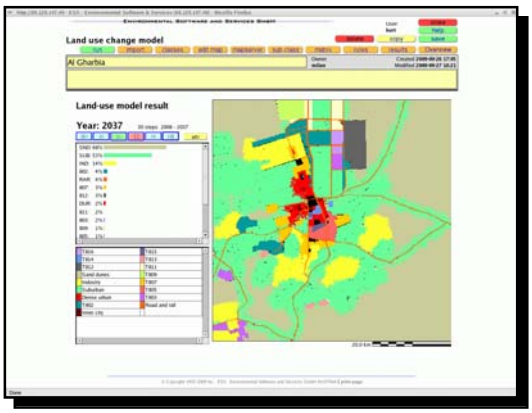
LUC : land use dynamics

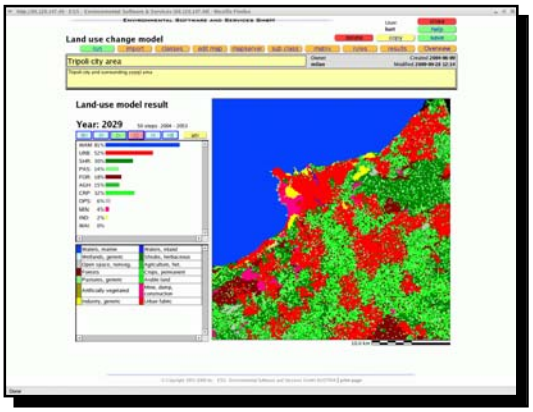
http://www.ess.co.at/LUC

LUC is an integrated spatial model system for the dynamic analysis of land use and land cover development. It combines a stochastic Markov chain state transition model with a hybrid expert system that integrates forward and backward chaining inference strategies with first-order production rules and a cellular automata model. Together these components provide a wide range of representation formats to describe natural and planned spatial development over long periods of time.

Modeling land use change: Transition Probabilities and Rules

LUC is an integrated, web-based model system that combines a number of basic components and functions within one shared data structure and user interface. Implemented as a client-server system, it can support high performance computing and parallel processing tasks for very high resolution, long-term and stochastic model runs including the non-linear multi-criteria optimization of land use plans and policies.





- Embedded GIS, import of standard map and RS data, background map composition and matrix editors;
- Land use Class editors (CORINE default classes and hierarchical structure)
- Definition of land use targets, master plans, policies and regulations;
- Transition probabilities matrix editor, expert system support for quantitative and qualitative parameters;
- Land class property editor (open list of attributes for WELMM analysis);
- Time series data base and editor for global boundary conditions;
- Optimization scenarios: definition of criteria, objectives, constraints; includes options for a participatory (group) decision making based on discrete reference point optimization;
- Probabilistic scenarios (with definitions of *a priori* PDFs around selected model parameters and RULES or plain Monte Carlo on the transition probability instantiations)
- Model scenario handling: includes the actual model runs on dedicated hardware, user information (by email or optional SMS), and results display, analysis, and post-processing including model animation (mpeg format for external players) and data export functions.

- Simulation model integration: LUC provides the possibility to integrate external simulation to either
  - generate dynamic boundary conditions as inputs,
  - post-process its results into additional criteria for assessment;
  - embed complex simulation models to post-process individual time step results and provide criteria for the next time step.
- Linked models include:
  - Dynamic driving forces and boundary conditions (simple socio-economic and demographics models)
  - Climate change: dynamic downscaling of IPCC scenarios as driving forces (dynamic boundary conditions for the RULES);
  - Transportation and topological network models;
  - Impact models: convert class specific (spatially distributed) properties into additional criteria, e.g., air pollution, water resources (rainfall/runoff, erosion, water quality
  - Economic evaluation (CBA) using piecewise linear cost- and benefit functions, hierarchical structure from individual cell based or administrative aggregates to total area.

Application domains

LUC is designed for application to

- regional and urban development, ICZM;
- agriculture and forestry, deforestation, watersheds;
- infrastructure development, (surface) mining.

Implementation

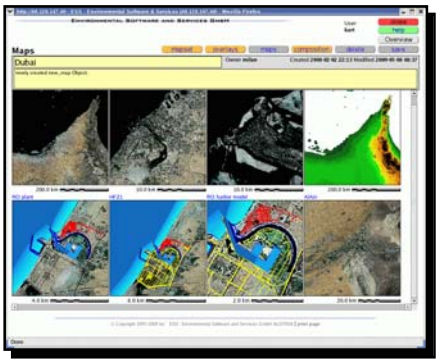
LUC includes the interactive editing and analysis part, and the modelling component (implemented on one or more dedicated model servers) for the model runs including scenarios driven by RTXPS a forward chaining real-time expert system framework. LUC is implemented as a client-server system under Linux Open Source operating system, using any standard web browser on any PC as client. For on-line examples and operational real-time demos

http;//80.120.147.40/LUC

The WEBAIR project is open for new partners. We are looking for new challenging case studies as well as partners with experience in ambient air quality and emission monitoring.

For more information, please visit http://www.ess.co.at/LUC
or contact us by e-Mail: info@ess.co.at

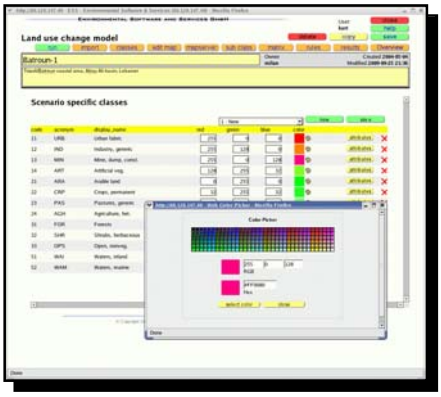
LUC: System components and tools



Embedded GIS, import of standard maps and classified RS data, background map composition and matrix editors; data import and export tools support basic raster formats and standard GIS formats such as ESRI Shape files or ArcInfo export formats (*.e00). The GIS tool provides collections of overlays, that can be combined (overlayed) into maps that can be used as background, or boundary conditions for the RULES. Individual overlays (such as line features e.g., road network) can be combined with the initial land cover maps (matrix) as initial conditions for the model runs. The embedded GIS tools also support the analysis of model results, overlay and buffer analysis, arbitrary zooming.

Land use Class editors: supports the definition of scenario specific land cover/use classes; (CORINE default classes and hierarchical structure) with display colors, short and display names, linked multi-media descriptions, example imagery.

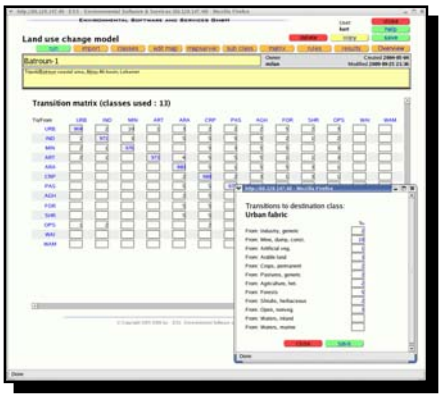
Land cover/use classes property editor (open list of attributes for WELMM analysis);



each land use class can be given a set of parameters to estimate secondary environmental and socio-economic variables such as energy consumption, emissions, population, employment, economic data, water use and wastewater generation, runoff and erosion, etc.

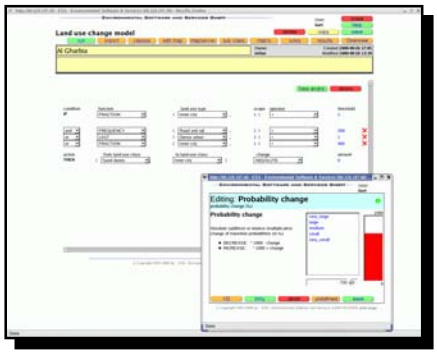
The editor can also be used to assign other parameters to spatial units such as geological and soil properties, elevation and slope, drainage characteristic etc, can be used to affect land possible use or land cover (e.g., vegetation) classes.

Master plans: definitions of land use targets, policies and regulations; target land use (can be imported as a map or map overlay) for a given spatial unit can be sued to affect the transition probabilities (gradual or absolute), and the RULES the can modify the transition probabilities



Transition probability matrix: can be defined and modified with interactive editors, expert system support for quantitative and qualitative parameters; editor can set numerical values, symbolic values with default numerical (range) interpretation, or fuzzy set definitions of numerical ranges corresponding to the symbolic definitions.

Transition probabilities are defined in parts per thousand (ppt) or promille: ‰



Rules: transition probabilities can be modified (relative or absolute) or set explicitly including setting to 0, exclusions, or 1 forced transition); Rules are basic first order production Rules of the form:

IF [condition]

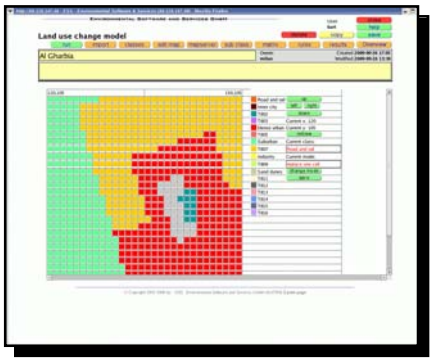
AN/OR [condition]

THEN [action]

where

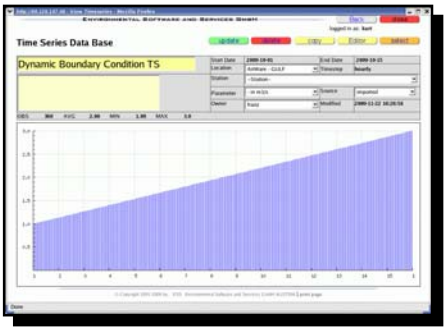
- [condition] includes properties of the spatial unit itself, TIMERS and COUNTERS that can be set, incremented, and read to accumulate values over time, its neighborhood in time (FREQUENCY) and space (FRACTION), as well as global boundary conditions and driving forces;
- [action] is an assignment of either
  - A legal value to any one of the dynamic knowledge base values that can be used in the RULES;
  - A specific transition probability (absolute or relative change)

Initial conditions: land cover matrix editing



An interactive editor can be used to define or modify maps (regular grid of land cover/land use classes). Initial conditions (land cover maps) can be edited from scratch (starting with areas as small as 30 by 30 cells; alternatively, an existing land cover map can be imported (possibly after conversion from a vector to a raster format) and then editor as required. The editor supports panning of the editor window in the overall map area.

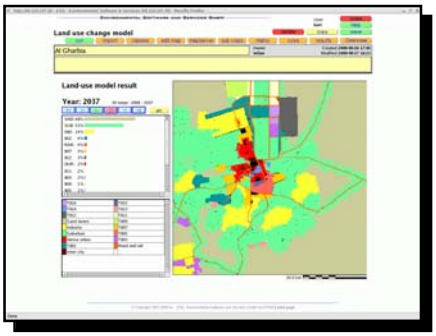
Time series data base and editor for global boundary conditions; these can be used as dynamic driving forces that affect the transition RULES; simple growth models (linear, exponential, sigmoid, Michaelis-Menten saturation types, etc.) or time series analysis tools (Box-Jenkins) can be used to generate time series of simple predictions.



Time series can be extracted from observation time series, or edited interactively by defining tuplets of time stamp – value, then interpolating with one of the pre-defined methods such as simple linear or cubic spline.

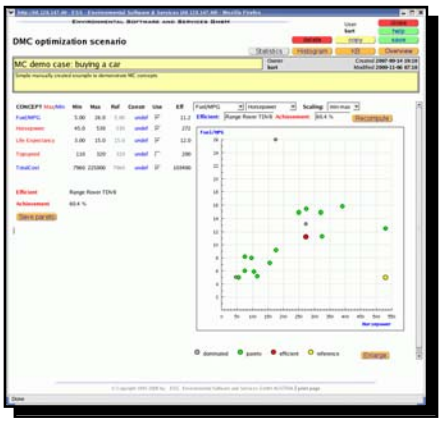
Please note that the time series of external driving variables can also be generated by external models such as climate, demography, or macro-economic forecasts and projections.

Basic model scenarios: interactive handling and editing of model scenarios; arbitrary temporal resolutions (default setting include monthly and yearly) arbitrary spatial resolution (defaults provided include 10 by 10 meter for detailed urban studies, to hectare and square kilometer), possibility to define regular scheduled and automated model runs with real-time data updates (e.g., RS data): includes the actual model runs on dedicated hardware, user information (by email or optional SMS), and results display, analysis, and post-processing including model animation (mpeg format for external players) and data export functions.



Probabilistic scenarios (with definitions of *a priori* PDFs around selected model parameters and RULES or plain Monte Carlo on the transition probability instantiations); analysis includes the probability distribution (derived from the frequency over all runs) of land use classes at a given location in time.

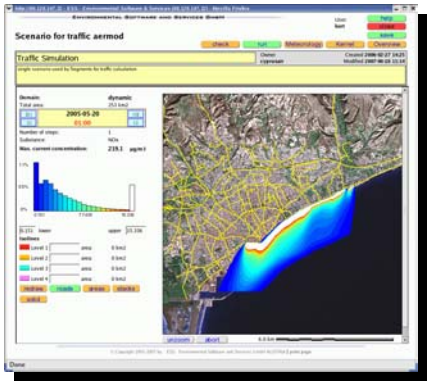
Optimization scenarios: two-phase non-linear, multi-criteria optimization strategy: definition of criteria, objectives, constraints for the initial satisficing runs; configuration of search strategies (adaptive heuristics, genetic algorithms, machine learning); second phase (on feasible subset) uses discrete reference point optimization, interactive DSS includes options for a participatory (group) decision making to define an efficient compromise solution from the pareto-optimal subset.



Post-processing, impact assessment

Based on the dynamically changing land cover and land use predicted by the model,
LUC provides the basis for impact assessment (EIA/SIA), which also provides additional criteria for the multi-criteria decision support functions (DSS).

This can use both the pressures including emissions and resource requirements from the new dynamically changing land use, but also these classes as targets areas.



This is accomplished by external (but directly linked and integrated) simulation models, urban air quality is one of the most common examples both for the entire urban area, but also for specific new sources such as major roads.
Different models can be used transient conditions (episodes)

Site Suitability Analysis

A related function is **site suitability analysis**: given a set of projects or planned activities and their spatial and resource requirements, we can identify the best (most suited) parcels of land in a domain to locate these activities.

This is based on discrete-multi-criteria optimization (reference point optimization) using both the data base as well as the land use model forecasts to identify and rank potential locations that meet all constraints and maximize the objective functions including overall net benefit.