SIAT, a Sustainable Impact Assessment Tool for Understanding the drivers in integrated impact assessment

P.J.F.M. Verweij[a], S. Sieber[b] , J.J.F. Wien[a] and K. Müller[b]: peter.verweij@wur.nl

[a] *Alterra, Green world research, Wageningen, the Netherlands*

[b] *Leibnitz-Zentrum für Agrarlandschaftsforschung (ZALF), Müncheberg, Germany*

Abstract: SENSOR is an Integrated Project within the 6th Framework program of the EU. The major outcome is the modeling approach Sustainable Impact Assessment Tool (SIAT). The knowledge-based model SIAT enables end users to assess the impacts of land-use relevant EU-policy strategies. The results are presented for European administrative regions (NUTS), though for specific issues the grid resolution of 1x1 km will be used. The six sectors agriculture, forestry, energy, transport, nature conversation and tourism are considered. Analytically, SIAT focuses on cross-sectoral trade offs and side effects of the impacts of new introduced EU-policies. The model concept is based on a wide set of pre-run model results that are implemented into SIAT in a consistent way. SIAT is a problem- and user-oriented tool that allows end users to modify basic parameter sets of Sustainability Impact Assessment according to the methodological framework of the EU-guidelines. SIAT facilitates analysis of impacts from policies and the process that lead to those impacts. Additionally it checks whether the impacts are within sustainability tolerance limits. In a first step the SIA-Tool is able to interpolate iteratively mechanistically single policy variables, but it will be widened by a generic approach that allows simultaneous simulations of newly grouped policy variables. Main challenges of the modeling approach are the consistent integration of pre-run model results by translating the policy variables into land use claims and land use claims into indicator values. A major challenge within the project is to keep all translations transparent.
SIAT will comprise a wide set of integrated policy instruments to be assessed simultaneously within bundles of policy variable sets that are currently of high importance in EU policy discussions. In this regard SIAT addresses the user group of EC policy maker, related joint research institutes and corresponding consultancies dedicated to outsourced Impact Assessments. A first prototype has been developed in October 2005. The second prototype will be developed at the beginning of June 2006.

***Keywords**:* Knowledge-based Model; Impact Assessment; Sustainability; Multi-functionality; Policy Consulting

1. PROJECT SENSOR

Ex-ante sustainability impact assessment is an important instrument towards the fulfillment of the European Sustainable Development Strategy [EC, 2001] and is obligatory to be conducted before each policy decision process at European level [EC, 2005].
Current operational tools address less integrated and comprehensive questions that include a wide range of analytical levels [Tamborra, 2002]. These tools are mostly restricted to qualitative sectored information on aspects of economic, social and environmental impacts, but in a very precise way or designed for ex-post analysis [Bartolomeo et al., 2004]. There is a strong need for integrated ex-ante impact assessment.
SENSOR is a European project to support this ex-ante sustainability impact assessment.
SENSOR is an Integrated Project within the 6th Framework Research Program of the European Commission and has a budget about 12 MEuro. Thirty-three research partners and eighty researchers from fifteen European countries constitute the consortium, which develops science based ex-ante Sustainability Impact Assessment Tools (SIAT) to support decision making on policies related to multifunctional land use in European regions. SENSOR directly responds to the European sustainability objectives as applied to land use and regional development.

1.1 Project Objectives

SENSOR's main product is the Sustainability Impact Assessment Tool (SIAT), developed to meet the needs of analysts and policy makers at the European level. SIAT will enable decision makers to assess the effects of land-use-related policies on sustainability by means of (1) European policy scenario analyses and (2) regional threshold assessments and target identification, which are validated via stakeholder participation at local level. Policy effects are expressed in terms of impact indicators which are calculated by making use of macro-econometrics and sectoral land use. European policy scenario analyses will be used to simulate future land-use changes, assess their multifunctional interrelations and analyze multi-criteria coherences of economic, social and environmental impacts.

In order to assess multifunctional land use effects at the regional level, impact indicators will be verified on the basis of sustainability thresholds and targets. Thresholds have a scientific basis while targets are derived from experts by Delphi-processes and stakeholder target findings at the local level. The outcomes will be validated by surveys conducted in case studies of sensitive regions such as mountains, coastal zones, islands and post-industrialized areas across Europe.

The principle of multifunctional land use can guide sustainable land management and policy development processes, since it seeks to combine a variety of social, economic and environmental functions. Single regions can provide goods and services for the international market while simultaneously satisfying local demands for rural populations (e.g. employment and quality of life), for urban centres (e.g. groundwater renewal, recreation) or for native species (e.g. habitats and biodiversity). Therefore, assessing the multi-functionality of land use is a key for understanding the trade-offs between the social, economic and environmental dimensions of sustainability. Regarding European policy decisions SENSOR addresses global economic and demographic trends and landscape impacts by analyzing the multifunctional interrelations of six leading rural land use sectors: agriculture, forestry, tourism, transport, energy and nature conservation at the regional level. The SIAT will allow the user to detect deficits, high-performances and conflicts regarding the multi-functional use of land.

2. SUPPORT OF SUSTAINABILITY IMPACT ASSESSMENT

Policies on land use are highly dynamic and have cross sectoral effects. Understanding the size and impacts of these effects as soon as possible improves effectiveness of policy creation.

Policies are made following the policy life cycle steps: (1) recognition, determine the nature and size of a problem, (2) policy formulation, issues are acknowledged and measures formulated, (3) solutions, measures are acknowledged and policies evaluated and (4) supervision, in which policies are implemented and (local) governments enforce and monitor the implementation [Winsemius, 1986].

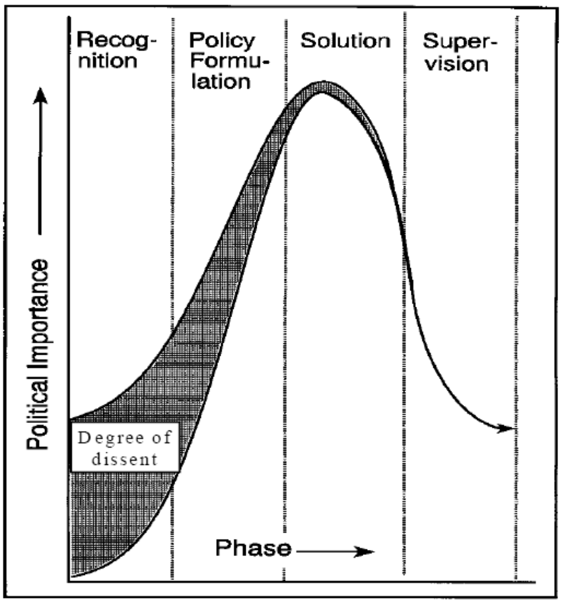

Figure 1. Policy life cycle

As a quick scan impact assessment tool SIAT supports both policy formulation and solution finding within the policy life cycle by indicating the strengths and weaknesses of different policy options (Figure 1). Alternative policy options can be compared within different reference scenarios.

2.1 Features

The SIAT modeling concept is defined as a transparent, quick scan and knowledge-based approach that offers a large number and high level of applied "real" policy options.

The knowledge based approach uses rules of thumb, which results in high performance. This is reflected by the short response time of the SIAT. To link the rules the SIAT complies to the Open modeling interface (OpenMI) standard for linking calculation components and tools [Gijsbers et al, 2002]. The use of this standard increases efficiency and minimizes the risk of system development [Wal et al, 2003].

Transparency of knowledge is guaranteed by (1) offering fact sheets for all implicit knowledge and (2) explicit back tracing of the knowledge used during calculations. Back tracing shows how and with which assumptions the calculations for a specific region within the EU were carried out, including information on the uncertainty bounds.

Policy options are a possible future change of policies of existing land use and range from non-monetary policy instruments (e.g. soil directive) to monetary instruments as taxes and subsidies (e.g. subsidies for renewable energies). For each of the policy options the impacts and risks are assessed in terms of sustainability indicators.

2.2 Methodology

SIAT is scenario driven and considers global economic, demographic and policy trends. It provides multidimensional perspectives for mid- and long-term land use changes. The tool focuses mainly on investigating multi-scale coherences as cross-scale analysis at a regionalized level of the EU. In addition, specific regions are analyzed and case studies for validations and verification are conducted.
In order to define the model SIAT, three model dimensions have been identified (figure 2).

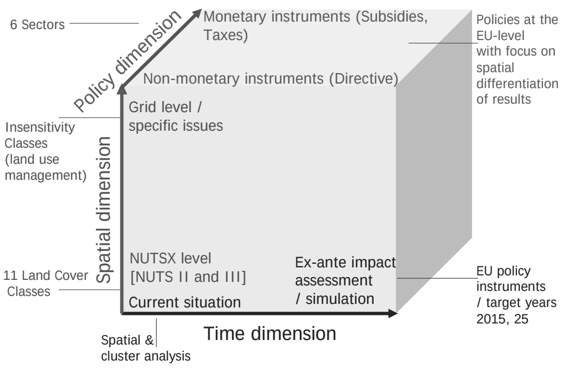

Figure 2. The three model dimensions in SIAT

The *time dimension* is subdivided into the current situation and the future perspective. SIAT focuses on the ex-ante impact assessment and simulate currently discussed EU-policies against the target years of 2015 and 2025.

The *policy dimension* consists of ranges from non-monetary policy instruments (e.g. the EU soil directive) to monetary instruments such as taxes and subsidies (e.g. subsidies for renewable energies).

The *spatial dimension* is defined by an administrative schematization (NUTS), which covers all 25 Member States plus four associated countries.
Macro economical modeling is carried out for administrative regions. In order to assess land use related impacts these administrative modeling results are disaggregated to grid level (1x1 km) using the CLUE model [Kok et al, 2000]. Consequently, land use modeling is done on this grid based schematization. Finally these grid based results are aggregated to the administrative schematization for sustainability impact assessment.

SIAT operates at two main analysis levels. At a first stage the (a) multi-functionality approach assesses the impacts of the cross-sectoral effects of introduced policy variables. This analysis level investigates the processes and shows the results via a wide set of multifunctional indicators. At a second level the (b) sustainability approach compares indicator results with introduced critical limits as thresholds and targets. The thresholds are defined as science-based tolerance limits, whereas the targets can be described in terms of policy-driven aims to be achieved. Both will be computed for clustered problem regions that reflect the same biophysical and socio-economic location factors with a similar multi-criteria profile.

The SIAT follows two main modeling-related principles: Transparency and back tracing. Transparency means that all calculation steps are explained by fact-sheets on indicators, model concept and quantified or ordinal reliability.
With back tracing actual computations of impacts can be backward analyzed to their drivers. This improves understanding of the factors that contribute most to the impacts. This improved understanding can lead to better policies.

The theoretical concept of multi-functionality has been developed as one key approach to implement sustainable development in the area of agriculture and land use [Cairol et al., 2005]. In this regard multifunctional land use is intended to integrate social, economic, and environmental effects simultaneously and interactively within the set of all observed land use actions.

Based on the multi-functionality concept, SENSOR aims at synthesizing assessment approaches for all three sustainability dimensions with quantitative tools where possible. If quantitative is not possible, qualitative information will be integrated.
Policy cases are translated into land use changes which are used to forecast sustainability impacts. Land use changes include multi-functionality aspects. Impacts are expressed in social, economic and environmental indicators.
A dual approach has been implemented (Figure 3) which (1) assesses the functional coherences between the introduced policy variable (policy response functions) with the claim of land use. This inter-correlation will be translated in a second step (2) by estimating the functional relation between land use changes and indicator values (indicator functions).

The innovation of SIAT is the derivation of response functions from integrated macroeconomic- and sectoral modeling. For each policy case (e.g. bio diesel) a separate derivation of sets of response functions will be made.
The *ex-post* policy case 'bio diesel' is used to validate the model's behaviour. There is a lot of data available on this policy case.

At national level the macro model NEMISIS [Kouvaritakis, 2004] safeguards the statistic accounting frame. The sectoral models CAPRI [Britz et al, 2003] and EFISCEN [Lindner et al, 2002] determine intra-sectoral coherences in agriculture and forestry. Feedback loops between the macro- and sectoral models assure model-specific equilibriums on the relation between policy instruments and sectoral land use claims. The consolidation of the model framework is reflected in equilibrium prices for demand driven land use claims. Only in the case of cross-model equilibrium, response function are derived and put into SIAT.

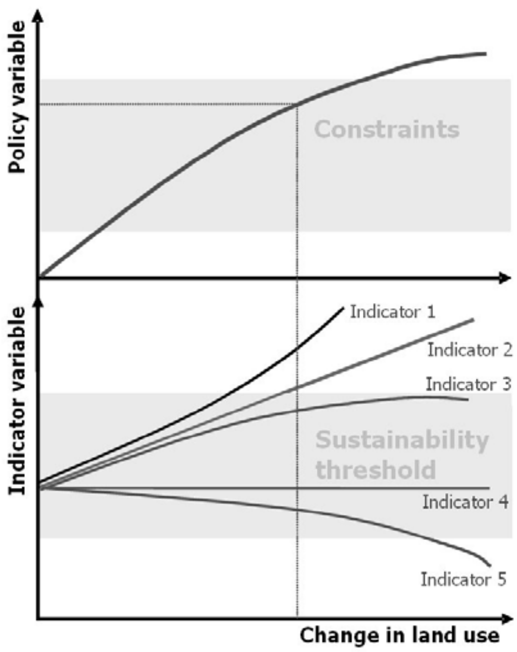

Figure 3. Dual approach of policy and indicator functions in SIAT

The main challenge of this modeling approach consists in the consistency of both (1) introduced policies to land use claims and (2) land use changes to changes in indicator values.

Another challenge is to create a truly stakeholder driven process of developing the SIAT. Since it are the experts who in general initiate the solution searching process, there is a natural tendency to provide tools that give too much direction in problem definition, solution space, and technical means to be used. This does not mean that the experts are wrong! Only, the increasing need to involve broader groups of stakeholders, and their increasing interest to be involved in policy requires an unbiased start [Wien et al, 2005].
Within the SENSOR project users are involved by the development of SIAT by means of continuous requirement analysis. Feedback from users is and will be derived through evolutionary prototyping [McConell, 1996].

Three main user groups have been identified: (1) The end user at the level of the EC, the (2) joint research institutes of the EU (e.g. JRC) and the (3) numerous consultancies, which dedicates to the outsourced EU-Impact assessments. Currently the requirements from end users at EC level and joint research institutes have been inventoried. Together with the experts' requirements these have resulted in the implementation of a SIAT application as described in this paper. This application will be used to gather new-, adapted requirements and improve the software product. The SENSOR project planned to have a number of these iterative improvements on the SIAT.

2.3 Application: The Simulation Procedure

The SIAT lays emphasis on simulating future scenarios. Thus, the procedure on how to define a scenario and how to solve the stepwise simulation run forms the heart of the tool.

The presentation sheets are derived from the first prototype and show the procedure on the basis of a "bio-diesel scenario". This scenario example consists of subsidies for bio-diesel production at regional level. The case shows that only those regions with a well developed infrastructure and high rape shares will gain in bio diesel production and therefore benefit from those subsidies. Less favorable regions will only gain in case of extremely high levels of subsidies.

A complete scenario comprises five steps: (1) base scenario, (2) applicable regions, (3) policy variables, (4) impacts and (5) risk assessment.

Step 1, base scenario

The first step (1) defines the macroeconomic reference scenario to compare results of different policy scenarios. The results of these reference scenario are projected to the same target year 2015 and 2025 of the policy scenario runs. SIAT distinguishes the reference scenarios: "business as usual", high-growth and low-growth. The high and low growth scenario respectively assume positive and negative anticipated developments of the incorporated land use drivers, oil price, R&D-expenditures, technological developments, demographic changes, climate change and global economic changes will be assumed. A fact sheet indicates the economic coherences and assumptions made.

Figure 4. Base scenario

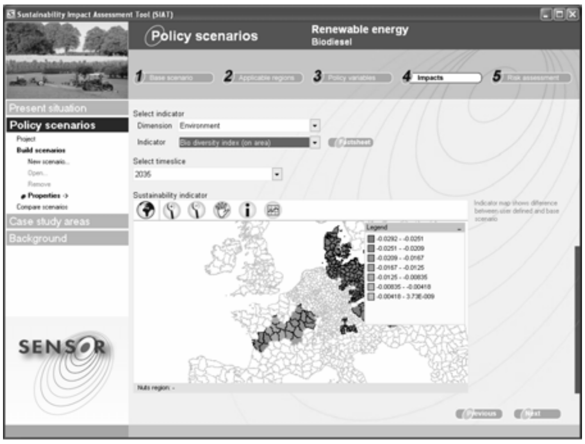

Figure 5. Impacts of the policy scenario

Step 2, Applicable regions

Once the reference run has been chosen, the next step (2) allows the end user to select the applicable regions for the policy measures.

Step 3, Policy variables

Step number (3) is the definition of policy measures expressed by policy variables. The user can choose from a wide set of sector- and policy-related policy variables.

Step 4, Impacts

Step number (4) investigates the impact results of the introduced policy variable "average subsidy renewables". SIAT shows in which regions the rape production was extended. In this case below the production increased only in those regions, in which the infrastructure for rape production is well developed and where high shares of rape already existed. Only in case of a very high amount of subsidies for renewable energies other less favorable regions will participate.

Figure 5 shows the changes on biodiversity. The biodiversity indicator is an easy compound of the local distribution and equal distribution of crop shares per region and indicates a potential of biodiversity change.

The relations of biodiversity and crop change caused by renewable subsidies are explained in detail in the fact sheets.

By pointing at a region SIAT shows which rules were used and how the outcome of an impact indicator value was determined. An example of an indicator function accompanied by reliability information is shown in Figure 6.

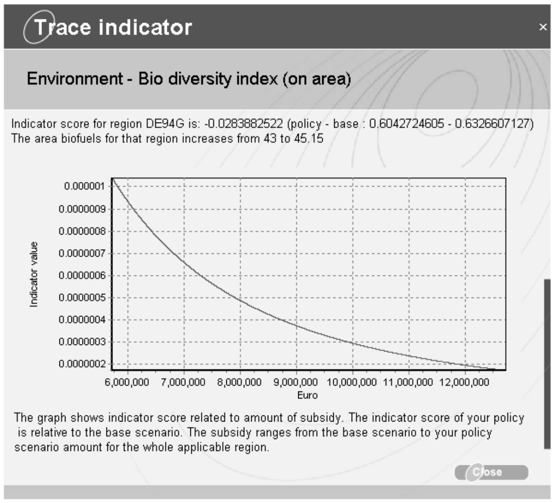

Figure 6. Impact indicator function

Step 5, Risk assessment

Step number five (5) is the sustainability impact assessment which is based on region specific indicator thresholds.

The policy scenario that has been defined and analyzed in these steps is based on a single indicator.

A more balanced analysis would take all or groups of indicators into account. Furthermore, multiple scenarios need to be compared with each other. Figure 7 shows an example of the amoebe type approach on how SIAT will address this multiple indicator / scenario comparison in the near future.

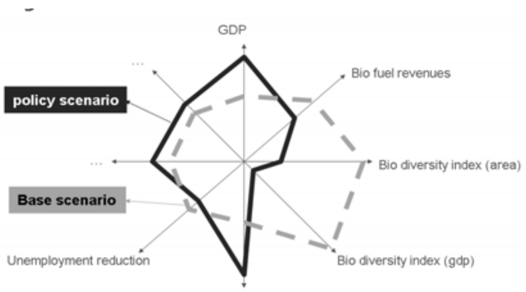

Figure 7. Integrated indicator overview

3. CONCLUSIONS

To find integrated solutions policy makers need to be supported by interactive Decision Support Systems (DSS). By making use of a DSS a quick scan of the impacts of different policy options can be made. These quick scan DSS's are powerful instruments in early policy development and contribute directly to the obligatory EC impact assessment.

The Sensor SIAT supports integrated impact assessment in terms of indicators and scenarios. An important feature of SIAT is transparency of and back tracing through model chains. This feature makes policy decision makers understand what factors drive the effects and risks and helps them improve their policies.

4. ACKNOWLEDGEMENTS

The authors wish to thank the complete SENSOR consortium for their kind collaboration and contribution on methods.

5. REFERENCES

Bartolomeo, M., P. Giugni, J. Hertin, K. Jacob, K. Rennings, A. Volkery, D. Wilkinson and D. Zanoni, Approaches to Impact Assessment in six OECD countries and at the European Commission. *IQ-Tools Project report, WP1A*, 2004.

Britz W., Perez I., Wieck C., Mid-Term Review Proposal Impact Analysis with the CAPRI Modelling System, *Mid-Term Review of the Common Agricultural Policy*. July 2002 Proposals Impact Analyses, European Commission, Directorate-General for Agriculture ed., 2003.

111-140, Brussels.

Cairol, D., E. Coudel, D. Barthélémy, P. Caron, E. Cudlinova, P. Zander, H. Renting, J. Sumelius, and K.H. Knickel, Multifunctionality of agriculture and rural areas: from trade negotiations to contributing to sustainable development. New challenges for research. *Summary of main results from the MULTAGRI project*. 23 pp. www.multagri.net, 2005

McConell, S , Rapid Development, Microsoft, 1996.

Gijsbers, P.J.A., R.V. Moore, C.I. Tindall (2002) Towards OMI, an Open Modeling Interface and Environment to harmonise European developments in water related simulation software, *Hydro-informatics*, 2002.

European Commission, A Sustainable Europe for a better world: A European Union Strategy for Sustainable Development. *COM(2001)264final*, 2001.

European Commission, *Impact assessment guidelines*. SEC791, 2005

Kok, K. & Veldkamp, A., Using the CLUE framework to model changes in land use on multiple scales, Tools for land use analsis on different scales, *Kluwer Academic Publishers, Dordrecht, pp. 35-63*, 2000

Lindner, M., B. Sohngen, L.A. Joyce, D.T. Price, P.Y. Bernier and T. Karjalainen, Integrated forestry assessments for climate change impacts. *Forest Ecology Management, 162, 117-136*, 2002.

Tamborra, M., Socio-economic tools for sustainability impact assessment – the contribution of EU research to sustainable development. *Energy, environment and sustainable development*, EUR 20437.1 Office for official publications of the European Communities, Luxembourg, 2002.

Wal, van der T., Wien J.J.F and A.J. Otjens, The application of frameworks increases the efficiency of knowledge systems. *Proceedings of the 4th EFITA conference on ICT in agriculture.*, 2003.

Wien, J.J.F., M. Blind and T. van der Wal, The Aquastress integrated solutions support system. *In Zerger, A. and Argent, R.M. (eds) MODSIM 2005 International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand*, December 2005, pp. 1567-1573. ISBN: 0-9758400-2-9, 2005.

Winsemius, P., beschouwingen over milieumanagement, *Gast in eigen huis*, (Dutch: guest on one's own house). Alphen aan den Rijn: Samson H.D. Tjeenk Willink, 1986.