Instruments and tools

Module 5

March 2011

PERI-URBAN LAND USE RELATIONSHIPS – STRATEGIES AND SUSTAINABILITY ASSESSMENT TOOLS FOR URBAN-RURAL LINKAGES, INTEGRATED PROJECT, CONTRACT NO. 036921

D5.2.1

Description of methodology of iIAT at pan-European level

Annette Piorr*, Ingo Zasada, Regine Berges, Dirk Pohle (ZALF)

*Responsible partner and corresponding author
Tel: +49 (0)33432 82-222; Email: apiorr@zalf.de

Document status:

Draft:	completed
Submitted for internal review:	completed
Revised based on comments given by internal reviewers:	completed
Final, submitted to EC:	completed

SIXTH FRAMEWORK PROGRAMME

Contents

Abstract

This deliverable report describes the European integrated Impact Assessment Tool (iIAT-EU) which has been conceptionally developed and technically implemented within the European IP PLUREL. As an important mean of dissemination of the research project's results, the *iIAT-EU* represents a novel interface between science and policy-making.

Introduction: The report introduces with the main research objective and motivation behind the tool-development as well as a brief review of existing research approaches in the field of impact assessment of land use changes.

Rationales: The main application principles of the tool – land use scenarios, regional differentiation and sustainability analysis and how they are implemented in the tool itself are comprehensively outlined in the second section.

Database: Further, the report gives insights into the database as the centrepiece beneath the tools' surface. Attention is called for the role of the *European Urbanisation Impact (EUI)* model within the preceding modelling process.

Functionality: Required by the participating stakeholders in PLUREL, an appropriate functionality represented an important issue within the development process. In accordance the graphical user interface (GUI) enables easy understanding and application of the tool.

Software: Technical specifics and methodologies are comprehensively outlined in this section. Particularly the application of the JAVA-platform is discussed here.

Conclusion: It could be summarised and concluded, that the *iIAT-EU* represents an easy accessible and applicable tool for decision support in the context of spatial development politics and planning.

PLUREL

Classification of results/outputs

For the purpose of integrating the results of this deliverable into the PLUREL Explorer dissemination platform as fact sheets and associated documentation please classify the results in relation to spatial scale; DPSIR framework; land use issues; output indicators and knowledge type.

Spatial scale for results: Regional, national, European	European
DPSIR framework: Driver, Pressure, State, Impact, Response	Driver – Pressure – State – Impact
Land use issues covered: Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation	Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation
Scenario sensitivity: Are the products/outputs sensitive to Module 1 scenarios?	YES
Output indicators: Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions	Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions
Knowledge type: Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks	GIS-based maps; Tables or charts

How many fact sheets will be derived from this deliverable:	1

1 Introduction

1.1 Urbanisation in Europe

Over the last decades, Europe, among other parts of the world, has experienced a rapid process of urbanisation. It comprises physical conversion of open, non-built areas for settlement purposes (EEA 2006) as well as socio-cultural transitions such as the adoption of urban life styles by the rural population or the influx of retirement residents into rural areas neighbouring urban agglomerations (Antrop 2004; Zasada et al. 2010). These processes of urbanisation entail a multitude of impacts on all dimension of sustainable development. Environmental degradation through soil sealing, fragmentation, pollution, etc. causes decreasing capability to provide ecological functions and services, such as hydrological and local climate balance, soil functions and biodiversity (Alberti 2005) and transforms agricultural activities, particularly in the urban fringe (Zasada 2011). But also societal and economic impacts are attached, such as household changes, segregation, changing economic environment or transportation pattern (Hall 1998).

1.2 Impact Assessment Approaches

Due to the far-reaching consequences of urbanisation, sustainability impact assessment of land use change has gained increasing relevance at all administrative and political levels within the European Union, as it enhances the information basis for policy and decision making (European Commission 2009). Often applied in the context of impact assessment, the DPSIR *(Driver-Pressure-State-Impact-Response)* framework, developed by the European Environmental agency assumes that land use change and its impacts on sustainability are embedded within a cause and effect chain that is forced by global driving forces such as economic, demographic and technological development, and climate change (EEA 1999). To assess sustainability impacts of future land use changes, ex-ante approaches make use of scenarios to explore the consequences of assumptions about future conditions including changes in society, economy, technology or climate. Ex-ante approaches to assess sustainability impacts of land use change has been previously established within several research projects, such as *Land Use and Land Cover Change (LUCC)* (Lambin and Geist 2006), *Advanced Ecosystem Analysis and Modelling (ATEAM)* (Rounsevell et al. 2006) or *SENSOR* (Helming et al. 2008), but without specific reference to urban land use dynamics. According to the impact assessment (IA) guidelines by the European Commission, IA should represent to a “basis of transparent, comprehensive and balanced evidence” for EU legislation and initiatives as “an aid to political decision-making” (European Commission 2009).

1.3 European integrated Impact Analysis Tool

The European research project PLUREL (Peri-urban Land Use Relationships) aimed at the development of methods and tools to assess the environmental, social and economic impacts of land use changes. Potential strategies and good practice examples will be identified in order to promote the sustainable development of land use systems in Rural-Urban Regions, especially the peri-urban fringe. A multi-level approach is essential, both to identify driving forces and pressures, and to explore policy responses and opportunities. Thus the results will be targeted to the pan-EU level as well as for several case studies (Nielsen et al. 2009).

The *European integrated Impact Analysis Tool (iIAT-EU)* has been developed to make comprehensive and complex scientific modelling accessible and understandable for a broad range of end-users, such as regional planners, European policy-makers and stakeholders of all kinds. The main purpose is to create awareness about sustainability development trajectories at different scales and for different types of regions. This is particularly essential for thematically and spatially configuration of policy response. Therefore the *iIAT-EU* synthesises the modelling results from the impact analysis of land use changes of PLUREL on peri-urban land use relationships into one tool. It is a tool for an integrated result presentation of a broad impact analysis and multipurpose and interactive in nature (Piorr et al. 2010; Haase et al. 2010). The *iIAT-EU* regionally differentiates impact modelling results for European NUTSX (spatially homogenised NUTS2 and 3) regions.

2 Main Principles – Land use scenarios, Regional differentiation and Sustainability analysis

The *iIAT-EU* is based on the three core elements of differentiation of future situations (scenarios), regional settings and sustainability analysis. This allows a high degree of flexibility to respond to individual requirements of the large variety of users and problem settings.

2.1 Land Use Futures Parameters – Scenario Setting

The *iIAT-EU* shows how the impacts of urbanisation under future scenario conditions will differ from the current situation (Nielsen et al. 2009). They represent no forecasts, but rather cover a broad range of possible and alternative futures as a method to structure thinking about future uncertainty. Based on explorative assumption of the development of global driving forces, future demographic and economic development is modelled and translated into urban development, by the *Regional Urban Growth (RUG)* model (Rickebusch and Rounsevell 2009). On the basis of these eight future and one present reference land use situations responding value changes of sustainability indicators are modelled and displayed in the tool. The reference situation of the year 2000 can be compared to four scenarios of future land use development – A1 (High Growth), A2 (Self Reliance), B1 (Sustainability) and B2 (Social Fragmentation) (Ravetz and Rounsevell 2008) for the two time steps 2015 and 2025. Figure 1 shows the example of value changes between the reference scenario year 2000 and the A1 (High Growth) scenario 2025 for the entire European Union (EU27).

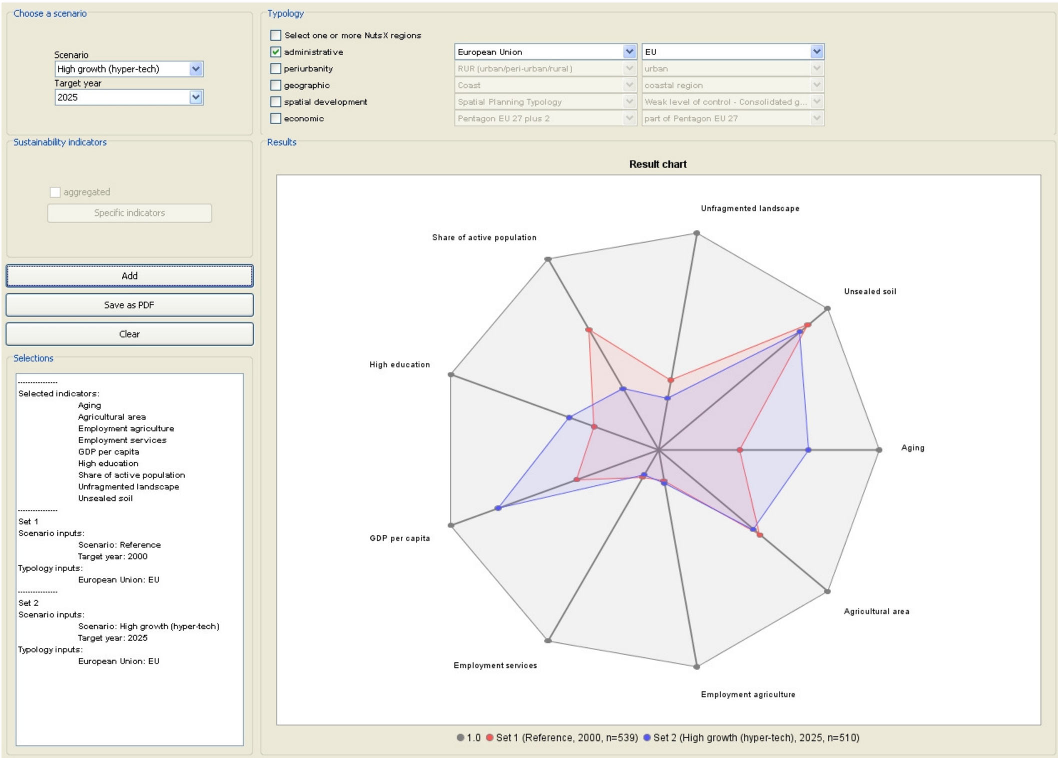

Figure 1: Scenario comparison "Reference" (red) and A1 "High Growth" 2025 (blue) for EU27

2.2 Spatial Parameters – Regional Typologies

The *iIAT-EU* tool provides various parameter selection opportunities regarding the spatial scope of analysis. The most basic one distinguishes between the selections of one or more NUTSX regions. If only one region is selected, indicator values for this specific region are taken into consideration. This is particularly useful to track sustainability impacts for this specific region under different scenario settings for instance (see figure 1).

Otherwise, one or the combination of two regional typologies can applied to specify the grouping requirement for a number of regions, e.g. of the same country, spatial planning typology or innovation potential, just to name some (see figure 2). Also the selection of the entire EU27 is possible. For a comprehensive list of typologies, see table 1. However, the regional differentiation enables inter-regional comparisons and supports the identification of hot-spot regions regarding future spatial development, related impacts and particular need to policy and planning intervention.

The *iIAT* software automatically aggregates and displays variable values for regions, which share the same type of the selected typology. By making use of the typologies the user will be enabled to carry out multiple comparisons between a single NUTSX region and an average of other region groups or between groups (types). The data themselves will be transformed into standardized values in order to unify the scale of output data values between indicators.

PLUREL

Table 1: Regional typologies overview

Typology	***Measurement***	***Source***
Administrative		
Country	all regions	-
European Union		-
Peri-urbanity		
Rural-Urban Region Type	Nominal classes	PLUREL (Loibl et al. 2008)
Settlement Structure Type	Nominal classes	(ESPON 2004)
Geography		
Coastal Region Type	yes / no	-
Natural Hazard Type	Ordinal classes	(ESPON 2006)
Technological Hazard Type	Ordinal classes	(ESPON 2006)
Spatial Development		
Spatial Planning Type	Ordinal classes	PLUREL (Lalenis and Tosics 2008)
INTERREG Structural Fun Type	Nominal classes	EC
Cohesion Fund Type	Nominal	EC
Economic		
Pentagon EU27+2 (yes/no)	yes / no	EC
Multimodal Accessibility Potential Type	Ordinal classes	(ESPON 2006)
European Innovation Score-board Index	Ordinal classes	(Hollanders 2006)

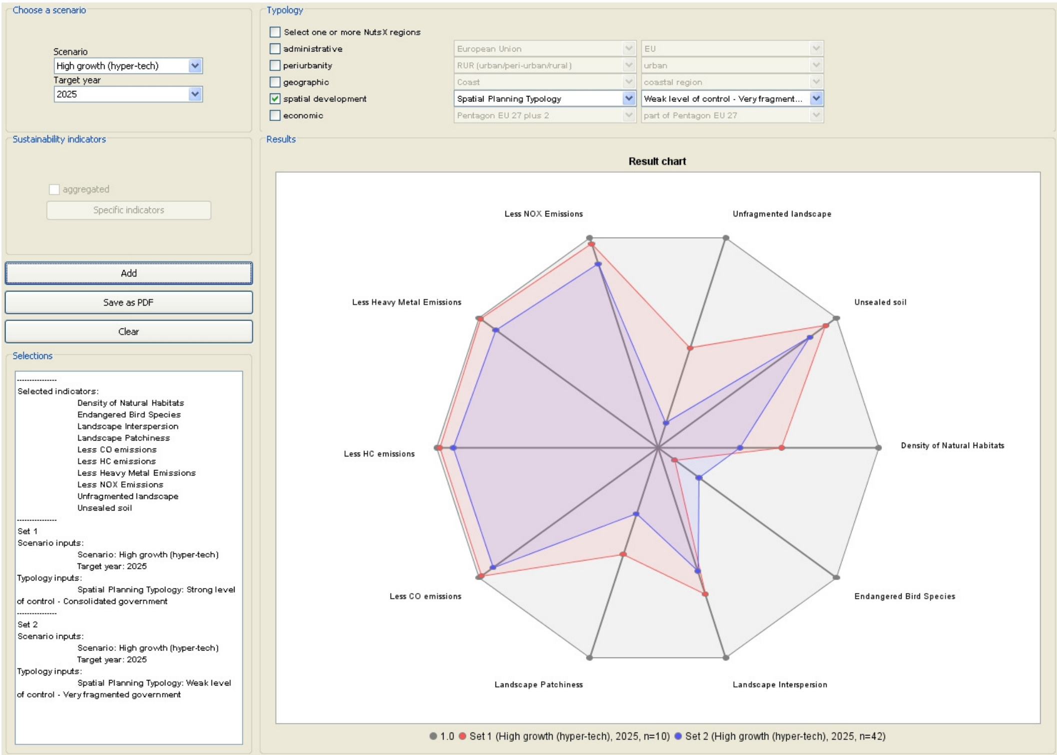

Figure 2: Typology comparison for region type "Weak level of control, very fragmented government" (red) and "Strong level of control, consolidated government" (blue) for scenario A1 2025

2.3 Sustainability Parameters – Indicator Framework

The *iIAT-EU* offers opportunities to display two sustainability indicator frameworks – either based on individual variables or making use of aggregated indicators representing the social, economic and ecologic dimension of sustainability. Table 2 gives an overview of specific sustainability indicators, which are included in the *iIAT-EU*. To enhance understanding of the modelling results, the *iIAT-EU* provides a condensed result representation of composite indicators, focussing on broader thematic issues, such as ecology and biodiversity, recreation or education. Using the methodology for composite indicators developed by the OECD (Nardo et al. 2005), the aggregation of variables was based on expert-estimations for value weighting.

Table 2: Sustainability indicator overview

Indicator	***Explanation***
Ecology	
Density of Natural Habitats	Indicator of naturality; Regional richness regarding natural land-cover types; Provided by the EEA. Aggregated Index of CORILIS components for "green" classes (Pastures & mixed farmland, Forests and transitional woodland shrub, Natural grassland, Heathland, Sclerophylous vegetation, Open space with little or no vegetation and Water bodies)
Endangered Bird Species	Measure of ecological integrity; Importance for the preservation of endangered species, Source: BirdLife International
Landscape Interspersion	Interspersion and juxtaposition index (IJI) is an index for spatial configuration of a landscape, which is based on patch adjacencies. It isolates the intersper-

	sion or intermixing of patch types.
Landscape Patchiness	Patch density (PD) expresses number of patches on a per unit area basis that facilitates comparisons among landscapes of varying size. It is a measure of land-scape configuration, describing the spatial character of a landscape. Without information about the area and spatial distribution of patches.
Landscape Fragmentation	The index MESH is based on the probability that in a certain area two individuals could meet without barri-ers. It is a measure of cumulative patch area distribu-tion and is interpreted as the size of the patches when the landscape is subdivided into S patches, where S is the value of the splitting index. It indicates the size of effective meshes, integrates extent and structure of the fragmentation by transportation infrastructure.
Soil sealing	Artificial surface covers all kinds of surfaces in urban area. The indicator gives insights in the amount of surface sealed.
CO Emissions	Index of CO Emissions
HC Emissions	Index of HC Emissions
NOx Emissions	Index of NOx Emissions
Heavy Metal Emissions	Index of cumulated and hazard-potential-weighted (thresholds) heavy metal emissions; Indicates the degree of pollution of water and soil. Database: EPER dataset 2008, reporting year 2001
Economy	
Agricultural Area	The share of agricultural area within a region gives information on the potentially utilizable area for agri-cultural purposes. It is calculated on the bases of Corine Land Cover classes 211-244
Farm Productivity	The Standard Gross Margin provides a measure of a holding's business size, irrespective of its area and intensity of production. Measure of agricultural in-come generation.
Part-time farming	Share of holders being a natural person: work time <25%
Gross Domestic Product per Capita	
High Education	Share of population with tertiary education
Share of Active Population	Share of population available for labour market
Society	
Aging	Share of population min. 65 years
Employment Agricultural Sector	Share of workforce in sector 1
Employment Administration/ Fi-nances Sector	Share of workforce in sector 2
Employment Industrial Sector	Share of workforce in sector 3
Employment Service Sector	Share of workforce in sector 4
Employment Total	Share of population
Large Family	Share of households with min. 4 persons
Children and Adolescence	Share of population max. 18 years
Social Individualisation	Share of households with 1 person

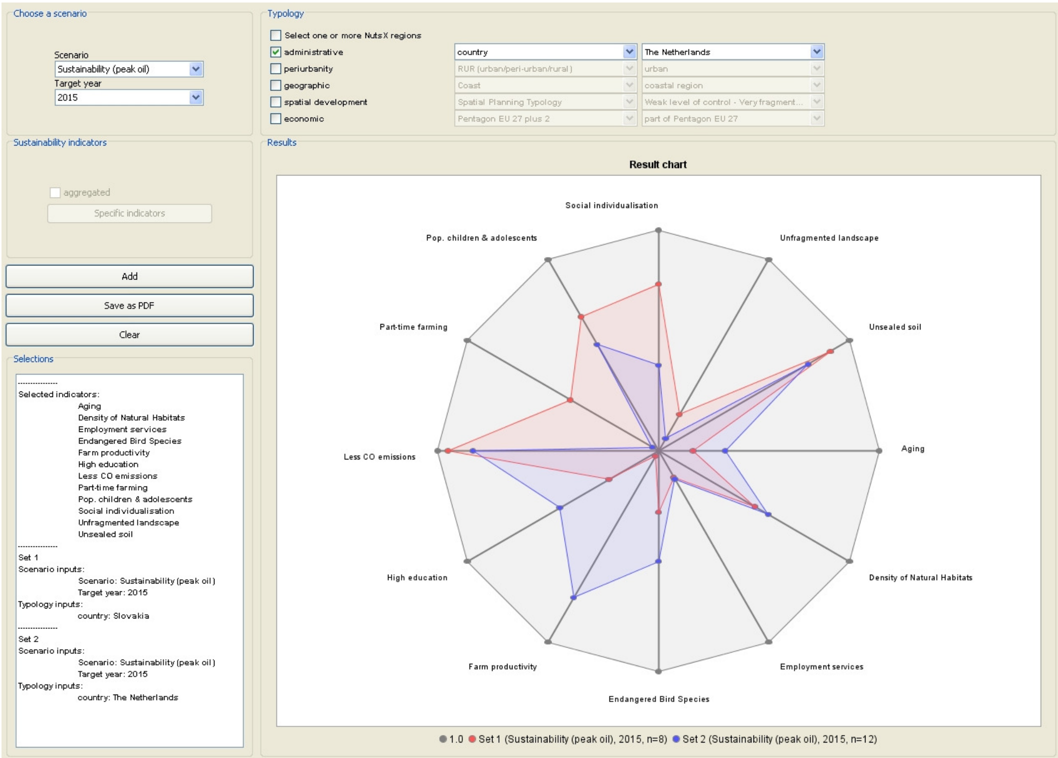

Figure 3: Comparison of specific indicators of Slovakia (red) and The Netherlands (blue) for scenario B1 2015

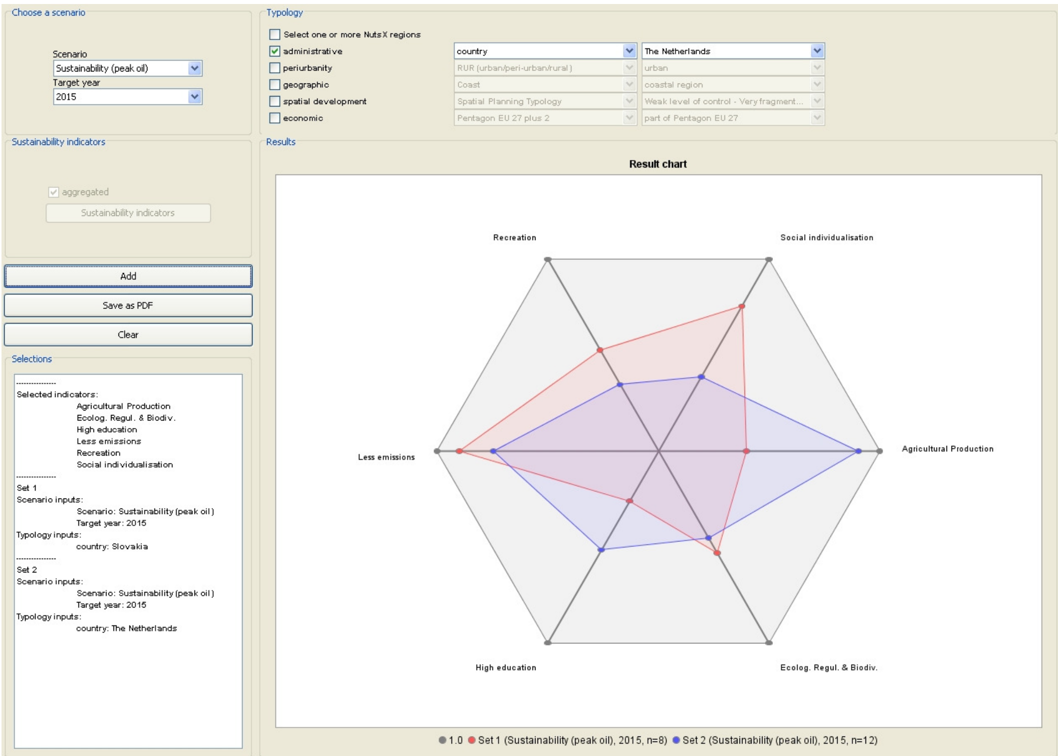

Figure 4: Comparison of aggregated indicators of Slovakia (red) and The Netherlands (blue) for scenario B1 2015

3 Functionality

3.1 Graphical User Interface (GUI)

The tool accesses the impact assessment result database of PLUREL and generates the demanded outputs in the graphical user interface (GUI). Via the GUI it is possible to explore the sustainability impacts of urbanisation in the context of the three main rationales of the *iIAT-EU* – scenarios, regional situations and indicators. The main purpose of the GUI is to provide access to the *European Urbanisation Impact (EUI)* modelling results for potential users. As the interface between the *EUI* and its extensive database on the one side as well as the user who presumingly has stake and insider knowledge of the modelling process on the other side, the GUI requires an intuitive and easy-to-understand and application of the *iIAT-EU* tool. In general, the GUI consists of three main components – parameter selection, spidergraph visualisation and the map visualisation (see figure 5).

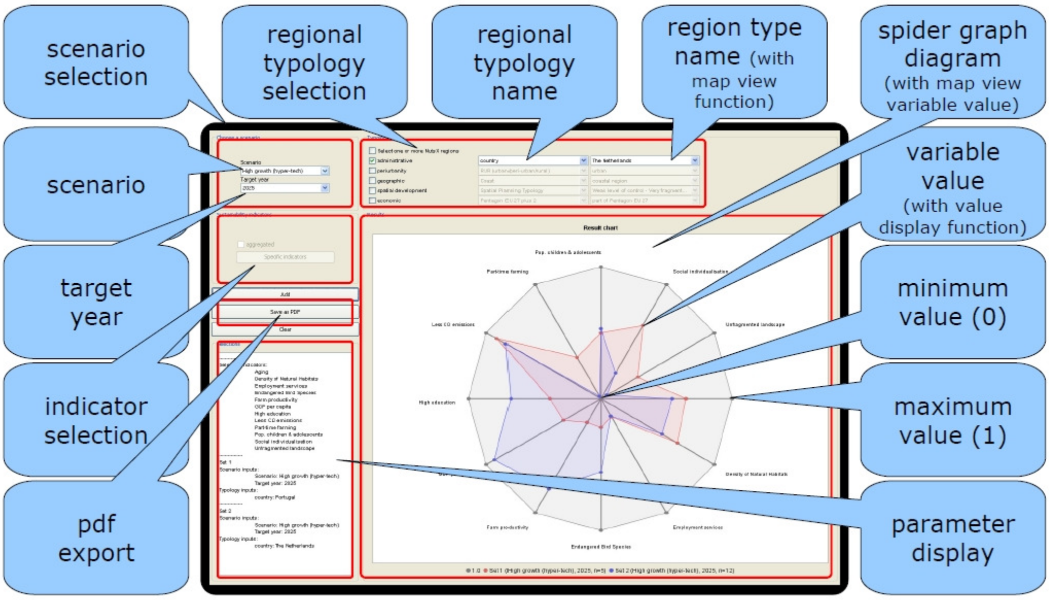

Figure 5: Functions of the graphical user interface (GUI)

3.2 Parameter Selection

Within the first component the user specifies the parameter of her/ his choice – scenario and time frame, spatial situation (regional typologies) and indicators selection (individual and aggregated). The selection is performed within drop-down boxes (scenarios and region) as well as so-called radio buttons (for indicators). Within the typology selection drop-down box, a tool-tip function provides an overview of characteristics of the particular region according to the respective typology values. In figure 6 all available information is displayed for the example of the Belgian NUTSX region *Province Antwerp*.

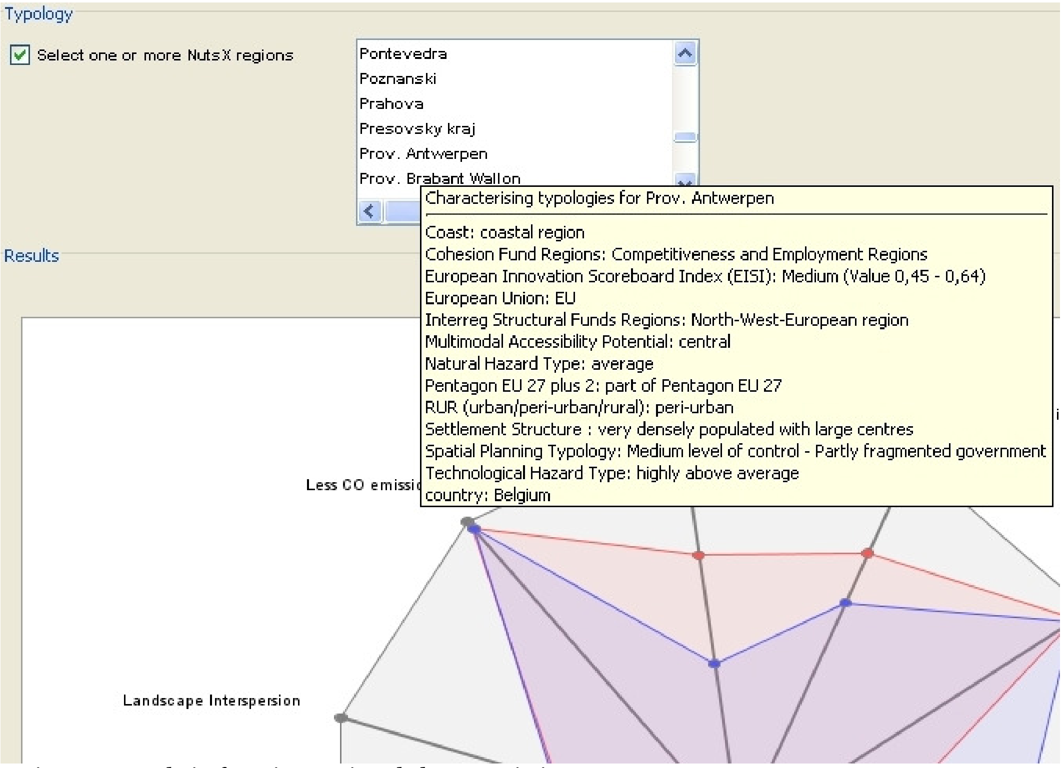

Figure 6: Tool-tip function regional characteristics

To allow easy orientation and transparency in the application process, the particular parameter selection is displayed in a box on the left hand side of the GUI. Together with the results to be analysed the parameter selection can be stored and printed as PDF-file (see figure 7).

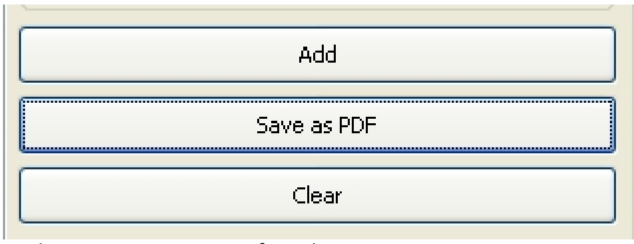

Figure 7: PDF export function

3.3 Spidergraphs Visualisation

The second component represents the visualisation of the impact analysis results. It is carried out through spidergraphs, as they are most suitable for the purpose of the comparison of variable value – either between different indicators within one setting or different settings. Thus, this form of indicator value expression encourages comprehensive capturing of particular sustainability trends – positive or negative. Different directions of shifts for two or more indicators thus show trade-offs between different dimensions of sustainability. The spidergraph visualisation provides following features (figure 8):

- One diagram can encompass between 3 and 12 indicator values
- Up to 3 spidergraphs can be compared simultaneously
- A legend indicate selected scenario name, time frame and number of regions
- Tool-tips at data points show variable value

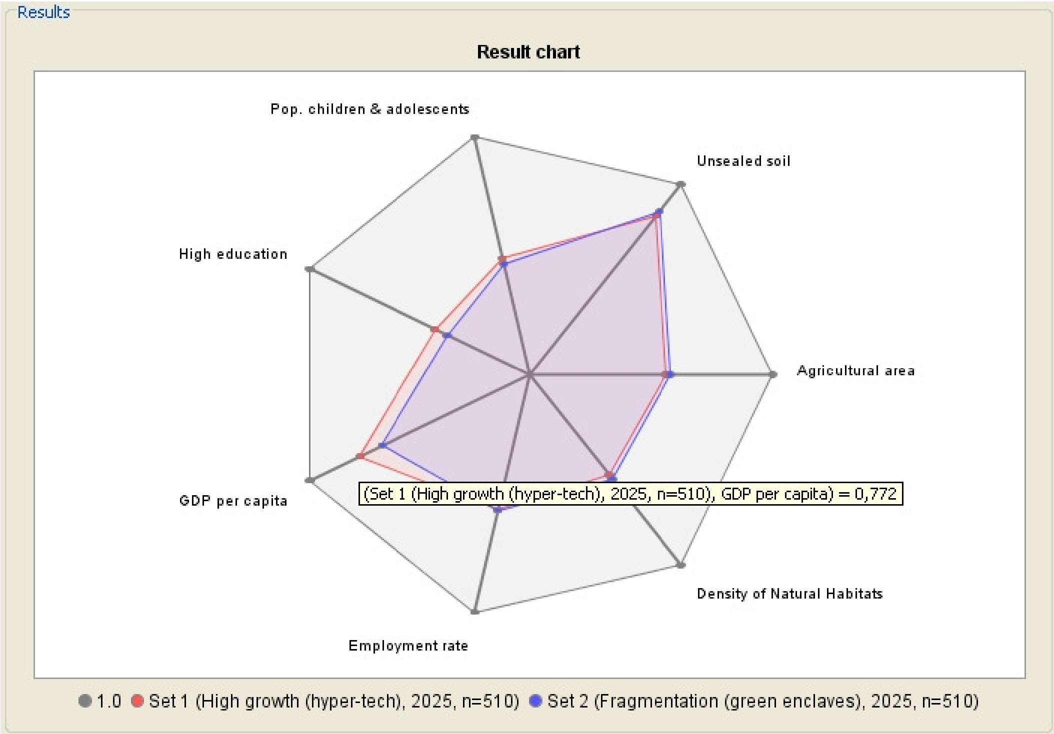

Figure 8: Spidergraph with tool-tip function for variable value display

3.4 Map Visualisation

A third functionality is provided by a tool-tip function which allows map visualisation of value distribution of indicators and typologies across EU27 (see figure 9). This already allows an overview of the regionalised sustainability impacts and the identification of hot-spot regions, where impacts are particularly high or low. Following maps are displayed in the *iIAT-EU*:

- Urbanisation typologies
- Geographical typologies
- Spatial development typologies
- Specific indicator values
- Sustainability indicator values

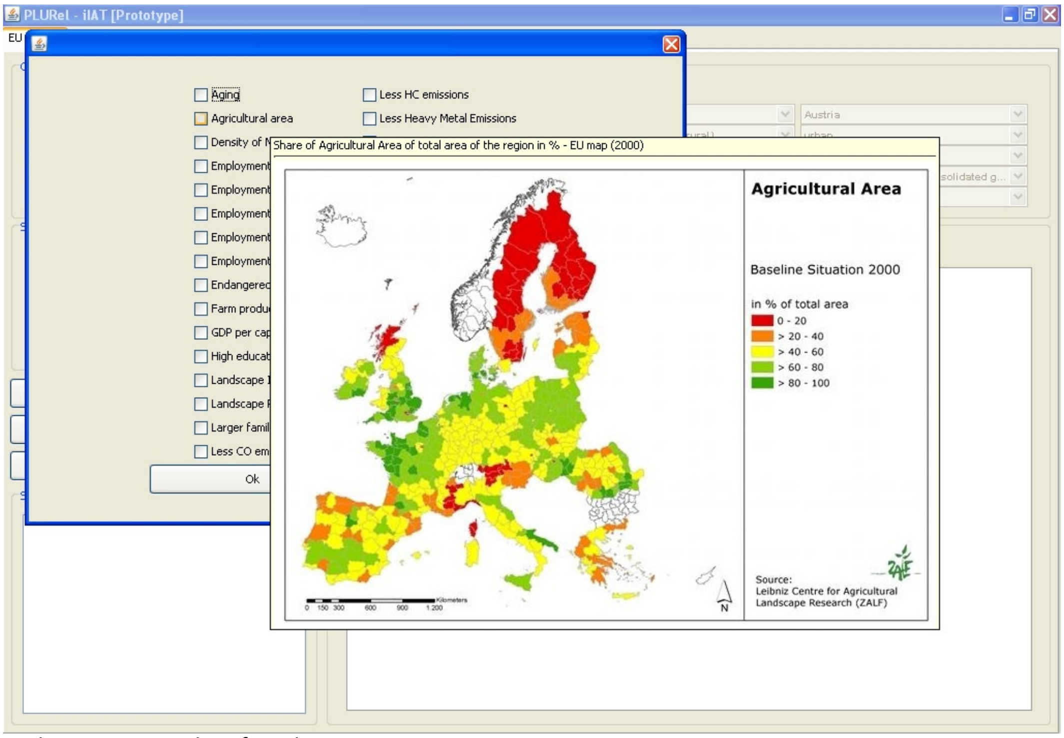

Figure 9: MapView function

4 Database and Technical implementation

4.1 Database – European Urbanisation Impact (EUI) Model

The database underlying the *iIAT-EU* is derived from the impact modelling algorithm of the *EUI* model with work contributions by W. Loibl and T. Tötzer (Austrian Institute of Technology), P. Korcelli and E. Kozubek (Institute of Geography and Spatial Organization Warsaw) and A. Piorr, R. Berges and I. Zasada (Leibniz-Centre of Agricultural Landscape Research).

The modelling was derived from raw data by European Spatial Planning Observation Network (ESPON), European Environmental Agency (EEA), EUROSTAT and BirdLife International.

Within the *EUI* regression analysis for variable values depending from land use change and other framework factors (response functions) has been applied. To allow comparability between variables of different dimensions, a value standardisation (normalisation) to values between 0 and 1 was necessary. Thus, outliers were removed – values above the 97.5 percentile were reduced to that value and all variables with a value below the 2.5 percentile were raised to this level. The final database encompasses data sets for each of the 539 individual NUTSX regions, 31 variables, the four scenarios and time steps 2015 and 2025 as well as the reference scenario (~150,000 single values).

Technically the database is stored on a PostgreSQL server version 8.4, physically located at ZALF or AIT server (design by D. Pohle, ZALF). According to user query specifications, the data aggregation is carried out by calculation of mean values.

4.2 Software Specification

The *iAT-EU* is technically implemented as a software programme based on the *JAVA*® platform (version 1.6) developed by Oracle Corporation. In addition, it integrates several open-source software libraries to extent the functionality – *GeoTools*, *Browser-Launcher2*, *iText* and *JFreeChart*. The *JAVA*-solution was necessary to comply with both the user requirements and the data processing. In communication with end-users which was carried out during a stakeholder workshop from PLUREL case studies, a number of restrictions and demand were formulated and had to be considered:

- Download and local software installation limitations (often only allowed for network administration staff, not for the end-users)
- Data security and data sharing restrictions (limited access to the raw data, terms of use restrictions from raw data provider (e.g. BirdLife International) regarding data re-distribution)

Therefore neither the distribution of data on storage media (CD-ROM) nor the regularly (installable) software proofed appropriate. Other opportunities, such as Microsoft *EXCEL* are very slow when handling greater data amounts, such in the *iIAT-EU* case. The *JAVA*-solution represents a much faster in combination with the *PostgreSQL* database server. Additionally, the internet application provides decisive advantages compared to local software:

- Far-reaching independency from operational system (OS) of the individual client
- No software installation necessary
- Up-date possible without re-installation on client computer
- No local data storage necessary, due to central data server

Still, some requirements are attached to the given solution, such as:

- Available internet connection
- JAVA runtime environment (freeware) has to be installed on the client computer

The software package of the *iIAT-EU* tool is easily accessible without any restrictions through the following link:

http://project1.zalf.de/iiat/iIAT/iiat.jnlp

Otherwise linkages (button) are integrated in the PLUREL toolbox *XPLORER* as well as within other PLUREL publications.

5 Conclusion

The *iIAT-EU* tool and the underlying *EUI* model represent one of the main PLUREL dissemination means of scientific results and knowledge related to the sustainability impact analysis of European urbanisation. Users of the iIAT-EU are enabled to explore possible future situations under the perspective of sustainable development and identify future policy issues and territorial action agendas for European policy-makers. It further represents an information basis and encouragement of European stakeholders of decision making within spatial development.

References

Alberti, M. 2005. The Effects of Urban Patterns on Ecosystem Function. *International Regional Science Review* (28), pp. 168-192.

Antrop, M., 2004. Landscape change and the urbanization process in Europe. *Landscape and Urban Planning* (67), pp. 9-26.

EEA, 1999. *Environmental indicators: Typology and overview*. EEA Technical Report 25, European Environmental Agency, Copenhagen.

EEA. 2006. Urban Sprawl in Europe - The ignored challenge. EEA Report 10/2006, European Environmental Agency, Copenhagen.

ESPON, 2004. Potentials for Polycentric Development in Europe. ESPON, Luxembourg.

ESPON, 2006. Integrated analysis of transnational and national territories based on ESPON results. ESPON Project Report 2.4.2. ESPON, Luxembourg.

European Commission, 2009. Impact Assessment Guidelines. European Community Brussels.

Haase, D., Piorr, A., Schwarz, N. and Zasada, I.,2010. A new tool for integrated and interactive sustainability impact assessment of urban land use changes: the PLUREL iIAT. Proceedings of the International Congress on Environmental Modelling and Software. Modelling for Environment's Sake. Ottawa, 5-7-2010. International Environmental Modelling and Software Society.

Hall, P. 1998. Cities in Civilisation. Phoenix, London.

Helming, K., Tscherning, K., König, B., Sieber, S., Wiggering, H., Kuhlman, T. Wascher, D.M., Pérez-Soba, M., Dilly, O., Hüttl, R.F. and Bach, H., 2008. Ex ante impact assessment of land use change in European regions: the SENSOR approach. In: Helming, K., Perez-Soba, M. and Tabbush, P. (Eds.), Sustainability Impact Assessment of Land Use Changes. Springer, Berlin, pp. 77-105.

Hollanders, H., 2006. Regional Innovation Scoreboard.

Lalenis, K. and Tosics, I., 2008. Typology of government relations and general national spatial planning concepts. PLUREL Milestone Report 2.2.3.

Lambin, E.F. and Geist, H.J., 2006. Land-Use and Land-Cover Change. Local processes and Global Impacts. Springer, Berlin.

Loibl, W., Köstl, M. and Steinnocher. K., 2008. Quantitative classification of the major European rural-urban regions. PLUREL Deliverable Report 2.1.3.

Nardo, M., Saisana, A., Saltelli, A., Tarantola, S., Hoffman, A. and Giovannini, E., 2005. Handbook on constructing composite indicators: Methodology and user guide. OECD Statistics Working Paper 3. OECD, Paris.

Nielsen, T.A.S., Piorr, A., Zasada, I., Werner, A., Berges, R., and Nilsson, K., 2009. Towards a balanced spatial development in peri-urban regions: which territorial policies? PLUREL: science for sustainable rural-urban regions. Proceedings of the PURPLE conference.

Piorr, A., Zasada, I., Berges, R., Pohle, D., Haase, D. and Schwarz, N., 2010. Sustainable urbanisation: new tool for impact analysis. PLUREL Newsletter (7), pp. 1-3

Ravetz, J. and Rounsevell, M.D.A., 2008. Scenarios – crystal balls for the urban fringe. PLUREL Newsletter (3), pp. 1-3

Rickebusch, S. and Rounsevell, M.D.A., 2009. Where will European live in the future? PLUREL Newsletter (6), pp. 1-3

Rounsevell, M.D.A., Reginster, I., Araujo, M.B., Carter, T.R., Dendoncker, N., Ewert, F. , House, J.I., Kankaanpaa, S., Leemans, R., Metzger, M.J., Schmit, C., Smith, P. and Tuck, G., 2006. A coherent set of future land use change scenarios for Europe. Agriculture, Ecosystems & Environment (114), pp. 57-68.

Zasada, I., 2011. Multifunctional peri-urban areas – A Review of societal demands and agricultural provision of goods and services. Land Use Policy in press.

Zasada, I., Alves, S., Müller, F.C., Piorr, A., Berges, R. and Bell, S., 2010. International retirement migration in the Alicante region, Spain: process, spatial pattern and environmental impacts. Journal of Environmental Planning and Management 53(1), pp. 125-141.