A modelling framework for assessing adaptive management options of Finnish agrifood systems to climate change

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Introduction

Projections from global models of climate in Finland during the 21st century indicate an acceleration of warming at rates greater than the global average and increased mean precipitation. Mitigation alone does not suffice as climate change will take place anyway to a certain extent. This implies that Finnish agrifood systems need to adapt to better cope with the risks and opportunities. Agricultural systems are concurrently affected by other global changes, including markets and policies. The associated impacts on food production, the environment and farmer's livelihood are not well understood. The extent of these effects will depend on the capacity of agrifood systems to adapt which is determined by various natural and socio-economic factors. There is an apparent need for improved assessment methodology and tools considering multiple factor and scale interactions. It requires to conceptually and operationally linking biophysical models with farming system and market models in order to increase insight in the complexity of interactions affecting agriculture and support policy making [1].

During 2008, a project on Integrated Assessment Modelling of agrifood systems (IAM-Tools) has been launched by MTT Agrifood Research Finland, and partner institutes. It aims at developing, refining and evaluating socio-economic and biophysical component models for agrifood systems in Finnish conditions and linking them in an IAM framework.

Modelling framework

The framework developed for *ex-ante* assessment of alternative policy and adaptive management options from field to regional level is called AGRISIMU (AGRIfood systems SIMUlation) (**Fig.1**). The basic idea calling for this multi-scale, integrated assessment tool is that both biophysical (climate change) and socio-economic (policy and market) drivers lead to changes in agricultural land use. These land-use changes will in turn have impacts on environmental quality, especially on nutrient loading and biodiversity. Currently, the main interventions to preserve environmental quality are through adaptive management at farm level. However, these short-term tactical responses need to be linked to long-term strategic options for whole regions supported by policies.

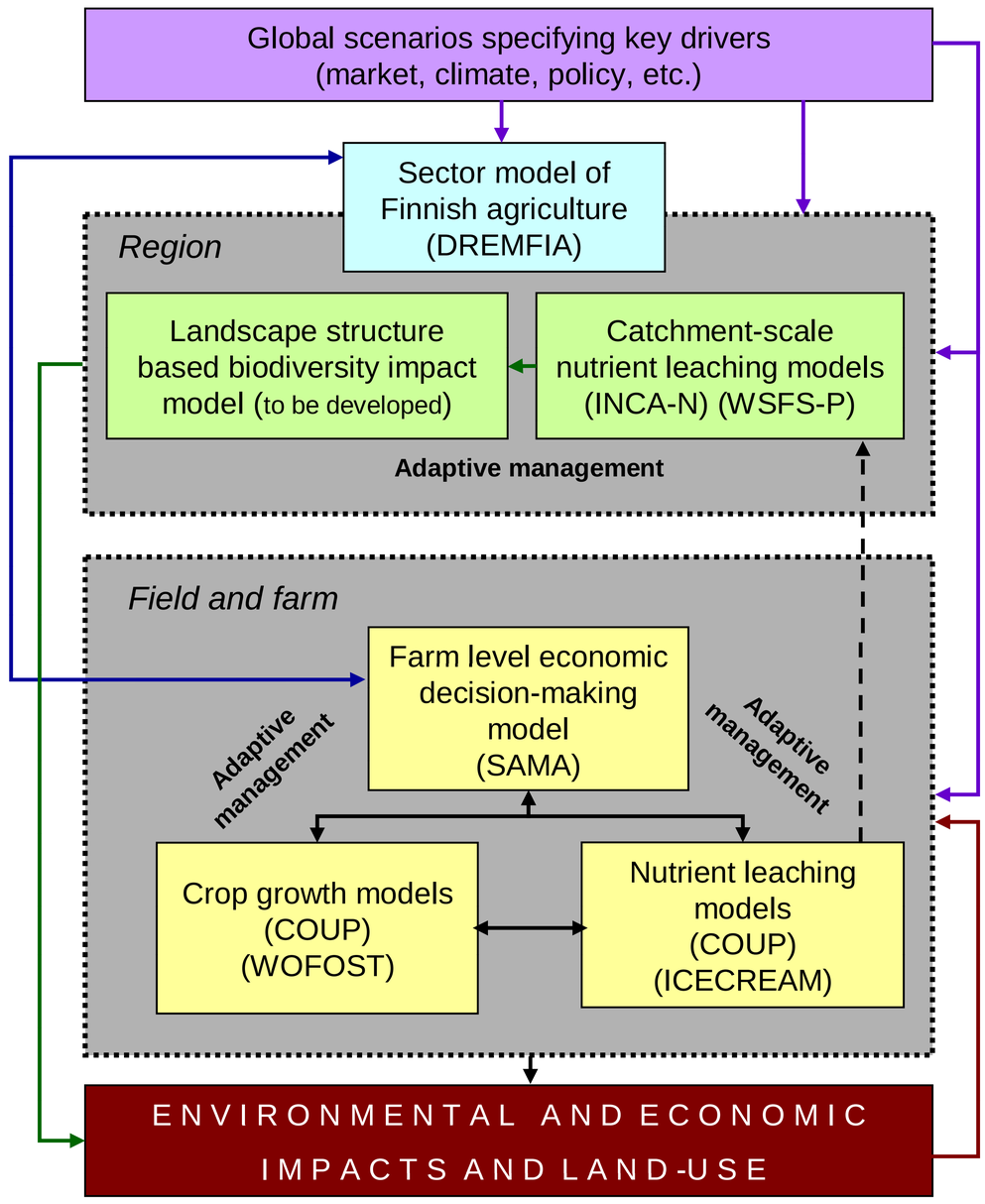

Fig.1. The integrated modelling framework AGRISIMU.

The starting point in the AGRISIMU modelling framework (**Fig 1.**) is a set of alternative scenarios of the main driving factors of global change, that are down-scaled to construct regional scenarios of the major factors likely to influence agro-ecosystems. While the analytical steps connect different management and decision levels from field to supra-national, the tools being developed and interlinked focus on the farm and regional levels. AGRISIMU is being build by revising existing and designing new models (see Box and [2]), interlinking the models or their results at the farm (in SAMA) and regional/catchment level (DREMFIA) and integrating the information in a GIS environment. At this stage, still most of the models require further evaluation and improvement before they can be integrated in AGRISIMU framework. A first test of AGRISIMU as a whole is planned in a data-rich LTSER (Long-Term-Socio-Ecological Research) catchment in south western Finland.

We conclude that AGRISIMU represents a novel approach to integrate data and output from several existing models. While sector models linking agricultural policy, economics and land use have long existed, a spatially explicit treatment of the interactions between land use and impacts on nutrient flows, biodiversity and climate change has not yet been attempted.

Models included in AGRISIMU Integrated Framework

DREMFIA – a dynamic regional sector model of Finnish Agriculture

Lehtonen, H. 2001. Principles, structure and application of dynamic regional sector model of Finnish agriculture. Academic dissertation. Systems Analysis Laboratory, Helsinki University of Technology. Publisher: Agrifood Research Finland, Economic Research (MTTL). Publications 98. Helsinki. 265 pages.

SAMA - Static Agent Model of Agriculture - developed for several farm types in Finland

Helin, J., Laukkanen, M., Kiokkalainen, K., 2006. Abatement costs for agricultural nitrogen and phosphorus loads: a case study of crop farming in south-western Finland .Agricultural and Food Science, 15(4): 351-374 http://www.mtt.fi/afs/pdf/mtt-afs-v15n4p351.pdf

COUP – a model for soil-plant-atmosphere systems

Jansson, P.-E. and Karlberg, L. 2004. Coupled Heat and Mass Transfer Model for Soil-Plant-Atmosphere Systems. Royal Institute of Technology, Dept of Civil and Environmental Engineering, Stockholm, Sweden, 435 pp.

WOFOST – a dynamic crop growth simulation model

Boogaard, H. L., C.A. van Diepen, R.P. Rötter, J.M. Cabrera, and H.H. van Laar, 1998. User's guide for the WOFOST 7.1 crop growth simulation model and Control Center 1.5, Alterra, Wageningen, The Netherlands, 143 pp.

INCA-N – an integrated nitrogen model for multiple source assessment in catchments

Wade, A., Durand, P., Beaujoan, V., Wessels, W., Raat, K., Whitehead, P.G., Butterfield, D., Rankinen, K. and Lepistö, A. 2002. Towards a generic nitrogen model of European ecosystems: New model structure and equations. Hydrology and Earth System Sciences 6, 559-582.

WSFS-P - a hydrological rainfall-runoff model

Huttunen, I., Huttunen, M., Vehviläinen, B., Tattari, S. 2007. Large scale phosphorus transport model. In: Heckrath, G.,Rubaek, G. H., Kronvang, B. (eds.). Diffuse Phosphorus Loss : Risk Assessment, Mitigation options and Ecological Effects in River Basins: The 5th International Phosphorus Workshop (IPW5), 3-7 September 2007 in Silkeborg, Denmark. Aarhus, Aarhus Universitet, Faculty of Plant Science. P. 215-217. *DJF Plant Science*; 130. ISBN 87-91949-20-3.
http://www.agrsci.dk/var/agrsci/storage/original/application/115f2ba1481b6a113288c6f9a773d572

ICECREAM - a field-scale nutrient transport model

Yli-Halla M., Tattari S., Bärlund I., Tuhkanen H.-R., Posch M.,Siimes K. and Rekolainen S. 2005. Simulating processes of soil phosphorus in geologically young acidic soils in Finland. Transactions of the ASAE 48(1): 101–108.

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[1]Van Ittersum, M.K., Ewert, F., Heckelei, T., Wery, J., Alkan Olsson, J., et al., 2008. Integrated assessment of agricultural systems - A component-based framework for the European Union (SEAMLESS). Agricultural Systems 96, 150-165.
[2]Rötter, R., Lehtonen, H., Aakkula, J. et al., 2008. A framework for integrated assessment modelling of agricultural systems. MTT Agrifood Research Finland (manuscript), 22 p.