



**System for Environmental and Agricultural Modelling;
Linking European Science and Society**

**Publishable final activity report of
SEAMLESS Integrated project**

Period from January 1, 2005 to April 1, 2009

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1 Introduction, Project objectives and Consortium

European agriculture and rural areas continuously change as a result of an enlarging EU, WTO agreements, introduction of novel agro-technologies, changing societal demands and climate change. Efficient and effective agricultural and environmental policies are needed to support sustainability of European agriculture and its contribution to sustainable development of society at large. Assessing the strengths and weaknesses of new policies and innovations *prior* to their introduction, i.e., 'ex-ante integrated assessment', is vital to target policy development for sustainable development. The European Commission has introduced Impact Assessment of its policies as an essential step in the development and introduction of new policies since 2003 (EC, 2005a). It is anticipated to contribute to a more coherent implementation of the European strategy for Sustainable Development (EC, 2001). Impact Assessment identifies the likely positive and negative impacts of proposed policy actions, enabling informed political judgements to be made about the proposed policies and identify trade-offs in achieving competing objectives. By nature it implies a demand for multi- and interdisciplinary research and tools, which allow inclusion and evaluation of views of different stakeholders.

The SEAMLESS integrated project (funded by the EU 6th Framework Programme for Research Technological Development and Demonstration, Priority 1.1.6.3. Global Change and Ecosystems (EC, DG Research, Contract No. 010036-2)) had the overall aims to overcome fragmentation in European efforts of modelling agricultural systems, and to provide a better information basis for impact assessment of agricultural and environmental policies. It has developed a computerized and Integrated Framework (SEAMLESS-IF) to assess and compare, ex-ante, alternative agricultural and environmental policy options, allowing:

1. Analysis at the full range of scales (farm to EU and global), whilst focusing on the most important issues emerging at each scale;
2. Analysis of the environmental, economic and social contributions of agriculture towards sustainable rural development and rural viability;
3. Analysis of a broad range of issues and agents of change, such as environmental policies, effects of an enlarging EU and trade liberalisation.

The integrated framework had the following specific objectives:

1. To develop and test a multi-perspective set of economic, social and environmental indicators of the sustainability and multifunctionality of systems, policies and innovations in agriculture and agroforestry, and to enable trade-off analysis.
2. To provide quantitative and qualitative tools and databases for integrated evaluation of agricultural systems at multiple scales and for varying time horizons.
3. To develop a software architecture that allows re-usability of model and database components and knowledge, also ensuring transparency of models and procedures developed.
4. To validate and demonstrate the applicability of SEAMLESS-IF in selected tests of its use.
5. To promote participatory development and use of SEAMLESS-IF, including dissemination, knowledge transfer and training.
6. To offer a generic and open structure, to allow SEAMLESS-IF to be open and applicable under changing policy demands.

In short, SEAMLESS-IF facilitates translation of policy questions into alternative scenarios that can be assessed through a set of indicators that capture the key economic, environmental, social and institutional issues of the questions at stake. The indicators in turn are assessed using an intelligent linkage of quantitative models. These models have been designed to simulate aspects of agricultural systems at specific scales, i.e. point or field scale, farm, regional, and European scales. Application of the models uses a pan-European database for environmental, economic and social issues. Some indicators, particularly social and institutional ones, are assessed directly from data or via a post-model analysis.

The linkage of models designed for different scales and from biophysical and economic domains uses a software architecture, and a design and technical implementation of models that allows this. The software architecture, SeamFrame, makes use of ontologies for consistency of concepts used throughout the framework and the Open Modelling Interface (OpenMI) to technically link components developed in different modelling environments.

SEAMLESS (www.seamless-ip.org) brought together 30 participants from 15 countries, with a vast amount of knowledge and expertise from economic, environmental, agronomic, social science and information technology disciplines. The project is coordinated by

1. WU, Wageningen University, The Netherlands
and has the following participants (numbers are the contract numbers):
2. INRA, Institut National de la Recherche Agronomique, France
3. CIRAD, Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France
4. UBER, Humboldt University of Berlin, Germany
5. ZALF, Centre for Agricultural and Landscape and Land Use Research, Germany
8. CRA, Agricultural Research Council, Italy
9. JRC, Joint Research Centre of EC, Italy
10. UMB, Norwegian University of Life Sciences, Norway
11. LU, Centre for Environmental Studies, Lund University, Sweden
12. IDSIA-SUPSI, Instituto Dalle Molle di Studi sull 'Intelligenza Artificiale, Switzerland
13. PRI, Plant Research International, Netherlands
14. LEI, Agricultural Economics Research Institute, Netherlands
15. ALTERRA, Alterra Research Institute, Netherlands
16. UNEW, Centre for Rural Economy, University of Newcastle upon Tyne, UK
17. SGGW, Warsaw Agricultural University, Poland
18. ILE ASVR, Institute of Landscape Ecology, Czech Republic
19. VUZE, Research Institute of Agricultural Economics , Czech Republic
20. LUEAB, Lund University Education AB, Sweden
22. UBONN, Institute for Agricultural Policy, University of Bonn, Germany
23. FLD (from 1-1-2007 replaced by 33. UOC)
24. IAMM, Mediterranean Agronomic Institute of Montpellier, France
25. UEVORA, University of Evora, Portugal
26. NUI Galway, National University of Ireland, Galway, Ireland

27. ANTOPTIMA, AntOptima, Switzerland
28. IER, Institut d'Economie Rurale, Mali
29. UVM, Gund Institute for Ecological Economics, University of Vermont, USA
30. CEMAGREF, Cemagref, France
31. UNIABDN, University of Aberdeen, UK
32. UEDIN, School of Geosciences, University of Edinburgh, UK
33. UOC, University of Copenhagen, Denmark

2 Work performed and End results

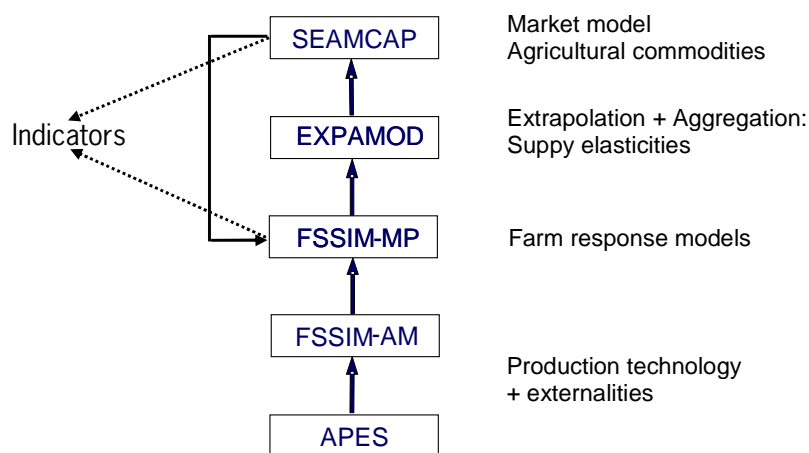
The major activities during the finalization of the project are described in the following and cover the following issues: (A) Completion of model components, both the components integrated in SEAMLESS-IF (Integrated Framework) and the presently not integrated components, (B) Completion of the Software infrastructure, (C) Completion of the Integrated database and typologies for agricultural systems in the EU, (D) Delivery of Prototype 3 and the final version of SEAMLESS-IF, and (E) Organization of the International conference AgSAP about Integrated Assessment of Agriculture and Sustainable Development (10-12 March, 2009) and the final meeting with users in Brussels (31 March, 2009).

Ad A) Completion of model components

A-1 Components integrated in SEAMLESS-IF

Existing and newly models, simulating for instance crop growth, farm behaviour and agricultural markets, have been integrated into SEAMLESS-IF (Figure 1). Key models are APES, FSSIM, EXPAMOD and SEAMCAP which are described in the following. The models simulate different aspects of the system at different levels of organization (from field to farm to region to EU) and have been further developed and integrated during the last year.

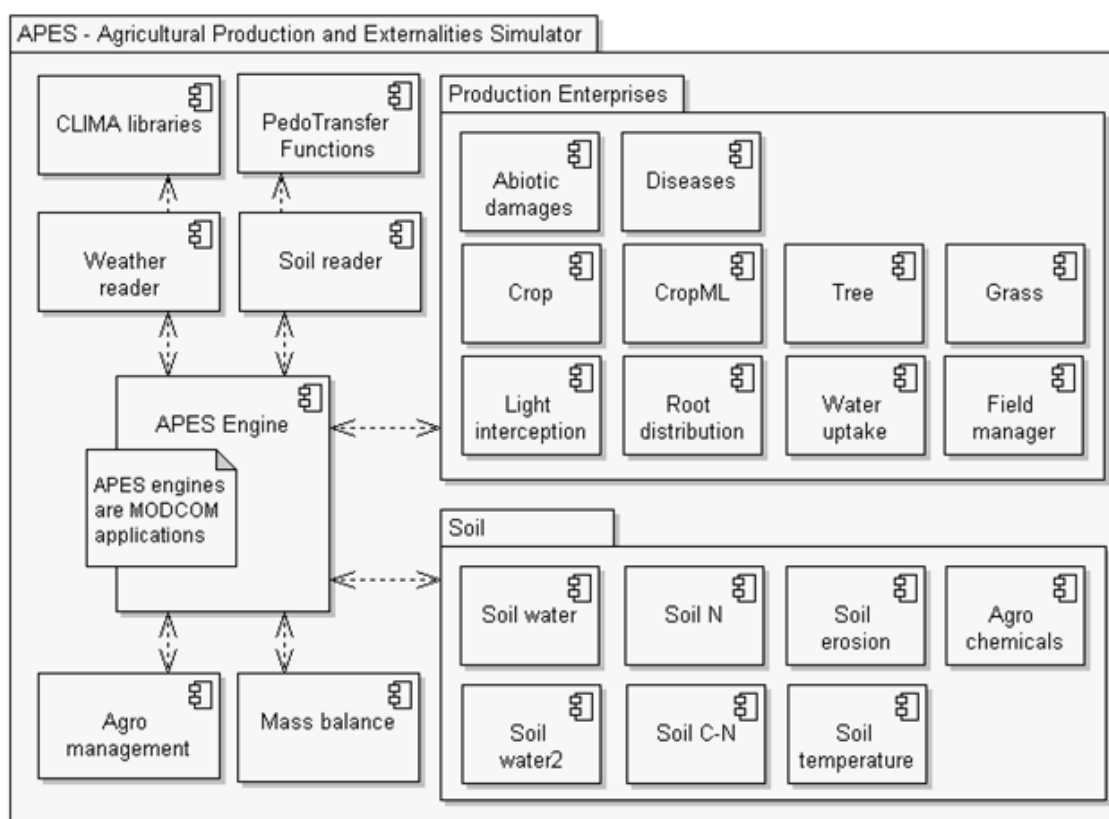
Figure 1: Backbone model chain of SEAMLESS-IF for field, farm and market level analysis (from the bottom to the top)



APES (Agricultural Production and Externalities Simulator; see home page: <http://www.apesimulator.it/>; Donatelli et al., in press) is a modular, deterministic simulation model targeted at estimating the biophysical behaviour of agricultural production systems in response to the interaction of weather, soils and different agro-management options. Using mostly modelling approaches already made available by research and previously tested in other simulation tools (cf. Van Ittersum and Donatelli, 2003), APES runs at a daily time-step in the communication among components and simulates one dimensional fluxes at *field scale*. APES computes the yields, both averages and variability across years, as well as inputs such as irrigation water and externalities of crop rotations. APES itself consists of several components representing land uses (crops, grassland, vineyards, orchards and agro-forestry), soil water, carbon and nitrogen, soil erosion, pesticide fate, and management activities (Donatelli et al., 2007; Donatelli & Rizzoli, 2007) and a component used to generate/estimate synthetic weather (Figure 2). The main components in APES required for its application

within SEAMLESS-IF, have been tested with data from several regions. APES has been designed to allow further extension of this list of components if required.

Figure 2: The APES “coarse” component diagram APES is composed of two main groups of software units: the simulation engine which uses the modelling framework Modcom, and the model components. Model components can be grouped into soil components, production enterprise components (crops, grass, etc.), weather, and agricultural management. Note that there are alternative options for simulating soil water and soil nitrogen (Soil water 2 and Soil C-N)



FSSIM (Farm System SIMulator) is a bio-economic farm model (Janssen and van Ittersum, 2007) developed to quantify the integrated agricultural, environmental, economic and policy aspects of farming systems (Louhichi et al., in press; 2007). FSSIM has been developed to assess the response of the major farm types across the EU in response to policies and agro-technological development. FSSIM includes a data module for agricultural management, FSSIM-AM, which computes the technical coefficients and costs for ranges of current and alternative agricultural activities, and FSSIM-MP, the mathematical programming part which aims to capture resource, socio-economic and policy constraints and the farmer’s major objectives. FSSIM-MP is a comparative, static mathematical programming model with a non-linear objective function representing expected income and risk aversion towards price and yield variations. It assumes that prices are exogenous to the farmer and these prices are provided through simulation by the SEAMCAP agricultural sector model.

FSSIM-AM comprises components for arable and livestock activities. It can be linked to APES to assess productivity and externalities for arable and livestock activities. Both current and alternative (e.g. arable) activities can be simulated through the use of the biophysical modelling system APES.

FSSIM-MP seeks to represent the actual farmers’ behaviour using the knowledge of technical and socio-economic constraints and includes:

1. the objective function describing the farmers' behaviour as a maximization of expected income minus a measure of its variability; and
2. the set of explicit constraints related to technical (land, water, equipment) and socio-economic resources (labour, finances, cash flow) as well as those related to policy and environmental measures (e.g. price and market support).

FSSIM aims to represent the main farming types of and geographic locations across the EU25. Hence, FSSIM models have been finalized for at least 13 regions over Europe and have been tested in two Test Cases (i.e. impacts of Trade liberalization at EU scale and of Nitrate directive at the regional scale). FSSIM has a modular structure such that it can be used for a broad range of applications (Janssen et al., 2009)

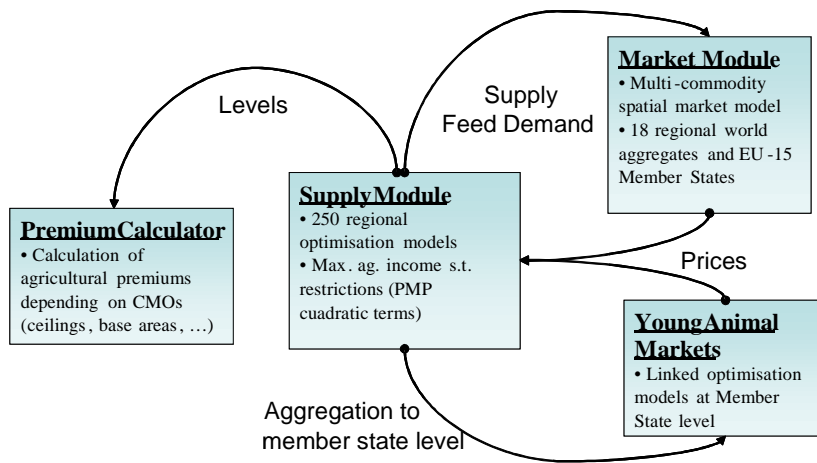
SEAMCAP is a version of CAPRI (Common Agricultural Policy Regionalised Impact) integrated in SEAMLESS-IF, i.e. an agricultural sector model of the EU (Heckelei and Britz, 2001; Britz et al., 2007). It is a comparative static equilibrium model, solved by iterating supply and market modules. SEAMCAP has been integrated in SEAMLESS-IF, after being tested and applied in many projects in its original form (i.e. CAPRI).

The economic model consists of two major modules, covering supplies and markets (Figure 3). The supply side of SEAMCAP consists of non-linear programming models at NUTS-2 level, allowing direct implementation of most policy measures with highly differentiated sets of agricultural activities. Allocation is based on profit maximising behaviour and calibrated multi-product cost functions. Prices are exogenous in the supply module and are provided by the market module of SEAMCAP. The regional supply modules (ca. 300 regions in the EU-25) represent activities of all farmers at farm type level captured by the Economic Accounts for Agriculture (EAA).

The programming models are a kind of hybrid approach, as they combine a Leontief-technology for variable costs covering a low and high yield variant for the different production activities with a non-linear cost function which captures the effects of limited labour and capital mobility among activities on farmers' decisions. The non-linear cost function allows for perfect calibration of the models and a smooth simulation response rooted in observed behaviour.

The market module consists of two sub-modules. The sub-module for marketable agricultural outputs is a spatial, non-stochastic global multi-commodity model for about 40 primary and processed agricultural products, covering the whole world aggregated to 18 trading blocks. Bi-lateral trade flows and attached prices are modelled based on the Armington assumptions (Armington, 1969). The behavioural functions for supply, feed, processing and human consumption apply flexible functional forms where calibration algorithms ensure full compliance with micro-economic theory. The market module endogenously adjusts EU- and international prices to achieve market equilibrium. It also allows the assessment of the impact of a large set of bi- and multilateral trade policy instruments.

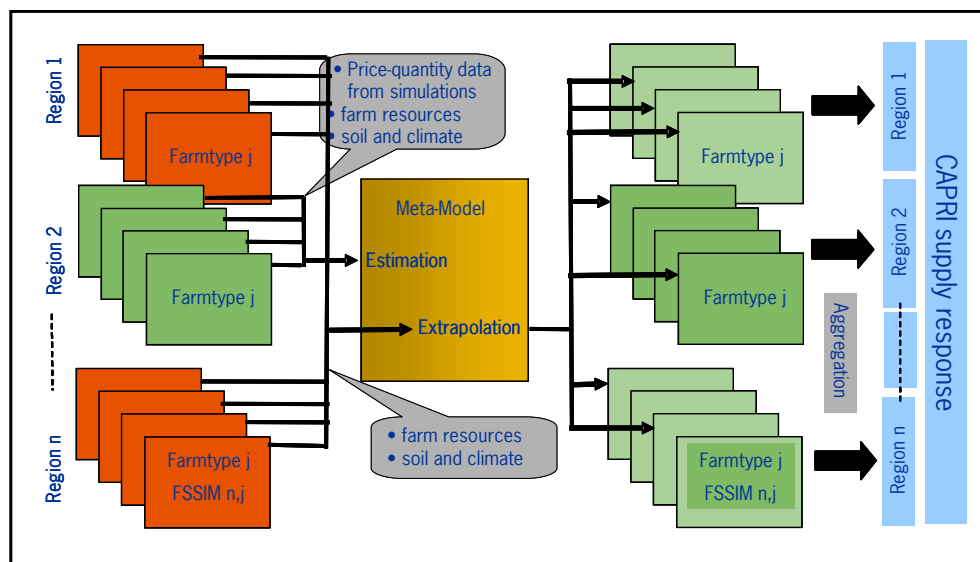
Figure 3: The SEAMCAP Modelling System



EXPAMOD (Extrapolation Model) is used for up-scaling the outcomes from FSSIM to the European scale, in the form of price-supply relationships (Pérez Domínguez et al., in press). EXPAMOD estimates a meta supply response function, by means of an econometric approach, depending on price variations, farm characteristics, and corresponding soil and climate conditions. The marginal effects of prices are extrapolated to those farm types and regions not covered by FSSIM models. Finally, price supply elasticities (relative marginal effects) are calculated and aggregated to match the product categories distinguished in SEAMCAP.

The applied approach for extrapolating the supply behaviour of the farm models (FSSIM) to the market model (SEAMCAP) with EXPAMOD is summarized in Figure 4.

Figure 4: Extrapolation of supply responses from FSSIM to SEAMCAP with EXPAMOD



A-2 Other model components presently not integrated in SEAMLESS-IF

GTAP-SEAMCAP linkage. GTAP (Global Trade Analysis Project) is a comparative static, multi-sector, and multi-region general equilibrium model developed by the GTAP consortium (www.gtap.org). In SEAMLESS the agricultural sector model (SEAMCAP) and GTAP have been conceptually linked in a flexible and generic manner (in the sense of not being focussed on a one-off application). The linking aims at combining the strength of CAPRI in detailed modelling of the EU agricultural sector with the economy-wide modelling of GTAP. The combination of the two models allows assessing in detail the impacts of changes in the overall economy on the agricultural sector in the EU as well as the impact of changes in this sector on the overall economy.

Structural change module. The structural change module in SEAMLESS is used to retrieve time-adjusted aggregation weights which allow to establish regional coverage and change the farm type distribution over time in the up-scaling procedure from the farm to the market level. Transition probabilities representing the likelihood of a farm to move from one farm type to another are estimated in a Markov chain approach and related to a number of explanatory variables (trend, unemployment rate, output prices). The analysis makes use of micro and macro data information coming from the FADN sample. The time series employed reach from 1990 to 2003 and cover the EU15. The farm typology applied distinguishes between a size and a specialisation dimension. In total 30 farm types are considered. In order to illustrate the functioning of the structural change module, the SEAMLESS test regions (the Netherlands as representative for Flevoland, Brandenburg, Midi-Pyrénées, and Andalucia) were analysed both in terms of a descriptive part and in terms of estimation results.

SEAMLESS Landscape Explorer. Three-dimensional (3D) visualisation of the landscape is often used for communicating with various stakeholders. The challenge in integrated assessment is to visualize future changes in agricultural land use, according to different scenarios. In SEAMLESS the pressures causing changes in landscape will come from the bio-economic farm model (FSSIM) which will then be translated into changes in the spatial configuration of the landscape. The mapped results (environmental data such as land cover and land use) will be used here to compute and visualise a 3D scene. In an integrated assessment, the landscape visualisation component (the SEAMLESS Landscape Explorer, SLE) can be launched at the end of a scenario simulation to allow for exploration of landscape changes. Visualisation could have a significant implication for the choice of effective land-use policy, and could be used as a basis for discussion and negotiation within the community.

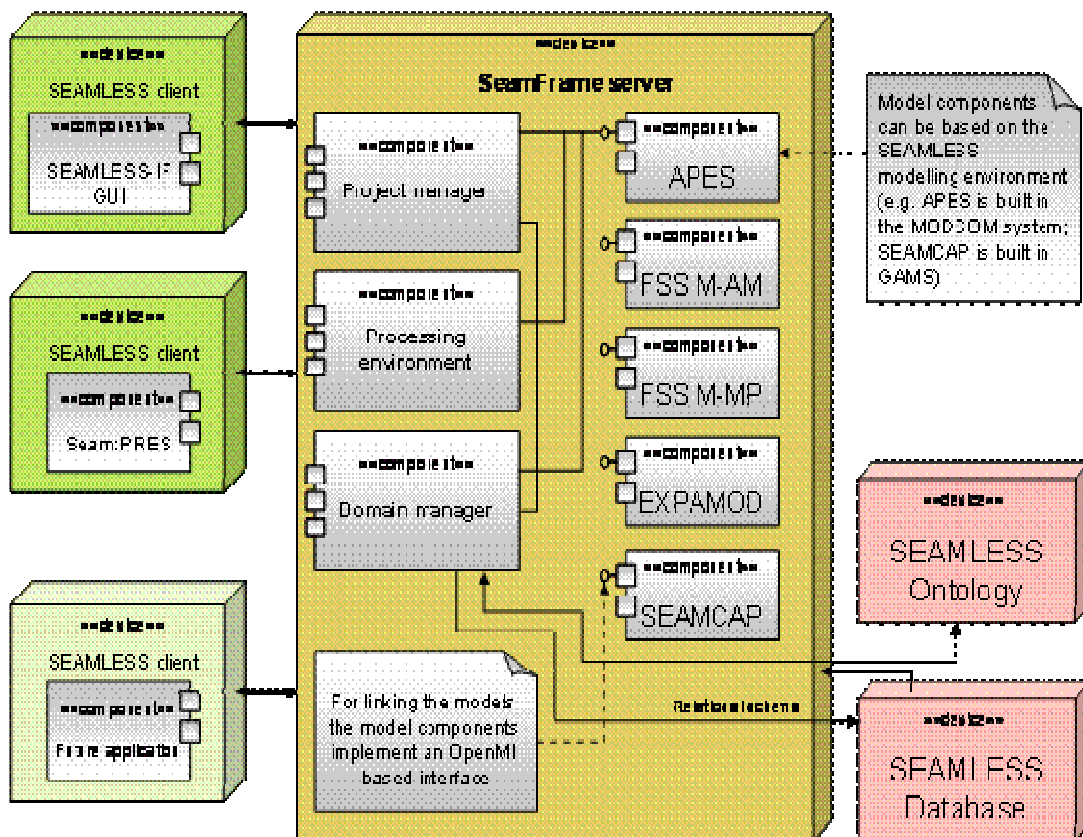
Procedure for Institutional Compatibility Assessment. The effectiveness of a policy depends to a large extent on the degree of compatibility between this policy option and the respective institutional context. Within SEAMLESS we have developed the 'Procedure for Institutional Compatibility Assessment (PICA)' as a systematic procedure to use information from ex-post case studies and indicator databanks for making ex-ante predictions of the institutional feasibility of policies. PICA comprises four steps: 1) policy options are clustered according to the type of intervention, the area of intervention and the nature of the problem addressed; 2) each policy cluster is linked to specific sets of crucial institutional aspects (CIA) that may constrain or foster policy implementation; 3) institutional indicators are used to evaluate the potential of a respective CIA; 4) a combination of the identified CIA and assessment of their relative explanatory power leads to statements about the probable effectiveness of a policy option. The mainly qualitative PICA outputs are arranged in thematic categories of institutional compatibility.

Indicator framework. The ambition of the Goal Oriented Framework (GOF) has been to create an indicator framework in which the environmental, economic and social dimensions of sustainable development (SD) can be related to each other in a consistent way. Integrated assessment tools rely on such frameworks to capture and visualise tradeoffs among indicators between and within the three SD dimensions. The major rewards of the GOF are its relative simplicity and the possibility to link indicators to policy goals of each dimension of sustainability. Another important feature of the GOF is its multi-scale perspective, which will enable the comparison of effects of a new policy between scales. Yet, as typical for all indicator frameworks, also the GOF is not free from biases either determined by the models used or the stakeholders' selection of indicators. However, due to the way the GOF and its indicators are technically implemented in the SEAMLESS-IF, it can easily be extended and include new indicators to increase and update its policy relevance. SEAMLESS-IF contains a comprehensive indicator library to assess the impacts on multiple scales covering the three dimensions of SD. Across scales a total of 80 environmental, 140 economic and 11 social indicators have been or will be integrated into SEAMLESS-IF.

Ad B) Completion of the Software Infrastructure

SeamFrame stands for the SEAMLESS-IF software infrastructure: its core runs on a server and provides the services that can be used by the several SEAMLESS client components and applications. SeamFrame is composed of a set of software tools and components such as the modelling environment, project manager, processing environment and the domain manager (Figure 5) and has been finalized. The SeamFrame server interacts with the SEAMLESS database and knowledge base.

Figure 5: SEAMLESS-IF software infrastructure, with its SeamFrame server and end-user (client) applications



Ontology

The SEAMLESS ontology plays a central role in SEAMLESS-IF to harmonize and relate different concepts expressed in the different representations of knowledge: from models, to indicators, down to source data formats, etc. (Janssen et al., in press). SeamFrame thus uses an ontology to structure domain-specific knowledge and to attach semantic meta-information to software components in order to facilitate organisation, retrieval and linkage of knowledge. To guarantee consistency between the database and the ontology, the domain manager automatically generates the relational database schemas from the ontology (Janssen et al., in press). The ontologies and their content are then stored in the knowledge base. The use of ontologies to semantically annotate the component models allows, among other things, for checking the match between sources in terms of linking the proper output variables of a component to the input variables of a second component. Ontologies have been very instrumental in realizing interdisciplinary collaboration within the project.

OpenMI to link components

Modellers can develop their models using different modelling environments, such as MODCOM for the biophysical models and GAMS for farm economic and market models. The models must then be “wrapped up” as software components to be used in SeamFrame. This is achieved by implementing an interface based on the standard Open Modelling Interface (OpenMI; www.openmi.org). OpenMI provides a standardized interface to define, describe and transfer data between software components that run simultaneously or subsequently. The model wrapper must also access the SEAMLESS database using specific data access objects, which are also automatically generated from the ontology.

Supporting users

The project manager assists the user in the configuration of the integrated assessment problems: the user is guided in the definition of the problem description, the selection of the indicators and the model chains used to compute them. The project manager also allows to set the model parameters, define which data sets are to be used as inputs and to choose among alternative policy options to be tested and evaluated.

The processing environment orchestrates the execution of the experiments associated with an integrated assessment problem: it launches simulations and optimisations within the model components. On the client side, there are the graphical user interface of the Project Manager (SEAMLESS-IF GUI) that assists the user in the formulation of a project to perform the integrated assessment of alternative policy options, and the graphical user interface of the result browser (Seam:PRES) which enables the user to easily access, display, and compare the results of the policy assessments. SEAMLESS-IF is based on a layered, client-server architecture.

Ad C) Completion of the Integrated database and typologies for agricultural systems in the EU

The database of SEAMLESS

Although the database in SEAMLESS is primarily developed to feed the core models and store their results, it has also stand-alone value beyond the lifetime of the project. It provides a rich source of European farm and environmental data. The SEAMLESS database has been finalized and the data include:

- 1) Farm data from the EU wide dataset Farm Accountancy Data Network (FADN) organized in different farm types per region (NUTS1/2). The typology is based on a combination of three different dimensions, size, combined specialisation and land use and intensity. Per farm type per region more than 1000 variables are available referring to the economic, production, size, labour and structural characteristics. The farm information is specified at different spatial levels ranging from river basins, Nitrate Vulnerable Zones, HNV farmland to administrative boundaries;
- 2) Farm activity data for the main farming types in a selection of SEAMLESS sample regions providing a detailed understanding of the farming practices and main environmental characteristics;
- 3) European wide environmental data on climate, soil and topography at different spatial levels from grid to region;
- 4) Socio-economic and demographic information for all NUTS-2 regions in the EU;
- 5) Global data on farming and agricultural markets;
- 6) SEAMLESS modelled output results organized according to a long list of pressure and state indicators.

Typologies

A *farm typology* is needed to enable integrated economic, environmental and social assessments; linking farming data to environmental data; linking market level modelling to farm/field level modelling; linking statistical sources and expert knowledge; creating “Open source” data bases and communicating results. The farm typology developed in SEAMLESS is a logical extension of the Farm Accountancy Data Network typology using the economic criteria Size and Specialisation with two environmental criteria Intensity and Land use (Andersen et al., 2007). Hence the new typology uses the following dimensions:

- Size: measured as the economic size of farms;
- Intensity: measured as the total output in Euro per ha;
- Specialisation: measured as the standard gross margins from different types of crops and livestock;
- Land use: measured as the proportion of the agricultural area covered by specific types of crops.

To reduce the number of farm types the two last dimensions are combined into one dimension. This is possible because not all combinations of these two dimensions are relevant. A total of 189 farm types are defined which is the result of 3 size types, 3 intensity types and 21 combined specialisation/land use types. An example of a SEAMLESS farm type is then: Small scale, low intensity, arable/cereal.

The Agri-Environmental Zonation (AEnZ) is a biophysical typology based on a recently available detailed database on organic carbon content of the topsoil of Europe, the Environmental Stratification (EnS) and an Agri-mask. The AEnZ is used within the integrated assessment framework of SEAMLESS for field and farm level modelling. The basis for this typology is the Environmental Stratification of Europe (EnS) building mainly on climate and altitude characteristics. The 84 environmental strata were aggregated into 13 environmental zones (EnZs). These were then combined with organic carbon topsoil data (OCTOP) to cover the wide range of agri-environmental diversity of Europe. The EnZs/OCTOP land units were combined with an Agri-mask representing major obstacles for farming resulting in the final AEnZ typology. The Agri-mask, which is based on CORINE Land Cover, soil, altitude and slope data, divides Europe into three zones with different agricultural potential (suited, unsuited and marginally suited). The AEnZ consists of 238 land types of which 82 classes are referred to as suitable for agriculture (75.8% of EU27+).

Ad D) Delivery of Prototype 3 and the final version of SEAMLESS-IF

Prototype 3 was released as an intermediate delivery in April 2008. Prototype 3 included: 1) Improved GUI, 2) Integrated models and 3) Improvements in software architecture, ontology and database. The prototype integrated all the work in progress, to get feedback from the users. Prototype 3 was updated with regular (bi-weekly) releases with additional functionalities during the rest of the project. The evaluation of the third Prototype served as a basis for the specifications of the next and final releases of SEAMLESS-IF.

The evaluation of Prototype 3 and the development of specifications for the final version of SEAMLESS-IF has been done during the WP1 meeting held in June 9-11, 2008 in Thessaloniki. In this meeting, the demands for features and outputs of SEAMLESS-IF as envisaged by the component developers and the task force leaders, have been presented and these demands are compared with the specifications of SEAMLESS-IF that appeared to be possible from a technical point of view. This discussion has led to the features of SEAMLESS-IF that should and also could be functional by the end of 2008. Specific attention was given to the attainable flexibility of SEAMLESS-IF. In addition, a detailed work planning was produced to guarantee the delivery of the final tested version of SEAMLESS-IF in February 2009.

The work in autumn 2008 has resulted in an internal release of the Final version of SEAMLESS-IF on December 5. This version has after testing, bug-fixing, enhancing stability and performance been used for completing the documentation and on-line help. Since its release, the Final version has been updated as the work proceeds towards satisfactorily running the three main model chains (FSSIM-EXPAMOD-CAPRI-FSSIM, FSSIM and FSSIM-APES) and displaying the simulation results in Seam:PRES. In the mean time, a group of testers has provided feedback on a (bi)-daily basis. This has resulted in the delivery of the final SEAMLESS-IF to the European Commission in March 2009.

Ad E) Organization of the International conference AGSAP about Integrated Assessment of Agriculture and Sustainable Development and a Final meeting with Users in Brussels, entitled The future of Impact Assessment of sustainable agriculture and land use – The use of integrated assessment tools

The international AgSAP conference was held on March 10 – 12, 2009 in Hotel Zuiderduin, Egmond aan Zee, The Netherlands. The conference aimed to i) present the status of scientific approaches to assess agricultural systems and sustainable development, and ii) set the agenda for future research in this domain. Alternative methods and modelling approaches, applications and policy support options were evaluated, compared and good practices defined. Focus was on the linkage and integration of models as a method for improving natural resource use planning, policy making and policy implementation in agriculture. More specifically, the conference:

- Identified key challenges for modelling to support policy on agriculture and sustainable development;
- Presented scientific progress and challenges related to integrated assessment, such as scaling, component-based modelling at field, farm, regional, market and global level, assessing environmental, economic, social and institutional aspects and interdisciplinarity;
- Presented applications of modelling tools to assess and evaluate impacts of agricultural innovations and policies;
- Presented the use and relevance of integrative modelling frameworks (use and users, testing and disseminating).

The conference was structured to arrive at clear research and policy recommendations which were presented on March 31, 2009 in the final meeting with users in Brussels. Participants were from agricultural, environmental, economic, social and information technology sciences. Contributions may address methodological or theoretical issues, applications or dissemination and participatory aspects. Applications related to for instance agro-technical innovations, agricultural policy reforms, agri-environmental policies, natural resource management, climate change, bio-based economy (incl. bio-fuels), rural development and trade liberalization.

The conference brought together ca. 300 participants from about 55 countries. A total of 133 papers and 96 posters have been presented; a book of Proceedings (Van Ittersum et al., 2009) presents 2 pages abstracts of these contributions. Selected papers are currently reviewed for publication in four special issues of scientific journals. The plenary session of the conference introduced the importance of a knowledge agenda towards agriculture and sustainable development. It targeted both the scientific and policy communities and included an opening address by the Dutch minister for Agriculture, and presentations by representatives from the OECD, IFPRI EC and SEAMLESS. This was followed by 17 parallel sessions on specific scientific topics related to integrated assessment of agriculture and sustainable development (see [parallel sessions](#) during the conference). The final part of the conference focused on the broader societal use and impact of integrated assessment tools, including the contribution of science-policy interaction and ends with a plenary discussion on (a) key findings from the conference on science-policy interactions, (b) research gaps, (c) strategies for improved decision making processes, and (d) development of proposals to strengthen a European knowledge agenda on agriculture and sustainable development.

The conference was very well received by its participants – some quotes from participants to illustrate this: “Thank you for the perfect organisation of AgSAP”; “My colleagues and I very much enjoyed the conference - the opportunity to hear Minister Gerda Verburg's vision, to meet with so many researchers from a wide range of disciplines, and discuss the results from the AgSAP project was really valuable”; “By the way, very nice conference in Egmond. I was really pleased with the quality of the papers/posters and the good mix of keynote speakers, congratulations for the effort!”; “The conference was very informative and I enjoyed the conversations”; “Congratulations to you and your colleagues to a successful event!”; “It was a great meeting, I enjoyed it a lot, it was also a pleasure to meet you and many of my friends in Wageningen”.

This is what we as organizers had in mind – the conference appeared to be a good basis for disseminating information about the SEAMLESS approach and other integrated assessment approaches among scientists. During the Forum meeting of the conference, highlights and concluding statements were identified in an interactive fashion. The conclusions were presented on March 31, 2009 during the final users meeting “The future of Impact Assessment of sustainable agriculture and land use – The use of integrated assessment tools”. Some of these conclusions are given in the following:

1. What are key scientific achievements and insights derived from the AgSAP conference:

- o Integrated Assessment has succeeded: models, data and computer technologies are there and integrated;
- o Research is moving away from “all-in-one” models to modularity and linkages;
- o Re-usability of methods allows us to focus on key research questions;
- o Progress in integrating of socio-economic and ecological models;
- o Direct iterative involvement of stakeholders in the research process;
- o Many contributions from young scientists; increasing human capital in the area;
- o The social dimension is also integrated, not only economy and environment;

- o Scaling up and down is receiving a lot of attention;
- o Ontologies facilitate interdisciplinary work;
- o SEAMLESS and the conference in general linked many top scientists;
- o The need for integrated databases is acknowledged but not to a full shared understanding => we need more effort in promoting this kind of integrative work;
- o Young scientists have established themselves in the project (permanent positions).

2. *What are main scientific challenge:*

- o Create simpler models to avoid data availability problems and better be able to explain and understand model results;
- o Model linking and integration that is consistent with up- and downscaling, as well as aggregation and disaggregation;
- o Need to better integrate the social dimension of sustainable development;
- o How to involve key stakeholders and methods into the integrated assessment approaches?
- o Share the scientific achievements in a standardized way (e.g. library of open source)
- o We need more integrative scientists;
- o Timing is important to stakeholders; methods (qualitative/quantitative) should be available;
- o Competence of researchers to communicate (translate) sound theoretical basis for IA (new discipline with integrative elements);
- o Theoretical basis for integration assessment needed;
- o Research into modeling architectures needed;
- o Lack of evaluation and validation actions (this includes problem of data scarcity);
- o Modelling architecture and software: tension between what is possible (and not) from IT perspective and what researchers are willing to accept and can do. IT has a lot to offer but there is a gap between science and IT;
- o Stakeholders have limited time and are approached by many projects; a limited resource we are all mining; some coordination e.g. through financiers of research would be good.

3. *How to strengthen science-policy interaction*

- o Need for long term committed user groups;
- o Mutual learning between scientists and policy makers;
- o Enough complexity describing the system, but simple enough to use and obtain meaningful results;
- o We need translators (wrappers) to make scientific achievements useful for policy making;
- o There is a tension between innovation (new tools) versus trust and confidence in old tools;
- o Coordination of stakeholder in and between projects;
- o Stakeholder groups ideally should survive across projects and they may themselves form new initiative in the science-policy interaction or be 'reused' for new projects;
- o Young researchers do not have incentives to focus on the science –policy dialogue as this is not (normally) rewarded in the academia. Does not result in papers;
- o Sabbatical leave among university staff could be spent in developing countries for

knowledge transfer; but sabbatical leaves are becoming more rare;

- o Internships can be used for scientists in policy organizations as well as policy people to spend time in scientific organizations;
- o Policy makers should encourage and reward scientists not only to develop models, but also to maintain systems;
- o Policy makers may appreciate different models and approaches.

For more information about the AgSAP conference, see <http://www.conference-agsap.org/> .

3 Dissemination and Use of Knowledge from the SEAMLESS project

Although modelling is central to integrated assessment in the SEAMLESS project, it is not seen anymore as a purely scientific activity that provides systems descriptions and prescriptions for decision makers but as a participatory approach with strong emphasis on communication. In fact, integrated assessment and modelling represent a problem-focused area of research, i.e. mainly project based and undertaken depending on stakeholder needs or demands (Parker et al., 2002). Thus, both modelling and stakeholder involvement are seen as important elements of the assessment procedure applied in SEAMLESS-IF.

In awareness of the importance of integrated assessment for policy decisions on sustainable development, the European Commission has introduced Impact Assessment (IA) of its policies as an essential step in the development and introduction of new policies since 2003 (EC, 2005b). IA (and thus SEAMLESS-IF as part of IA) should contribute to an effective and efficient Regulatory Environment and, with regard to the economic, social and environmental dimension of Sustainable Development, to a more coherent preparation of EU decision-making.

In order to develop a useful, up to date policy tool for integrated assessment of agricultural and environmental policies within the SEAMLESS project, the interaction with users, stakeholders and the general public has been and will be of major importance. The engagements with the public included activities aiming at spreading awareness and knowledge and at exploring the wider social implications of the proposed work.

Prime potential users of SEAMLESS Integrated Framework are the Directorates General (DG Agriculture, Environment and Economics and Finances) of the European Commission, the JRC and the European Environment Agency (EEA). In addition to that, we also aim at making the tool relevant for national/regional policy making agencies, farmer's organizations (e.g. COPA) and NGOs (e.g. EEB). A third important future user group we targeted is the scientific community. In order to learn about the needs of these potential user groups, a key objective in the SEAMLESS project was to involve users in the development of the tools from the very beginning of the project.

The activities related to the dissemination of knowledge during the project can principally be categorized under the following headlines as described in the following:

- (a) User Forum and user meetings;
- (b) Press items;
- (c) Course activities;
- (d) Presentations at scientific conferences and meetings;
- (e) International scientific conference AgSAP;
- (f) Newsletters and SEAMLESS website;
- (g) Publications, special issue and SEAMLESS book.

User Forum and user meetings

A Prime User Forum core group representing three DGs (Agri, Environment and EcFin), JRC and EEA has been established in year 1 and 2 of the project. User Forums have been held twice a year. The participants of this meeting were updated about the main progress in the project, user requirements were defined and feedback was collected. The information and the discussions clearly affected the work in the project and the design of SEAMLESS-IF

(Bäcklund et al., in press). Subjects and items that were affected and shaped due to the interactions included: (a) Development of SEAMLESS-IF as a modular system to allow re-use and flexibility; (b) Development of the graphical user interface; (c) Definition of Test Case and possible future applications of SEAMLESS-IF and their users/stakeholders, (d) Identification of indicators; (e) Approach to uncertainty analysis, and, importantly, (f) Organization of maintenance, availability and extension of SEAMLESS beyond the lifetime of the project through a SEAMLESS Association (Section 4).

From 2008 onwards, more targeted user meetings have been held. In March 2008 information about SEAMLESS-IF has been presented and discussed in a user meeting with DG-EcFin and a meeting with COPA-COGECA.. In September 2008 meetings have been held at JRC-IPTS, Seville and at JRC, Ispra. The first meeting at IPTS was to present SEAMLESS-IF, to plan the work and to discuss ideas for future collaboration (one researcher of JRC-IPTS will stay involved in the further development of micro-macro linkages). The second meeting at JRC, Ispra was to discuss the use of JRC data by SEAMLESS and the quality of the results, and to discuss the availability of JRC data bases for future SEAMLESS work. In addition, contacts with national ministries have been intensified during 2008 and resulted a meeting to discuss science-policy interactions during the International AgSAP conference (see Section 2) and the participation of three member states (France, Sweden and The Netherlands) in the final workshop with users in Brussels on March 31, 2009. Three representatives gave a presentation about the experiences with impact assessment in their country. Generally, the set-up of SEAMLESS and the concrete plans for continuation were well received and users will follow opportunities for collaboration with interest.

Press items

Information about the SEAMLESS project has been published by various news media. Most interesting was the production by the Swiss TV programme microMacro of a documentary about the SEAMLESS project. The TV programme is based on filming in Lugano, Wageningen, on two farms in the north-eastern part of The Netherlands, Bonn and Brussels. This all took place in June 2006, being a basis for the 25 minutes documentary. The documentary has been broadcasted on the Swiss television in November 2006, is a professional piece of work, and is available now for wider use after substituting English for Italian speakers.

Course activities

The SEAMLESS project is an integrated project that deals with many scientific challenges. These are related to the interdisciplinary nature of the project, the linking of models ranging over scales from field to global, and the participatory methods. The advanced approaches applied within the project in these and other fields are of high interest to students involved in various courses of the participating partner universities. Many students have been participating in these courses.

Two training courses about the Integrated Framework SEAMLESS-IF and the application of integrated assessment tools in general have been held. The first SEAMLESS post-graduate course entitled *Integrated Assessment of Agriculture and Sustainable Development*², has been held in Wageningen, from November 16-22, 2008. Subsequently, the Division of Resource Economics at the Humboldt-University, the Institute of Systems Biology and Ecology of the Academy of Sciences of the Czech Republic and the Leibniz Institute of Agricultural Development in Central and Eastern Europe have organized the second training course entitled *Integrated Assessment of Agriculture and Sustainable Development in Central and Eastern European Countries*. The course took place in Nové Hradky (Czech Republic) on 2-6 February 2009. The objectives of the SEAMLESS courses were to present concepts for integrated assessment of agricultural systems and to understand how integrated

assessment and modelling can support ex-ante integrated assessment and decision-making processes. These courses were for PhD candidates, post-docs and all others interested in impact assessment and agri-environmental modelling. A new SEAMLESS course has already been scheduled for September 2010 in Montpellier. For more information about the training course in Nové Hradý, see

http://www.seamless-ip.org/PDF_files/CEE_SEAMLESS_training%20course_2_Call.pdf.

Presentations at scientific conferences and meetings

Presentations at meetings by SEAMLESS participants have been given in particular during six conferences:

- 1) the Symposium of Farming systems design, 10-12 September 2007, Catania, Italy with the objectives (a) to provide an opportunity to integrate knowledge across disciplines targeted at farming system analysis, design and innovation, (b) to compare approaches being used/developed in different research groups, and (c) to identify the available operational tools and the future research needs;
- 2) the Conference on the Science and Education of Land Use: A transatlantic, multidisciplinary and comparative approach, 24-26 September 2007, Washington DC, USA, seeking to explore the causes and consequences of current land use trends and dynamics related to society, economy and environment;
- 3) the ModSim07 Conference, 10-13 December 2007, Christchurch, New Zealand, International congress on modelling and simulation, focussed on Land, water and environmental management: integrated systems for sustainability;
- 4) the International Conference on Impact Assessment of Land Use Changes (final conference of the SENSOR project), April 7-10, 2008, Berlin, Germany: SEAMLESS project is co-organizer; meeting is focused on impact assessment, land use and landscape research, environmental economics, rural sociology and the science policy interface;
- 5) the 4th Summit of the International Society for Environmental Modelling and Software, July 7-10, 2008, Barcelona, Spain; SEAMLESS participated in various sessions to foster the discussion and interchange of challenges, ideas, and future research lines in environmental modelling & software;
- 6) The Congress of the European Society for Agronomy, September 15-19, 2008, Bologna, Italy: to identify new perspectives and frontiers for European agriculture in the third millennium.

As the development SEAMLESS-IF is continuing, we see the presentations of new SEAMLESS work at scientific conferences in 2008 and 2009 reflecting this development. Of course, many presentations about SEAMLESS work were given at the ***International scientific conference AGSAP*** about Integrated Assessment of Agriculture and Sustainable Development in March 2009 (see Section 2).

Newsletters and SEAMLESS website

SEAMLESS external newsletters have been distributed about two times a year. As the newsletters aimed at for a broad SEAMLESS external audience, the topics were chosen to give a general introduction to the project followed by more specific articles. Topics of the fifth issue were for example: (a) Status of the project; (b) Data bases in SEAMLESS-IF, (c) Procedure for Impact Assessment in SEAMLESS-IF, (d) APES model, the field level model in SEAMLESS-IF, (e) User's involvement in the testing of SEAMLESS-IF, and (f) International AgSAP conference. The newsletters have been sent to international stakeholders as well as national interest organizations and research colleagues. The newsletters have generally been received well and several contacts with additional stakeholders have been

initialised from newsletter recipients. At the occasion of the end of the project and the AgSAP conference a 20 page brochure of SEAMLESS and its main deliverables has been produced. The newsletters, brochure and other information material (animations) are available on the SEAMLESS website (<http://www.seamless-ip.org/>).

Results from the SEAMLESS project are made available through the SEAMLESS website. These results are available for scientific cooperation and for non-commercial applications. Available output from SEAMLESS consists of reports, software, data bases and the prototypes of SEAMLESS-IF. Besides, a list of publications that has resulted from the scientific work within SEAMLESS, has been made accessible here. The website gives the latest SEAMLESS news, information on objectives and organisation of the project (e.g. by way of flyer, newsletters, and introduction video), and the structure of SEAMLESS-IF.

Publications, special issue and SEAMLESS book

An overview article of the SEAMLESS project and its first results was published (Van Ittersum et al., 2008) in the journal Agricultural Systems and a special issue of Environmental Science & Policy about SEAMLESS approaches and a book volume of Springer with 13 chapters about SEAMLESS work are both in press (see References).

Four special issues of the scientific journals are in preparation as a follow up to the AgSAP conference. These issues will include ca. 10 SEAMLESS related publications.

4 Continuation of the work through the SEAMLESS Association

The SEAMLESS project has started to bring together key European research institutions and scientists in the domain of integrated assessment of agricultural systems. The delivered versions of SEAMLESS Integrated Framework, its components and components to be integrated in future are a starting point for continued and new research, testing and applications. New research projects have already been established and will be stimulated, both with SEAMLESS partners and new partners. To coordinate this continuation a SEAMLESS Association has been established.

SEAMLESS Association (established in March 2009) takes the maintenance and development of SEAMLESS Integrated Framework and several of its components further after the lifetime of the SEAMLESS project. SEAMLESS Association (www.seamlessassociation.org) has the role to maintain, license and disseminate SEAMLESS-IF and several of its components (models, database, tools). The Association brings together the method and expertise for model linkages, SEAMLESS-IF and improved and extended versions of several components.

All organizations that want to use SEAMLESS-IF and its components for not-for-profit purposes or that want to contribute to their development, can become member of the Association if they subscribe well defined conditions. Two types of membership exist: Developers and Users. For details, see the website of the Association.

It has always been an important principle of the SEAMLESS project that software and models developed in the project must be available under Open Source conditions. This indeed applies to almost all models and components developed, including SEAMLESS-IF; they are freely downloadable from websites. However, a pre-installed version of SEAMLESS-IF and the database on dedicated servers can only be used with login credentials obtained through membership of the Association.

Several applications of SEAMLESS-IF are anticipated during the years 2009 and 2010, including integrated assessments of high and low prices of agricultural commodities and adaptation strategies to climate change. New and continued research is also anticipated on specific components to improve landscape and regional assessments and modelling of structural change.

5 Pictures from the SEAMLESS project

Some pictures of the AgSAP conference and of the Integrated research work within the SEAMLESS project are presented in the following:

Figure 6: Impressions from the AgSAP Internal Conference: Opening by Dutch Minister Verburg of Agriculture and key notes by Rector magnificus Kropff of Wageningen University and Dr. Legg of OECD



Figure 7: Integrated research work and discussions in the SEAMLESS project

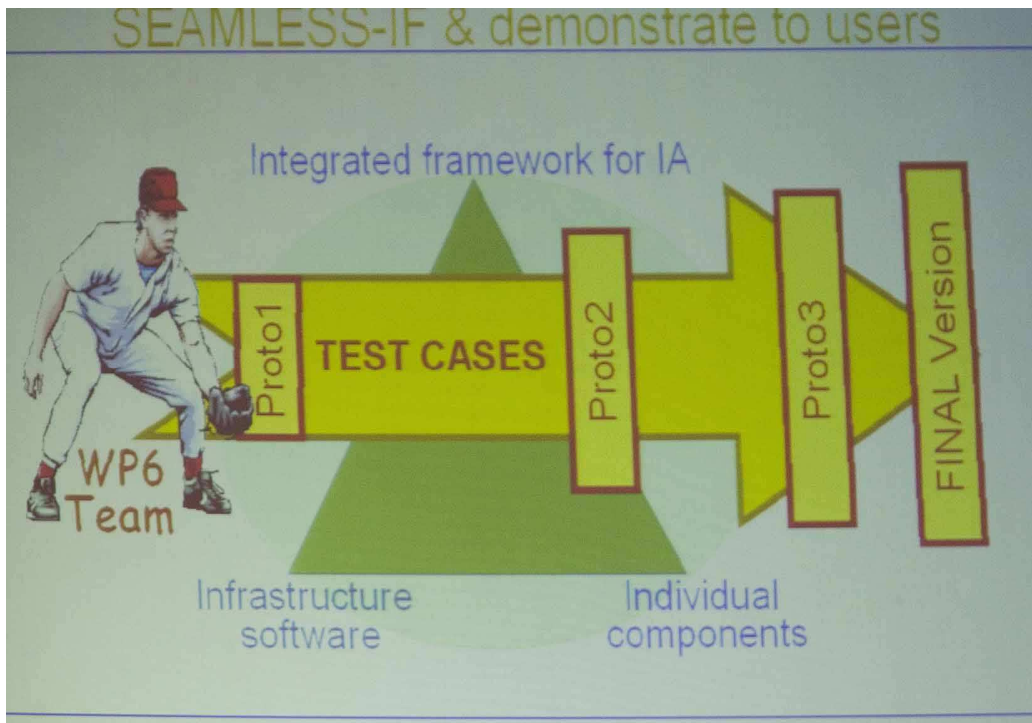
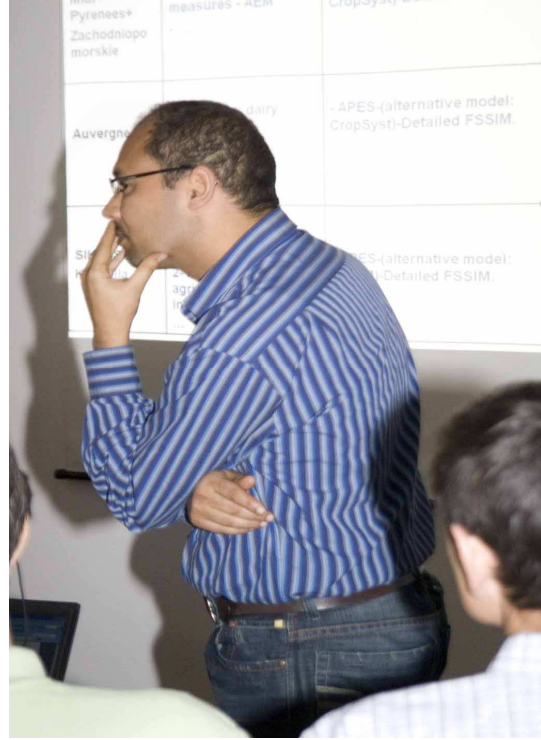
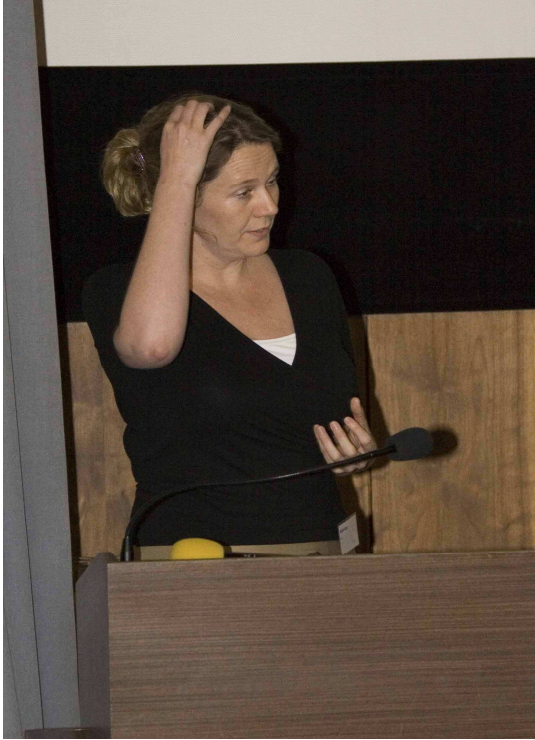


Figure 8: Impressions from the Annual symposium in Evora, May 2008



References for further reading

For more information about SEAMLESS-IF and its components, see <http://www.seamless-ip.org/> and choose (to the left) Publications.

There you can find:

- the full list of publications with links to the articles
- SEAMLESS reports to download.

Selected publications:

Overview article

Van Ittersum, M.K., F. Ewert, T. Heckeley, J. Wery, J. Alkan Olsson, E. Andersen, I. Bezlepina, S. Brogaard, M. Donatelli, G. Flichman, L. Olsson, A. Rizzoli, T. van der Wal, J.E. Wien, J. Wolf, 2008. Integrated assessment of agricultural systems – A component-based framework for the European Union (SEAMLESS). *Agricultural Systems* 96, 150-165.

Special issue (in press) of Environmental Science & Policy with the following articles (guest editors: Martin K. van Ittersum, and F. Brouwer, (see [ESP link](#)):

Alkan Olsson, J., Bockstaller, C., Stapleton, L.M., Ewert, F., Knapen, R., Therond, O., Geniaux, G., Bellon, S., Pinto Correira, T., Turpin, N., Bezlepina, I., 2009. A goal oriented indicator framework to support impact assessment of new policies for agri-environmental systems

Ewert, F., Van Ittersum, M.K., Bezlepina, I., Therond, O., Andersen, E., Belhouchette, H., Bockstaller, C., Brouwer, F., Heckeley, T., Janssen, S., Knapen, R., Kuiper, M., Louhichi, K., Alkan Olsson, J., Turpin, N., Wery, J., Wien, J.E., Wolf, J., 2009. A methodology for enhanced flexibility of integrated assessment in agriculture.

Janssen, S., Andersen, E., Athanasiadis, I., Van Ittersum, M.K., 2009. A European database for policy evaluation and assessment of agricultural systems.

Pérez Domínguez, I., Bezlepina, I., Heckeley, T., Romstad, E., Oude Lansink, A., Kanellopoulos, A., 2009. Capturing market impacts of farm level policies: a statistical extrapolation approach using biophysical characteristics and farm resources.

Therond, O., Belhouchette, H., Janssen, S., Louhichi, K., Ewert, F., Bergez, J-E, Wery, J., Heckeley, T., Alkan Olsson, J., Leenhardt, D., Van Ittersum, M., 2009. Methodology to translate policy assessment problems into scenarios: the example of the SEAMLESS Integrated Framework.

Zimmermann, A., Heckeley, T., Pérez Domínguez, I., 2009. Modelling Farm Structural Change for Integrated Ex-ante Assessment: Review of Methods and Determinants

A Springer book volume (in press): Brouwer, F.M., van Ittersum, M.K. (Eds.), Environmental and agricultural modelling: integrated approaches for policy impact assessment. Springer, Dordrecht, The Netherlands, with the following book chapters:

Bäcklund et al. - Science - policy interfaces in impact assessment procedures

Bergez et al. – Evaluating integrated assessment tools for policy support

Britz et al. - A comparison of CAPRI and SEAMLESS-IF as Integrated Modelling Systems

Brouwer and Van Ittersum - Introduction

- Donatelli et al. - APES: The Agricultural Production and Externalities Simulator
- Griffon et al. - Visualising changes in agricultural landscapes
- Hazeu et al. - The SEAMLESS Biophysical Typology: A Spatial Agri-Environmental Modelling Framework
- Louhichi et al. - A generic Farming System Simulator (FSSIM) for modelling European arable farming sectors
- Terluin et al. - Intensity of farming in EU regions
- Theesfeld et al. - New Frontiers in Institutional Policy Assessment
- Turpin et al. - Towards indicators of multifunctionality: assessing jointness between commodity and non-commodity outputs
- Van der Heide et al. - Usage of valuation studies in policy analysis, an international literature review with a focus on agriculture and agroforestry
- Wien et al. - Semantically rich model integration: the use of ontology in integrated assessment tools

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