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Manual Elbescanner. Simulating residential land use changes in scenarios

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Manual Land Use Scanner Elbe

Simulating residential land use changes in scenarios

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- Vrije Universiteit/FEWEB/SPINlab,
- Landbouw Economisch Instituut(LEI),
- Object Vision BV.

The Land Use Demand Tool is developed within the project GLOWA-Elbe by members of the Technische Universität Berlin:

- Chair in Land Economics: Jana Hoymann, Henrik Pilz, Michael Hewing

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Part 1   Introduction

The purpose of this technical document is to help those who will operate the Land Use Scanner (LUS) get started with the model. In addition it will explain the basic functionalities of the model and specify how specific components of the model can be adjusted to define new policy alternatives. The tutorial also points at relevant documents for background information and more advanced manipulation of the model. The text only refers to the Land Use Scanner application developed for TU Berlin as part of the GLOWA ELBE-project, hereafter referred to as the Land Use Scanner Elbe.

1.   What is the Land Use Scanner Elbe?

The Land Use Scanner Elbe is a tool to simulate future scenarios of residential land use changes for the Elbe River Basin. These land use change scenarios are generated as raster maps. To allocate residential land use changes on grid cells two important inputs need to be provided. First, the quantity of changes must be defined for regions within the Elbe River Basin, and second, locations must be specified that indicate the suitability of that location for becoming residential area or not. Results can be visualised with any GIS-software.

The Land Use Scanner Elbe includes the full functionality to first make scenario-specific projections of residential land use demand, second to adjust the importance of location characteristics for their suitability for new residential areas and third allocates this demand to grid cells based on the algorithm of the Land Use Scanner model, accordingly the defined suitability. Consumption of space for residential land will be on the expense of other land use types like agricultural land or pasture.

The Land Use Scanner Elbe is part of the GLOWA-Elbe Expert Toolbox (EET). Therefore, derived parameters such as surface sealing and population distribution are also provided from the land use change scenarios to be used by other tools of the EET. This chapter explains the main structure/workflow of the tool, the installation procedure and how to start the tool on your computer.

1.1.   The Land Use Scanner within the GLOWA-Elbe Expert Toolbox

The EET is a toolbox for the analysis of the impact of socioeconomic and climatic change on the hydrological cycle of the Elbe River Basin. The Land Use Scanner Elbe is a land allocation model positioned at the heart of the multi-scale, multi-model, framework of the GLOWA-Elbe project. It bridges sector models and indicator models and connects Global and European scale analysis to the local level of environmental impacts.

The Land Use Scanner Elbe model is one of the main components within the subproject regionalisation. It translates the results of the socioeconomic sectoral models REGE and RAUMIS to land use demand and disaggregates this land use demand to a raster map. Next, with help of the modelled future land use first a new land use map is generated. Second, the different land uses are reaggregated on conflict-specific levels, for example on level of hydrological response units for the hydrological model or on sub-catchment level for MONERIS (which calculates nutrient emissions on different pathways). From the disaggregated residential land use pattern the population development is calculated on municipal level. It is used by the model KIWA, which simulates the future demand for water by households.

1.2.   General workflow of the Land Use Scanner Elbe

The Land Use Scanner Elbe consists of three components. First the Demand Tool calculates demand for residential land use change for spatial planning regions and regions of Nuts level 2 based on the socioeconomic projections of the REGE Tool and further socioeconomic data. For a methodological description of the demand calculation see Part 2, section 2.2. The settings for the demand calculation are explained in Part 2, section 1.1.2. Second, suitability maps need to be calculated to indicate which grid cells are suited to become residential area. Therefore, a weighted sum of thematic and policy maps is calculated. This procedure is explained in Part 2, section 1.1.3. The underlying methodology is explained in Part 2, section 2.3. Third, after defining the input the land use change is allocated to grid cells. The Land Use Scanner allocates the demand of residential land based on the suitability with a doubly-constrained logit approach. It also produces the output that is used by other models of the EET. A short explanation of using the Land Use Scanner within the EET is given in Part 2 section 1.3. A detailed explanation of the Land Use Scanner and its methodology can be found in Part 3 section 1. Figure 1 illustrates the workflow.
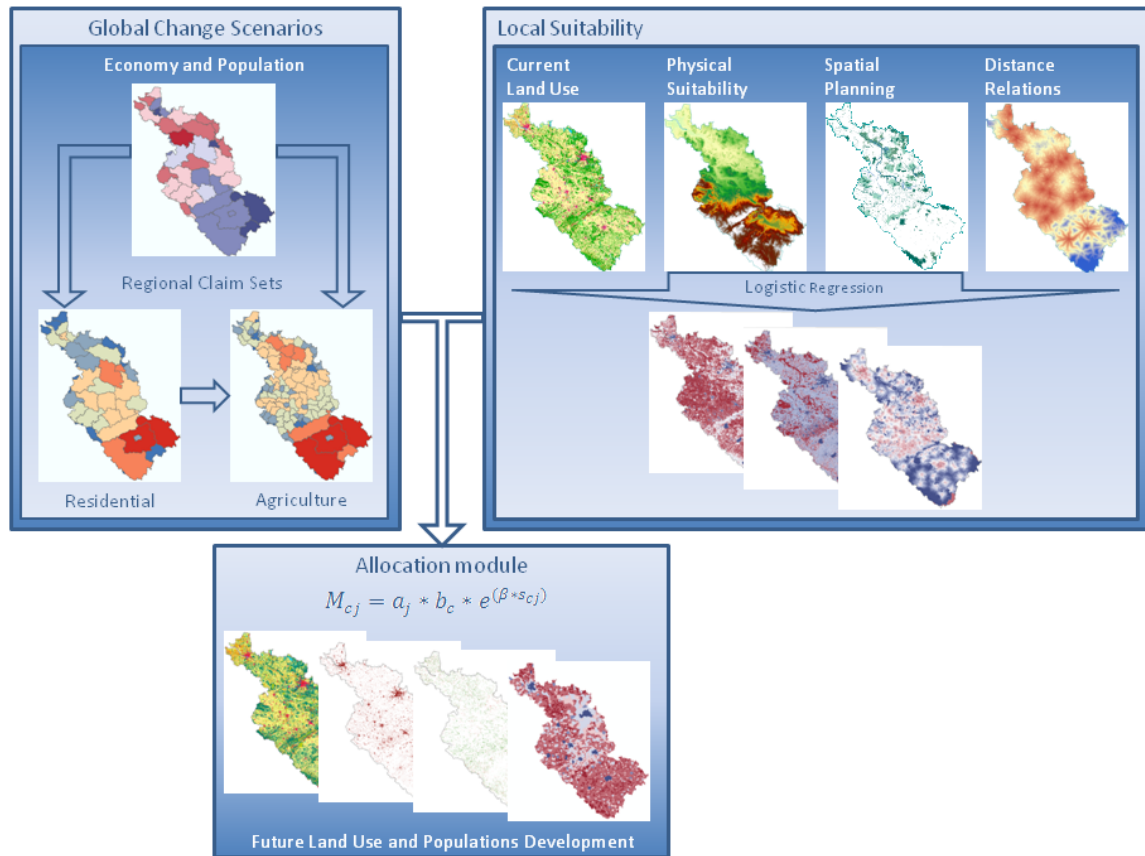
Figure 1: Logical Workflow Land Use Scanner Elbe
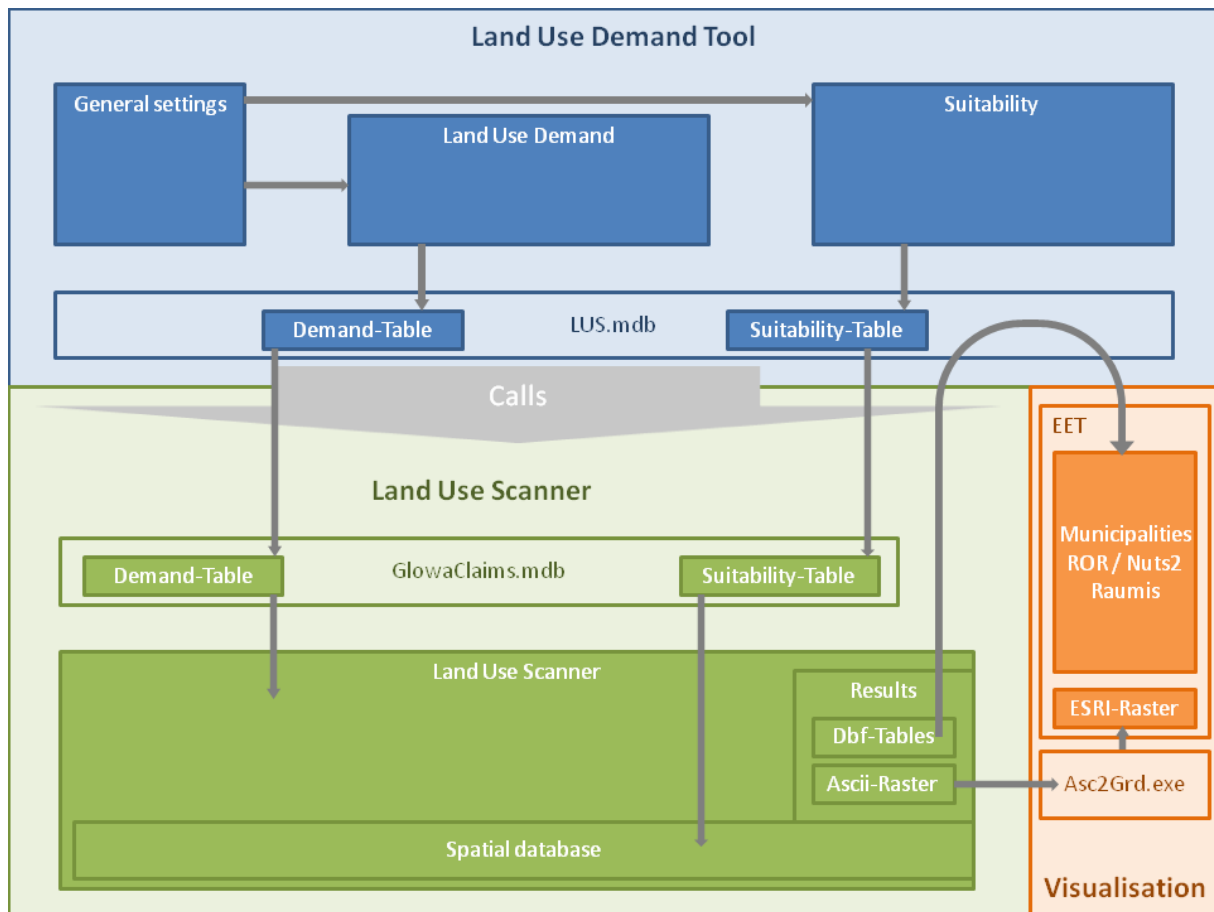
Figure 2: Technical Workflow of the Land Use Scanner Elbe

The tool integrates three different software components and many processing steps which are illustrated in more detail in Figure 2.

The first software component is the Land Use Demand Tool. Within this tool the general settings for a new scenario are defined. Additionally, all parameters that influence the demand for residential land use are adjusted here. The location characteristics which indicate the suitability of a certain location for new residential areas are provided in an extensive spatial database within the Land Use Scanner. The importance for these location characteristics is defined within the Land Use Demand Tool. All settings are saved in the LUS.mdb.

Based on the adjustments in the Land Use Demand Tool the residential land use demand is calculated and also saved in the LUS.mdb. These demand numbers and the suitability adjustments are transferred to the Land Use Scanner and its GlowaClaims.mdb. Additionally, the Land Use Scanner is started. It allocates the changes on grid cells based on the provided input from the Land Use Demand Tool. Results are automatically saved in ascii-grids and dbf-tables.

These results can be visualised in any standard GIS-software. Since the Land Use Scanner Elbe is running within the EET, certain constraints exist for providing the results for visualisation. First, the ascii-grids are converted into ESRI-raster automatically by a tool called asc2grd.exe. The ESRI-raster files are visualised in the EET. And second, the dbf-tables are imported into the LUS.mdb. The EET accesses the LUS.mdb and uses the imported tables for visualising the results on levels of municipalities, spatial planning regions, regions on Nuts level 2 and Raumis regions.

2. First steps

2.1 Installation procedure

Two different installation procedures are described, because the Land Use Scanner Elbe is able to run within the EET and to run stand alone. **For use of the Land Use Scanner Elbe within the EET please first read the general introduction to the EET.**

2.1.1 Within EET

To install the Land Use Scanner Elbe log on in Administrator mode. Double click on the SilentSetupLudLusFuerWasy.exe. Allow the system to execute the setup if you are asked for this. Since this is the installation routine for the EET you are not able to change the directory into which the tool will be installed. Instead, the setup is executed in the background completely. No further action is necessary. The setup of the Land Use Scanner Elbe installs the following components (Table 1):

Table 1: Installation components

Installation component	Installation directory	Description
GeoDMS 5.55	…\Program files\Glowa\ObjectVision\555\…	Software to run the land use change model
FoxPro-Driver		Database driver for Visual FoxPro databases
DemandTool	…\Program files\Glowa\LUD\…	Tool to calculate residential land use demand

All necessary statistical and spatial datasets are not provided with this setup. They are located on the EET-System in the following directories (Table 2).

Table 2: Storage locations for statistical and spatial datasets

Directory	Description
…\Templates\SimulationWorkspaceTemplate\LUS	This directory contains information that changes in relation to the different scenario calculations. The information that is included in this directory refers to the Land Use Scanner Elbe configuration, the statistical data to calculate residential claims and the results data.
…\Templates\Static\LUS	This directory contains all spatial data sets that do not change and are therefore static. This is related mostly to the location factors of the suitability maps.

After the installation of the Land Use Scanner Elbe the tool must be configured in the EET. This procedure is also described in Part G of the Technical Documentation of the GLOWA-Elbe III Elbe Expert Toolbox. To configure the Land Use Scanner Elbe start the EET and log on as Administrator. Choose the tab **Configure models** from the left column. Select the tool LUS from the list of models.

The Land Use Scanner Elbe has the integration type **Out of process (EXE)**. Select this integration type. Under Path type in the path to the executive file of the DemandTool: **C:\\Program files\Glowa\LUD\lud_setup.exe**. Additionally, type in the following parameter: **-eet:%EET%**. This parameter is passed to the tool, when the DemandTool is started and ensures that the tool knows which workspace is used and therefore, where the required datasets are and where to save the results. Furthermore, add a second parameter to the Parameter text box: **-static:…\Templates\Static\LUS**. This parameter provides the information where all static datasets are saved. This information is also passed to the tool. Finally, click the Apply button to save the configuration. The tool can be used now.

2.1.2 Stand alone

The LUD-LUS Tool runs under Windows operating system (XP or later). Your computer should have the following hardware components:

- .Net Framework 3.5 SP1,
- Processor: Intel Pentium 4 or Pentium compatible,
- Internal RAM: 1 GB (3 GB recommended),
- External storage: The GeoDMS Program files need 25MD disk space available. The project data needs around 6 GB disk space and another 50 GB disk space should be available because the calculation produces a large amount of temporary files (CalcCache) that can be deleted after each model run but they are necessary for the simulation process,
- Software: Win32 Operating system (XP or later),
- To edit configuration (*.DMS) files: an ASCII text editor (Crimson Editor with additional DMS-files in the link- and spec-subdirectories recommended; see the readme-file). The DMS-files can be downloaded from www.feweb.vu.nl/gis

The LUD-LUS Tool is distributed as a self-installing executable file. Installation starts by double-clicking the SetupLudLus_Ohne_Daten.exe file. The installation proceeds nearly fully automatic. The following settings are required:

- Allow the computer to execute the setup file if you are asked for this. Provide the path to the destination folder for the installation of the Land Use Scanner model.

- In the second step the driver for Visual FoxPro databases is installed silently.
- In the third step the DemandTool is installed. Select the language that guides you through the installation process. Follow the instructions on the desktop.
- Provide the path to the destination folder for the installation of the DemandTool. It is recommended to use the default settings. Define also whether you want to the setup to create a folder in the start menu and whether a desktop icon should be created. Confirm your settings by clicking the Continue button. Finally, check your settings and click install to start the installation procedure.
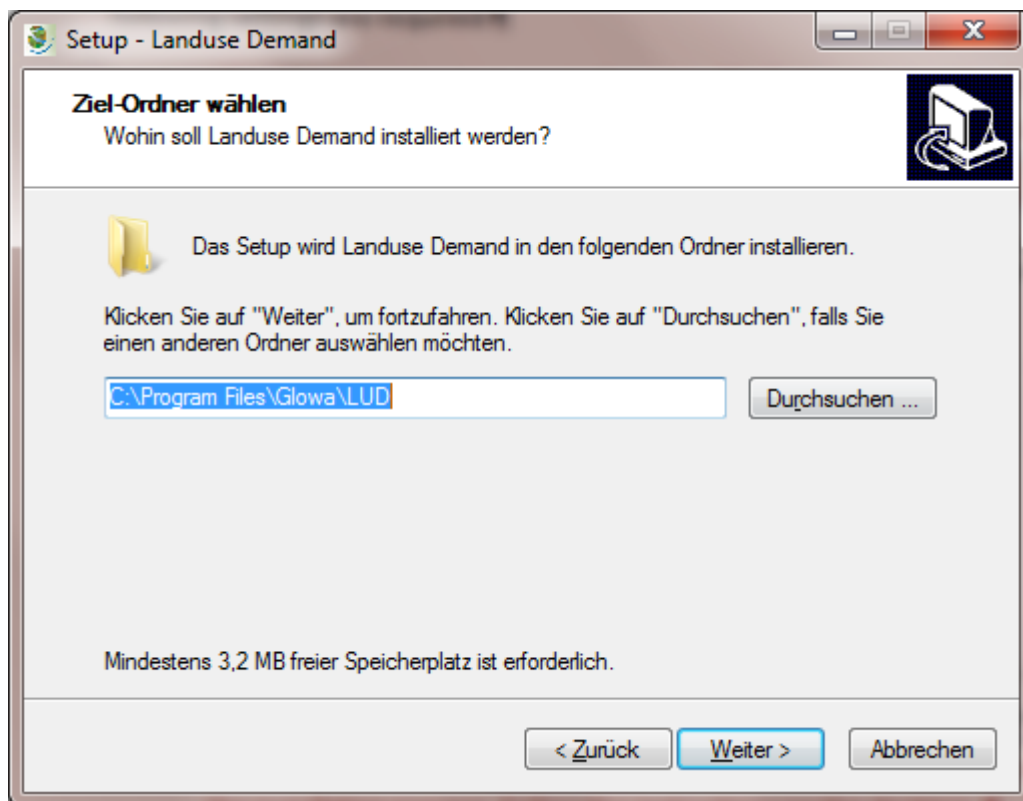
After the installation procedure the project data needs to be copied to the disk. By default they are not included in the setup files.

2.1.3 Data installation

By default no project data is included in the setups because the statistical and spatial datasets are subject to licensing. The datasets that are necessary for the EET were provided but are not allowed to be distributed. The specific datasets are described in the respective chapters of the manual.

2.2 Starting the LUD-LUS Tool

2.2.1 Within EET

Start the EET and logon as EET-Simulator. The username and password are provided by the administrator of the EET. A standard ArcGIS opens with the EET integrated. From the task list on the left-hand side select "Regionalisation". Select the task Land Use Scanner and click on the "Start" button. The Land Use Demand Tool opens. The displayed window is called **Landusedemand** (Figure 3).
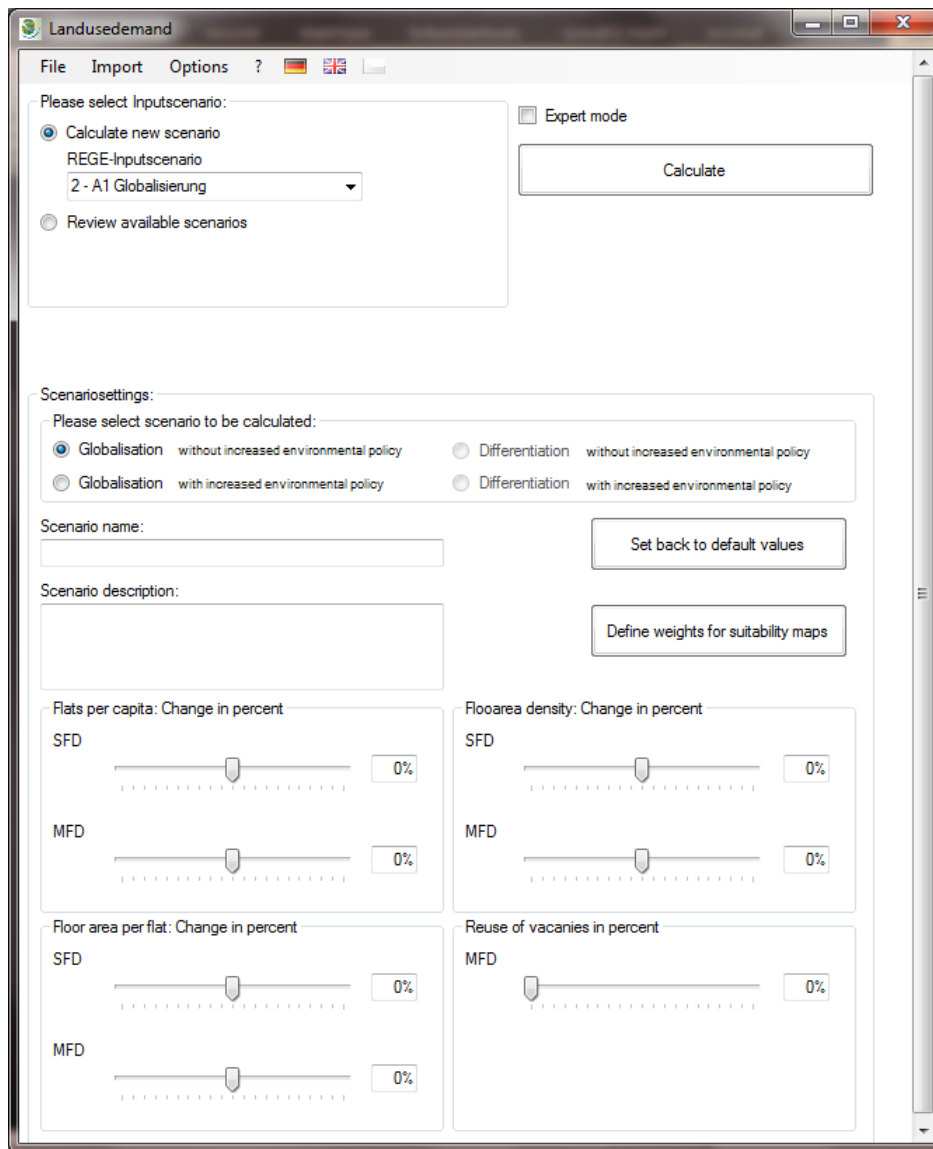
Figure 3: User Interface of the Landusedemand Tool.

2.2.2 Stand alone

The tool is started by double-clicking on the **Landuse Demand** icon on the desktop or by clicking on *Start/Program Files/GLOWA/Landuse Demand/Landuse Demand*. When the Tool is started for the first time the window **Initial Parametersetting** opens (Figure 4). In this window the initial settings for paths to software and data are defined and saved. Table 3 explains the different settings in more detail. If defined once, this window does not appear again. After saving the settings by clicking on the button **Save**, the actual window **Landusedemand** for the tool opens (Figure 4Figure 3).
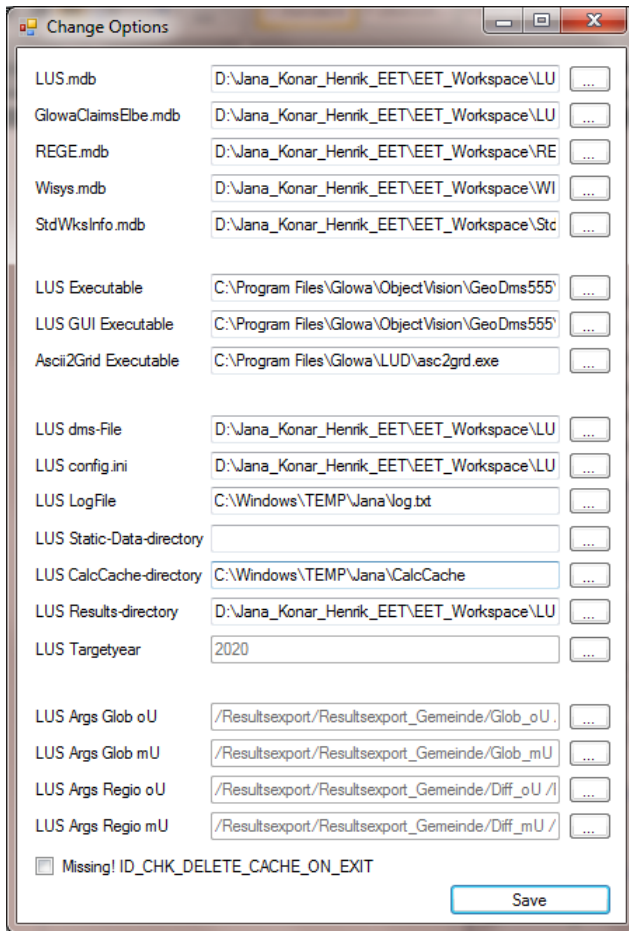
Figure 4: Initial Parameter settings (left) and User Interface for the LUD-LUS Tool (right)

Table 3: Description of parameter settings

Parameter	Description	Path
LUS.mdb	This database is the initial database that stores all relevant information for your project: base data, scenario-specific settings, results. Do not change the structure of this database. Within the EET other	Within the folder of the EET under *LUS*
Glowaelbe_claims_2000.mdb	This database is used by the LUS model and contains all information on the regional claims (first module in Figure 1) and the weights for the suitability maps that are calculated in the LUS model	Within the folder of the EET under *LUS\data\Scenarios\RegionaleClaimSets*
REGE.mdb	This database has in general the same structure and purpose as the LUS.mdb but for the tool REGE. It is only available when the tool is used within the EET. The LUS.mdb accesses this database to	Within the folder of the EET under *REGE*
Wisys.mdb	This database is only available when the tool is used within the EET. It contains spatial references that are needed for visualising results.	Within the folder of the EET under *WISYS*
LUS Executable	The path for the exe-file of the Land Use Scanner model.	Within the Program Files under *GLOWA\ObjectVision\ GeoDms555\GeoDmsRun.exe*
LUS GUI Executable	The path for the .exe file of the Land Use Scanner model if used in batch modus.	Within the Program Files under *GLOWA\ObjectVision\ GeoDms555\GeoDmsGui.exe*
LUS Config	The LUS model accesses a number of script files (*.dms) that contain the configuration of the model.	Within the folder of the EET under *LUS\cfg\Glowaelbe.dms*
LUS LogFile	This is a LUS specific log-file.	To be saved into a temp-folder for example: *C:\temp\log.txt*
LUS Static-Data directory	All basic datasets that do not change over time (current land use, thematic and policy maos) are saved in this staic data directory	Within the folder of the EET under *Static*
LUS CalcCache directory	The Land Use Scanner model produces a large number of temporary files that are saved in the CalcCache directory. Choose a place with enough disk space.	Choose a space with enough disk space.
LUS Results directory	The LUS model produces dbf-tables and raster files as output, that are accessed by the LUS.mdb and other tools within the EET. The path to the export folder is to be defined.	Within the folder of the EET under *LUS*
LUS Args Glob oU	For every scenario the before mentioned outputs need to be defined. Normally, no changes are necessary. These arguments are needed when the LUS model is executed to let it know what has to be calculated.	
LUS Args Glob mU		
LUS Args Diff oU		
LUS Args Diff mU		

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Part 2   Demand tool

1   Technical documentation

While working with the EET it is assumed that the Land Use Scanner was selected from the task list in the EET. Then the **Landusedemand** window opens. Otherwise, double-click on the **Landuse Demand** icon on your desktop (see section 2.2.2 of Part 1).

The window **Landusedemand** has a structure that allows a workflow from top to bottom. In the upper left corner it is specified what to do: calculate a new scenario or watch an old one. Below the scenario is selected and some basic information is typed in. In the middle of the window on the right a button allows to specify the weights for the calculation of suitability maps. At the bottom the settings for the calculation of the regional claims are made. Finally, with a click on the button **calculate** the simulation starts.

1.1   Calculate a new scenario

1.1.1   General settings

First it is to be decided whether to calculate a new scenario or whether to watch an already calculated one. In this section only the option **Calculate new scenario** is described.

Select the option **Calculate new scenario** (see red box). Additionally, a REGE-Scenario needs to be selected. REGE provides the socioeconomic development the new calculation is based on.

Please note: Depending on the selected REGE-scenario it is defined whether a globalisation or a differentiation scenario will be calculated. If a globalisation scenario is selected from REGE the LUD-LUS tool can only calculate a globalisation scenario either with current environmental policy or with strengthened environmental policy. If a differentiation scenario is selected from REGE only a differential scenario can be calculated with the LUD-LUS tool, either with current or with strengthened environmental policy. Impossible scenario combinations are greyed out and therefore not selectable.
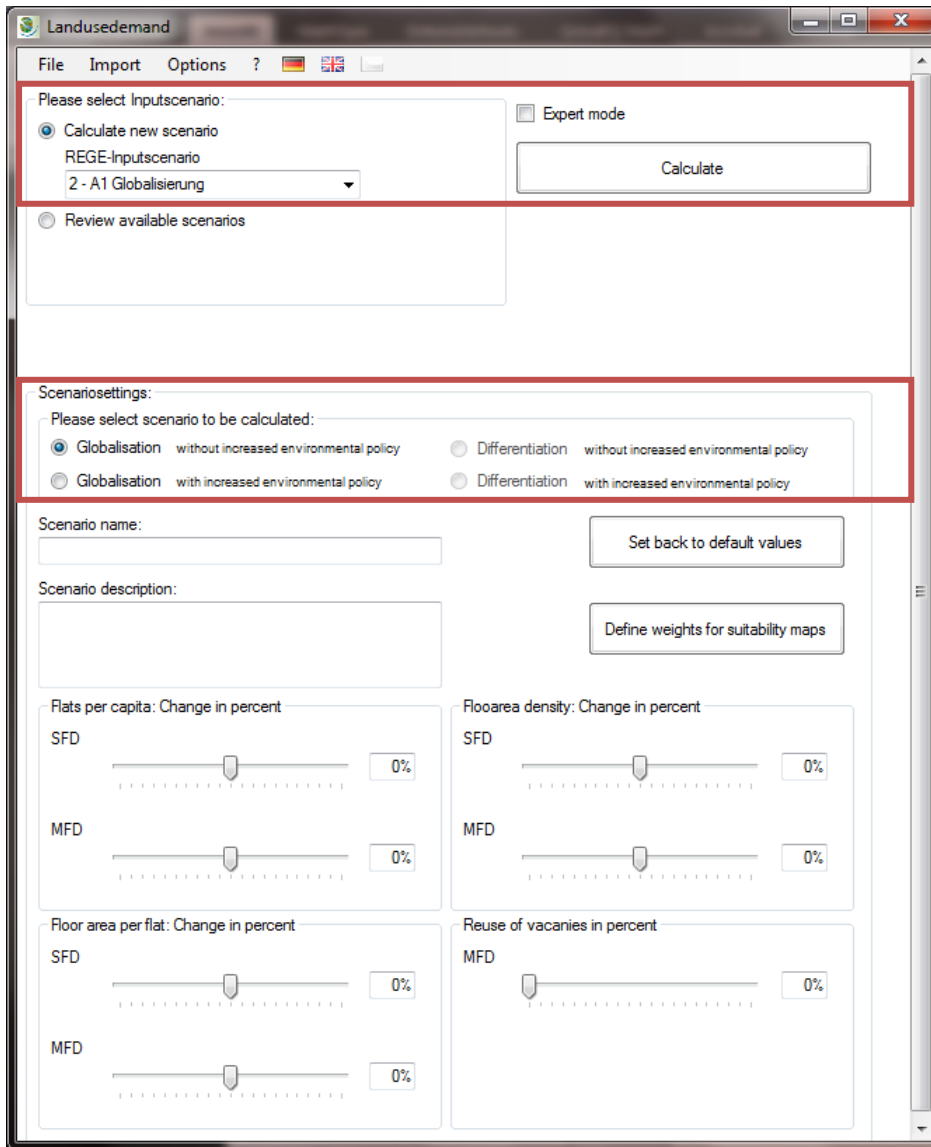
By now clicking the button **Calculate** a Warning message is produced. It says that a REGE-scenario must be selected. Furthermore, a name and a description for the new scenario must be typed in.
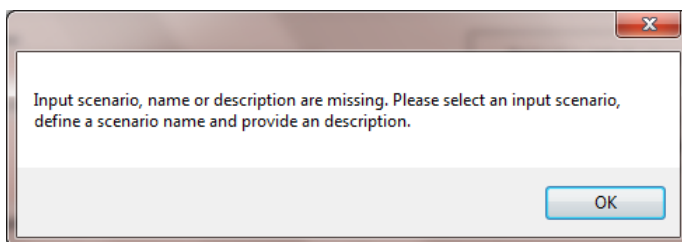
Click **OK.** The fields in the **LanduseDemand** window that are mandatory are coloured red now.
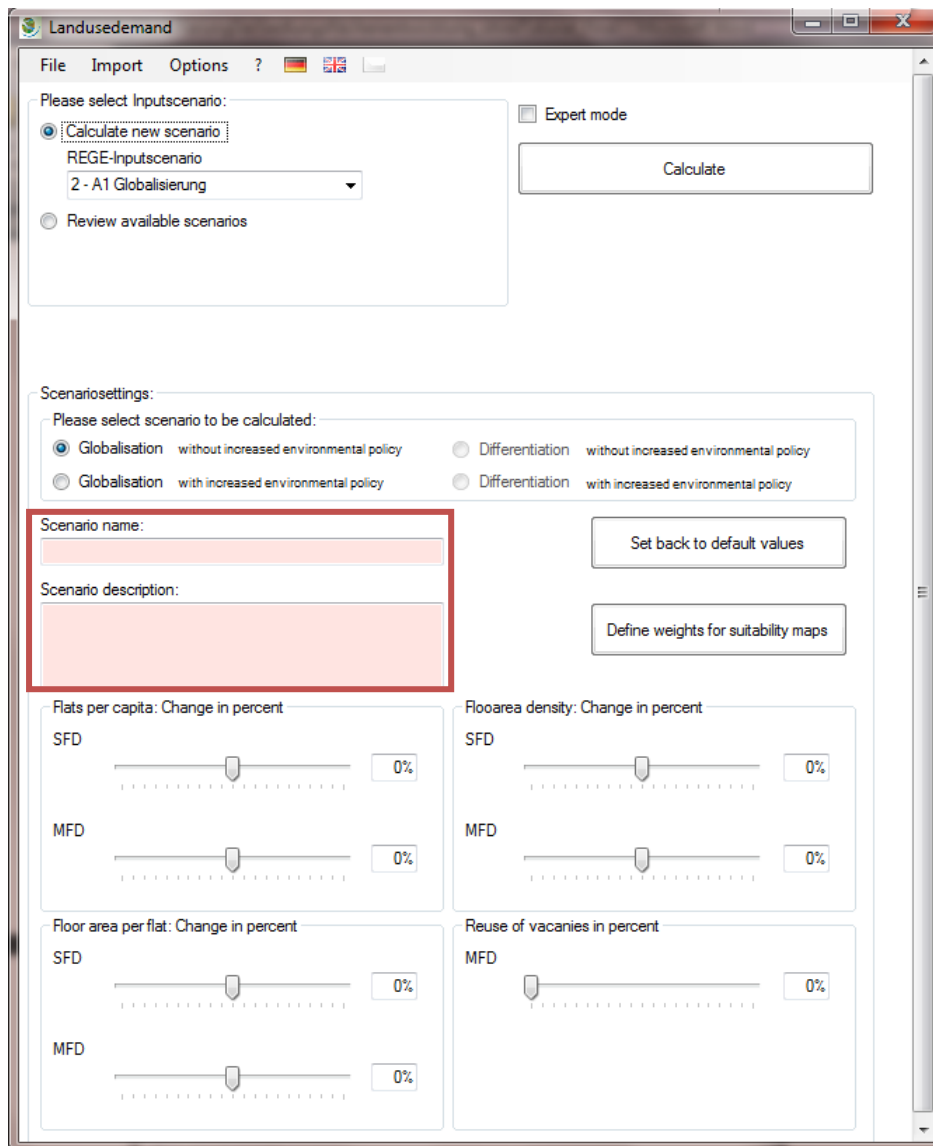
Fill in a name and a description for the new scenario. The red colour disappears while typing.
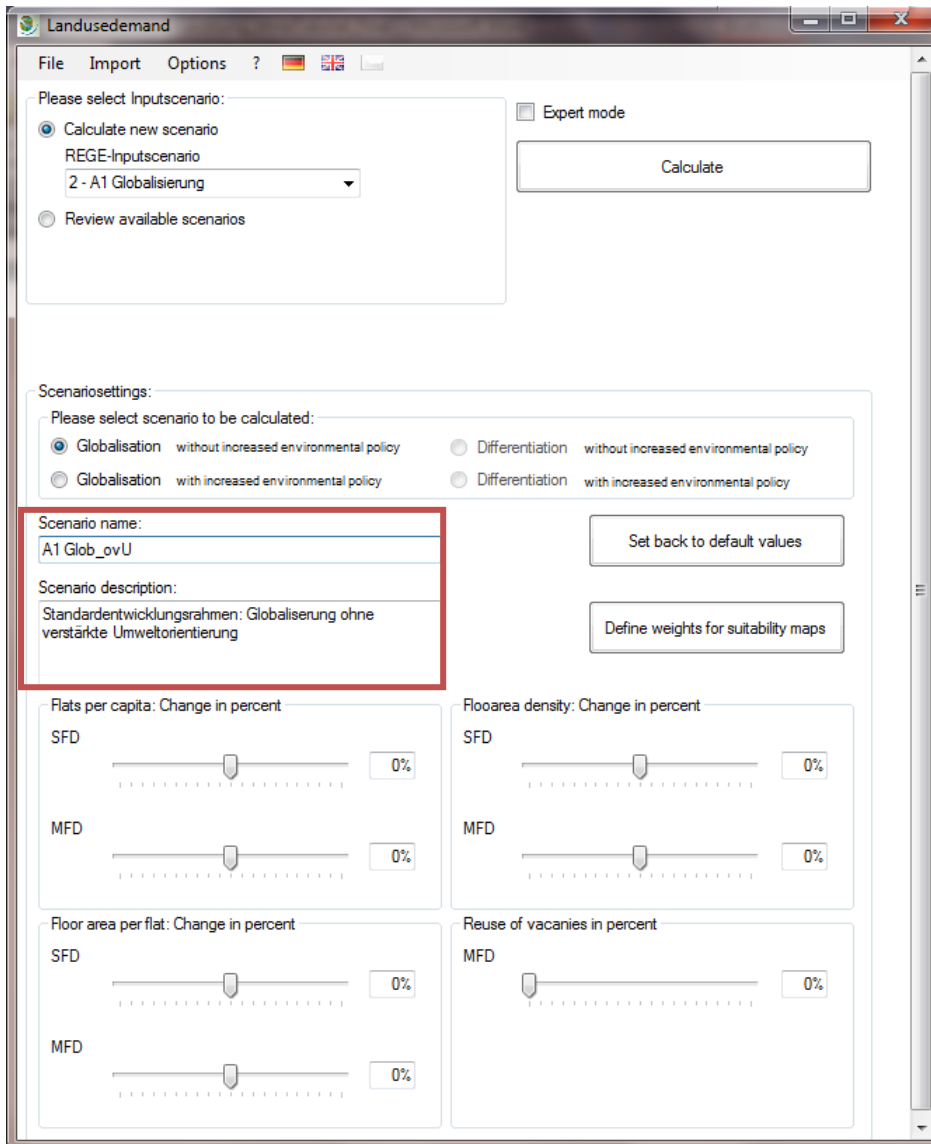
By now clicking the button **Calculate** another message may occur, if a scenario with the same parameter settings already exists. The message informs about the corresponding scenario ID.
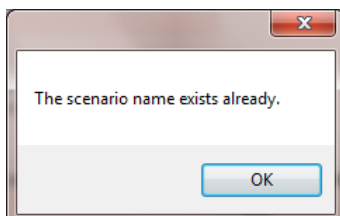
1.1.2   Defining the Residential Land Use Demand

Finally the parameter settings for a new scenario can be changed in the lower part of the **Landusedemand** window. The settings for four variables can be changed by simply dragging the corresponding slide-bar in one direction. This influences the demand for residential areas. The adjustable parameters are subsequently described:
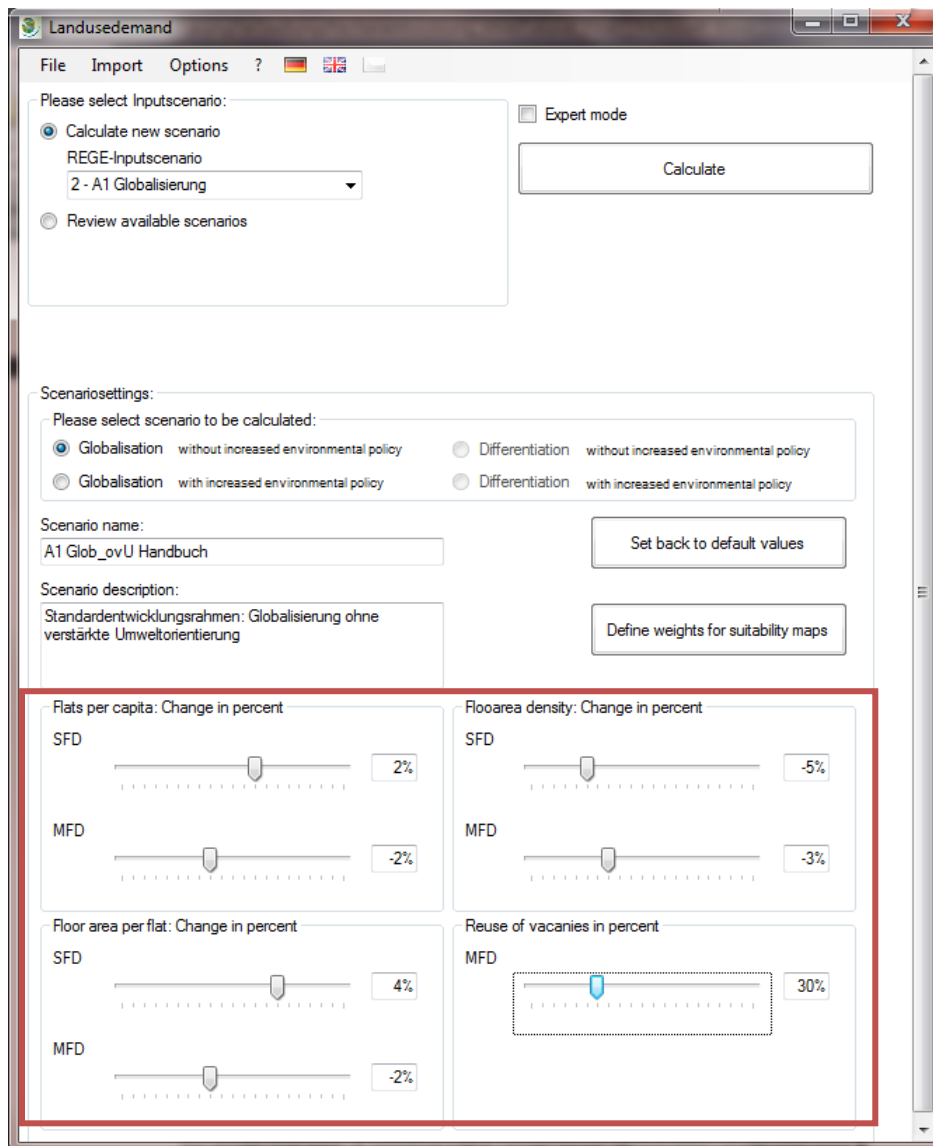
- **Per capita dwellings:** is an indicator for household size. Select a percent change of the currently implemented starting value. A positive value causes a higher demand for residential area. A negative value causes lower demand for residential area.
- **Floor area per dwelling:** is an indicator for the size of the dwelling and economic wealth, respectively. Select a percent change of the currently implemented starting value. A positive value cases a higher demand for residential area. A negative value causes lower demand for residential area.
- **Floor area density:** is an indicator for structural density. It measures the floor area per hectare settlement area. Select a percent change of the currently implemented starting value. A positive value causes a lower demand for residential area. A negative value causes higher demand for residential area.

All three indicators can be adjusted separately for single-family dwellings (SFD) and for multi-family dwellings (MFD). An overview of the currently saved values can be found in Appendix 5. These values are used for the standard scenarios within the GLOWA-Elbe project.

- The fourth indicator is a measure of reusing current vacancy. Select the percentage of currently vacant dwellings to be reused. Reusing vacant dwellings reduces the demand for residential area. The current status of vacancies can be seen at http://www.bbsr.bund.de/nn_23744/BBSR/DE/Raumbeobachtung/GlossarIndikatoren/indikat oren__dyncatalog,lv2=104636,lv3=106508.html.

By clicking the button **Set back to default values**, all adjustments are reset and the currently implemented values are used.

1.1.3   Define Suitability maps

In addition to the adjustment for the calculation of residential land use demand, the weighting for the calculation of suitability maps can be changed. To adjust suitability weighting click the button **Define weights for suitability maps.** A new window opens which is called **suitability maps**.
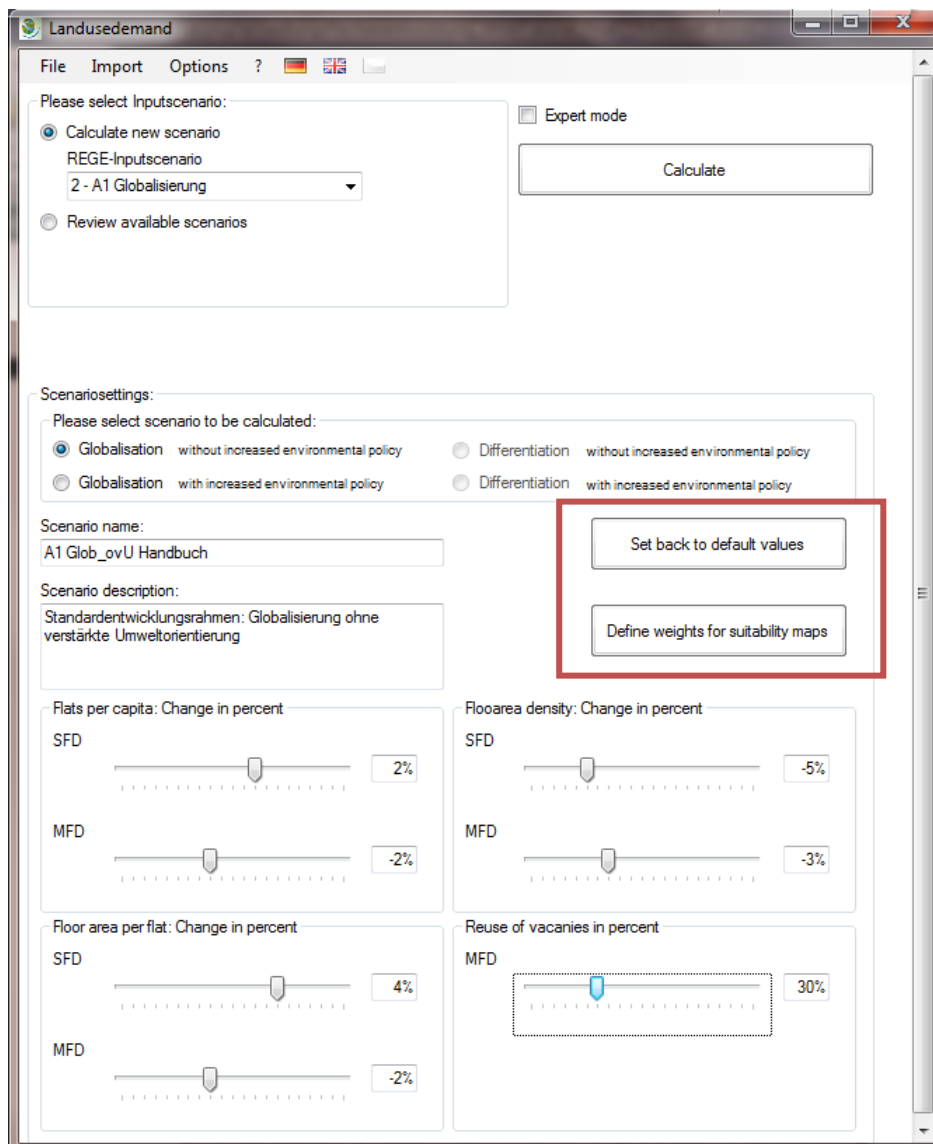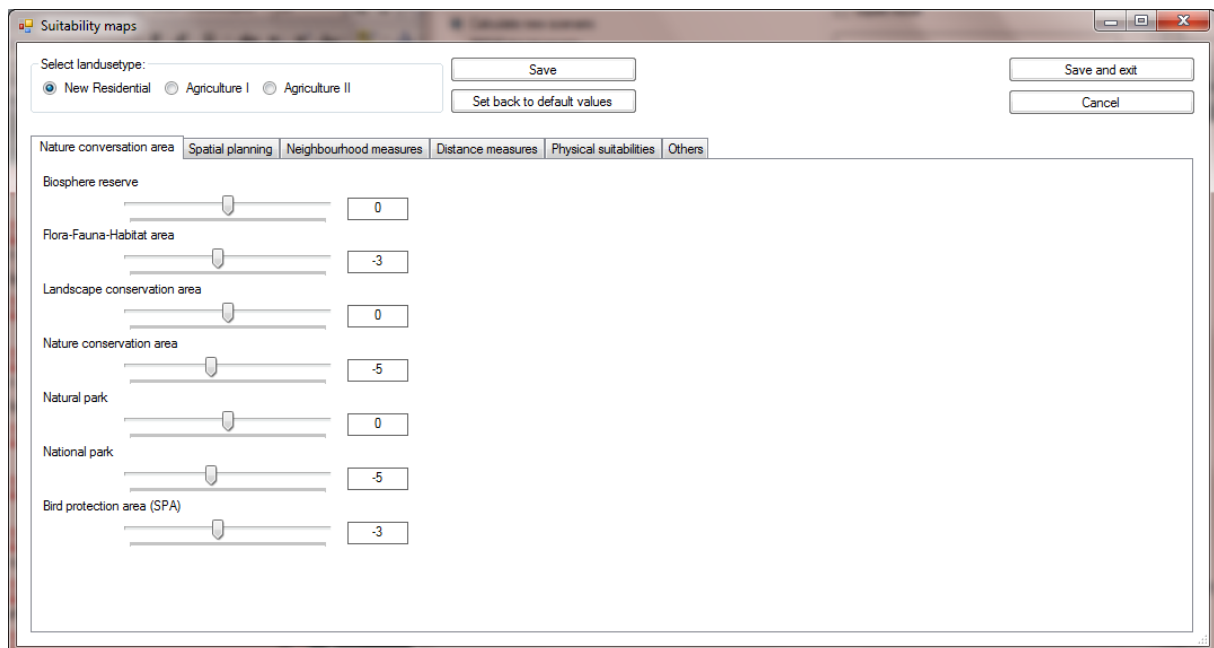
In the upper left part of the window the land use type can be selected for which the suitability maps are to be adjusted. There are three land use types available: residential areas, pasture and arable land. The demand for pasture and arable land is calculated as residual from the residential land use demand.

The different adjustable suitability factors are organised in groups. They are accessible via six tabs. By moving the slide control the importance of single suitability factors, which determine the allocation of land use changes can be determined. This can be done for every suitability factor in the six tabs. The higher a positive weight is, the higher is its importance for the allocation of a certain land use type in a raster cell (at least partially) occupied by that suitability factor. The lower a negative weight is, the higher is its importance to avoid the allocation of a certain land use type in a raster cell (at least partially) occupied by that suitability factor.

All adjustments must be saved for every land use type separately. Therefore click the **Save** button, if adjustments for one land use type are finished. Thereafter, weights for another land use type can be adjusted, and again saved.

To reset the adjustments click the **Set back to default values** button. All currently implemented weights are used in that case. For their calculation see section 2.3 of Part 2.

When all weights are adjusted, save the settings by clicking the **Save and Close** button and close the window. The window can be closed without any changes by clicking **Cancel**.

1.1.4   Calculating the scenario

All necessary settings are finished now. In the **Landusedemand** window click the **Calculate** button to start the calculation of the LUD-LUS Tool.

The following calculations are now executed:

- Residential land use demand is calculated.
- Residual land use demand for Pasture and Arable land is calculated.
- The results of the demand calculation and the weights for the suitability maps are passed to the Land Use Scanner model.
- A window MS-DOS prompt opens while the Land Use Scanner is simulating the land use change on grid cells. No action is required. The window closes itself when the calculations within the Land Use Scanner are completed.
- A number of raster files are produced by the Land Use Scanner model for visualisation within the EET. Details about visualisation are explained in Part 4.
- A table is exported with results on municipal level and imported into the LUD-LUS Tool for use by other tools of the EET and for visualising results within the EET. Details about visualisation are explained in Part 4.
- (only within EET): A number of MS-DOS prompts open. During this procedure ascii-grids which were exported from the Land Use Scanner are converted into ESRI-grids to be visible in the EET. Normally, no action is required and the prompts close automatically. If you are asked for the permission to execute the asc2grd.exe confirm (This should not happen though).
- (only within EET): The LUD-LUS Tool imports the table-information gets the information that the calculation is completed.

Finally a message box appears that the calculated scenario can be visualised now. Click **OK**.
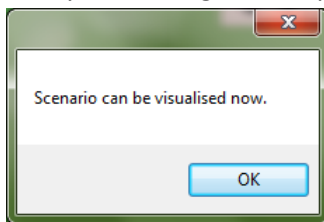
1.2 Watch an already calculated scenario

There is also the possibility to watch an already calculated scenario. Therefore, select the option **Review running scenarios**. This selection alters the drop down list. It now does not show the available REGE scenarios but all scenarios that were calculated already, at least scenarios with calculated land use demand (this refers to the Expert Mode as described in section 1.3 of this part).

Select a scenario from the list and review the corresponding settings like name, description and variable settings.
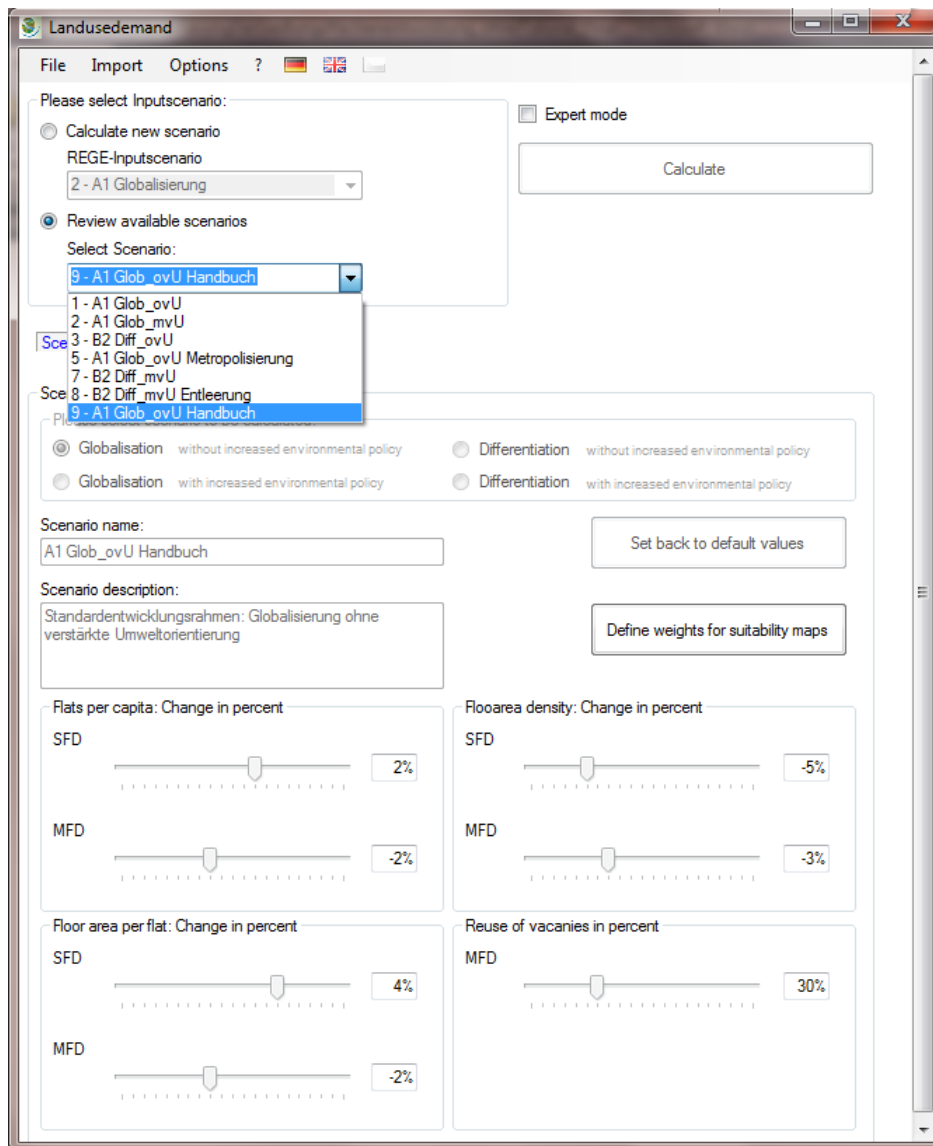
It is not possible to make any adjustments for an already existing scenario. Therefore, the corresponding functions are all disabled. For the case a scenario was calculated completely already, the following message is visible in blue colour: **Scenario has already been calculated.**

It is possible to calculate the scenario again, when the calculation was not finished. This can happen, when the Expert Mode is used. Details about the expert mode can be found in section 1.3 of this part. In this case a message occurs below the drop down list in red colour: **This scenario is still in calculation!**

1.3 Use expert mode (for advanced users only)

Until now the whole Land Use Scanner model has been running as black box. The user had no ability to get an inside look into the allocation module of the LUD-LUS Tool. This can be achieved though by using the **Expert Mode** of the tool. Then, check the box **Expert Mode** in the upper-right of the **Landusedemand** window. Instead of one button Calculate, two buttons appear now (see the red square in the figure).
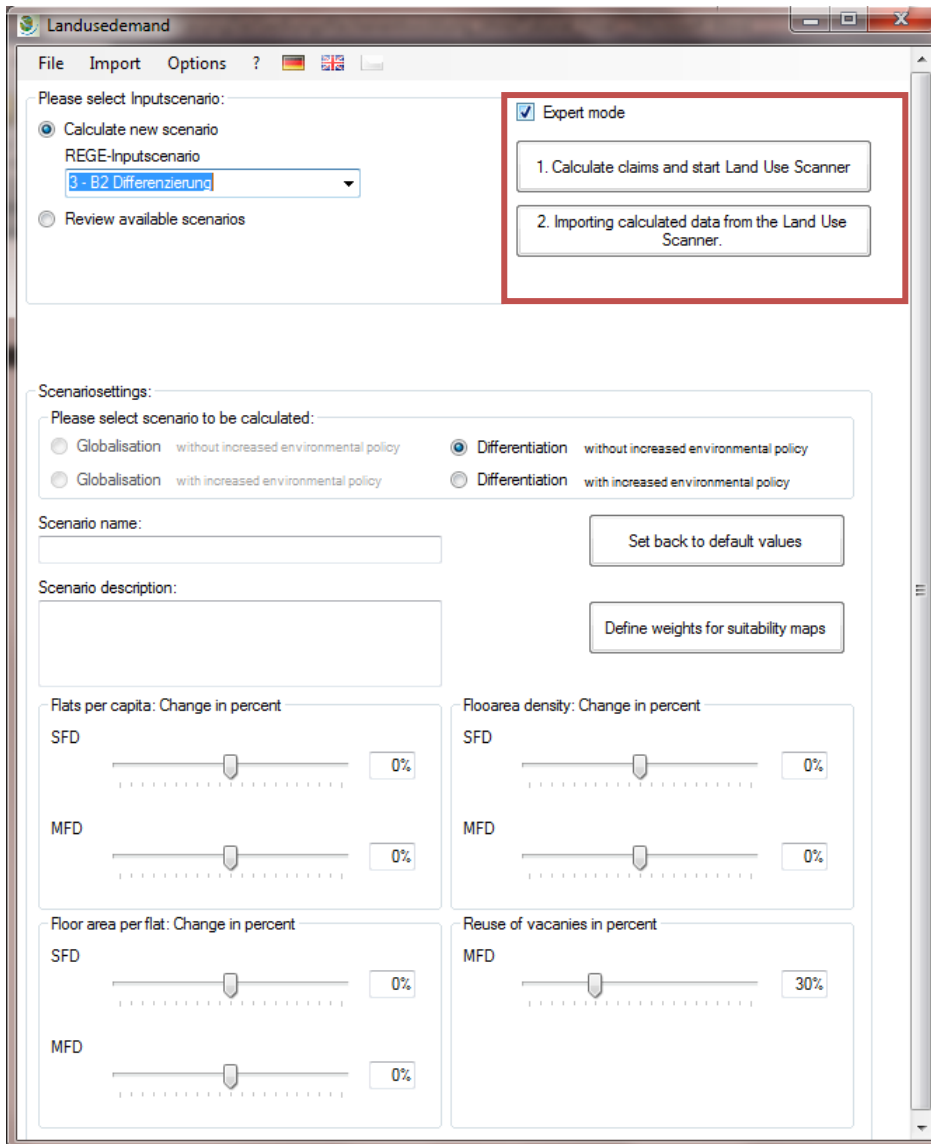
1.3.1   Calculate a new scenario

To calculate a new scenario in Expert Mode make all necessary settings as described in section 1.1.1 to 1.1.3 of this part. Do not consider section 1.1.4.

- **1. Calculate claims and start Land Use Scanner:** By clicking this first button only the land use demand for the three land use types is calculated and passed to the Land Use Scanner model. The following message box is displayed:
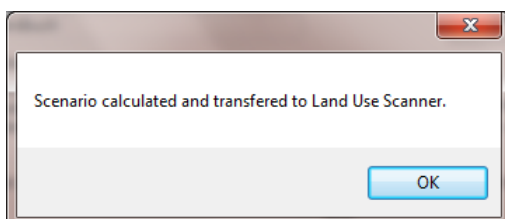
Click **OK**. The Land Use Scanner model is not running in the background now, but it is started in a separate window.
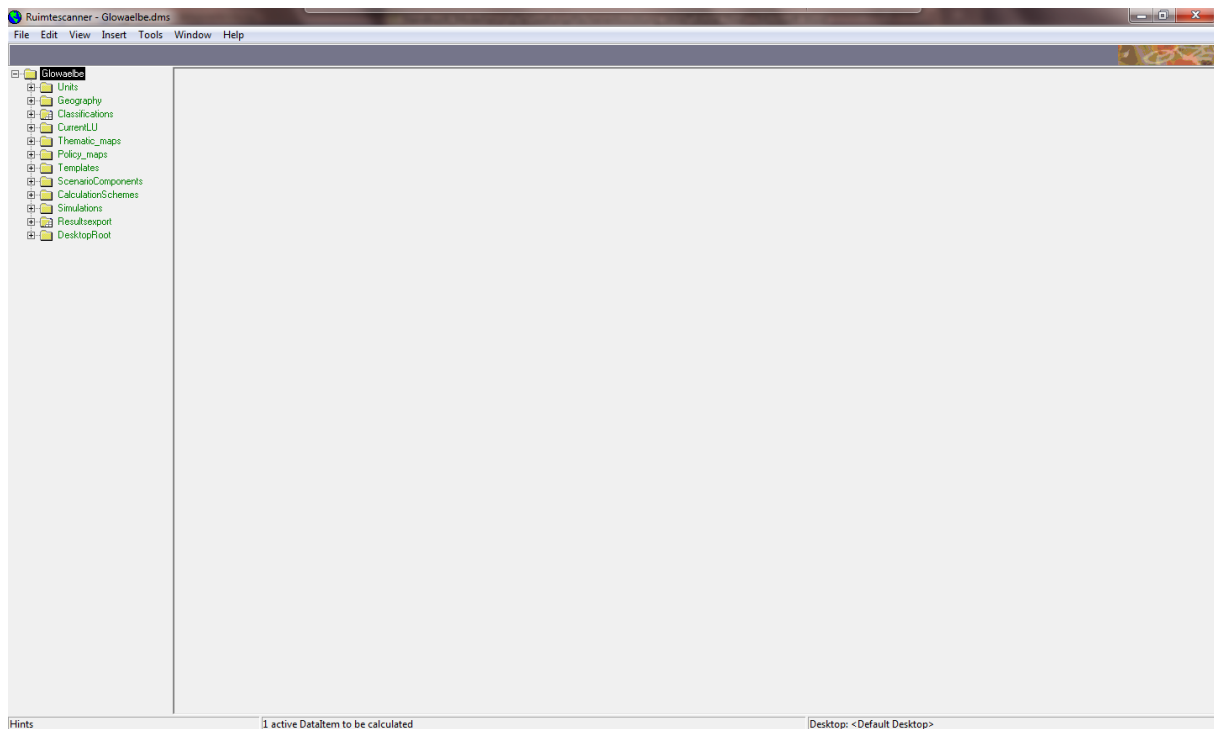
- The model needs to be executed separately by the user. All necessary results must be produced manually by the user (raster and table files). For details about using the Land Use Scanner model and producing the results, refer to Part 3.

  The simplest way to produce the results for the EET is by clicking on *Resultsexport\Resultsexport_Gemeinde* und *Resultsexport\Resultsexport_Raster* in the Treeview. In this two tree-branches double-click the corresponding scenario. The results are calculated and saved as files.

- **2. Importing calculated data from the Land Use Scanner:** After executing the Land Use Scanner model and producing the results for use in the EET, this second button needs to be clicked. Now all necessary steps are calculated to use the results within the EET for visualisation and to provide the results for other tools of the EET.

The complete workflow must be executed in the explained order. Otherwise the scenarios are not calculated completely.

1.3.2 Complete a calculation of not yet completed scenario

In some cases it is possible that only step 1 (calculating land use demand) was finished but not the steps execute Land Use Scanner model and importing calculated data from the Land Use Scanner. In this case the LUS.mdb has information that this certain scenario is not yet completed. Therefore, it is not available for other tools of the EET. To make it available the already calculated land use demand needs to be passed again to the Land Use Scanner model. Therefore, select the option **Review running scenarios** from the **Landusedemand** window. Select the respective scenario from the drop down list. A red message appears that confirms that the scenario has not yet been calculated completely: **This scenario is still in calculation!** Since the demand was calculated already it is not possible to alter the parameter settings of this scenario. Then follow the three steps of the Expert mode to first pass the calculated demand to the Land Use Scanner model and open the Land Use Scanner model, second execute the Land Use Scanner model (refer to Part 3) and third re-import the results to complete the scenario and to visualise them within the EET.

2   Methodology

2.1 Scenario description

The current setting of the Land Use Scanner Elbe analyses four scenarios. The outline of the scenarios are narrative storylines based on the global socioeconomic assumptions of the IPCC scenarios and are therefore qualitative to a certain extent (Nakicenovic and Swart 2000, Hartje et al. 2008). However, they are also quantitative because models are applied to numerically estimate the impact of the narrative storylines. The starting point is the present date. Based on growth rate assumptions, the future is explored. Thus, the scenarios are exploratory. The analysed scenarios do not take into account new policies or measures, but the degree to which existing policies are enforced can be varied. Therefore, scenarios are defined as multiple reference or baseline scenarios.

The scenarios applied from the IPCC are A1 and B2. Since none of the IPCC scenarios includes any assumptions about future policies on the global scale they are suitable for the present study, which aims to analyse the impact of regional policies. The A1 scenario, also referred to as the globalisation scenario, assumes very rapid economic growth with a global population peak in the middle of the 21st century and a rapid introduction of more efficient technologies. Cultural, social and economic interactions increase globally. The contrasting B2 scenario, also referred to as the differentiation scenario, describes a future with local solutions to economic, social and environmental sustainability. The economic growth is on an intermediate level with less rapid and more divergent solutions for more efficient technologies. This scenario focuses on social equity and environmental protection on the regional and local levels (Nakicenovic and Swart 2000).

On the basis of these global storylines, consistent national and regional storylines are developed. This is necessary because the global development has different regional specifications. This was observed for past developments and will probably also be the case in the future. The two scenarios are further differentiated by the degree to which land use policies are enforced. It is assumed that environmental protection and economic growth in a globalising world or increasing environmental pressure in a regionally-oriented world must not be mutually exclusive. Therefore, a set of four scenarios is considered with two pathways of socioeconomic development and two orientations of land use policy.
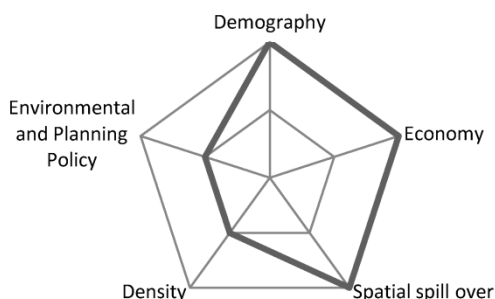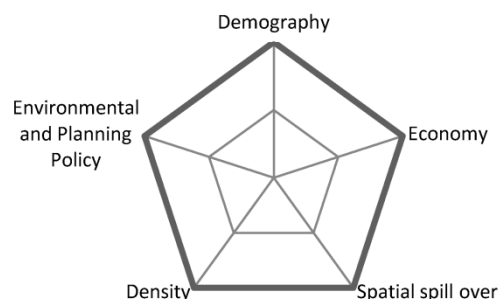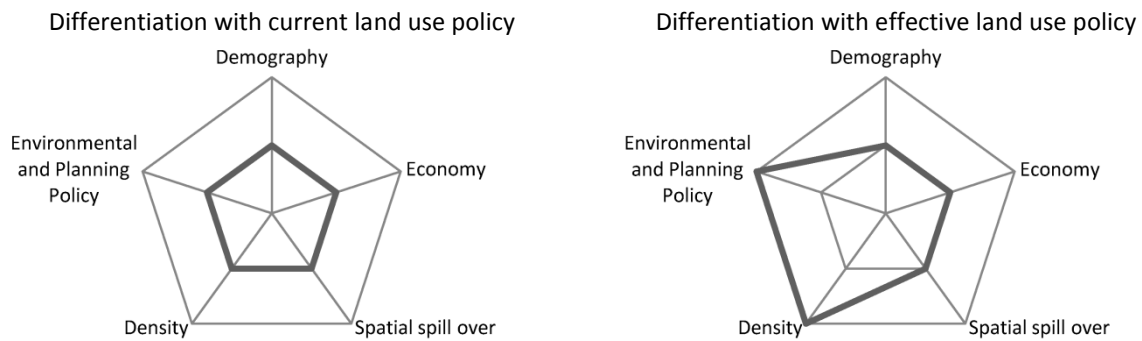
Figure 5: Simplified spider diagrams of the GLOWA-Elbe scenarios for residential areas.

Figure 5 presents a simplified qualitative interpretation of the key driving forces that were considered in the scenario analysis of built-up areas. The regional socioeconomic specification of the two IPCC scenarios for the study area assumes high economic growth rates, an increasing participation of Germany and the Czech Republic in international trade, a reduction of regional disparities and a service-oriented economic development for A1. The reduction of regional disparities is represented by spatial spill-overs of socioeconomic development and the development of built-up areas from growth centres to peripheral regions. B2 is characterised by lower economic growth rates, a decreasing participation in international trade, the persistence of regional disparities and missing spill-over effects from growth centres to the peripheral regions. The current land use policy (^{0}) represents current politics and the current enforcement of measures. The more effective land use policy ($^+$) does not consider a new policy but ensures that existing measures are completely accomplished. The environmental and planning policy therefore considers regional planning documents but also realised building densities, which are higher when the more effective land use policy is realised. A comprehensive description is given in Hartje et al. 2008.

2.1.1   A1^0 – Globalisation with current land use policy

The scenario of globalisation with current land use policy assumes that current trends of housing preferences are continued, due to strong economic growth and personal economic wealth. These preferences are characterised by the desire to own property in the green areas in the periphery of cities, which results in ongoing suburbanisation, especially in the rural periphery of metropolitan cities. Due to the strength of the economy, the ongoing suburbanisation radiates to the outskirts of large and medium sized cities. The metropolitan areas act as "lighthouses" for the study area (Adam and Göddecke-Stellmann 2002, Blazejczak et al. 2008). It is assumed that the supply of floor area and demand diverges and the inner city quarters show significant vacancy.

2.1.2   A1$^+$ – Globalisation with effective land use policy

The socioeconomic development of the scenario of globalisation with effective land use policy is the same as in A1^0. However, to avoid ecological and economic drawbacks, preferences for housing are changing. This development is induced by new instruments of land use policy. Newly introduced planning instruments aim to direct residential development onto sustainable pathways and to reduce the demand for residential land use. In this scenario calculation, this is expressed by a stronger increase in building density than was observed in the past. All applied policy instruments should not hamper the economic development.

2.1.3   B2⁰ – Differentiation with current land use policy

In the scenario of differentiation with current land use policy, a weaker demographic and economic development is assumed as well as regionally-oriented life styles. The radiation of economic wealth from metropolitan regions is weak and does not reach smaller cities. Metropolitan areas act more as "islands" within the study area (Adam and Göddecke-Stellmann 2002, Blazejczak et al. 2008). The desire to own property still exists but the wealth of the people is not enough to realise their desire. Instead, it is assumed that vacancies in the inner city quarters are reused. Regional discrepancies of economic development lead to a concentration of residential development close to large and metropolitan cities.

2.1.4   B2⁺ – Differentiation with effective land use policy

The socioeconomic development in the scenario of differentiation with effective land use policy is the same as in B2⁰. In contrast to the globalisation scenarios, people recognise the attractiveness of inner city quarters with their good accessibility of supply infrastructure. This results in an increased demand for existing dwellings, especially in inner city quarters, which reduces vacancies. In combination with the application of efficient land use policy instruments, suburbanisation is reduced to a minimum. Again, the building densities rise more than in the past. Weak economic development contributes to these ambitions due to the limited radiation effects of growth to places other than metropolitan cities. A polarisation of spatial structures can be expected due to the depopulation of the periphery.

2.2   Calculating Residential Land Use Demand

2.2.1   Input data

First, a population projection considering a cohort model prepared by Blazejczak et al. 2008 is applied (REGE tool). This projection is favoured over population forecasts by the Federal Office of Building and Regional Planning (BBR) or the Federal Statistical Office (STABU) because it implements a migration matrix that changes according to the labour supply. This approach allows for the consideration of the specific migration patterns of the past two decades in the Elbe River Basin. In contrast, BBR and STABU provide pure cohort models with a fixed migration matrix. Blazejczak et al. 2008 delivers two regionalised scenarios of demographic development based on the IPCC-SRES storylines A1 and B2. While the overall population in Germany grows in A1, it declines in B2. Both scenarios are characterised by regional population declines in peripheral regions. A similar development is denoted for the Czech part of the study area.

Nevertheless, the household and housing forecasts of the BBR for spatial planning regions are useful in the second step, since they are the only area-wide forecasts of the housing sector in Germany. The proportion of heads of households distinguished by age group, sex and size of the households are applied to the BBR population forecast; these result in the expected number of households. The same procedure can be carried out with the members of households also resulting in the expected number of households. Both results are subsequently harmonised. The past trends of the proportion of heads and members of households are analysed for trends and extrapolated into the future based on statistical surveys (BBR (Bundesamt für Bauwesen und Raumordnung) 2006). The total number of households will slightly increase in West Germany. This increase is driven by the increase in the number of small households. In East Germany the number of households will stagnate until 2020.

Following the household forecast, a housing forecast is conducted by BBR. Based on the proportions of owner-occupied dwellings, per capita floor area of owners and tenants distinguished by household size, age and nationality of the household, the demand for floor area is calculated for the expected number of households. The development of the driving forces of the demand for floor area are analysed for their trends and extrapolated into the future. The total demand for floor area is distinguished in floor area in single- and multi-family dwellings whereas the demand for single-family dwellings exceeds demand for multi-family dwellings. The demand for multi-family dwellings decreases in peripheral regions of East Germany by more than 10%, while that for single-family dwellings increases by 10%, especially around Berlin. The demand for floor area is translated into demand for new buildings by dwelling type in the next step. In the first half of the projection period the demand for new buildings declines due to the impact of demographic change. In the second half of the projection period the demand stabilises. A slight increase in demand for multi-family dwellings is caused by an increasing number of young people living in cities and an increasing ratio of owner occupied apartments in multi-family dwellings. The translation of floor area into number of new buildings also considers the supply of floor area. For instance, the supply of floor area is influenced by marketability and competition between submarkets (old/new dwellings). This can result in demand for floor area even though there is a supply surplus. The consequence is new developments and vacancies at the same time (BBR (Bundesamt für Bauwesen und Raumordnung) 2001, 2006).

2.2.2 Demand calculation based on input data

Figure 6 shows the procedure for calculating the residential land use demand. The population forecast of the BBR, on which the housing forecast is based, and the projections of Blazejczak et al. 2008, show considerably different results due to their different methods. Thus, an approach must combine the results of the housing forecast by BBR and the population projections of Blazejczak et al. 2008 to make them applicable for calculating residential land use demand. This procedure is explained in the following paragraph.

The housing forecast delivers the per capita demand for the development of new dwellings by dwelling type. This indicator is used as a proxy and multiplied by the future population calculated by Blazejczak et al. 2008. This procedure assumes the same household structure development as was proposed by the household forecast although the population projections of both studies vary considerably. The housing forecast also produces the mean floor area per dwelling type, which is then multiplied by the previously determined demand for new dwellings distinguished by dwelling type. This results in the total demand for additional floor area.
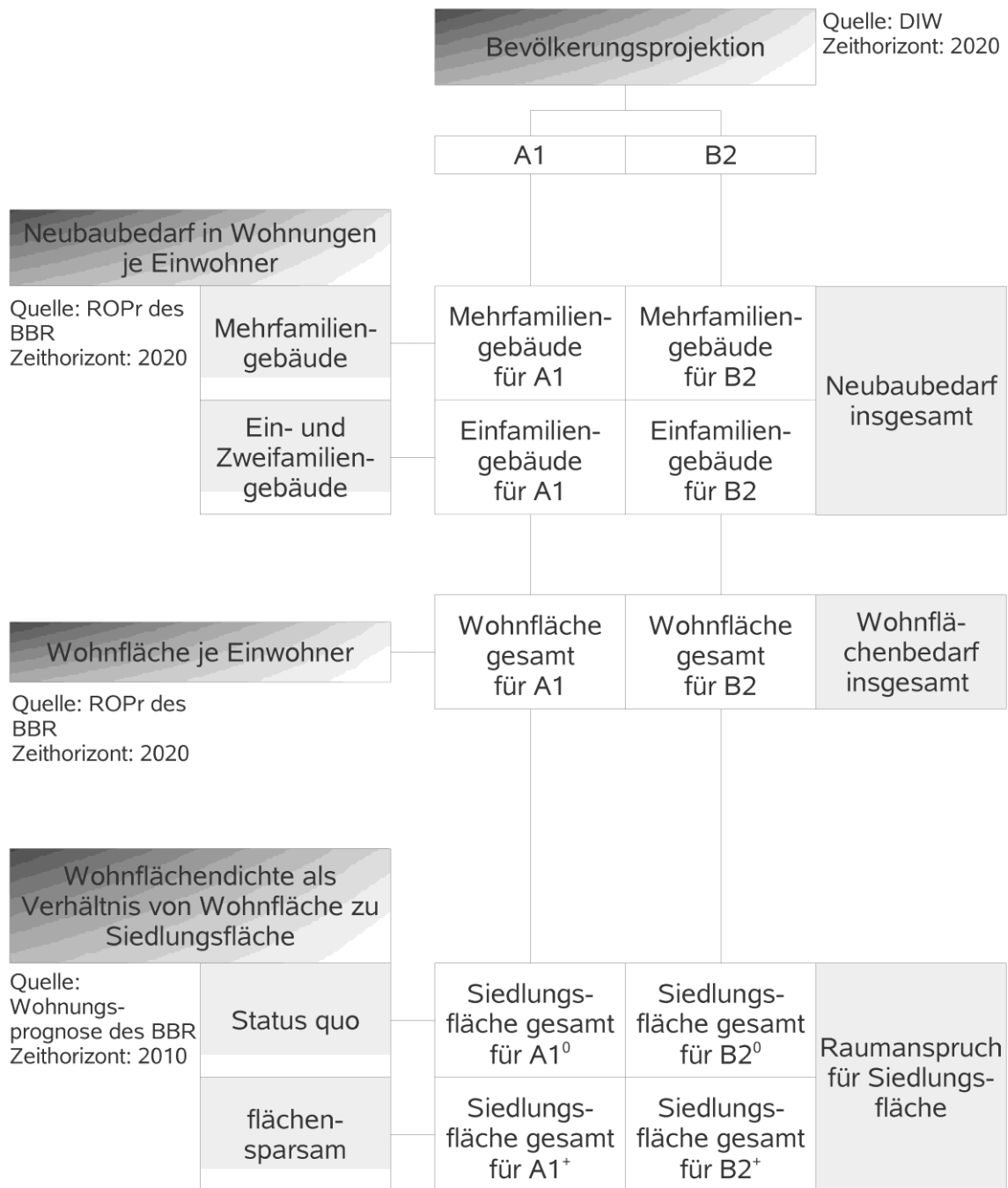
Figure 6: Methodology for calculating residential land use demand

For the determination of residential land use demand, specific land requirements for different dwelling types are needed. Specific land requirements are preferred over density measures like population density (population per spatial unit residential area). The required number of dwellings by dwelling type represents demographic change as well as changes in lifestyles. Distinguishing dwelling types allows for the direct accounting of changes in housing preferences over time.

Unfortunately, there exist hardly area-wide surveys of land requirements for dwelling types in the study area. Until 1996, the STABU surveyed the lot sizes of different dwelling types for Federal States. From this time on, no information is available. While for West Germany, a historical time series is available from before 1996, for the eastern parts, which account for most of the German

part of the Elbe river basin, information is available for only two years. These two years, 1994 and 1996, can give an indication of current developments, but are not very reliable because of the structural changes after the political changes during the first half of the 1990s decade. Due to the influence of these structural changes no trend extrapolations are possible. Since the developments of residential areas (including architecture, migration, etc.) differed considerably in West Germany, specific land requirements from West Germany are not transferable to the East. For this reason, it is not possible to conduct empirical estimations of future specific land requirements or to do a trend extrapolation. Finally, assumptions must be made about how the specific land requirements develop. Based on available information, the specific land requirements will decrease steadily, resulting in higher densities (BBR (Bundesamt für Bauwesen und Raumordnung) 1996). The degree to which the density measure decreases varies among different types of settlement structure and in the different scenarios to account for different types of lifestyle and living.

The specific land requirements for different dwelling types are expressed as floor area per square meter lot size. This indicator shows the percentage of lots that is covered by floor area. The higher the indicator value, the higher the density, and the lower the specific land requirement. In the case of multi-storey buildings, densities can theoretically reach above 100%. Multiplying the specific land requirements by the projected floor area in dwellings, results in the demand for residential land use.

The calculated residential land use can be reduced by reusing vacant multi-family dwellings. The share of vacancies is reported by Braun and Faller 2005. The amount of reusing vacancies depends on the underlying preferences for living and lifestyle which are defined in the specific scenario assumptions.

For the Czech part of the study area, no housing forecast is available. As a result, assumptions about the housing demand were made following past trends. The per capita floor area and the building density are extrapolated until 2020 using trends from 1995 to 2005. Apart from this, the same procedure is applied here.

2.3 Defining suitability maps

A binomial logistic regression analysis was carried out to empirically determine weights for the calculation of suitability maps in the Land Use Scanner. The probability of residential land use change at a certain location is assessed relative to all other locations depending on its suitability for this location using the following equation (Verburg et al. 2004):

$$P_c(y = 1) = \frac{e^{(\alpha * X_c)[20]}}{1 + e^{(\alpha * X_c)}}$$

where:

$P_c(y=1)$ is the probability of cell c being converted into residential land;

α is a vector of the estimated coefficients of the explanatory variables X_c; and

X_c is a vector of explanatory variables for cell c.

The dependent variable equals one if the land became a residential area and is zero otherwise.

The advantage of using this approach rather than determining weights by expert knowledge is the empirical and more objective determination of weights for location factors. The logit specification of the regression equation is identical to the original, unconstrained allocation algorithm of the Land Use Scanner, and this approach therefore allows the estimated coefficients to be included as weights for the calculation of the suitability maps in the land use change model in a straightforward way (Rietveld et al. 2001).

The interpretation of the resulting coefficients is difficult because the relationship is not linear. The signs of the coefficients indicate a negative or positive correlation of the independent and dependent variables. Instead, the absolute value of the coefficients only shows a steep or shallow curve. The higher the absolute value is, the steeper the curve and the higher the change in the probability for residential change when the independent variable changes by one unit (Backhaus et al. 2006).

A model is considered that both land use in neighbouring cells and location factors estimates. The consideration of neighbouring cells is important because it is assumed that surrounding land use types have a substantial influence on land use at a certain location (Verburg et al. 2004). This influence was assigned explicitly and therefore accounts for spatial autocorrelation (Tobler 1979, Anselin 1988). The estimation approach was applied to residential changes between 1990 and 2000 as in Verburg et al. 2004. A full set of variables is presented in Table 4.

A sample of the database was chosen because the database is very large (containing 2.3 million grid cells) and the proportion of residential land in comparison to all other land use types was very disproportionate. Choice-based sampling was applied where sampling rates for the categories of the dependent variable were unequal. King and Zeng 2001 and Prentice and Pyke 1979 showed that estimated coefficients are not biased by this sampling technique. The total sample size was 8500, consisting of 30% new residential land and 70% of cells showing no change.

The results were validated by applying a ROC-curve (Relative Operating Characteristic; Pontius and Schneider 2001). The ROC is a statistic that was used in the present study to measure the extent to which grid-cells with larger probability values were concentrated at locations that truly became residential area between 1990 and 2000. The ROC statistic measures the area under the curve with values from 0.5 (completely random) and 1 (perfect fit).

With respect to the applied logistic regression analysis, the suitability, s_c, which is calculated in the Land Use Scanner for residential land use corresponds with the logit of P_c:

$$s_c = \ln\left(\frac{P_c(y=1)}{1 - P_c(y=1)}\right) = \boldsymbol{\alpha} * \boldsymbol{X_c}$$

Thus, the suitability of residential land use changes is a weighted sum of a number of location characteristics. The weights were determined by the logistic regression analysis and can be adjusted by the user of the Land Use Scanner Elbe. For details of the adjustment see this part, section 1.1.3.

Table 4: List of implemented suitability maps[1]

		Abbreviation/ Classification	Description		Spatial coverage
Applied for simulations in LUS — Applied in regression analysis and Applied in LUS	Nature conservation areas	potstrcprot	Biosphere reserve		Elbe River Basin (ERB)
		potstrcprot	Flora-Fauna-Habitat areas		ERB
		potstrcprot	Landscape conservation area		ERB
		strcprot	Nature conservation area		ERB
		potstrcprot	Natural park		ERB
		strcprot	National park		ERB
		potstrcprot	Bird protection area		ERB
	Policy maps	Attracting	Potential residential areas		Berlin-Brandenburg
		Restricting	Regional green belts		Berlin-Brandenburg
		Restricting	Green corridors		Mecklenburg-Western Pomerania, Thuringia, Admin. Distr. of Leipzig
		Restricting	Priority area for arable land		Mecklenburg-Western Pomerania, Thuringia, Saxony-Anhalt, Saxony
		Restricting	Reserved area for nature and landscape		Mecklenburg-Western Pomerania, Thuringia, Saxony-Anhalt, Saxony
		Restricting	Priority area for nature and landscape		Mecklenburg-Western Pomerania, Thuringia, Saxony-Anhalt, Saxony
		Restricting	Reserved area for mining		Mecklenburg-Western Pomerania, Thuringia, Saxony-Anhalt, Saxony
		Restricting	Priority area for mining		Mecklenburg-Western Pomerania, Thuringia, Saxony-Anhalt, Saxony
		Restricting	Reserved area for flood protection		German part only
		Restricting	Priority area for flood protection		German part only
		Restricting	Reserved area for forest areas		Thuringia, Saxony
		Restricting	Priority area for forest areas		Thuringia, Saxony
		Attracting	National Development Plan		Czech part only
	Accessibility	FREEWAY EXITS	Euclidian distance to:	Freeway exits	ERB
		AIRPORTS		Airports	ERB
		STATIONS		Train stations	ERB
		RAILROADS		Railroads	ERB
		ROADS		Roads	ERB
		RESIDENTIAL AREAS		Current residential areas	ERB
		METROPOLITAN CITIES		Metropolitan cities	ERB
		MIDDLE ORDER CENTRES		Middle and high order centres	ERB
		RECREATION		Recreation areas	ERB
		SLOPE	Slope		ERB
	Auto-regressive	Variables are explained as example, only. The share of all three land use types is calculated for both time steps and every ring.			
		FC3_GG1_00	Share of residential area (GG1) in the year 2000 (00) within the first ring (3x3 cell neighbourhood		ERB
		FC3_GG1_90	Share of residential area (GG1) in the year 1990 (90) within the first ring		ERB

		(3x3 cell neighbourhood)	
FC5_GG9_90	Share of arable land (GG9) in the year 1990 (90) within the second ring (5x5 cell neighbourhood)	ERB
FC9_GG10_00	Share of pasture (GG10) in the year 2000 (00) within the third ring (9x9 cell neighbourhood)	ERB

[1] Note: In the LandUse Scanner configuration many more suitability maps are implemented. This table lists only those maps that were used within the logistic regression analysis. A complete list of suitability maps can be found in the appendix 4.

Part 3   Land Use Scanner

This first chapter provides an initial introduction to the model in general and the application for TU Berlin in particular. It helps users getting started with the model and describes the most important model components. Chapter 2 describes how existing policy alternatives can be viewed and explains the main elements of the graphical user interface (GUI). It discusses how various types of data can be viewed, how the calculation process can be traced and how land-use results and indicator values can be retrieved. Chapter 3 helps the user to save and export results for use in further analyses. The fourth and final chapter discusses the specific adaptations made for the GLOWA-Elbe version of the Land Use Scanner. The appendices at the end of this tutorial contain in-depth information on various model elements and include amongst others, an overview of the basic land-use classes and included spatial data sets.

1   General Introduction to the Land Use Scanner

The Land Use Scanner is a spatial model that simulates future land use. The model offers an integrated view of all types of land use, dealing with urban, natural and agricultural functions. Since the development of its first version in 1997, it has been applied in a large number of policy-related research projects. Applications include, amongst others: the simulation of future land use following different scenarios (Schotten and Heunks 2001, Borsboom-van Beurden et al. 2007, Dekkers and Koomen 2007, Koomen et al. 2008a, Koomen et al. 2008b), the evaluation of alternatives for a new national airport (Scholten et al. 1999), the preparation of the Fifth National Physical Planning Report (Schotten et al. 2001), and an outlook for the prospects of agricultural land use in the Netherlands (Koomen et al. 2005). Apart from these Dutch applications, the model has also been applied in several European countries (Hartje et al. 2008; Wagtendonk et al. 2001). A full account of the original model is provided elsewhere (Hilferink and Rietveld 1999). For an extensive overview of all publications which are related to the Land Use Scanner, the reader is referred to www.lumos.info and www.feweb.vu.nl/gis.

Unlike many other land-use models the objective of the Land Use Scanner is not to forecast the dimension of land-use change but rather to integrate and allocate future land-use demand from different sector-specific models or experts. Figure 1 in Part 1 presents the basic structure of the Land Use Scanner model for the GLOWA ELBE-project. External regional projections of land-use change,

which are usually referred to as demand or claims, are used as input for the model. These are land-use type specific and can be derived from, for example, sector-specific models of specialised institutes. The projected land-use changes are considered as an additional claim for the different land-use types as compared with the present area in use for each land-use type. The total of the additional claim and the present area for each land-use function is allocated to individual grid-cells based on the suitability of the cell. This definition of local suitability may incorporate a large number of spatial datasets referring to the following aspects that are discussed below: *current land use*, *physical properties*, *operative policies* and *market forces* generally expressed in distance relations to nearby land-use functions.

Current land use, of course, offers the starting point in the simulation of future land use. It is thus an important ingredient in the specification of both the regional claim and the local suitability. Current land-use patterns are, however, not necessarily preserved in model simulations. This offers the advantage of having a large degree of freedom in generating future simulations according to scenario specifications, but calls for attention when current land-use patterns are likely to be preserved.

The *physical properties* of the land (e.g. soil type and groundwater level) are especially important for the suitability specification of agricultural land-use types as they directly influence possible yields. They are generally considered less important for urban functions, as the Netherlands have a long tradition of manipulating their natural conditions.

Operative policies, on the other hand, help steer Dutch land-use developments in many ways and are important components in the definition of suitability. The national nature development zones and the municipal urbanisation plans are examples of spatial policies that stimulate the allocation of certain types of land use. Various zoning laws related to, for example, water management and the preservation of landscape values offer restrictions on urban development.

The *market forces* that steer, for example, residential and commercial development are generally expressed in distance relations. Especially the proximity to railway stations, motorway exits and airports are considered important factors that reflect the locational preferences of the actors that are active in urban development. Other factors that reflect such preferences are, for example, the number of urban facilities or the attractiveness of the surrounding landscape.

The selection of the appropriate factors for each of these components and their relative weighing is a crucial step in the definition of the suitability maps and determines, to a large extent, the simulation outcomes. The relative weights of the factors that describe the market forces and operative policies are normally assigned in such a way that they reflect the scenario storylines (Koomen et al. 2008b).

2   View existing policy alternatives

This Section helps the user to get familiar with the main components of the Land Use Scanner Elbe model. First the main elements of the Graphical User Interface (GUI) are explained. Subsequently the main components of the model are described. These relate to the available spatial data (land-use and factor data) and policy alternatives (claim data, runs, results, tracing calculation process and indicators). Note that this Section is partially based on an adaptation of Koomen et al. 2010, which was in his turn partially based on the first two chapters of the GeoDMS GUI user guide (van der Beek

2008), which can be found at http://www.objectvision.nl/geodms/ under the menu item User Guide > GeoDMS GUI. For details on the Declarative Model Script (the .dms files) look at the menu item Modelling.

2.1   Tree View and main GUI elements

The graphical user interface (GUI) provides the modeller with a range of windows to view data layers, look-up background information, inspect simulation results and follow the simulation process. Figure 6 presents an overview of the many different windows in a typical application. Which windows are shown in a session depends on the options that are selected (ticked) in the main menu under View.
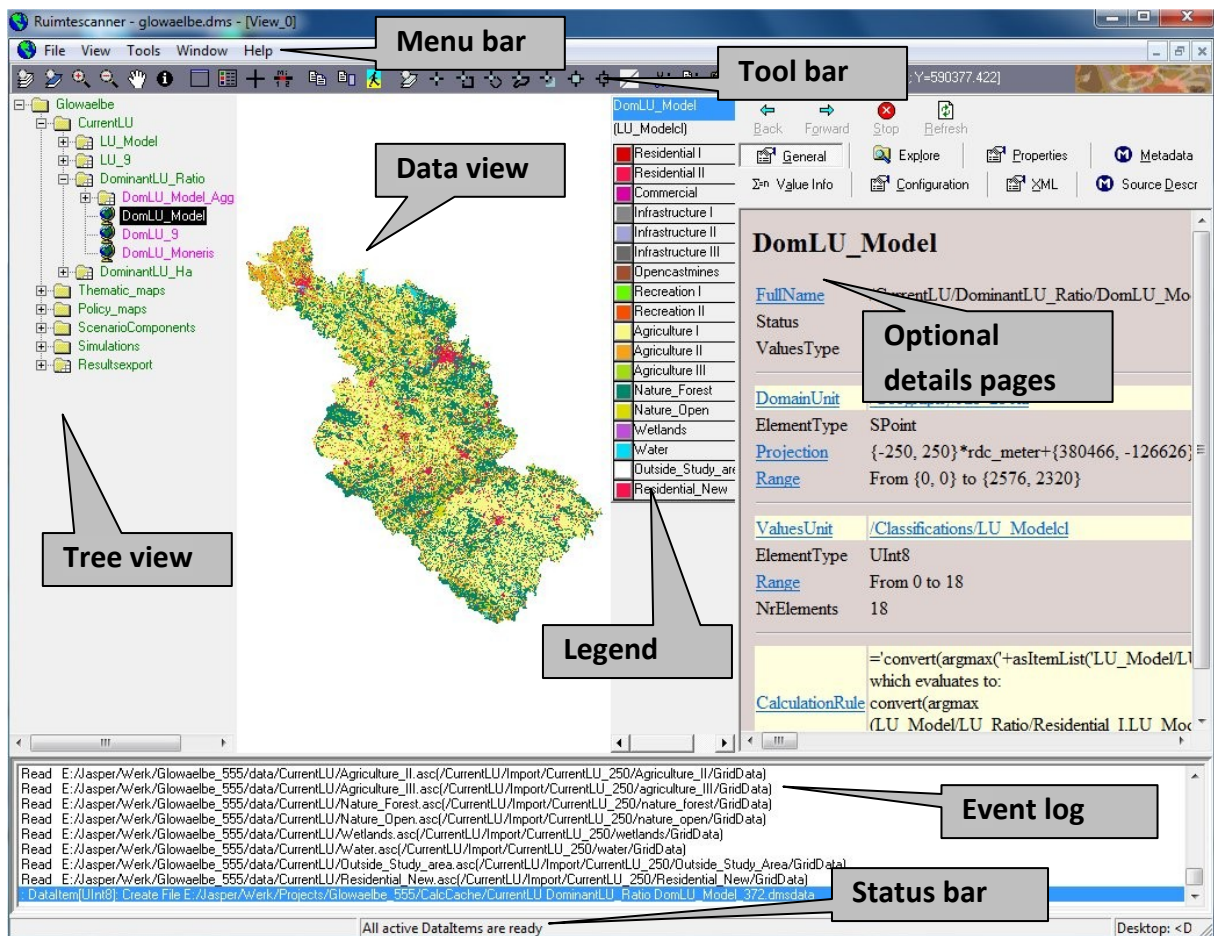
Figure 7: Tree view and main components of the GeoDMS interface.

The GUI contains the following elements:

- the **Menu bar** with several pull down menus;
- an initially empty dark-grey **Tool bar** that contains window-specific tools;
- on the left hand side a **Tree view** that allows navigation through the available data sets and model result;
- a **Data view** that displays data as tables or maps;
- a **map Legend** that appears with map in the Data views;
- various **Details pages** containing technical and background information that appear or disappear by simultaneously clicking ALT + 1;

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- an **Event log** that presents information on the processed steps. This event log appears/disappears by simultaneously clicking ALT + 2;
- a **Status bar** that presents hints and status information about ongoing processes.

The **Tree view** is the main navigation component within the application. It is comparable to Windows Explorer and allows easy access to the huge collection of data and model result items that are available in the model. The Tree view presents the hierarchical structure of the Land Use Scanner Elbe configuration. By default the root item is expanded and the first level items are shown (i.e. CurrentLU, Thematic_maps, Policy_maps, ScenarioComponents, Simulations and Resultsexport). Each item in the tree (called a *tree item*) is presented with a name and an icon. The icons are related to the default viewer for the corresponding tree item. These are explained below.

The selected item in the Tree view is the *active item* in the application. This is an important concept, as many functions of the application work on the active tree item. By clicking the right mouse button a pop-up menu can be activated, with a set of menu options that work on this active tree item. This also applies to most main menu options and to the Detail pages. The pop-up menu options, most main menu options and the details pages are described in chapters 4 and 5 of the GeoDMS user guide.

Icons used in the Tree view

The main purpose of the icons is to show which default viewer is used for an item. Double clicking or pressing the enter key on a selected tree item activates this viewer. The following icons are used to indicate this default viewer:

 Data item that can be viewed in a map. This implies the domain of the data item has a geographic relation. Depending on the geographic domain, the data is visualized in a grid, point, arc or polygon layer.

 Data item that cannot be visualized in map (has no geographic relation) but can be viewed in a Datagrid (which resembles a table).

 Data item that contains a classification (a set of classes). A classification can be made or edited with the classification and palette composer, see GeoDMS user guide Chapter 10.

Not all tree items are data items. For the non-data items (these items cannot be viewed with a primary data viewer), the following icons are in use:

 A tree item with no data item and subitems that also have no data items. The icon is used for containers (a container is similar to a directory in Windows Explorer) grouping other containers or units.

 A tree item with no data item, but with data items as subitems. All subitems of this item with the same domain unit can be viewed in a Datagrid.

 A tree item with no data item and no subitems, for example a unit.

When you want to visualize an active tree item in the **Data view**, you can double click it with the mouse or just press Enter and then it opens in its Default View. For a Map data item, the Default View is a map, for a Datagrid tree item, the Default View is a table. If you want to open a tree item in a non-default view, right-click the item with the mouse and select either one of the available Views. These views can also be selected for an active tree item by pressing CTRL+M for the Map View, CTRL+D for the Datagrid View and CTRL+H for the Histogram View.

To put it another way: maps can be drawn in the data view area in three different ways:

1. by double-clicking on any of the data layer names. This option allows multiple data layers to be drawn in *the same* map view window.
2. by activating (clicking on) the data layer and then simultaneously pressing the Ctrl-M key combination. This option will open *a new* map view window for every data layer.
3. by giving a right mouse-click on the data layer and selecting the Map View or the Default option from the appearing menu. The other options allow showing the data as a table (which does not make sense here) or histogram. The latter option shows the frequency distribution of the different land-use types.

Right mouse-clicking on the **legend** area allows the user to select, amongst others, the statistics function. This option provides some basic statistics on the selected dataset, e.g. minimum and maximum value per grid cell and the total area (sum) covered by this land-use type. The edit palette pop-up menu option allows you to change the classification and colour as is explained in more detail in the GeoDMS user guide.

The tool-bar now contains several standard GIS-functions such as: zoom in, zoom out, pan, get info, zoom to full extent,

 copy visible area to clipboard, toggle scale bar. For a full description of all available tools, we refer to the GeoDMS User Guide, Section 7.4.

The objective of these and other functions is indicated with a mouse-over text. For a full description of all tools, including options to export specific views and datasets as bitmaps or other data formats, see the GeoDMS user guide.

The **Event log** shows the progress of calculations during simulation. It lists, amongst others, the amount of data items that still have to be calculated (see the **Status bar**) and thus gives an indication of the additional time needed to complete a calculation.

The elements of the **Menu bar** are described in detail in the GeoDMS User Guide. One interesting element is described here, namely the option to turn on the *Administrator mode* of the Land Use Scanner Elbe model. In the Menu bar, click on Tools > Options to activate the dialog menu. In this menu, there is a section *User modes.* By default, the Administrator mode is not checked. If you now check this item and click OK, you will find that you suddenly have much more tree items to access. This mode gives you the opportunity to explore the model more in-depth, to open up at least partially the black box so to speak. We will not further discuss all elements that are now visible in the tree view, but rather refer to the GeoDMS User Guide.

The next sections explore the five main components of the tree view: land-use data, other spatial data sets (thematic and spatial planning), scenario components, simulations and resultsexport.

2.1.1 Current land use (tree item Current_LU)

The Corine Land Cover database for the year 2000 (CLC2000) was selected as base data for the Elbe application as it was, at the time the project started, the most recent, consistently developed and available pan-European source of land-use related information. The CLC2000 data was aggregated to a 250m^2 spatial resolution representing 16 main land-use types for inclusion in the land-use model. Table 5**Fehler! Verweisquelle konnte nicht gefunden werden.** describes the thematic integration of the initial land-cover classes in CLC2000 to this set of 16 main classes. The table, furthermore, lists for which land-use types future patterns are simulated.

Table 5: Simulated land use types

Land Use[1]	CLC (main) class[2]	Description	Simulated[3]
Residential_I	1.1.1	Continuous built-up area	No (0)
Residential_II	1.1.2	Discontinuous built-up area	No (1)
Commercial	1.2.1	Industrial or commercial units	No (2)
Infrastructure_I	1.2.2	Road and rail networks and associated land	No (3)
Infrastructure_II	1.2.3	Port areas	No (4)
Infrastructure_III	1.2.4	Airports	No (5)
Opencastmines	1.3	Mine, dump and construction sites	No (6)
Recreation_I	1.4.1	Green urban areas	No (7)
Recreation_II	1.4.2	Sport and leisure facilities	No (8)
Agriculture_I	2.1/2.1/2.4	Arable land, Permanent crops, Heterogeneous agric. areas	Yes (9)
Agriculture_II	2.3	Pastures	Yes (10)
Nature_Forest	3.1	Forests	No (12)
Nature_Open	3.2/3.3	Shrub and/or herbaceous vegetation associations, Open spaces with little or no vegetation	No (13)
Wetlands	4.1	Inland wetlands	No (14)
Water	4.2/5.1/5.2	Coastal wetlands, Water bodies (inland & marine)	No (15)
Residential_New	New	See Section 4.2 for more explanation for this LU-class	Yes (16)

Notes:

[1]This column shows the individual land-use types distinguished in the Land Use Scanner Elbe.
[2]For reference purposes the corresponding (main) land-cover classes from the CLC2000 dataset are shown. See Appendix 1 for a complete overview of the CORINE 2000 land cover classes.
[3]The numbers between brackets refer to the coding generally used within the model (referred to as LU_Model).

Although the CLC data technically refer to land cover we use the more common term 'land use' in this report as it better corresponds to phenomena such as abandoned farmland that are simulated by the model.

A land use type is *exogenous* when it is not simulated, i.e. it is specified apart from a scenario simulation. This also means that the allocation module is not allowed or able to allocate *endogenous* (i.e. simulated) land use in locations (i.e. grid cells) where these exogenous land use types are already present. Roads, railways, airports, water bodies and exterior are typical exogenous data types. Exogenous developments can also be specified in a scenario such as new roads or flooding areas, or reversely, the creation of new land in water areas.

2.1.2 Tree items Thematic_maps and Policy_maps

The Land Use Scanner Elbe also contains a wide range of spatial data sets that describe specific themes such as accessibility, geomorphology, spatial policies and land use in neighbouring cells.

These datasets were collected by TU Berlin for the GLOWA-Elbe project and they are listed in Table 2 at the end of Part 2 of this manual. These maps can be used for scenario simulations and they can have a restricting or attracting influence that differs per scenario per land use type.

2.1.3 Tree item ScenarioComponents

The three item ScenarioComponents lists all items that are necessary for running a scenario-simulation. In the sub item Source_Data lists Current land use, Thematic maps and Policy maps. The sub item General_Factors describes things like the costs of urban demolition and exogenous developments for each land use type within each scenario. The remaining four sub items are the four scenarios.

2.1.4 Tree item Simulations, including Evaluation items and Indicators

In the three item Simulations, all the information from ScenarioComponents is brought together for each specific scenario and here the actual simulation is run. The scenario simulations for the GLOWA-Elbe project can be found in Simulations > Continuous_Model > LndRorKrs > m250. These tree item names mean that for the project the continuous allocation algorithm is used (see Hilferink and Rietveld, 1999 for a description of the algorithm). Further, it means that future land use claims for the different simulated land use types can be defined on three different spatial regional levels: Bundesland, Raumordnungeregion and Kreise. [Finally, it signifies that the grid size of the model is 250 metre per cell.

Simulation results can be viewed by clicking tree items in *Simulations > Continuous_Model > LndRorKrs > m250 > Results.* If you want to, for example, view the resulting dominant land use map of the Glob_oU scenario, you have to select the tree item Simulations > Continuous_Model > LndRorKrs > m250 > Results > Landuse > DomLU_Model.

Another interesting element that can be found in the Simulations tree item is the *Evaluation* tree item. This tree item contains a range of subitems on different spatial scale levels: the Study area, the Claim region level, various aggregated levels (subcatchments, Gemeinde, Kreise, Raumis-regions), and grid cell level. These items can be convenient if you, for example, want to know the number of hectares of future land use for each land use class per Gemeinde. There are also some indicators among the evaluation items, describing for instance the level of urbanisation or the amount of sealed surface. See Appendix 3 for a complete list of all available evaluation items in the Land Use Scanner Elbe.

2.1.5 Tree item Resultsexport

The final tree item called Resultexport is an Elbe adaptation of the original Land Use Scanner model. See Section 4.8 for more details.

2.2 Tracing calculations in the Land Use Scanner Elbe

All calculations in the Land Use Scanner Elbe can be traced back, so that the user can see what tree items are used in the calculation process in what way. The **Detail Pages** can be used for this purpose. These pages can be opened for any active tree item by simultaneously pressing ALT + 1 or by clicking on the menu bar on the menu item View > Detail pages. As an example, Figure 7 contains the Detail pages of the suitability map of Agriculture_I for the Glob_oU scenario.
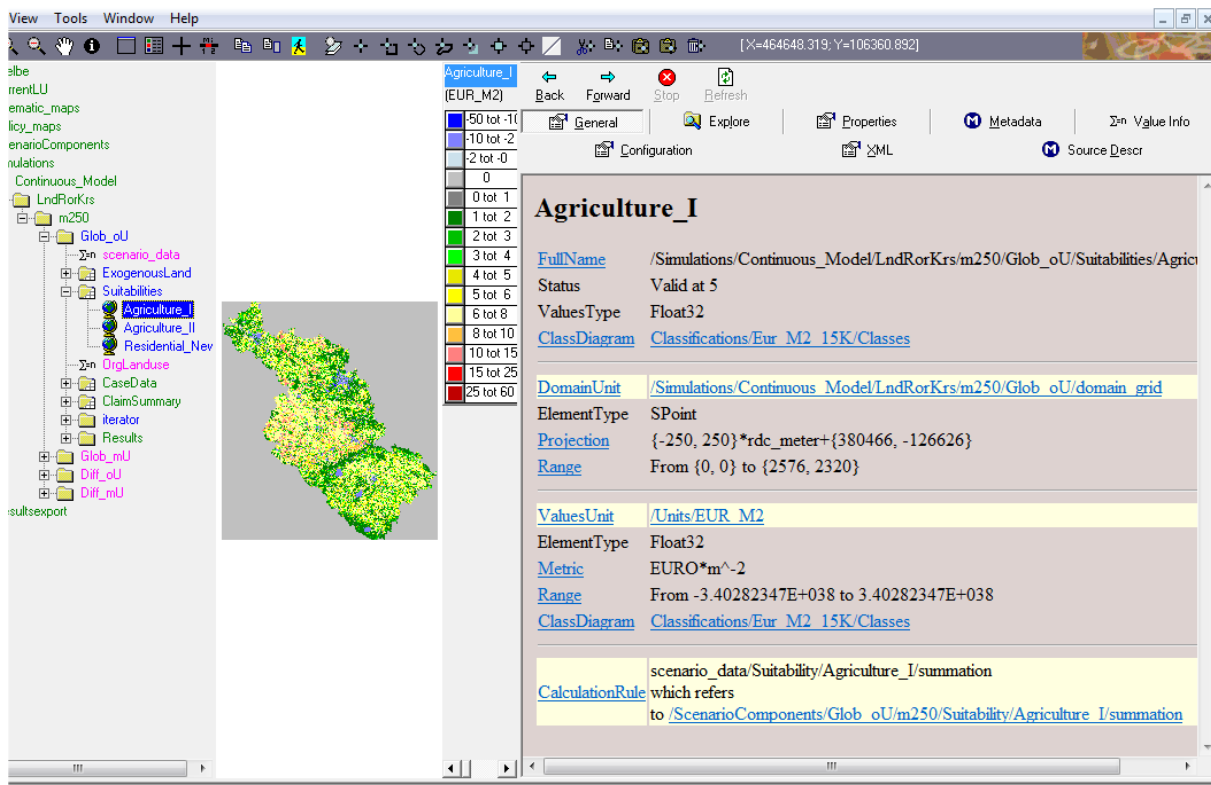
Figure 8: Detail pages of a tree item

The detail pages contain lots of information on the tree items, e.g. Metadata, Source description, Configuration and General information. We refer to the GeoDMS User Guide, Chapter 5 for an extensive description of all elements of the Detail pages. For now, we limit ourselves to describing how these pages can be used to check how a tree item is calculated. In the example shown above, in the General tab, there is a section called 'CalculationRule'. Here are references to source tree item listed as hyperlinks. If you click on such a hyperlink, in this case /ScenarioComponents/Glob_oU/m250/Suitability/Agriculture_I/summation, you a referred back to this tree item in the tree view. Behind CalculationRule the calculation rule that determines the suitability value for this land use type is shown (Figure 8):

Figure 9: Calculation rule

This rule states, for every single grid cell: if a cell lies at least for a part within the study area, then sum up the value of the maps current land use, policy maps and thematic maps. And if the cell lies completely outside the study area, assign to it the value 0 euro per square metre.

Since the tree items current_Landuse, policy_maps and thematic_maps are shown without any tree structure in front of their names, you can conclude that these tree item are in the same container as the tree item for which the calculation rule is shown.

3   Export Results / Output

As mentioned before, the Land Use Scanner Elbe includes an automatic export of results, see Section 4.8 for more details. However, next to this fully-automatic export function for simulation results, you can also export individual tree item in the Land Use Scanner.

Please note that all basic spatial data sets (i.e. current land use, thematic maps and spatial planning maps) that are used in the Land Use Scanner Elbe are stored as ascii grids on the hard disk of your computer. These data set can be copied directly (so: outside-the Land Use Scanner Elbe) from here to be used in, for example, a GIS environment. Alternatively all data items that can be viewed in a map, such as the land-use data sets, can be exported by right-clicking on the active data item in the tree view and selecting the option *export primary data* (see Figure 9). The user can then choose to export data in various formats, such as *ascii grid* or *bitmap (bmp) with world file* (reference to a coordinate system). It is necessary to first draw the map in the map window before this option is selected. These export options will create a copy of the whole data set, using its full extent. When the user only wants to export the part of the map that is visible in the map window, the tool bar option '*copy visible area to clipboard*' should be selected.
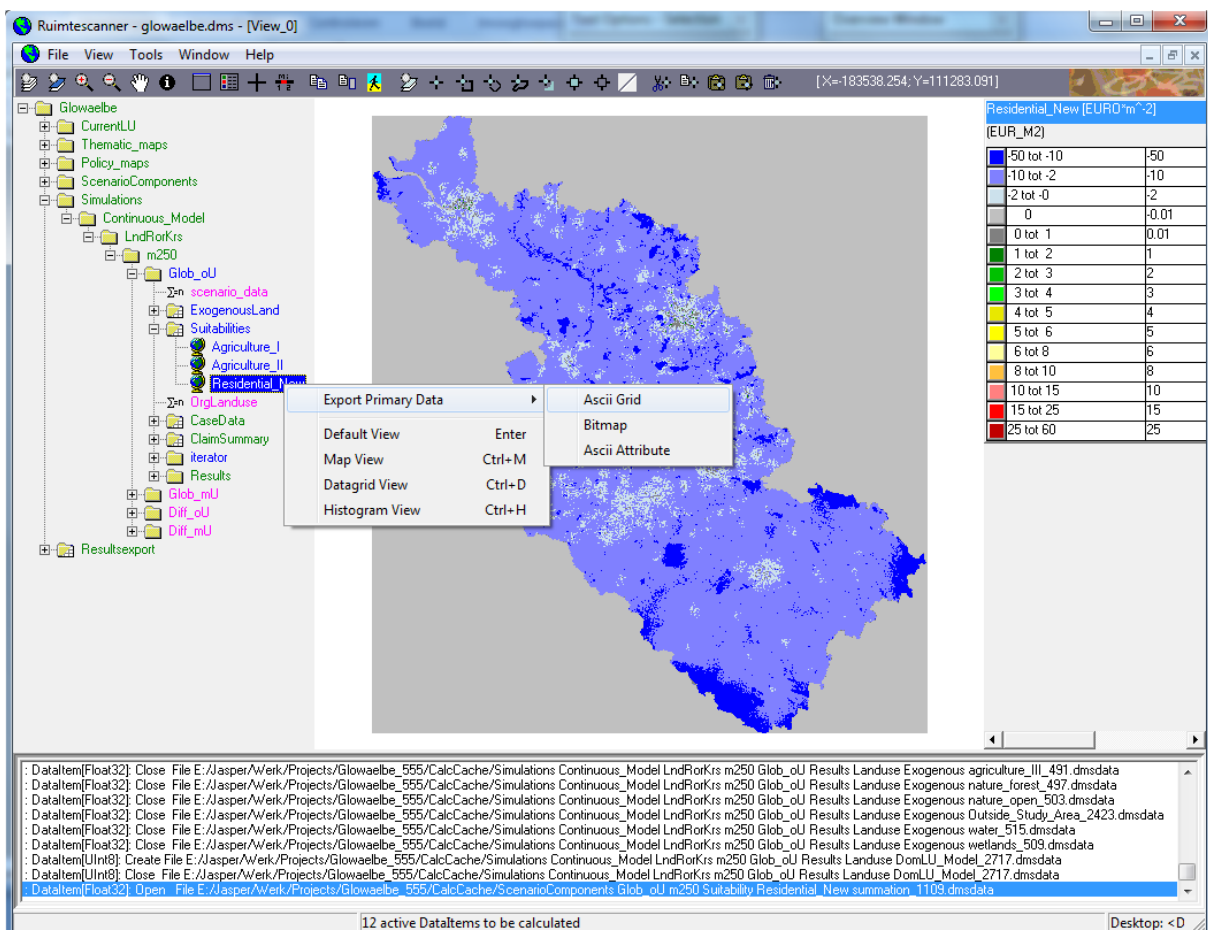
Figure 10: Exporting a tree item using the right-mouse button

4   Elbe adaptation

This chapter describes the specific adaptations that were made for the GLOWA-Elbe version of the Land Use Scanner.

4.1   Current land use

The current land use is provided as ascii-file for each land use type. The ascii-files contain the ratio the specific land use type in every grid-cell. This procedure was necessary because a pre-processing of the land use data was conducted to synchronise two different data sources of land use information. This procedure did not influence the results of the model but caters for the congruency of applied data sets within GLOWA-Elbe.

4.2   New residential areas

The standard version of the Land Use Scanner theoretically allows for a declining share of a certain land use type although the overall claim of this land use type is positive. An example is the residential development. While the overall residential area further increases, the destruction of buildings may also be possible in the same claim region. Indeed, this process can be observed in the Elbe River Basin. But unfortunately, the applied land use database, Corine Land Cover, cannot represent this development. Due to the coarse spatial resolution of the CLC destruction processes are currently not observable in the study area. To avoid the simulation to reduce residential areas and therefore to project a development that the CLC cannot map, a new land use type, called Residential_New, was introduced. The share of this land use type at the starting point of the simulation is zero, the spatial claims are positive. Therefore, a projection of declining residential areas cannot result.

The two land use types Residential_I and Residential_II remain constant over time (they are exogenous in the model).

With the new version of the CLC (from 2006) the spatial resolution was refined. It needs to be analysed whether the destruction processes can now be reproduced with the CLC dataset. If this is the case, in the future the Residential_New land use type should be eliminated again and the destruction processes should be modelled endogenously.

4.3   Population development on municipal level

Within the GLOWA-Elbe project, the population development is provided on regional level (for spatial planning units in Germany and Nuts2 regions in the Czech Republic). The downstream model KIWA, which projects the water demand for households on municipal level, requires the population development also on municipal level. Thus, the spatially explicit simulation of the residential development was used to regionalise the regional population numbers to the local level.

4.3.1   Methodology

The methodological challenge was to consider specific processes that are typical for a region in post socialist transformation. While a massive suburbanisation process for detached single family dwellings take place, the share of vacancies in the multi storey dwellings increases. This leads to the deconstruction of some dwellings already. At the same time out-migration to the western part of

Germany and in the Czech Republic to the city of Prague set in. Thus, the population density declines steadily. All together it cannot be stated whether the population density changes due to population changes or due to changes in residential area. Both processes can occur at the same time. Therefore a simple proportional distribution of the population based on residential development is not useful.

Instead, the relationship between the municipal share of population to the population of the region and the municipal share of residential areas to the total residential area of the region was analysed. This procedure allows the increase of residential area but the share of the residential area in this municipality declined. This would lead to smaller share of the municipal population and therefore to a population decline. The statistical analysis of both variables indicates a linear relationship if the variables are logarithmised. The estimation result is presented in the following table:

Table: results for the estimation of municipal population share to the population in regions (dependent variable).

	Coefficient	Standard error
Constant value	0.483	0.021
log. Share of municipal residential area to residential area in regions	1.158	0.004
adj. R²	0.896	

4.3.2   Technical implementation

The regional population development is provided in the Glowaelbe_claims_2000.mdb. The formula in the script describes the regression equation. It calls the regional population development and uses the scenario-specific residential areas on municipal level. The calculation is implemented in the evaluation.dms.

4.4   Sealed surface

The calculation of the sealed surface is another indicator that is calculated within the GLOWA-Elbe version of the Land Use Scanner. A review of approaches to estimate the ratio of sealed surface reveals that only a rough approximation is possible. Therefore, the approach of the Environmental-Economic Accounting of the German Federal Statistical Office is applied. Although this approach was developed for the spatial level of federal states, it was used in analogy for the municipal level. The results for the municipal level are further applied to the single grid-cells within the Land Use Scanner. The results can be viewed within the Evaluation folder for every scenario.

4.4.1   Methodology

The sealing ratio for different land use types within urban areas is conducted from several high resolution case studies. There is currently no area wide information about surface sealing. The mean sealing ratio is weighted with respect to settlement density. Settlement density is the ratio of urban area within a region and the size of the region. Due to this procedure, different types of settlement structure can be taken into account.

The weighting process is as follows. From the local case studies the minimum and maximum sealing ratio of each land use type is determined. These values are related to the settlement densities of the regions. Thus, the minimum sealing ratio of a land use type is assigned to the region with the lowest

settlement density and vice versa. The relationship of the two regions can then be described by a linear equation. The sealing ratio of all other regions is determined by this linear relationship. A detailed description of the approach can be found in Gunreben et al. 2007.

The specific adaptation for GLOWA-Elbe consists in the applied database and in the spatial resolution. Instead of the statistical survey of urban area, the CLC database is used. Since both datasets do not match for the single land use types, they are not differentiated. Thus the minimum and maximum sealing ratio is corresponds to the total urban area. But, the analysis differentiates between the German and the Czech Part of the Elbe River Basin. Furthermore, the approach was developed for federal states. Within the Land Use Scanner the approach was also assigned to the municipalities.

4.4.2 Technical implementation

The analysis of the sealed surface is implemented in the evaluation.dms. It is available for all administrative spatial scales and grid cells.

4.5 Residential and urban development in policy areas

The consideration of policy alternatives is very important within the GLOWA-Elbe scenarios. Thus it is of concern which impact the different policy instruments have on the residential development. Therefore, the Land Use Scanner calculates the residential and the urban area within the different areas affected by policy measures. A comparison of different scenarios shows immediately the impact of the specific policy measure.

4.6 Suitability values

The weights for the calculation of suitability maps are not defined within the script anymore but within the Demand-Tool if the Land Use Scanner is used within the EET. Otherwise the weights are defined in the table "Eignungsbewertung" in the Glowaelbe_Claims_2000.mdb. The advantage for the user of the EET is that it is not necessary to open the different configuration files of the Land Use Scanner. For a detailed description of the Demand-Tool refer to Part 2, section 1.1.3.

4.7 Claims

In the GLOWA-Elbe version of the Land Use Scanner, the regional claims are determined with the Demand-Tool. For a detailed description refer to Part 2 of this documentation.

4.8 Results export

This version of the Land Use Scanner includes an automatic export of results. If used within the EET, all necessary results are exported fully automatic. If the Land Use Scanner is used stand alone, the user only needs to double click the specific scenario under Resultsexport/"Spatial Level"/"Scenario name" in the tree view of the model. The results are saved to the results folder in the project-directory.

Part 4   Visualising results

1   What can be visualised?

The simulation results of the Land Use Scanner Elbe can be visualised as raster maps or for administrative units. A general overview of information that can be visualised is given in Table 6.

Table 6: Available files for visualisation.

Raster maps
Land use, aggregated for SWIM
Land use, aggregated for MONERIS
New residential area (ha per grid cell)
Total residential area (ha per grid cell)
Total urban area (ha per grid cell)
Arable land (ha per grid cell)
Pasture (ha per grid cell)
Sealed surface (ha per grid cell)

Maps of administrative units	Municipal data	Kreis data	Raumis data	ROR data
ID of the administrative unit	✓	✓	✓	✓
Scenario-ID	✓	✓	✓	✓
New residential area per municipality in ha	✓	✓	✓	✓
Total residential area per municipality in ha	✓	✓	✓	✓
Total urban area per municipality in ha	✓	✓	✓	✓
Arable land per municipality in ha	✓	✓	✓	✓
Pasture per municipality in ha	✓	✓	✓	✓
Sealed surface area per municipality in ha	✓	✓	✓	✓
Population	✓			

2 Within the EET

It is assumed that you calculated new scenarios already within the EET. This section only describes the visualisation procedures.

2.1 As EET-Simulator

Visualising results as simulator is important for consistency checks between the assumption in the scenario story line and the simulation results.

You should have read the general introduction to the EET. Start the EET and select the role EET-Simulator. Enter user name and password and open your project. From the task list on the left hand side select **Results**.
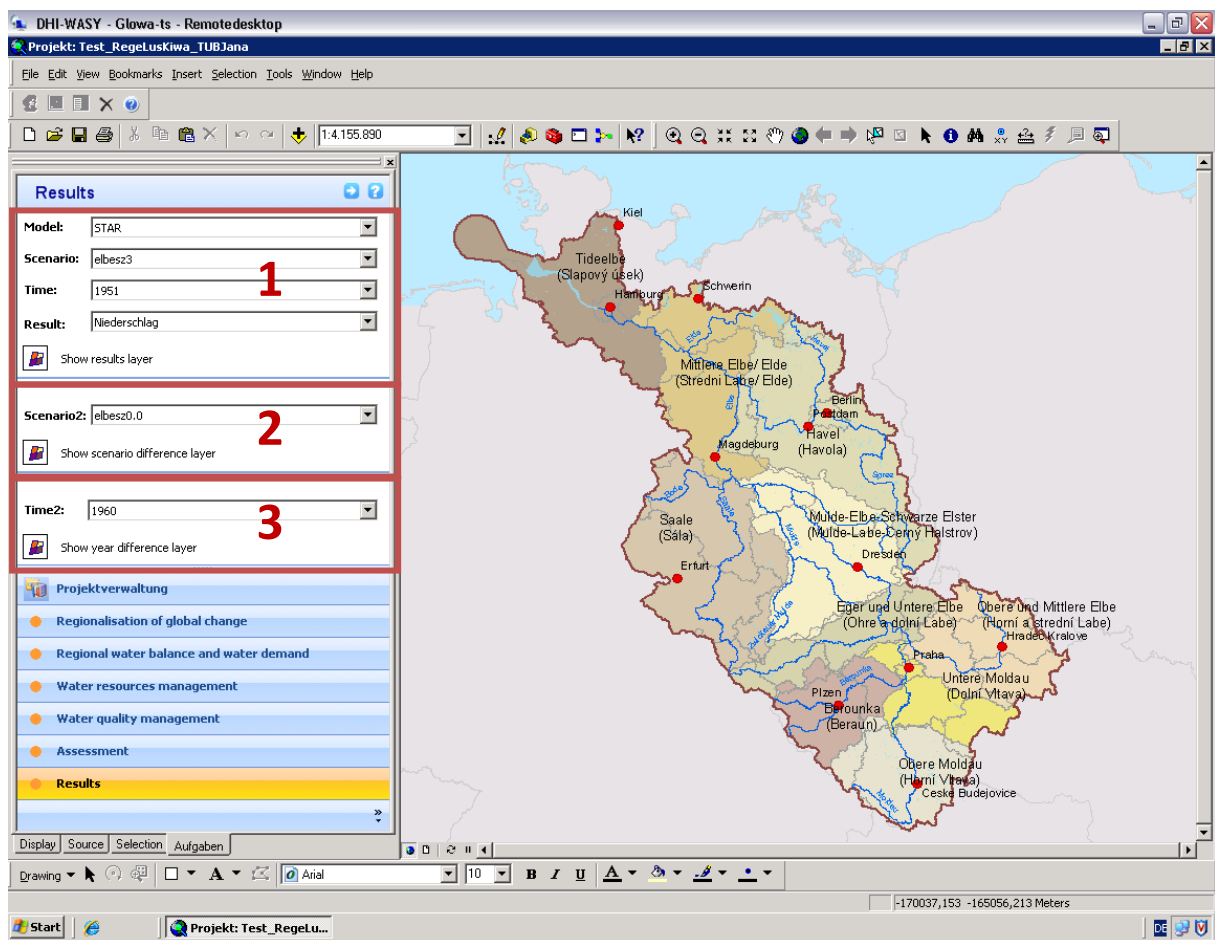
There are three blocks visible that allow selections for visualising results. Block 3 is only important if difference maps between two time steps or time series data is visualised. This is not the case for the results of the Land Use Scanner Elbe. Therefore, only Block 1 and 2 are described.

2.1.1 Visualise one scenario
Select the LUS from the drop down list **Model** (Figure 11 (a)). Then select a scenario from the drop down list **Scenario** (Figure 11 (b)). A selection from the drop down list **Time** is not necessary, since results are only provided for the year 2020. Finally, select a results layer from the drop down list **Result** (Figure 11 (c)). Every raster file is listed with the prefix RASTER and every attribute saved in

tables is listed. Municipal data have the prefix MUN, Raumis data has the prefix RAUMIS and data on level of spatial planning regions have the prefix ROR. The layer name corresponds to the names listed in Table 6.

(a)

(b)

(c)
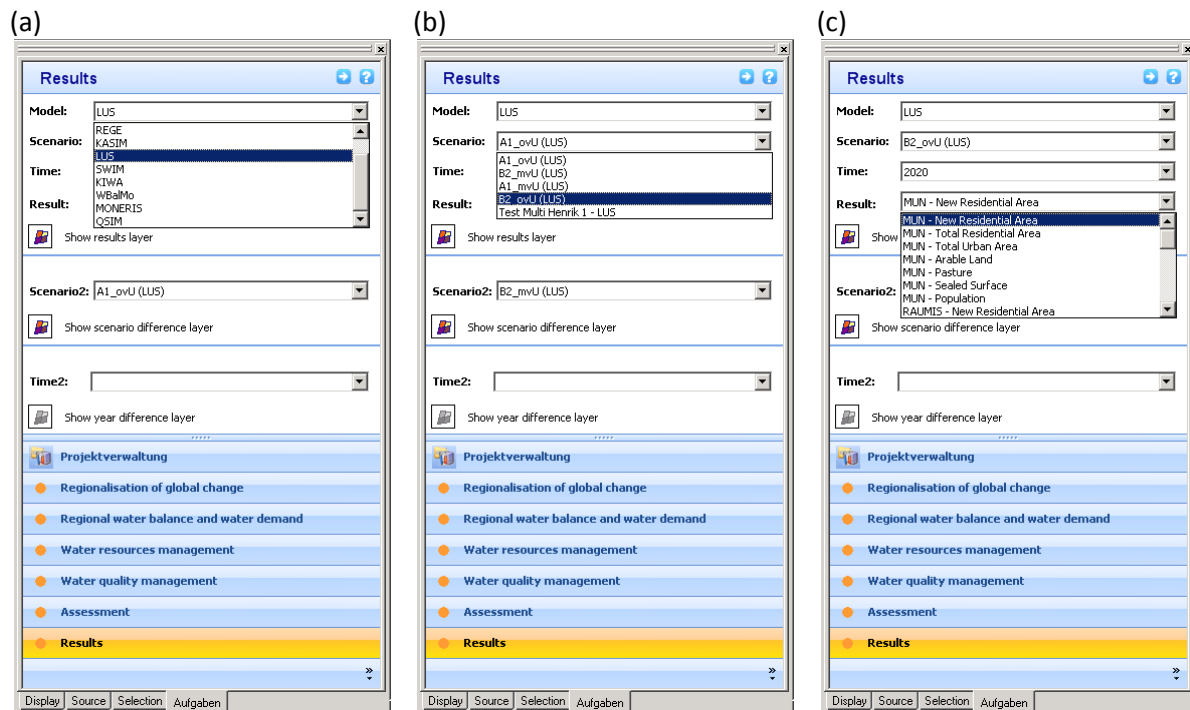
Figure 11: Selection process for visualising result within the EET
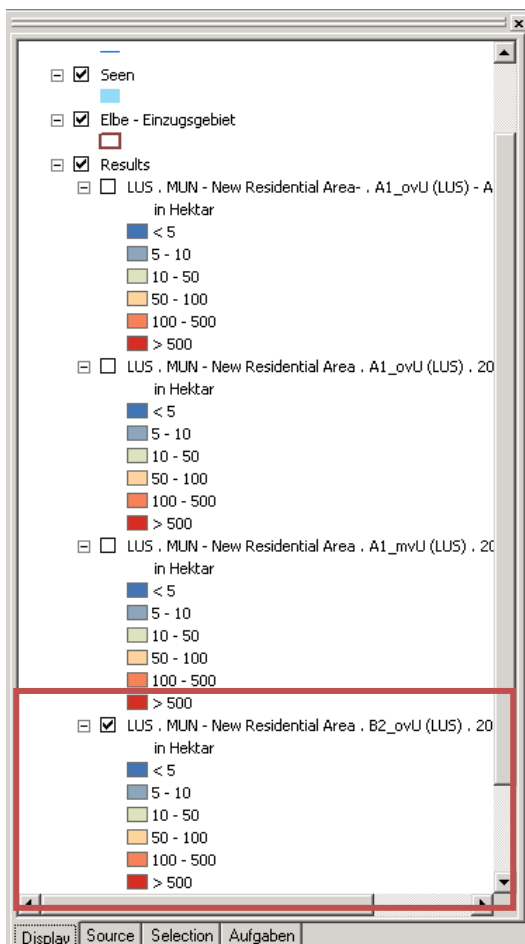
To view the results click the icon before **Show results layer**.

Currently this view does not contain a legend. To see the legend, select the **Display** tab. Only the currently visible results layer is checked in the Display tab. Therefore, you always know which legend is important for you.

2.1.2 Visualise the difference between two scenarios

Beside the visualisation of results for one scenario, it is also possible two visualise the difference between two scenarios. Difference layers cannot be visualised for raster layers. Only for administrative units (based on tabular data) difference layers can be visualised.

To select the first of two scenarios follow the steps of section 2.1.1. Then select from Block 2 another scenario from the drop down list **Scenario2**. Click the icon before **Show scenario difference layer**. To see the legend, change to the Display tab. The checked layer is the currently visible scenario difference layer.

2.2 As EET-Visualiser

If you are not interested in simulating new scenarios there is still the possibility to view already calculated scenarios. However, the functionality for visualisation is restricted.
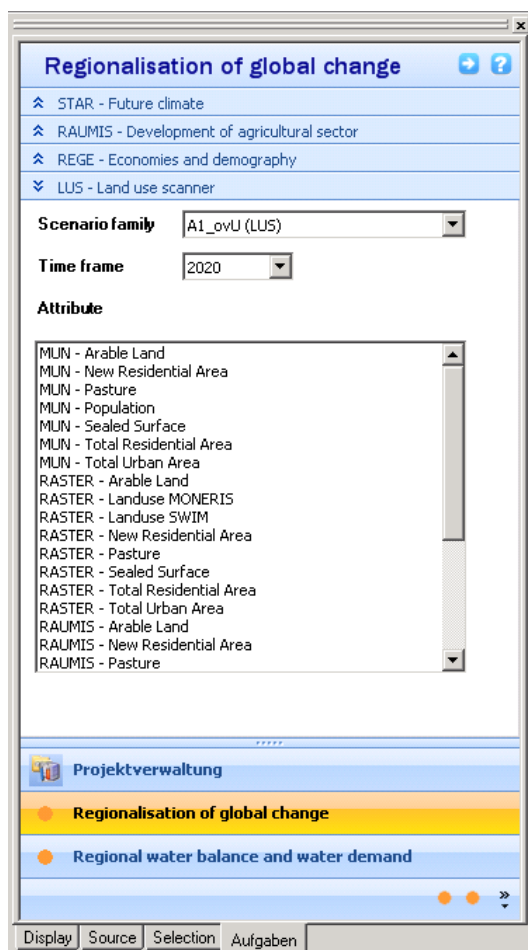
You should have read the general introduction to the EET. Start the EET and select the role EET-Wisys Visualiser. Enter user name and password and open your project. By using the role EET-Wisys Visualiser, it is not possible to calculate new scenarios. From the task list on the left hand side select **Regionalisation of Global Change**. Then, select the Land Use Scanner from the available list.

Select the scenario you want to visualise from the drop down list **Scenario family**. It is not necessary to select a **Time frame** because all datasets are only available for the year 2020. Finally, select an Attribute that is to be visualised. Only one attribute (results layer) can be visualised at one time.

Every raster file is listed with the prefix RASTER and every attribute saved in tables is listed. Municipal data have the prefix MUN, Raumis data has the prefix RAUMIS and data on level of spatial planning regions have the prefix ROR. The layer name corresponds to the names listed in Table 6.

The results layer automatically appears in the map window.

Currently this view does not contain a legend. To see the legend, select the **Display** tab. Only the currently visible attribute is checked in the Display tab. Therefore, you always know which legend is important for you (see section 2.1.1).

3   Stand alone

The results can be visualised in the Land Use Scanner itself. For a detailed structure of the model refer to Part 3. For visualising results within the Land Use Scanner, the application of the Expert Mode of the tool is recommended. Details about the use of the Expert Mode can be found in Part 2, section 1.3.The applied colours and classification schemes differ from those used in the EET. But the results are the same.

Additionally, all results that are presented in Table 6 are saved as ascii-raster and dbf-table files and are therefore suitable for usage in any standard GIS software or a table calculation programme. The following Table 7 gives an overview of the file path and file names of the single result files of the Land Use Scanner Elbe.

Table 7: File path and file name for results of the Land Use Scanner Elbe for use in external software programmes

Content	File path and File name	Floating numbers
Land use, aggregated for SWIM	*LUS\Raster\%ScenarioID%\2020\LanduseSWIM.asc*	
Land use, aggregated for MONERIS	*LUS\Raster\%ScenarioID%\2020\LanduseMONERIS.asc*	
New residential area (ha per grid cell)	*LUS\Raster\%ScenarioID%\2020\NewResArea.asc*	✓
Total residential area (ha per grid cell)	*LUS\Raster\%ScenarioID%\2020\ResArea.asc*	✓
Total urban area (ha per grid cell)	*LUS\Raster\%ScenarioID%\2020\UrbanArea.asc*	✓
Arable land (ha per grid cell)	*LUS\Raster\%ScenarioID%\2020\ArableLand.asc*	✓
Pasture (ha per grid cell)	*LUS\Raster\%ScenarioID%\2020\Pasture.asc*	✓
Sealed surface (ha per grid cell)	*LUS\Raster\%ScenarioID%\2020\SealedSurface.asc*	✓
Municipal data as table	*LUS\Tables\%ScenarioID%\2020\Gemeinde.dbf*	
Kreis data as table	*LUS\Tables\%ScenarioID%\2020\Kreise.dbf*	
Raumis data as table	*LUS\Tables\%ScenarioID%\2020\Raumis.dbf*	

The file path refers to the folder that contains the complete data package of the Land Use Scanner Elbe. The path is within the Land Use Scanner Elbe configuration folder and is therefore automatically defined when a path for the configuration is set in the LandUseDemand Options menu. For every scenario a single folder is created with the scenario-ID as folder name. Within this folder another folder with the year of the simulation result exist, where the raster files are found in. For all floating number raster files a converted ESRI-raster file is also provided with the same file names.

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Appendix 1 Data sources of datasets used in LUD and/or LUS

Table 8: Data sources of datasets that are processed within the Land Use Demand Tool and the Land Use Scanner

ID	Type of data	Dataset	Source	Licensing
1	**Statistical prognosis or projections**	Raumordnungsprognose 2010	BBR, (Bundesamt für Bauwesen und Raumordnung) (1996): Raumordnungsprognose 2010. Teilbereiche: Private Haushalte, Wohnungen, Wohnbauland. Materialien zur Raumentwicklung 74. Bonn.	
2		Raumordnungsprognose 2020	BBR, (Bundesamt für Bauwesen und Raumordnung) (2006): Raumordnungsprognose 2020/2050. Berichte 23. Bonn.	
3		Haushaltspgrognose der Tschechischen Republik	Bartonová, D. and M. Kucera (2005): Prognóza Cenzových Domácností v České Republice na Období do Roku 2030. In: Demografie 47(7), 229–244.	
4		Socioeconomic development developed within GLOWA-Elbe	Blazejczak, J., M. Gornig, E. Schulz et al. (2008): Szenarien zur Demographie und Ökonomie in der Elbe-Region. In: Wirkungen des globalen Wandels auf den Wasserkreislauf im Elbegebiet — Risiken und Optionen. Kapitel 2 des Schlussberichts zum BMBF-Vorhaben GLOWA-Elbe II. Potsdam, 116–139.	
5	**Statistical base data**	Statistik Regional 2006	STABU (2006a): Statistik regional. Daten für die Kreise und kreisfreien Städte Deutschlands. Wiesbaden: Statistische Ämter des Bundes und der Länder.	
6		Czech Statistical Office Public Database	http://vdb.czso.cz/vdbvo/en/uvod.jsp, 14.09.2010	
7		Regionaler Informationsservice des Zentrums für Regionalentwicklung der Tschechischen Republik	Portál Regionálních Informačních Servisů, 2006	
8		Census 2001 der Tschechischen Republik	http://www.czso.cz/sldb2011/redakce.nsf/i/datove_publikace, 14.09.2010	
9	**Land use data**	Landnutzung 1990 Deutschland	CORINE Land Cover; Umweltbundesamt, Statistisches Bundesamt 1997	
10		Landnutzung 2000	CORINE Land Cover;	

		Deutschland	Umweltbundesamt, DLR-DFD 2004	
11		Landnutzung 1990 Tschechien	Corine Land Cover, EEA (European Environment Agency), 2006	
12		Landnutzung 2000 Tschechien	Corine Land Cover, EEA (European Environment Agency), 2006	
13	**Spatial planning data**	Entwicklungsgebiete und Entwicklungsachsen	Daten zur Regionalentwicklung, ÚÚR (Ústav Územního Rozvoje), 2008	GLOWA-Elbe
14		Geschützte Naturgebiete, Naturparke, Gebietssystem der ökologischen Stabilität, Natura 2000	Daten zum Bereich Natur- und Landschaftsschutz, Agentura Ochrany Přírody a Krajini ČR, 2008	GLOWA-Elbe
15		Spatial development policy of the Czech Republic	MMR, (Ministerstvo pro Místní Rozvoj) and (Česká Republika Ústav Územního Rozvoje) ÚÚR (2006): Spatial Development Policy of the Czech Republic. Prague.	GLOWA-Elbe
16		Landesentwicklungsplan Thüringen	Ministerium für Bau und Verkehr des Freistaates Thüringen (2004) Landesentwicklungsplan 2004. Erfurt	GLOWA-Elbe
17		Landesentwicklungsplan Sachsen-Anhalt	Ministerium für Landesentwicklung und Verkehr des Landes Sachsen-Anhalt (1999) Landesentwicklungsplan Sachsen-Anhalt. Magdeburg	GLOWA-Elbe
18		Regionalplan Oberes Elbtal / Osterzgebirge	Regionaler Planungsverband Oberes Elbtal/Osterzgebirge (2001) Regionalplan Oberes Elbtal/Osterzgebirge. Radebeul	GLOWA-Elbe
19		Regionalplan Oberlausitz-Niederschlesien	Regionaler Planungsverband Oberlausitz-Niederschlesien (2002) Regionalplan Oberlausitz-Niederschlesien. Bautzen	GLOWA-Elbe
20		Regionalplan Südwestsachsen	Regionaler Planungsverband Südwestsachsen (2007) Regionalplan Südwestsachsen. Plauen	GLOWA-Elbe
21		Regionalplan Westsachsen	Regionaler Planungsverband Westsachsen (2001) Regionalplan Westsachsen. Leipzig	GLOWA-Elbe
22		Landesentwicklungsplan Sachsen	Sächsisches Staatsministerium des Innern (2003) Landesentwicklungsplan Sachsen. Dresden	GLOWA-Elbe
23		Landesentwicklungsprogramm der Länder Berlin und Brandenburg	Senatsverwaltung für Stadtentwicklung Berlin und Ministerium für Landwirtschaft, Umweltschutz und Raumordnung (2003) Gemeinsames Landesentwicklungsprogramm der Länder Berlin und Brandenburg.	GLOWA-Elbe

24		Landesraumordnungsprogramm Mecklenburg-Vorpommern	Der Wirtschaftsminister des Landes Mecklenburg-Vorpommern, Landesplanungsbehörde (1993) Erstes Landesraumordnungsprogramm Mecklenburg-Vorpommern. Schwerin	GLOWA-Elbe
25	**Other spatial datasets**	Digitales Landschaftsmodell Deutschland	ATKIS[®] VG1000, © Bundesamt für Kartographie und Geodäsie 2004.	GLOWA-Elbe
26		Verwaltungsgrenzen Deutschland	ATKIS[®] VG250, © Bundesamt für Kartographie und Geodäsie 2007.	GLOWA-Elbe
27		Verwaltungsgrenzen Tschechische Republik	MMR, (Ministerstvo pro Místní Rozvoj) and (Česká Republika Ústav Územního Rozvoje) ÚÚR (2006)	GLOWA-Elbe
28		Verkehrsinfrastruktur Tschechische Republik	http://www.maproom.psu.edu/dcw/, download 01.07.05	

Appendix 2 Overview of original CLC2000 classes (Land Use Scanner Elbe)

Corine land cover classes

1. Artificial surfaces
1.1 Urban fabric
- 1.1.1. Continuous urban fabric
- 1.1.2. Discontinuous urban fabric

1.2 Industrial, commercial and transport units
- 1.2.1. Industrial or commercial units
- 1.2.2. Road and rail networks and associated land
- 1.2.3. Port areas
- 1.2.4. Airports

1.3 Mine, dump and construction sites
- 1.3.1. Mineral extraction sites
- 1.3.2. Dump sites
- 1.3.3. Construction sites

1.4 Artificial, non-agricultural vegetated areas
- 1.4.1. Green urban areas
- 1.4.2. Sport and leisure facilities

2. Agricultural areas
2.1 Arable land
- 2.1.1. Non-irrigated arable land
- 2.1.2. Permanently irrigated land
- 2.1.3. Rice fields

2.2 Permanent crops
- 2.2.1. Vineyards
- 2.2.2. Fruit trees and berry plantations
- 2.2.3. Olive groves

2.3 Pastures
- 2.3.1. Pastures

2.4 Heterogeneous agricultural areas
- 2.4.1. Annual crops associated with permanent crops
- 2.4.2. Complex cultivation patterns
- 2.4.3. Land principally occupied by agriculture
- 2.4.4. Agro-forestry areas

3. Forest and seminatural areas
3.1 Forests
- 3.1.1. Broad-leaved forest
- 3.1.2. Coniferous forest
- 3.1.3. Mixed forest

3.2 Shrub and/or herbaceous vegetation associations
- 3.2.1. Natural grassland
- 3.2.2. Moors and heathland
- 3.2.3. Sclerophyllous vegetation
- 3.2.4. Transitional woodland shrub

3.3 Open spaces with little or no vegetation
- 3.3.1. Beaches, dunes, and sand plains
- 3.3.2. Bare rock
- 3.3.3. Sparsely vegetated areas
- 3.3.4. Burnt areas
- 3.3.5. Glaciers and perpetual snow

4. Wetlands
4.1 Inland wetlands
- 4.1.1. Inland marshes
- 4.1.2. Peat bogs

4.2 Coastal wetlands
- 4.2.1. Salt marshes
- 4.2.2. Salines
- 4.2.3. Intertidal flats

5. Water bodies
5.1 Inland waters
- 5.1.1. Water courses
- 5.1.2. Water bodies

5.2 Marine waters
- 5.2.1. Coastal lagoons
- 5.2.2. Estuaries
- 5.2.3. Sea and ocean

Appendix 3 List of available Evaluation items

The tree item Simulations > Continuous_Model > LndRorKrs > m250 > Results > Evaluation contains various data items, both maps and tables, that describe the simulation results in different ways. There are also some indicators among the evaluation items.

Evaluation item	Default View	Description (of sub-items if applicable)
Study_Area	Datagrid	**CurrentLU, AllocatedLU, ChangedLU, Minimum and Maximum claims, Minimum and maximum total claim realisation, Minimum and mximum additional claim realisation**
Claim_Regions	Datagrid	**CurrentLU, AllocatedLU, ChangedLU, Minimum and Maximum claims, Minimum and maximum total claim realisation, Minimum and mximum additional claim realisation**
Claim_Regions > Sealed surface	Map & Datagrid	**A range of sealed surface indicators: All land uses, current sealed surface, allocated sealed surface. Available for urban area and residential area. Also included: sealed surface fraction and average settlement density**
Aggregated _Levels		
Subcatchments	Map	**CurrentLU, AllocatedLU, ChangedLU, Sealed surface**
Gemeinde	Map	**CurrentLU, AllocatedLU, ChangedLU, Sealed surface, different types of population indicators**
Kreise	Map	**CurrentLU, AllocatedLU, ChangedLU, Sealed surface**
Raumis	Map	**CurrentLU, AllocatedLU, ChangedLU, Sealed surface**
Cell_level		
TotalLU	Map	**CurrentLU, AllocatedLU, ChangedLU**
CurrentLU	Map	**Current land use for the three endogenous land use types**
AllocatedLU	Map	**Allocated land use for the three endogenous land use types**
ChangedLU_Endogenous	Map	**Changed land use for the three endogenous land use types**
ChangedLU_Exogenous	Map	**Changed land use for the exogenous land use types**
ChangedLU_9cl	Map	**Changed land use in 9 main land use classes**
Urbanisation	Map	**Urbanisation measures (surface and area) for current, allocated and changed land use. Current land use also contains an indicator that describes the connectedness of urban areas**
ResidentialDevelopment	Map	**Residential development measures (surface and area) for current, allocated and changed land use.**
ResidentialDev_in_Policy_areas	Map	**Residential development in nature protection and in spatial planning areas**
ResidentialCurr_in_Policy_areas	Map	**Current residential land use in nature protection and in spatial planning areas**
Urban_in_Policy_areas	Map	**Level of urbanisation in nature protection and in spatial planning areas**
SealedSurface	Map	**A range of sealed surface indicators: Current sealed surface, allocated sealed surface. Available for urban area. Also included: sealed surface fraction and average settlement density**
Openness_Landscape	Map	**Indicator describing the openness of the landscape (in surface and area) for current, allocated and changed land use**
SWIM_MONERIS_landuse	Map	**SWIM land use and MONERIS land use**

Appendix 4 List of all implemented suitability maps

Name of suitability map	Description
Landuse	Current land use type
biosphaerenreservate	Biosphere reserve
FFH	Flora-Fauna-Habitat areas
landschaftsschutzgebiete	Landscape conservation area
naturschutzgebiete	Nature conservation area
naturparks	Natural park
nationalparks	National park
spa	Bird protection area
wirkungsbereiche_zo	Areas that are influenced by central places
entwicklungsachsen	Development achses
dist_to_pot_Siedlung_BB	Distance to potential residential areas in Brandenburg
pot_Siedlung_BB	Potential residential areas in Brandenburg
dist_to_gruenzaesur	Distance to regional green belts
gruenzaesur	Regional green belts
gruenzuege_freiraum	Green corridors
trinkwasserschutz	Protected areas for drinking water
vs_landwirtschaft	Priority area for arable land
vs_natur_landschaft	Reserved area for nature and landscape
vr_natur_landschaft	Priority area for nature and landscape
vs_rohstoffe	Reserved area for mining
vr_rohstoffe	Priority area for mining
vs_trinkwasserschutz	Reserved area for drinking water
vr_trinkwasserschutz	Priority area for drinking water
vs_hochwasserschutz	Reserved area for flood protection
vr_hochwasserschutz	Priority area for flood protection
vs_wald	Reserved area for forest areas
vr_wald	Priority area for forest areas
verdichtungsraum	Densely polulated area
A113_infrastructure_I	New infrastructure: freeway A113
BBI_infrastructure_III	New infrastructure: airport Berlin-Brandenburg-International
military	Military zones in Czech Republic
entwicklungsachsen_cz	National Development Plan
fc13_gg10_00	Share of pasture in the 13x13 cell neighbourhood in the year 2000
fc13_gg9_00	Share of arable land in the 13x13 cell neighbourhood in the year 2000
fc13_gg2_00	Share of industrial areas in the 13x13 cell neighbourhood in the year 2000
fc13_gg1_00	Share of residential areas in the 13x13 cell neighbourhood in the year 2000
fc17_gg10_00	Share of pasture in the 17x17 cell neighbourhood in the year 2000
fc17_gg9_00	Share of arable land in the 17x17 cell neighbourhood in the year 2000
fc17_gg2_00	Share of industrial areas in the 17x17 cell neighbourhood in the year 2000
fc17_gg1_00	Share of residential areas in the 17x17 cell neighbourhood in the year 2000
fc9_gg10_0	Share of pasture in the 9x9 cell neighbourhood in the year 2000
fc9_gg9_00	Share of arable land in the 9x9 cell neighbourhood in the year 2000
fc9_gg2_00	Share of industrial areas in the 9x9 cell neighbourhood in the year

	2000
fc9_gg1_00	Share of residential areas in the 9x9 cell neighbourhood in the year 2000
fc5_gg10_00	Share of pasture in the 5x5 cell neighbourhood in the year 2000
fc5_gg9_00	Share of arable land in the 5x5 cell neighbourhood in the year 2000
fc5_gg2_00	Share of industrial areas in the 5x5 cell neighbourhood in the year 2000
fc5_gg1_00	Share of residential areas in the 5x5 cell neighbourhood in the year 2000
fc3_gg10_00	Share of pasture in the 3x3 cell neighbourhood in the year 2000
fc3_gg9_00	Share of arable land in the 3x3 cell neighbourhood in the year 2000
fc3_gg2_00	Share of industrial areas in the 3x3 cell neighbourhood in the year 2000
fc3_gg1_00	Share of residential areas in the 3x3 cell neighbourhood in the year 2000
slope	Slope
yield_potential	Yield potential on agricultural sites
dist_roads_m	Travel time to Metropolitan cities along roads
dist_roads_m_oz	Travel time to Metropolitan cities and high order central places along roads
dist_roads_m_oz_mz	Travel time to Metropolitan cities, high and medium order central places along roads
dist_roads_m_oz_mz_p	Travel time to Metropolitan cities, high, medium and low order central places along roads
dist_railroads	Travel time along railroads
dist_railroad_m	Travel time to Metropolitan cities along roads
dist_railroad_m_oz	Travel time to Metropolitan cities and high order central places along roads
dist_railroad_m_oz_mz	Travel time to Metropolitan cities, high and medium order central places along roads
dist_stations	Distance to train stations in Kilometre
dist_stations_meter	Distance to train station in Metre
dist_recreation	Distance to recreational areas
dist_recreation_zo	Distance of recreational areas to central places
dist_pasture	Distance to pastures
dist_river	Distance to river network
dist_forest	Distance to forest areas
dist_residential	Distance to current residential areas
dist_metropole	Distance to Metropolitan cities
dist_metropole_mz	Distance to Metropolitan cities, high and medium order central places
dist_roads	Distance to roads in Metre
dist_railroads_meter	Distance to railroads in Metre
dist_from_str_to_zores_sec	Travel time from streets to the residential areas of central places
dist_from_str_via_bhf_rr_to_ zores_sec	Travel time from streets vie train stations and railroads to residential areas of central places
dist_airport	Distance to airports
dist_highwayexit	Distance to highway exits
buffer_forest	Buffer area around forests
transitional	Land use in transition to forests
waldmehrungsplanung	Spatial planning document for forests
dist_WaldNat	Distance to forest and nature areas

Appendix 5 Currently used values for the adjustable parameters of the Land Use Demand Tool

Dwellings per capita

Name	ID	Globalisation scenario		Differentiation secenario	
		Single-family dwellings	Multi-family dwellings	Single-family dwellings	Multi-family dwellings
Schleswig-Holstein Süd-West	2	0,34	0,17	0,34	0,17
Schleswig-Holstein Mitte	3	0,24	0,29	0,24	0,29
Schleswig-Holstein Süd	5	0,27	0,21	0,27	0,21
Hamburg	6	0,11	0,41	0,11	0,41
Westmecklenburg	7	0,25	0,28	0,26	0,28
Mecklenburgische Seenplatte	10	0,25	0,33	0,25	0,33
Bremerhaven	13	0,3	0,26	0,3	0,27
Hamburg-Umland-Süd	14	0,34	0,15	0,35	0,15
Südheide	20	0,34	0,17	0,35	0,17
Lüneburg	21	0,33	0,2	0,33	0,2
Braunschweig	22	0,26	0,3	0,26	0,3
Göttingen	24	0,33	0,26	0,33	0,26
Prignitz-Oberhavel	25	0,29	0,22	0,29	0,22
Uckemark-Barnim	26	0,26	0,25	0,26	0,25
Oderland-Spree	27	0,26	0,25	0,26	0,26
Lausitz-Spreewald	28	0,27	0,29	0,27	0,29
Havelland-Fläming	29	0,24	0,26	0,24	0,26
Berlin	30	0,06	0,5	0,06	0,51
Altmark	31	0,32	0,26	0,32	0,26
Magdeburg	32	0,25	0,35	0,25	0,35
Dessau	33	0,3	0,33	0,3	0,34
Halle/S.	34	0,24	0,38	0,24	0,38
Nordthüringen	53	0,31	0,21	0,31	0,21
Mittelthüringen	54	0,23	0,31	0,23	0,31
Ostthüringen	56	0,24	0,35	0,24	0,35
Westsachsen	57	0,17	0,41	0,17	0,42
Oberes Elbtal/Osterzgebirge	58	0,16	0,41	0,16	0,41
Oberlausitz-Niederschlesien	59	0,26	0,32	0,26	0,32
Chemnitz-Erzgebirge	60	0,2	0,41	0,2	0,41
Südwestsachsen	61	0,22	0,41	0,22	0,42
Oberfranken-West	83	0,31	0,18	0,31	0,18
Oberfranken-Ost	84	0,3	0,24	0,3	0,24
Oberfranken-Nord	85	0,32	0,15	0,32	0,16
Praha	101	0,06	0,47	0,07	0,49
Stredni Cechy	102	0,25	0,24	0,27	0,26
Jihozapad	103	0,21	0,31	0,22	0,32
Severozapad	104	0,14	0,38	0,14	0,4
Severovychod	105	0,22	0,29	0,23	0,3
Jihovychod	106	0,23	0,25	0,24	0,26
Stredni Morava	107	0,24	0,25	0,24	0,26

Floor area per dwelling in m²

Name	ID	Single-family dwellings	Multi-family dwellings
Schleswig-Holstein Süd-West	2	102	1264
Schleswig-Holstein Mitte	3	98	26365
Schleswig-Holstein Süd	5	104	28472
Hamburg	6	100	345441
Westmecklenburg	7	95	10041
Mecklenburgische Seenplatte	10	90	3789
Bremerhaven	13	102	5784
Hamburg-Umland-Süd	14	109	6115
Südheide	20	105	2034
Lüneburg	21	109	2443
Braunschweig	22	101	64244
Göttingen	24	93	9236
Prignitz-Oberhavel	25	87	5011
Uckemark-Barnim	26	90	3662
Oderland-Spree	27	95	7533
Lausitz-Spreewald	28	91	14120
Havelland-Fläming	29	96	25235
Berlin	30	96	1853323
Altmark	31	94	1120
Magdeburg	32	87	39483
Dessau	33	83	7989
Halle/S.	34	86	32643
Nordthüringen	53	91	2852
Mittelthüringen	54	90	25186
Ostthüringen	56	85	24741
Westsachsen	57	87	95935
Oberes Elbtal/Osterzgebir	58	85	86070
Oberlausitz-Niederschlesi	59	85	14357
Chemnitz-Erzgebirge	60	75	53424
Südwestsachsen	61	79	21951
Oberfranken-West	83	99	7618
Oberfranken-Ost	84	94	7299
Oberfranken-Nord	85	99	4373
Praha	101	73	138337
Stredni Cechy	102	70	35019
Jihozapad	103	68	56423
Severozapad	104	69	74762
Severovychod	105	67	74441
Jihovychod	106	68	69609
Stredni Morava	107	67	35752

Floor area density (Ratio of floor area and residential area)

NL-AL	Region type	Year 2000				Year 2020			
		Single family dwellings		Multi family dwellings		Single family dwellings		Multi family dwellings	
		Curr. env. policy	Incr. env. policy	Curr. env. policy	Incr. env. policy	Curr. env. policy	Incr. env. policy	Curr. env. policy	Incr. env. policy
West Germany	Agglomeration	60	45	50	64	31	45	51	64
	Urbanized area	20	36	40	54	21	36	40	54
	Rural area	18	32	34	50	19	31	34	50
East Germany	Agglomeration	19	43	52	61	21	43	54	61
	Urbanized area	16	40	45	58	16	40	45	58
	Rural area	13	32	39	51	14	32	40	51
	Czech Republic	18	18	18	18	18	42	18	42