A methodology for enhanced flexibility of integrated assessment of policy impacts in agriculture

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Introduction

Agriculture interrelates with the socio-economic and natural environment and faces increasingly the problem of managing its multiple functions in a sustainable way. Growing emphasis is on adequate policies that can support both agriculture and sustainable development. Integrated assessment and modelling (IAM) can provide insight into the potential impacts of policy changes. An increasing number of IA models is being developed, but these are mainly monolithic and are targeted to answer specific problems. Approaches that allow flexible IA for a range of issues and functions are scarce. Recently, a methodology for policy support in agriculture has been developed that attempts to overcome some of the limitations of earlier IA models. The final project version of the proposed framework (SEAMLESS-IF) will be released shortly and initial results from the testing of the framework are available. The present paper provides a first evaluation of this methodology to improve flexibility of IAM in agriculture.

Method

SEAMLESS-IF is a component-based framework for agricultural systems to assess, *ex-ante*, agricultural and agri-environmental policies and technologies across a range of scales, from field–farm to region and European Union, as well as some global interactions. The framework is based on a software infrastructure that allows a flexible (re-)use and linkage of components. The components considered include individual models, database and indicators that are linked depending on the IA problem to be addressed. Usability of SEAMLESS-IF is supported by a Graphical User Interface (GUI) specifically developed to support interactions with end-users for all steps of the IA procedure. The methodology is described in more detail in Vvan Ittersum *et al*. (2008) and Ewert *et al*. (2009). Two example applications are used to demonstrate the flexible application of SEAMLESS-IF. These examples refer to (i) the impacts on European agriculture of changes in world trade regulations and (ii) regional impacts of the Nitrate Directive in combination with agro-management changes. The improved flexibility of SEAMLESS-IF is assessed with respect to its individual framework components (such as the indicator framework and library, database and models including their linking) and the phases and steps of the IA procedure (such as system, problem and scenario description, and the visualization of results).

Results

A summary of the results of the evaluation for the different framework components and the IA steps is provided in Table 1, whereas detailed information can be obtained from Ewert *et al*. (2009). A high level of flexibility has been achieved for most framework components. For some components, e.g., the indicator framework the flexibility to change this or add new frameworks is still limited, which may be subject to future development. Importantly, we show that improving the flexibility of IAM requires flexibility in model linking but also a

Table 1. Achieved degree of flexibility in SEAMLESS-IF for selected IA steps and framework components.

IA step / framework component	Characteristics	Degree of flexibility
System description	Spatial and temporal extent and resolution	Flexible
Problem and scenario description	Defines policies, farm characteristics, changes in external conditions and indicators	Flexible
Indicator framework	Considers four classifiers such as level of organization, environmental and economic goals, etc.	Limited
Indicator library	Organizes indicators according to the indicator framework characteristics	Very flexible
Database	Database of all model inputs and outputs including indicators and assessment results	Very flexible
Model linking	Linking of models available in SEAMLESS-IF and considered in the SEAMLESS-IF ontology	Very flexible
Visualization of results	Presentation and evaluation of results in form of tables, graphs, maps.	Flexible

generic set up of all IA steps. This includes the problem and scenario definition, the selection and specification of indicators and the indicator framework, the structuring of the database, and the visualization of results. A very important aspect is the flexibility to integrate, select and link data, models and indicators depending on the application. For instance, the linking of cropping and farming system models allows consideration of a range of crop successions, crop management options and their combinations which was not possible in earlier frameworks. Technical coupling and reusability of model components are greatly improved through adequate software architecture (with SEAMLESS-IF using OpenMI) and the use of ontology strongly supports the conceptual consistency of data-model-indicator linkages.

Conclusions

We demonstrate that the proposed framework enhances flexibility in IAM and that it is a good basis to further improve integrated modelling for policy impact assessment in agriculture. The presented framework has also limitations which require further development, e.g., the integration of new models (which requires specific programming expertise) or the propagation of model uncertainties (which requires a close link to the end-users). Also, the scientific basis for linking models across disciplines and scales is still weak and needs specific attention in future research. Importantly, enhancing flexibility can have negative trade-offs affecting model performance, quality of simulation outcomes and framework understanding and transparency. Accordingly, finding the right balance between specific and generic model solutions is crucially important when trying to improve flexibility in IAM.

References

Ewert, F., *et al*., 2008. Environmental Science & Policy. (in review)
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