost more importantly due to abandonment close to natural areas or in marginal lands, e.g. mosaic landscapes. Many scenarios expect some expansion of cropland in Spain and France, and in parts of the EU-12.

Drivers for changes in arable land are population, GDP, trade liberalization, climate, yield, biofuel policies, and CAP measures. In most scenario studies a quite high GDP estimate is used, as well as quite high yield increases. The high GDP estimate can result in overestimation of the demand for food, and thus for land. The high yield increase can have resulted in underestimation of the required cropland area, especially in scenarios that attribute a larger share of crop production to the EU. In less developed regions, agricultural technology advances are commonly expected, leading to higher expected yield increases. Finally, climate change effects on arable production are not considered. Within the short timeframe of most studies, climate changes are assumed to have little effect on crop production. However, using more up-to-date weather data might improve estimates.

Additional policies that affect agricultural land mainly focus on increasing the multifunctionality and decreasing the impact of agricultural expansion on existing nature (*Table 2*). Within the context of VOLANTE FP7, a policy option was simulated where “as stimulation for land stewardship in areas with a high potential to provide ecosystem services policy mechanisms need to be established that offer incentives for farmers or landowners tin exchange for managing areas with specific services, e.g. cultural heritage landscapes and landscapes with potentially high values for rural tourism”.

As for spatial implications, specific agricultural areas are assumed to become protected: Areas with a high potential for recreation, or a high biodiversity, or a high density of green linear elements. In total 25% of the agricultural area is assumed to receive such incentives. This policy scenario causes a substantial shift in spatial distribution of agriculture. Most importantly, less abandonment is expected in these multifunctional areas at the cost of less favoured areas. These results most importantly illustrate the importance of the selection of areas to be included in such schemes as trade-offs with other land uses can be expected. Also no clear impacts of the change of land use on e.g. fragmentation could be observed (Verburg et al. 2013b).

Pasture: Unlike urban land and arable land, there is no agreement on the direction of change of pasture areas. Most land use change studies expect a decreasing pasture area. However, annual increases up to 0.21% are expected as well. Increases in pasture area are expected in regionalization scenarios that target at self-sufficiency of the EU and consequently more animal production within the EU. Especially when combined with a high economic growth, leading to more consumption and a shift to a diet with more animal products, this leads to increases. Decreases are seen in globalization and market-oriented scenarios, where production is moved outside Europe due to lower production costs. Additionally, scenarios with a low economic growth and a strong sustainability focus can result in decreases of grassland area due to the decreasing demand for animal products.

Several existing policies could result in a higher protection of permanent grassland, especially on areas with high soil carbon content (*Table 2*). Additionally, policies exist that aim at increasing multifunctionality of agricultural land use. This might also stimulate continuation of permanent pastures. A policy option was analysed within VOLANTE FP7 where introduction of policies that aimed at increasing carbon sequestration was assumed. This policy option resulted in 7% more permanent pasture than the baseline scenario, with increased pasture persistence throughout the EU (Verburg et al. 2013b).

Forest and nature: Recent scenario studies expect an increase of forest area in the EU. The increases are a result of the demand for other land use types. Forest and nature are generally simulated as a remaining category with no independent demand calculation. Abandoned agricultural land is assumed to undergo a succession into forests. The succession speed and consequently the area of resulting forests might be overestimated in the modelling studies. Another drawback is that the impact on the demand for forest products is never included as a driver for forest land use changes, as the current modelling tools are not able to distinguish between managed and natural forests.

Protected areas: All recent scenario studies, except an extreme liberalization scenario (Liberalization scenario, SCENAR2020, Nowicki et al. 2006), assume protection of Natura2000 areas and, consequently, little land use dynamics in those areas. Often, conversion of forest and other nature into artificial land is strongly limited as well.

Several policies could influence forest and nature extent and patterns (*Table 2*). These could result in more development of green infrastructure, local offsetting of land take, expansion of protected areas, and a general decrease of land take. Similar policies were simulated in VOLANTE (a policy option aiming at increased nature protection) (Verburg et al. 2013b) and Tucker et al. (2014). Verburg et al. (2013b) included national protected nature areas in a more strict protection regime, resulting in lower land take rates overall. Similar effects were observed by Tucker et al. (2014). Additionally, Tucker et al. (2014) simulated different offsetting regimes and showed that offsetting could limit net loss of nature close to built-up areas, resulting in net increases of fragmentation (See section 5.2.4).

3.4.2. Future trends of land abandonment

Most drivers for land abandonment are forecasted to remain, and some of the key drivers are expected to intensify, most importantly as a response to increasing exposure to global agricultural markets. This is likely to result in increasing specialization and scale enlargement, and will decrease the viability of already marginal systems. These pressures will interact with (i.e. contribute to) ongoing soil erosion and degradation, and widespread rural depopulation. Additionally, decreases in yield are expected in southern Europe that further decreases the viability of marginal agricultural systems. This might further increase abandonment. CAP measures, most importantly agri-environmental payments and Less Favoured Areas (LFA) policies, to a certain extent mitigate land abandonment (Keenleyside and Tucker 2010).

As a consequence, significant levels of farmland abandonment over the next 20-30 years in the EU are likely. Recent scenario projections expect annual abandonment rates between 0.04% and 0.2% over the next 20-30 years. Abandonment rates tend to be high in scenarios with a high level of global competition and low CAP support. However, also scenarios with high CAP support, high levels of regulation and reduced global competition still expect significant abandonment. CAP measures thus mitigate abandonment, but do not stop it. Abandonment is reduced in scenarios that assume high levels of biofuel production in the EU.

Hotspots of abandonment are seen in Finland and Sweden, the Pyrenees, northwestern Spain and Portugal, the Massif Central, Apennines, Alps, upland areas of Germany, and the border area of the Czech Republic and the Carpathian Mountains. Most of these areas are likely to include large proportions of HNV farmlands. Particularly extensive grazing areas are risking abandonment.

3.4.3. Future trends of intensification

Little information was found on likely future trends of input intensification. Based on an inventory of recent scenario studies, Tucker et al. (2014) expect that the past trends of polarization in land use (i.e. intensification on one hand and abandonment at other locations) are likely to continue. They expect an increase in food and energy crop production, declining livestock production, decrease of agricultural employment and number of farm holdings and continued specialization. Further intensification is most likely in the EU-12 Member States. Lotze-Campen et al. (2013) expect decreasing amounts of mineral fertilizer application per hectare in all scenarios except A2. All scenarios expect slightly increasing amounts of animal manure application per hectare.

3.4.4. Future trends of habitat fragmentation and green infrastructure

The study by Tucker et al. (2014) on policy options for a No Net Loss Initiative analysed the expected future changes of fragmentation. In the study, the baseline (BaU) scenario showed a decrease of connectivity (i.e. increase of fragmentation), especially in areas that are already poorly connected (see Figure 4) (Tucker et al. 2014). This is due to the expansion of built-up areas and some expansion of arable land. The study then analysed four policy scenarios with different types of measures to enhance connectivity. Scenario A only includes measures that aim at avoiding the loss of ecosystems; these measures reduce the connectivity loss. In the scenarios B-C-D, increasing percentages of land take are compensated; this still leads to connectivity loss in currently poorly connected areas, but eliminates ecosystem losses elsewhere.

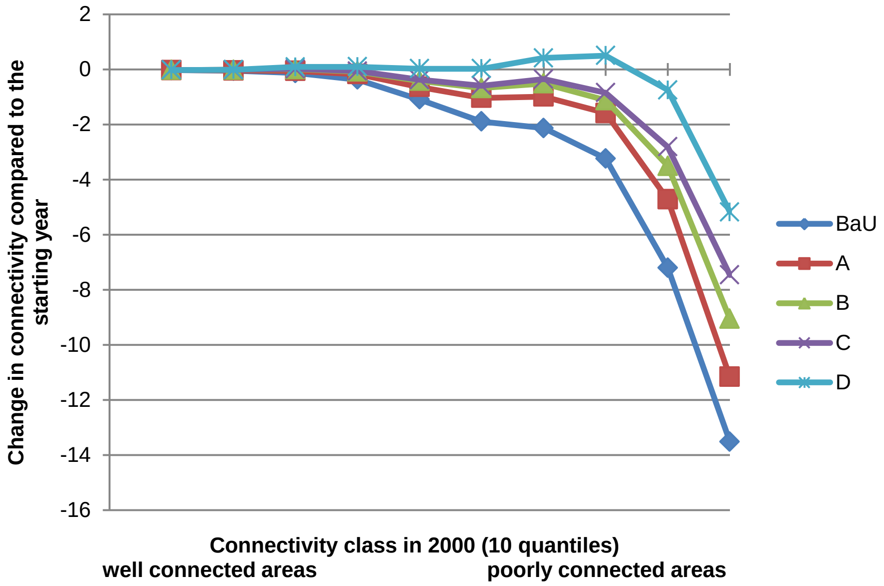


Figure 4: Impact of five policy scenarios on ecosystem connectivity (Tucker et al. 2014). The regions are classified into 10 quantiles ranging from well-connected areas in the year 2000 (left), to the least connected (most isolated) areas in the year 2000 (right). The graph shows the change in mean connectivity for areas in each of these quantiles. Positive values indicate improvement in connectivity, negative values indicate more isolation compared to the year 2000

3.5. Applicability of existing EU-scale scenarios to cultural landscapes

The scenarios on future land use in the EU described in this deliverable provide insight in the impact of a wide range of driving factors on EU landscapes. They provide a broad-scale picture, indicating the size of the impacts and likely locations. Progress towards simulating changes in intensity and with that land use polarization is being made as well. By overlaying existing scenario results with a map of the spatial distribution of cultural landscapes locations, hotspots, and types of land use changes in cultural landscapes can be identified.

The scope of the described scenario studies was to analyse the impacts of a few specific policies and they tend to focus on agricultural land. For cultural landscapes specifically, additional or other policies can have impacts as well. Scenarios for cultural landscapes thus can strongly build on the existing agricultural scenarios, but need an additional evaluation of existing and potential policies and their possible impacts on land use change. To account for additional policies, an inventory will be made of relevant EU-scale policies, their likely and desired impacts, and the level of implementation. Following this inventory, contrasting policy options will be designed and parameterized in the EU-scale modelling framework. Similarly, scenario options can be envisioned that account for e.g. regional changes in demographic developments.

Although identifying size and locations of land use changes in cultural landscapes provides useful information on the threats to cultural landscapes, it does not tell the impact these changes have. For that, additional impact assessment in more detail can be done following the land use change analysis to quantify changes in e.g. the character and functioning of the cultural landscapes. Additionally, demand for such functions can be included in policy options by e.g. protecting landscapes with a high level of functionality. A final overall limitation of this EU-scale approach is that subtle changes in e.g. land cover pattern cannot be identified. This is inherent to the approach and the analysis of study landscapes will here complement the EU scale analysis.

4. Case study scale scenario development

Task 5.2 of WP5 aims to provide a more detailed analysis of the impact of changes in drivers on the composition, structure, and management of cultural landscapes. This is done because these impacts that are missed at EU scale can be better studied at case study scale. This applies for both social and economic impacts, such as how land managers actually deal with EU policies, and for biophysical impacts, such as the impact of measures on land cover structure or e.g. variation in biophysical characteristics like groundwater variation, which also goes mainly through the land managers.

For developing case study scale scenarios, stock can be taken of approaches of local-scale scenario development, but existing scenarios themselves cannot be applied as these are location specific.

This analysis involves a range of uncertainties in e.g. the direction and magnitude of changes in the drivers. This includes both the EU scale drivers described in the previous chapters as well as possible additional drivers that are relevant to the case study. To account for these uncertainties at different scales and their linkages, a multi-scale scenario framework is proposed.

The Millennium Ecosystem Assessment did combine a global-scale scenario analysis with smaller scale case studies and provides several examples of approaches towards multi-scale scenarios. Basically, scenarios at different scales can be tightly or loosely coupled across scales. In a more tightly coupled approach, the larger-scale scenarios are used as the boundary conditions of the small-scale scenarios or the storylines from large-scale scenarios are further elaborated or specified to the local conditions. In the MEA scenarios for example levels of technical innovation are prescribed. The local scenarios for Portugal further elaborate on how this could be achieved. Such a linkage method ensures consistency across scales, but allows less stakeholder involvement.

In a loosely coupled approach, scenarios are developed independently at different scales. Subsequently, scenarios are summarized into a few archetypes based on the drivers and outcomes and scenarios at different scales fitting under a comparable archetype are compared. This approach has been applied in MEA local assessments in Southern Africa and the Caribbean. A disadvantage of this approach is a risk of inconsistency between the scenarios at different scales. Main advantage is that it accommodates a strong stakeholder involvement and ensures credibility of the scenarios at each considered scale (Biggs et al. 2007). Especially if the uncertainties in future development are highly regional specific, scenarios specified independently at different scales are an asset for identifying the range of consequences of future drivers.

A final option is to have a more independent analysis of land use and cover changes in the study landscapes. This can be relevant in case the macro-scale drivers have a relatively low uncertainty, while region specific developments play a dominant role. Van Berkel et al. (2011) analysed such a situation in a case study in Portugal. In the study area, main concerns are the continuation or abandonment of current management practices, attraction of tourism, and developments in the National Park in the study area. These topics were addressed in four scenarios, which were visualized with maps and photo-realistic montages. The scenarios and visualization were used to as discussion support tools, to show the impact of future management strategies on the landscape and to show the constraints and opportunities for adaptation and mitigation to negative developments.

An independent set of scenarios for a study landscape can provide useful insight in the impact of specific management options. In case the management options playing a role in a study landscape are representative for other parts of Europe as well, such an independent analysis is highly valuable for detailing the EU scale analysis.

5. Drivers and threats for cultural landscape change

While chapter 3 focused on landscapes in general, several issues specific to cultural landscapes are expected to cause changes in cultural landscapes. This chapter summarizes drivers for cultural landscape changes specifically, and threats and opportunities for cultural landscape development as identified in an EU scale workshop. Next, it summarizes the assets and gaps of existing scenarios with respect to cultural landscapes.

5.1. EU scale

HERCULES WP9 organised a workshop in May 2014 where several EU scale issues for the future of cultural landscapes were discussed. Although the attention for (cultural) landscapes in policies is limited, it is currently increasing and is now under the attention of the Commission and the Council.

Main issues on the future of European cultural landscapes, its opportunities and its threats as raised by the stakeholders present at the workshop are:

- Cultural landscapes should provide a living environment where people live and work. Inhabitants should be able to live and work in cultural landscapes, as that is the essence of cultural landscapes.
- Conflicting with this is the idea that cultural landscapes are non-renewable. While it is possible to re-introduce lost species, it is not possible to re-introduce lost cultural heritage.

- Land owners and rural stakeholders are most importantly the ones that make decisions on responsible and sustainable land stewardship and thus are important actors for landscape change.

Several opportunities were identified with the potential to strengthen cultural landscapes:

- Operationalising payment for ecosystem services, e.g. subsidising based on the amount of carbon sequestered.
- The use of nature-based solutions is expected to enable rural as well as urban areas to improve resource efficiency. This is expected to help managing cultural landscapes.
- Recreation in cultural landscapes is an important contribution to the well-being of urban citizens. Acknowledging this and operationalizing in policies can provide incentives for cultural landscape developments. At the same time, tourism can be a threat to many cultural landscapes and already has shaped and changed many of them by now. A careful balance is needed here.

Threats to cultural landscapes:

- Windmills could be a threat to cultural landscapes but are probably only the top of the iceberg.

Overall, main drivers are socio-economic, political, technological, natural, and cultural drivers (Plieninger et al. 2014). Especially relevant for cultural landscapes are changes in demographics (population, age) associated with land abandonment, as well as changes in policy such as the Common Agricultural Policy (CAP) of the European Union. The CAP has supported agricultural production with the aim of self-sufficient agricultural practice but has become an incentive for intensification of agriculture (van Zanten et al. 2013). Furthermore, the Landscape Convention of the European Union also is important for the protection of cultural landscapes in Europe. Although implementation has been limited, the potential exists (Plieninger et al. 2013c).

These drivers can cause intensification as well as extensification, leading to a polarization of land use which is seen as the principle land use change process threatening the persistence of cultural landscapes (Plieninger et al. 2014).

5.2. Case study scale

Within case studies, the same drivers of landscape change can play a role as at EU scale. A main difference with the EU scale is that several large-scale drivers can be out of control of the actors in the region, and that the range of variation of the drivers differs. For example, while at a EU scale polarisation of land use is expected, in a local case study most likely one of the change directions is dominant. However, in a meta-analysis of land use intensification and disintensification, Van Vliet et al. (2014) found that in 65 of the 218 case studies intensification was described as the main change process, while also disintensification was observed in the same case study. Demographic and economic drivers are found important for disintensification, while drivers describing technological developments were often identified in intensification case studies. Institutional drivers, location factors and farm / farmer characteristics are drivers for intensification as well as disintensification (Van Vliet et al. 2014).

As intensification of agricultural land manifests itself as an increase in management intensity, e.g. decrease in landscape elements, change towards more intensive agricultural activities or specialisation of activities (Van Vliet et al. 2014), these drivers of change may threat the character and functioning of cultural landscapes. The land abandonment associated with disintensification may threat cultural landscapes when these are characterized by intensive agriculture but may also provide opportunities for cultural landscape developments in areas where the original landscape character has been lost due to recent intensification.

6. Conclusion: Framework for multi-scale scenarios

HERCULES WP5 builds heavily on scenarios and will use EU-scale scenarios to map potential future threats to cultural landscapes (Task 5.2). Also, case study scale scenarios will be used to explore landscape dynamics at local scale (Task 5.2). Alternative landscape management visions will be tested under different scenario conditions (Task 5.3). For the EU scale as well as for the case studies, scenarios will cover a timeframe of a few decades. The scenarios will build on the driver inventory conducted in WP1. The analysis of scenarios in the study landscape can inform the visions for re-coupling social and ecological components in cultural landscapes, and vice versa. Finally, good practice options developed in WP8 can either use insights from the WP5 study landscape results, or can help informing the management scenarios (as described in section 6.2).

This section described the approach for developing the scenarios based on the insights presented in chapters 2-4.

6.1. EU-scale scenarios

For the European scale context, we build on previous scenario studies. Many studies on the future of rural Europe have been performed that assessed the range of future changes of drivers for landscape change. Based on an inventory of these driver changes and scenarios, we identify the most important and most divergent drivers of change and identify knowledge gaps specific to cultural landscapes. Second, in the first EU-scale HERCULES workshop, future threats and the actors for cultural landscapes were discussed. Based on these inventories we will specify a set of EU-scale scenarios.

All EU scale scenarios assessed here originate from research programmes where there was close co-operation with EC officers and other EU scale stakeholders, which ensures that the scenarios are relevant to EU scale stakeholders. The present scenarios focus on agricultural land and on the consequences of a few specific policies, not necessarily including policy options relevant to cultural landscapes. Many of these policies have shown pronounced changes in land use patterns that will certainly affect cultural landscapes, although unknown where and how much. There is less attention for landscape patterns, as well as for urban areas and the links between cities and landscapes in the form of ecosystem service supply and demand.

For analysing future threats and opportunities to cultural landscapes, the evaluated existing scenarios can be used to identify hotspots of changes in cultural landscapes by overlaying with a cultural landscape map. This does however not address the shortcomings of existing scenarios to cultural landscapes as described above. To increase the relevance of scenarios specifically for cultural landscapes, more elaborate scenario runs are needed that explicitly address issues important for (features of) cultural landscapes. For that, scenario development for the EU scale will focus on:

- Evaluating the potential impacts of additional policies on both land demand in the EU and on landscape structure, and, if relevant, include them in the scenarios. This applies most importantly for policies on landscapes (European Landscape Convention) and ecosystem services (most importantly, Biodiversity Policy). An inventory will be performed of relevant policies, their potential impact on cultural landscapes, and their level of implementation. Based on this review, policy option(s) can be designed and parameterised that capture the additional effect of such policies.
- Specifically, policy options that account for protecting natural areas for biodiversity conservation will be explored. Such measures impose a demand for nature areas and with that change the land area available for agriculture, thus influencing the level of intensification required.
- Evaluate better differentiation of population dynamics between rural and urban population dynamics. Country or region specific population projections will be reviewed and, if necessary, population dynamics will be disaggregated for rural and urban areas.
- Including differentiation between different farming systems: A land use system or specifically a farming system represents both land cover and land use in mosaic landscapes with different land use intensities, livestock densities or population densities (Van Asselen and Verburg 2013). We will explore the possibilities for simulating changes in cultural landscapes based on farming systems instead of based on land cover. Although in principle independent of the scenario development, this potentially provides the possibility of better accounting for the role of demand for ecosystem services in shaping the future of cultural landscapes. Also, a set of policy options can be envisioned that focuses on the protection of areas with a high potential for ecosystem service provision.
- Climate change: the average climate change levels over the past few decades are expected to have a limited impact on agricultural land use compared to other drivers, such as globalisation or demography. However, increasing probabilities of extreme events (droughts, floods) are already observed over the past years and new climate change scenarios better include this. These changes in extreme values do influence the suitability of the land to support agricultural land use but are, however, difficult to capture. We will evaluate if available spatially explicit climate change scenarios provide sufficient basis to include these effects in the EU scale scenario assessment.

6.2. Case study scale scenarios

Within the case studies, opportunities and threats specific to the case study will be elaborated, however focusing on issues that are widespread in cultural landscapes in Europe. Examples are the impact of tourism; impact of ageing farmer population; or the impact of within- or between-country migration. As such, the scenario studies in the study landscape provide a more detailed elaboration of a selection of drivers of landscape change important at EU scale and with that fitting in the EU scale context. The EU scale scenarios will be used to set the boundaries for the developments in the study landscape. From the case studies identified in WP3, two study landscapes will be selected where some of these issues play a role. Scenarios for the study landscapes will be primarily developed to cover the relevant issue(s) in the best possible way.

Following Van Berkel and Verburg (2012), the scenarios will be defined with the help of local experts and data of current regional trends and development processes, combined with modelling. Use will be made of the advantages of normative scenarios and exploratory scenarios in parallel (*Figure 5*).

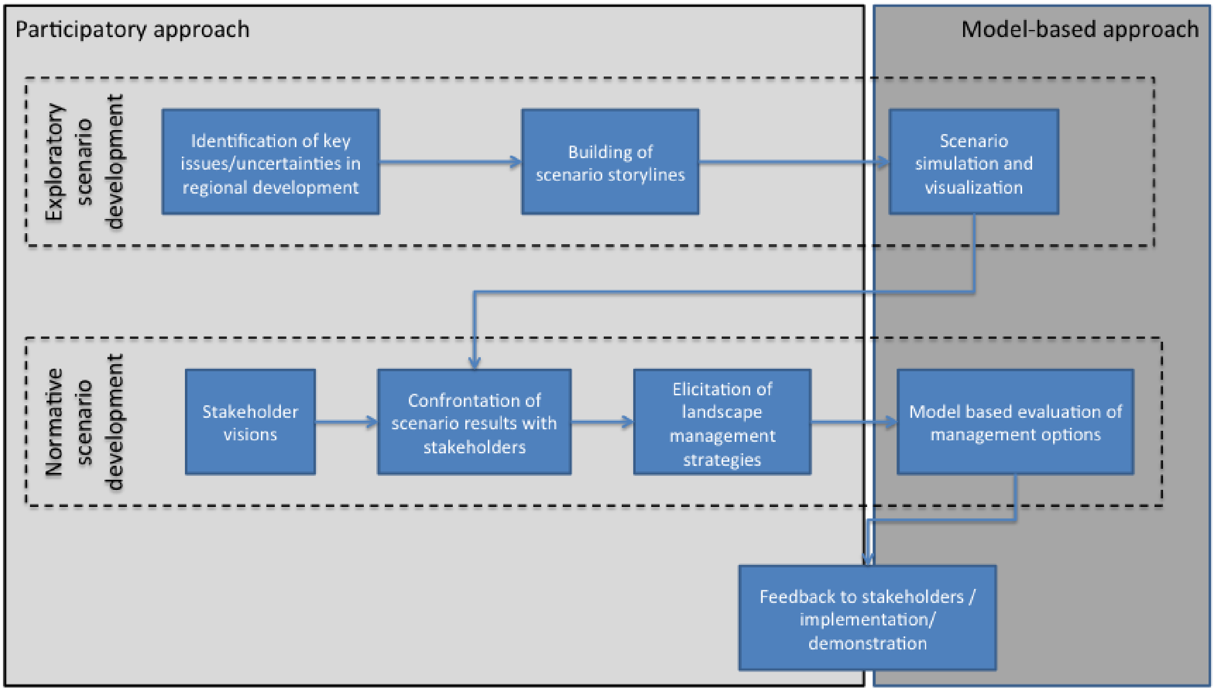


Figure 5: Set-up for scenario development

- Exploratory scenarios will be developed with the participation of the stakeholders. In interviews with stakeholders, challenges for different regional developments given the emergent trends will be discussed. Based on these interviews, a few (e.g. two) diverging trends for socio-economic and / or policy trends are selected and used to simulate possible futures for the case studies. Alternatively, these can be derived from the EU-scale scenarios. Next, the impact on the cultural landscape and the landscape services is analysed using simulation models.
- In parallel, stakeholders are asked to participate in developing visions for the future of their cultural landscape. These visions provide a set of normative scenarios. Using mind

maps, stakeholders can formulate actions necessary to achieve the goals specified in these visions within the framework of the model outcomes.

- In a workshop, the results of the simulations of the exploratory scenarios are evaluated with the stakeholders and compared with the normative stakeholder visions. The stakeholder visions are then used to further inform the scenarios. With a participatory backcasting an evaluation is made of measures that potentially bring the extrapolatory scenarios closer to the desired visions. These measures are again evaluated in a simulation model and evaluated with the stakeholders.

References

Biggs, R., C. Raudsepp-Hearne, C. Atkinson-Palombo, E. Bohensky, E. Boyd, G. Cundill, H. Fox, S. Ingram, K. Kok, S. Spehar, M. Tengö, D. Timmer, M. Zurek (2007). Linking futures across scales: a dialog on multiscale scenairos. Ecology and Society 12:17.

BIO by Deloitte (2014). Resource Efficiency Policies for Land Use Related Climate Mitigation. Second Interim Report (updated) prepared for the European Commission, DG CLIMA.

Börjeson, L., M. Höjer, K.-H. Dreborg, T. Ekvall, G. Finnveden, (2008). Scenario types and techniques: Towards a user's guide. Futures 38:723-739.

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

Dearing, J. A., A.K. Braimoh, A. Reenberg, B.L. Turner, S. van der Leeuw (2010). Complex land systems: The need for long time perspectives to assess their future. Ecology and Society 15(4):21.

Dietrich, J.P., C. Schmitz, H. Lotze-Campen, A. Popp, C. Müller (2014). Forecasting technological change in agriculture – an endogenous implementation in a global land use model. Technological Forecasting and Global Change 81:263-249.

Eickhout, B., A.G. Prins (eds.) (2008). EURURALIS 2.0. Technical background and indicator documentation. Wageningen UR and Netherlands Environmental Assessment Agency (MNP), Bilthoven.

Erb, K.-H., H. Haberl, M. Rudbeck Jepsen, T. Kuemmerle, M. Lindner, D. Mueller, P.H. Verburg, A. Reenberg (2013). A conceptual framework for analysing and measuring land-use intensity. Current Opinion in Environmental Sustainability 5:484-493.

European Commission (2014). EUROSTAT database. www.ec.europa.eu/eurostat (accessed 30 September 2014).

European Commission DG Energy (2010). EU Energy trends to 2030 - Update 2009. http://ec.europa.eu/energy/observatory/trends_2030/doc/trends_to_2030_update_2009.pdf (accessed 30 September 2014).

Ewert, F., M. Rounsevell, I. Reginster, M. Metzger, R. Leemans (2005). Future scenarios of European agricultural land use. Agriculture, Ecosystems & Environment 107:101-116.

Geist, H.J., W. McConnell, E.F. Lambin, E. Moran, D. Alves, T. Rudel (2006). Causes and trajectories of land-use/cover change. In: E.F. Lambin, H.J. Geist (eds.), Land-Use and Land-Cover Change. Local Processes and Global Impacts. Springer, Berlin/Heidelberg: 41-70.

Gellrich, M., N.E. Zimmermann (2007). Investigating the regional-scale pattern of agricultural land abandonment in the Swiss mountains: A spatial statistical modelling approach. Landscape and Urban Planning 79:65-76.

Lotze-Campen, H., A. Popp, P. Verburg, M. Lindner, H. Verkerk, E. Kakkonen, E. Schrammeijer, N. Schulp, E. van der Zanden, J. Helming, H. van Meijl, A. Tabeau, T. Kuemmerle, C. Lavalle, F. Batista e Silva, D. Eitelberg (2013). Description of the

Translation of Sector Specific Land Cover and Land Management Information. VOLANTE Deliverable 7.3. EU FP7 no. 265104.

Intergovernmental Panel on Climate Change (IPCC) (2012). Glossary of Terms Used in the IPCC Fourth Assessment Report. IPCC, Geneva. http://www.ipcc.ch/publications_and_data/publications_and_data_glossary.shtml (accessed 30 September 2014).

Keenleyside, C., G M Tucker (2010). Farmland Abandonment in the EU: An Assessment of Trends and Prospects. Report prepared for WWF. Institute for European Environmental Policy, London.

Kuemmerle, T., P. Hostert, V. C.Radeloff, S. Linden, K. Perzanowski, I. Kruhlov (2008). Cross-border comparison of post-socialist farmland abandonment in the carpathians. Ecosystems 11:614-628.

Kuemmerle, T., C. Levers, D. Müller, K. Erb, C. Plutzar, P.H. Verburg, P.J. Verkerk (2013b). Report on Drivers of Recent Land Use Transitions in Europe. VOLANTE Deliverable 3.3. EU FP7 no. 265104.

Kuemmerle, T., K. Erb, P. Meyfroidt, D. Mueller, P.H. Verburg, S. Estel, H. Haberl, P. Hostert, M.R. Jepsen, T. Kastner, C. Levers, M. Lindner, C. Plutzar, P.J. Verkerk, E.H. van der Zanden, A. Reenberg (2013a). Challenges and opportunities in mapping land use intensity globally. Current Opinion in Environmental Sustainability 5:484-493.

Kuhlmann, T., P. Le Mouël, C. Wilson (2006). Baseline Scenario Storylines. SENSOR Report series 2006/2. ZALF, Müncheberg.

Lambin, E. F., Geist, H. (eds.) (2006). Land-Use and Land-Cover Change. Springer-Verlag.

Lambin, E. F., B.L. Turner, H.J. Geist, S.B. Agbola, A. Angelsen, J.W. Bruce, O.T. Coomes, R. Dirzo, G. Fischer, C. Folke, P.S. George, K. Homewood, J. Imbernon, R. Leemans, X. Li, E.F. Moran, M. Mortimore, P.S. Ramakrishnan, J.F. Richards, H. Skanes, W. Steffen, G.D. Stone, U. Svedin, T.A. Veldkamp, C. Vogel, J. Xu (2001). The causes of land-use and land-cover change: Moving beyond the myths. Global Environmental Change 4:261-269.

Lavalle, C., S. Mubareka, C. Perpiña Castillo, C. Jacobs-Crisioni, C. Baranzelli, F. Batista e Silva, I. Vandecasteele (2013). Configuration of a Reference Scenario for the Land Use Modelling. JRC Technical Report EUR 26050 EN. Publications Office of the European Union, Luxembourg.

Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-Being: Scenarios, Volume 2. Island Press, Washington.

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

Metzger, M. J., M.D. Rounsevell, H.A.V. den Heiligenberg, M. Perez-Soba, P. Soto Hardiman (2010). How personal judgment influences scenario development: An example for future rural development in Europe. Ecology and Society 15(2):5.

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

Nakicenovic, N., J. Alcamo, G. Davis, B. de Vries, J. Fenhann, S. Gaffin, K. Gregory, A. Griibler, T. . Jung, T. Kram, E.L.L. Rovere, L. Michaelis, S. Mori, T. Morita, W. Pepper, H. Pitcher, L. Price, K. Riahi, A. Roehrl, H.-H. Rogner, A. Sankovski, M. Schlesinger, P. Shukla, S. Smith, R. Swart, S. van Rooijen, N. Victor, Z. Dadi (2000). Special Report on Emissions Scenarios. Cambridge University Press, Cambridge.

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

Nowicki, P., C. Weeger, H. van Meijl, M. Banse, J. Helming, I. Terluin, D. Verhoog, K. Overmars, H. Westhoek, A. Knierim, M. Reutter, B. Matzdorf, O. Margraf, R. Mnatsakanian, M. Belling, T. Leibert, S. Lentz, P.H. Verburg (2006). Scenar2020. Scenario Study on Agriculture and the Rural World. European Commission, DG Agri. Office for Official Publications of the European Communities, Luxembourg.

OECD (2013). OECD-FAO Agricultural Outlook. http://www.oecd.org/site/oecd-faoagriculturaloutlook/ (accessed 30 September 2014).

Overmars, K. P., C. J. E. Schulp, R. Alkemade, P. H. Verburg, A.J.A.M. Temme, N. Omtzigt, J. H. J. Schaminée (2014). Developing a methodology for a species-based and spatially explicit indicator for biodiversity on agricultural land in the EU. Ecological Indicators 37 Part A:186-198.

Paterson, J., M. Metzger, A. Walz (2012). The VOLANTE scenarios: framework, storylines and drivers. VOLANTE Deliverable 9.1. EU FP7 no. 265104.

Pérez-Soba, M., P.H. Verburg, E. Koomen, M.H.A. Hilferink, P. Benito, J.P. Lesschen, M. Banse, G. Woltjer, B. Eickhout, A.-G. Prins, I. Staritsky (2010). Land Use Modelling - Implementation. Preserving and Enhancing the Environmental Benefits of "Land-Use Services". Final report to the European Commission, DG Environment. Alterra Wageningen UR, Geodan, Object Vision, BIO, LEI and PBL.

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

Plieninger, T., S. Dijks, E. Oteros-Rozas, C. Bieling (2013b). Assessing, mapping, and quantifying cultural ecosystem services at community level. Land Use Policy 33:118-129.

Plieninger, T., T. Kizos, J.Kolen, M. Buergi, T. Kuemmerle, P. Verburg, C. Bieling, G. Milcinski, G. Girod, M.-A. Budniok (2013c). HERCULES. Sustainable Futures for Europe's Heritage in Cultural Landscapes: Tools for Understanding, Managing, and Protecting Landscape Functions and Values. Description of Work. EU FP7 no. 603447.

Plieninger, T., K. Trommler, T. Kizos, G. Tsilimigkas, L. Stenchok, T. Balatsos, M.-A. Budniok, M. Bürgi, C.L. Crumley, G. Girod, P. Howard, J. Kolen, L. Le Du-Blayo, T. Kuemmerle, G. Milcinski, H. Palang and P.H. Verburg (2013). Report Describing the

Cultural Landscapes Framework Developed, Including a Dictionary of Terms. HERCULES Deliverable 1.1. EU FP7 no. 603447.

Poyatos, R., J. Latron, P. Llorens (2003). Land use and land cover change after agricultural abandonment. Mountain Research and Development 23:362-368.

Renwick, A., T. Jansson, P.H. Verburg, C. Revoredo-Giha, W. Britz, A. Gocht (2013). Policy reform and agricultural land abandonment in the EU. Land Use Policy 30:446-457.

Rounsevell, M.D.A., M.J. Metzger (2010). Developing qualitative scenario storylines for environmental change assessment. Climate Change 1:606-619.

Rounsevell, M., I. Reginster, M. Araujo, T. Carter, N. Dendoncker, F. Ewert, J. House, S. Kankaanpaa, R. Leemans, M. Metzger, C. Schmit, P. Smith, G. Tuck (2006). A coherent set of future land use change scenarios for Europe. Agriculture, Ecosystems & Environment 114:57-68.

Seppelt, R., S. Lautenbach, M. Volk (2013). Identifying trade-offs between ecosystem services, land use, and biodiversity: A plea for combining scenario analysis and optimization on different spatial scales. Current Opinion in Environmental Sustainability 5:458-463.

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

Settele, J., G. Fanslow, S. Fronzek, S. Klotz, I. Kuehn, M. Musche, J. Ott, M. Samways, O. Schweiger, J. Spangenberg, G.-R. Walther, V. Hammen (2010). Climate change impacts on biodiversity: A short introduction with special emphasis on the ALARM approach for the assessment of multiple risks. Biorisk 5:3-29.

Müller, D., T. Sikor, J. Stahl (2009). Land fragmentation and cropland abandonment in Albania: Implications for the roles of state and community in post-socialist land consolidation. World Development 37:1411-1423.

Temme, A.J.A.M., P.H. Verburg (2011). Mapping and modelling of changes in agricultural intensity in Europe. Agriculture, Ecosystems & Environment 140:46-56.

Tucker, G., B. Allen, M. Conway, I. Dickie, K. Hart, M. Rayment, C. Schulp, A. van Teeffelen (2014). Policy Options for an EU No Net Loss Initiative. Report to the European Commission. Institute for European Environmental Policy, London.

Valbuena, D., P.H. Verburg, A.K. Bregt, A. Ligtenberg (2010). An agent-based approach to model land-use change at a regional scale. Landscape Ecology 25:185-199.

Van Asselen, S., P.H. Verburg, J.E. Vermaat, J. Janse (2013). Drivers of wetland conversion: A global meta-analysis. PLoS ONE 8:e81292.

Van Asselen, S. van, P.H. Verburg (2013). Land cover change or land-use intensification: Simulating land system change with a global-scale land change model. Global Change Biology 19:3648-3667.

Van Berkel, D.B., S. Carvalho-Ribeiro, P.H. Verburg, and A. Lovett (2011). Identifying assets and constraints for rural development with qualitative scenarios: A case study of Castro Laboreiro, Portugal. Landscape and Urban Planning 102:127-141.

Van der Leeuw, S., R. Costanza, S. Aulenbach, S. Brewer, M. Burek, S. Cornell, C. Crumley, J.A. Dearing, C. Downy, L.J. Graumlich, S. Heckbert, M. Hegmon, K. Hibbard, S.T. Jackson, I. Kubiszewski, P. Sinclair, S. Sörlin, W. Steffen (2011). Toward an integrated history to guide the future. Ecology and Society 16(4):2.

Van Vliet, J., H.J.M. de Groot, P. Rietveld, P.H. Verburg (in review). Manifestations and underlying drivers of agricultural land change in Europe. Landscape and Urban Planning.

van Zanten, B.T., P.H. Verburg, M. Espinosa, S. Gomez-y Paloma, G. Galimberti, J. Kantelhardt, M. Kapfer, M. Lefebvre, R. Manrique, A. Piorr, M. Raggi, L. Schaller, S. Targetti, I. Zasada, D. Viaggi (2013). European agricultural landscapes, common agricultural policy and ecosystem services: A review. Agronomy for Sustainable Development 34:309-325.

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

Verburg, P.H., A. Tabeau, E. Hatna (2013a). Assessing spatial uncertainties of land allocation using a scenario approach and sensitivity analysis: A study for land use in Europe. Journal of Environmental Management 127:132-144.

Verburg, P.H., H. Lotze-Campen, A. Popp, M. Lindner, H. Verkerk, E. Kakkonen, E. Schrammeijer, J. Helming, A. Tabeau, N. Schulp, E. van der Zanden, C. Lavalle, F. Batista e Silva, D. Eitelberg (2013b). Report Documenting the Assessment Results for the Scenarios Stored in the Database. VOLANTE Deliverable 11.1. EU FP7 no. 265104.

Vos, W., H. Meekes (1999). Trends in European and cultural landscape development: perspectives for a sustainable future. Landscape and Urban Planning 46:3-14.

Westhoek, H., M. van den Berg, J. Bakkes (2006). Scenario development to explore the future of Europe’s rural areas. Agriculture, Ecosystems & Environment 114:7-20.

Zimmermann, R. (2006). Recording rural landscapes and their cultural associations: Some initial results and impressions. Environmental Science & Policy 9:360-369.

Zurek, M.B., T. Henrichs (2007). Linking scenarios across geographical scales in international environmental assessments. Technological Forecasting and Social Change 74:1282-1295.