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Land-use scenarios for Europe: qualitative and quantitative analysis on a European scale

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Acronyms

ACCELERATES	Assessing climate change effects on land use and ecosystems, from regional analysis to the European scale
ATEAM	Advanced terrestrial ecosystem analysis and modelling
CIESIN	Centre for International Earth Science Information Network
CO_2	Carbon dioxide
Corine	Coordinated information on the European environment
EEA	European Environment Agency
EFSOS	European forest sector outlook studies
ESPON	European Spatial Planning Observation Network
GDP	Gross domestic product
GIS	Geographical information system
GTAP	Global trade analysis project
IIASA	International Institute for Applied System Analysis
IMAGE	Integrated model to assess the greenhouse effect
IPCC	Intergovernmental panel on climate change
NUTS	Nomenclature of territorial units for statistics
Pelcom	Pan-European land use and land cover monitoring
PRELUDE	PRospective Environmental analysis of Land Use Development in Europe
SAS	Story-and-simulation
SRES	Special report on emission scenarios
UN	United Nations

1 Landscapes to the living: which way to the future?

Land-use change is a pressing challenge to sustainable development in Europe. Land is a limited resource in Europe. The need for resources and space and the capacity of the land to absorb and support this need can lead to use conflicts, especially in urban environments. Over the past few decades, cities have been spreading in a scattered way across Europe. The amount of space consumed per person in cities has more than doubled over the last fifty years. At the same time the share of agriculture areas has declined. Land abandonment concerned especially extensively farmed areas, often with a high agricultural biodiversity (EEA, 2006; 2005).

The need to preserve the European landscape is now an accepted topic on the political agenda. A range of policies has been set up at European level and within the Member States, most notably the European Landscape Convention, the Habitats Directive and the Water Framework Directive (EEA, 2005). A cross-section of European policy areas ranging from agriculture to transport and environmental protection to regional development will be affected by the need to preserve Europe's landscape. But will we be able to maintain this common natural heritage?

Many of our decisions today will affect our ability and capacities to achieve this challenge over the long term. When we build a road, for example, it will be with us for 50, 100 or even more years. Just consider the roads that were built during the Roman Empire. Many of our activities leave long lasting footprints on the land. Many of them accumulate over time, leading to drastic and sometimes irreversible change. Housing and transport infrastructure, for example, might change the character of surrounding landscapes and limit their recreational and environmental values.

If we want to keep and improve peoples living conditions, we have to better understand the potential long-term consequences of our actions, and design policies, that stand the test of time. This is still a major challenge to our modern society. Over the last years, much progress has been made in better analysing future developments and their implications. For example, we already know many facts about the potential long-term impacts of climate change or of demographic change. Forward studies have been developed to scan the future of agriculture, transport and energy, climate change and air pollution. And more and more governments have started to assess the impacts of their policies in a systematic manner.

However, there are still major shortcomings. Most of the available long-term studies focus only on one sector or one dimension of a problem. This comes at the expense of analysing inter-linkages of the many socio-economic driving forces that contribute to problems in our increasingly complex and fast changing world. Moreover, most studies are still built around the extrapolation of current trends to a distant future — the so-called business-as-usual or baseline scenario-approach — against which alternative policies are tested.

While this approach is useful for short-term assessments, it is doubtful, whether it is sufficient for understanding potential long-term trend developments. In the long run, trend discontinuities may become the norm, rather than the exception, due to disruptive events or political action itself. Business-as-usual scenarios struggle to represent the complexity of future dynamics and its potential for disruptive change.

Long-term contrasting scenarios analyse a whole range of plausible, but very different and surprisingly rich futures. They help organisations to rethink the robustness of existing strategies and to discuss potential options to adapt or successfully survive fundamental changes in society, economy or the environment. Scenario development has become a frequently used tool in international organisations, companies and governments worldwide (see Shell International Limited, 2005; Raskin, 2005; EEA, 2000).

A number of upcoming policy initiatives will impact on future socio-economic and environmental developments in Europe's regions. This concerns for example the review of the Common Agriculture Policy in 2008 ('health check') and subsequent activities or the implementation of the new European Agriculture Fund for Rural Development (EAFRD) that entered into force in 2007. But it concerns also the planned mid-term review of European Cohesion policies in 2010 or the adoption of policies to correspond to Europe's objective of fostering the production of biofuels.

Long-term contrasting scenarios can provide context and a backdrop against which the debate on land use and our environmental future can take place. The European Environment Agency initiated the PRELUDE project (PRospective Environmental analysis of Land Use Development in Europe) to develop coherent scenarios that describe plausible future developments for land use in EU-25 plus Norway and Switzerland and their potential environmental impacts for the period 2005–2035.

An analysis of historic and possible future patterns of land use and landscape changes requires good data, scientific rigour, imagination and expertise from different perspectives. The PRELUDE scenarios combine imagination, data, modelling and narratives. The narratives, or storylines, were developed in order to also illustrate the impact of possible events and developments that cannot be represented with state of the art models — and tend to be ignored in policy discussions. With the PRELUDE initiative, the EEA decided to embark on a truly participative scenario building process. In order to achieve this, the project team carefully selected a group of stakeholders from across Europe, representing a wide variety of interests and perspectives. The stakeholders where professionally lead through an intensive scenario building process, which included direct interaction with the modelling teams responsible for the quantification of the scenarios. Building on different assumptions about societal, economic, political, technological and environmental change, the panel arrived at five qualitative scenarios. Each scenario implies specific land-use changes and impacts on the environment, which have been analysed and quantified by land-use experts using state-of-the art simulation models.

The findings of the PRELUDE scenarios are neither predictions nor forecasts. They describe a range of possible futures, which are meant to inspire strategic thinking about some of the key challenges that Europe may face in the future in the field of land-use, agriculture, rural development and the environment. Much of the information generated in this project is available in an audio- and video-animated interactive tool. It is advisable to access the contents of this tool at the EEA website (1) to gain a better understanding of the scenarios and the results of the environmental analysis. This technical report describes the scenario approach and the modelling applied on a European scale (2). It analyses the PRELUDE scenarios and compares them in terms of their consequences.

The structure of the report is as follows: the next chapter discusses the methodological framework for the scenario development and modelling on a European scale; the third chapter describes the main logics and drivers of the scenarios, while the fourth chapter illustrates the five scenarios in detail. Chapter five provides snapshot analysis of land-use changes and environmental impacts across the different scenarios and discusses implications for policy-making. The report finishes with overall conclusions regarding the main lessons learnt in the PRELUDE project, concerning both content and process.

(1) Please visit http://www.eea.europa.eu/multimedia/interactive/prelude-scenarios/prelude.

(2) Regional analysis complements the modelling at the European level by providing more detail and showing the implications of the scenarios for three contrasting regions. It covers Northern Italy, Estonia and the Netherlands and includes up to 32 land-use classes, mapped at a resolution of 25 ha. A background document can be obtained upon request from the European Environment Agency.

2 Methodological framework

2.1 Background: building compelling scenarios

There is widespread agreement on the assumption that scenario development is a useful tool to support decision-making in the context of uncertainties that are beyond our control. In spite of many different definitions there is also a clear tendency to agree on the understanding that a scenario is neither a forecast nor a prediction but should be understood as 'coherent, internally consistent and plausible description of a possible future state of the world' (Nakícenovíc *et al.*, 1994) ([3]).

Scenario studies differ from other assessment studies. As the direction of developments in the future is unknown, we are confronted by a profound lack of information. Different future developments are all possible, even though they may be contradictive. A scenario thus cannot be judged as right or wrong. Scenarios often deal with so many uncertainties that they can never be true in the strict classical scientific sense as there is no factual evidence to refer to (Ravetz, 2003). Consequently, the requirements for sound and successful scenarios are rather different from those of other policy studies.

Scenarios come in many variants, often tailored to the specific circumstances of the sponsoring organisation. Despite different attempts in the past no dominant, commonly agreed methodological framework has evolved yet (Voros, 2006; Godet, 2004; Leney *et al.*, 2004; van Notten *et al.*, 2003). Nevertheless we can say that good scenarios should:

- fulfil the objectives of the scenario exercise;
- be plausible and internally consistent;
- tell an appealing story that is not easily dismissed by experts and policy-makers;
- refer to sound data and provide a convincing comparative analysis.

A credible and persuasive scenario should challenge prevailing mindsets of experts and policy-makers and stimulate strategic discussions about policies that are robust enough to stand the test of time (EEA, 2001a; Schoemaker, 1998).

Involving different societal stakeholders helps meeting these criteria (Welp *et al.*, 2006; Roubelat, 2006; Kok *et al.*, 2006; Pahl-Wostl, 2002a; van Asselt, Rijkens-Klomp, 2002). Participatory scenario development helps to:

- give access to practical knowledge and experience about new problem perceptions and identify new challenging questions, i.e. avoid narrow thinking;
- bridge gaps between the scientific communities and governments, businesses, interest groups or citizens, and thus provide a reality check for research assumptions and methodology;
- improve communication between scientists and stakeholders and facilitate collaboration and consensus-building on problem-solving strategies;
- increase the salience and legitimacy of the scenario and thus the acceptance among end users ([4]).

Scenarios should be relevant for potential end users. It is therefore helpful to involve them in the design process from the outset. This is even more relevant if scenarios address large, complex and rather uncertain problems that affect the interests of many different societal groups and are thus likely to stimulate controversial discussions. Furthermore, a broad diversity of perspectives is needed to avoid too narrow thinking on the subject of matter — the more homogenous the group the greater the risk is that it will produce only one vision of the future (Roubelat, 2006).

However, diverging interests, conflicting views and possible hidden agendas of participants can lead a process into a stalemate. This makes the choice of participants a crucial task. Furthermore, it is helpful to involve a professional facilitator who can reveal interest conflicts in the beginning

([3]) The EEA, has adapted the IPCC definition (http://glossary.eea.europa.eu/EEAGlossary).
([4]) The term 'salience' refers to the ability of the scenario exercise to address the special concerns of users, i.e. convince the user that the results are relevant to support decision-making processes, whereas the term 'legitimacy' refers to the perceived fairness of the exercise, i.e. the users are convinced that their interests have been taken into account in a fair way and that the assessment is not one-sided. 'Credibility' is the third attribute of a successful assessment (EEA, 2001b).

and provide neutral management of the process (EEA, 2001c) ([5]). Otherwise, trust relationships among stakeholders are difficult to build. And trust is a key important factor: if actors try to manipulate the process, the scenarios might lose their credibility for other participants; and if there is a lack of support and ownership, scenarios are difficult to communicate (Kasemir, Jaeger, Jäger, 2003).

2.2 The story-and-simulation approach in PRELUDE

A modified version of the so called story-and-simulation (SAS) approach was chosen to develop the PRELUDE scenarios. The SAS-approach incorporates many of the requirements for building compelling scenarios as discussed above. It has been conceptualised in earlier works of the European Environment Agency. Its main parts are (see EEA, 2001a and Figure 2.1):

- A group of stakeholders provides the creative input into the process: they develop the qualitative storylines, based on in-depth discussions about key uncertainties and underlying driving forces of social, political, economic, technological and environmental development.
- Experts underpin and complement the storylines by quantitative modelling as feedback into the process.
- Stakeholders, experts, modellers and scenario writers engage in an iterative process of refining storylines and quantification until a set of compelling, coherent, plausible and relevant stories and simulations about the future is reached.
- A scenario team coordinates the exercise. The sponsoring organisation constitutes the majority of the team, but it can include also external stakeholders and experts.
- The process of scenario development is open, i.e. stakeholders, experts and other interested parties are involved from the beginning. It uses a variety of venues to solicit comments and contributions to the scenarios and to communicate scenario results.

This approach requires quite some time for iterations and refining of qualitative and quantitative assessments. However, combining participatory-driven storyline development and model simulation offers unique opportunities to mix good data, scientific rigour, imagination and expertise from different perspectives. It can create well-founded and provoking scenarios that really represent a wide range of angles about possible future developments (see for a detailed discussion of the advantages and problems of this approach: Volkery, Ribeiro *et al.*, 2007).

The approach was modified with regard to the degree of responsibility that stakeholders had for the overall scenarios. With the aim of increasing the legitimacy and relevance of the scenarios, the EEA embarked on a far-reaching participative scenarios building process, where stakeholder involvement surpassed the traditional *consultation* role and moved towards a *co-decision* role ([6]): stakeholders had full decision making power concerning the scenario logics and narratives. They were supported in this task by the EEA and modellers. The EEA project team designed the process and supported the modelling teams in the quantification exercise.

In the beginning of the project, a stakeholder panel was set up, following a number of criteria for identifying the final composition of the panel. The main objective was to have the widest possible diversification in terms of interests and perspectives on the issue. It comprised around thirty stakeholders and experts from across Europe with a broad diversity of backgrounds, i.e. policy-makers, researchers, representatives of interest groups and independent thinkers. The participants also represented important levels of decision-making, i.e. European, national and regional ([7]).

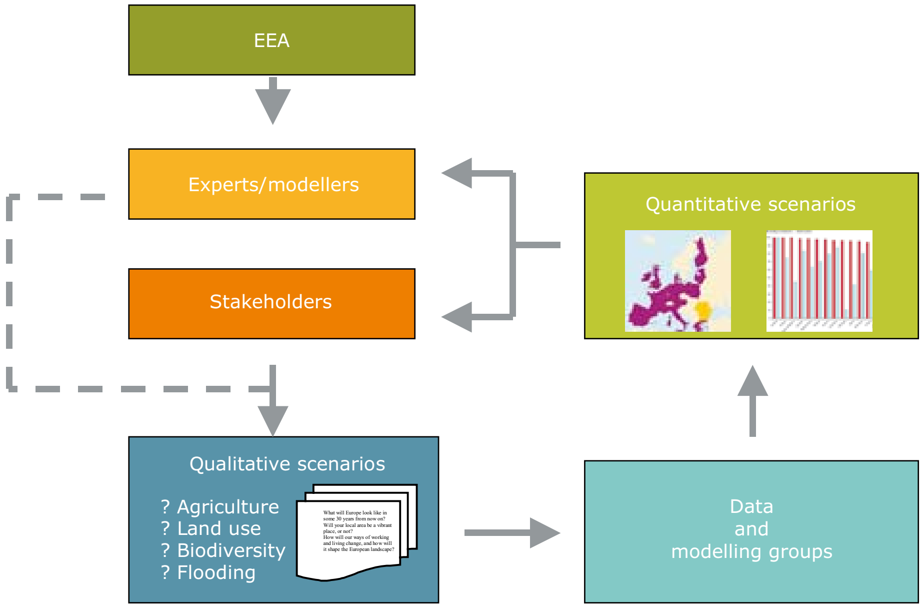
The EEA organised three workshops to develop the PRELUDE scenarios. Each workshop lasted for three days. Experienced professional facilitators conducted the working sessions in order to arrive at the final storylines. The first workshop focused on identifying key uncertainties, driving forces and the scenario logics, as well as considering potential land-use related environmental impacts. After the workshop the draft scenarios were analysed and reviewed by the EEA project team and a scenario analysis support

([5]) Stalemates can be caused by unrealistic goals and expectations, confusion about roles and failures to develop a clear road map for the scenario generation process. Participants can expect too much from scenarios and are disappointed if the final results don't match their expectations (Schoemaker 1998). Developing too many scenarios dilutes the attention and energy of participants. An experienced facilitator can help to define clear goals, clarify roles and concentrate on reviewing few, but key questions in greater depth (Schwartz, Ogilvy, 1998).

([6]) The issue of stakeholder participation in scenario development is further discussed in: Volkery, Ribeiro *et al.*, 2007.

([7]) A list of all stakeholders and consultants that were involved can be found in the acknowledgements section at the beginning of this report. Not all of them could be present at all workshops.

Figure 2.1 The story-and-simulation approach



group that comprised land-use experts and modellers also present at the workshop. The draft scenarios were then quantified using spatial explicit data from land-use simulation models (see Section 2.4).

The objective of the second workshop was essentially to revise the first round of model results, check for inconsistencies, and refine the scenario storylines in view of the modelling data. Interaction between modellers and stakeholders resulted in the translation of the narratives qualitative statements into numerical valuations (see Section 2.3). These numbers were further calibrated based on modelling data from existing relevant exercises. Subsequently, the model results were revised to accommodate the changes agreed during the workshop. In addition, efforts were made for improving the communication of the scenarios, including multimedia illustration and editing of the narratives. The third workshop had three objectives: a) a final review of the five scenarios, b) a review of the environmental impacts of the scenarios and c) a process to build consensus among participants concerning the final PRELUDE results, main products and future dissemination initiatives.

2.3 PRELUDE scenario logics

2.3.1 Driving forces

The PRELUDE scenarios combine the assessment of changes in the bio-physical environment with simultaneous changes in the socio-economic environment. Whereas environmental change scenarios have been widely developed, socio-economic change scenarios are less well developed. Up to now most scenarios of this kind focus on qualitative descriptions. This is especially true for the construction of integrated long-term scenarios for land-use change, which face the problem of integrating a set of different driving forces within a consistent framework of analysis (Rounsevell, Ewert, Reginster *et al.*, 2005).

The stakeholders categorised a broad variety of driving forces that influence different land-use types and land-use change in Europe. Consequently, a common basis for comparison was needed. This was carried out in the following stepwise approach:

- 'influence chains' were generated by the group and agreed upon.
- the influence chains and general driving force categories were used to derive a consistent set of 20 driving forces.
- the magnitude of change of the driving forces was qualitatively valued for each scenario on a scale from 0 (minimum value) to 10 (maximum value).
- this scale was adjusted for the model inputs into acceptable quantitative values for each driving force, based on past data and existing authoritative scenarios for other issues (i.e. IPCC SRES scenarios).
- finally, the 20 driving forces were clustered into five main categories. Scenario-specific 'spider diagrams' were created, visualizing the different driver values in a comprehensive and easily comparable way.

Table 2.1 Overview of 20 driving forces in the PRELUDE project (qualitative values for base-year 2005)

Driving force	Qualitative value	Driving force	Qualitative value
Subsidiarity	4	Environmental Awareness	5
Policy intervention	5	Economic growth	5
Settlement density	7	International trade	7
Population growth	2	Daily mobility	6
Ageing society	8	Self-sufficiency	8
Immigration	3	Technological growth	5
Internal migration	3	Agricultural intensity	5
Health concern	5	Climate change	8
Social equity	5	Renewable energy	6
Quality of life	5	Human behaviour	5

2.3.2 *Scenario logics and key drivers*

The five PRELUDE scenarios are (see annex for full storylines)

Scenario 1: Great Escape — Europe of contrast
Scenario 2: Evolved Society — Europe of harmony
Scenario 3: Clustered Networks — Europe of structure
Scenario 4: Lettuce Surprise U — Europe of innovation
Scenario 5: Big Crisis — Europe of cohesion

Figure 2.2 shows the simplified spider diagrams for all five scenarios. The qualitative values for all 20 driving forces are included in the specific scenario descriptions in Chapter 3 of this report.

Table 2.2 shows how these simplified diagrams have been derived from the original set of 20 driving forces, following mathematical routines.

The construction of spider diagrams offers the advantage of portraying a higher number of key scenario characteristics while maintaining easy comparability ([8]). Following this overview of the approach for the qualitative scenario development, Chapter 2.4 describes the approach for the quantitative assessment of land-use change on a European level.

2.4 The Louvain-la-Neuve model

The Louvain-la-Neuve land-use/cover change model was used for assessing the changes in land use/cover at the European level. The model employs the methodology developed in the ATEAM project and Accelerates project (funded by the EC Directorate General of Research Fifth Framework Programme, see for descriptions of the model: Ewert, Rounsevell, Reginster *et al.*, 2005; Rounsevell, Ewert, Reginster *et al.*, 2005; Kankaanpää, Carter, 2004).

The modelling approaches embedded in the Louvain-la-Neuve land-use/cover model have been developed with the specific aim of constructing spatially-explicit, land-use change scenarios for Europe. Furthermore, the approaches have been simplified as much as possible (whilst retaining scientific soundness) in order to be 'transparent' and 'flexible'. The model uses interpreted satellite data from the Pelcom database as a starting point ([9]). It simulates land-use changes in two main steps:

- first, the demand for six different land-use types (defined as an area) is derived at an aggregated spatial level, i.e. country or NUTS 2 (depending on the land-use type) ([10]);

([8]) Another prominent approach in scenario studies is the 2 x 2 scenario matrix, which is most prominently used in the SRES scenarios of the IPCC (Nakícenovíc, Alcamo, Davis *et al.*, 2000). Here, the two most important driving forces are identified, i.e. those that are most uncertain and have potentially far-reaching consequences. They form the axes of a matrix with four different quadrants for the development of four different storylines (vant Klooster, van Asselt, 2006).

([9]) Pelcom is a 1 km² pan-European land cover database developed mainly from remotely sensed data for the year 2000. To adjust this database to 2005, statistical data as well as existing scenario work was used (Section 2.5.1). The project could not use Corine land cover data for the European level analysis, since the work on these data was not finalised in 2004, when the PRELUDE scenarios were quantified. Pelcom was at that time the only land cover database that provided data for the EU-25.

([10]) The acronymn NUTS stands for *Nomenclature des Units Territoriales Statistiques*. The system was established by Eurostat and provides a single uniform breakdown of territorial units for the production of regional statistics for the European Union.

Figure 2.2 Simplified spider diagrams of key drivers

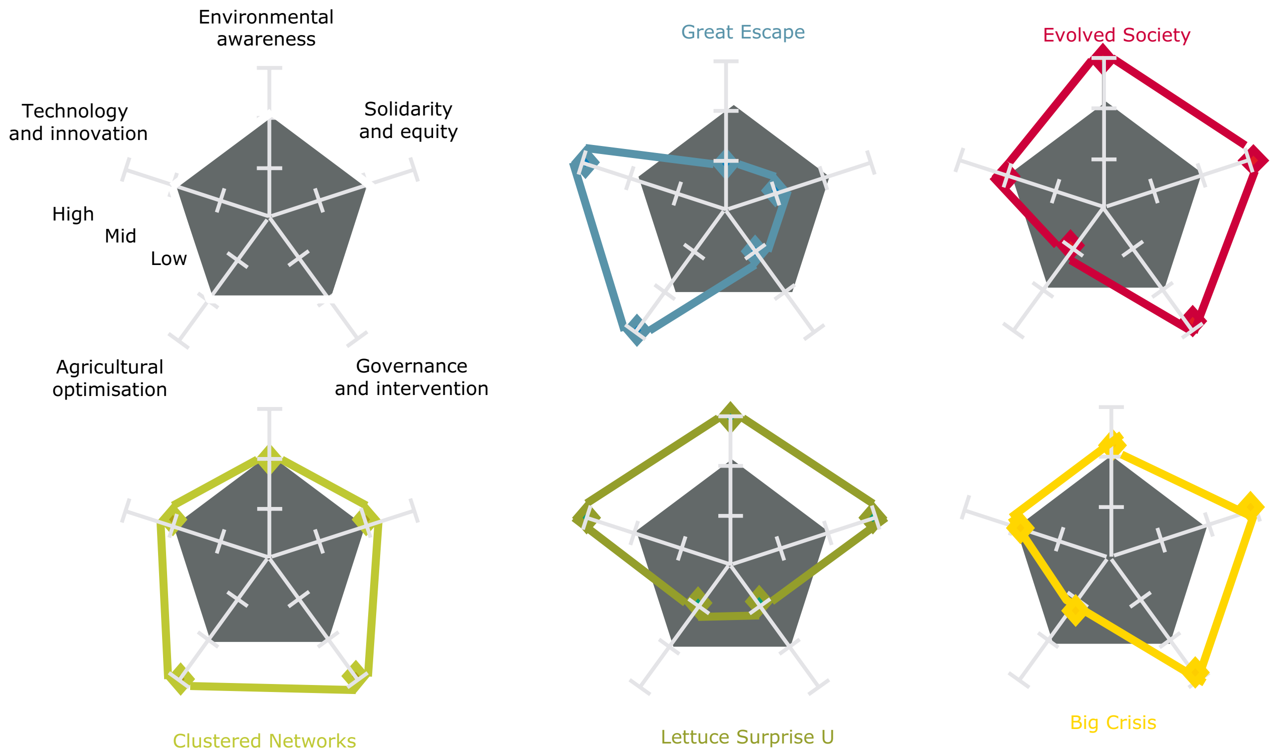


Table 2.2 Aggregate driving forces to describe scenarios

Driving Force	Description
Environmental awareness	= ((2 x renewable energy) + (2 x environmental awareness) + climate change))/5
Solidarity and equity	= ((4 x social equity) + quality of life + (2 x human behaviour) + health concern)/8
Governance and intervention	= ((3 x policy intervention + subsidiarity)/4
Agricultural optimisation	= ((4 x agricultural intensity) + self-sufficiency + international trade)/6
Technology and innovation	= Technological growth

Note: Of the original 20 driving forces the ones addressing economy and population were not used in this aggregation. They are: population growth, ageing society, settlement density, internal migration, immigration, daily mobility, economic growth.

- these land-use areas are disaggregated for EU-25 plus Norway and Switzerland using spatial allocation rules and GIS data layers that include spatial planning zones.

The following land-use/cover classes are simulated:

- Urban
- Cropland
- Grassland
- Biofuels crops
- Forests
- Abandoned land

The following paragraphs give a brief overview of the three sub-models that were used to estimate the different land-uses changes.

2.4.1 Urban land use

The urban land-use model (see Reginster, Rounsevell, 2005) includes a demand module and a spatial allocation module. The two main driving forces for urban demand are:

- population, reflecting demographic trends and the demand for housing;
- economic development, representing the degree of activity, types and intensity of activities, and economic dynamism.

Urban demand estimates are calculated using an empirical-statistical model with population and GDP distributed at the NUTS 2 level as independent drivers (Reginster, Rounsevell, 2005). The GDP distribution at the NUTS 2 level only influences the distribution of urban demand changes and no other land-use changes. The spatial distributions of GDP are scenario-specific. They were based on an interpretation of the storylines and concern rural/urban allocation rules ('Great Escape' and 'Clustered Networks') or centre/periphery allocation rules ('Big Crisis') (see the explanations in the scenario descriptions in Chapter 3).

Four additional variables are used as pattern drivers, i.e. within the spatial allocation rules:

- accessibility of the transport network, the type of innovation in transport and the quality of the infrastructure;
- severity of restrictions due to land-use planning;
- relative attractiveness of small, medium and large cities (reflecting different urbanisation processes);
- competition with other land uses (for example, urban development is not permitted in protected areas in all scenarios except for 'Great Escape').

2.4.2 *Agriculture land use (including bio-energy crops)*

The quantities for cropland, grassland and biofuels land uses (defined as an area) were derived for each scenario on a European scale based on a simple demand/supply model and were then disaggregated to a 10 minute lat/long spatial grid using spatial allocation rules and GIS data layers that include policy rules. The basic premise is that the area of agricultural land use grows if the demand for agricultural goods also increases, but areas decline if supply (productivity) increases, i.e. meeting the same demand (production) requires less land. The supply-demand model assumes that per capita food demand increases up to a saturation value with increasing income (annual GDP/cap), and that total food demand is the product of per capita demand times future population (Rounsevell, Ewert, Reginster e*t al.*, 2005).

The parameters included in the supply/demand model on a European scale are:

- relative changes in demand of agricultural goods ([11]);
- relative changes in oversupply;
- relative changes in productivity (supply).

The factors, which are assumed to influence future productivity, are the effects of:

- temperature and precipitation changes;
- elevated atmospheric CO_2 concentrations;
- technology development.

The pattern drivers included in the scenario-specific spatial allocation rules are:

- the spatial distribution of yield and of high intensity agriculture;
- the prices and costs for agricultural production disaggregated to the cell level;
- the location of protected areas, e.g. Natura 2000 sites.

Agricultural land is allocated to specific locations based upon the 'most suitable' land for crop production. Suitability depends on many factors, including distance to markets and potential crop yield. The higher the potential crop yield, the higher the assumed suitability. Crop yield is computed in the model as a function of fertilizer inputs, technological improvements in crops, changing atmospheric levels of CO_2 and climate. As crop yield per hectare increases due to greater inputs and climate, less land is needed for the same agricultural production. The spatial allocation rules take into account policy and economic assumptions within the PRELUDE scenarios. Biofuels crops were allocated on the land that remains after accounting for food production, using potential distributions determined for each biofuels crop species (Tuck, Glendining, Smith e*t al.*, 2006).

The linkages between the various sub-model input parameters have been defined according to priority by the PRELUDE scenario storylines. Some internal consistency may be lost because of this method. Otherwise, an attempt has been made to derive parameter values that are internally consistent within the scenarios using external sources of information ([12]).

2.4.3 *Forest land use (including protected areas)*

Forests have very long rotation times. Even if rapid changes are described in the storylines they may not materialise in the project period up to 2035, but take more decades to unfold. Moreover, forest policy is mainly shaped on the national and regional levels, not so much on the European level like agriculture (Kankaanpää, Carter, 2004). Many variables that drive forest change are qualitative and difficult to be described in quantitative form. Furthermore, they vary from region to region and through time. For

([11]) This reflects not only demand (and supply) of the internal market, but also demand that derives from outside of Europe (which is derived from the IMAGE 2.2. model).
([12]) See Ewert, Rounsevell, Reginster e*t al.*, 2005 and Rounsevell, Ewert, Reginster e*t al.*, 2005.

this reason, the assessment of forest land-use change has been based on expert judgment within the context of each scenario.

Protected areas are not a land-use type because many of these areas enclose agriculture, forest or semi-natural landscapes (Rounsevell, Reginster, Araújo *et al.*, 2006). Accordingly, they were assessed after the socio-economic land activities were accounted for. Main drivers for protected areas are policies for nature conservation, agriculture, forestry and spatial planning at European and national level, as well as the demand for areas for tourism and recreation. It is assumed that land use within these areas remains constant, but that the areas themselves may change as a function of the scenario assumptions.

2.4.4 *Competition between land uses*

The methodology accounts for the competition for geographic space between the different land uses. This is implemented through a simple predefined hierarchy when allocating land uses in space that reflects both the economic trends of land rent, as well as the potential for spatial planning policy (Rounsevell, Reginster, Araújo e*t al.*, 2006):

Protected (designated area) > urban > cropland > grassland > bioenergy crops > commercial (unprotected) forest land > not actively managed land (surplus land) ([13]).

Urban land use thus takes precedence over agriculture, which depending on the location characteristics usually dominates forestry. However, housing demand and spatial planning policies at defined locations may limit urban development or protect certain types of land-use and/or landscape structure, such as forests. The hierarchy can also be implemented differently between scenarios in order to reflect the consequences of alternative policy visions, and can be adjusted to account for regional productivity differences between land uses ([14]).

2.5 Model input

2.5.1 *Updating the 2000 baseline: driving forces, input parameter and allocation rules*

The Louvain-la-Neuve land use/cover change model uses observed 2000 land-use data for a baseline year (Mücher, 2000). The PRELUDE project, however, covers the period of 2005–2035. In order to start the scenario exercise in 2005, an update of the 2000 baseline had to be created (modelled), mainly for the following two reasons:

- The *agricultural demand* figures in the five scenarios are based on different SRES scenarios which, however, have their baseline in 1990 and not in 2000. As a result, the computed agricultural demands in 2000 are different for different scenarios which, in reality cannot be true. Therefore, just the SRES B1 scenario was used for calculating the updated baseline which according to our judgement best reflects current trends (B1) between 2000 and 2004 in order to obtain the same baseline agricultural demand for all five scenarios in 2005.
- Two of the five scenarios ('Evolved Society' and 'Clustered Networks') assume a *disruptive event* to happen at the beginning of the scenario period, which then triggers a change in values. Current trends were therefore continued between 2000 and 2005, followed by adjustment to accommodate the changes brought about by such events.

For another two of the five scenarios ('Lettuce Surprise U' and 'Big Crisis') the assumption was that current trends continue until a major disruptive event occurs (i.e. a breakpoint introduced into the scenario). The change in values happens, however, only in 2015. Driving forces change accordingly. As Table 2.3 presents the continuation of current trends, these same assumptions were used for the 10-year period from 2005 until their breakpoints in 2015. All percentage changes are calculated on an annual basis and represent European averages.

Matching the qualitative information of the scenario storylines and the quantitative input needs of the model was a challenging process. During the translation of the verbal descriptions into quantitative model input parameters, modellers needed to make some adjustments in order to harmonise all scenarios. A further revision would have been necessary to correct all inconsistencies, and therefore a few inconsistencies still remain; there is not always a one to one match between the qualitative valuation and the actual model input parameter used. Furthermore, not every driving force quantification was linked to model parameters or to a specific spatial allocation rule — quantitative models cannot fully accommodate the richness of the narratives (e.g. cultural values), which is one

([13]) The surplus category characterises the land that is left after all economic activities have been accounted for. The main part is composed of abandoned agriculture land.
([14]) For example, in northern latitudes forest is usually given precedence over agriculture because the agricultural productivity in these regions is low (Rounsevell, Reginster, Araújo e*t al.*, 2006).

reason to combine qualitative and quantitative information in such assessments.

Table 2.3 gives an overview of the choices and assumptions used for constructing the updated (modelled) baseline 2005. A detailed description of all driving forces and their relation to the model input parameter and spatial allocation rules is given in Chapter 7.2 of this report. The first column of Table 2.3 presents the input parameters and allocation rules used in the quantification. The second column presents the values of the parameters used as input to the model, whereas the third column represents the qualitative values assigned to each parameter by the stakeholders on the 1–10 scale (where 0 = low and 10 = high). The last column describes the sources used for quantifying the parameters and the adjustments made.

Some parameters have been quantified based on the IPCC SRES scenario parameters (IPCC, 2001) or on the ATEAM project scenarios which interpret the SRES scenarios for Europe (Rounsevell, Reginster, Ewert *et al.*, 2005). For the other parameters, the descriptions of the stakeholders were not consistent with the IPCC SRES scenario parameters or parameters of other scenario studies. Some adjustments were needed, based on observed data of past and recent trends as well as on expert judgement about alternative plausible trends.

The following paragraphs outline how the input parameters and allocation rules have been implemented in the modelling according to the provisions of the PRELUDE storylines (see also annex for an overview of all driving forces).

Urban land use
The two input parameters population and GDP/capita were used. Due to similar assumptions the quantification of the two input parameters was mainly based on the IPCC SRES A1 scenario parameters, using an approach for downscaling to the country level developed by IIASA (IIASA, CIESIN, 2003), and further scenario-specific downscaling to the NUTS 2 level for PRELUDE. The change in urban land use was first estimated at the regional NUTS 2 level and this quantity of land use allocated to each 10' grid cell. The annual rate of increase in population and GDP/cap were derived from the observed trends.

Some of the storylines describe specific migration trends, as for example migration to urban or rural areas. Based on Eurostat EU-25 data, population migration from rural to urban areas was also introduced in the downscaling of the population data to the NUTS 2 level. The allocation of the quantity of urban land use to the grid cells was based on a counter-urbanization pattern (i.e. an increase in urban land use close to small and medium-sized cities), as suggested by the Corine 2000 land cover change maps (EEA, 2004). No east-west migration is assumed for the period 2000–2005: since overall migration is low we took it all as urban to rural or vice versa. An increase of 0.5 % per year is assumed for migration from rural to urban areas.

In concrete terms, this means that the urban potential transition cells are located at less than 20 km from medium cities, or less than 10 km from small cities. An accessibility condition was also included: potential urban increases may occur at less than 15 km along the road network.

Map 2.1 shows the resulting map with the percentage of urban cell fraction in the base-year.

Starting from this baseline data, the scenario-specific values for the population and GDP/cap parameter were derived by scenario-specific downscaling of the IIASA/UN values, expert judgement and the stakeholder evaluation of the parameters.

The urban allocation rules are also scenario-specific and based on the storyline descriptions, i.e. landscape buffer zones were created for the 'Clustered Networks'-scenario to maintain the quality of landscapes around cities (see Chapter 3.4).

Agricultural land use
Four input parameters were used in the agriculture sub-model (see Table 2.3):

- total demand for agricultural production;
- impact of CO_2 on crop yield;
- impact of technology on crop yield;
- renewable energy demand (area for the production of biofuels crops).

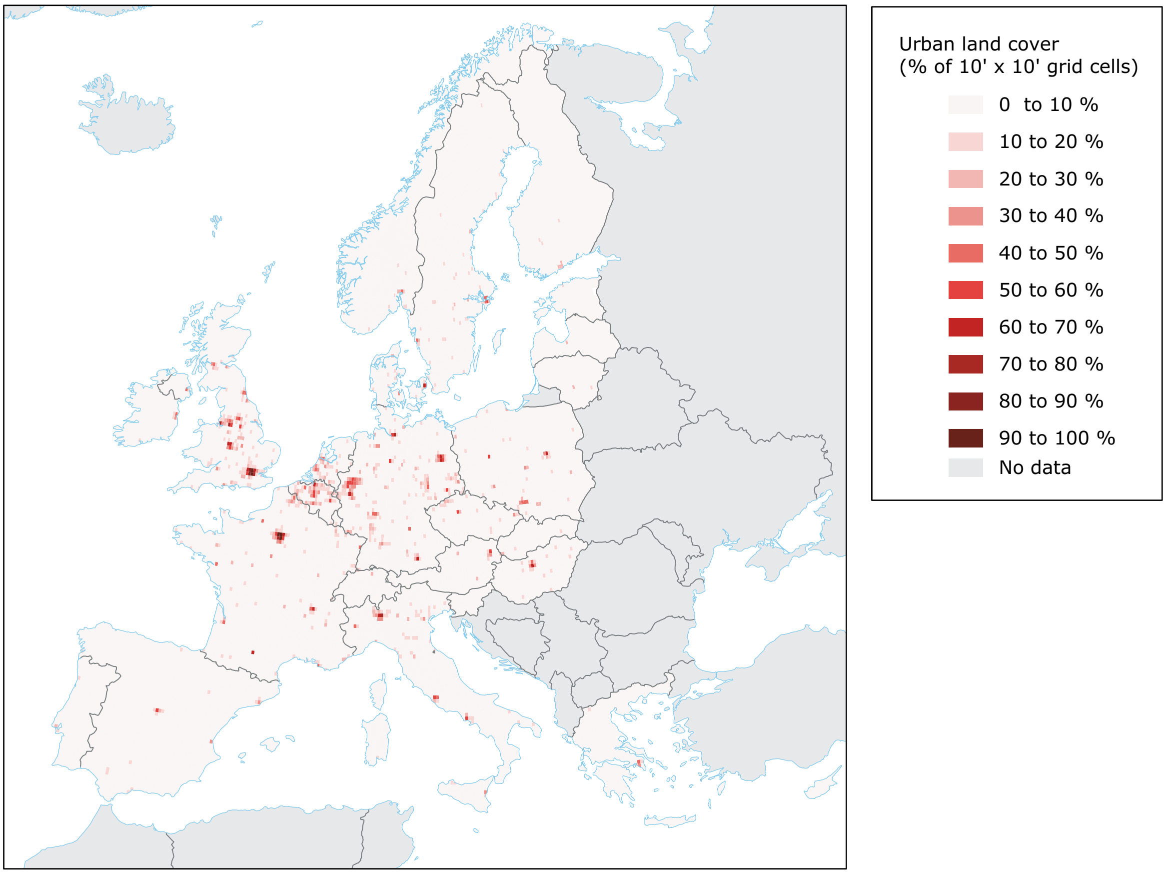
The total demand figures for agricultural production change are exogenous figures. They have been taken from the IMAGE 2.2 model estimates of the SRES B1 scenario. A slight increase of cropland (+ 0.9 %) and a slight decrease of grassland (– 0.5 %) in the period 2000–2005 is assumed (Table 2.3, Image Team, 2001).

Demand figures for the different scenario storylines have been taken from the IMAGE 2.2 model and the related ATEAM project estimates (Rounsevell, Ewert, Reginster *et al.*, 2005) if they were consistent with the storyline descriptions. If not they have been adjusted according to the stakeholder evaluations and the descriptions of the storylines (see further details in the specific scenario descriptions in Chapter 3).

Table 2.3 Updated baseline 2005 (starting with 2000 values)

Input parameter/ allocation rule	2000–2005 European average % change per year	Qualitative valuation by stakeholders	Sources and justification
Population	+ 0.12	2	Carried out per country based on UN/IIASA data
NUTS 2	Downscaling from national data		
East/west	No migration	3	Since overall migration is low, we took it all as urban to rural or vice versa
Rural/urban	+ 0.5 (urban population)	3	Since overall migration is low, we took it all as rural to urban (based on Eurostat/EU-25 data)
GDP/capita	+ 2.8	5	Carried out per country based on SRES A1
NUTS 2	Downscaling from national data		
Allocation rules: urban land use	Counter-urbanization		Urban land-use increase in small and medium-sized cities (threshold < 500 000)
Total demand of agricultural production	Cropland: + 0.9 Grassland: – 0.5	Agricultural intensity = 5	Based on SRES B1
Domestic demand			Not needed as model input
Import	Yes	7	Based on SRES B1 (A1 is too high — Europe feeds China)
Export	Yes	7	Based on SRES B1 (A1 is too high — Europe feeds China)
Change in Oversupply	Factor = 1.0		Current European oversupply is about 20 %; no change
Impact of CO_2 on crop yield	+ 0.3	7	High, based on SRES A1
Impact of technology on crop yield	+ 1.7	5	Based on SRES A1
Biofuels energy demand (area)	+ 0.1 % of current areas	6	Based on SRES A1 Current area for biofuels constitutes 0.06 % of total area of Europe
Allocation rules for agriculture	Decrease in marginal areas (a rent map)	Agricultural intensity = 5	
Cost for wheat production (labour + fertilizer + transport)	+ 1.63		Based on SRES B1
Price of wheat (euro/tonne)	+ 0.1		Based on SRES B1
Forest	+ 0.005		Current trend
Protected areas		Environmental concern = 5	Natura 2000 for EU-15 and WCMC database for the new member states used as new baseline
Surplus	Cropland → grassland Grassland → shrubs		Current policy

Map 2.1 Urban cell fraction (%) in the 2005 base-year



Demand for agricultural production is affected by consumer trends in Europe (e.g. population development, consumption preferences) as well as trends outside the European territory, mainly the trends in global trade. However, only the total agriculture demand is modelled, independent of whether it is international or domestic ([15]). Both import and export values have been based on the SRES B1 parameters.

For the baseline, an oversupply of food production was assumed on the basis of the SRES B1 scenario, which is consistent with the current European oversupply (about 20 %). Oversupply is used as an adjustment factor to ensure that supply meets demand.

The supply side of the model is defined by the agriculture yields. Yields are a function of productivity multiplied by area. The values are again derived from the IMAGE 2.2 model (IMAGE team, 2001). Production volumes and agriculture yields are combined to simulate the agriculture area. Yield changes are a function of impacts of increasing CO_2 concentration and technological development. The ATEAM SRES A1FI scenario values were used as an expert judgment based on their high values. Based on this estimate, the impact of elevated atmospheric CO_2 levels on agricultural productivity in 2000–2005 accounted for 0.3 % ([16]). Technological development was assumed to affect cropland stronger than grassland which is due to the extensive management of many grassland livestock production systems

([15]) The total demand for agricultural production is the quantity of all agricultural products minus the trade balance (export minus import). Demand comprises animal products, food crops and grass and fodder species (Rounsevell, Ewert, Reginster *et al.*, 2005). The demand calculation includes an import and an export estimate and a self-sufficiency ratio (domestic production divided by domestic demand which is the sum of domestic production minus the trade balance (exports minus imports). Estimates of import and export of food in Europe is taken from results of the GTAP model/project (see https://www.gtap.agecon.purdue.edu/).

([16]) The impact of CO_2 on crop yields is global and has long-term effects. It is, therefore, relatively independent of the other parameters (e.g., transport policy, type of economic development etc). The values were derived from the description of the stakeholders. For all scenarios they suggest a high impact of CO_2 concentration. Therefore the SRES A1F1 ATEAM estimate was used for all scenarios. The calculation of the CO_2 effect on agriculture productivity was based on estimations of future CO_2 concentration from the IMAGE 2.2 model (IMAGE team 2001). It has to be acknowledged, however, that the understanding of the impacts of elevated CO_2 concentrations on crop growth and yields is still limited and that relevant crop yield models have critical deficits in estimating yields for regional and larger scales (Ewert, Rounsevell, Reginster *et al.*, 2005).

(Rounsevell, Ewert, Reginster e*t al.*, 2005) ([17]). For the period 2000–2005 an annual change of 1.7 % in agriculture yields due to technological change has been estimated.

Based on Faostat figures for 2000 to 2003 (http://faostat.fao.org), decreases in cropland and grassland were equally distributed across Europe ([18]). Map 2.2 shows the percentage cell fraction of cropland and grassland in the 2005 base-year.

The demand for renewable energy was determined for the baseline and for each scenario by taking account of related policy and economic assumptions, i.e. agricultural policy objectives, global energy trade, global food trade and global timber trade. Crops were allocated (as it was already described) after land had been allocated to food production (see Tuck, Glendining, Smith, 2006).

A distinction was made between woody and non-woody bio-fuels crops. Based on the SRES A1 scenario a rather low value of 0.1 % increase for the period 2000–2005 was assumed; the current production area constitutes ca. 0.06 % of the total area of Europe. Areas for production of biofuels crops were allocated to suitable production areas with surplus agricultural land. The assessment of the overall area quantities that are suitable for production is based on the IMAGE 2.2 model estimates (Rounsevell, Ewert, Reginster e*t al.*, 2005).

Forest land use (including protected areas) and surplus land

Three other parameters were used in the model to represent changes in forest land use:

- forest area changes;
- protected area changes;
- possible use of surplus land.

For the base-year 2005 a very small increase of 0.005 % in forest area per year was defined which was assumed to continue until 2035 due to the long rotation times of forests (EEA, 2003). Additional policy interventions that may influence forested land in a positive way have been implemented in scenario-specific ways (see scenario descriptions in Chapter 3).

Currently, almost 14 % of the EU-15 area is designated for nature conservation or recreation area. As for the updated baseline, the protected areas were defined as the Natura 2000 sites for the EU-15 countries (except for Germany) with an estimate of the sites based on the WCMC database for the new Member states and Germany (EEA, 2004, World Conservation Monitoring Centre, 2000). Changes in land use were generally not permitted inside these protected areas (see scenario descriptions in Chapter 3 exceptions according to storylines). Map 2.3 shows the percentage of forest and other land cell fraction (surplus) in the 2005 base-year.

Since surplus land results from abandonment of mostly agricultural land it does not figure in the base-year but only occurs in 2035. For surplus land, the following order was established: cropland turns into grassland, grassland turns into shrubs and shrubs turn into forests. Specific assumptions have been made for surplus land in each of the scenarios (see Chapter 3).

2.5.2 *Additional assumptions*

In addition, some other concepts and information needed to be quantified in order to run the land-use model and better understand changes in land use.

Agriculture rent map

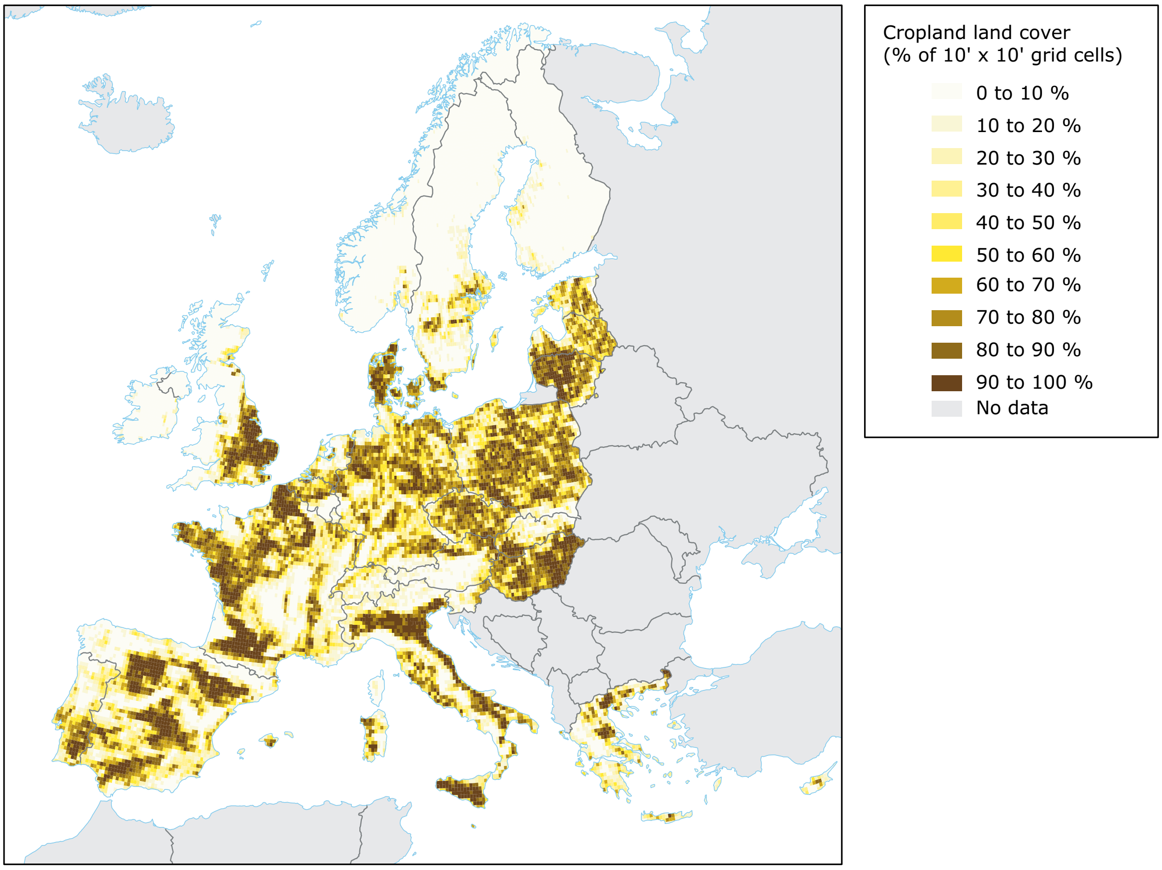
Agricultural demand was allocated to different grid cells according to two different procedures depending on the scenario. For the 'Lettuce Surprise U', 'Big Crisis' and 'Evolved Society'-scenarios, agricultural demand was equally distributed across Europe, as it was done for computing the baseline. For the 'Great Escape' and 'Clustered Networks'-scenarios, agriculture demand was distributed according to the most valuable land for agriculture as indicated by a land rent map. For the rent calculation, wheat was used as a proxy (see Table 2.3). The agricultural land rent was calculated as:

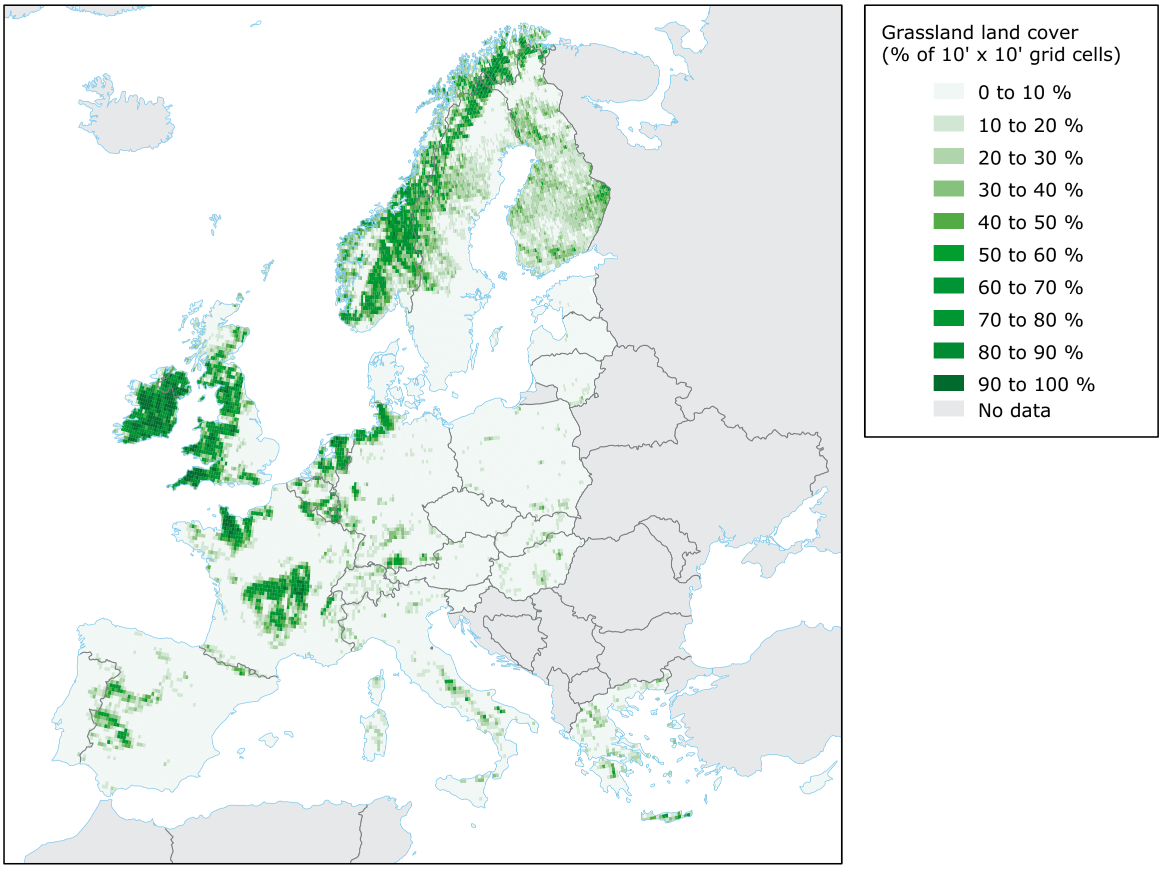
Assessed rent = (yield [t/ha] x producer price [euro/t] – sum of the costs (transport, fertilizer, labour [euro/ha])

([17]) Technology development refers to all measures of crop management and breeding. Future impacts of technological development have been modelled based on historical yield trends (see Ewert, Rounsevell, Reginster *et al.* (2005) for a detailed description of the methodology).

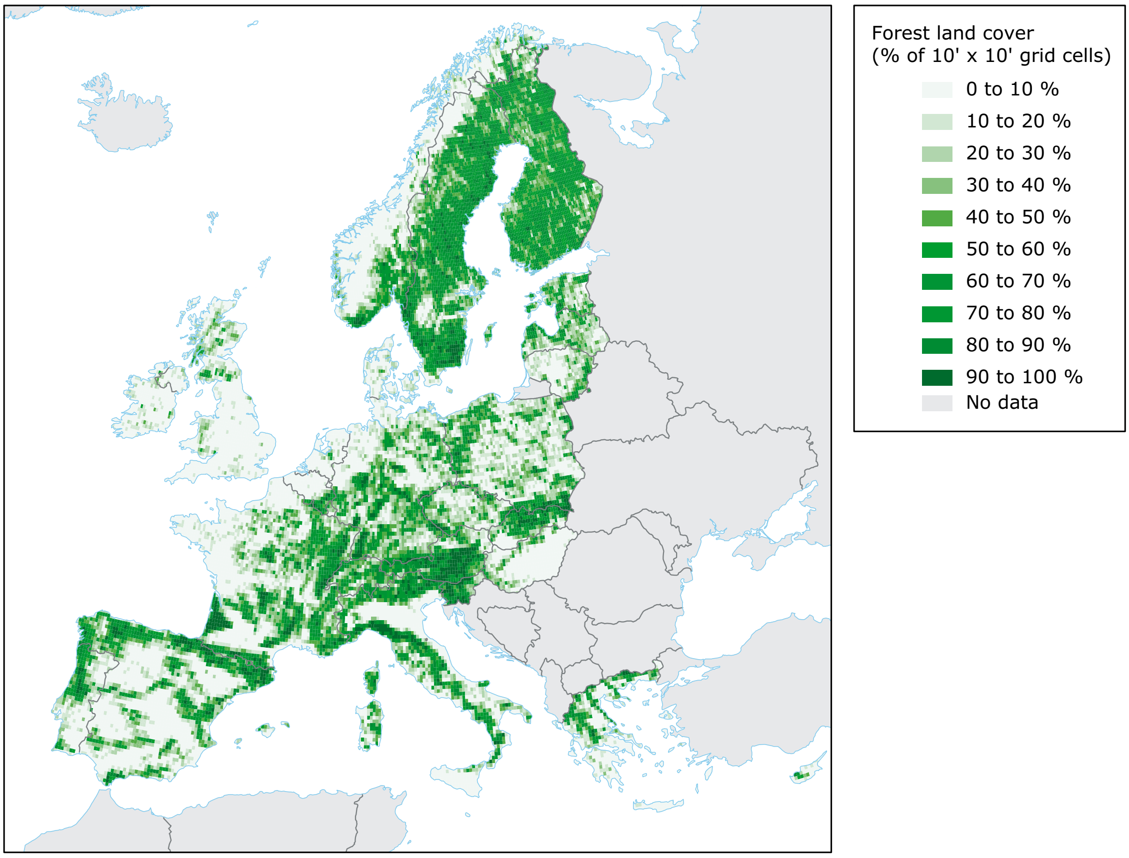
([18]) Figures were derived from the following website: http://faostat.fao.org.

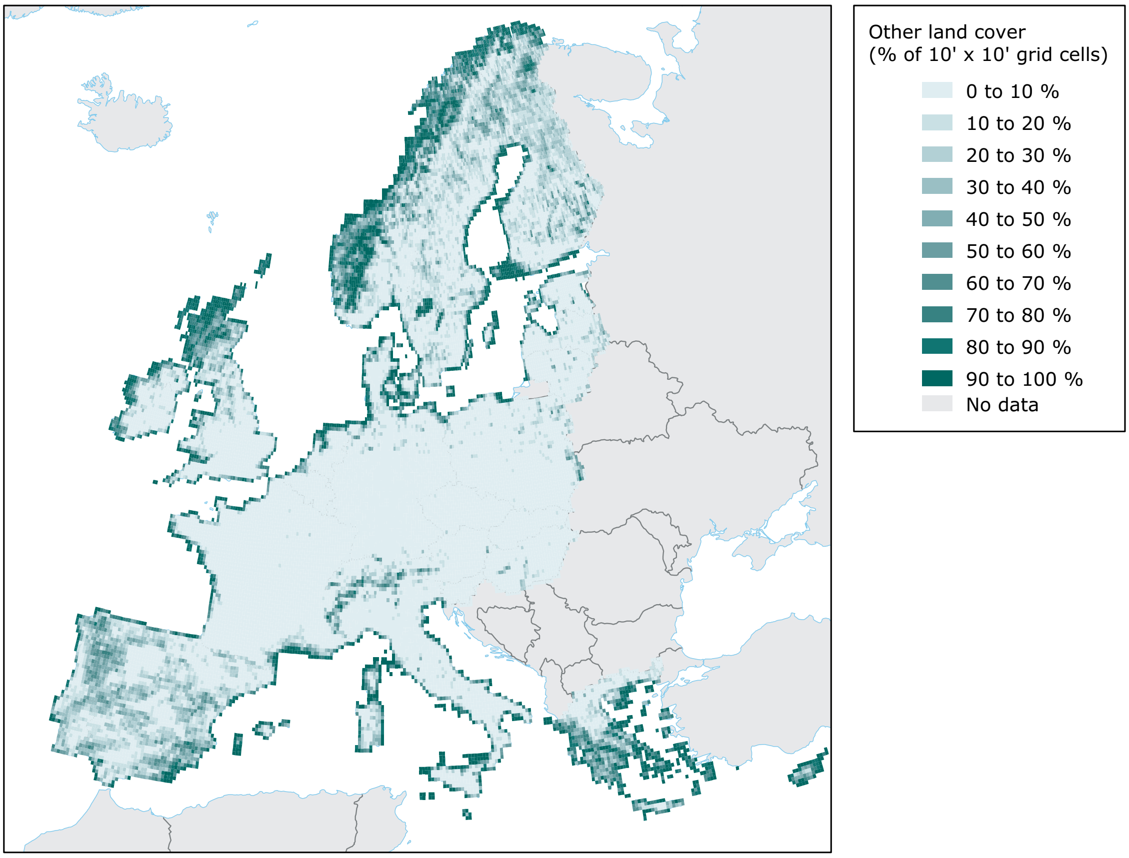
Map 2.2 Cropland (top) and grassland (bottom) cell fraction (%) in the 2005 base-year



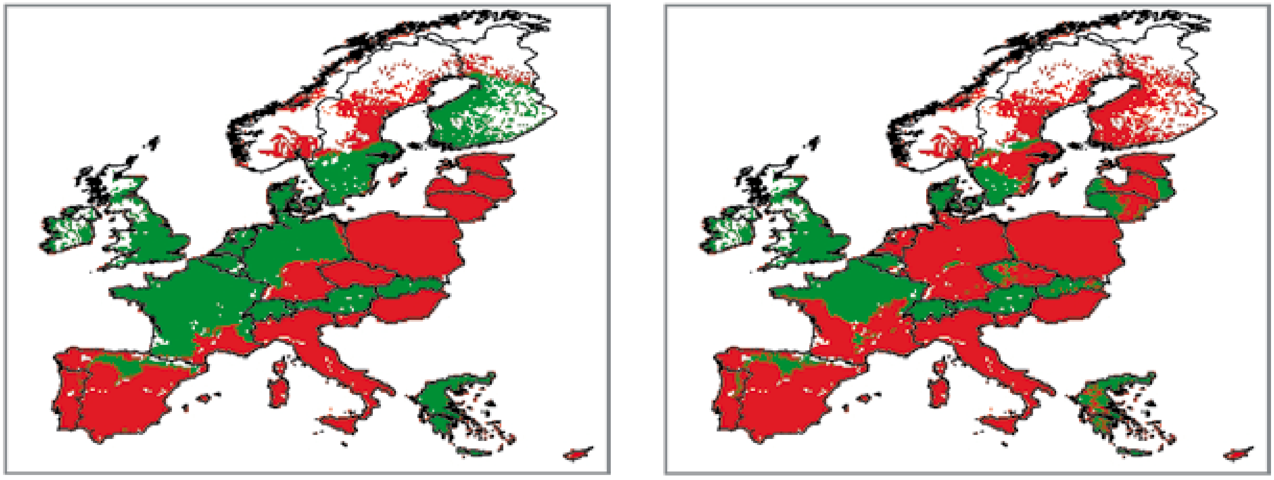


Map 2.3 Forest (top) and other land (bottom) cell fraction (%) in the 2005 base-year





Map 2.4 Rent map of calculation for the base-year situation in 2005 (left) and 'Great Escape' and 'Clustered Networks'-scenarios (right) in 2035



Red = negative land rent, Green = positive land rent.

Data were derived from the FAOSTAT dababase (http://faostat.fo.org), the Eurostat REGIO database (Eurostat, 2000) and from DG Agriculture ([19]). For the quantification of the single scenario storylines, prices were adjusted based on the price/costs scenarios developed in the ACCELERATES project (see Audsley, Pearn, Simota e*t al.*, 2006).

A new agricultural rent map was created for the 'Great Escape' and 'Clustered Networks'-scenarios, because free optimal location for the allocation of cropland and grassland is assumed. Map 2.4 shows the rent map for the base-year situation in 2005 and the new situation in 2035.

'Blue Banana' or 'Blue Kangaroo'

The stakeholders introduced the notion of a 'Blue Banana' to represent the core, high population density part of Europe. The term stems from the fact that, at night, the core population centres in Europe show this shape when observed from space. However, there is no general agreement as to its precise shape or location. This notion is one of a two-speed Europe structured on the centre-periphery model. For the purpose of the PRELUDE project, a new map was developed of what is called the 'Blue Kangaroo' (Map 2.5).

The new map takes the 'Blue Banana' as a starting point and includes areas in Europe which we consider the core, high population density part of Europe based on an urban density map and an accessibility map (ESPON project). The part outside this 'Blue Kangaroo' is referred to as the European periphery defined by the lack of major European towns. The 'Blue Kangaroo' plays a role in four of the five scenarios (except for 'Lettuce Surprise U').

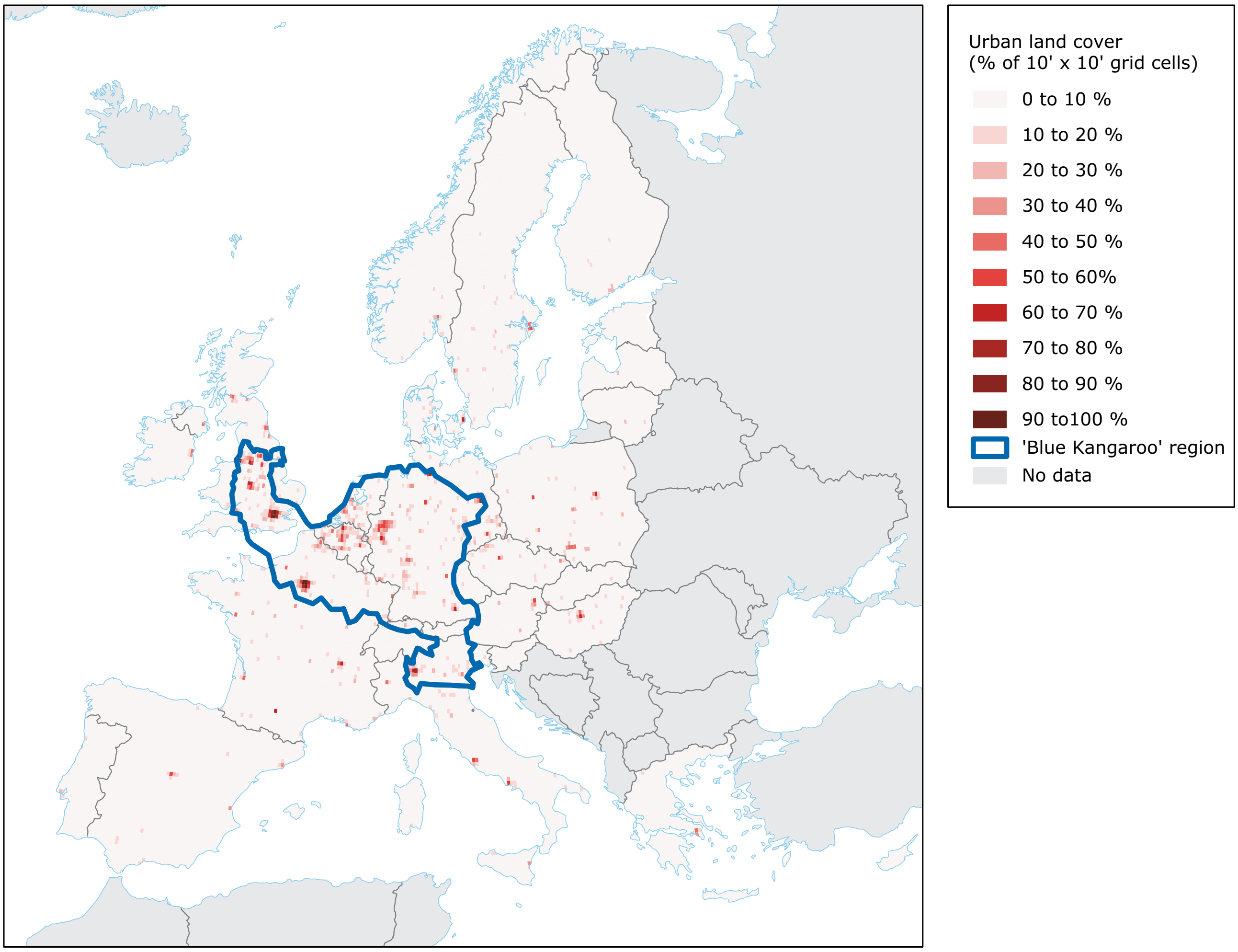
European flooding zones

Although a flood risk map for Europe is available from the ESPON 'Hazards' project for the current situation, these risks will change in the future. A new flood risk map representative of the time period 2015 to 2035 was needed. As a basis, the current flood risk map of the ESPON project was taken and combined it with a map of changes in flood frequency distribution until 2020 (Lehner *et al.*, 2001). This new flood risk map is shown in Map 2.6 and identifies the regions with high vulnerability to floods in the year 2020. The generation of the flood-risk map within the ESPON project and the combination of this map with the flood frequency map from the EURO-Wasser project should be briefly described below.

In the ESPON 'Hazards' project, a vulnerability map (with vulnerability classes) and a flood hazard map (with flood hazard classes) were combined by simple addition into a flood risk map. The assessment of vulnerability is based on population density and GDP of each NUTS 3 region in Europe for the year 2002, assuming that the higher the population density and the GDP in a region, the more vulnerable it is to hazards in general. Flood hazards were classified according to the frequency of flooding events that occurred between 1987 and 2002, also at the NUTS 3-level.

([19]) See http://europa.eu.int/comm/agriculture/agrista/2002/table_en/Costs.

Map 2.5 Map of the 'Blue Kangaroo'-region



The EURO-Wasser project generated a map of changes in flood frequency distribution available which shows, on 0.5 x 0.5 ° grid, changes in 100-year floods in 2020 compared to today's frequency based on the 1961–1990 average climate. This map was produced by using the global water balance model WATER GAP (Alcamo *et al.*, 2001) and the global climate model HadCM3 (Pope *et al.*, 2000). Afterwards, a simple overlay of both the flood risk map of the ESPON project and the flood frequency map of the EURO-Wasser project was carried out. Increasing frequencies of 100-year floods in the EURO-Wasser map were divided into three classes and the mean class values were simply added to the existing values of the ESPON flood-risk map. The same procedure was carried out for decreasing 100-year flood frequencies.

This flood risk map for 2020 with a scale from 1 to 11 is used in the allocation rules of the Louvain-la-Neuve land-use/cover change model to give priority to migration away from those areas with high to very high risk classes and to abandoning cropland in those same areas.

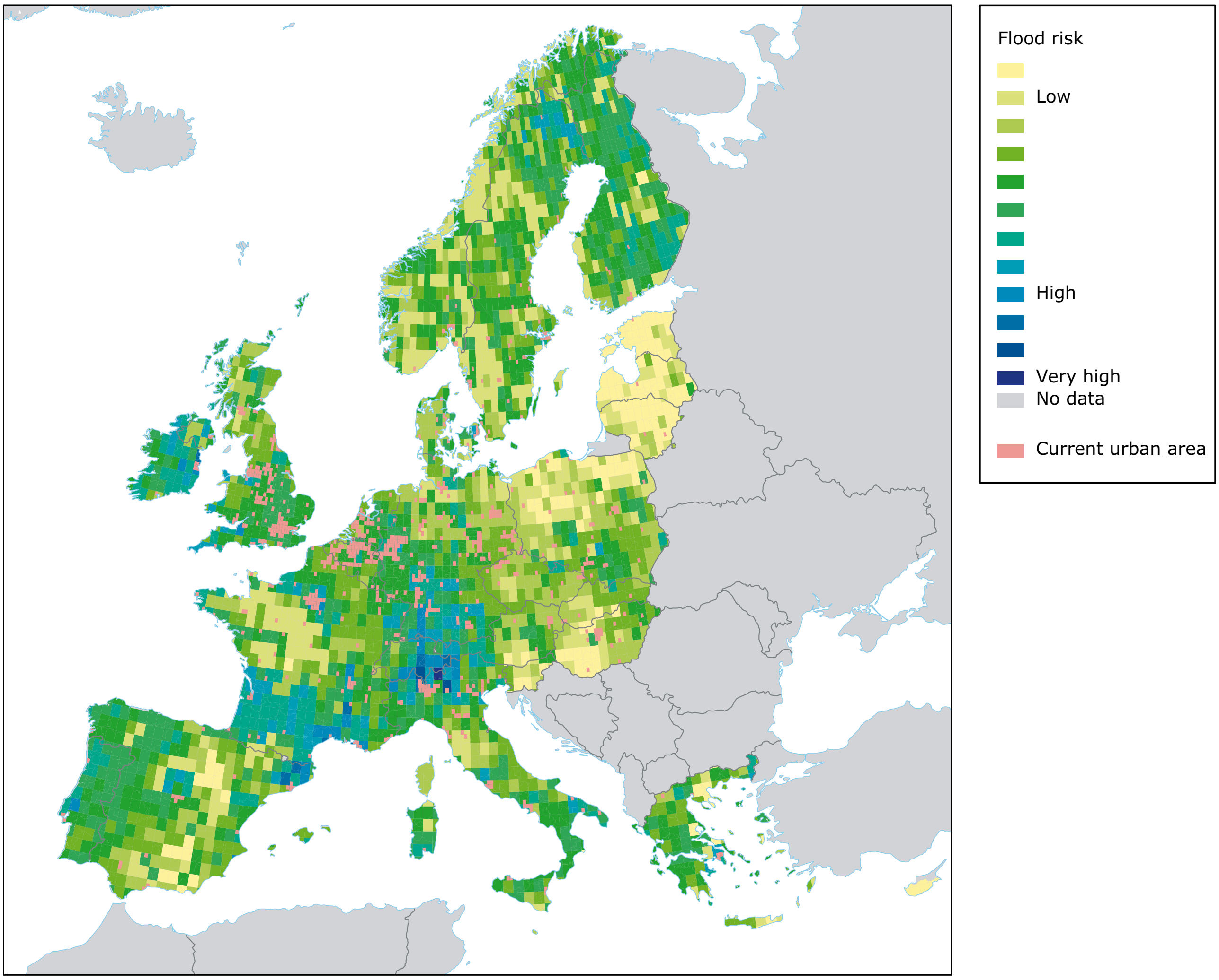
2.6 Model output

Land-use/land cover classes

The model produces maps and data tables for Europe (EU-25 plus Norway and Switzerland) with the percentage change of each land use/cover class as compared to the total area of the 10 minute (latitude and longitude) grid. New spatially-explicit land use/cover maps were developed for the five PRELUDE scenarios for two future time slices (2015 and 2035). The 2015 time slice was introduced to account for the breakpoint in the two scenarios 'Lettuce Surprise U' and 'Big Crisis'.

The PRELUDE scenario descriptions and analysis refer to six broad land cover classes which are

Map 2.6 Flood risk map in 2020



(1) urban land, (2) cropland, (3) grassland, (4) forest, (5) other land, and (6) surplus land. Table 2.4 describes these six land cover classes in detail.

Landscape typology

In order to make the link between land use/cover changes and environmental impacts, we used the concept of 'dominant' landscape types and land-use intensities. 'Dominant' means that a landscape type comprises one or more land cover types which share more than the European average plus the standard deviation of this particular land cover type.

Table 2.5 shows the European average and the standard deviation for the above five land cover classes. The last column of this table indicates what we call the 'dominance threshold'. This means that for example the landscape type with a dominant agricultural character has to comprise more than 65 % of cropland because the European average share of cropland is 33 % and the European-based standard deviation of this is 32 %, which combined add up to 65 %. It should be noted that for urban land and grassland this dominance threshold is well below 50 % so that in model cells that are dominated by either of theses two land cover types, the cells may well be dominated by more than one land cover class.

Starting with the five land cover classes (1) urban land, (2) cropland, (3) grassland, (4) forest, and (5) other land, dominant landscape types were assigned to each model cell for both the base-year situation and for each of the five scenarios in 2035. Based on this analysis of the dominance that occurs in the model cells in all of Europe, nine landscape types are derived.

Table 2.6 gives an overview of the nine landscape types listed in order of land-use intensity.

Table 2.4 Land-use/land cover classes used in the modelling

Land use	Definition
Urban land	Land covered by buildings and other man-made structures. Includes residential land use, services, commercial uses and infrastructure.
Cropland	Cultivated areas that have been tilled as well as areas with permanent crops which means crops not under a rotation system which provide repeated harvests and occupy the land for a long period before it is ploughed and replanted; e.g. vineyards, orchards.
Grassland	Land with herbaceous types of cover. Tree and shrub cover is less than 10 %.
Forest	Land dominated by trees and shrubs.
Surplus land	Abandoned agricultural land.
Other land	Unmanaged areas such as scrubland, barren land, wetlands, inland waters, sea, permanent ice and snow.

Table 2.5 European average statistics for land cover classes in base-year (2005)

Land cover type	European average %	Standard deviation %	Dominance threshold %
Urban land	2	5	7
Cropland	33	32	65
Grassland	16	17	33
Forest	30	28	58
Other land	20	33	53

Table 2.6 Classification of landscape types

Landscape type	Landscape characteristics (based on land cover classes in Table 2.4)
Urban areas	Urban land use is dominant. All other land cover classes are not dominant.
Urban landscape	Urban land use is dominant but any other land use could be dominant as well.
Rural landscape (cropland character)	Cropland is dominant, any other land use is dominant.
Rural landscape (grassland character)	Grassland is dominant, any other land use is not dominant, or grassland in combination with other land and surplus land is dominant.
Rural mosaic landscapes (agricultural character)	With majority of agricultural land, i.e. cropland and grassland > 50 % of model cell area.
Rural mosaic landscapes (abandoned character)	Other land category in combination with surplus land is dominant.
Natural mosaic landscape	With majority of semi-natural land, i.e. other land, surplus land and forest > 50 % of model cell area.
Forest landscapes	Forest is dominant.
Non-forested mosaic landscape	Other land category is dominant.

3 The PRELUDE scenarios

3.1 The base-year situation

Figure 3.1 shows the composition of the European landscape in the base-year 2005 according to the typology of the model. Rural landscapes (particularly those that are cropland-dominated) present a majority of landscapes in Europe, especially in eastern and parts of western and northern Europe. In comparison, urban areas and landscapes present a minority of landscapes in Europe. Urban areas are largely concentrated in north-western Europe.

3.2 Great Escape — Europe of contrast

3.2.1 Scenario summary

Economic globalisation increases global competition pressure. Market concerns dominate the political agenda. Governments do not intervene in markets and cut back welfare policies. Technological innovation rates are high. Social protection becomes more and more individualised. Societal tension builds up as the impoverished and poor immigrants move to urban city centres. Rich gated communities in the countryside stand in sharp contrast to urban ghettos.

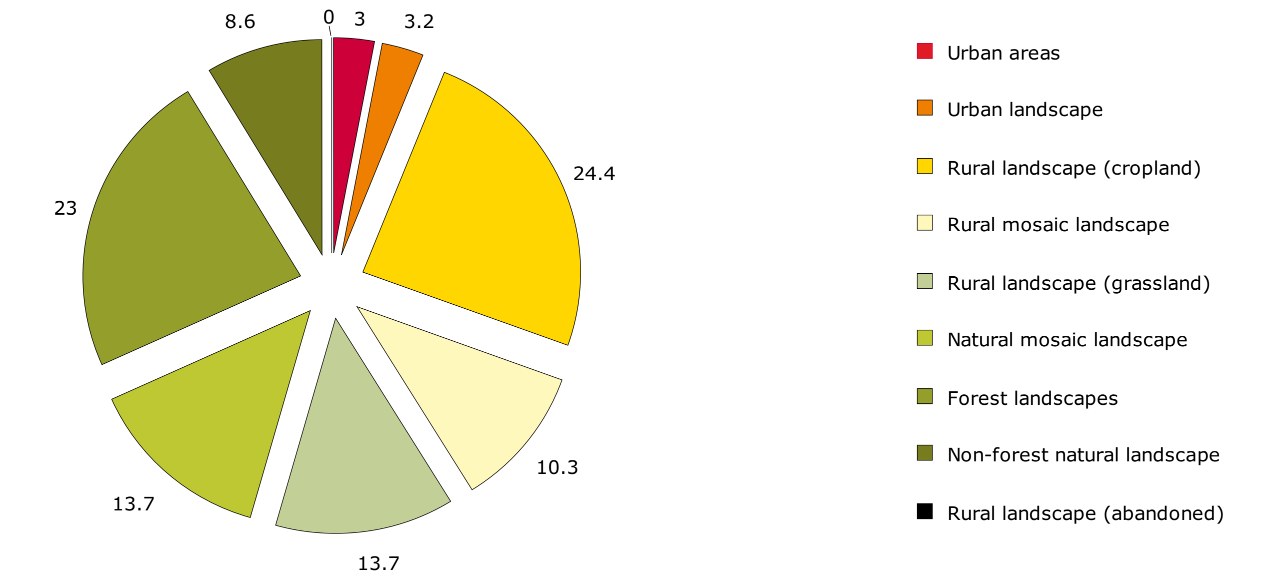
Agriculture is market-oriented and maximises profit. Production intensifies but total agriculture diminishes, affecting almost 75 percent of the total European landscape. Many grasslands are abandoned or converted into arable land. Agricultural intensification and urban sprawl affect the rural environment negatively. Many nature reserves and extensive farmland areas with high nature value are lost. However, in some areas of agriculture cessation, soil and water quality improve and more diverse natural habits may develop. Key developments in this scenario concern the increased importance of international trade (economic globalisation), the decreasing societal solidarity and the strong reduction of policy interventions.

3.2.2 Scenario analysis

Trust is placed in further globalisation and liberalisation of markets to enhance corporate and individual wealth. Governments cut-back social welfare and environmental regulation to promote international competitiveness. Social protection and health care is largely privatised and society individualises. The level of subsidiarity is low, too, since the retreat of government concerns all levels of governance.

The economy flourishes, with a high level of technological innovation. Conditions for immigration are eased in order to fill gaps in the labour force (0.03 % per year). The implications of the ageing of society are felt more and more.

Figure 3.1 Allocation of European landscape types in the base-year 2005



This explains the slightly higher overall population growth of 0.15 % per year. Internal population growth of 0.12 % contributes to further urbanization.

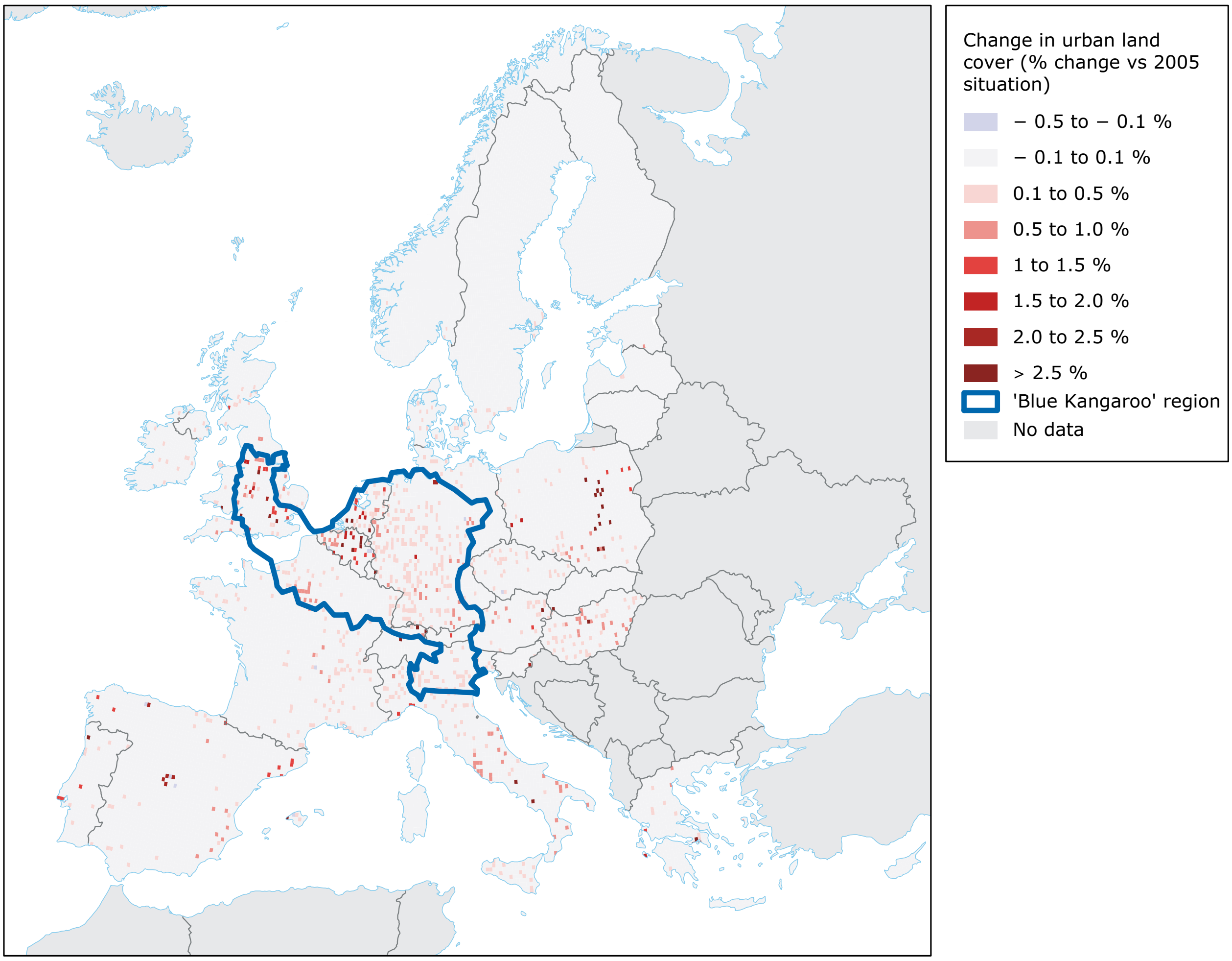
The economy flourishes and social inequalities rise, especially in urban areas. Living conditions of poorer people worsen due to increasing prices of food and energy. Solidarity decreases, leading to social tensions, which cause real problems in urban areas. Whereas the overall economic growth is assumed to be 2.8 % per year, there is a distinct split between economic growth of 2.3 % per year in urban areas and of 2.9 % per year in rural areas. The result is increasing spatial separation between the more affluent communities living in comfortable surroundings with high standards of living and the poorer ones living in urban centres with a low quality of life.

Concerns for the environment are initially quite low. There is no further agreement on effective international environmental agreements to curb global environmental change. Environmental pressure increases over the scenario period, as urban pollution intensifies and floodings and heat waves occur more often.

Between 2005 and 2015, people who can afford to start leaving the major cities (> 500 000 inhabitants) inside the so-called 'Blue Kangaroo' to live in safer, more rural areas. The wealthiest settle in so-called 'Gated communities' that spring up in the countryside far from cities and in non-flooding areas. Poor people from rural areas who move to these cities balance this migration.

This changes, however, during 2015 to 2035, when more and more disadvantaged members of society move to rural areas (1.0 % per year) leaving the cities inside the 'Blue Kangaroo' (1.0 % per year). People move because there is a strong need for workers to provide basic services, private health, education, leisure and security in the 'Gated communities'. They are housed in sprawling prefabricated bungalow patterns outside, but still close to, the 'Gated communities'.

Map 3.1 Changes (%) in urban area in the 'Great Escape'-scenario based on total surface area of each model cell



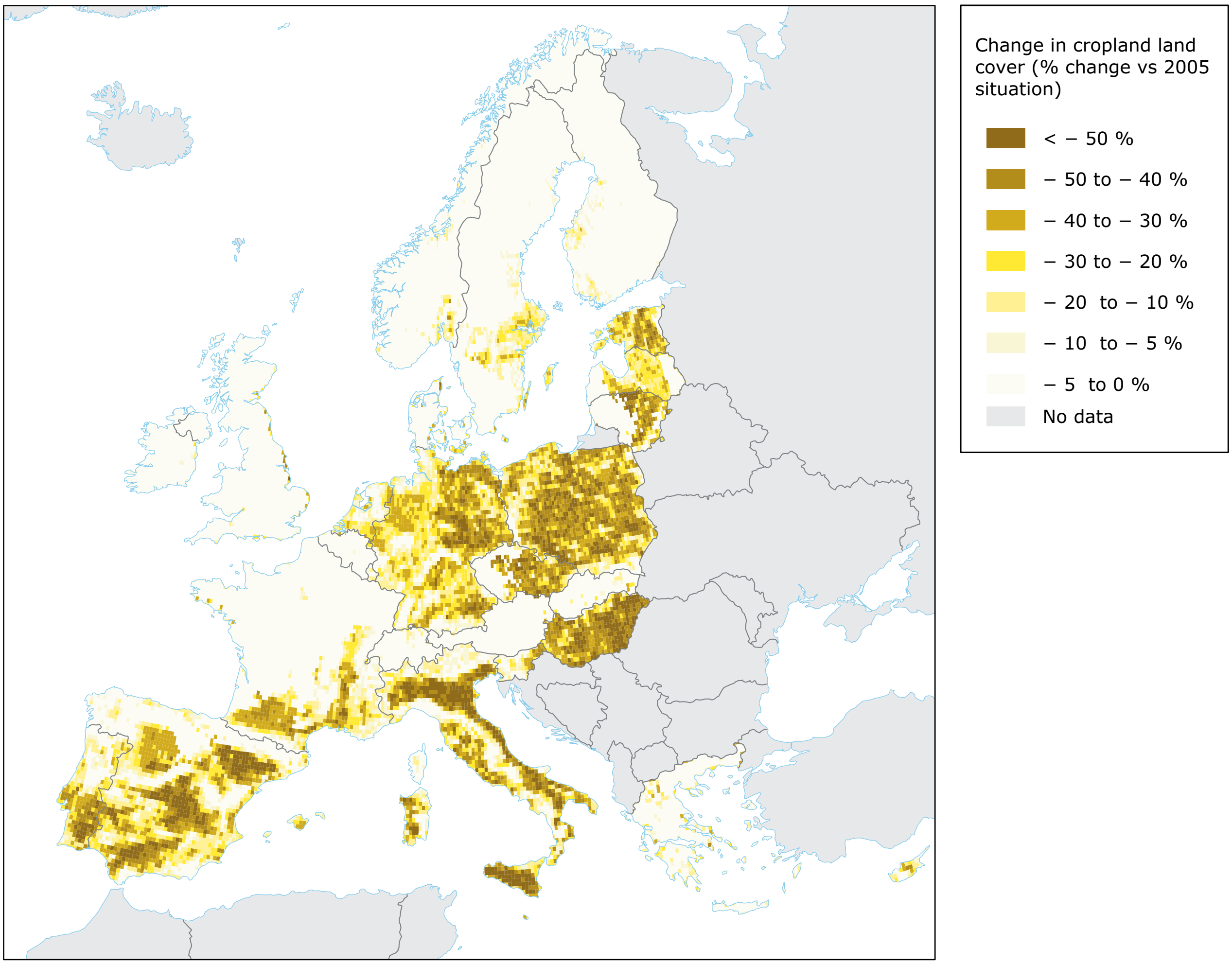
As a result, there is a relatively high growth of settlement area of 3 % between 2005 and 2035. Due to limited spatial planning and government interference, the urbanisation pattern is rather diffuse. Map 3.1 shows dispersed pattern of settlement around larger cities (> 500 000 inhabitants) from where people migrate away.

In this scenario the largest increase in urbanisation is in areas where in 2005 less than 5 % is urban land use. The urban population decline in large cities will cause some abandonment of existing urban areas. Despite low environmental awareness only a very small fraction (0.01 %) of further urbanisation takes place inside designated or protected areas. This development is reflected in Map 3.1 by the new urban communities of 2035 in the rural settings.

Further liberalisation of agricultural markets and reduction of support-schemes have important impacts. The scenario assumes a market-oriented maximisation of profits from agricultural production, which is characterised by a further increase in crop yields. It causes a shift of agricultural areas to optimal locations based on an agricultural rent map and a decrease in cropland in flooding areas. Structural change in the agricultural sector continues. Small extensive farms largely disappear; the remaining agriculture is high-tech and intensive.

Agricultural production and intensity are thus high; the demand for crop production increases by 1.2 % per year and the demand for production from grassland diminishes by 0.7 % per year. This is because grassland production is relatively extensive and thus not as profitable. It therefore decreases and is replaced by cropland production. Agriculture intensifies and concentrates on areas that are optimal for agricultural production. The sector is largely competitive in global agricultural markets. The export of agricultural products exceeds their import, and the current European oversupply is diminished (0.9 % p.a.). CO_2 concentrations and

Map 3.2 Changes (%) in cropland area in the 'Great Escape'- scenario based on total surface area of each model cell



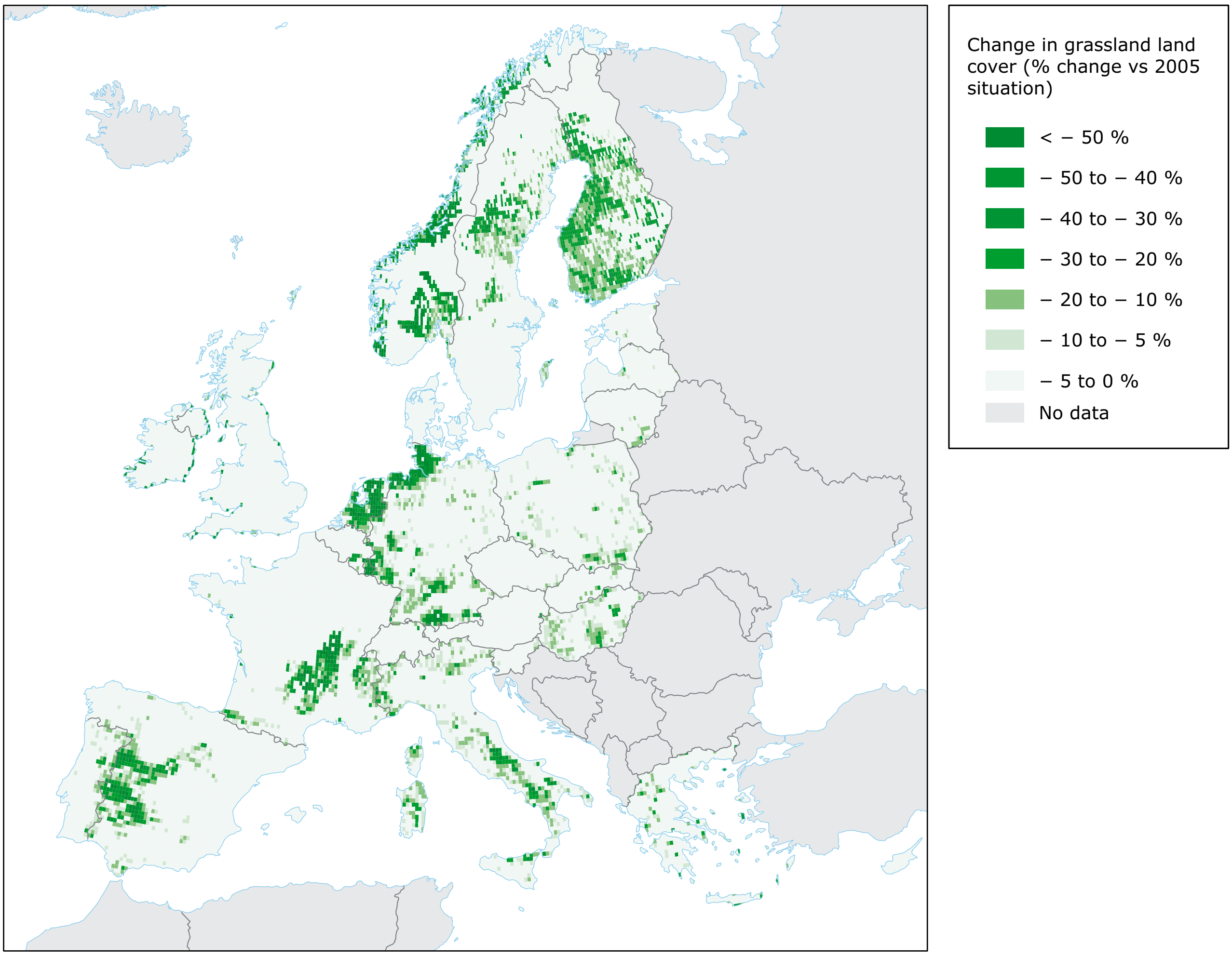
technology development have a strong impact on crop yields (0.3 % p.a. and 1.7 % p.a. respectively).

Profound landscape changes take place in this scenario. Cropland decreases by 37 % and grassland by 35 % between 2005 and 2035. Due to the concentration of agricultural production on optimal production areas, the reduction of both grassland and cropland area is regionally even higher than 50 % between 2005 and 2035 in large parts of Europe. Cropland is substantially reduced in the Mediterranean region and in Eastern Europe as well as in flooding areas such as some river basins in south-western France or some smaller river basins in central Spain. In some regions, this decrease exceeds 80 % between 2005 and 2035. There is also some reduction in agriculture: in agriculturally optimal area due to the high pressure for urban land as has already been seen by past trends around mega-cities (e.g. the Paris region). The spatial pattern is shown in Map 3.2.

Reductions in grassland, shown in Map 3.3, are highest in areas of the Netherlands, the Massif Central in France and in Norway. Large areas show losses of more than 50 % compared to the base-year situation in 2005. In total, reductions in agricultural area affect almost 75 % of the European landscape and have very important impacts on the rural landscape of Europe. They also affect the natural wildlife in these areas, e.g. bird habitats.

Due to the low environmental awareness and the limited diversification of energy sources, demand for biofuels does not strongly increase. It is assumed to be the same as its current value (0.1 % p.a. of current areas). Some of the crops will be produced on surplus agricultural land, and managed forests will also be used for energy production. However, overall surplus land in 2035 in EU-25 + 2 will be 15.5 % and the additional biofuels demand only compensates for roughly 1 % of the decrease in cropland. Since there are no subsidies for abandoned

Map 3.3 Changes (%) in grassland area in the 'Great Escape'-scenario based on total surface area of each model cell



land due to the *laissez faire* market conditions of this scenario, the surplus land is assumed to go back to being shrub land and subsequently forests. These changes are however very small on a European scale, so impacts may only be observed locally.

The increase in forest area per year is assumed to be the same as its current value of 0.005 % (EEA, 2003). In certain areas, such as parts of the United Kingdom and Belgium, forests will have to yield to the pressure from demand for urban land. Due to reduced environmental awareness, protected areas no longer prevent land-use change in these areas. Nature conservation regulation is weakened, leading to a reduction of the number of protected sites. Accordingly, new urban settlements also develop inside these areas; the overall fraction, however, is still very small at 0.01 %. The impacts on landscape and its multiple values, including its recreation potential and biodiversity, are thus likely to be very high.

3.2.3 Overview of driving forces, model input parameters and allocation rules

Table 3.1 presents the qualitative values for the trends in this scenario.

Table 3.2 shows all choices and assumptions that have been used for the quantification of the 'Great Escape'-storyline.

As for the population values, the evaluation of the 'Great Escape'-scenario seems slightly higher and high immigration is described in the storyline. A higher annual rate of increase was, therefore, used (0.15 p.a.) than in the other scenarios that follow the standard SRES scenario annual growth rate of 0.12 %.

For urban land use, mixed urban patterns were implemented including development in urban areas due to immigration and new arrivals, and development in rural areas due to the migration of rich people to the countryside. These patterns were made spatially explicit as an urban potential transition map.

Potential urban increases may occur at less than 50 km from large cities (potential increases close to cities) and potential urban increases may occur at less than 3 km from isolated urban cells (potential increase in rural areas). An accessibility condition was also added: potential urban increases may occur at less than 15 km along the road network. New urban settlements were allowed in protected or designated protected areas due to the low level of environmental awareness in this scenario.

Values for the demand of agricultural production have been chosen based on the SRES A1 scenario and were derived from the IMAGE 2.2 model and the ATEAM project estimates (Image Team, 2001; IPCC, 2001; Rounsevell, Ewert, Reginster e*t al.*, 2005; see Table 3.2). In order to fill the gap between the yields in western and eastern European countries in 2035, technology factors for eastern European countries were multiplied by 1.3. As described in Section 2.5.2, a new agricultural rent map was used to allocate agricultural demands assuming optimal locations.

A low value for the parameter renewable energy demand has been used (equal to the baseline value of 0.1 % p.a.) due to the low degree of environmental awareness in this scenario. To reflect on the low environmental awareness, a 1.6 % decrease p.a. of the protected areas was imposed. Because of

Table 3.1 Driving forces of scenario: 'Great Escape'

Driving force	Qualitative value	Changes vs current trend	Driving force	Qualitative value	Changes vs current trend
Subsidiarity	1	– 3	Environmental awareness	2	– 3
Policy intervention	1	– 6	Economic growth	5	0
Settlement density	1	– 4	International trade	9	2
Population growth	4	2	Daily mobility	6	0
Ageing society	8	0	Self-sufficiency	8	0
Immigration	9	6	Technological growth	8	3
Internal migration	7	4	Agricultural intensity	9	4
Health concern	5	0	Climate change	8	0
Social equity	1	– 4	Renewable energy	6	0
Quality of life	3	– 2	Human behaviour	2	– 3

Table 3.2 Model input parameters and allocation rules for the 'Great Escape'–scenario

Model input parameter/allocation rules	2005–2035 European average % change per year	Qualitative valuation	Sources and justification
Population	+ 0.15	4	Slightly higher than UN/IIASA data due to higher valuation (4 rather than 2) based on first evaluation of fuzzy sets + high immigration.
NUTS 2	Downscaling from national data		
East/west	No migration	Internal migration = 7	No reason to assume any migration between East and West.
Rural/urban	Inside 'Blue Banana': immigration into large urban areas 2005–2015: 0 2015–2030: – 1.0 in urban areas + 1.0 in rural areas	Internal migration = 7	Overall immigration is 0.03 % per year which explains the slightly higher population growth (values are taken from Eurostat/EU-25 net migration data). 2005 to 2015: The affluent leave the cities all over Europe to live in more rural areas. This migration is balanced by poorer communities from rural areas moving to the cities. 2015 to 2035: Both affluent and disadvantaged communities move to rural areas.
GDP/capita	+ 2.8	5	Carried out per country based on SRES A1 = Market oriented scenario.
NUTS 2	Urban areas: + 2.3 Rural areas: + 2.9		Poorer communities live in urban centres. The affluent live in more rural areas.
Allocation rules: urban land use	Urbanization in large cities + rural sprawl of rich people in attractive areas, far from cities, and in non flooding areas		Internal population growth of 0.12 % contributes to urbanization.. Population growth due to immigration (0.03 %) takes place in large cities (threshold > 500 000) — Urban land use increase in large cities. Migration between rural and urban areas is balanced so that there is no net effect on population. Urban land use increases in rural areas due to the more affluent moving into rural areas.
Total demand of agricultural production	Cropland: + 1.2 Grassland: – 0.7	Agricultural intensity = 9	Based on SRES A1.
Domestic demand			Not needed as model input.
Import	Yes	9	Based on SRES A1.
Export	> import	9	Based on SRES A1.
Change in oversupply	Factor = 0.9		Current European oversupply is diminished.
Impact of CO_2 on crop yield	+ 0.3	8	High, based on SRES A1.
Impact of technology on crop yield	+ 1.7	8	Based on SRES A1.
Biofuels energy demand	+ 0.1	6	= baseline.
Allocation rules for agriculture	In optimal location based on agricultural rent map and decrease of cropland in flooding areas	Agricultural intensity = 9	Market-oriented = maximization of the profit for agriculture.
Cost for wheat production (labour + fertilizers + transport)	+ 0.8		A1 SRES scenario.
Price of wheat (euro/tonne)	– 0.8		A1 SRES scenario.
Forest	+ 0.005		Same as baseline.
Protected areas	– 1.6	Environmental concern = 2	Over the 30 years scenario period the protected areas are reduced .
Surplus	Shrubs and then forests		Market orientation: no subsidies for abandoned land.

the strong market orientation in this scenario, no subsidies are granted for abandoned agricultural land which changes into shrubs and then into forests. However, due to the long rotation times and the absence of supporting policy intervention measures, the base line value of 0.005 % p.a. was used.

Regarding the impacts of flooding, no increase in urban land use will occur within the cells that are located in a flood risk area higher than 6 (on a scale from 1–11). Cropland will decrease by 25 % within cells that are located in a flood risk area higher than 6 and cropland will decrease by 10 % within cells that are located in a flood risk area with values of 5–6.

3.3 Evolved Society — Europe of harmony

3.3.1 Scenario summary

Heavy floods and exploding energy prices reinforce environmental awareness. Many people come to believe that lifestyles and economy should change. A revival of the countryside takes places as many people move away from densely populated (lowland) areas and settle in more rural and safe areas, especially in Eastern Europe. Local community action is getting new impetus by concerns for social equity. Policies focus on rural development and eco-efficient technologies at the expense of structural change.

Farming is high-tech and increasingly organic. Agricultural area remains approximately the same size while farming intensity decreases. In areas that are prone to repeated flooding, cropland is reduced considerably. Overall land-use changes are not dramatic, and extensive farmland with high nature value is relatively well conserved.

Key developments in the scenario concern a far-reaching energy crisis, which triggers increased support for renewable energies. A strong increase in environmental awareness sets off broader life-style changes and ambitious policies by European and national institutions in favour of environmentally sustainable regional development.

3.3.2 Scenario analysis

'Evolved Society' shows a trend away from the 'rat race' lifestyle in western European cities to more pastoral living in rural areas, especially in Eastern Europe. Tipping points for this development are (1) intensified floodings that cumulate into several weeks of heavy flooding, leaving hundreds of thousands of people in Europe without a home, (2) a subsequent international energy crisis after a series of terrorist attacks on oil pipelines causing oil prices to sky-rocket. The running out of reserves in many countries makes the search for new ways of producing energy inevitable.

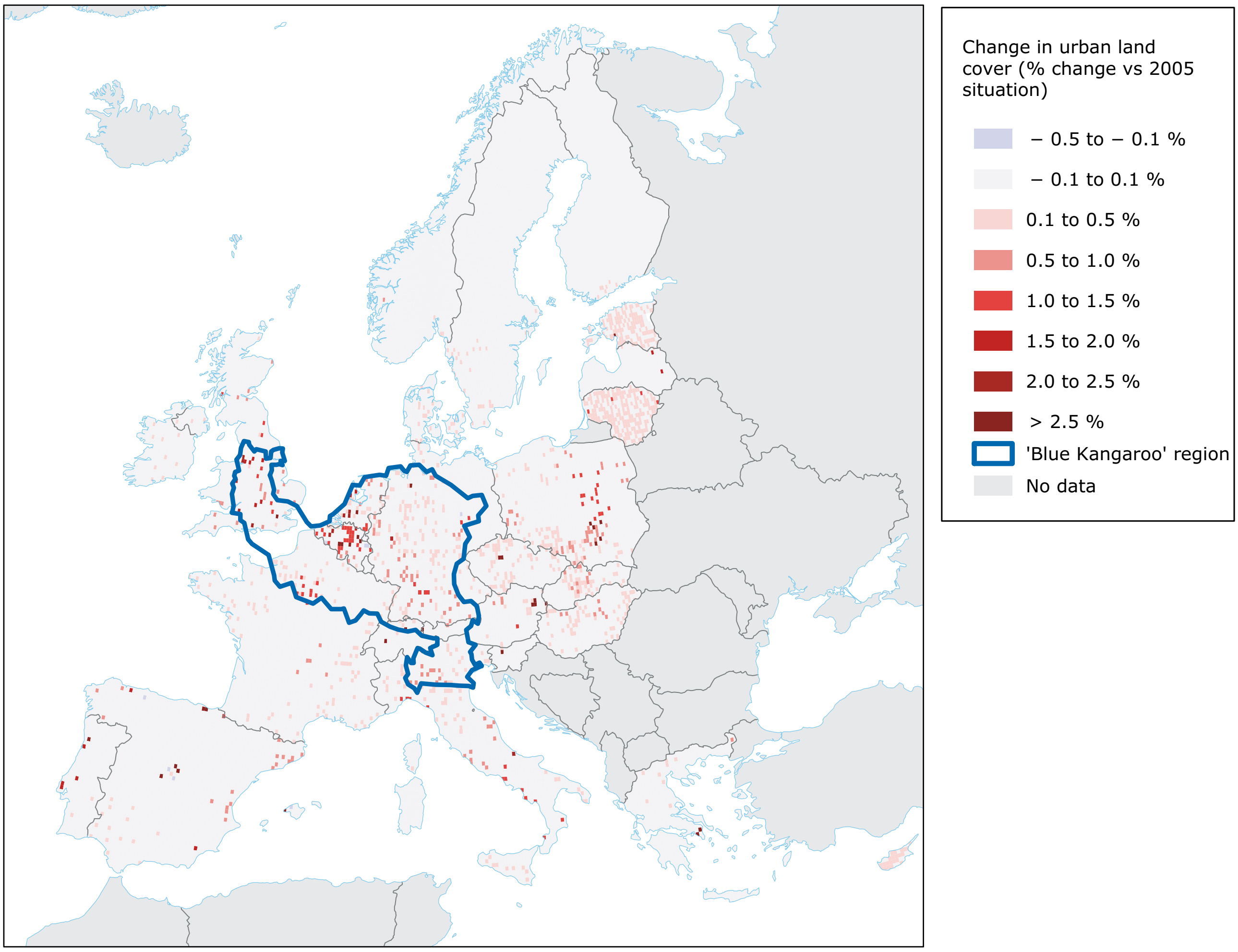
Many people come to believe that lifestyles and economy should change into more environmental sustainable forms. A revival of the countryside takes places as many people move away from densely populated (lowland) areas (flood risks) and settle in more rural and safe areas, especially in Eastern Europe. Governments aim to support this development by providing funds for moving and settling down.

'Evolved Society' has high values for government intervention and subsidiarity. However, the most important factor behind the far-reaching social and economic changes in this scenario is the shift in mindsets of the majority of the European population. Social equity and economic well-being of the individual are being achieved in a society with a high level of environmental awareness, which combines high-tech development and agricultural production from organic farming. The overall growth is assumed moderate at current rates of 1.5 % p.a. Overall, population trends continue at current levels (0.12 % per year) throughout the scenario period.

Due to the development of strong regional identities within a united Europe, high transportation costs and the advancement in new technologies, many people work and live in semi-rural, non-flooding areas without having to travel much. There is a net migration away from the most densely populated urban areas towards peripheral regions. Migration from west to east is considerably high; we assume a rate of 0.1 % per year (based on the rate of people who migrated west after the end of communism). We also assume that the urban population decreases by 0.7 % per year and rural population increases at the same rate.

A comparatively high overall increase of 3 % in settlement areas in Europe between 2005 and 2035 is the result. In certain areas, especially in the Baltic States with small and medium-sized cities, these increases are much higher (as shown in Map 3.4). The migration to rural areas leads to an increase of urban land use in the new EU Member States, which is rather diffuse. More than 60 % of urban area increase takes place in regions with less than 5 % of urbanised area in 2005 in this scenario. The

Map 3.4 Changes (%) in urban area in the 'Evolved Society'-scenario based on total surface area of each model cell



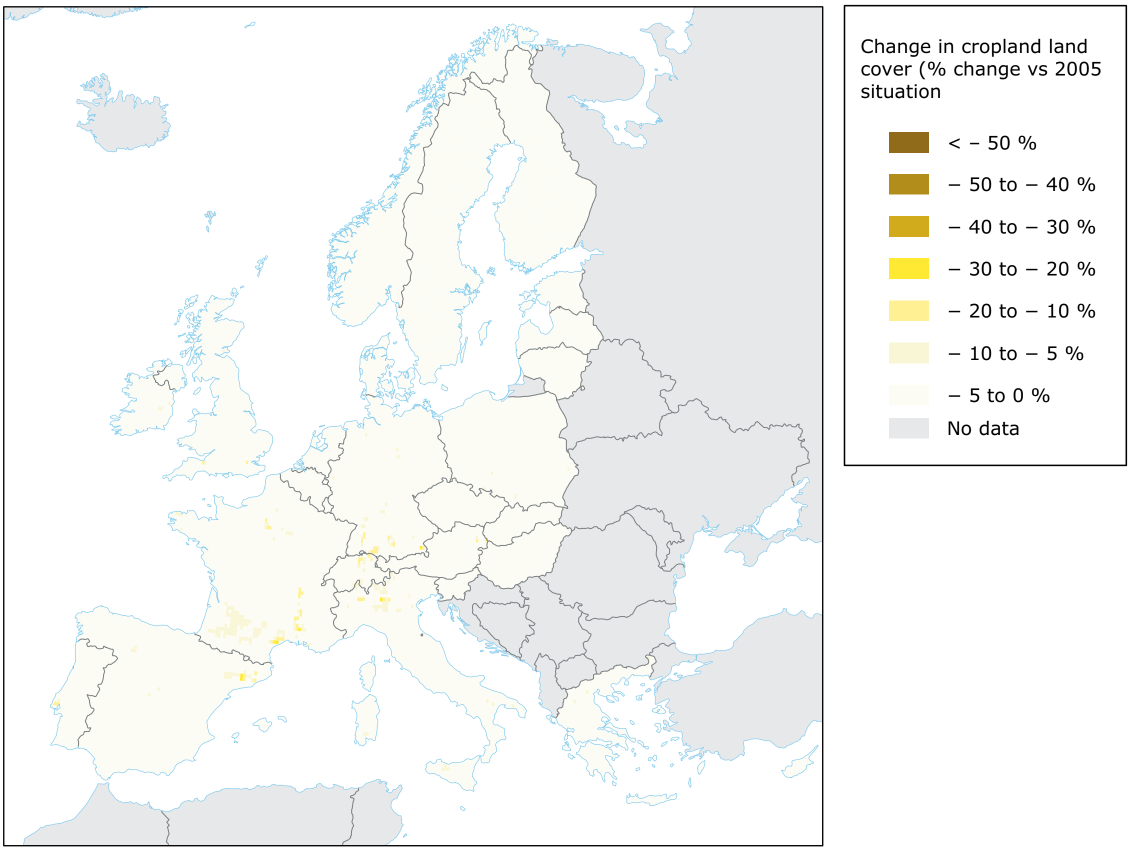
downside of this diffuse pattern of new urban settlements in rural areas is an increased demand for infrastructure (such as roads, administration buildings, etc.) with likely negative impacts on regional landscape quality. However, this is partly offset by new forms of living and working without much travelling. Because of the west-to-east migration, there is also a decrease in urbanised areas in some metropolitan parts of the 'Blue Kangaroo'.

Due to the pronounced migration to Eastern Europe, we see large-scale farming popping up there; the farming is low intensity. The impact of technology on crop yield is negligible. Because of the high degree of environmental awareness, there is a substantial shift of agricultural land to so-called designated areas but no increase in protected areas. In addition, since the import of feed crops is reduced, increasing areas are under grain production to feed pigs. Since organic farming is subsidised, and import and export takes place in a globalised world, the oversupply is assumed to remain at the current level of 20 % per year. Total demand of agricultural production from cropland increases at a rate of 1.2 % per year.

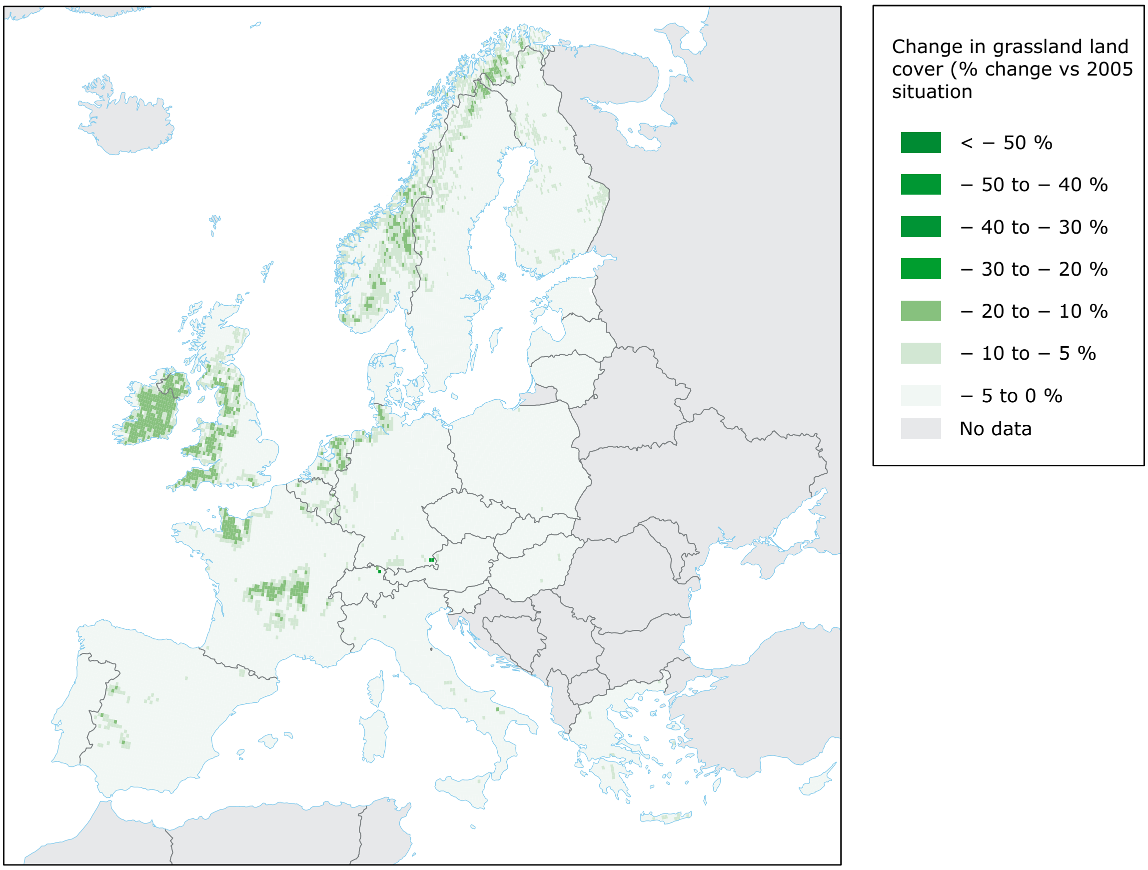
Map 3.5 shows a slight decrease in cropland that is equally distributed across Europe. Demand for production from cropland increases slightly (0.7 p.a.) but the total cropland area decreases slightly which can be explained with productivity gains. However, in areas that are prone to repeated flooding, cropland is reduced between 10 % and 20 %, e.g., in the Garonne region in south-western France, some alpine regions as well as western parts of Portugal.

Despite extensive livestock production with fodder from grassland, there is a decrease in grassland due to a rise in pig production, which is caused by changing consumer preferences and production for the world market. Pigs feed on grain, and thus the demand for grassland is reduced. Grassland decreases moderately by 14 %, and impacts on rural

Map 3.5 Changes (%) in cropland area in the 'Evolved Society'-scenario based on total surface area of each model cell



Map 3.6 Changes (%) in grassland area in the 'Evolved Society'-scenario based on total surface area of each model cell



landscapes are small, especially if compared with the global market oriented scenarios 'Great Escape' and 'Clustered Networks' (Map 3.6). Changes are more pronounced in flood risk areas where no increase in urban land use and decreases in cropland and grassland are assumed for certain parts of the flood risk areas (see Section 3.3.3 for definition of allocation rules).

Due to the very high fossil fuel prices, renewable energies are strongly promoted. Biomass becomes one important element of the diversification of the energy mix. The area for biofuels energy demand, therefore, increases by 0.3 % p.a., tripling the baseline value of 0.1 %. Since biofuels are subsidised, we see new forest plantations for energy production and, thus, a small increase in forests of 0.1 % per year (corresponding to the EFSOS alternative scenario, see Schelhaas *et al.*, 2003). In addition, bioenergy crops production takes place on cropland formerly used for food production. Thus, there is no longer surplus land. Even though in this scenario the afforestation across Europe is high if compared to the other scenarios, it is still very small in total.

3.3.3 Overview of driving forces, model input parameter and spatial allocation rules

Table 3.3 presents the qualitative values for the trends in this scenario.

Table 3.4 shows the choices and assumptions that have been used for the quantification of the 'Evolved Society'-storyline.

For urban land use, it was assumed that people leave cities all over Europe to live in rural areas. Thus, the allocation of urban land use occurred only in rural areas. These patterns were also made spatially explicit in an urban potential transition map. Potential urban increases may occur at less than 3 km from isolated urban cells. An accessibility condition was added: potential urban increases may occur at less than 15 km along the road network. Scenario-specific down-scaling of the IIASA values was used to re-distribute the values at NUTS 2-level according to the description of strong migration to Eastern European countries.

Values for the demand of agricultural production have been chosen based on the SRES A1 scenario and were derived from the IMAGE 2.2 model and the ATEAM project estimates (Image Team, 2001; IPCC, 2001; Rounsevell, Ewert, Reginster e*t al.*, 2005). This reflects the strong international trade and thus import and export of agricultural goods that takes place in 'Evolved Society'. The low agricultural intensity that was described in the storyline was introduced via the allocation rules. The impact of technology on crop yield was defined as non-existent (0) to reach the objective of extensification of agricultural land as described in the storyline.

Like in the 'Great Escape'-scenario, a high impact of CO_2 concentration on crop yields was assumed (+ 0.3 % p.a.). Since 'Evolved Society' refers to a strong push for renewable energies, the value for the biofuels demand (0.3 % p.a.) was tripled compared to the baseline values (0.1 % p.a.). Energy crops were allocated to surplus cropland and grassland following the same allocation rules as used for the computation of the updated 2005 baseline.

The forest increase of 0.1 % p.a. was allocated to surplus agriculture land, and the cells with a percentage of forest lower than the national average were given priority for afforestation. A type of designation of cropland and grassland was introduced for this scenario to represent

Table 3.3 Driving forces of scenario: 'Evolved Society'

Driving force	Qualitative value	Changes vs current trend	Driving force	Qualitative value	Changes vs current trend
Subsidiarity	7	3	Environmental awareness	9	4
Policy intervention	6	– 1	Economic growth	3	– 2
Settlement	1	– 6	International trade	10	3
Population growth	2	0	Daily mobility	2	– 4
Ageing society	8	0	Self-sufficiency	6	– 2
Immigration	7	4	Technological growth	6	1
Internal migration	9	6	Agricultural intensity	1	– 4
Health concern	9	4	Climate change	9	1
Social equity	8	3	Renewable energy	9	3
Quality of life	9	4	Human behaviour	7	3

Table 3.4 Model input parameter and allocation rules for the 'Evolved Society'-scenario

Model input parameter/allocation rules	2005–2035 European average % change per year	Qualitative valuation	Sources and justification
Population	+ 0.12	2	Done per country based on UN/IIASA data — same as baseline.
NUTS 2	Downscaling from national data		
East/west	First: + 0.1 to East	Internal migration = 9	People from the West migrate to the East at the same rate as eastern Europeans migrated west after the end of communism.
Rural/urban	Second: in rural areas: + 0.7 of urban population to rural areas in cities: – 0.7 of urban population to rural areas	Internal migration = 9	People leave the cities all over Europe to live in more rural areas. Plausible (compared to the change in the Brussels periphery in 10 years).
GDP/capita	+ 1.5	3	Same representation as in the baseline.
NUTS 2	Downscaling from national data		
Allocation rules: urban land use	Rural in non flooding areas		People leave the cities all over Europe to live in more rural areas.
Total demand of agricultural production	Cropland: + 0.7 Grassland: – 0.4	Agricultural intensity = 1	First assessment based on SRES A1 because import and export exist, adjustment to avoid important surplus. Low agriculture intensity will be introduced via the allocation rules.
Domestic demand			Not needed as model input.
Import	Yes	10	Based on SRES A1.
Export	Yes	10	Based on SRES A1.
Change in Oversupply	Factor = 1.0		Organic farming is subsidized oversupply = baseline.
Impact of CO_2 on crop yield	+ 0.3	9	High, based on SRES A1.
Impact of technology on crop yield	+ 0	6	High technology improvement on the quality of crop rather than on the yield.
Biofuels energy demand (area)	+ 0.3	8	Triples the baseline value.
Allocation rules for agriculture	Extensification: no or minor reduction in agricultural area equally distributed decrease in flooding areas	Agricultural intensity = 1	
Cost for wheat production (labour + fertilizer + transport)			
Price of wheat (euro/tonne)			
Forest	0.1		Small increase corresponding to EFSOS alternative scenario.
Protected areas		Environmental concern = 9	Twice the past increase based on Natura 2000 (WCM database).
Surplus	0		New forest plantations. Subsidies for biofuels. No surplus.

the respective assumption made in the scenario storyline correctly. The value for the protected areas was set twice the past increase based on Natura 2000 (World Conservation Monitoring Centre, 2000). As regards the impacts of flooding, no increase in urban land use will occur within the cells that are located in a flood risk area higher than 6 (on a scale from 1–11). Cropland will decrease by 25 % within the cells that are located in a flood risk area higher than 6 (i.e. 7–11) and cropland will decrease by 10 % within cells that are located in a flood risk area with values of 5–6.

3.4 Clustered Networks — Europe of structure

3.4.1 Scenario summary

Globalisation propels economic growth but environmental and health conditions, especially in the urban centres, get worse. People in the countryside struggle as many local shops and services close down. The needs of an ageing society lead to the development of coherent spatial planning policies. Migration away from polluted urban areas is encouraged. New cities with a service economy are founded as economic and social focal points in peripheral regions.

Urbanisation is concentrated and rural development focuses on green belts around urban centres. Agriculture marginalises. Because of large-scale land abandonment, cropland and grassland strongly decrease. Biodiversity, water, soil and air quality benefits from receding agriculture and creation of green belts. Natural habitats develop in the wider countryside, but to the detriment of high nature value farmland.

Key developments in this scenario concern the impacts of population dynamics (ageing of society), the effects of deepened international trade relations which lead to a strong marginalisation of agriculture and the occurrence of strong spatial planning interventions to cope with the challenges of the ageing of the society.

3.4.2 Scenario analysis

Globalisation of economy and the ageing of society set the scene in the 'Clustered Networks'-scenario. The European economy flourishes, but negative impacts on human health and the environment rise. Rural economies are under pressure; agriculture loses much of its attractiveness for younger people. It comes to a division between 'movers' and 'holders': young, highly educated people mainly stay in or move to urban areas. Older people and the less skilled try to hold on to existing wealth by staying in or retreating to rural areas.

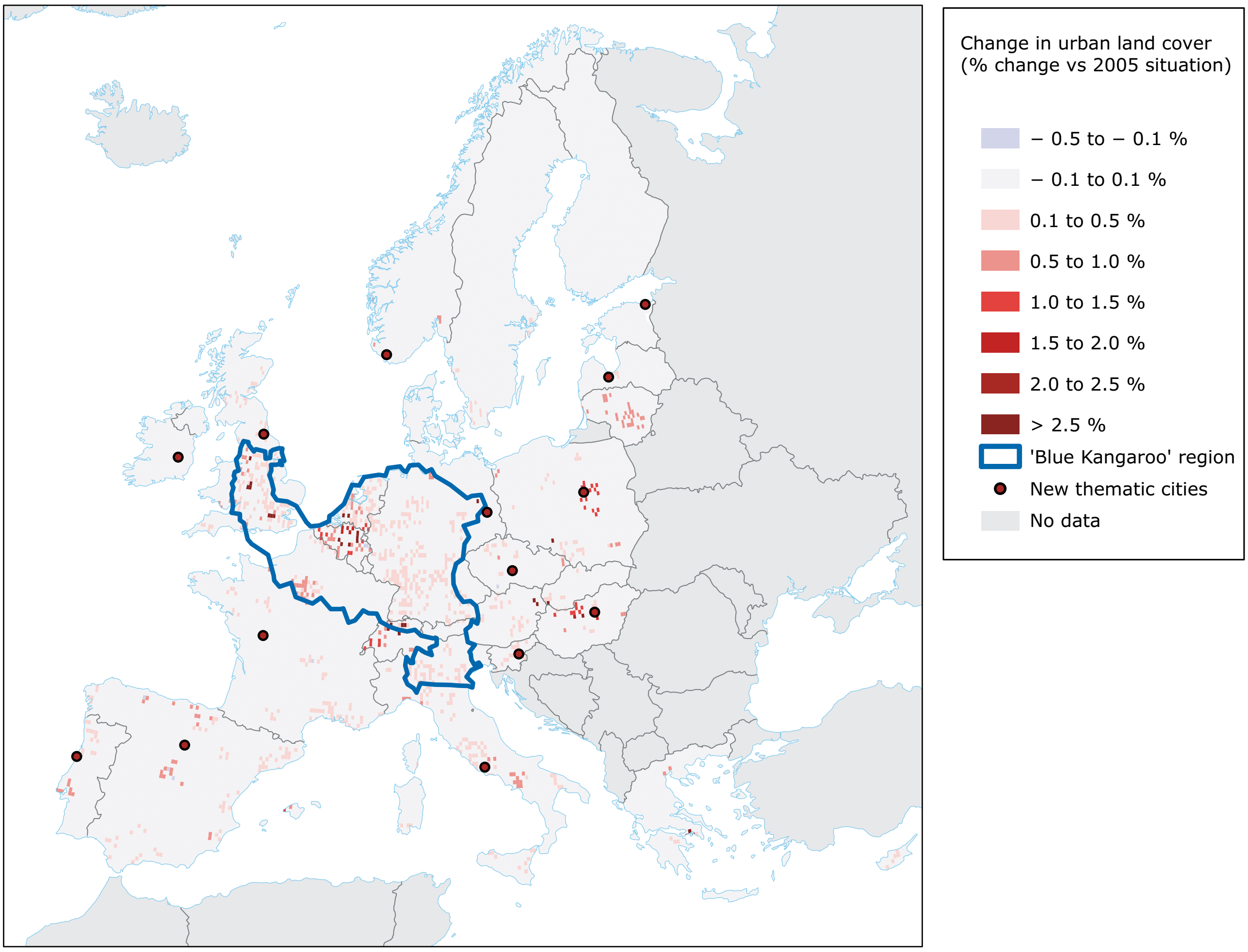
Environmental awareness rises as urban air pollution intensifies. Rather than letting this trend develop into a crisis, strong planning programs at European and national level are set up to avert further deterioration. Migration away from polluted urban areas is encouraged. Provisions for immigration are also eased to cope with the short-cuts in the labour force. Regarding the revival of the countryside, new ground is broken with the creation of 14 new medium-sized cities outside the so-called 'Blue Kangaroo'; each city hosts a population of approximately 250 000 people. These cities act as focal points for economic and social development, and they develop into centres of excellence for technology development. This results in an overall population decrease over the 30-year scenario period of 3.5 million people moving out of the highly populated 'Blue Kangaroo' area in Western Europe.

Urban areas increase by about 3 %. Urbanisation is concentrated; new settlements are located in the peri-urban areas of large and medium-sized cities as seen in Map 3.7. This map also shows how the 14 new cities are distributed across Europe (in form of dots, as provided by the storyline), which locally will produce major urban increases of up to 60 %. These new cities generate major local changes in infrastructure, new employment opportunities, and activities in peripheral European regions. On the other hand, the migration of 3.5 million people out of the 'Blue Kangaroo' is likely to produce a decline of activities and income in the centre of Europe. Overall, population trends continue at current levels (0.12 % per year) throughout the scenario period.

Despite the deepening of economic globalisation governments do not retreat from regulating markets. Rather, strong European and national spatial planning and rural development policies shape economic and social development in peripheral regions. Part of the funding comes from shifting subsidies from agricultural production to rural economic development. Different development patterns (for urban areas, agricultural land, etc.) in the different regions due to strong cultural identities are seen as providing added value. Environmental values also play an important role.

The overall economic growth is 3.5 % per year, being higher in the cities (3.7 % per year) and lower in the

Map 3.7 **Changes (%) in urban area in the 'Clustered Networks'-scenario based on total surface area of each model cell**

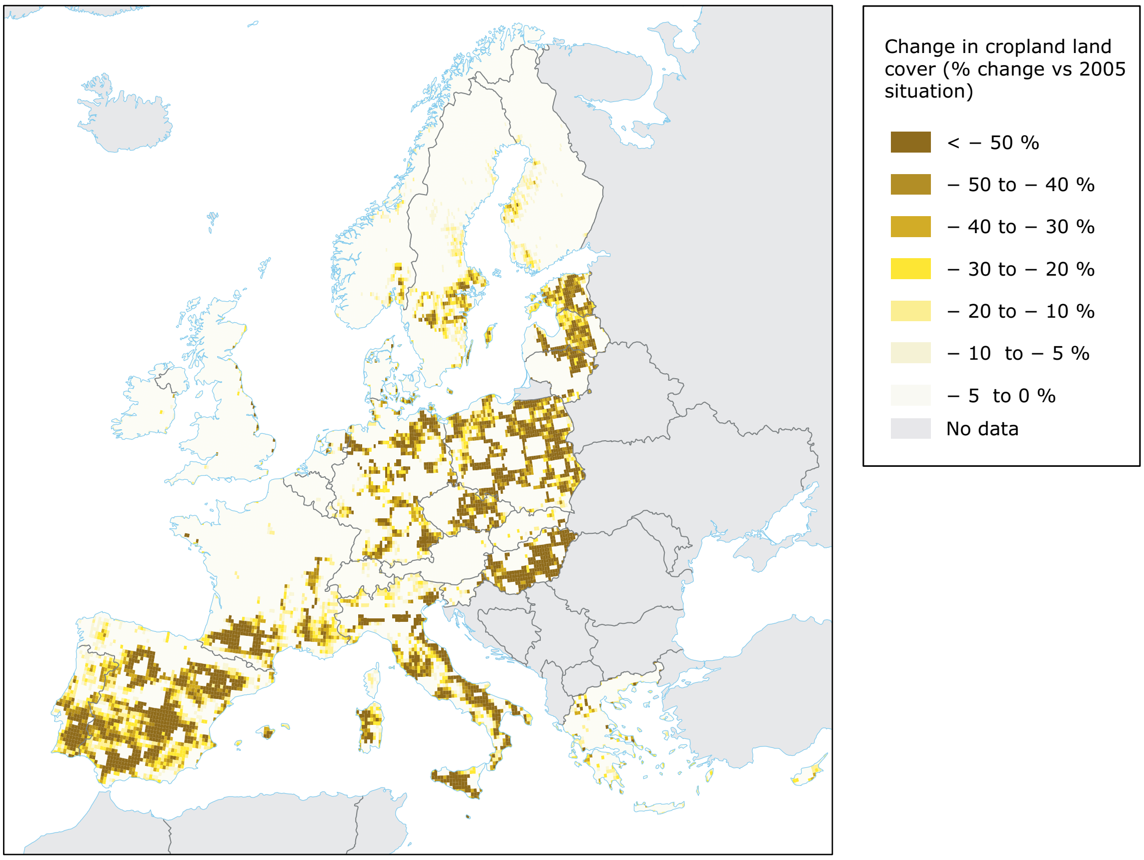


rural areas (3.1 % per year). Due to market rules and prices, and because of the high environmental awareness, a high import rather than export of agricultural goods takes place. Net agricultural production within Europe is reduced. As a result, the total demand for agricultural production from within Europe diminishes at 1.0 % per year for both cropland and grassland (based on experts storyline interpretation). Since this landscape stewardship around cities is subsidised, agricultural oversupply is assumed to remain at the current level of 20 %. The impact of technology on agricultural production is .7 % per year that is low compared to the base-year situation in 2005 (1.7 % per year).

Agriculture marginalises in this scenario. Only in the most favourable conditions does agriculture continue and intensify production. These farms are competitive on international markets. As shown in Map 3.8 and Map 3.9, the resulting decreases in cropland and grassland are about 35 % and 33 %, respectively, between 2005 and 2035, which apart from 'Great Escape' scenario are the highest of all the scenarios developed here. Grassland decreases the most in areas where agriculture is currently extensive. These large decreases arise from increased imports and are observed in less profitable regions mainly affecting the Mediterranean and eastern countries. Local decreases are also observed in some optimal agricultural areas due to the pressure from urban land-use requirement. The amount of agricultural land is further reduced in flooding zones (see Section 3.4.3 for details).

The quality of urban areas is maintained by creating belts of 'cultural landscapes' around cities that are, at the same time, protected areas (i.e. Natura 2000 around cities), serving both recreational and high quality food production purposes. Therefore, agricultural areas around cities are generally maintained. This pattern is well reflected for cropland in Map 3.8 and can also be seen for grassland in Map 3.9.

Map 3.8 Changes (%) in cropland area in the 'Clustered Networks'-scenario based on total surface area of each model cell



Map 3.9 Changes (%) in grassland area in the 'Clustered Networks'-scenario based on total surface area of each model cell

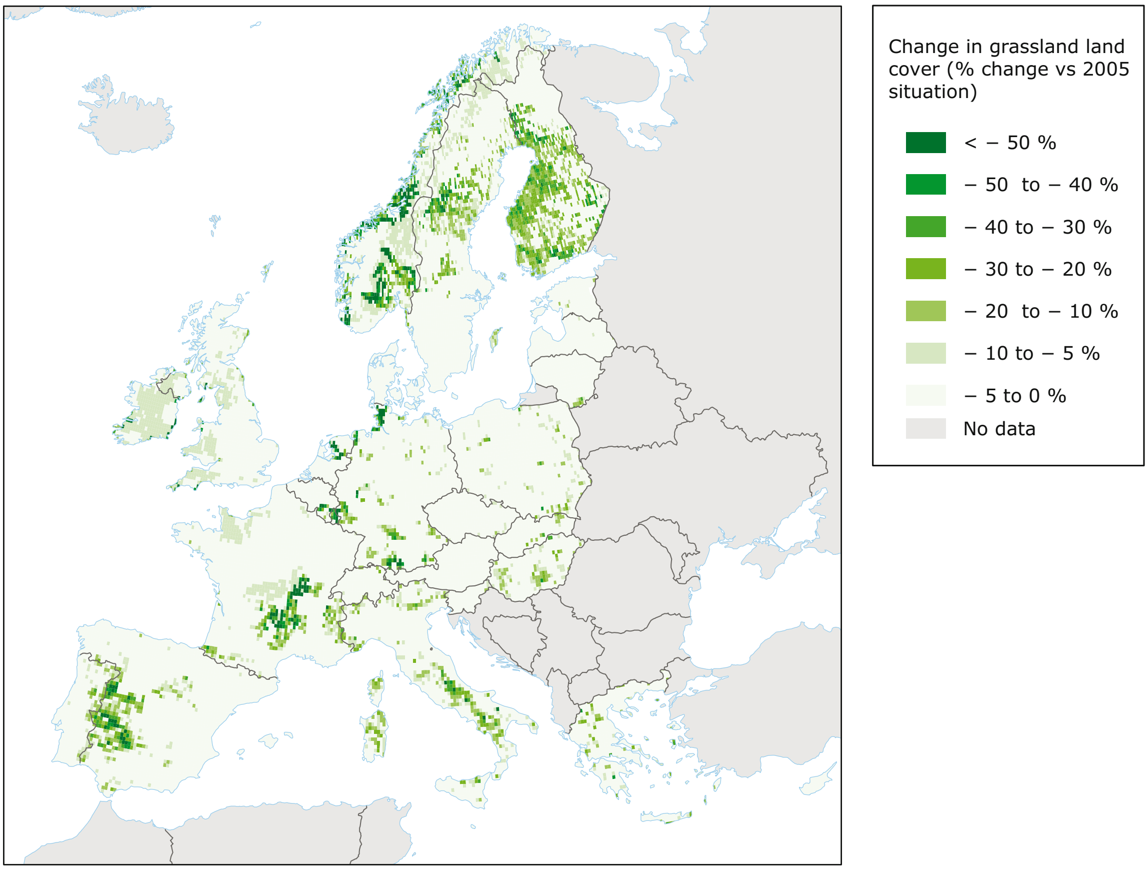


Table 3.5 Driving forces of scenario: Clustered Networks

Driving force	Qualitative value	Changes vs current trend	Driving force	Qualitative value	Changes vs current trend
Subsidiarity	8	4	Environmental awareness	8	3
Policy intervention	7	0	Economic growth	9	4
Settlement density	8	1	International trade	7	0
Population growth	2	0	Daily mobility	5	– 1
Ageing society	7	– 1	Self-sufficiency	2	– 6
Immigration	7	4	Technological growth	6	1
Internal migration	8	5	Agricultural intensity	6	– 1
Health concern	7	2	Climate change	10	2
Social equity	6	1	Renewable energy	6	0
Quality of life	6	1	Human behaviour	9	4

Biofuels are partly subsidised. Crops are grown on the surplus agricultural land. However, there is no similar increase in biofuels energy demand compared to the baseline year (0.1 % p.a.). The remaining surplus land develops first into shrub land and then into forests. This development will have important impacts on the rural landscape because surplus land will be twice as large as grassland in 2035. A decrease in forest areas is observed in some peri-urban areas due to urban pressure, although the net forested area increases slightly, which is also due to additional policy interventions that influence forested land use in a positive way.

3.4.3 *Overview of driving forces, model input parameters and spatial allocation rules*

Table 3.5 presents the qualitative values for the current trends as described by the stakeholders.

Table 3.6 shows the choices and assumptions that have been used for the quantification of the 'Clustered Networks'-storyline.

Regarding land-use patterns, peri-urban patterns were implemented including diffuse developments close to cities. These patterns were again made spatially explicit in an urban potential transition map. Potential urban increases may occur at less than 100 km from large cities, less than 30 km from medium cities, or less than 10 km from small cities. An accessibility condition was also added: potential urban increases may occur at less than 15 km along the road network. Additionally, the cells affected by settlements of the 14 new cities were included in the potential transition map.

Values for the parameter agricultural demand were chosen as different from estimates derived with the IMAGE 2.2 model. This choice was based on the stakeholders' evaluation and the description of the storyline. The high values of a 1 % p.a. decrease for cropland and grassland take into account the very high import of agricultural goods from other continents in this scenario. As described in Section 2.5.2, a new agricultural rent map was used to allocate agricultural demands assuming optimal locations.

As for the other scenarios, a high impact of increased CO_2-concentration on crop yields was assumed. Based on the SRES B2 scenario, technological development was assumed to increase crop yields by 0.7 % p.a. (IPCC, 2001). In order to fill in the gap between the yields in western and eastern European countries in 2035, the technology factors for eastern European countries were multiplied by 1.3. Special landscape buffer zones were created and implemented via the spatial allocation rules. This reflects the notion in the storyline that green belts of cultural landscape are surrounding cities and serve for recreation and nature protection. Landscape buffer zones are located less than 10 m from small cities, at less than 30 km from medium-sized cities and at less than 50 km from large cities.

Surplus areas are partly used for bio-energy crop production. However, the storyline does not give reason to assume a real intensification of efforts to produce bio-energy crops, which is why the baseline value has been taken for this scenario. Protected areas were added to maintain the landscape quality around cities (= increase in cultural landscape around cities). As in the 'Evolved-Society'-scenario, policy interventions were assumed to increase the forested area by 0.1 % p.a. compared to the 0.005 % increase in the baseline. The forest increase was allocated to surplus agricultural land, and the cells with a percentage of forest lower than the national average were given priority for afforestation.

Table 3.6 Model input parameters and allocation rules for the 'Clustered Networks'-scenario

Model input parameter/allocation rules	2005–2035 European average % change per year	Qualitative valuation	Sources and justification
Population	+ 0.12	2	Carried out per country based on UN/IIASA data — same as baseline.
NUTS 2	Downscaling from national data		
East/west	No migration	Internal migration = 8	No reason to assume any migration between East and West.
Rural/urban	14 new cities of 250 000 inhabitants each decrease of 3.5 10^6 inhabitants within the high intensive activity polygon	Internal migration = 8	The new cities will be located outside the 'Blue Banana'-region.
GDP/capita	+ 3.5	9	
NUTS 2	In rural areas: + 3.1 In urban areas: + 3.7		Poor people in rural areas Rescale the baseline.
Allocation rules: urban land use	Peri-urbanisation + 14 new cities		
Total demand of agricultural production	Cropland: – 1.0 Grassland: – 1.0	Agricultural intensity = 9	Not based on an SRES scenario Storyline interpretation: very high import.
Domestic demand			Not needed as model input.
Import	Yes	7	
Export	No	7	
Change in oversupply	Factor = 1.0		Landscape stewardship is subsidised around cities and thus, no change in oversupply.
Impact of CO_2 on crop yield	+ 0.3	10	High, based on SRES A1.
Impact of technology on crop yield	+ 0.7	6	Based on SRES B2.
Biofuels energy demand (area)	+ 0.1	6	Same as baseline.
Allocation rules for agriculture	Maintain landscape quality around the cities Elsewhere in optimal locations Large decrease due to import Decrease of cropland in flooding areas.	Agricultural intensity = 9	
Cost for wheat production (labour + fertilizer + transport)	+ 0.8		Based on SRES A1.
Price of wheat (euro/tonne)	– 0.8		Based on SRES A1.
Forest	0.1		Small increase corresponding to EFSOS alternative scenario (regional threshold)?
Protected areas		Environmental concern = 8	Natura 2000 around cities: 'cultural landscape' (based on WCM database).
Surplus	Shrubs and then forest		Subsidies for biofuels.

3.5 Lettuce Surprise U — Europe of innovation

3.5.1 Scenario overview

A major food security crisis hits Europe. As crisis management fails, faith in central government and in the safety of Europe's food supply decreases strongly. An alternative food production and control regime as well as regional self-sufficiency with regard to food and energy are strived for. Political decentralisation becomes prominent. New communication technologies facilitate local participatory decision-making and open-source development of innovative technologies. Migration is limited and urbanisation patterns do not really change.

Environmental awareness grows, leading to wide demands for environmentally friendly, produced food. Technological innovations offer new opportunities in this regard: New crop varieties are invented that enable higher yields with lower inputs. Agriculture in the core production areas is high-tech, clean and relatively small-scale. Due to increased productivity, cropland decreases strongly. Grassland decreases at a slower rate. The reduction of agricultural area and input leads to an increase in biodiversity and improvements in soil, water and air quality. Land abandonment affects high nature value farmland, but only moderately.

Open-source technological breakthrough innovations play a prominent role in this scenario. Other key developments concern a strong increase of environmental awareness and far-reaching decentralisation of political decision-making. The degree of central policy interventions is reduced, self-regulation becomes more important.

3.5.2 Scenario analysis

'Lettuce Surprise U' assumes the continuation of current trends until 2015, so that all driving forces continue as in the updated 2005 scenario. In 2015 there is widespread illness affecting all parts of Europe; this is the worst outbreak in a series of food-related health disasters. Millions of animals have been treated with a new vaccine that was supposed to protect all species of livestock against most diseases. However, two years later millions of animals started to develop a wasting disease. Their meat becomes unfit for human consumption and millions of animals have to be slaughtered. Prices for organically produced meat or for meat imported from a few countries where the vaccine has not been adopted rise dramatically. The causes of the crisis are not sufficiently explained to the general public; this is the tipping point for widespread public frustration with institutions on the national and international level.

Rather than only demanding an alternative control regime, people start to use the widespread communication technology networks for investigating new technological opportunities for increasing agricultural self-sufficiency, for example using E-forums. The focus is on enhancing the quality of life rather than economic growth. As a result, a new system starts to emerge in Europe after 2015 that combines high-tech development with quality of life and decentralised approaches to self-regulation and innovation.

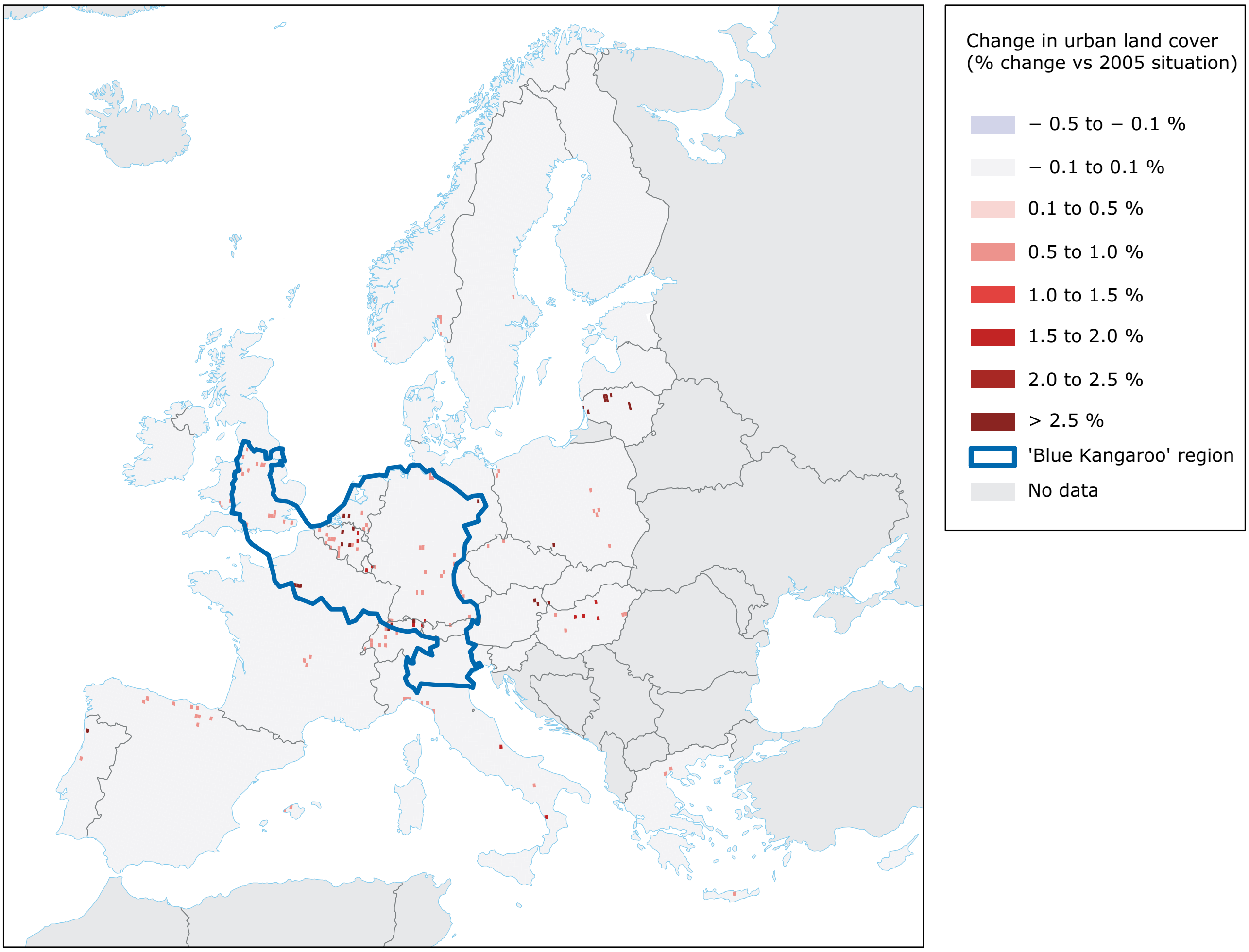
Overall economic growth is moderate at 2.8 % per year compared to the high-growth scenarios like 'Clustered Networks'. Because of the break down of the food supply system due to the food-related illness, agricultural self-sufficiency becomes a prominent goal for European policy. Technological development focuses on environmentally friendly and sustainable technologies, but is driven bottom-up rather than top-down.

After 2015, 'Lettuce Surprise U' is characterised by low government intervention and high subsidiarity scenario. Population trends continue at current levels (overall population growth in Europe of 0.12 % per year) throughout the scenario period. A relatively small rural to urban migration of 0.5 % also continues over the entire scenario period.

The growth in settlement area is 1.2 % until 2035 and represents the lowest of all five scenarios. This growth is due to the sustained growth in urban population across Europe. It is lowest in the scenario because there is no major migration and thus no need for new settlements apart from those required to cover population growth. Map 3.10 depicts the changes in urban area between 2005 and 2035. From 2005 to 2015 urban growth occurs around medium- and small-sized cities, and after 2015 it occurs in peri-urban areas.

Due to the prominent status of the goal of food and energy self-sufficiency, there is no more export, import or oversupply of agricultural goods after 2015. Whereas the total demand of agricultural production from cropland was 0.9 % per year before 2015, it changes to 0 % per year after 2015. Technological development of improved varieties of high value crops is fostered. 'Cultural landscapes' are created and environmentally protected, so that abandoned agricultural land can be used for recreation.

Map 3.10 Changes (%) in urban area in the 'Lettuce Surprise U'-scenario based on total surface area of each model cell



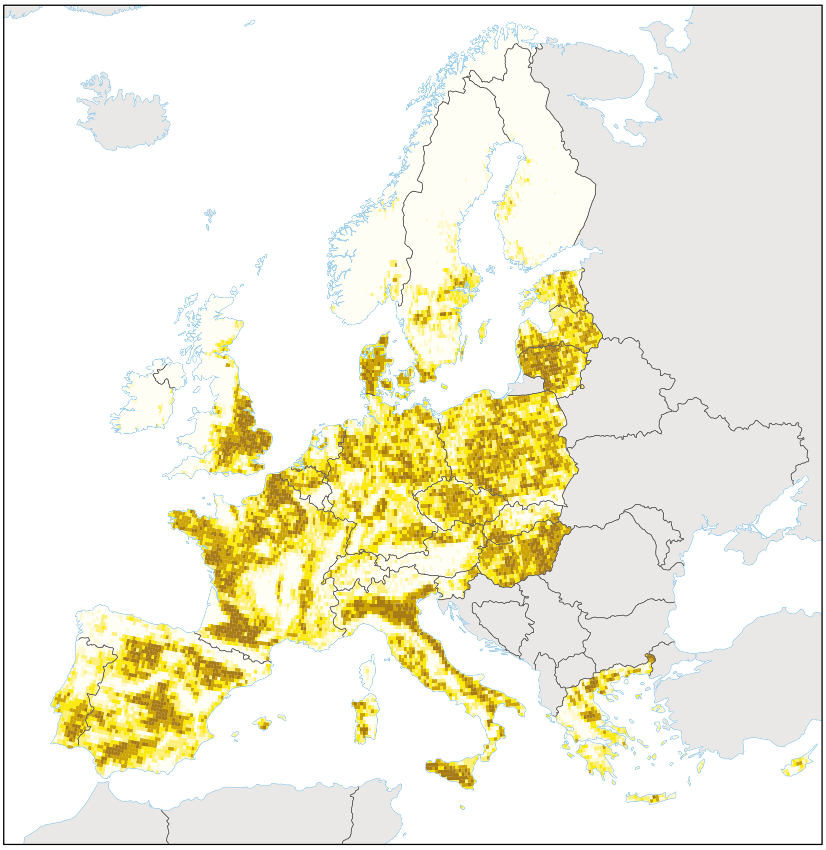
The impacts of technology on crop yield changes from + 1.7 % per year until 2015 to a more moderate rate of + 0.7 % per year. This is based on the bottom-up invention of self-fertilizing plants, thus, constituting a high-tech but low input development in agriculture. Until 2015, the total demand of agricultural production from grassland diminishes at a rate of 0.5 % per year. After 2015, beef cattle slowly replace pigs and therefore, the total demand of agricultural production from grassland increases at a rate of 0.7 % per year. This is the only scenario with an increase in the demand of production from grassland.

Until 2015, the resulting decreases of 14 % in cropland and of 15 % in grassland take place; they are equally distributed across Europe reflecting current trends. After 2015, cropland and grassland continue to decrease.

As depicted in Map 3.11 cropland decreases at a significantly higher rate of 40 % due to high-yield and self-fertilizing crops. As shown in Map 3.12, grassland diminishes at a significantly lower rate of 20 % because of an increased demand of cattle production.

Self-sufficiency with regard to energy becomes another prominent objective. Open technology development pushes the development of low-carbon energy systems. The production of biofuels and use of other renewable energy sources is fostered. Agriculture resources are channelled into improving different varieties of high value crops as raw material for food, energy and other industrial purposes. After 2015, biofuels increase at a rate of + 3 % per year. Although this is the scenario with the highest value for biofuels, there is still a large amount of surplus land because even with this high rate of increase the total area for biofuel energy demand is significantly smaller than the abandoned cropland for food production.

Map 3.11 Changes (%) in cropland area in the 'Lettuce Surprise U'– scenario based on total surface area of each model cell



Map 3.12 Changes (%) in grassland area in the 'Lettuce Surprise U'-scenario based on total surface area of each model cell

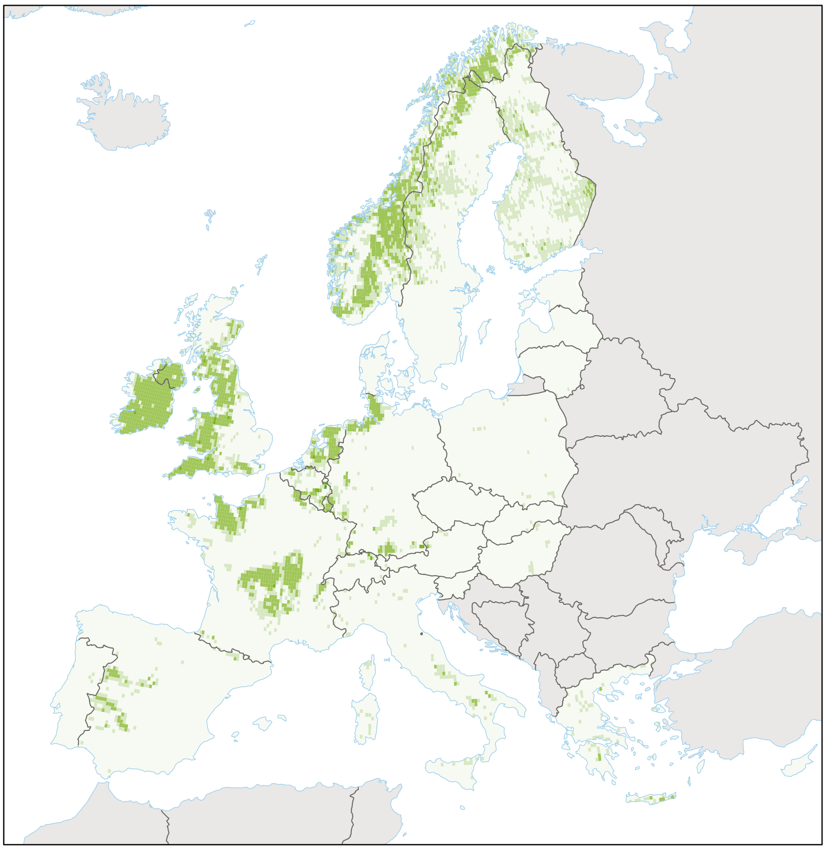


Table 3.7 Driving forces of scenario: 'Lettuce Surprise U'

Driving force	Qualitative value	Changes vs current trend	Driving force	Qualitative value	Changes vs current trend
Subsidiarity	9	5	Environmental awareness	8	3
Policy intervention	1	– 6	Economic growth	6	1
Settlement density	6	– 1	International trade	6	– 1
Population growth	2	0	Daily mobility	3	– 3
Ageing society	8	0	Self-sufficiency	4	– 4
Immigration	2	– 1	Technological growth	9	4
Internal migration	2	– 1	Agricultural intensity	2	– 3
Health concern	8	3	Climate change	9	1
Social equity	8	3	Renewable energy	9	3
Quality of life	8	3	Human behaviour	8	3

3.5.3 Overview of driving forces, model input parameters and spatial allocation rules

Table 3.7 presents the qualitative values for the current trends as described by the stakeholders. A detailed description of how the qualitative values were translated into quantitative model input can be found in the annex.

Until 2015, the new urban settlements were located following the counter-urbanisation patterns as in the updated baseline. After 2015, for the 'Lettuce Surprise U'-scenario, peri-urban patterns were implemented including diffuse developments close to cities. These patterns were also made spatially explicit in an urban potential transition map. Potential urban increases may occur at less than 100 km from large cities, less than 30 km from medium cities, or less than 10 km from small cities. An accessibility condition was added: potential urban increases may occur at less than 15 km along the road network.

Values for the parameter agricultural demand were chosen as different from estimates derived with the IMAGE 2.2 model. This choice was based on the stakeholders' evaluation and the description of the storyline. The values of 0 % p.a. increase for cropland and 0.7 % p.a. increase for grassland takes into account the assumed transfer from cropland to grassland. Import and export do not take place in this scenario. They are equally distributed across Europe.

Like in the other scenarios, a high impact of CO_2-concentration on crop yield (0.3 % p.a.) was assumed. An annual growth rate of 0.7 % was estimated to reflect the impact of technological development on crop yield. In order to fill the gap between the yields in western and eastern European countries in 2035, the technology factors for Eastern European countries were multiplied by 1.3.

Until 2015, the focus is on other renewable energies than biofuels which is why the value of the baseline (0.1 % p.a.) has been used for the renewable energy demand. After 2015, a high value for renewable energy demand (0.3 % p.a.) was attributed responding to the information in the storyline that production of biofuels is fostered in order to become more self-reliant in energy.

Regarding forest land use, current trends were assumed to continue throughout the scenario period. To reach the objective of extensification, a special type of designation of cropland and grassland was introduced (increase in cultural landscape around cities). Impacts of flooding have not been mentioned in the storyline. The issue has thus not given special consideration.

Urban land use is allowed in flood risk areas. However, cropland will decrease by 25 % within the cells that are located in a flood risk area higher than 6 (i.e. 7–11) and cropland will decrease by 10 % within cells that are located in a flood risk area with values of 5–6.

3.6 Big Crisis — Europe of cohesion

3.6.1 Scenario overview

A series of environmental disasters highlights Europe's vulnerability and inability to effectively adapt. There is widespread support for a strong coordination of policies at European level and new concerns for solidarity and equity arise. A whole set of new policies for sustainable and regionally balanced development is consolidated at European

Table 3.8 Input parameter and spatial allocation rules for the 'Lettuce Surprise U'-scenario

Model input parameter/allocation rules	2015–2035 European average % change per year	Qualitative valuation	Sources and justification
Population	+ 0.12	2	Carried out per country based on UN/IIASA data — same as baseline.
NUTS 2	Downscaling from national data		
East/west	No migration	Internal migration = 2	No reason to assume any migration between East and West.
Rural/urban	+ 0.5	Internal migration = 2	Increase of urban population = baseline.
GDP/capita	+ 2.8	6	
NUTS 2	Downscaling from national data		Same representation as in the baseline.
Allocation rules: urban land use	Peri-urbanization		
Total demand of agricultural production	Cropland: 0.0 Grassland: + 0.7	Agricultural intensity = 2	Not a SRES scenario, interpretation of the storyline. Transfer from cropland to grassland due to fewer pigs, and maintained cattle.
Domestic demand			Not needed as model input.
Import	No	6	
Export	No	6	
Change in oversupply	Factor = 0.9		Decrease.
Impact of CO_2 on crop yield	+ 0.3	9	High, based on SRES A1.
Impact of technology on crop yield	+ 0.7	9	Based on SRES B2.
Biofuels energy demand	+ 0.1	9	Focus of renewables is not on biomass. Based on SRES B1, same as baseline.
Allocation rules for agriculture	Extensification and if reduction: equally distributed	Agricultural intensity = 2	No or very little reduction due to extensification.
Cost for wheat production (labour + fertilizer + transport)			Not introduced in the model because we do not use the rent map.
Price of wheat (euro/tonne)			
Forest	+ 0.005		Current trend.
Protected areas		Environmental concern = 8	Increase in 'cultural landscape' around cities (based on Natura 2000 and WCMC database).
Surplus	0		No surplus.

level. Efficient public transport systems are strongly promoted as environmental awareness grows.

Agricultural intensification is largely reversed after 2015. Agricultural oversupply diminishes; the main focus of agriculture is on landscape stewardship. Land-use changes are limited. The population in current urban core areas decreases slightly. Cropland and grassland decrease moderately. The initial environmental pressures are relieved. Soil, water and air quality benefit from agricultural extensification and limited land abandonment. The loss of high nature value farm-land remains relatively small.

Key developments in this scenario concern the growing environmental awareness and social solidarity resulting from an increased number of environmental disasters. Key changes are mainly triggered by ambitious, top-down policy programs.

3.6.2 Scenario analysis

'Big Crisis' assumes that far-reaching political and societal changes occur after an initial crisis. During the crisis of 2015, current trends are assumed to continue. The crisis is brought about by a series of environmental disasters that happen within one month of each other and have vast consequences. Basically all major river systems of Europe flood following some terrible storms. Millions of Europeans are left homeless or in danger and try to flee. However, the transportation system collapses. Many people cannot escape from the flooded areas and public catastrophe management is simply overwhelmed. Insurance companies face horrendously huge compensation claims.

These events are the final push that triggers major political changes. Governments agree on developing a coherent set of new policies for sustainable and regionally balanced development, and provide the means for its effective implementation. Regulatory competences are bundled and major budget shifts take place. The new policies equally focus on developing the periphery of Europe and reducing population density in the previously most populated areas in Europe (i.e. the 'Blue Kangaroo'). Europe's ability to adapt to environmental disasters is improved. After quite a painful transition period, these changes lead to a geographically more balanced and sustainable growth in Europe.

There is an increase in urban land use in the periphery and an increase in population of 2.0 % per year in cities outside the 'Blue Kangaroo'. By contrast, urban population decreases by 2.0 % per year inside the 'Blue Kangaroo' There is an overall 0.5 % per year increase in the urban population. Overall, population trends continue at current levels (0.12 % per year) throughout the scenario period.

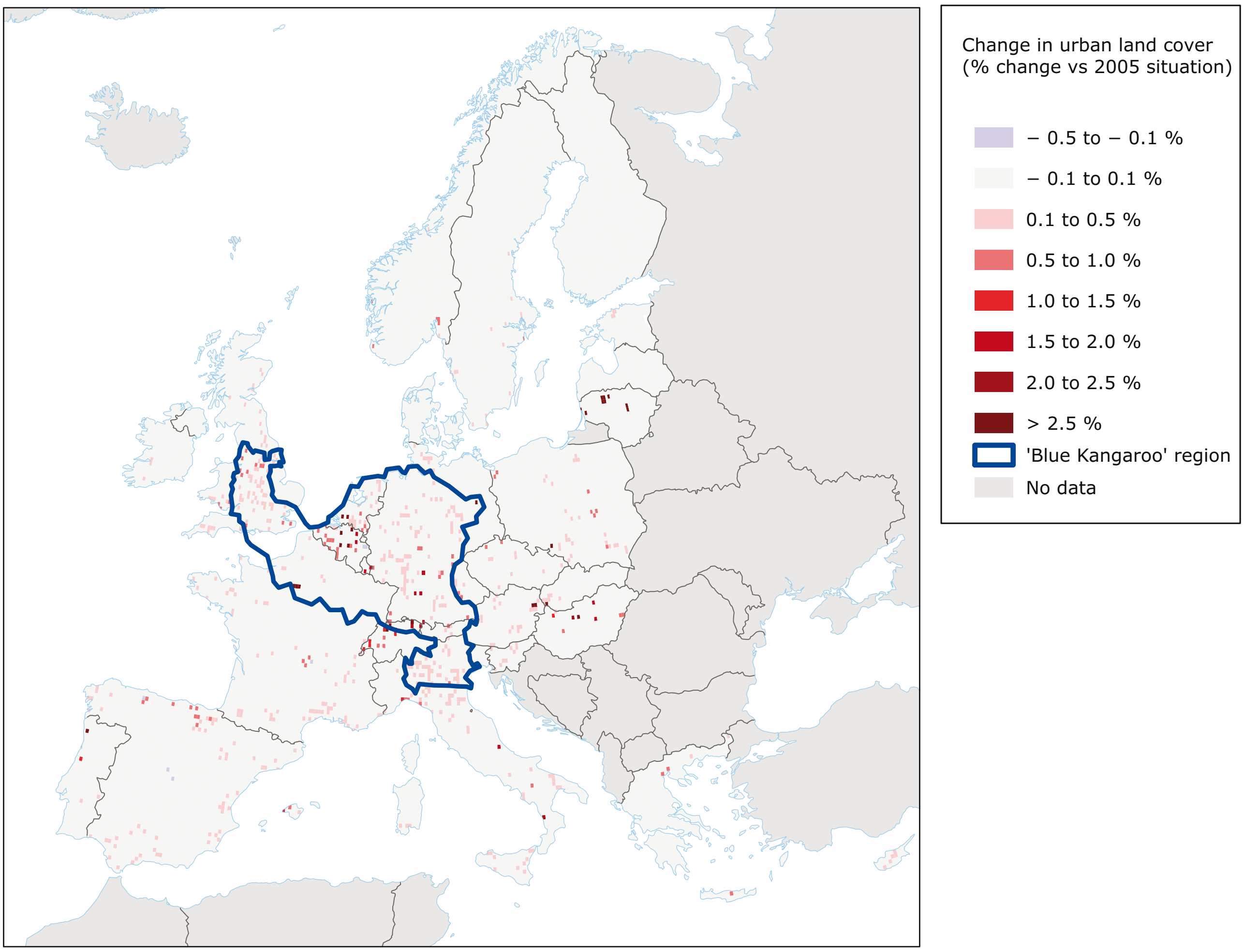
The increase in settlement area until 2035 is 1.2 % and, therefore, low compared to the other scenarios. This growth is due to sustained urban population growth across Europe. Map 3.13 depicts the changes in urban area between 2015 and 2035. Whereas, from 2005 until 2015 counter-urbanisation causes urban growth around medium- and small-sized cities, after 2015, new urban settlements are spread in peri-urban areas.

The growth in urban areas is slightly higher than in the 'Lettuce Surprise U'-scenario, as people migrate away from major flooding areas and incentive policies strengthen the periphery of Europe. Government intervention and subsidiarity are high. The implementation of these new policies in several of the new European core areas along the periphery focuses on the way people and goods are being moved across Europe. In addition, the transportation infrastructure is subsidised in these regions. A special network of high-speed trains is established, making the cities in the periphery more attractive for living and working.

Economic growth remains moderate over the 30 year scenario period at 2.8 % per year until 2015 and slightly lower at 2.5 % per year after 2015 (based on the SRES A1 scenario). Until 2015, total demand for agricultural production from cropland increases by 0.9 % per year, whereas production from grassland decreases at a rate of 0.5 % per year. Since a major shift in eating patterns away from meat is observed after 2015, less grassland for grazing and less cropland for fodder production are required. The total demand of production from agricultural land diminishes at a rate of 0.9 % per year for both cropland and grassland.

After 2015 agricultural intensity is very low and no further intensification takes place; the impact of technology on crop yield changes from 1.7 % per year before 2015 to 0 % per year after 2015. Due to globalised markets import and export are very high and are based on the SRES B1 scenario (IPCC, 2001). Agricultural oversupply diminishes by a factor of 0.9 after 2015. After 2015, the main focus in agricultural land use is on landscape stewardship. Until 2015, the resulting decreases of 14 % in cropland and 15 % in grassland are equally distributed across Europe reflecting current trends. This pattern changes drastically after 2015 because of extensification.

Map 3.13 Changes (%) in urban area in the 'Big Crisis'-scenario based on total surface area of each model cell



Cropland and grassland remain almost stable (1 % and 1.5 %, respectively) and therefore, we see no surplus land in 2035.

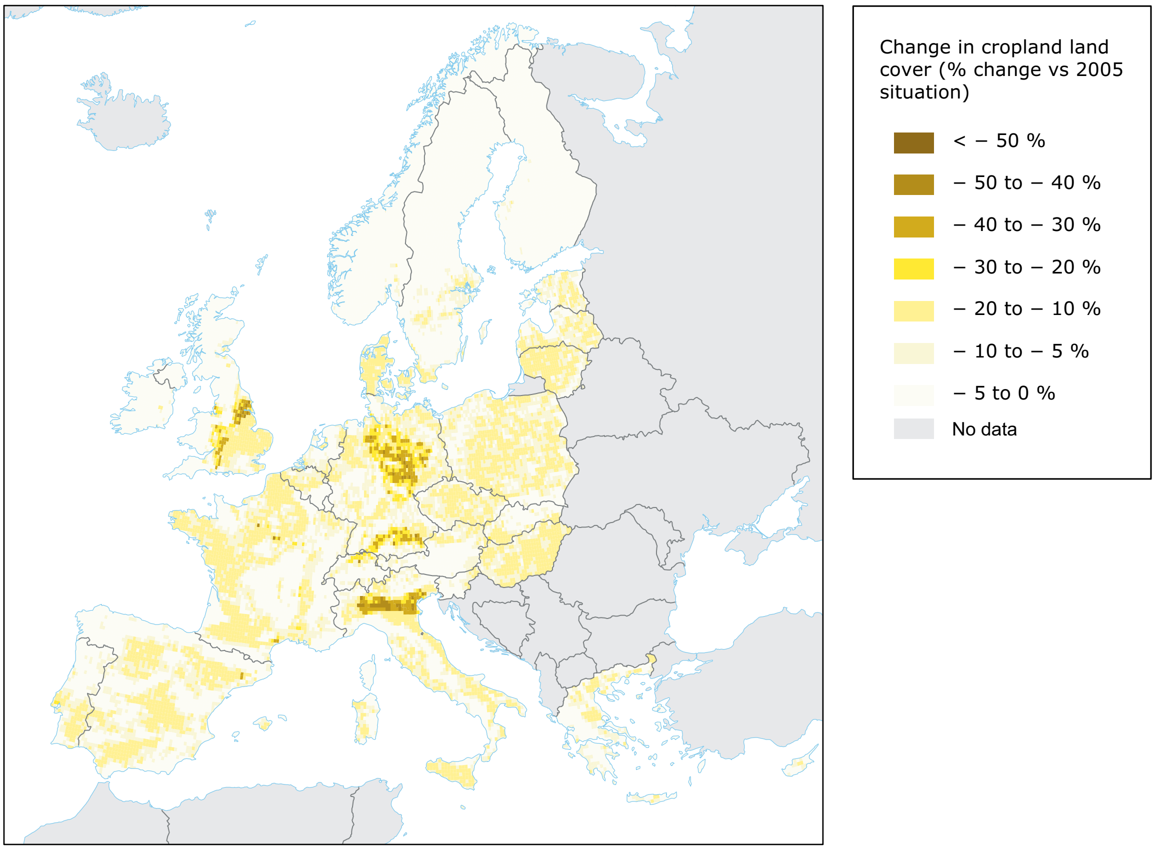
However, Map 3.14 and Map 3.15 show some considerable local decreases in both cropland and grassland, which happen after 2015. Such cropland decrease is observed in flooding zones and inside the 'Blue Kangaroo' because people move away from these areas. Grassland decrease occurs predominantly inside the 'Blue Kangaroo' and results from people moving to the European periphery.

As environmental awareness increases after 2015, more and more protected areas are designated; they mostly take the form of 'cultural landscapes'. Furthermore, the scenario assumes a shift towards environmentally friendly, carbon-low energy systems. However, the main focus of this energy shift is not on biofuels. Other technologies, and especially efficiency measures, are prioritised. Accordingly, the demand for bio-energy crops slightly increases over the scenario period, but the annual increase of 0.05 is lowest compared to the other scenarios and lower than current values. Crops will be grown on approximately 1 % of the abandoned cropland for food production, and therefore compensate slightly for the reduction in cropland after 2015. As a result of strong regional environmental policies, afforestation accelerates in a similar fashion to the 'Clustered Networks' and 'Evolved Society' scenarios.

3.6.3 Overview of driving forces, model input parameters and spatial allocation rules

Table 3.9 presents the qualitative values for the current trends as described by the stakeholders. A detailed description of how the qualitative values were translated into quantitative model input can be found in the annex.

Map 3.14 Changes (%) in cropland in the 'Big Crisis'-scenario based on total surface area of each model cell



Map 3.15 Changes (%) in grassland in the 'Big Crisis'-scenario based on total surface area of each model cell

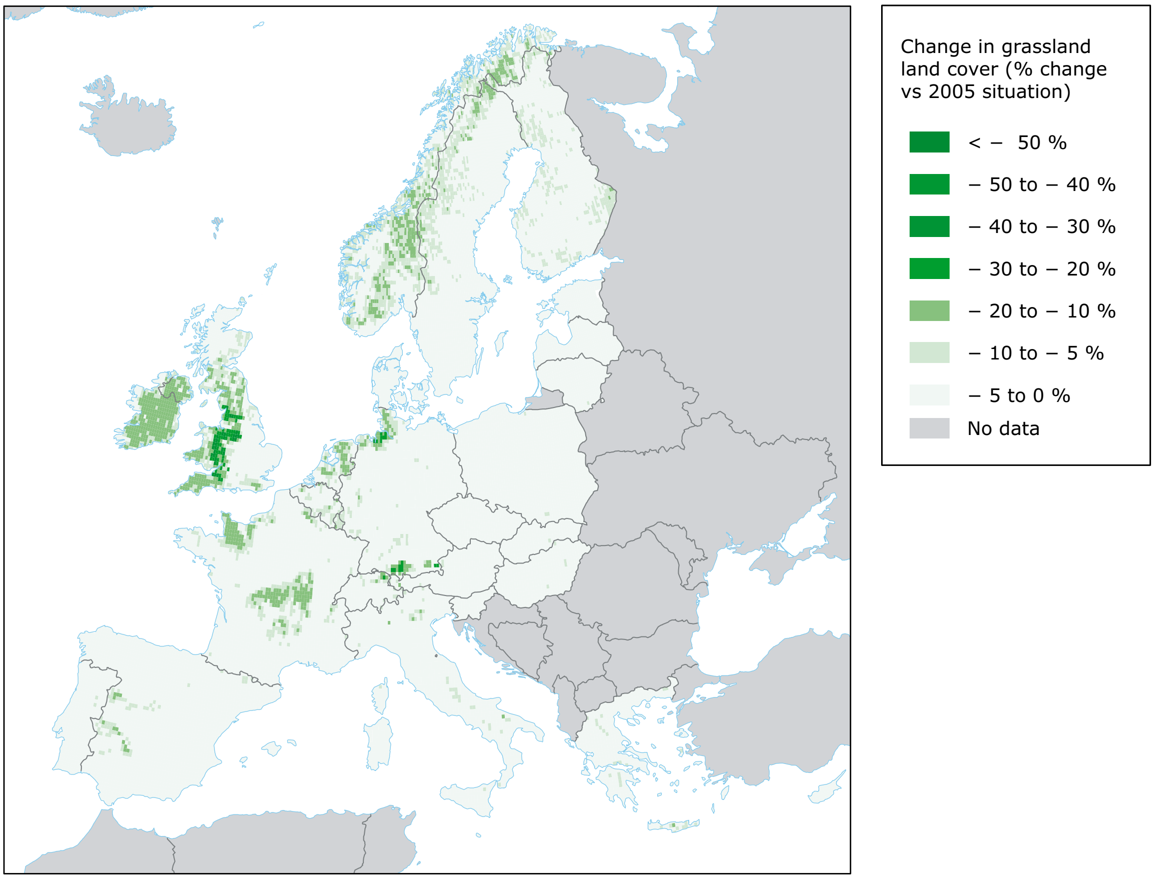


Table 3.9 Scenario driving forces: 'Big Crisis'

Driving force	Qualitative value	Changes vs current trend	Driving force	Qualitative value	Changes vs current trend
Subsidiarity	8	4	Environmental awareness	9	4
Policy intervention	10	3	Economic growth	5	0
Settlement density	5	– 2	International trade	9	2
Population growth	2	0	Saily mobility	4	– 2
Ageing society	7	– 1	Self-sufficiency	4	– 4
Immigration	4	1	Technological growth	5	0
Internal migration	3	0	Agricultural intensity	1	– 4
Health concern	7	2	Climate change	7	– 1
Social equity	9	4	Renewable energy	3	– 3
Quality of life	9	4	Human behaviour	10	5

Table 3.10 presents the assumptions and choices made for the quantification of the 'Big Crisis' storyline.

As regards urban land use, the assumed migration out of flooding areas after 2015 is represented by a 0.5 % p.a. increase of the urban population. Scenario-specific down-scaling of the IIASA values was used to re-distribute the values at NUTS 2-level according to the description of long-range migration out of the 'Blue Kangaroo'-region. The urban land use increases occur mainly in rural areas and around small and medium-sized cities. The spatial allocation rules define a 2 % p.a. decrease of population in the 'Blue Banana'-region and a 2 % increase of population in the peripheral regions.

Potential urban increases may occur outside the 'Blue Kangaroo' less than 3 km from isolated urban cells and at less than 20 km from medium cities or less than 10 km from small cities. An accessibility condition was added: potential urban increases may occur at less than 15 km along the road network.

The total demand of agricultural production until 2015 was estimated with the IMAGE 2.2 model on the basis of the SRES B1 scenario (IPCC, 2001, IMAGE Team, 2001). This was adjusted for the period from 2015 up to 2035 to correspond to the changes mentioned in the storyline, i.e. changes in diet (less meat). The decrease of cropland, as described by the stakeholders, has been concentrated in the 'Blue Kangaroo'-region. To reach the objective of agricultural extensification as described in the storyline, the impact of technology development on crop yields was defined as non-existent (= 0).

With regard to forest land use, the baseline value of 0.005 % p.a. was assumed to continue until 2015. Afterwards, a slightly higher value of 0.1 % was imposed based on the EFSOS alternative scenario (Schellhaas e*t al.*, 2003). The forest increase was allocated to surplus agricultural land, and the cells with a percentage of forest lower than the national average were given priority for afforestation.

Concerning the impact of flooding, no increase in urban land use will occur within the cells that are located in a flood risk area higher than 6 (on a scale from 1–11). Cropland will decrease by 25 % within the cells that are located in a flood risk area higher than 6 (i.e. 7–11) and cropland will decrease by 10 % within cells that are located in a flood risk area with values of 5–6.

Table 3.10 Model input parameters and spatial allocation rules for the 'Big Crisis'-scenario

	2015–2035 European average % change per year	Qualitative valuation	Sources and justification
Population	+ 0.12	2	Carried out per country based on UN/IIASA data.
NUTS 2	Downscaling from national data		
East/west	no migration	3	We took it all as urban to rural or vice versa.
Rural/urban	+ 0.5	3	Increase of urban population = baseline.
GDP/capita	+ 2.5	5	Carried out per country based on SRES A1.
NUTS 2	Downscaling from national data		
Allocation rules: urban land use	Inside 'Blue Banana': – 2.0 In cities outside 'Blue Banana': + 2.0 (of 'Blue Banana' population)		Increase of urban land use in the peripheries.
Total demand of agricultural production	Cropland: – 0.9 Grassland: – 0.9	Agricultural intensity = 1	New suggestions. See storyline: change in diets less meat less food crop production. Extensification — allocation rules
Domestic demand			Not needed as model input.
Import	= export	9	Based on SRES B1 (A1 is too high — Europe feeds China).
Export	= import	9	Based on SRES B1 (A1 is too high — Europe feeds China).
Change in Oversupply	Factor = 0.9		Decrease.
Impact of CO_2 on crop yield	+ 0.3	7	High, based on SRES A1.
Impact of technology on crop yield	+ 0	5	To reach the objective of extensification, the impact of technology on yield is 0.
Biofuels energy demand (area)	+ 0.05	3	
Allocation rules for agriculture	Main decrease inside 'Blue Banana' and in potential flooding areas	Agricultural intensity = 1	
Cost for wheat production (labour + fertilizers + transport)	+ 0.8		A1 SRES scenario.
Price of wheat (euro/tonne)	– 0.8		A1 SRES scenario.
Forest	+ 0.1		Small increase according to the ESFON scenario.
Protected areas		Environmental concern = 9	Increase in 'cultural landscape'.
Surplus	0		No surplus.

4 Land-use change and environment

This section focuses on the land-use changes and environmental impacts the five scenarios. It compares the magnitude of changes in the four main classes of urban area, cropland, grassland, and forest area per scenario. Based on this comparison, the concept of landscape types is used to compare the land-use intensities in the five scenarios.

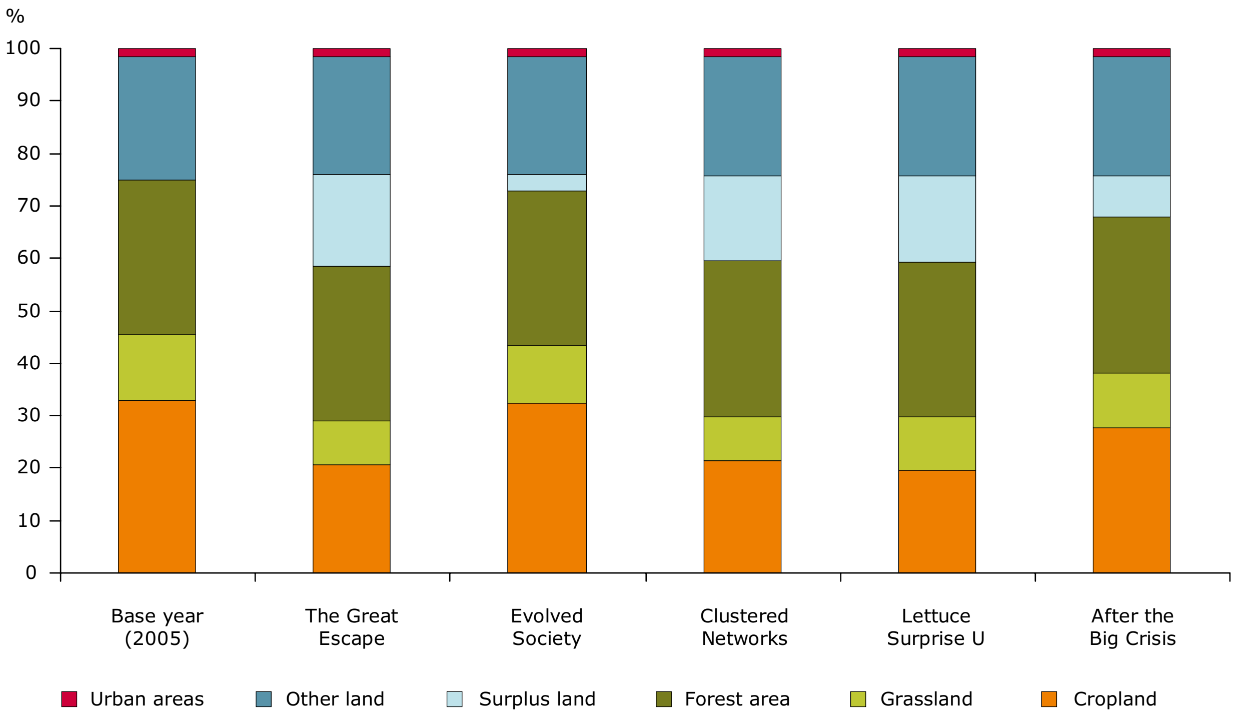
4.1 Land-use/land cover changes

Figure 4.1 summarizes for all five scenarios the relative changes in major land cover types between 2005 and 2035 for the EU-25.

The highest *urban changes* are observed for the scenarios with migration between different European regions, i.e. the 'Clustered Networks'-scenario with major increases in urban land use due to the construction of 14 new cities, and the 'Evolved Society'-scenario with a strong migration from the west to rural areas in eastern Europe. ' Big Crisis' is also characterised by long distance population migration out of the so-called 'Blue Kangaroo', but since this process is only assumed to kick in after 2015, the cumulative increases in urban land use by 2035 will be smaller than in the above two scenarios. For the other two scenarios, total urban land cover changes are lower because there is much less migration. All scenarios except for the 'Lettuce Surprise U'-scenario assume a net migration from urban centres towards the periphery, which is often triggered by increasing environmental pressures or disasters.

However, the overall share of urban land use does not change much in any scenario compared to the base-year (2005). Urban land-use changes are rather localised compared with the dominant role agricultural land use plays [20]. Nonetheless, sealing

Figure 4.1 Major land cover types in 2035 for all five scenarios compared to the base year 2005



([20]) Urban land-use accounts for about six percent of Europe's total area (2005 base-year value, model results), so that even strong increases are small in total. This does not mean, however, that their impacts are negligible.

of soils or fragmenting natural landscapes can have quite far-reaching environmental impacts, especially in coastal areas or in regions with an already high population density and economic activity.

The spatial patterns of urban change are different for all scenarios, but for the majority of them rural areas or small cities are more attractive than large cities. Only in the 'Great Escape'-scenario are the new urban settlements located in large cities, due to new arrivals from international immigration and the migration of poorer communities from rural areas. All scenarios exhibit some diffuse urban growth patterns. With the exception of the 'Great Escape'-scenario, no new urban settlements are permitted within designated areas and so the landscape is preserved in these areas.

The *highest changes in cropland* are observed in the global market-oriented scenarios, i.e. the 'Great Escape'-scenario with its profit-maximisation logic and the 'Clustered Networks'-scenario with its large imports, where more than a third of all cropland areas diminish. Cropland decreases strongly in 'Lettuce Surprise U' too. It should be noted that this scenario shows the highest decrease rate after 2015, which is mainly due to high-yield and self-fertilizing plants and partly due to a transfer of cropland to grassland. Fewer changes in cropland are observed for the more environmentally-oriented scenarios because of the extensification of agricultural land and landscape preservation: In the 'Evolved Society'-scenario, cropland decreases only slightly and the decrease slows significantly after 2015 in the 'Big Crisis'-scenario as well. However, considerable local decreases are still observed in both scenarios.

Grassland changes are highest in the 'Great Escape'- and 'Clustered Networks'-scenarios too, where a third and more of all grassland areas disappear. Slower declines are observed for the other three scenarios. However, also in the environmental friendly scenario 'Evolved Society', grassland declines about 14 %. It is the 'Big Crisis'-scenario after 2015, where grassland remains nearly stable only ([21]).

The spatial patterns of agricultural change are similar for 'Great Escape' and 'Clustered Networks', where losses of agricultural land are only observed in less suitable areas, and agriculture is preserved within optimal locations. Rural landscapes in less suitable areas are impacted more by the changes than in agriculturally optimal areas; the main effects of the socio-economic scenario changes thus occur in the margin regions of Europe. Traditional agricultural areas largely disappear in these scenarios ([22]). For 'Evolved Society', 'Lettuce Surprise U' and 'Big Crisis', the changes in agricultural land use are equally distributed throughout Europe, i.e. they occur everywhere, except in protected areas.

The surplus areas stemming from abandoned land for agricultural production are very high for the three scenarios 'Great Escape', 'Clustered Networks', and 'Lettuce Surprise U'. In the other two scenarios, pressure towards a large decline of agricultural areas is counterbalanced by effective policy mechanisms that aim at large-scale agricultural extensification and organic production. Surplus land is used to grow bio-energy crops or forest for production of biofuels. However, this constitutes a small fraction of the surplus land (less than 1 %) for four of the five scenarios. Even in the 'Lettuce Surprise U'-scenario, which shows the highest increase in biofuels, the total area for production is significantly smaller than the abandoned cropland for production.

Visible changes in the composition of *other land* (i.e. unmanaged areas such as scrubland, barren land, wetlands, inland waters, sea, permanent ice and snow) are not noticeable over the scenario period in all the scenarios ([23]).

Forest changes increase only slightly for all scenarios, based mainly on current, low trends of afforestation. For 'Great Escape' and 'Lettuce Surprise U' current trends continue throughout the scenario period, whereas additional policy measures lead to slightly higher rates of afforestation in the other three scenarios. Succession time in forests is rather long, so surplus land that is just left to scrubland (and later forest land) will not produce much new forest after the 30-year scenario period.

4.2 Landscape type changes

Landscape types are compared based on the nine landscape type classes that have been discussed

([21]) Grassland decreases at a slower rate than cropland after 2015 in 'Lettuce Surprise U' since there is an increased demand for cattle production (see Section 3.4.3).

([22]) One has to note so that for the 'Clustered Networks'-scenario, the agricultural landscape around cities is designated as protected areas and thus preserved irregardless of suitability.

([23]) This can have two explanations: First, changes in this land-use category might not generate changes in other land-use categories but only substitution effects within the same land-use category (i.e. a reduction of permanent ice and snow does not lead to an increase of urban or agricultural land, but to other forms of land that is part of the same land-use category). Second, overall changes are relatively small and do not count too much.

in Section 2. As highlighted above, urban land use increases slightly in all scenarios. The main difference between the scenarios is the shift between urban areas and urban landscapes. As an example of this development, we look at the 'Lettuce Surprise U'-scenario where a considerable shift towards urban landscape takes place. This increase is, however, not due to an increase in urban area itself. It is because landscapes with an urban character, which were dominated by both urban areas and cropland in 2005, are only dominated by urban land in 2035. On the other hand, in the case of the 'Clustered Networks'-scenario, the agricultural area is maintained around urban areas as landscape buffer zones, so that the ratio of urban to agricultural land is not changed. Therefore, we see no change in the landscape with urban character.

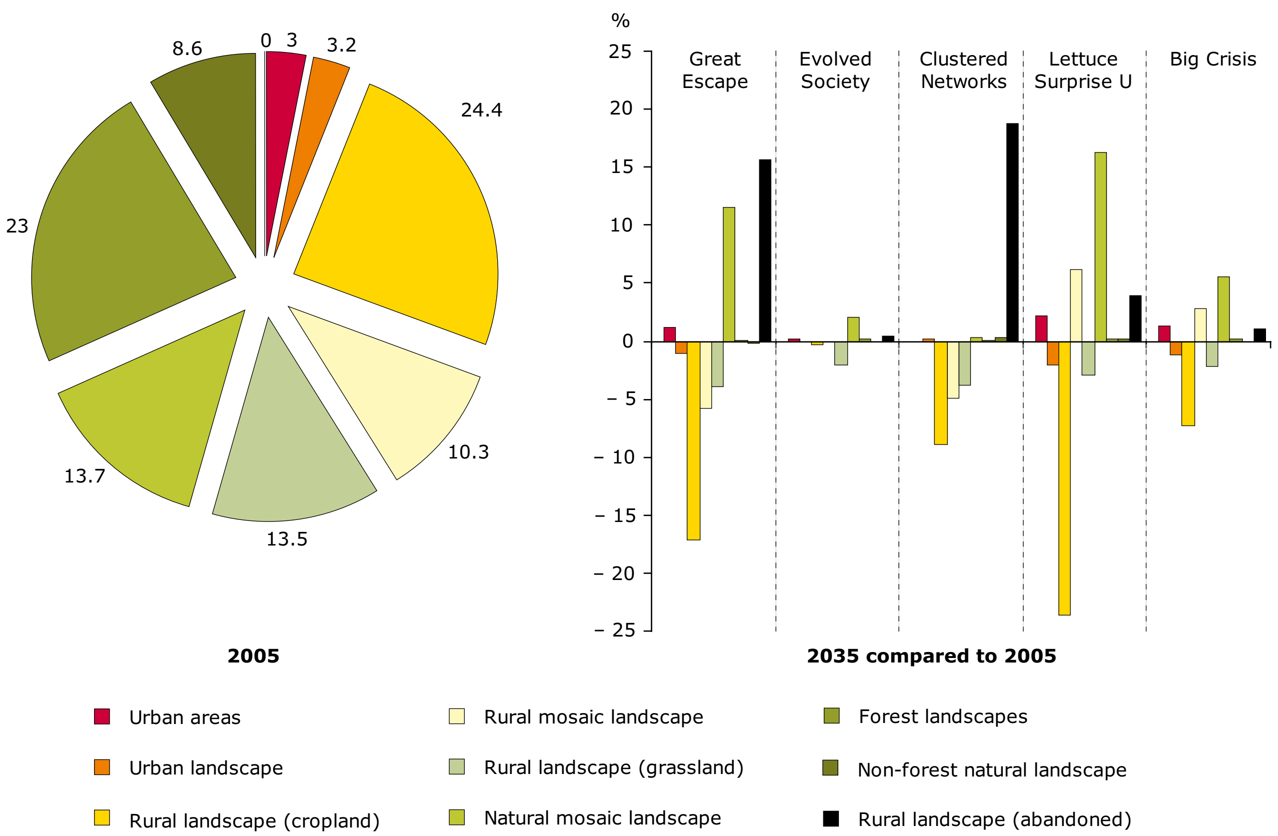
Agricultural land use decreases in all scenarios. Whereas in 2005, rural landscapes (particularly those that are cropland-dominated) present a majority of landscapes in Europe, in 2035 this is only true for the 'Evolved Society'-scenario. Due to substantial abandonment of both cropland and grassland, there is a shift in dominance in 'Great Escape', 'Lettuce Surprise U', and 'Big Crisis' towards at least one of the three other rural landscape types.

Shifts in land use patterns do not occur homogeneously throughout Europe. Whereas Scandinavia remains almost unchanged in all five scenarios, changes are particularly large for eastern Europe, the Iberian Peninsula and some countries inside the 'Blue Kangaroo', depending on the particular scenario. Figure 4.2 shows the landscape type comparison between 2005 and 2035 for all scenarios.

Great Escape: This scenario is the only scenario where landscapes with agricultural character are maintained only in cropland areas that are optimal for production. Therefore, we see a large shift from cropland-dominated rural landscapes towards rural mosaic landscapes in central and Eastern Europe whereas in southern Europe, especially in Spain, these turn into rural landscapes with large fractions of abandoned land.

Evolved Society: In this scenario the landscape patterns of the base-year situation are almost maintained. Land abandonment remains limited, mainly due to targeted policies. The reduction of grassland by about 14 % has relatively small overall impacts.

Figure 4.2 Landscape type comparison between 2005 and the scenarios in 2035



Clustered Networks: In this scenario, we see that the cropland-dominated rural landscapes are well preserved in cropland areas that are optimal for production as well as around cities due to the establishment of buffer zones. Especially in the southern and eastern parts of Europe, there is a considerable shift of cropland-dominated rural landscapes towards rural landscapes with large areas of abandoned land.

Lettuce Surprise U: In this scenario, virtually no cropland-dominated rural landscapes are left. They have all shifted to rural mosaic landscapes or other landscape types. Grassland-dominated rural landscapes however are largely maintained due to a shift from crop-based pig production to grassland-based livestock production. These changes occur homogeneously throughout Europe.

Big Crisis: The main characteristics of this scenario are that cropland-dominated rural landscapes are surrounded by rural mosaic landscapes, similar to the situation in 2005. Also in the case of the other landscape types, this scenario shows similar pattern to the base-year situation in 2005. Only in large parts of Germany, cropland-dominated rural landscape areas shift to other rural landscape types.

The landscape patterns corresponding to the different scenarios are shown in Map 4.1.

4.3 A scan of potential environmental consequences

The assessment of environmental impacts at European level necessarily has to be general since many impacts are local and cannot be captured adequately by European land-use models. What are the respective development prospects in the different scenarios?

Great Escape: Pollution in urban areas increases. Agricultural intensification and urban sprawl affect the rural environment negatively. Many nature reserves and extensive farmland areas with high nature value are lost. There are however also regional benefits for the environment. In areas of agricultural abandonment, soil and water quality might improve and more diverse natural habitats may develop.

Evolved Society: This scenario has rather mild environmental impacts. Overall, land-use changes are not dramatic. Farming intensity decreases and cropland areas remain nearly the same, while the share of grassland areas decreases moderately. Extensive farmland with high nature value is relatively well conserved, and stronger negative impacts remain rather localised.

Clustered Networks: This scenario leads to increased differences between urban areas and the countryside. The quality of soil, water and air benefits from receding agriculture and the development of green belts around cities. Natural habitats develop in the wider countryside, but to the detriment of high nature value farmland. The assumed development of the new thematic cities leads to a stronger habitat fragmentation of habitats in the peripheral regions.

Lettuce Surprise U: The reduction of agricultural area and inputs leads to a general increase in biodiversity, soil and water and air quality. Land abandonment affects high nature value farmland, but less so than in other scenarios.

Big Crisis: The initial environmental pressures are quite strong and the rate of environmental disasters increases. Half way through the scenario period, these pressures start to be gradually relieved by the increased focus on sustainable and regionally balanced development. Soil, water and air quality benefit from agricultural extensification and limited land abandonment. The loss of high nature value farmland remains relatively small.

Table 4.1 summarizes the respective development prospects with regards to environmental impacts in the different scenarios.

Map 4.1 Landscape type comparison between 2005 and the five scenarios in 2035

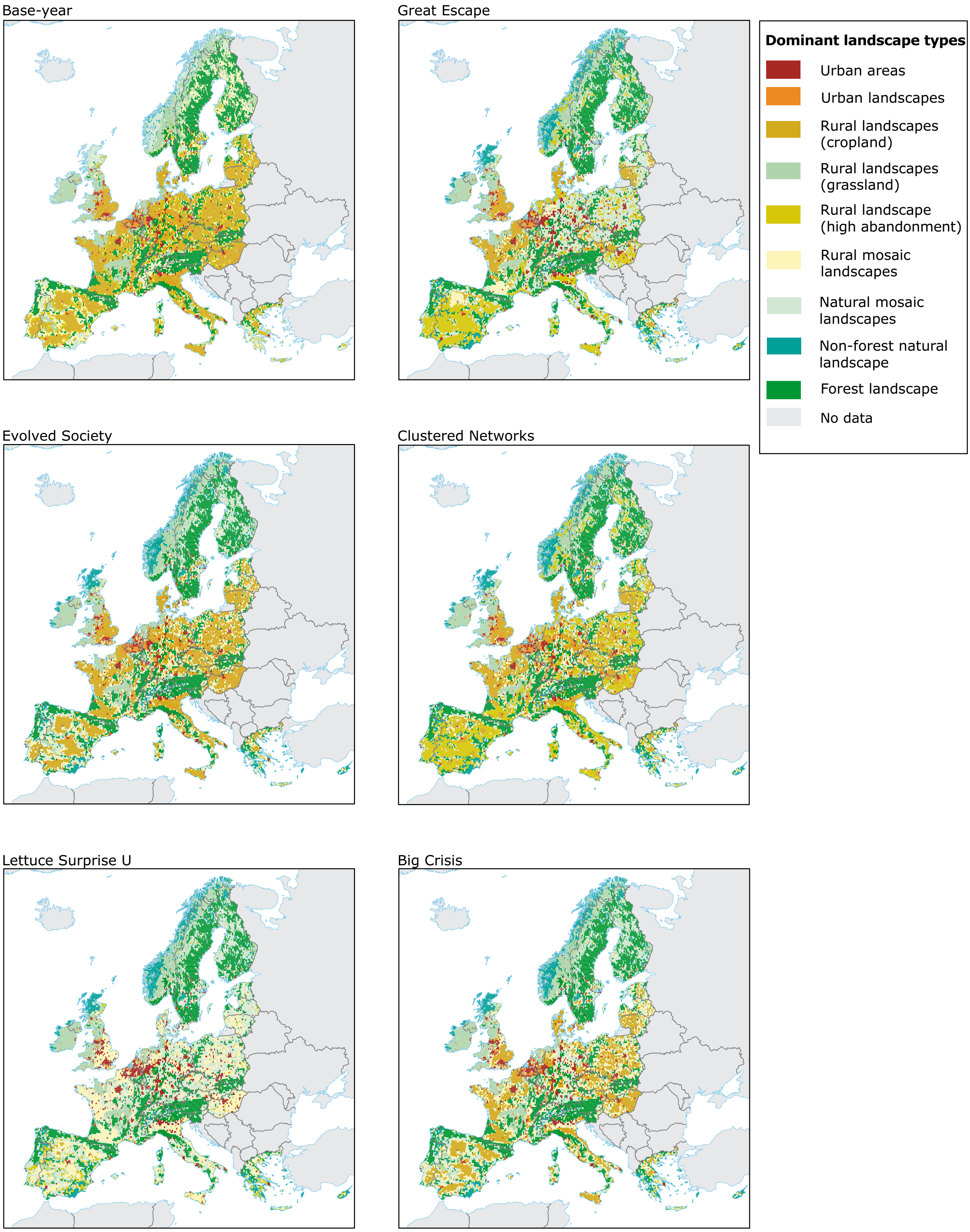


Table 4.1 Development prospects for environmental impacts in the scenarios

Stress factors		Great Escape	Evolved Society	Clustered Networks	Lettuce Surprise U	Big Crisis
Land abandonment		++	O	++	+	+
Agricultural intensification		++	–	+	–	O*
Habitat fragmentation		+/–	+	–	+/–	+
Protected areas		–	++	+	+	+
Effects						
Biodiversity	general	+/–	+	+	+	+
	HNV farmland	–	O	–	–	–
Water quality		+/–	+	+/–	++	O*
Soil quality		+/–	+	+/–	++	O*
Air quality (agri-related)		+/–	+	O	++	O*
Landscape identity		–	O	+/–	+/–	O

Note: ++ : increases substantially.
\+ : increases.
O : remains approximately the same.
– : decreases.
–– : decreases substantially.
../.. : differentiated regional effects.
* Discontinuous development where initial pressures are relieved.

5 Lessons from participatory land-use scenario development and outreach action on a European scale

The PRELUDE project was motivated by the assumption that the participatory development of long-term, contrasting scenarios adds useful value to already established decision support tools. Scenarios like the PRELUDE scenarios can help:

- *to go beyond the perspective of one legislative period,* which is necessary since key trends can change significantly in the medium-to-long term and
- *to broaden our view, which* is necessary since trends are not our destiny. In the longer run, discontinuities or surprises may become the norm rather than the exception. Looking at plausible futures in a systematic manner helps us detect signals of change and prepare for otherwise potentially surprising developments.

Long-term scenarios help to create a language and a common platform for different policy communities to jointly discuss — and learn about — complex and uncertain problems. Broad participation of key stakeholders from the beginning helps to facilitate this process:

- Bringing together a multitude of perspectives and different types of expertise enhances the *information basis, relevance and originality* of the exercise. Ideally, the scenarios do not only address relevant policy concerns, but also present broader, innovative and more appealing analyses than studies that are based on the views and expertise of one societal or research community only.
- Broad participation enhances the *credibility* and *legitimacy* of the scenarios. Ideally, it signals to different target groups that different societal interests and perspectives have been taken into account in a fair way and that the assessment is not one-sided.

Many of these considerations are reflected in the 'story-and-simulation' (SAS)-approach to scenario development used in PRELUDE, where stakeholders create qualitative storylines which are subsequently underpinned by quantitative modelling in an iterative process (see Chapter 2). Following this approach, the EEA invited up to 30 stakeholders and experts to create five contrasting long-term scenarios of what Europe might look like in some thirty years from now. Stakeholders were given full responsibility for developing the scenario storylines, while experts and the EEA took a supporting role.

This extensive participatory approach was without precedent in the EU at that time. The rationale for this decision was to create an atmosphere of trust and responsibility that would allow stakeholders with very different backgrounds to engage in an open and productive discussion about potential future land-use developments without being intimated by expert knowledge.

Another prime objective of the PRELUDE project was to engage in a broad outreach process. Too often, scenarios are not really used to engage policy-makers and key stakeholders in discussions about the implications of the scenarios and related response strategies. Scenario outreach action can be structured alongside the categories of type of audience and type of discussion. The EEA embarked upon a broad outreach process that covered the following types of action:

- targeting a specific audience (for example a ministry or interest organisation) and focusing on a specific policy issue in the context of the scenarios;
- bringing together a broad audience (ministries, interest organisations, academics), but focusing on a specific policy issue in the context of the scenarios;
- targeting a specific audience but exploring more generic trend developments and their uncertainties; and
- bringing together a broad audience and exploring more generic trend developments and their uncertainties.

The remainder of this report analyses the lessons learnt during the production of the PRELUDE scenarios and their outreach process: does it pay off to go down the — challenging — road of developing long-term contrasting scenarios in a participatory manner?

Our experience suggests a positive answer to this question. Investments into long-term scenario development can generate a whole stream of benefits over a longer period of time: this does not only include triggering strategic conversations among key stakeholders that are normally out of reach due to undisputed processes of day-to-day politics. It also concerns opening up discussions across policy areas and networks which can help to foster integrative policy approaches. Scenarios have a longer and more versatile shelf-life than, for example, environmental datasets that are updated at regular intervals and useful for specific purposes. Scenarios don't need to be constantly updated, and can be applied in different circumstances over a longer period of time.

The participative, qualitative-quantitative approach

First of all, the benefits of running a broad participatory approach to scenario development are visible in the content of the PRELUDE scenarios. Bringing together a broad group of stakeholders ensured that a set of interesting, contrasting and innovative scenarios could be developed. But the stakeholders did not only manage to create interesting stories. In addition, they developed a strong trust in the validity and suitability of their problem analysis and the scenarios. Nearly all stakeholders felt a strong feeling of ownership for the scenarios in the end and did not leave the process. The project was thus successful in bridging gaps and improving communication and collaboration between quite different actors.

One prerequisite was to create an atmosphere of ownership and trust among stakeholders. A competent facilitation of the working process was crucial to avoid a stalemate due to diverging interests of stakeholders. Because stakeholders held responsibility for creating the scenario storylines they abstained from persisting with inflexible, predetermined opinions or views. Instead, they aimed at a common solution when problems arose during the storyline development. PRELUDE confirms the assumption that creating ownership early on in the process helps to reduce opposing views and facilitate better cooperation.

Problems emerged, however, with the formalisation and quantification of the scenarios. It takes substantial time to align the output of the stakeholder meetings with the requirements of the modelling, and vice versa. Time was limited in the PRELUDE project and only one round of iterations from the stakeholder outputs to modelling outputs and back could be run. It complicated the translation of the qualitative assumptions on driving forces into quantitative model input, since stakeholders and modellers were not always able to find a common understanding. This in turn created problems of ensuring overall consistency between the qualitative assumptions and quantitative input. The stakeholders also worked with assumptions that could not always be brought into a meaningful quantitative format or appeared not to be consistent across the scenarios. At this point, concerns of the scientific experts focused more on the scientific credibility of the exercise than on the exploratory value of the exercise, i.e. uncovering new avenues of possible developments that over time might yield important new insights.

It was, however, a deliberate decision not to constrain stakeholders too much. Experiences from the outreach process underline the wisdom of this decision: If scenarios want to stimulate policy-makers and stakeholders to re-think existing policy strategies and instruments, they need to express contrasting qualitative information in a convincing and appealing way. The benefits of triggering strategic conversations and learning processes among policy-makers and key stakeholders can outweigh the problems of quantification. However, aligning the outputs of qualitative storyline development with the requirements of formalisation and quantification in a more effective way remains a major challenge for further research development. In the end, it is the combination of formal and non-formal approaches that makes scenarios a useful and powerful tool.

Using the PRELUDE scenarios

The main aim of the outreach process was to communicate the key outcomes of the exercise to selected target audiences and to stimulate discussions about the probability, relevance and desirability of the different scenarios. The scenarios have also been used for other purposes, as for example testing the robustness of existing policy strategies and instruments in the area of high-nature value farmland protection. One of the objectives for future work is to transfer this kind of strategy analysis into a more formal format and to explore more systematically the 'scenarios to strategy'-interface.

Bringing together actors from various backgrounds for this kind of open and strategic discussion worked out surprisingly well. The PRELUDE scenarios indeed helped to create a language and a common platform for the different policy communities to jointly discuss and explore new ways of thinking about policies and instruments related to land-use change and its environmental implications. Furthermore, and despite time constraints, the scenarios provoked strategic discussion about distinctive governance models that Europe may require to deal with future challenges.

Conducting these kinds of discussions needs, however, sufficient time; at least a day. Normally, many participants, and especially participants that have not been working with scenarios before, express some scepticism about the overall approach and the content of the scenarios. However, this initial scepticism seems to decrease with the number of scenarios 'visited' as well as with the time spent in exploring them. Seeing all scenarios usually allowed for a better understanding of the purpose and the framework of PRELUDE, as well as for a broader and strategic discussion of the issues in focus.

Participants experienced the scenarios in very different ways. Comments for the same scenario often ranged from strong refusal ('this is not possible') to strong agreement ('this is already happening'). A diversity of comments from observers is a common feature of scenario development, because the attitude of each individual towards a scenario is undeniably dependent on his or her experience of the surrounding environment, as well as his or her implicit assumptions about the future — the so-called official future. Recognising that scenarios can be perceived differently by different participants can trigger valuable learning effects. Participants might come to acknowledge that other worldviews and assumptions are valid and might challenge their own mental map of the future throughout this process. This is the added value of long-term contrasting scenarios as compared to more traditional baseline scenarios with policy variations; and it was clearly accomplished in many PRELUDE outreach discussions.

A topic of concern that stems from the outreach process is the need for a clear understanding of the concepts of plausibility and probability. Plausibility is a crucial objective of any scenario exercise. Any good scenario should be internally consistent, logical and should not easily be refused by policy-makers and experts. Plausibility, however, needs to be distinguished from probability: low probability does not equal implausibility — some extreme weather events, for example, have low probability, yet, they can happen and we have seen them happening, i.e. they are plausible. Participants, however, did not always distinguish between plausibility and probability and criticised scenarios as implausible when they presented developments that were of rather low probability. In fact, another added value of scenarios is the search for developments or events with low probability, but far-reaching consequences. Naturally, it is these kinds of developments that take us by surprise.

In the end, the five PRELUDE scenarios were generally considered as plausible. However, the inconsistency of some assumptions and presentation of drivers across the scenarios caused rightful criticism. Due to the time constraints, a final cross-check of the overall consistency of assumptions across the PRELUDE scenarios, or a critical 'wind-tunnelling', could not be done which explains the inconsistencies that were criticised. In further scenario exercises of this kind more time needs to be booked for this final important step of analysis.

Model restrictions and time constraints also prevented sufficient analysis of Europe's inter-linkages with the rest of the world, especially regarding market developments in agriculture and the development of global food demand. These shortcomings received criticism from participants during the outreach workshops. In a highly inter-connected globalised word, so the argument of Europe's impacts on other regions of the globe and vice versa cannot be ignored. In further scenario exercises, careful attention needs to be paid to finding a balance between sufficiently representing Europe's role in what is without doubt a global economic and governance system, and a manageable degree of complexity for analysis.

Policy implications of the PRELUDE scenarios

PRELUDE helps us to understand that land-use change is a key and pressing challenge to sustainable development. Rich and varied landscapes, often shaped by traditional farming practices, are part of our common European cultural and natural heritage. Since they contain many hot spots of biodiversity, their effective preservation represents an important contribution to halting the loss of biodiversity. They also constitute a tourist attraction, so play an important economic role. However, Europe's society is continuously changing, propelled *inter alia* by a globalising economy, new communication technologies and increased mobility. Throughout the last decades, urbanisation, infrastructure development and intensifying agriculture have left their mark on the landscape. Climate change and the ageing of society could trigger further change in the future (EEA, 2005). Will efforts to preserve traditional rural landscapes and their biodiversity bring success against this background of changing socio-economic and environmental framework conditions?

The PRELUDE scenarios illustrate the magnitude of the challenge. Abandonment of agriculture land, for example, occurs in all scenarios, even in the scenarios that work with strong assumptions on effective policies. Land abandonment directly threatens traditional, rich rural landscapes. While they disappear in all scenarios, the scope and speed differs significantly. Southern and eastern Europe could be particularly affected by the combined effects of intensification of agriculture and rural land abandonment.

Demographic developments and climate change will have a major impact on future developments. The farming population in Europe is already older than average in most EU Member States. The impacts of climate change affect socio-economic and environmental framework conditions in all scenarios. Eastern and southern landscapes seem to be more susceptible to the assumed social and environmental changes and show the greatest variations across scenarios. Northern and western European areas appear to be more robust.

The PRELUDE scenarios suggest that the conservation of all areas of interest seems unlikely against this background. They underline a need to set stricter spatial priorities for rural development, and find new approaches for monitoring the effectiveness of related programs and measures. In some situations, all efforts might be needed to conserve a valuable landscape. In others, the right decision could be to let change happen, as it cannot be prevented in the long-term. Targeted, coordinated policies are an important differentiating factor in the scenarios. They can help minimise the loss of areas of interest, i.e. in 'Evolved Society' and 'Big Crisis'. Strong spatial planning also leads to concentrated urban development and helps in creating green belts around cities in 'Clustered Networks'. Autonomous developments like in 'Great Escape' are not beneficial in this respect.

Setting stricter intervention priorities requires better information. This concerns a better understanding of the distribution of areas of high nature value and biodiversity in order to be able to draw a priority list. Current data provide an insufficient overview. But it also concerns a better understanding of the impacts and effectiveness of related spending, such as agri-environment programmes or less-favoured areas support. This understanding cannot be restricted to selected areas only, but necessarily needs to be achieved from an overall European level to channel resources most effectively. A lot of funding will be made available over the course of the next years via the European Agriculture Fund for Rural Development, the European Regional Development Fund, the European Fisheries Fund and the Life+-regulation. It will shape the development of Europe's landscape considerably.

On the other hand, setting stricter intervention priorities needs a common agreement about the long-term objectives for agriculture and rural development. What kind of agriculture do we want to have in the future — concentrated and intensive or area-wide and extensive? What should be the prospects for rural development — creating rather equal, similar framework conditions of development in all regions or differentiating framework conditions of development according to regional differences?

Scenarios like PRELUDE offer a framework for discussing governance approaches in agriculture, rural development and the environment from a broader, longer-term perspective that brings legitimacy to considering 'unusual' developments of courses of action too. The current format of the Common Agricultural Policy, for example, does not stand the test of time in many PRELUDE scenarios, due to different influencing factors. Moreover, land-use change is informed by many policy drivers, such as transport, energy security, housing, infrastructure or tourism. Demographic and socio-economic changes like globalisation and migration must be considered too. Land use is a cross-cutting political issue of European relevance — ensuring a sustainable terrestrial development requires active coordination and integration across a wide range of policies. But is might also require improving spatial planning capacities at the European level to respond more effectively to overarching planning and information needs. Current governance and policy approaches don't seem to be well suited for this task.

The PRELUDE scenarios also illustrate that land abandonment offers unique opportunities for large scale nature development. If land-use issues are solved in an integrated manner, there appear to be opportunities for regional increases in biodiversity. Biodiversity can benefit from the local retreat of agriculture that occurs in most scenarios, hand in hand with the quality of air, water and soils. Land abandonment also offers opportunities for the production of biomass and thus combating climate change. PRELUDE, however, also shows that autonomous developments of different policies that compete for land can lead to environmentally harmful developments. Better policy coordination is necessary to avoid negative impacts and inefficiencies of related projects, especially in relation to biomass production.

For a number of reasons, such as time constraints, a sensitivity analysis of policy options was not feasible within the original project set-up. PRELUDE offers, however, a useful framework for an alternatives assessment of multi-annual strategic programmes such as the support schemes for the production of biomass for use as biofuels, for example. Assessments of this kind should become a more commonly applied tool. Long term contrasting scenarios help to better understand uncertainties related to those policies and programmes, and increase the effectiveness and efficiency of their design and implementation.

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7 Annex

7.1 Scenario storylines (included in the PRELUDE presentation tool)

7.1.1 *Scenario 1: Great Escape*

Maria stands on a ladder up against a high wall, pruning the roses. But her mind is elsewhere. She's worrying about how on earth she's going to raise half a million GCUs (Global currency units) to pay for her son's heart treatment. It would be years before she could save up the money out of her wages. Is there no-one she can ask for help?

A whirring sound disturbs the tranquillity of the landscaped garden and she looks up. A helicopter lands not far away on the Parkville helipad. A man climbs out and makes his way towards a house. There's something strangely familiar about him…

Thirty years earlier, in the year 2000, Maria was a fifteen year old schoolgirl living in Poland. That summer, a German boy, Karl, came on a school exchange trip and stayed on Maria's family's small farm near the Carpathian Mountains. It was an idyllic time for both of them, but their lives were to take quite different paths in the years to come.

In 2010 Maria was living in Berlin and working in a canteen at the prestigious DGC Health Tech Corporation. Karl had excelled at school and university and had recently completed his PhD in applied physics. As a postgraduate researcher he'd made a name for himself by helping to develop an arterial-cleaning nanobot which had great potential for treating the symptoms of heart disease.

He was head-hunted by DGC and employed in their Berlin laboratories. Soon after starting work, Karl bumped into Maria in the canteen. They were delighted to see each other again, and arranged to meet for dinner that night. In the restaurant, Maria told Karl that she'd left Poland five years earlier to find a job in Berlin. There was no work for her on the family farm because it had been bought up by a UK-based agribusiness which had amalgamated it into a new mega-farm unit of 5 000 hectares growing cereals for the world market.

The EU Common Agricultural Policy (CAP) had unravelled recently. The promise of enlargement turned out to be empty for Poland. The World Trade Organization agreement in 2008 forced the EU to liberalise, and Germany had refused to go on bankrolling the CAP. International climate change negotiations had collapsed, and the European Union was having difficulties paying for the third season of major flooding in a row.

Karl reminisced with Maria about the peace and tranquillity of the Polish countryside. He told her he had a promising career, but disliked the pollution and decay in Berlin. More and more manufacturing and service jobs had been farmed out to China and India, and unemployment in Europe was rising.

Although the economy was growing through hi-tech innovation, a smaller proportion of the workforce was benefiting. The steady running down of the welfare state across Europe was producing a growing underclass of socially excluded, so not surprisingly crime was on the increase. Karl had had enough of urban squalor and was looking for a house in a safe, affluent Berlin suburb.

Ten years later, Karl was a very wealthy man. He'd successfully patented and developed several new nanotechnologies including the extraction of the trapped oil reserves, which bought the world an unforeseen extra twenty years for the carbon economy. To celebrate his appointment to the Board of the WorldGovCorp (the corporation that oversees global economic policy and ensures minimal regulation and barriers to business) Karl travelled to California. During his trip, he was struck by the emerging concept of large-scale gated communities in rural settings. These surrounded Los Angeles and he'd previously seen them in Bangalore and Brazil. Karl decided to develop new, gated communities in the more pleasant parts of rural Europe. In the summer of 2020 he toured the continent by helicopter, assessing suitable locations.

Much of southern Europe was becoming hot and barren. He wanted to avoid places that were at risk from a rapidly changing climate — flooding, heat and drought — and major urban centres. He looked for areas with existing high landscape value and secure water supplies.

Parkvilles, as Karls company branded them, tended to be for around 500 households. Spacious homes were set in beautifully landscaped environments, with spectacular water features, and stocked with attractive plants and animals. Around 5 000 workers were needed to provide basic services, private health, education, leisure and security, and they were housed in sprawling prefab bungalow developments outside, but close to, the Parkvilles.

In 2020, at the age of 35, Maria had lost her job at the canteen when HealthTech relocated to Bangalore. She still managed to scrape a living in Berlin, but she was surviving rather than thriving. She was worried about the city environment that her 9 year old son, Jan, was growing up in, as it was affecting his health. And then her life changed once more when her mother fell ill and Maria and Jan had to move back to Poland to help look after her.

By 2030 Karl had developed 15 Parkvilles across Europe. He lived inside the one in southern Poland, and though he didn't realise it, Maria and her son lived outside the same Parkville walls, in a small prefab bungalow. Maria had got a job as a gardener for the Parkville residents, while Jan earned money cleaning their helicopters. Maria's elderly parents had both died as a result of the summer heat wave of 2029.

With a jolt, Maria realises that it's Karl who's walking away from the helicopter. She calls out his name but he strides briskly off, head down. Perhaps he didn't hear her. She plucks up courage and climbs down the ladder to run after him. He turns round, and Maria sees in his eyes a momentary annoyance at being approached by a Parkville employee. Then he recognises her and says 'hello', embarrassed, formal. Maria apologises for bothering him and tells him how she needs money for Jan's heart operation. Karl looks away then curtly says he's afraid he can't help. Shocked by his coldness, Maria doesn't tell him that Jan is his son, too. She simply says she quite understands and cuts short the conversation. Karl walks off towards his house, and waits for a second while the smart entry system recognises him. The door swings open and shuts behind him. Maria goes back to the rose garden and climbs wearily up the ladder again.

7.1.2 Scenario 2: Evolved Society

It was so hot that even the cicadas were silent. Luckily, here on the Tuscan hillside there was shade from the olive trees and a light breeze, but it hadn't rained for four months and the earth was like dust.

Paolo was bored and fractious. He was too hot even to kick the football back to his grandfather. 'Come on, lets go into the house where its cooler', said Sander. Paolo left the ball and ran inside. 'When will it rain, Grandpa?' 'Soon, I hope. Look, why don't you run upstairs and fetch my photo album and I'll show you what life was like when I was young in the early 2000s.' In a minute Paolo came back with the album and they looked at it, sitting side by side at the dining room table.

On the first page were photos of Sander as a boy and as a young man, Sanders first car, and his old house in Leiden. 'We didn't always live here in Tuscany, you know. I was born in the Netherlands in 1973 and when I grew up I worked in an office with hundreds of other people. We didn't worry about fuel in those days and every week I'd spend about two days driving all over Europe to other offices and factories. 'It was very stressful in those days. Our jobs were pressurised, and everywhere you went was crowded. You had to queue in shops and there weren't enough houses for everyoneall the people there were. 'On top of that, the floods in the Lowlands were getting worse. Sometimes we had to leave our home for weeks on end until the waters went down.'

'Is that why you and Grandma and Mummy and Auntie Lotje came here?' 'Yes, it was all of those things. We felt there should be more to life than sitting in traffic jams and worrying about the waters rising. So one year, when the floods came, we decided to up sticks and start a new life in Tuscany. We already had a holiday home here and had always loved the peace and quiet and the rolling landscape, so we sold our house in Leiden and made the move.

'It was just as well we settled here when we did because the energy crisis was just around the corner. War started when terrorists blew up an oil pipeline in Russia and soon pipelines all over the Middle East were being attacked. The West panicked not only because oil prices were rocketing but also because reserves were running out. We Europeans had to find new ways to make energy.

'Imagine, nowadays we pay about 100 times more for a barrel of oil than we did thenthan what it cost back then for a barrel of oil! It's so expensive that it can't be used for fuel any more. It only goes to companies like the one your mother works in, where they process it for medicines and valuable chemicals.'

'But we use oil, Grandpa!'

'Yes, but our oil is made from olives and plants like oilseed rape, not the kind that's pumped from deep underground.'

Paolo thought for a moment.

'Is that why we don't have a car? Because underground oil is so expensive?'

'That's right. After the energy crisis we couldn't afford a car anymore and I had to work from home. But we had a computer so we could keep in touch with our friends. And it meant I could do the same job in Tuscany that I did in Leiden. We already got on well with our neighbours here, too. So all in all it worked out far better than we'd hoped.'

Sander showed Paolo photos of his old neighbours from Leiden, the Nijdams, in their garden in Poland.

'We weren't the only ones to move. Lots of people in central and north western Europe decided they'd had enough of the rat race and the floods and they looked for homes elsewhere. Places with plenty of space, beautiful countryside and an unspoilt pace of life, like Poland and the Ukraine. The flooding and summer droughts aren't too bad there, and they're close to where our food is grown.

'The government made it easy for people to settle in less crowded parts of Europe, by helping us to pay the costs of moving. And they put money into agriculture, so it made sense for people to work on farms or start up their own.

'We had to look for more efficient ways of growing our food in Europe, because the energy crisis had changed the balance of the world economy and we couldn't afford to go on importing food from abroad. There's lot's of fertile land in eastern Europe, so that's where we grow our grain.'

'We make lots of our food here, though, don't we?'

'That's right. Nowadays we produce most of what we eat, but we still have to get some supplies from the cooperative. Flour and a lot of the meat we eat come from other parts of the continent by hover rail.

'You see how things have changed, Paolo. One day you're living in a chaotic, congested town and wondering how you're going to pay for the latest flood damage, and the next you're in a beautiful Tuscan village, making your own olive oil and having long leisurely lunches in the garden with your family and neighbours.

'You have a nice life, going to school in the village, playing with your friends in the fields, helping grandma look after the vegetable garden and cycling to visit your aunt and uncle. But by the time you're my age, things will be very different again. The world is always changing.'

By now Paolo was bored again and starting to fidget, and before Sander had stopped speaking he ran over to the window.

'Look Grandpa, black clouds!'

Sander got up and walked outside. It was true. There were rain clouds on the horizon. He could scarcely wait for the first drops and the smell of the wet earth at last.

7.1.3 Scenaria 3: Clustered Networks

(This storyline takes the format of fictive newspaper articles)

Smog now causes more lung cancer than smoking

4 November 2010

Europe's cities now have an unacceptably high level of air pollution. According to a report published today by the German Institute of Air Quality and Human Health, air pollution in big cities has increased significantly over the last twenty years and for the first time has overtaken tobacco smoking as the leading cause of lung cancer.

Although old-style smog like the notorious 1952 London peasouper that caused more than 4 000 premature deaths in just one week are now a thing of the past, the air that today's city-dwellers breathe has been proved to be just as dangerous in the long-term. Less visible to the naked eye, modern pollution is nevertheless a cocktail of dangerous particulate matter which comes from many sources, including power stations, chemical plants and vehicles.

Traffic congestion is the worst offender. EU limits for concentrations of particulates in ambient air in urban areas have now been exceeded in most European cities, mainly due to local road transport emissions.

What can be done to address the problem? Dr. Stephan Braun, one of the reports authors, writes that measures to reduce congestion and accelerated replacement of urban vehicle fleets are essential if we are going to reduce limits to safe levels. The report recommends better urban planning, for example by creating safe off-road cycle lanes-ways. It also stresses the need for coordinated spatial planning at EU level and for new initiatives to strengthen development outside the main metropolitan areas.

Responding to the report, EU Planning Minister, Pieter Wagenaar, said that a range of cross-departmental measures are currently under discussion, including investment in rural areas to provide incentives for businesses to move out of cities, higher penalties for polluting industries, and restrictions on the use of vehicles in the inner city.

Green turns grey: The ageing countryside

18 March 2015

It is well known that Europe's population is growing older, but we are now seeing signs of a marked split in population age between town and country. More and more young people are settling in towns and cities, while older people are retiring to, or remaining in, our countryside.

A recent publication by the Demographic Statistics Bureau in Madrid shows that the net reproduction rate in almost all European countries is insufficient to keep the population stable in the long term. Dramatic decreases are forecast particularly for many rural areas.

The countryside as we know it is changing dramatically, demographer Maria Alvarez claims. Farmers are on average more than ten years older than the general public. Many of them have no successors and when they retire, no-one takes their place, so large areas of arable land are lieying fallow. In many villages, local shops are disappearing and the general level of services is rapidly deteriorating. It is a serious problem. We need strong policy incentives to keep these areas attractive for young people.

The problem has been recognised by many regional authorities and is on the agenda of a pan-European conference on rural development to be held in Budapest next week.

Pietro Giulini wins prestigious EuroNova architecture award

12 December 2035

Pietro Giulini, designer of Europe's first Thematic City, has been awarded the 2035 EuroNova award for lifetime achievement.

With his revolutionary concept of integrated town planning around dedicated themes, Giulini has greatly contributed to reviving the countryside. The 14 existing thematic cities are now world famous centres of excellence that have put Europe at the forefront in high growth areas such as nanotechnology, virtual reality and medi-care.

Later this year a 5th Health City (HC) — which is also the 15th Thematic City — is scheduled to be opened north of Rome. With its accent focus on quality of life and health care, the Health City idea has proven to be hugely popular, particularly with the elderly.

In his acceptance speech, Giulini said it would never have happened if he had not been able to persuade the project developers, health care companies and city planners to buy into the concept. 'Everyone was very doubtful to begin with and talked about segregation and ghettoisation. But that's not how I saw it at all. After all, people who lived in inner cities were suffering from breathing problems because of the atmospheric pollution, and older people in the country were fed up with the lack of rapid access to medical and other services. So the prospect of a safe, clean, friendly community with people their own age and all kinds of healthcare on the doorstep was very attractive to them. We now have three and a half million people over 65 living in HCs.'

The seeds of the idea lay in Giulini's own background. 'I come from a farming family and my wife Lucia is in healthcare. We saw HCs as a logical solution to the problems of traditional rural and urban areas, bringing the two worlds together. Alleviating traffic congestion and air pollution problems, improving the level of care for the elderly, and finding a solution for the collapse of the rural economy were our main objectives.'

The new cities have indeed helped boost the rural economy by attracting more companies to the areas around HCs to meet the service requirements of the over 65s. In turn this has created employment opportunities for both the young and elderly people, particularly part-time jobs which often suit older people better, asand which they canare able to do themin some cases well into their 80s and 90s.

Each TC is easily accessible by hyper-rail and no more than 200 km from a major city. The air is very clean because vehicle use is kept to a minimum, and there are no new roads or buildings in the green belts around the HCs.

Giulini is particularly proud that the HC concept is being introduced into China and India which now face the same problems of urban air pollution and an ageing pollution that Europe was up against twenty years ago.

So, what's next for the award-winning planner? Giulini ended his speech by hinting that he is developing a new concept for climate-proofing the coastal old towns of Venice and Amsterdam, and that work is anticipated to begin by the end of the decade.

7.1.4 Scenario 4: Lettuce Surprise U

The e-forum on fenceless pastures had been going very well. The representatives were making constructive suggestions and Cliff felt that an agreement had nearly been reached. Then Eric Winters face appeared on the screen.

'Its all very well, Mr Chairman,' Eric said, 'but supposing the Agri-GPS doesn't work? My herd will wander all over the roads and into peoples gardens. It'll cost me a fortune in compensation.'

Oh dear. Most people had begun to trust the new technologies, but there were always some people who objected to progress. Cliff tried to remain positive. He reflected on the fact that it was a good thing that the system was so much more democratic than it had beenwas before the political upheaval at the beginning of the century.

Cliff Brown had been elected chairman of the regional board a year ago, in 2030, because he was a natural leader and had a no-nonsense manner that people felt comfortable with. And of course he was well known for his remarkable biological discovery, the bungi.

Biology was in his family, so to speak. Thirty years ago, his father Harry, as R&D director of the multinational AgriMed, had helped to develop a cheap new wonder vaccine that seemed to protect all species of livestock against most diseases. But Harry had been very uneasy when the company directors pushed his team to release the product on to the world market too soon, before it had been thoroughly tested.

Harry had talked to the media about his fears, and as a result had lost his job. Several independent experts had been wheeled out to endorse the product and the story had been buried. But two years later, millions of animals which had been treated with the new vaccine started to develop a wasting disease. Their meat was not fit for human consumption and they all had to be slaughtered.

Almost overnight, people were forced either to become vegetarians or pay enormous sums for organically produced meat or meat imported from the few countries in the world which had not adopted the vaccine. It was the worst in a long series of food-related health disasters and had sparked a worldwide crisis of confidence in government bodies and multinational corporations.

The crisis had a far reaching impact on local and EU politics. People now demanded leaders who would listen to the voice of the people. A new political system emerged that focused on quality of life rather than economic growth.

More decisions were debated and taken at regional level – such as the e-forum Cliff was now chairing – and one result was that local people started looking into ways of increasing agricultural self-sufficiency instead of importing most of the regions food from abroad.

When Cliff grew up, he followed in his fathers footsteps and became a biological researcher. While working on a new type of environmentally-friendly pesticide, he accidentally discovered a new organism that lived in symbiosis with crop plants. He called it a bungi as it combined the quality of N fixating bacteria and soil-P exploiting fungi. The organism was able to boost agricultural production tremendously by reducing input and increasing output.

The success of the bungi was the catalyst for a new political movement based on minimal government intervention and on trust in technological advances, as long as they were sustainable and could be proven to be useful.

The movement was also founded on the concept of open technology, which had been so successfully adopted in the energy sector with its new generation of low-carbon energy systems. In line with this approach, Cliff decided not to profit from his discovery but to share it in the public domain. For the first time, everyone — whether they had small city gardens or land in the country — had the tool to grow their own healthy, abundant food.

People understood that it was vital to have a highly effective agricultural sector, but under the new system, only technologies that were environmentally friendly and that would preserve nature and the beauty of the landscape were adopted.

Self-sufficiency was seen as a goal not only in food but also in energy. The agricultural sector channelled its resources into improving different varieties of high value crops as raw material for food, energy and other industrial purposes.

The highly effective low-input agricultural system meant that intensive farming and forestry could coexist – an excellent way of preserving the rural mosaic landscapes in the areas where most people lived.

Bulk production of staple crops was still needed but was based in more remote, less heavily populated areas of the EU. Beef production was kept high because grasslands help to preserve the landscape, and a new Agri-GPS system had recently been developed which controlled beef herds in fenceless pastures – the subject currently under debate.

Eric Winter clearly wanted an answer to his question, but before Cliff could respond, another farmer appeared on screen and started patiently explaining about the safeguards that had been built into the system. Cliff hoped this would swing the argument and a vote could soon be taken. Then they could move on to discussing the new super-efficient fuel crop that his team had been working on. He was really excited about its potential.

7.1.5 Scenario 5: Big Crisis

(This storyline takes the format of fictive emails)

From: Ingrid Karlsson
(mailto:iKarlsson@europarl.eu.int)
Sent: 1 September 2010 11:49
To: Hans W. Grünfeld
Subject: Get me out of here!

Hi Hans

This plane has been sitting on the runway at Brussels airport for 3 hours! I'm going to suggest that all MEPs take the train from now on. It would be far quicker AND greener.
I thought of you last week during the storm. Were all the BaChemFer plants OK? And your home? I dread to think what the bill will be for all the damage in northern Germany this last month – billions I should think. Oh we're off at last, I'd better power down. Give my best to Katrein and the children.

Ingrid

From: Hans W. Grünfeld
(mailto:grünfeld@BaChemFer.de)
Sent: 3 September 2010 18:02
To: Ingrid Karlsson
Subject: Re: Get me out of here!

Ingrid, you're mad if you think MEPs will willingly trail around Europe by train with all the meetings they have to go to. It reminds me of the time at university when you lobbied the other students to buy nothing but organic food. Get a grip, woman!

But I agree transport is a problem; traffic jams most of all. You know we have to allow at least 30 mins to drive Wilhelm to school? You should propose a drastic new policy, as long as I'm allowed to keep my Bentley Continental of course!

Thanks, none of us was hurt in the storm but there was some damage to the Essen plant. I just hope there isn't yet another one.
Regards to you and Sven

Hans

From: Ingrid Karlsson
(mailto:iKarlsson@europarl.eu.int)
Sent: 9 September 2010 13:12
To: Hans W. Grünfeld
Subject: Call me!

Hans, you must call me if you get this. I tried to call you on your landline and your mobile but there was no answer. The pictures on TV are really worrying, cars being swept down streets, all that churning debris. Are you OK?

Ingrid

From: Hans W. Grünfeld
(mailto:grünfeld@BaChemFer.de)
Sent: 12 September 2010 07.22
To: Ingrid Karlsson
Subject: We're OK

It's all right Ingrid, we're safe, but I think we were almost the last people to get on the last train out and I have an awful feeling our neighbours didn't make it.

I'll be in touch again as soon as were settled.

Hans

From: Ingrid Karlsson
(mailto:iKarlsson@europarl.eu.int)
Sent: 13 September 2010 08:01
To: Hans W. Grünfeld
Subject: Re: Were OK

Hans – I AM glad you're OK. We were so shocked at how the transport system broke down when it was needed most. It might seem brutal but I think this tragedy will focus people's minds and, who knows, it might all have a silver lining, change our priorities about how we live our lives? And you will give up your Bentley, you'll see!

Ingrid

From: Hans W. Grünfeld
(mailto:grünfeld@BaChemFer.de)
Sent: 17 September 2010 22:54
To: Ingrid Karlsson

Subject: My beloved Bentley? Never!

Nothing will change, Ingrid. You know how these things work. A disaster happens and everyone says never again, and then a month later it's back to normal. Public transport certainly needs more money, but where's that going to come from?

Hans

From: Ingrid Karlsson
(mailto:iKarlsson@europarl.eu.int)
Sent: 22 September 2010 07.44
To: Hans W. Grünfeld
Subject: Interesting article

You're quite right, Hans. Transport does need higher subsidies. And the money is there, it's just a question of allocating it differently. It's very exciting, what's happening at the moment – did you read that article about growth and sustainability in the Frankfurter Allgemeine Zeitung? I really think we can bring about something radical if we all think beyond our own interests.

Ingrid

From: Ingrid Karlsson
(mailto:iKarlsson@europarl.eu.int)
Sent: 3 May 2013 11:00
To: Hans W. Grünfeld
Subject: It's happening!

Good to see you and K last month and talk late into the night – quite like our student days. I thought you'd like to be the first to know, we've got our new policy through! (That's a drink you owe me, you old sceptic.) Every single country voted to focus development more on the periphery of Europe and the most depopulated cities.

So we're going to have our core areas, AND you'll get your subsidized transport infrastructure.

Ingrid

From: Hans W. Grünfeld
(mailto:grünfeld@BaChemFer.de)
Sent: 4 May 2013 08:16
To: Ingrid Karlsson
Subject: Congratulations, I suppose.

Well, well. I see I shall have to eat my hat when we next meet.

I do have some questions, though. 1: where will you find the money? 2: do you honestly expect multinationals to base their businesses on the outskirts of Europe (Salonika, Warsaw, Glasgow!)? And 3: am I really going to have to transport my pesticides and fertiliser by sea and rail???

Hans

From: Ingrid Karlsson
(mailto:iKarlsson@europarl.eu.int)
Sent: 5 May 2013 18:09
To: Hans W. Grünfeld
Subject: Re: Congratulations, I suppose.

Really, Hans! (1) We're shifting resources from more traditional policies like the CAP, and (2) Yes, we do. There are going to be incentives to move, and getting there is going to be easier with the new network of high-speed trains. Besides, people are recognising that the centre of Europe is too dangerous because of flood risk.

Oh, and (3). Yes. I never said it wouldn't be painful. Sorry.

Ingrid

From: Hans W. Grünfeld
(mailto:grünfeld@BaChemFer.de)
Sent: 8 June 2019 21:56
To: Ingrid Karlsson
Subject: You won't believe this.

Hi Ingrid

I took Wilhelm to Tallinn last week because he wanted to have a look round the university. He liked it, and I did too. The city has a real buzz. Amazing how cosmopolitan it's become. People from all over the world – China, India, Africa.

Things have settled down in the last couple of years and everyone seems to be getting on much better together. And it's surprisingly relaxing. On Saturday we took a train out into the countryside, walked in meadows of wild flowers and had an excellent brunch in a village pub.

In fact (much as I hate conceding a point to you) I'm even thinking of moving our head office here.

Hans

From: Ingrid Karlsson
(mailto:iKarlsson@europarl.eu.int)
Sent: 11 June 2019 08:19
To: Hans W. Grünfeld
Subject: Re: You won't believe this.

Wonderful news, Hans! I love that part of the world too and I know you'll appreciate the better quality of life if you move.
Did you find the different use of agricultural land interesting from a professional point of view? One of the reasons Tallinn is so popular (like the other new metropolitan regions) is that the area surrounding it isn't intensively farmed. Nice landscape, high quality locally produced foods, different varieties of plant and animal life, and habitat management have all helped the region develop and attracted lots of tourists. It's turned out really well, and we got there by carefully planning how the land could best be used.

It's all about balance and sustainability.

Ingrid

From: Ingrid Karlsson
(mailto:iKarlsson@europarl.eu.int)
Sent: 4 October 2023 07:41
To: Hans W. Grünfeld
Subject: Essen

Do you know, Hans, I was in Essen a couple of weeks ago and I agree, the new trams and street layout and parks make all the difference. It's beautiful.

I'm not surprised Wilhelms considering moving back there with his girlfriend.

Ingrid

From: Hans W. Grünfeld
(mailto:grünfeld@BaChemFer.ee)
Sent: 27 December 2028 11:18
To: Ingrid Karlsson
Subject: To the next 25!

Congratulations on your first 25 years in politics, Ingrid. Looking back, don't you feel pleased at what you've achieved? Europe has come such a long way in the last 20 years. Who would've imagined back in 2010 that Europe would take the lead economically?

Hans

PS The latest hybrid-fuel Bentley is a dream! I shall take you and Sven out in it next time you visit.

7.2 Description of driving forces and their relation to model input parameter and spatial allocation rules

Table 7.1 gives an overview of the driving forces of the PRELUDE project and how they have been related to the model input parameters and spatial allocation rules embedded in the Louvaine-La-Neuve land-use model.

Governance and planning
The driving force *subsidiarity* has been interpreted as the degree of central planning: a high degree of central planning is equal to a low degree of subsidiarity. There is, however, no direct link to any model parameter.

For the driving force *policy intervention* it is assumed that the degree of concentrated urban development determines the rigidity of spatial planning: the higher the degree of concentration the stricter the intervention. This is implemented through spatial allocation roles for migration and urbanisation patterns. The driving force can also change other parameters like agricultural production, overproduction (subsidies) or demand for energy crops (energy policy) and allocation rules like buffer zones (environmental measures). The concrete impact differs from scenario to scenario.

For the driving force *settlement concentration and accessibility*, it is assumed that a high density of settlements leads to a stronger clustering of urban concentration. The driving force changes the models spatial allocation rules, e.g. counter-urbanisation and peri-urbanisation.

Demography
Assumptions on the *ageing of society* have been kept the same for all but one scenario ('Great Escape') because four of the five storylines do not display differences.

This holds also true for *population growth*, where the total sum is remained but differently distributed across the regions in all scenarios (except 'Great Escape').

Table 7.1 Driving forces and their relation to model input parameters and spatial allocation rules

Driving force	Interpretation of driving forces as a basis for quantification and modelling
Governance and planning	
Subsidiarity	No direct link to model parameters.
Policy intervention	Global trade policies — agricultural production (values) Subsidies — overproduction (values) Spatial planning — migration/urbanization patterns (allocation rules) Environmental measures — buffer zones/nature areas (allocation rules) Energy policy — demand for energy crops (values)
Settlement concentration and accessibility	Urbanization patterns (allocation rules), e.g.: Counter-urbanization — migration away from large agglomerations Peri-urbanization — migration from city centers to more surrounding rural areas *See also Chapter 2.5.1*
Demography	
Ageing society	Age-specific migration patterns (allocation rules)
Population	European data on total population growth downscaled to NUTS II regions (values). Internal migration assumptions (allocation rules). See also Internal Migration.
Immigration	Based on historical trends in the EU- 25 countries, immigration was assumed to stimulate population growth in urban areas (allocation rules) See also Section 2.5.1.
Internal migration	Three types of migration were taken into account: (1) rural — urban (2) center — periphery, and (3) East/west (allocation rules).
Societal values	
Health concern	No direct link to model parameters. Indirect links through Demography, e.g., people migrate to rural areas or move away from frequently flooded areas to have access to better living conditions (allocation rules).
Social equity	Urban /rural income — migration assumptions (allocation rules).
Quality of life	Analogous to health concern.
Environmental awareness	Biofuels uptake (values, allocation rules). Buffer areas (allocation rules, see additional assumptions section). Agricultural intensification (values, see also agricultural intensity).
Economic development	
Economic growth	GDP growth per capita (values). Agricultural production costs (values). Prices for agricultural goods (values). Urban/rural income (allocation rules).
International trade	Ratio European import/export (values).
Daily mobility	Taken into account indirectly through Demography, e.g. new settlements in rural areas with increased working at home (allocation rules).
Europe self sufficiency	Ratio of European import/export of agricultural goods (values).
Technological development	
Technology growth	Crop yield (values).
Agricultural intensity	Geographical distribution crops (allocation rules — involving high productivity areas, flooding areas, buffer zones). Crop yield (values).
Environmental impacts	
Climate change	CO_2 impact on crop yield (values). Flooding incidence/area (value, allocation rules).
Renewable energy production	Rates of production of biofuels forest plantations/energy crops (values).
Human behaviour	No direct links. Migration behaviour addressed through demography.

Note: (values) indicates that a driving force leads to changes in the model input parameter, (allocation rules) indicates that a driving force leads to changes in the models spatial allocation rules.

Immigration is assumed to stimulate population growth in urban areas and affects spatial allocation roles of the model. Although the scenarios contain different assumptions on immigration, the values are rather low, which explains why the sum of population growth remains unchanged in nearly all scenarios. Immigration has only minor impacts.

The assumptions on *internal migration* patterns differ between all scenarios with regard to rural-urban migration, centre-periphery migration (see Section 2.5.1) and east-west migration. Internal migration is interpreted on a high-low scale.

Societal values
The driving force *health concern* is not directly linked to model parameters. It has some indirect links and can have different effects in the scenarios. For example, people migrate to rural areas or move away from frequently flooded areas to have access to better living conditions and changing consumption styles, which then trigger changes in agricultural production.

Social equity does not directly feed into the model too. It affects the spatial patterns of GDP, affecting thus the rate of urban development in different areas on top of migration/immigration. Everything else being equal, social equity will make a difference between regions in terms of GDP which then makes a difference in term of urban development.

Quality of life is treated as an output of the model. It does not provide input into the model.

Environmental awareness affects different model input parameters and allocation rules, i.e. biofuels uptake is increased when environmental awareness is high and agriculture intensification increases when environmental awareness is low. High environmental awareness simplifies the implementation of buffer areas for landscape protection.

Economic development
Economic growth is a key driver of urban-land use as urban/rural income co-determines urban demand. Moreover, economic growth affects agricultural production costs, prices for agricultural goods and GDP growth per capita.

International trade as such is not modelled. Only the total agricultural demand is modelled irrespective of whether it is international or domestic. Total demand figures are the ratio of import/export. Quantitative data on export are not available. Changes in international trade affect the parameter for agricultural demand.

Daily mobility as a driving force is only indirectly taken into account through demography, i.e. new settlements in rural areas lead to urbanisation. *Self-sufficiency* affects the parameter for the ratio of European import and export of agricultural goods — a higher degree of self-sufficiency leads to a lower trade balance.

Technological development
Changes in the driving force of *technological growth* affect the model parameter for crop yields — a higher technological growth stimulates crop yields.

Higher crop yields are also induced by changes in the driving force of *agricultural intensity*. Yield changes are a function of changes in technological growth and CO_2 (see environmental impacts section). Changes in agricultural intensity also affect the allocation rules for geographical distribution of crops — a higher intensity leads to more high productivity areas; and buffer zones in one scenario ('Clustered Networks').

Environmental impacts
The driving force *climate change* was not differentiated between scenarios (only stochastic variation of weather events). The SRES A1 assumptions on precipitation and temperature were used. Changing crop growth conditions were not modelled. Yield figures were adapted on the basis of CO_2 increase (same parameter for all scenarios). Spatial allocation was done on the basis of a flood risk and rent map (see Section 2.5.1). The flood risk map was identical for all scenarios. The rent map is not related to climate change, but to cost assumptions, which were different for 'Great Escape' and 'Clustered Networks'.

Renewable energies as a driving force are taken into account through the areas for the production of biofuels crops. Crops (wooden, non-wooden, liquid) are allocated on the land that remains after accounting for food production, using potential distributions determined for each biofuels crop species.

The driving force of *human behaviour* is not be related to a model parameter. It does not feed into the model. Internal migration as an indirect link is addressed through the demographic driving forces.

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