EUROPEAN
COMMISSION

DG ENVIRONMENT

LAND USE MODELLING — IMPLEMENTATION

Preserving and enhancing the environmental benefits of "land-use services"

EXECUTIVE SUMMARY of FINAL REPORT

Version 1 April 2010

CONSORTIUM

Coordination:

ALTERRA
WAGENINGEN UR

In cooperation with:

Geodan next

Object Vision

bio Intelligence Service

Affiliated partners: LEI and PBL

Executive summary

In the next 20 years the EU is anticipated to face new challenges with respect to land use change and its related impacts, which mainly involve the agricultural, forestry, energy, transport, tourism and nature conservation policy sectors. Environment is a transversal policy field across these sectors and therefore, the European Commission is currently involved in several discussions in which land use and its environmental impacts play a key role. Those are for example the further implementation of measures for adaptation to climate change, the role that the new Common Agricultural Policy might have to maintain the 'green' services, the assessment and management of flood risks, etc.

In order to find out the potential that a European land-use modelling framework could have to support environmental policy making within the European Commission, the Environment Directorate-General of the European Commission commissioned a project from December 2008 to February 2010. This study is a second phase that builds upon a scoping study reported in June 2008, which analysed the options for a quantitative modelling at EU scale of trade-off and impact of land use, and defined a roadmap for the preferred option.

The Final Report describes the methodology and work developed from December 2008 to December 2009. It reflects the discussions and agreements achieved in seven meetings between the officers of the European Commission (mainly from DG Environment), and the researchers in charge of the project implementation. These meetings have strongly contributed to an encouraging and engaged policy-science interaction, which has become a key feature of the project. The integrated land-use modelling framework, the reference scenario and policy alternatives used as example to test the implementation of the model, the main results, policy-oriented conclusions and final evaluation of the limitations and uncertainties are summarised below.

The integrated land use model and its implementation in eight policy scenarios

- The EU-ClueScanner is a land allocation model positioned at the heart of a multi-scale, multi-model, framework. It bridges sector models and indicator models and connects Global and European scale analysis to the local level of environmental impacts.
- The core of the modeling framework is formed by the land use model Dyna-CLUE (Verburg et al., 2002; Verburg and Overmars, 2009). In addition, the global multi-sectoral models LEITAP and IMAGE (van Meijl et al., 2006; Eickhout et al., 2007) are used to define demand for different types of land use, which are based on predictions on world-wide economic drivers.
- Indicator models either consist of well-established models or targeted, simplified indicator models such as used in EURURALIS projects (WUR/MNP, 2008).
- The framework is designed in such a way that it is flexible in including other models and indicators if needed for a specific policy scenario application. The framework is based on the Data & Model Server (DMS) software which is a flexible system for linking specialised models and data within a consistent workflow. The model framework and its base implementation with a land use model and a series of indicator models is provided as documented, open source software including a short user tutorial instruction and access to the modellers-reference of the declarative DMS scripting language and set of operators (http://www.objectvision.nl/dms).

- In all scenarios considered in this study, the global influence is accounted for through changes in climate and global demand for goods and commodities based on outcomes of the LEITAP and IMAGE models. Results from these simulations relate to the demand for various types of land use and are, in Europe, delivered at Member State level. The output of the global-level models is translated into a land demand in km2 for the specific land-use types distinguished in the Dyna-Clue land allocation model.
- Two reference scenarios were used in order to explore future trends as realistically as possible, i.e. the B1 (Global Co-operation) from IPCC-SRES reference scenarios, and Policy promoting biofuel use in five non-European countries (USA, Canada and Japan, Brazil, South Africa) and EU27 with unrestricted land conversion of forests into agricultural land (second option of the Biofuel policy alternatives), which is to some extent comparable to the IPCC A2 scenario (Continental markets) since it involves a high demand for land.
- Eight policy alternatives are used as examples, which are only intended to illustrate the possibilities and deliverables of the model but are not an actual impact assessment of envisaged policies. The first set of policy alternatives deals with different implementation options of the proposed Renewable Energy Directive (Directive 2009/28/EC) and considers potential changes in the demand of land (through biofuel production) that can be associated with this policy. In addition, two policy alternatives are defined. The biodiversity alternative introduces a number of ambitious policies to increase the protection of specific ecological and landscape related values, including policy options for the following policy themes: fragmentation control and promotion of clustering of nature, controlling urban growth, natural corridors, Natura 2000, high Nature Value protection, Less Favoured Areas and protection of peat land. The Soil and Climate Change alternative focuses on adaptation and mitigation measures related to water management and soil protection, including the following policy themes: flood damage reduction, restoring water balance, protection of permanent pastures, protection of peat land, soil protection and erosion prevention.
- The implementation of the modelling framework shows that it is successful in simulating different spatial land use policy options. The main policy-oriented considerations are presented below for the three policy alternatives, keeping in mind that the policy alternatives are only intended as illustration. The conclusions focus on those scenarios and results showing major differences compared to the reference scenario:
    - Policies promoting biofuel use have large impact on land use, although impacts within Europe are relatively small as compared to impacts outside Europe. The protection of forest in the tropics will increase land use pressure in Europe. The scenario assessing the impact of Biofuel policies in five non-European countries (USA, Canada and Japan, Brazil, South Africa) and EU27 with unrestricted land conversion of forests into agricultural land predicts the strongest impact in EU27, i.e. the demand for agricultural land is the largest, which results in a striking decrease of 50% in abandoned agricultural land compared to the reference scenario. In addition, an increase of 15% of arable land and 4% decrease of forest total area are calculated. The agricultural expansion is mainly observed in Central Europe, which happens at the

expense of agricultural land that would become abandoned according to the reference scenario. This increase in arable land results in a net loss of carbon sequestration rate, which is approx. 20% lower in 2030 compared to the reference scenario, where more forest is maintained and more agricultural land is abandoned.

- The hypothetical policies considered in this study aiming at protecting biodiversity have as main effect an increase of 6% in total arable land area in 2030 compared to the reference scenario. This increase is mainly based on (i) the increase in set-aside land (since high set-aside with the same cropping area means more agricultural land), especially in those countries where the demand for agricultural land remains the same, e.g. Poland and other Central European member states and (ii) a decrease of agricultural abandoned land in Western Europe. The arable land expansion is at the cost of forest area, whereas semi-natural vegetation increases due to incentives to protect semi-natural grasslands that slow down the succession to forest. The conversion to nature is occurring mainly within the ecological corridors. The impact on biodiversity measured by changes in the Mean Species Abundance (MSA) is rather limited since the MSA index is for a great part determined by the total areas of the different land cover classes, and to lesser extent by the distribution of these classes. The difference with the reference scenario is therefore are not large, since the spatial policies to promote and protect biodiversity are mainly affecting the location of certain land use and not so much their total area. It is however a clear difference between the biodiversity scenario without the increase in set-aside and the biodiversity scenario with the high demand for agricultural land. This shows that spatial policies do have a positive impact on biodiversity, but that the demand for land has a larger effect that cannot be compensated by the spatial policies that promote the protection of biodiversity, i.e. a high land use pressure will outweigh the effect of subsidies to convert arable land to nature.
- Policies aiming at mitigating and adapting to climate change related to water management and soil protection mainly result in different land use patterns at local scale which are reflected in some improvements in biodiversity as a result of the protection of permanent grassland and peat soils. At hotspots erosion is decreasing compared to the reference scenario, due to additional incentives for soil conservation.
- When comparing main land cover changes in 2030 compared to 2000 a general increase in built-up area is observed. This increase is lower in the Soil and Climate change scenario because of policies stimulating compact forms of urbanisation. Arable land shows the largest differences between scenarios: it increases substantially in the EU Biofuel policy options to accomodate for the increased demand for biofuel crops, and decreases under the Biodiversity and Soil and Climate Change alternatives where set-aside policies are maintained or even increased. Pasture area increases slightly and permanent crops area decreases for all scenarios.
- All results can also be shown at local level and hotspots of change can be identified.

Limitations and uncertainties of the EU-CLUE scanner modelling tool

- The modelling framework is very flexible and can be adapted to various needs for specific assessments and scenarios. However, modifications of the modelling framework are to some extent limited by the available data and the state of understanding the land system.
- Modelling changes in land use intensity is in principle possible in the modelling framework. However, this is hampered by the low current availability of spatially explicit data on land use intensity, which would allow to properly model the integrated environmental impacts of policies e.g. difference between extensive and rotational grasslands. As alternative, a coupling with more detailed sector models capable of simulating changes in land management could be used.
- Increasing the spatial resolution from 1 km^2 to 1 ha, for example, is in principle possible since CORINE Land Cover data support such a higher resolution. However, many of the data used to identify the location factors that determine the competitive advantage of the different land use types do not support such a lot of spatial detail and would require consistent and harmonised spatial data available at national level.
- The current model implementation is limited in its capacity to address feedbacks between the environmental impacts and the driving factors of land change and needs further research.
- The current model implementation addresses a restricted set of relevant indicators. Some of these indicators are proxies for ecosystem services provided by the land. Further research should focus on quantifying the ecosystem service trade-offs for the different scenarios.
- Although coupling of the modelling framework to many alternative detailed indicator models is possible it may not be always recommended. Many indicator models are based on detailed understanding of processes at the micro-level and therefore be subject to scaling errors when applied at a 1 km spatial resolution. It is therefore important to choose indicator models that are suited and sensitive to the information provided by the EU-CLUEScanner framework at the thematic, spatial and temporal scale of analysis. Also a good fit with the thematic content of the different land use classes is requested.