Knowledge for Climate

Midterm Review Report

NWO Sustainable Earth – Knowledge for Climate project

IGLO: Integrating global and local assessment models; improving an integrated multi-scale modelling framework to assess the inter-relationships between land use and climate change

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Netherlands Organisation for Scientific Research

IGLO – midterm report

Project number: 830.10.002/003: Integrating Global and LOcal assessment models (IGLO)
Reporting period: May 1, 2010 – August 1, 2012
Project leader: Prof. Dr. P. Rietveld (002) and Prof. Dr. Verburg (003)
Names project staff: Dr. E. Koomen (002) and Dr. S. van Asselen (003)
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Main objectives and expected results

The Integrating Global and LOcal assessment models (IGLO) project has the objective to improve integrated multi-scale modelling frameworks to assess the interrelationships between land use and climate. The project aims to consistently address the integration of processes operating across different scales and enhance the linkages and feedback between socio-economic processes and biophysical processes within the land change system. Modelling is used as a central tool to address these issues resulting in improved concepts and methods for integrated assessment.

More specifically the project has the following objectives:

- Improved insight and conceptual models on linking land-use change processes across different scales;
- Improved insight and conceptual models for addressing feedbacks and interactions between economic and biophysical processes in land use;
- Implementation of conceptual models in consistent operational land-use modelling frameworks (through new modules and consistent linkage of existing models) to be used in assessments of climate change and ex-ante evaluation of policies.

The anticipated results of the project include:

- Scientific understandings published in five scientific papers in peer-reviewed journals; editing of a special issue/section of a journal;
- Contribution to the scientific discussion in this field through an international workshop and special session/symposium during an international conference;
- Enhanced collaboration between research groups from different disciplines/universities;
- An integrated, operational modelling system based on linked models for application within ex-ante and scenario studies. Such applications can take place in the context of the Dutch Knowledge for Climate (KfC) research programme project and other international initiatives. The modelling system will especially help to provide explicit insights in the role of feedbacks and interactions between biophysical and socio-economic processes addressed in the context of the applications.

Summary of conducted research

The project is carried out by two post-docs that interactively work together on the overall concepts and framework in order to arrive at consistently linked models. However, each of the post-doc projects has its own focus. Sanneke van Asselen is the post-doc researcher who focuses on the linkage of global scale integrative assessment models to land-use modelling and regional assessments (subproject 830.10.003), while Eric Koomen is the post-doc researcher who focuses on the linkages and feedbacks between socio-economic processes and biophysical processes influencing land change at local scales (subproject 830.10.002).

Understanding land-use change processes across different scales

An initial step in improving insight in the links of land-use change processes across different scales is made by Sanneke van Asselen by creating a new representation of land cover and land use at the global scale. Most existing global land-change models use relatively coarse pixels of 0.5 degree (approximately 50x50 km at the equator) that represent one dominant land cover, which often do not represent the landscape accurately. To improve this, raster base maps are collected and created at 5 arc minute resolution (approximately 10x10 km at the equator) that represent land cover, agricultural intensity and livestock composition. These maps are used to classify Land Systems that represent mosaic land covers with different land-use intensity and livestock composition, which are two very important aspects of the land system. Next, logistic regression is used to estimate the probability of occurrence of each Land System, using a set of biophysical and socioeconomic explanatory factors as independent variables. The resulting regression (probability) equations can subsequently be used in land change models to predict future land changes. The new Land System classification and the regression analyses are the main subjects of a paper that is published in Global Change Biology. Furthermore, a paper was written and published in a special issue of Landscape Ecology regarding the representation of landscapes in global scale assessments of environmental change.

Eric Koomen started his research with exploratory analyses of land-use changes in several European countries to better understand the dynamics and drivers involved This work was performed in cooperation with the Joint Research Centre of the European Commission and aimed at calibrating the EU-ClueScanner100 model that VU Unversity in cooperation with others helped develop. The knowledge obtained in developing high-resolution (100 m) land-use maps in various European countries has been applied by Eric Koomen in the definition of a procedure to obtain a refined pan-European land use/cover map in cooperation with the Joint Research Centre of the European Commission. This procedure has been documented in a paper that has been accepted for the Journal of Land Use Science. Another research paper focused on land-use change processes in a specific country (Portugal) and was submitted to Cartographica for a special issue on land change methods.

Addressing feedbacks and interactions between economic and biophysical processes in land use
To develop an integrated approach that incorporates both socio-economic and biophysical processes at the local scale in land-use modelling a unified assessment framework for land suitability is proposed by Eric Koomen that describes the local potential for all types of use (urban, agricultural and natural) following a monetary (utility based) approach. Suitability for a particular type of land use is calculated as the net benefits for that use, in line with bid-rent theory and the host of literature on land markets and land evaluation. This approach allows for assessments of land suitability that can be directly linked to human behaviour and can, potentially, be defined in a relatively objective way. It provides a common reference scale for the definition of suitability that allows for straightforward interpretation, direct comparison between different types of land use and regions, and a framework for the inclusion of future changes in location characteristics. It thus offers the possibility to insert discontinuities, policy alternatives or anticipated scenario-based changes, that are particularly relevant in the context of, for example, climate change. The initial framework was presented at the ERSA 2011 conference in Barcelona.

Furthermore, Sanneke van Asselen made an important contribution to a global-scale study on wetland conversion led by PBL Netherlands Environmental Assessment Agency. Based on local-scale case study papers, collected from peer-reviewed scientific papers' search engines, a meta-analysis is performed to evaluate which (combinations of) proximate causes and underlying forces drive wetland conversion. In addition, a regression analysis is performed to estimate the probability of wetland conversion at the global scale. For this, a set of biophysical and socioeconomic variables is used to explain the current spatial patterns of wetland conversion. The regression equations can subsequently be used to predict future wetland conversion. A paper on this subject is almost ready to be submitted to Global Environmental Change.

In addition Eric Koomen pays specific attention to the way zoning policies influence local-scale spatial developments. Results of an empirical case study on the impact of spatial planning restrictions on the urbanisation patterns in the Netherlands have been used to construct what-if type of scenarios for future urban development related to a currently proposed adjustment of national spatial policies. This knowledge has been applied in a Strategic Environmental Assessment of revised national spatial planning strategy carried out by Royal Haskoning and Geodan (Elings et al., 2011). The results were also presented at the Cities and Nature conference in 2011 in Haifa and are currently being described in a chapter for a scientific book edited by Czamanski, Benenson and Malkinson.

Implementation of new conceptual models in operational land-use modelling frameworks
The knowledge gained from the activities discussed above was implemented in operational land-use modelling frameworks that can be used in assessments of climate change and ex-ante evaluation of policies. The new global Land Systems modeling units are applied by Sanneke van Asselen to develop a new global-scale land change model whose structure is based on the existing Dyna-CLUE model (Verburg and Overmars, 2009). The main model adaptation relates to handling a demand specification that links

multiple demand types to changes in pixels representing various mosaic landscapes. This is more complex than the classic modeling approach in which pixels represent a single dominant land cover or land use that is associated with only one demand type. The new model is tested for three regions: the USA, Europe and Brazil. The next step is to perform regression analyses for different world regions (work in progress), which serve as input for the global land change model. A paper on a first concept of a global land change model including human-environment interactions has been published in Environmental Research Letters.

The new land utility-based suitability framework has been applied by Eric Koomen in a special validation version of the Dutch Land Use Scanner model. This version compared the merits of the new approach with two commonly applied, purely statistical approaches to define local land suitability. Initial results were presented at the AGILE2012 conference and a full paper will be submitted to a scientific journal later this year.

The European Commission was extremely interested in the expertise of the project partners in developing a multi-scale land-use modelling framework and asked VU University Amsterdam to participate in the application and further development of a pan-European land-use modeling framework. This cooperation has resulted in two scientific publications.

Scientific value of the research

This project provides a better understanding of the various processes and scales that are relevant to land-use change. In this way it strengthens both the underlying scientific basis and provides operational tools for cross-scale and multi-sector land-use analysis. Our results contribute to the Global Land Project and the objectives formulated in its science plan.

The value of the research is indicated by the fact that we have already been able to get five papers accepted for publication in international scientific journals. In addition we have contributed a chapter to a scientific book. Several other papers are currently being prepared for publication.

To exchange knowledge on the modelling of urban dynamics with international experts in this field Eric Koomen helped organise a workshop on “Complexity Modeling for Urban Structure and Dynamics” that was held April 24 2012 preceding the AGILE2012 conference in Avignon, France. The international recognition of his work on urban dynamics is exemplified by his recent admission to the Editorial Board of the Urban Studies Research journal.

The new representation of land cover and land use at the global scale, and the associated regression analyses used for calculating the probability of the occurrence of Land Systems, was presented by Sanneke van Asselen at the Institute for Environmental Studies, 2 April 2012. She also presented the meta-analysis on wetland conversion at the Global Land Project meeting (16 May 2012).

Peter Verburg presented the Land System approach in his keynote lecture on 'Land change: from subtle modifications to large global transitions', IAMO Forum 2012, Halle, Germany.

How and to which broader debate and/or societal issues does the project contribute

The new Land System classification enables to better describe and predict interactions between natural and human processes, using the new global land change model. Such models can, for example, be used by PBL Netherlands Environmental Assessment Agency to assess global environmental impacts of human activities and proposed (e.g. climate-related) policies. This information can be used to develop, test and refine different kinds of (environmental) policies.

Recently, a GLOBIO-aquatic model was developed by the GLOBIO consortium at PBL, with the objective to assess changes in aquatic biodiversity. The results from the wetland conversion study will be implemented in this model and used to predict the probability of wetland conversion, and therewith loss of biodiversity, in different regions and for different scenarios regarding driving processes.

The work on developing different approaches for the definition of local land suitability and testing these in the Dutch Land Use Scanner model is particularly relevant to PBL Netherlands Environmental Assessment Agency that operates the same model in policy related assessments. The present research has led to an intensification of the existing cooperation with PBL and Eric Koomen is currently advising them on the definition of local land suitability in their simulation of land-use scenarios for the Dutch National Delta Program that aims to keep the Netherlands safe and attractive in the 21st Century. The results of his empirical case study on the impact of spatial planning restrictions on the urbanisation patterns in the Netherlands have been applied in the Strategic Environmental Assessment of revised national spatial planning strategy carried out by Royal Haskoning and Geodan for the Ministry of Infrastructure and Environment (Elings et al., 2011).

The present research has also led to the submission of a new research proposal that focuses on the application of the land-use modeling tool in a spatial planning context. This proposal has been approved as part of the NWO- Urban Regions in the Delta program. In addition the European Commission is interested in the research findings and cooperates with VU University Amsterdam in the application and further development of a pan-European land-use modeling framework as was discussed above.

References

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Verburg, P.H. and Overmars, K. (2009) Combining top-down and bottom-up dynamics in land use modeling: exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model. *Landscape Ecology 24*, 1167-1181.

Output of the project (classified according to SEP protocol)

Scientific publications	
a. in "refereed" journals	Batista, F., Lavalle, C., Koomen, E. (2012) A procedure to obtain a refined European land use/cover map. Journal of Land Use Science. DOI 10.1080/1747423X.2012.667450 Diogo, V., Koomen, E. (submitted) Land-use change in Portugal 1990-2006: main processes and underlying factors. Cartographica (resubmitted July 20, 2012). Koomen, E., Vasco, D., Rietveld, P., Dekkers, J.E.C. (in preparation) A utility-based, multi-sector framework for local scale land-use modeling. To be submitted to Journal of Geographical Systems. Letourneau, A., Verburg, P.H., Stehfest, E. (2012) A land-use systems approach to represent land-use dynamics at continental and global scales. Environmental Modelling & Software 33, 61-79. Van Asselen, S., Verburg, P.H., Vermaat, J., Janse, J. (in preparation) Drivers of wetland conversion: a global meta-analysis. To be submitted to Global Environmental Change. Van Asselen, S., Verburg, P.H. (2012) A Land System representation for global assessments and land-use modeling. Global Change Biology. DOI: 10.1111/j.1365-2486.2012.02759.x. Verburg, P.H., Ellis, E., Letourneau, A.(2011) A global assessment of market accessibility and market influence for global environmental change studies. Environmental Research Letters 6 034019 http://stacks.iop.org/1748-9326/6/034019 Verburg, P.H., Koomen, E., Hilferink, M., Perez-Soba, M., Lesschen, J.P. (2012) An assessment of the impact of climate adaptation measures to reduce flood risk on ecosystem services. Landscape Ecology 27, 4: 473-486. DOI 10.1007/s10980-012-9715-6 Verburg, P.H., Van Asselen, S., Van der Zanden, E., Stehfest, E. (2012) The representation of landscapes in global scale

	assessments of environmental change. Landscape Ecology. DOI: 10.1007/s10980-012-9745-0
b. other scientific publications and output	Koomen, E., Dekkers, J.E.C. and Rietveld, P. (2011) The impact of land use policy on urban fringe dynamics; evidence from the Netherlands. Abstract and presentation for the Cities and Nature Conference, October 2-5, 2011, Haifa, Israel. Koomen, E., Rietveld, P., Dekkers, J.E.C. (2011) Towards an integrated approach for incorporating socio-economic and biophysical processes in local scale land-use modelling, Abstract and presentation for the European Regional Science Conference, Barcelona, Spain, 30 August-3 September, 2011. Koomen, E., Vasco, D., Dekkers, J.E.C., Rietveld, P. (2012) A utility-based, multi-sector framework for local scale land-use modeling. Abstract and presentation at the workshop on Complexity Modeling for Urban Structure and Dynamics, 15th AGILE international conference on Geographic Information Science, April 24-27, 2012, Avignon, France.
Book contributions	Koomen, E., Dekkers, J.E.C., Rietveld, P. (in preparation) The impact of land-use policy on urban fringe dynamics; Dutch evidence and prospects. In: Czamanski, D., Benenson, I. and Malkinson, D. (eds.) Cities and Nature book series. Springer, Berlin. Lavalle, C., Baranzelli, C., Batista e Silva, F., Mubareka, S., Rocha Gomes, C., Koomen, E., Hilferink, M. (2011) A High Resolution Land use/cover Modelling Framework for Europe: introducing the EU-ClueScanner100 model. In: Murgante, B., Gervasi, O., Iglesias, A., Taniar, D., Apduhan, B.O. (eds.) Computational Science and Its Applications - ICCSA 2011, Part I, Lecture Notes in Computer Science vol. 6782, Springer-Verlag Berlin Heidelberg, pp: 60-75.
Monographs	-
Dissertations	-
Professional publications and products	Van Asselen and Koomen, E. (2012) Milieugevolgen veranderend landgebruik beter inschatten. Bijdrage aan Nieuwsbrief Duurzame Aarde (NWO), Maart 2012. http://www.nwo.nl/nwohome.nsf/pages/NWOP_8SBEBM
Patents	-