University of South Bohemia

Faculty of Science

Master thesis

Applicability of the EURURALIS Scenarios at the Fine Spatial Scales

Author: Bc. Jitka Strakova

Supervisor: Keith Edwards, Ph.D.

Consultant: Ing. Eva Semancikova

Ceske Budejovice 2009

Strakova, J., 2009. Applicability of the scenarios EURURALIS at the fine spatial scales. Faculty of Science, University of South Bohemia, Ceske Budejovice, 81p.

Annotation:

The submitted thesis tests the applicability of the EURURALIS scenarios at the area of tens of square kilometres. In addition, it finds main differences between supposed development of EU27 and the specific study region and suppose potential for strategic planning at the level of Czech rural regions.

Declaration:

I declare the independent elaboration of the submitted master thesis. This work is based on the use of the referred literature.

Prohlašuji, že jsem tuto diplomovou práci vypracovala samostatně, pouze s použitím citované literatury.

Prohlašuji, že v souladu s platným zněním § 47b zákona č.11/1998Sb. souhlasím se zveřejněním mé diplomové práce, a to v nezkrácené podobě (v úpravě vzniklé vypuštěním vyznačených části archivovaných Přírodovědeckou fakultou), elektronickou cestou ve veřejně přístupné části databáze STAG provozované Jihočeskou univerzitou v Českých Budějovicích.

30 April 2009, Ceske Budejovice

……………………...

Bc. Jitka Strakova

Abstract:

The submitted thesis tests the applicability of the EURURALIS scenarios at the fine spatial resolution and evaluates their potential for the strategic planning at small scales. Secondly, it provides a tool for learning about the forces that drive the future of Czech rural regions and about main differences between supposed development of the EU and the case study specific trends. This work specifies Global Economy and Regional Communities scenarios to the case study area and evolves the specific methods of land cover trends extrapolation and European trends interpolation. The CLUE-s model provides interface for quantification of land cover changes according to scenarios. The simulation of the Global Economy scenario reveals transition from the open agricultural landscape to the area, where semi-natural succession stadiums prevail. The Regional Communities scenario leads to the mosaic structure of the landscape. The reformulation of scenarios across scales reduces digestibility of storylines for users and does not keep contrast for meaningful discussion. Not urbanisation, but agricultural land abandonment and consequential building-up and forest spreading change landscape structure. The case study area is highly dependent on the European Common Agricultural Policy and the Less Favoured Area concept. The limitations of scenarios application present data unavailability, absence of multidisciplinary approach and insufficient incorporation of stakeholders.

Acknowledgments:

I would like to thank Dr. Edwards, Ing.Semancikova and Dr.Verburg for many valuable advices, acquired experience and their precious time.

Table of content

1 INTRODUCTION

Czech rural areas are nowadays facing rapid changes including intensification of land use in some areas and land abandonment in other ones. With increasing pressure on countryside, it becomes more important to monitor and couple land use change and, if necessary, to influence these changes through policy mechanism. To effectively select, develop and implement land use policies we need to explore, project and predict land use (Stoorvogel and Antle, 2001). One of the available technologies for land use prediction, mitigation of land use conflicts and minimizing of environmental effects is integrated scenario approach. It was EURURALIS project, developed in 2004 that supports policy discussion about European rural development. EURURALIS offers a conceptual framework and powerful toolbox with data and models that supports interactive use. Maps and graphs indicate a variety of possible futures for European rural areas, with four plausible scenarios as starting point (Eururalis 2.0, 2008).

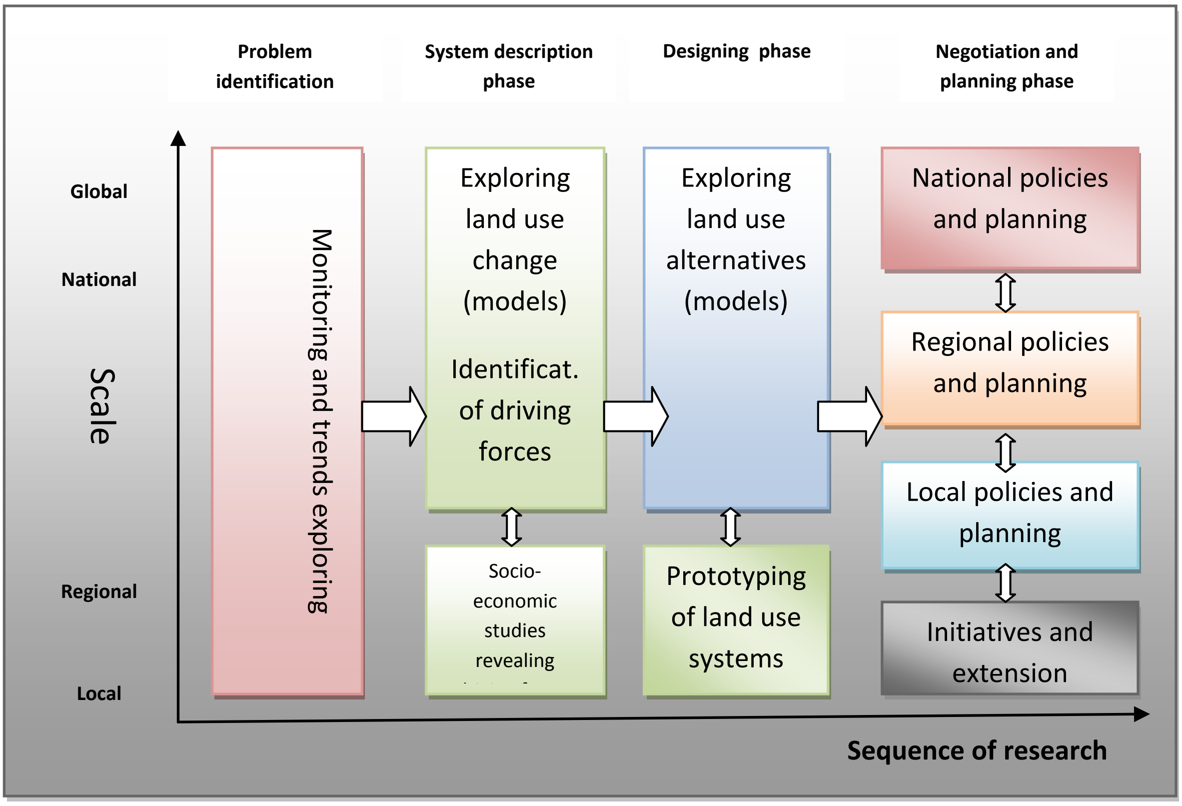
Will the future of Czech rural marginal regions be shaped by global forces? Will the agricultural abandonment be dependent on liberalization and bio-energy? The ambition of the submitted master thesis is threefold. Firstly it wants to apply two contrastive EURURALIS scenarios at 30-square-kilometers large case study area and find main differences between supposed development of EU27 and specific study region. Secondly it wants to learn about the interacting of many forces that drive the future of Czech rural regions within less favourable areas. Thirdly it wants to test applicability of EURURALIS scenarios at small spatial scale and evaluate their potential for strategic landscape planning at regional extent. All the ambitions of master thesis are going to be reached by application of scientifically sound EURURALIS approach at 30-square-kilometers large rural region determined by catchment area of Mracnicky and Podhajsky brook in western Bohemia, the Czech Republic. This master thesis is linked to bachelor study “Landscape development and analysis of spatial structure within catchment of Mracnicky and Podhajsky brook” (Strakova, 2006) that revealed main land use changes of the case study area in last thirty years and connected them with historical development.

2 LITERACY REVIEW

2.1 Methods for regional land use analysis

Complexity of regional land use analysis demands interdisciplinary approaches connecting various scientific disciplines in such a manner that take into account all relevant aspects for decision-making at different spatial units. One example of land use research progress in connection with diffusion of spatial unit is shown in the Figure No 1.

Figure No 1: Time sequence in dependence on research phase and spatial scale



An integrated assessment associates different methods and techniques for land use data analysis. "The variety in tools is a logical consequence of differences in questions that need to be answered and the boundary conditions that are set during the development of the methods" (Stoorvogel and Antle, 2001). Each of methods is more or less suitable for specific situation and application and call for specific should-be data (see Table No 1). E.g., the pattern of land use can be observed from an airplane window or through remotely sensed images and all the spatial data can be processed by Geographical Information Systems (GIS). Nevertheless these methods do not give insight in the implications of land use change on, for instance, the environment or the economy. For this purpose, we can use statistical methods, which evaluate the relation between land use changes and their driving factors or analysis of specific indicators, which implicate land use change for specific policy issues.

Table No 1: Mapping methods and should-be data

	Spatial data	Quantitative	Points	Landscape	Literature
Linking data	x	x			
Decision				x	x
Statistical		x	x		

Other tools of integrated assessment are scenarios due to their ability to address complex issues including social problems, ability to deal with system changes or serve as tools for communication and participation. One fraction of quantitative or combined scenarios can be land use model that indicates possible future configuration of land use under various scenarios. They give independently from scenarios clear picture where in the landscape opportunities and conflicts occur. Both scenarios and models will be discussed and sampled in the next sections.

2.2 Scenarios

In this section we will discuss term scenario, possible application of this scenario tool, methods for its formation and at the end we will explore two famous world scenarios (IPPC and MA) and three European scenarios. First of them (Europe2010) is qualitative in nature, other ones (GEO-3 and EURURALIS) present combination of qualitative and quantitative approach. We will pay extra attention to EURURALIS scenarios, which are the bases of this master thesis.

2.2.1 Definition of term "scenario"

Scenario study presents method that combines known facts about the future, such as demographics, geography, ecology, and political, industrial information, with plausible alternative social, technical, economic and political trends which are key driving forces. An explanation of term scenario often involves following: it is hypothetical description of possible future, dynamic processes and consecution of events; it is pool of alternate states, events, effects and driving factors which are put together. Let us have a look at a few of definitions. The Intergovernmental Panel on Climate Change (IPCC) defines scenarios as "images of the future, or alternative futures", Nakicenovic et al (2000) characterizes this method as "an alternative images of how the future might unfold", Wikipedia (2006), free encyclopaedia, presents scenarios as a strategic planning method, which can be used (especially by military resort) to make flexible long-term plans. Buson (2007) suggests: "Scenario planning is a method for learning about the future by understanding the nature and impact of the most uncertain and important driving forces affecting our future. He continues with list of advantages: “It is a group process which encourages knowledge exchange and development of mutual deeper understanding of central issues important to the future of your business". UNEP/RIVM (2003) reveals main benefits from exploring different future scenarios for today’s decision-makers by putting on “clearer picture of what tomorrow might bring in terms of human and environmental health and what the impact of their decisions is likely to be". As most of definition indicated, scenarios are in particular a mechanism for learning.

2.2.2 Use of scenarios

Though the concept of scenario was firstly introduced, as "La Prospective", by Berger in 1964 and the word "scenario" itself was probably firstly used by Herman Kahn in 1967, the theoretical foundations of scenario forecasting were mainly developed in the 1970s, especially by Godet (1987). "By the early 1980s these approaches had developed into a sophisticated forecasting technique which was primarily recommended for the integration of the output from other sophisticated (qualitative) approaches to long-range forecasting" (Wikipedia, 2006). In the 1980s, this forecasting had also been used by academic and commercial organizations.

Scenarios may be used in a number of ways. For example, as containers for the drivers / event strings, background for decision making, tests for consistency or positive perspectives. Scenarios must assimilate an enormous amount of information, in both quantitative and qualitative form and must be communicated to a large audience. Scenario analysis is used to analyse future paths for world development at the global scale, e.g., to analyse development of national preparedness standards at the national scale (Howe, 2004) and to demonstrate alternative futures for concrete region at the regional level. Scenario studies are useful for economy, military sector, implementing of technologies, energetic or environment.

In the environmental assessment scenarios can provide a picture of future alternative states of the environment. "Scenarios are a device for illustration the impacts of society on the natural environment and for pointing out the need for environmental policies to avoid these impacts" (Alcamo and Ribeiro, 2001). Authors continue that scenarios can be used to raise awareness about the future connections between different environmental problems, to illustrate how alternative policy pathways can achieve an environmental target, and to combine qualitative and quantitative information about future evolution of an environmental problem. Scenarios identify the robustness of environmental policies under different future conditions, they help stakeholders, policymakers and experts to "think big" about an environmental issue and they also help raise awareness about the emergence of new or intensifying environmental problem. "The goal of developing these multiple scenarios is not to improve the odds of correctly predicting the future, but rather to allow managers to fully understand the driving forces affecting the future. By understanding and recognising these driving forces, the ability of managers to plan for alternative operating environments and to react to change is enhanced" (Fahey and Randall, 1998).

On the contrary, in business organizations, strategic plans have often been considered only a straight-line graph of current trends carried into the future. Strategic military intelligence organizations also construct scenarios. "This process was first carried out (arguably the method was invented by) the Prussian general staff of the mid-19th century" (Wikipedia, 2006).

Main uses of scenario planning for policy- and decision-makers can be summed up by helpfulness to anticipate hidden weaknesses and inflexibilities in politic decision, organizations and methods.

2.2.3 Consistence and formation of scenario

A typical scenario used in environmental studies consist of (Alcamo and Ribeiro, 2001) description of step-wise change, driving forces as determinants that influence step-wise changes, base year (usually the most recent year in which adequate data are available), time horizon (most distant year covered by scenario), time steps and storyline.

Alcamo and Ribeiro (2001) defined a storyline as “a narrative description of a scenario, which highlights its main features and the relationships between the scenario's driving forces and its main features". From this definition it is perceptible how important is to expertise a set of driving factors, to define mutual relationships between them, to use methods to quantify influences and effects of them and to pay attention to important relations and feedbacks. Wollenberger et al. (1999) argue that information about the forces shaping the system includes the structure of resources, actors, institutions, events and relations among them. It contains identification of slow changing, predictable trends and identification of uncertainties and potential major drivers of change.

To create a scenario study, we can use e.g., expert's knowledge, extrapolation of trends or mathematical method (e.g., regression).

As scenario methods have used various forms of stakeholders input to make it relevant to various users (Wollenberg et al, 1999), we distinguished a few of scenario types (see chapter below).

2.2.4 Types of scenarios

Scenarios are generally divided into 2 essential groups – qualitative studies, which are expressed by words, and quantitative ones, represented by numbers. For deeper description, dis-/advantages and differences see Table No 2. Other variations are baseline and policy scenarios. Baseline studies are defined by Alcamo and Ribeiro (2001) as presentation of “future state of society and the environment in which environmental policies either do not exist or do not have a discernible influence on society or the environment” in contrary to policy which “depicts the future effects of environmental protection policies”. Main divergences of mentioned scenarios are in their purposes. Baseline scenario evaluates the consequences of current policies and try take into account the uncertainty of both driving forces and environmental conditions. In contrast, policy scenario identifies policies that attain specific environmental goals or norms and examines the economic and environmental impacts of specific environmental policies and try to take into account the uncertainty of future environmental conditions and societal driving factors. Last subdivision of scenarios, which we will follow, is exploratory and anticipatory type. "Exploratory scenarios (also known as descriptive scenarios) are those that begin in the present and explore trends into the future. On the other hand, anticipatory scenarios (also known as prescriptive or normative scenarios) start with a prescribed vision of the future and then work backwards in time to visualise how this future could emerge" (Alcamo and Ribeiro, 2001). Examples of exploratory scenarios are the SRES emission scenarios, of anticipatory scenarios IIASA scenarios. In environmental studies, exploratory scenarios are much more common.

Table No 2: Differences between qualitative and quantitative scenarios

Differences	Qualitative	Quantitative
Form	words, visual symbols	numbers
Shape	diagrams, phrases, outlines, texts	tables, graphs, computer models
Representation	the views of several different stakeholders and experts at the same time	one point of view about how the future will unfold
Advantage	- well-written storylines are an understandable way of communicating information about the future - can easily incorporate human motivations, values and behaviour	- transparent assumptions - greater rigour, precision and consistency - conclusions can be traced back to the assumption
Drawback	- don't satisfy a need for numerical information - include shocks and discontinuities	- difficult for non-specialists
Example	Scenarios Europe 2010	IMAGE scenarios

2.2.5 Examples of two famous global and a few minor European scenarios

The Intergovernmental Panel on Climate Change (IPCC) decided in September 1996 on its plenary session in Mexico City to develop a new set of emissions scenarios. The scenarios had the task to “encompass different future developments that might influence greenhouse gas (GHG) sources and sinks, such as alternative structures of energy systems and land-use changes" (Nakicenovic et al., 2000). This set of emissions scenarios was intended for use in future IPCC assessments and by wider scientific and policymaking communities for analysing the effects of future GHG emissions and for developing mitigation and adaptation measures and policies. SRES (The Special Report on Emission Scenarios) writing team formulated a set of emissions scenarios for a period of 100 years (to 2100) and covered a wide range of the main driving forces of future emissions. For this goal were used: AIM, IMAGE, MARIA, MESSAGE and MiniCAM models. Each of the four scenario families (A1, A2, B1 and B2) has a narrative storyline and consists of 40 scenarios developed by six modelling groups. Thus the SRES scenarios involve both qualitative (a formal modelling approaches) and quantitative components (a narrative storylines and a number of corresponding quantitative scenarios for each storyline).

The Millennium Ecosystem Assessment was summoned by the Kofi Annan (United Nations Secretary-General) in 2000 and carried out between 2001 and 2005 "to assess the consequences of ecosystems change for human well-being and to establish basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contribution to human well-being" (Carpenter et al., 2005). The MA developed four scenarios of ecosystem services and human well-being (Adapting Mosaic, Techno Garden, Global Orchestration, and Order from Strength) to 2050, with selected results up to 2100. To this purpose IMAGE, IMPACT, AIM, WaterGAP and Ecopath/Ecosim models was used. They work with multiscale assessment operating at local, watershed, national, regional, and global scales. The approach to scenario development in the MA combines qualitative storyline development and quantitative modelling.

The project "Scenarios Europe 2010" was begun in 1997 with the objective of producing a set of coherent and thought-provoking images of the European future. European Commission set this project up. The principal aim of Scenarios Europe 2010 was twofold: "to stimulate debate inside and outside the Commission on the future of European integration and to develop a tool to put the Union's policies and strategies into perspective and contribute to their improvement" (Bertrand et al., 1999).Europe 2010 scenarios (Triumphant markets, Hundred flowers, Shared responsibilities Creative societies and Turbulent neighbourhoods) are entirely qualitative in nature.

The third Global Environment Outlook (GEO-3) was published by UNEP/RIVM on the Johannesburg summit in 2002. This project should explore the ways our society can advance, including implications for environmental and social goals. "Characteristically, GEO-3 examines in a relatively deep fashion how its global scenarios can be interpreted in the context of each of the world's regions" (UNEP/RIVM, 2003). To this goal is used the IMAGE, GLOBIO and WaterGAP model. GEO-3 presents the pan-European elaboration of the four scenarios: Markets First, Policy First, Security First and Sustainability First. In these scenarios qualitative narratives take main role and quantitative tools play a supporting role.

The European Environment Agency initiated in 2005 the PRELUDE project (Prospective Environmental analysis of Land Use Development in Europe) to develop coherent scenarios that describe plausible future developments for land use in EU-25 plus Norway and Switzerland and their potential environmental impacts for the period 2005–2035. The targets of the PRELUDE scenarios are "to describe a range of possible futures, which are meant to inspire strategic thinking about some of the key challenges that Europe may face in the future in the field of land-use, agriculture, rural development and the environment" (EEA, 2007).

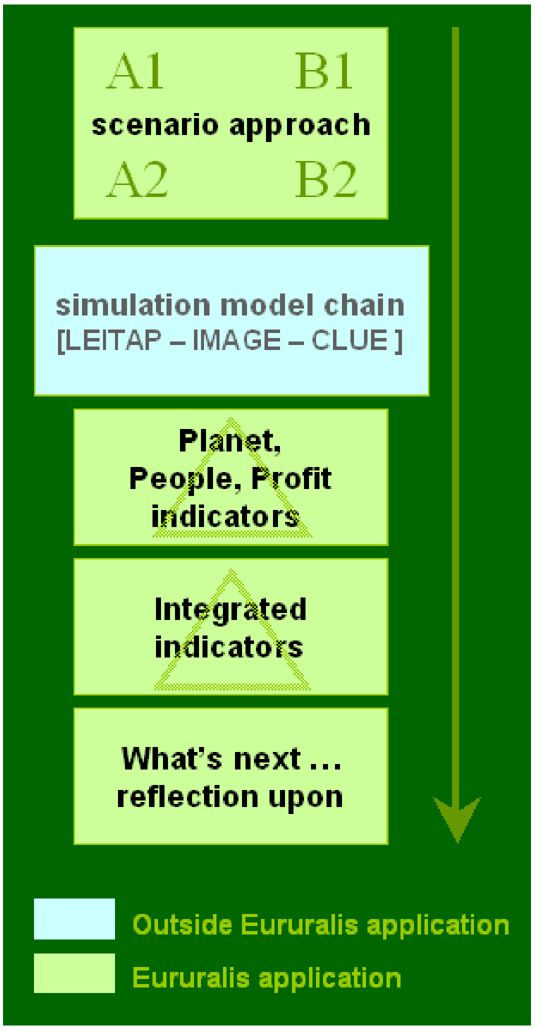
A modified version of the so called story-and-simulation (SAS) approach was chosen to develop five PRELUDE scenarios (Great Escape, Evolved Society, Cluster Networks, Lettuce Surprise and Big Crisis). The Louvain-la-Neuve land-use/cover change model was used for assessing the changes in land use/cover at the European level. Thus the PRELUDE project combines both qualitative and quantitative scenarios by using imagination, data, modelling and narratives.

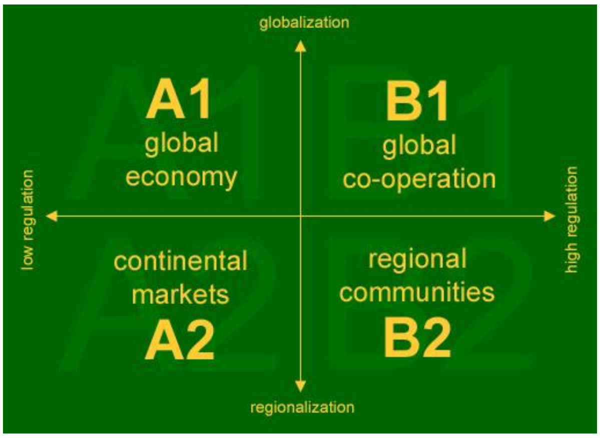
2.2.6 EURURALIS: A scenario study on Europe's Rural Areas to support policy discussion

The EURURALIS project was initiated by the Working Group Sustainable Development and System Innovation, Wageningen University and Research Centre in the Netherlands, and commissioned by the Dutch Ministry of Agriculture, Nature and Food quality in 2004. This project was developed "to stimulate the strategic discussion among both national policy makers and policy makers at the European Union level on the future of Europe's rural areas and the role of policy instruments" (Westhoek et al, 2006). Klijn et al (2005) describe the general aim as "building a tool that supports discussion on the future of the rural areas of Europe (EU 25) based upon a scenario-approach addressing the major issues playing in the areas seen from the perspective of sustainable development".

EURURALIS is a scenario study starting from four contrasting world vision (see Table No 3) taking a time horizon of three decades, in 10 years steps: 2000, 2010, 2020 and 2030. These scenarios were quantified with a chain of models (LEITAP, IMAGE and CLUE), ranging from global models to a spatially explicit model, which covers the EU 25 countries in various detail (simulates land use on a 1 km × 1 km grid for the whole EU) and show impacts on People, Planet and Profit indicators. The Figure No 2 shows general framework for the EURURALIS project and Figure No 3 below presents mutual position of scenarios (from Eururalis 1.0, 2004).

Figure No 2 and 3: General framework of EURURALIS (on the left) and mutual position of scenarios (on the right)





EURURALIS is relied upon some central concepts and philosophies:

- **DPSIR approach** (Klijn et al., 2005)**:** this idea can be distinguished between driving forces (D) affecting a defined system by so-called pressures (P) affecting its state (S). This can be seen as the impact (I), which has to be assessed from society's interests. This assessment can lead to policy interventions, response (R).

- **Explorative scenario approach**

- **Sustainability approach**: this idea is summarised by the 3P concept distinguishing ecological properties and values (Planet), socio-cultural values (People), and values belonging to the economical domain (Profit). For all 3P domains are defined the following indicators (**People**: employment in the agricultural sector, self sufficiency and

animal diseases; **Planet**: biodiversity in natural areas, biodiversity in semi-natural areas, pollution, soul erosion risk, salinization risk and CO_2 storage;
Profit: yield, income and expenses. The output was generalised for the non-experienced users by the following meta-indicators (Integrative indicators): overall 3P scores, East-West, North-South, Hot-spot areas and "Should be versus will be differences".

As major drivers within EURURALIS are distinguished (Eururalis 1.0, 2004):

World economy/welfare (demand and supply, exchange of goods and services; these determine the flow of labour, income, consumption patterns, capital investment and many other factors);

Climate change and related conditions (shifts in precipitation, temperature and water discharge or sea level rise bring various risks or opportunities);

Technology (it has significant effects on land use and other aspects, for example mobility and communication; as such it is hard to include in models; dissemination of new technology can be assumed more easily);

(Geo-) political change (they imply change in international politics and policy making; the increasing role of international governance, international treaties; on continental level the formation and expansion of the EU);

Consumer patterns (they are sometimes hard to define, but they are influential: e.g. consumption patterns =diet changes, an increased awareness of ecological or social problems or concerns on animal welfare) and

Policy measures (as most relevant for the policy context are considered the World Trade negotiations, the Common Agricultural Policy and its two pillars, policies and measures regarding the environment, e.g. on the Kyoto agreements on the reduction of greenhouse gases, directive on nutrients or pollutants, Nature conservation, e.g. Natura 2000, Habitat and Bird Directives, Water management alias Water Framework directive and European Spatial Planning).

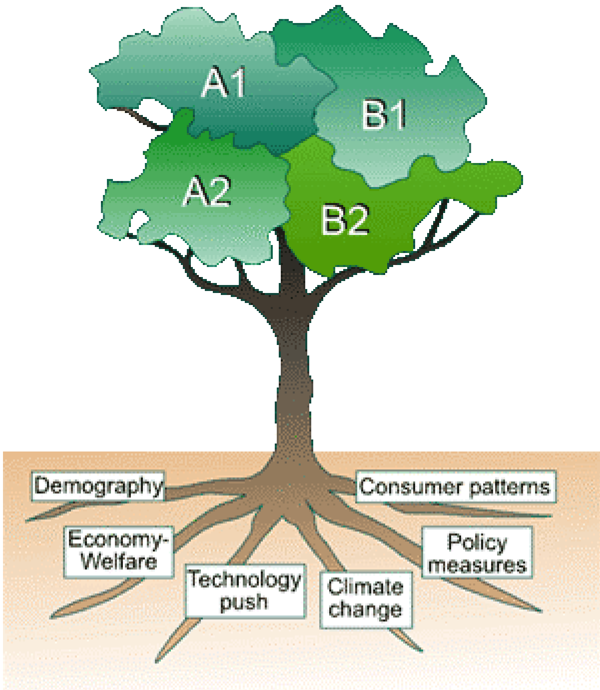


Figure No 4: Mutual position of major drivers, land use and values or functions in the European rural areas and scenarios (from Eururalis 1.0, 2004)

Figure No 4 shows the major drivers, land use and values or functions in the European rural areas, going from the outward rim to the inner circle of the diagram.

Table No 3: A total of four EURURALIS scenarios

Scenario	Description of development policy
A1 Global economy	- Emphasis on market-oriented solutions (low taxes; free trade; an optimum balance between demand and supply of goods, services and environmental quality) - Market support phased out - Government intervention is limited as possible - Farm payments decoupled and phased out - Rural development support reduced - Less favoured areas concept abolished - Protected sites maintained
A2 Continental market	- Emphasis on self-sufficiency (protection from other markets; regionally oriented; higher taxes than A1) - Market support slightly reduced - Government intervention is limited to core responsibilities with a strong focus on defence and security - Farm payments partially decoupled - Rural development support maintained - Less favoured areas concept maintained - Protected sites maintained
B1 Global co-operation	- Emphasis on fair distribution of wealth, social justice and environmental stewardship (high international standards; removal of trade barriers; high taxes in between A2 and B2) - Market support strongly reduced - Relatively strong government's intervention - Farm payments decoupled and reduced - Rural development support more targeted to environment - Less favoured areas concept merged with Natura 2000 - Protected sites extended
B2 Regional communities	- Emphasis on self-reliance, local dynamics, ecological stewardship and equity (regional markets; highest tax) - Market support targeted at self sufficiency and employment - Government intervention is necessary - Farm payments partially decoupled and reduced - Rural development support increased and more target to environment - Less favoured areas concept maintained - Protected sites extended

2.3 Models

In this chapter I will focus on the modelling approach that has been receiving attention by landscape ecologists and researchers in recent years. "Mainly because it offers a way of incorporating the influence of human decision-making on land use in a mechanistic, formal, and spatially explicit way, taking into account social interaction, adaptation, and decision-making at different levels" (Matthews et al, 2007). I will describe a few global and especially spatially explicit models, which are differentiated one from another in goals, scales and questions which they try to answer. In the next paragraphs I will go through the chain of models GTAP/LEITAP – IMAGE – CLUE/CLUE-s, which were used for quantification of EURURALIS scenario study. Then I will continue with the description of GEOMOD model, which was chosen because of its orientation on an estimation of carbon exchange which is widely discussed topic among both public and scientists. This chapter will be finished by introduction of exemplary tool for integration bio-physical and economic modelling of agricultural system -Tradeoff Analysis Model (TAM).

The chain of models GTAP – IMAGE – CLUE or TAM can serve as a good example of integrated approach that provide insight into complex nature of landscape systems and that deal with issues of transiting agricultural and rural policies of European Union, technological development or with changes in environmental conditions.

2.3.1 GTAP

(The Global Trade Analyses Project)

GTAP (Global Trade Analyses Project) was initiated by Hertel (1997) with the goal of supporting high-level quantitative analysis of international trade, resource, and environmental issues in an economy wide context (Eururalis 1.0, 2004). This approach can be described as a comparative static multi-regional general equilibrium model maintaining a huge database, which is usually characterized by an input-output structure and international trade flows of primary goods, their processing, and final consuming. "The GTAP database contains detailed bilateral trade, transport and protection data characterizing economic linkage among regions, linked together with individual country input-output database which account for intersectoral linkages" (Eururalis 1.0, 2004).

In the past GTAP was used for investigation of the effects of tariff liberalization on the global forest sector (Liu et al, 2005), for estimation of the impact of global merchandise trade distortions and services regulations on agricultural value added in various countries (Anderson and Valenzuela, 2007), for analyzing the impacts of multilateral market access liberalization of the Doha Round agricultural negotiations (Brockmeier and Pelikan, 2008), for measuring restrictiveness of bilateral trade policies in developed opposite to developing countries (Antimiani et al, 2008). Various GTAP users developed adaptation of the standard model. Special attention was attracted by the extended version addressing environmental and energy problems (GTAP-E), which served for modelling the impacts of international climate change policies (Nijkamp et al, 2005). For the purpose of the EURURALIS study, there was constructed “a special purpose version of the GTAP database model, designed to make it more appropriate for the analyses of the agricultural sector” (Eururalis 1.0, 2004). This new version was called LEITAP model.

Within the LEITAP model EURURALIS team (2004) extended the land allocation structure by taking into account that the degree of substitutability of types of land can be varied between types. For this purpose information from the OECDs Policy Evaluation Model (PEM) was used to improve the production structure. The relation between land supply and rental rate proposed by Abler (2003; in Eururalis 1.0, 2004) is specified through the supply curve. For capturing of a wage differentials between agriculture and non-agriculture, Eururalis team (2004) incorporated segmented factor that transforms agricultural labour and capital into non-agricultural labour and capital by segmentation these market factors with a finite elasticity of transformation. In the LEITAP model, agricultural production quotas are implemented as complementary problem. For Eururalis (2004) the social accounting data have been aggregated to 13 sectors, which are engaged in Common agricultural policy (CAP) and 37 regions.

2.3.2 IMAGE

(The Integrated Model to Assess the Global Environment)

The first version of the IMAGE (formerly known as the Integrated Model to Assess the Green house Effect; Rotmans, 1990) was set up primarily as a tool for long term greenhouse policy analysis and demonstration sessions. Focused more deeply, it was a global simulation model created especially for “the calculation of historical and future emission of greenhouse gases on global temperature and sea level rise and ecological and socio-economic interests in specific regions” (Rotmans, 1990). This deterministic computer simulation model consisted of interlinked modules; each of them worked with a specific element of climate change (the source module, the emission module, the concentration module, the climate module, the sea level rise module and the socio-economic impact module for the Netherlands) and enabled describing of global trends in driving forces and the consequences for climate change and impacts on key sectors (Eickhout et al, 2008). Within the model, ‘there are still changing land cover and other factors used to compute the flux of carbon dioxide and other greenhouses gases to the atmosphere” (Bouwman et al, 2006).

The current version of the IMAGE (The Integrated Model to Assess the Global Environment) has evolved through series of new versions and revisions. With regard to effects of climate change, possible feedbacks, and estimation of emission resulting from energy, a regional set of modules was implemented to drive grid-based impact calculation as part of the ESCAPE framework (European Comission, 1992). IMAGE then consisted of three clusters of modules (the Energy-Industry System, the Terrestrial Environment System and the Atmosphere-

Ocean System). Further refinements were implemented with the aim to enhance the model´s performance and broaden its applicability by improved computation of future regional energy use and by the recommended two-track strategy for the climate model (Eickhout et al, 2006). The current version IMAGE 2.4 distinguishes a few components. First of them are driving forces (demography, world economy, agricultural economy and trade and energy supply and demand), which interact through land use and emission with the Earth system. Subsequently, there are addressed land cover and land use, contemporaneous and historical land cover, the carbon cycle and nutrients, followed by climate and climate variability, including its interaction with land cover (Bouwman et al, 2006).

The IMAGE model was applied to a variety of global studies. The mentioned model was used by IMAGE-team (2001) to contribute to the work on the Special Report on Emission Scenarios of the Intergovernmental Panel on Climate Change (Nakicenovic et al, 2000), to predict ecosystem services up to 2050 (Carpenter et al, 2005), to explore alternative climate change abatement goals in support Greenhouse Gas Reduction Policy (European Comission, 2005) and last but not least to develop future prospects for agriculture and rural areas in the EU-25 countries (Eickhout et al, 2006).

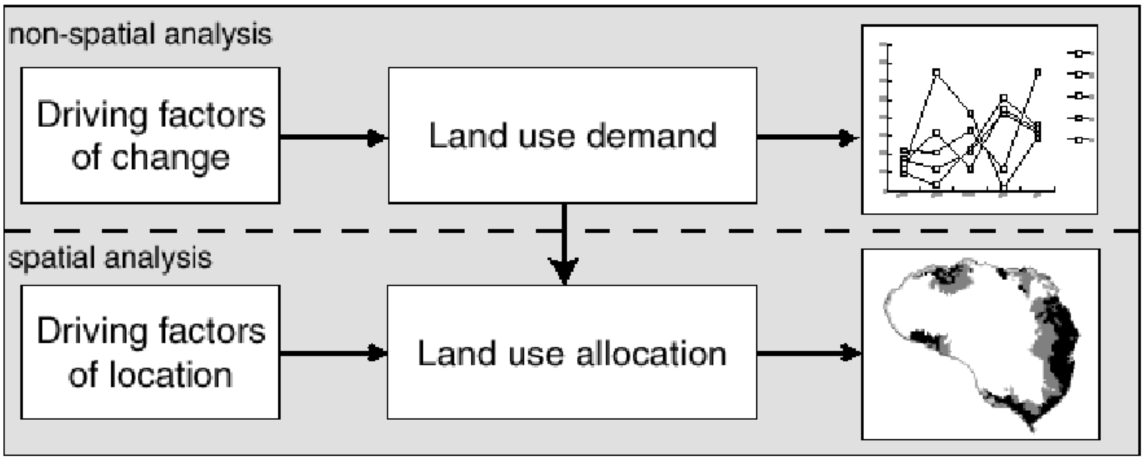
2.3.3 CLUE

(The Conversion of Land Use and its Effects modelling framework)

"CLUE (The Conversion of Land Use and its Effects modelling framework, Veldkamp and Fresco, 1996) was developed to simulate land use change with relation to socio-economic and biophysical factors. "Besides tracking past or historical land use changes, the objective is to explore possible land use changes in the near future under different development scenarios" (The CLUE Group, 2006). CLUE model can be described as multiscale stepwise regression model which relates changes in the area of the different land use types to socio-economic and biophysical factors. For this purpose the model uses empirically quantified relations between land use and its driving factors in combination with dynamic modelling of competition between land use types (Verbung et al., 1999b). The main concepts implemented within CLUE framework are (The CLUE Group, 2006): connectivity (locations that are spatially distant influence each other as a consequence of direct process, neighbourhood effects or feedback over higher scale levels), hierarchical organization (higher level processes can steer and constrain lower level processes while, at the same time, higher level features might emerge from lower level dynamics), stability and resilience (land use systems are able to absorb disturbances before the structure of the system is changed), and driving factors (a large set of socio-economic and biophysical factors can be seen as the drivers of land use change, steering the rate and/or location of change).

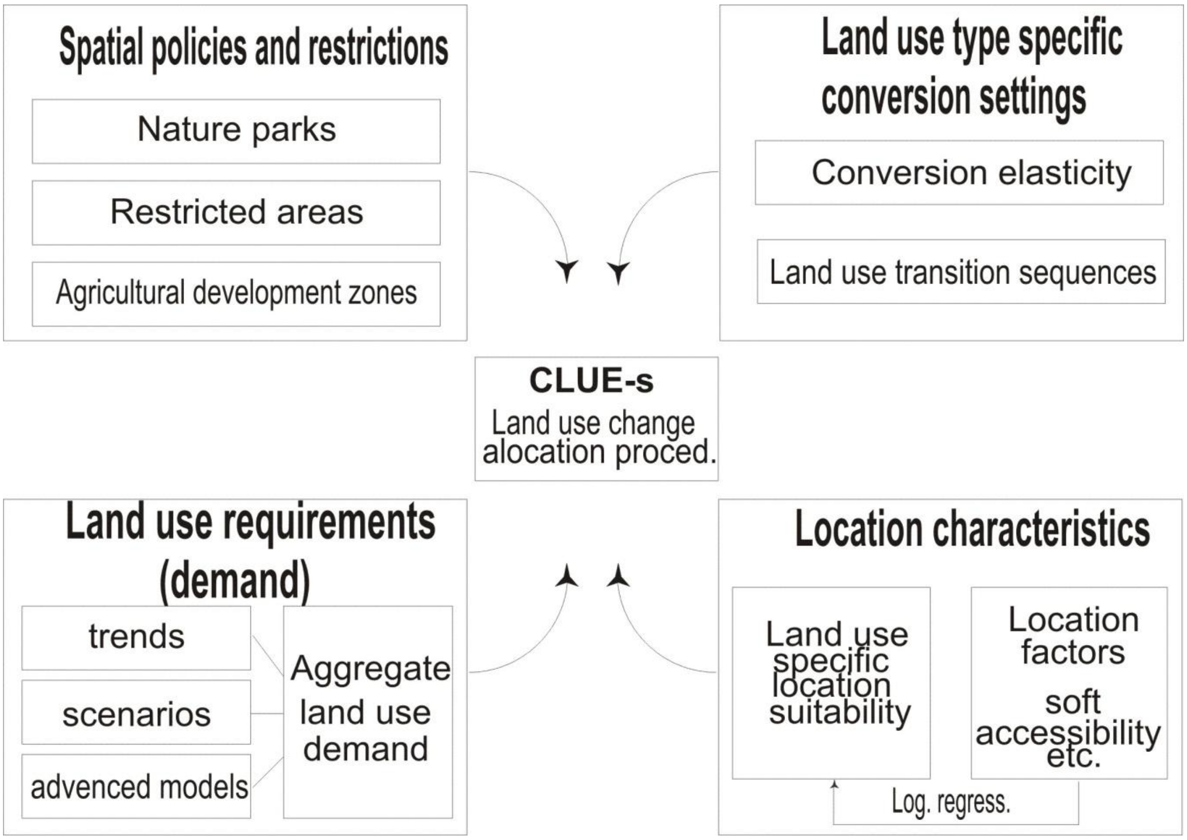
The CLUE model is divided into two distinct modules – the non-spatial demand module and the spatially explicit allocation module (see the Figure No 5). "In the non-spatial module, changes in area for the different land use types are calculated and based on sectoral models or trend extrapolation and results in a specifications of the area covered by the different land use types" (EURURALIS 1.0, 2004). The area change for all land use types is calculated at the aggregate level. In the spatial module, the land use demands are allocated to locations in the study area.

Figure No 5: Role of spatial and non-spatial module within CLUE model (Verbung et al., 2007)



Besides the demand, information on spatial policies and restrictions, land use type specific conversion settings and location characteristics are needed to run the model (The CLUE Group, 2006). For more information and deeper insight into modelling procedure see Figure No 6.

Figure No 6: An overview of the entrance data needed to run the CLUE-s model (from Verbung et al., 2007).



The CLUE project is organized in the form of different case studies available for Costa Rica (Schoorl et al, 1997), Philippines (Overmars, 2007), Ecuador (Koning et al, 1999), Central America (Kok and Winograd, 2002), China (Verburg and Veldkamp, 2001), Java (Verburg et al, 1999a), or Vietnam (Castella and Verburg, 2007). Within EURURALIS project CLUE allocates the national level land use changes to different locations within the EU-25 countries.

CLUE model cannot be directly implemented because of the differences in data representation applied at the regional scale. Modified modelling approach for regional application is called CLUE-s (see Table No 4).

Table No 4: Differences between scales and data representations within CLUE and regional variation of model (CLUE-S).

Scale of application Data source	Data representation	Land use simulation model selection
- national to continental extent - coarse resolution data (more than 1x1km) - land use data derived from census or survey	sub-pixel information on land use (percentage of land use in grid cell)	CLUE Verbung et al., 1999a Veldkamp and Fresco, 1996
- local to regional extent - fine resolution data (less than 1x1km) - land use data derived from maps or remote sensing images	dominant land use (dominant land use in grid cell)	CLUE-s Verbung et al., 2002

2.3.4 GEOMOD

Hall et al (1995) developed two spatially explicit models for calculating total amounts and spatial distribution of the carbon content and carbon dioxide exchange resulting from land use change, especially deforestation, in the tropic zone. Their overall plan was to capture the essence of how people develop land over space and time in a computer model. Team of creators indicate the goal of their work to “refine the estimates of carbon exchange due to land use change for the entire tropics and to provide a spatially and temporally explicit estimate of this change for use in the general circulation model of the oceans and atmosphere...”. Authors used two basic approaches for simulation of rates and patterns of tropical land use change: hypothesis deduction (GEOMOD1) and the statistical deduction (GEOMOD2). Hall et al (1995) based the hypothesis deduction for selecting pattern drivers on user-supplied assumption about how people actually use land and opposite to this the statistical deduction on analysing historical patterns of land use change. These changes are compared with user-supplied map layers of physical and cultural attributes. The model develops land from initial pattern as a function of a various affecting factors which is basis for key simulation of how these factors affect the pattern of land use change. GEOMOD2 can select locations for land-use change according to any of the three decision rules based on (1) nearest neighbours, (2) stratification by political sub-region, and/or (3) the pattern of biogeophysical attributes (Pontius et al, 2001).

The entrance data consist of grid cells from which is indicated their relative sustainability for a given land use change, series of algorithms that represent the adjacency, dispersion and regional heterogeneity. For each land use type, the model calculates a coefficient of relative suitability. This is represented spatially in an additional map. The simulation of land conversion is directed by 1 year long steps.

Authors estimated global and regional development as the main options. “Global development means that the entire area simulated is searched for the most appropriate land available without regard for contiguity, in the regional simulation mode, the area is searching for favourable land” (Hall et al, 1995).“The model then chooses drivers based on the best fit of the patterns” (Hall et al, 1995).

Modelling the spatial pattern of land use change trough GEOMOD was used in many studies in both tropical and boreal zone examining forest fragmentation and disturbance (Tchir et al, 2004; Pontius et al, 2001; Pontius et al, 2004; Echeverria et al, 2008; Brown et al, 2007; Claessens et al, 2006).These studies used GEOMOD to describe which parts of a forest landscape are selectively cleared for agriculture (Tchir et al, 2004), to simulates the progressive loss of closed-canopy forest (Pontius and Schneider, 2001), to explain the spatial patterns of forest loss and fragmentation (Echeverria et al, 2008), to make baseline projections of tropical deforestation at the regional scale (Brown et al, 2007) or to indicate affects of historical changes in land use on the water budget (Claessens et al, 2006).

2.3.5 TAM

(The Tradeoff Analysis Model)

Stoorvogel et al (2004) proposed a methodology for an integrated analysis of tradeoffs between economic and environmental indicators. “The methodology is based on spatially-explicit econometric simulation models linked to spatially-referenced bio-physical simulation models to simulate land use and input use decision” (Stoorvogel et al, 2004). Outputs of this approach are tradeoff curves, which “show the opportunity cost of what must be given up in one dimension to obtain more in another dimension, for example, what we give up in terms of environmental quality in order increase agricultural production or income” (Stoorvogel and Antle, 2001).Within mentioned tradeoff studies, researchers attempt both to value environmental effects through the quantification of trade-offs among different sustainability indicators and present this information to decision makers and simultaneously let the decision makers impose their own value judgements (Stoorvogel and Antle, 2001).

Tradeoff Analysis framework starts by identifying a social concern by stakeholders (the general public, policy makers) and scientists. They try to formulate the relationships between sustainability indicators. These interested persons also identify scenarios that may shift the tradeoff curves. As the next step Stoorvogel et al (2004) indicates utilization of suitable quantitative tools to simulate how these sustainability indicators behave under the scenarios. Results are presented first of all through the tradeoff curves between different indicators what allows an analysis of the current state, distinguish of the effects of different scenarios on the position and slope of tradeoff curve. Stoorvogel and Antle (2001) inform that this approach requires GIS data on the spatial characteristics of land units and survey data that describe the land allocation and land management decision of the population of farmers.

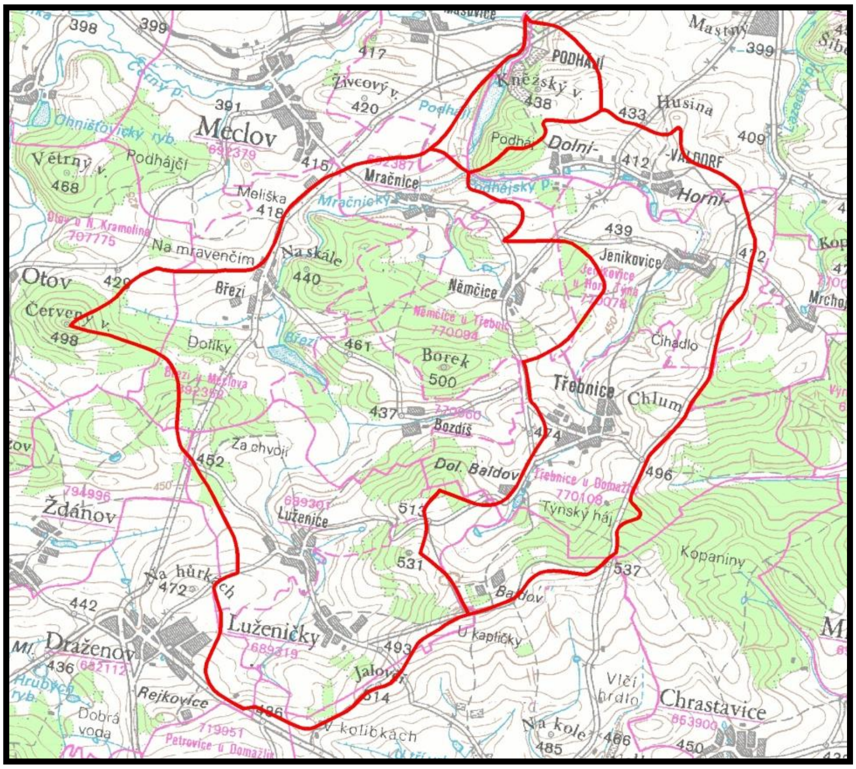
The Tradeoff Analysis Model was firstly applied for the potato-pasture zone in Carchi, Ecuador (Crissman et al, 1998). The main purpose was to predict agricultural land use through the simulation model. In 2003, results of a 60-year simulation based on data from Beltsville Agriculture Research Centre, Maryland were published (Lu et al, 2003), to analyze tradeoffs between profitability and environmental stewardship.

3 CHARACTERIZATION OF CASE STUDY

3.1 Introduction of the case study area

Main goals of submitted thesis were indicated in the Introduction. The using of integrated and complex approach for scenarios application is possible especially within cadastral or naturally defined areas. For these purposes there was chosen catchment area of Mracnicky and Podhajsky brook in western Bohemia, the Czech Republic (for location indication see Figure No 7). The mentioned territory is located along Sudeten boundary region called Cesky les. Investigated watershed belongs to Upper Vltava drainage basin. Case study area is restricted by 7 thousand-inhabitant Horsovsky Tyn in the north and originally district town Domazlice in the south. Nearby the north-western boundary you can find main road that connects Pilsen and German frontier border. The overall area covers about 30 square kilometres.

Figure No 7: Indication of Mracnicky and Podhajsky catchment area on the map



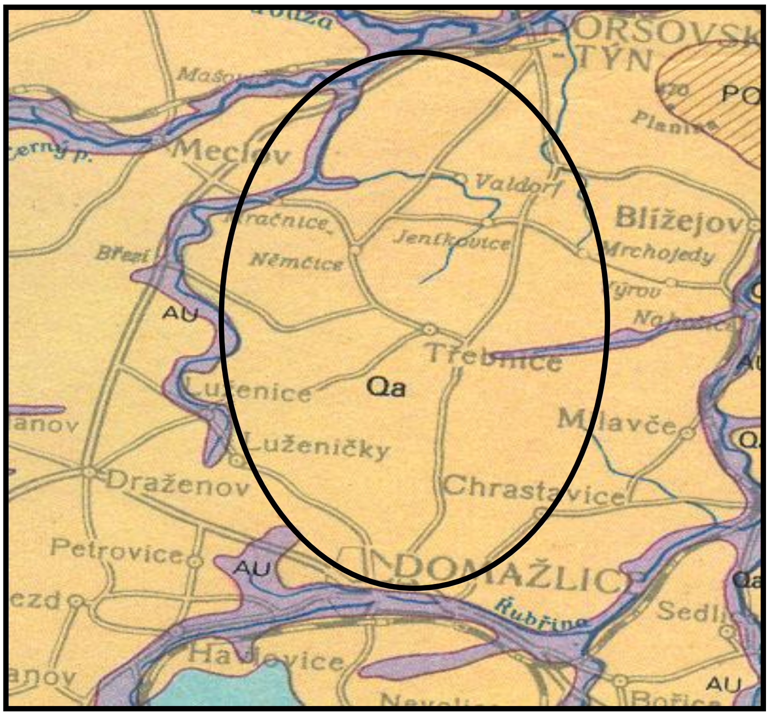
As fundamental descriptors of the case region are distinguished prevailing geometry-shaped arable fields which create landscape matrix. Therefore both of brooks run through agricultural land of arable fields. They are not at all preserved against runoff from arable land and suffer from absence of sewage drains and sewerage plant (see result of chemical analysis in Appendix). Huge drainage led to overall devastation of brook pattern. Most of length is straightened, banks are reinforced and brooks partly piped. The basic characteristic of catchment area is low retention ability.

Within the landscape matrix, there are located enclaves of villages and islands of forest that are completed by linear features of roads. In the upper part of the area huge arable fields with few of dispersed trees completely dominate. Land cover type of forest is represented by fragments or edges, mainly bound to river plain. Meadows and grasslands are rare and often unnatural or ruder, eventually bound to river plain and wet soils. Small orchards can be found on the edges of villages. The middle and the bottom part differs from each other little bit. Arable land is concentrated into smaller units. Land cover type of forest and meadow/grassland is more frequent. This part deals with coniferous cultural forests, mainly with spruce or pine. Minor is larch, beech and at the edges is characteristic birch. Most of grasslands were drained in the past. From the nature conservation point of view, one-hectare-large natural monument Cerveny vrch and memory tree Luzenicka lipa (Tilia cordata) are important. The area of Cerveny vrch was used for spar mining. Thanks to mining management visitors can find relics of surface and underground winning (Zahradnicky et al, 2004). Most of the area is covered by pine (Pinus sylvestris) and extensive undergrowth of bramble-bush (Rubus fruticosus).

Based on Quitt (1971), the study area assigns “Softly Hot Region 9” and “Softly hot region 10”. They are characterized by average temperature 6.5 °C, average winter precipitation 425 mm and average precipitation during vegetation period 110 mm.

Biogeographically, the watershed is situated within Hercynian subprovince, the bioregion of Tachov (Culek, 1995 and 2005). Acidophil oak lands are the major (see Figure No 8). Although both acid substrates and huge distance from centre of warm biota get poor biota, the area belongs to fourth (oak) vegetation degree. Two specific biogeographical units lead through the region (Culek, 2005) – **3RE**: Table land on the loess of third vegetation degree, **4PS**: Upland on the acid metamorphisms of the fourth vegetation degree.

Figure No. 8: Potential natural vegetation in the case study area (black oval)



Legend:

AU: Alno-Padion (Alnetea glutinosae, Salicetea purpureae)

Q_a: Quercion robori-petraeae

3.2 Historical and agricultural development of the case study region

Jilek (2005) argues, that the oldest grain of local settlement springs from ancient Stone Age, first farmers came bit later – at the end of (Younger) Stone Age. At that time human settlement was rare, located at most fertile soils. Permanent inhabitation of the region was established during Bronze Age (Jilek, 2005). Important culture of primeval ages was barrow culture of Middle Bronze Age and Culture of Milavce (1500-900 B.C.). On the contrary at the time of the Roman and Moving of Nations era, the western part of Bohemia was not densely populated. Our Slavonic ancestors, who settled foreland of Bohemian Forest, came to almost depopulated region.

At the beginning of 13th century, there were established first towns (Domazlice and Horsovsky Tyn). In the 14th century, most of current villages due to colonization of Bohemian Forest were formatted. At that time the rise of agricultural development is dated.

Huge cultural changes took place in the post-Battle of Bila Hora period due to confiscations of estate by German aristocracy. The area of Bohemian Forest (excepting Chodsko) was getting German. After finishing of Thirty-year-old warfare only one third of inhabitants stayed there.

The development of the mentioned boundary area was tragically disturbed in the first half of 20th century. Germans of Heinlan´s movement refuses establishing of independent Czechoslovakia. After subscribing of Munchen Agreement the area of Bohemian Forest (excepting Chodsko) fell to Germany. After Second World War, almost everything what people created was destroyed. Due to transfer of Germans and settlement of new inhabitants from Czech inland, relationship to land was severed and trade interrelations were destroyed.

After 1948, period of land and technical adjustments started (year-books suggest that one third of fallow land was ploughed up and one third changed about pasture), expropriation, collectivization and nationalization. At that time, start of socialistic alteration of village is dated. When in 1955 amelioration- brigade-work passed in the region, most of arable fields and meadows were drained. Nationalization of land was finished in 1959. At that time, seven farmers´ associations (in Czech called JZD) was managing 90% of arable fields and 90% of forest, which were later on joined together. Between 1969 and 1989 the second turn of large-area drainage was implemented.

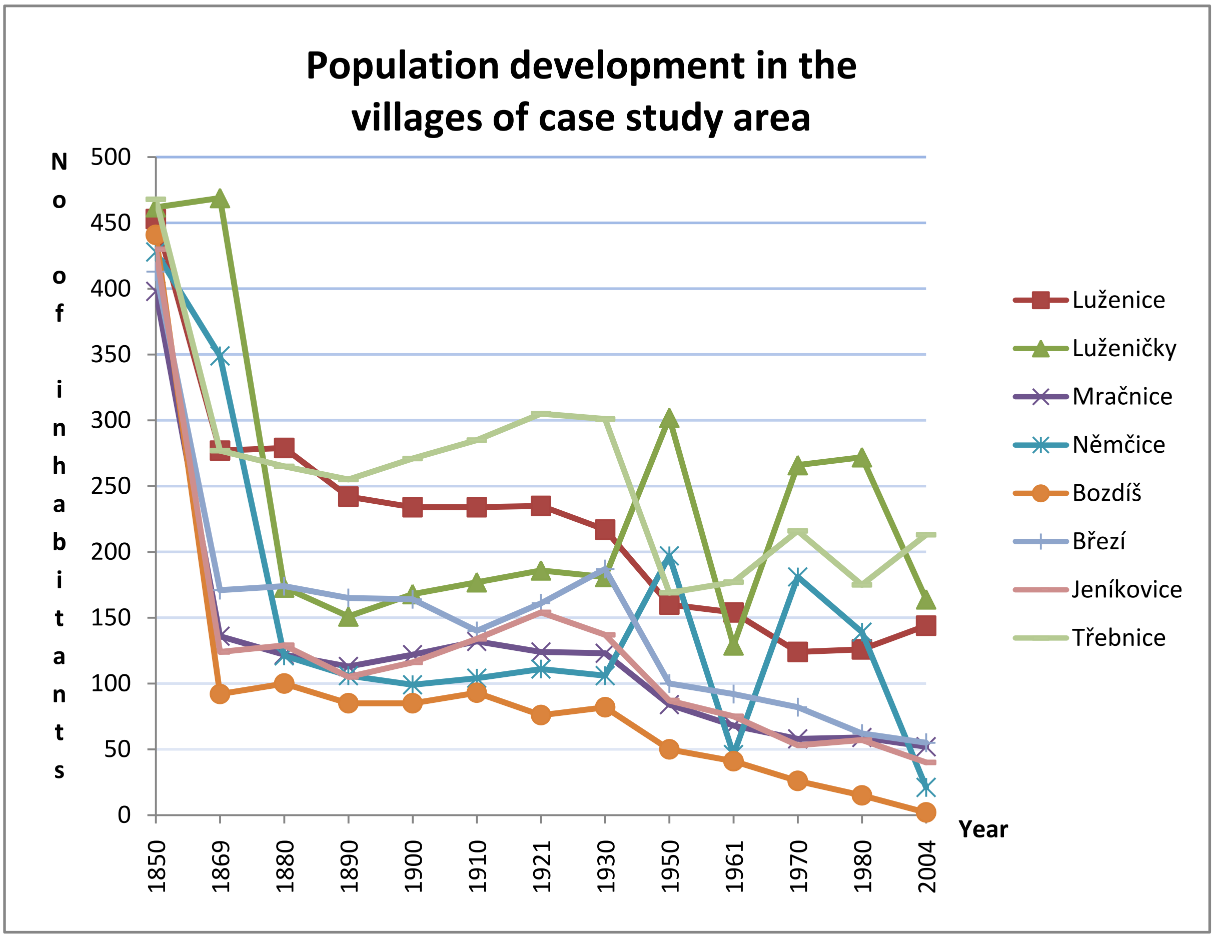
All of boundary areas much like the case study region went through fundamental changes after 1989. "Land of nobody" was changed due to cancelling of bars of entrance and implementation of privatization and restitution laws (1992). Area of Bohemian Forest was added to the class of less favourable areas (LFA). Agricultural company in Meclov, which is managing most of agricultural land within the case study area, draw the agri-environmental subsidies (per hectare of arable land and grassland within less favourable area and intercrops) from European Union. Agricultural management follows rotation of trifolium-wheat-barley-rape-wheat-maize-wheat-bean and charges the land by average 130 tons of fertilizers (N, P, K) per hectares and year.

3.3 Socio-economy

Villages of the case study area are described by residentially productive function. Major feature within urban structure is village called Trebnice (established in 1369), other seats are essentially smaller. Overall pattern of municipalities creates regular net of anthropogenic centres of cadastral areas in the average altitude of 450 meters. Most of villages were established in 14th century. The northern part of the area is crossed by important international road Pilsen-Furt im Wald and two main roads connecting Domazlice (in the south) and Horsovsky Tyn (in the north).

The case study region is no more inhabited like before year 1850 (See Figure No 9). Decrease of inhabitants during Second World War and post-war years is evident. Exceptions to the rule are Luzenicky and Trebnice, which were used by both Sudeten Germans and new post-war-settlers of Sudeten. Novakova (1991) estimates that 50-80% of economic active inhabitants commute to the cities with the view of work. Agriculture, few light industry concentrated in Domazlice present few of work opportunities. Education of settlers is worst than average of the western margin of Bohemia (Dudak, 2005). Application of religion is low (30%), majority of religious people is concentrated within Roman Catholic Church.

Figure No 9: Population development in present villages



4 METHODOLOGY

4.1 Data collection and exploring

4.1.1 Input datasets

The modelling of spatially explicit changes in land use pattern requires a large spatially explicit database of biophysical and socio-economic factors for at least 1 year. List of data in use, its source and reclassification clue are summarized in the Appendix. CLUE framework (2004) argues that “to allow model calibration and validation, it is necessary to have data of other 2 years, preferably about 10 years apart". For this purpose, aerial photos from 1973 (VGHUR, Dobruska[1]) and current orthographically rectificated pictures (CUZK, Prague[2]) were used.

4.1.2 Landscape mapping

For detailed mapping of current land use within the case study area and overall estimating of landscape elements I used instituted methodological approach of Vondruskova et al (1994). This system introduced transparent instruction for particular land use types classification by assignment homogenous landscape segments to one of described (sub-) categories. The field survey was processed during June - August 2005 and set in my bachelor thesis “Analysis of Landscape Development and Spatial Structure within Catchment Area of Mracnicky and Podhajsky Brook” (Strakova, 2006). Every of the landscape segments was mapped; joined to identifier; coded in term of methodological guide; evaluated by ratio of ecological stability (0-5) and rate of irrigation (1-5) and at the end signed by nature conservation status (important landscape element, bio-centre, bio-corridor, nature monument). For the retrenched version of mapping clue and subtle scales of ecological stability and irrigation see Appendix.

The field survey was followed by digitizing mapped segments on the background of orthographically rectificated aerial photographs (CUZK, Prague2). These photographs deal with spatial resolution of 0.5 meter and radiometric resolution of 8 bits. Digitalization process can be basically described like manual vectorization or converting features on the paper map into digital format of GIS layer/shape file (Tucek, 1998). Landscape segments are recorded and stored as vector (polygon) data thanks to digitizing tool of ArcGIS (ESRI®), which works with Cartesian x, y coordinate system. A shapefile is adjusted in coordinate system “S-JTSK East-North”. S-JTSK deals with mandatory coordinate system of the Czech Republic, which is characterized by parameters of Bessel´s ellipsoid.

In order to use field data in consequential analysis field tabular data was translated into database structure using Microsoft Office Excel 2007 (Microsoft®). Database tables were joined to polygons (landscape segments) with the help of numeral identifiers (id) and tools of software ArcGIS 9.2 (ESRI®).

4.1.3 Questionnaire

In winter 2007, three hundreds of local adult inhabitants were interviewing. Main purpose of questioning was to explore public opinion in term of local landscape perception and expectation. Fulfilled questionnaires should indicate to which of scenario local inhabitants tend. For exact terms of questions see Appendix. For consequent analysis it is necessary to come up with 250 of fulfilled answer sheets.

4.2 Land cover/use analysis

4.2.1 Exploring of spatial change in time by comparing aerial photographs

For analysis of historical land use, I used first set of aerial photos that covered the whole area of studying catchment. First suitable set came from 1973 and disposes with spatial resolution of 1 meter and radiometric resolution of 8 bits (VGHUR, Dobruska[1]). Mentioned photographs had to be rectificated (georeferenced) and projected by coordinate system in order to use this data in GIS analysis (Tucek, 1998). The Czech mandatory coordinate system "S-JTSK East-North" was used for this purpose. Kempen et al (2006) describe start of overall procedure by image registration that refers to the process of the identification of corresponding points in an input image (historical aerial photographs) and a reference dataset in a known map projection (orthographically rectificated aerial photographs in S-JTSK coordinate system, source: CUZK, Prague[2]). Retrieved control points were used in the second step to determinate coefficients of geometric transformation, which was followed by resampling of output cells (Kempen et al, 2006).

Landscape elements were digitized on the basis of pre-processed aerial photographs. These features were classified into 7 visually cognizable classes of land cover (build-up area, arable land, grassland, orchard, forest, water body and fallow). For comparison purposes, shapefiles describing current land use were reclassified into same 7 classes of land cover.

Land use changes in time were estimated by calculating and comparing the overall area of land use type in 1973 and 2005 and by identifying and measuring area of land cover/use change. This analysis was elaborated within my bachelor thesis "Analysis of Landscape Development and Spatial Structure within Catchment Area of Mracnicky and Podhajsky Brook" (Strakova, 2006).

4.2.2 Identification of potential explanatory factors of land use allocation and change

Methodological approach of landscape mapping (Vondruskova, 1994) for analysing landscape structure and potentials followed by evaluation of land use change in time served as the main source of quantitative data for consequential analysis. A relation of land use change to historical development and interpretation of land cover/use allocation by roundup was engaged as the base concept for explanatory factors identification.

4.3 Data processing for scenario adjusting

4.3.1 Exploring of explanatory factors trends

Actual information about the case study area was fulfilled by exploring of trends of potential explanatory factors. This assessment helps to explore a control scenario (scenario of current development continuation).

4.3.2 Processing of files for scenario application

The modelling of spatially explicit changes in land use pattern requires a large spatially explicit database of biophysical and socio-economic factors. This database was created thanks to three main data sources – landscape mapping database, data ZABAGED® (CUZK, Prague[2]) and digital layer of soil-ecological units BPEJ (VUMOP, Prague[3]). "ZABAGED® is a digital geographic model of the Czech Republic, which contains 106 types of vector objects with descriptive and qualitative attributes" (CUZK, Prague). Thanks to ZABAGED®, there are available information about residential areas, roads, rivers and brooks, nature conservation area and relief. Digital BPEJ layer contains vector features bounding agricultural land and five-digit code expressing climate conditions, ecological properties of soil, slope and exposition of plot. It also contains scaffold and deepness of soil profile (Notice of Czech Ministry of Agriculture No 327/98 Digest).

All of entrance datasets went through complicated process of interpolation and reclassification that is indicated through data action models and visualised by flowchart in the Figures No 10, 11 and 12 and classification scale of last step before output detailed described in the Appendix. In the figures, file name ***sc1gr**** predicates about driving factor files and ***cov_all.0*** about initial land use. All of mentioned files were aggregated to 1460x1404 grids covering the case study area. The initial land use file (***cov_all.0***) contains the grid values indicating the dominant land use type for each grid cell at the start of simulation. Driving factors files (***sc1gr****) contains the grid values of the explanatory factors. For areas outside the simulation the code -9999 was used. One cell extended 5x5 meters, fills the area of 0.0025 hectares. All the grids are finally converted into ASCII files that communicate with CLUE software interface.

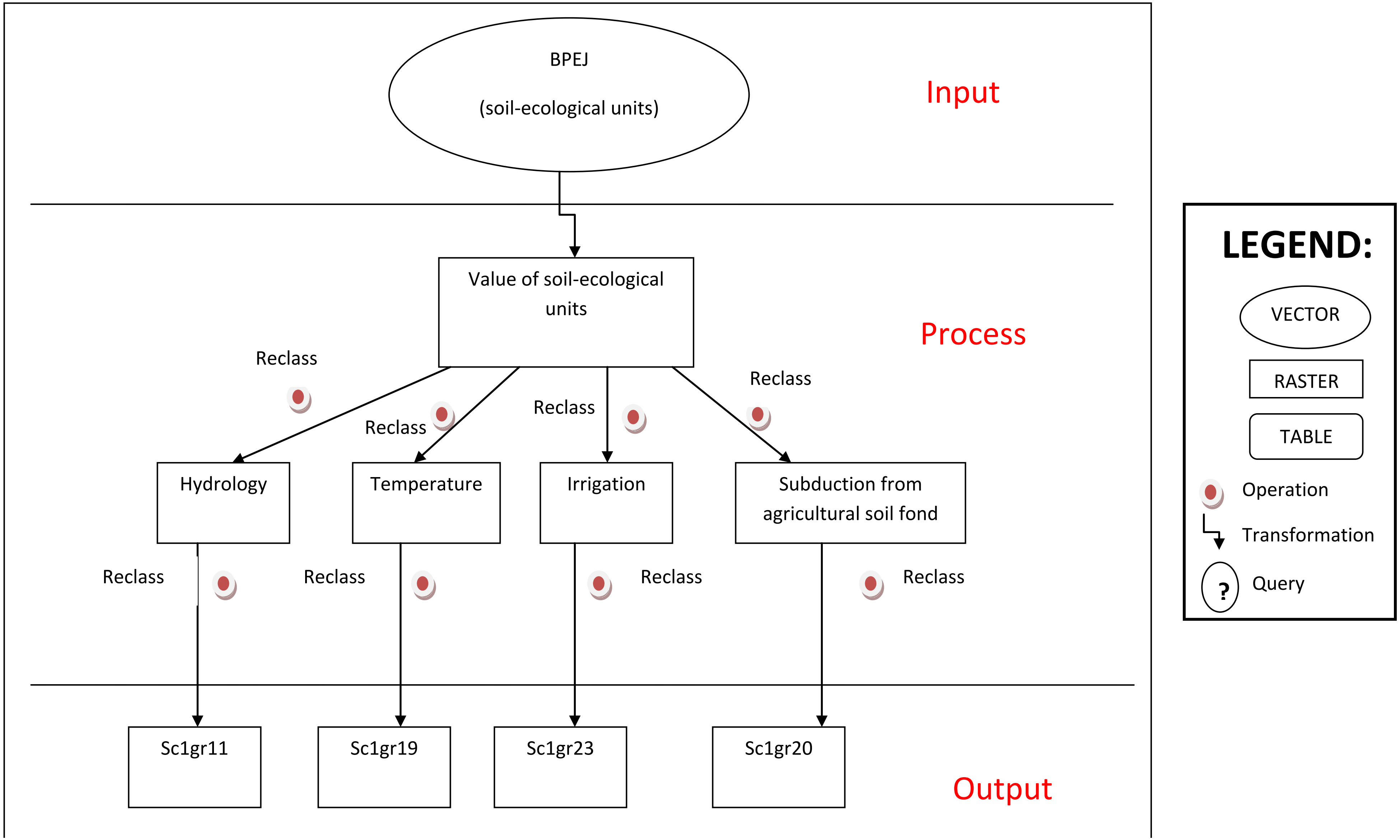


Figure No 10: Flowchart describing soil-ecological data (BPEJ) handling to produce connected explanatory factor grids of same spatial extent

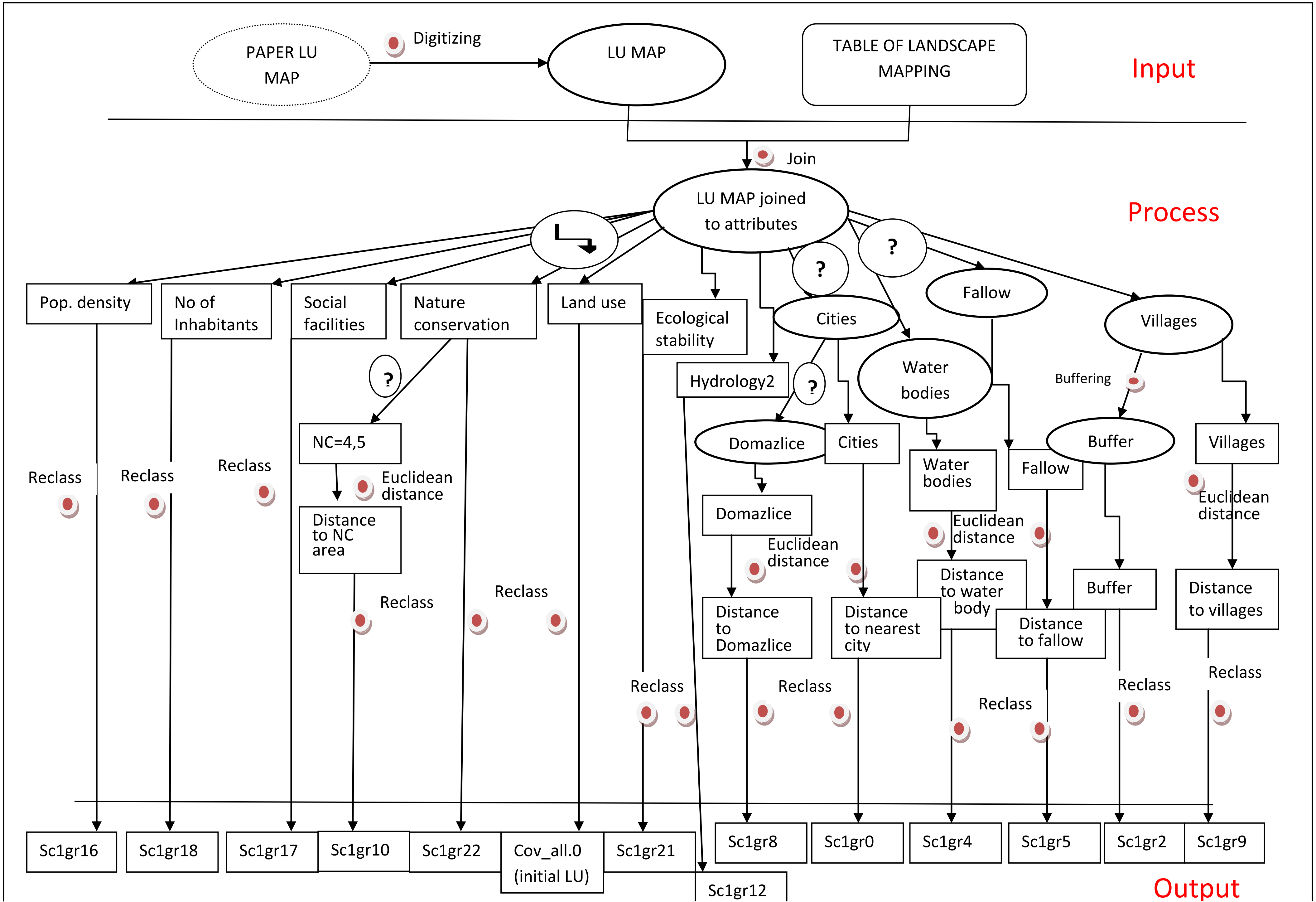


Figure No 11: Flowchart describing process of landscape mapping data handling to produce connected explanatory factor and initial land use grids of same spatial extent

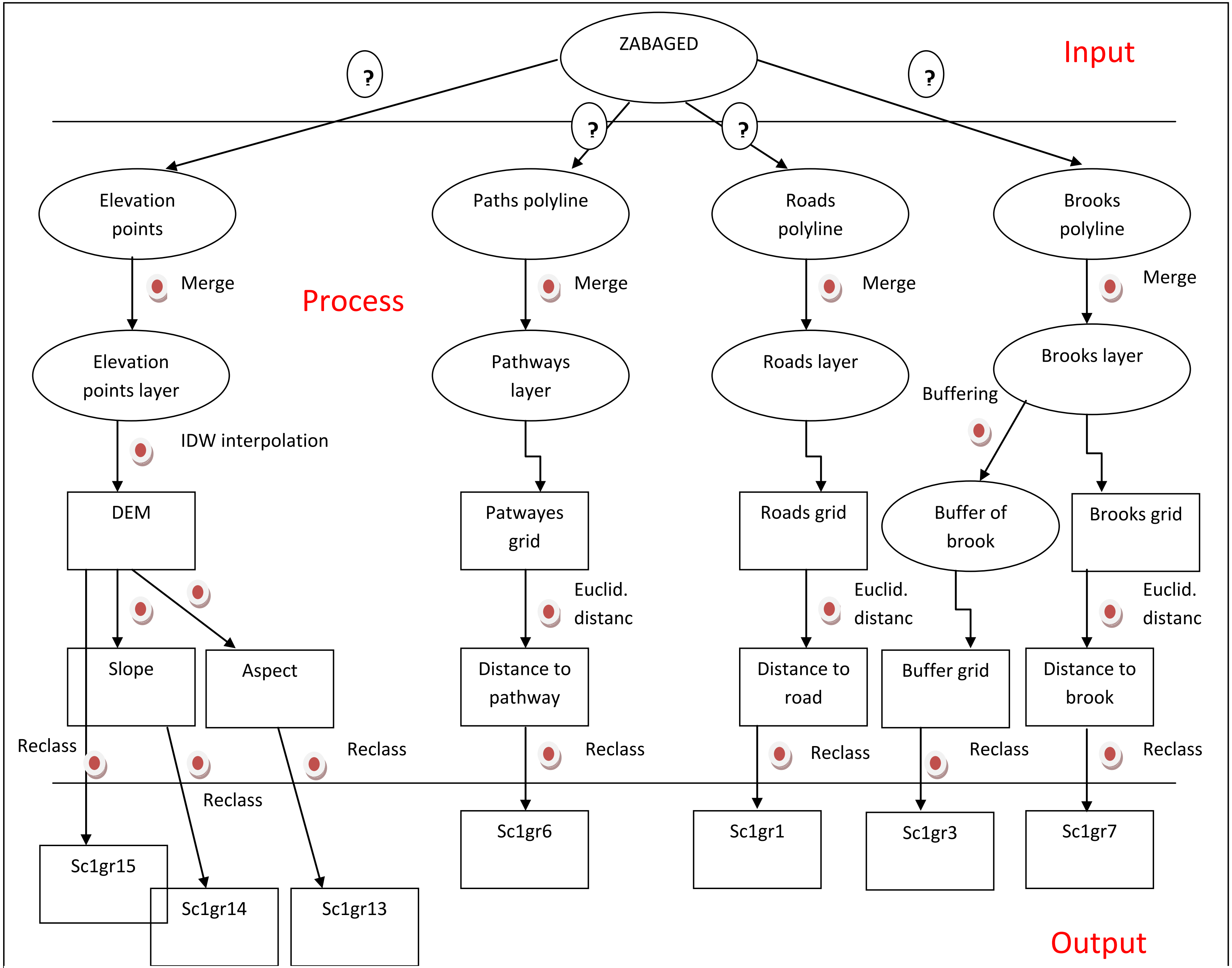


Figure No 12: Flowchart describing data ZABAGED® handling to produce connected explanatory factor grids of same spatial extent

4.3.3 Quantification of relation between the location of land use and explanatory factors by statistical analysis

"A statistical analysis is used to reveal and quantify the relations between the locations of land use and a set of explanatory factors" (The CLUE Group, 2004). For this purpose, there was chosen logistic (binomial) regression that indicates the probability of a certain grid cell to be devoted to a land use type. It is expected that land use conversion takes place at the location with the highest preference for the specific type of land use at the moment in time (Verburg et al, 2004). The function that relates these preferences/probabilities with the biophysical and socio-economic location characteristic is defined in a logit model following:

$$\log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 x_{1,i} + \beta_2 + x_{2,i} + \ldots \beta_n x_{n,i}$$

In the regression equation $\mathbf{P_i}$ means probability of a grid cell for the occurrence of the considered land use type at location **i. X** presents the explanatory factor and **β** is a coefficient estimated in logistic regression, where land use pattern takes place of dependent variable and location factors of independent variable. Factors that have not significant contribution to the explanation of land use pattern are excluded from the equation.

All of ASCII files predicating about explanatory factors had to be converted within File Convertor v2 (component of CLUE modelling software®), which produces text files that are accepted by common statistical packages. Initial land use grid (***cov_all.0***) was reclassified and subdivided into eight raster datasets. Each of eight grids presents certain land use type map. On these maps value 1 indicates presence of specific land use, 0 absence and -9999 cells outside of the case study area. The mentioned grids were two-times converted – first into ASCII files (ArcMap, ESRI®) and second along with explanatory factors (Convertor v2). Relationships between explanatory (driving) factors and allocation of land use were evaluated within SPSS 15.0 software.

The goodness of fit was evaluated with the ROC method (relative operating characteristic). ROC evaluates the predicted probabilities by comparing them with the observed values over the whole domain of predicted probabilities instead of only evaluating the percentage of correctly classified observations at a fixed cut-off value (Verburg et al, 2002; Verburg et al, 2004; Pontius and Schneider, 2000; Leschen et al, 2005).

4.3.4 Translation of scenario storylines from global to local level

For the purpose of evaluation of EURUALIS applicability at regional extent, two of scenario storylines (Global Economic and Regional Communities) were translated from global to local level.

4.4 Data processing for scenario application within CLUE-S model

The model is subdivided into two distinct modules: the non-spatial demand module and the spatially explicit allocation procedure (see Figure No 13). The demand module is specified on a yearly basis and serves as a direct input for the allocation procedure. Specific scenario is defined by set of factors (see Figure No 14): spatial policies and restriction, land use type specific conversion setting, land use requirements and location characteristics (regression results) that could be followed by location specific preference addition.

Figure No 13: Overview of modelling procedure (The CLUE Group, 2004)

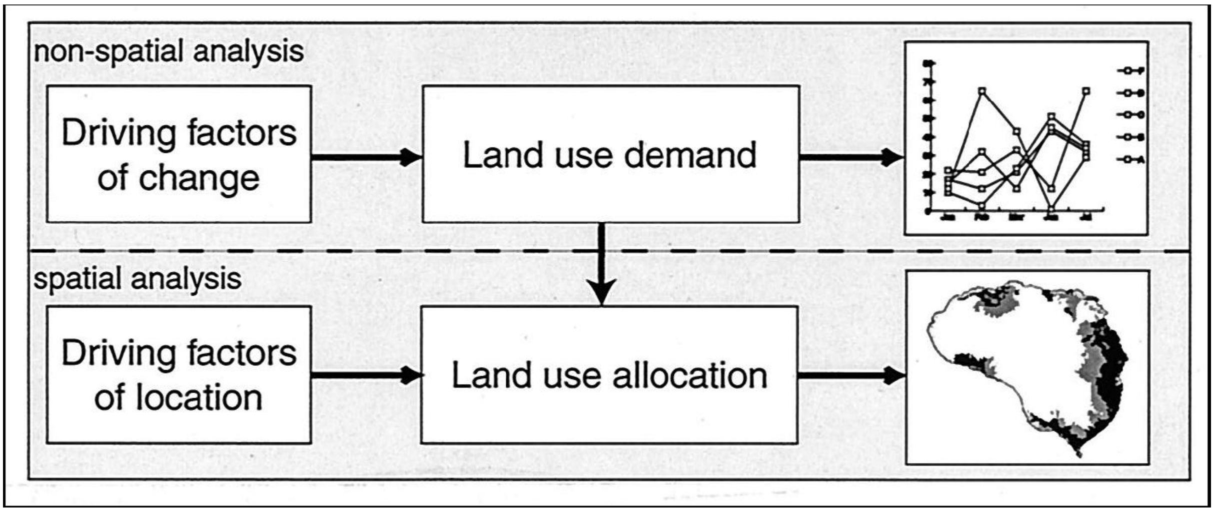
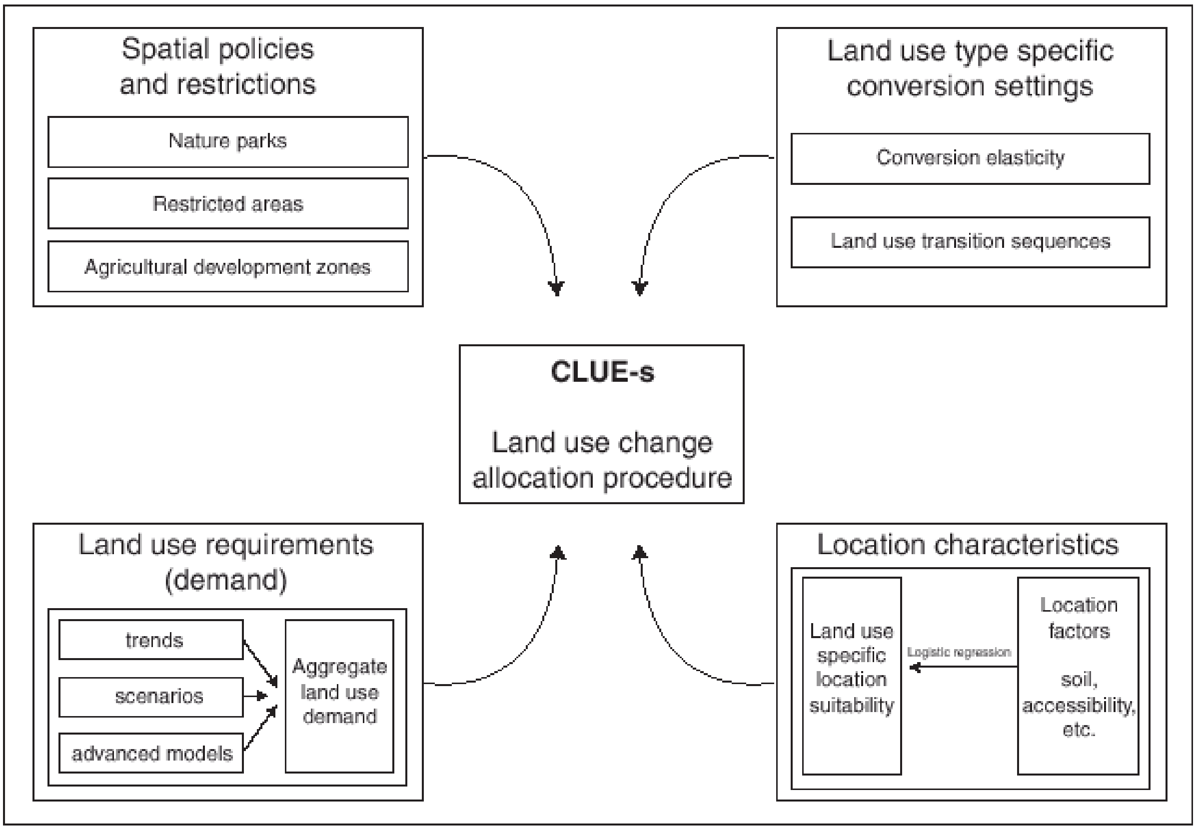


Figure No 14: Overview of the information flow in the CLUE-S model (The CLUE Group, 2004)



4.4.1 Quantification of land requirements (demands) above scenarios by extrapolation of trends

Land use requirements are calculated as a part of a specific scenario. It constrains required total change in land use type, which was estimated by extrapolation of trends from 1973 to present. Convergence criteria are expressed as absolute values (hectares) on a yearly basis.

4.4.2 Land use type specific conversion setting (conversion elasticity, conversion matrix)

Two sets of parameters are needed to characterize the individual land use types: conversion elasticities and land use transition sequences. The first parameter set, the conversion elasticities, is related to the reversibility of land use change. “Land use types with high capital investment will not easily be converted in other uses as long as there is sufficient demand” (Verburg et al, 2007). For each land use type a value was specified that represents the relative elasticity to change, ranging from 0 (easy conversion) to 1 (irreversible change).

The second parameter set is the specific conversion setting and its temporal characteristics that are specified in a conversion matrix. That matrix defines (The CLUE Group, 2004): what other land use types the present land use type can be converted to or not; how many years the land use type at the location should remain the same before it can change into another land use type and the maximum number of years that the land use type can remain the same. Maps, that indicate the regions, where specific conversion is allowed, had to be supplied. The code 1 was used for areas upon conversion allowance, for active areas 0 and for area outside the simulation -9999.

4.4.3 Area restriction and policies

Spatial policies and restriction indicate areas where land use changes are restricted (e.g., a forest reserve, a residential construction). Spatial policies can directly influence the pattern of land use change (The CLUE Group, 2004). Maps that indicate the area for which the spatial policy is implemented had to be supplied. The code 1 was used for areas upon restriction, for active areas 0 and for area outside the simulation -9999.

4.4.4 Location specific preference addition

Location specific preference addition was used for increase of preference for certain land use on location (as results of spatial policies). Maps that indicate the area for which the location specific preference is implemented must be supplied. These additions are between 0-1 in order to fit the range of the regression results (The CLUE Group, 2004).

4.4.5 Main parameters

After the scenario specific setting of land use types conversion, land requirements, restrictions and preference addition configuration of simulation have to be determined. It is done through the main parameters file that contains 20 lines. Each parameter in the file is discussed in the Table No 5.

Table No 5: Main parameters

Line	Description	Format	Setting
1	Number of land use types	Integer	8
2	Number of regions	Integer	1
3	Max. number of independent variables in a regression equation	Integer	18
4	Total number of driving factors	Integer	24
5	Number of rows	Integer	1460
6	Number of columns	Integer	1405
7	Cell area	Float	0.0025
8	x coordinate	Float	-864283
9	y coordinate	Float	-1097154
10	Number coding of the land use types	Integers	0 1 2 3 4 5 6 7
11	Codes for conversion elasticities	Float	Scenario specific (see Results)
12	Iteration variables	Float	1 2 4 (1: in hectares; 0.0025: average deviation between demand and allocated change; 0.05: max. deviation between demand and allocated change)
13	Start and end year of simulation	Integers	1995 2030
14	Number of coding of explanatory factors that	Integers	0

Line	Description	Format	Setting
	change every year		(model simplified by only stable driving factors)
15	Output file choice	1,0,-2 or 2	1 (ArcGIS headers in output files)
16	Region specific regression choice	0,1 or 2	0 (only 1 region)
17	Initialization of land use history	0,1 or 2	1 16 (1: random number assigns to all pixels to represent the number of years above current land use; 16: max. number of years generated by randomizer)
18	Neighbourhood calculation choice	0,1 or 2	0 (model simplified by excluding neighbourhood setting)
19	Switch for location specific preference addition and weight factors	Integers	Scenario specific (see Results)
20	Iteration parameter	Float	0.1

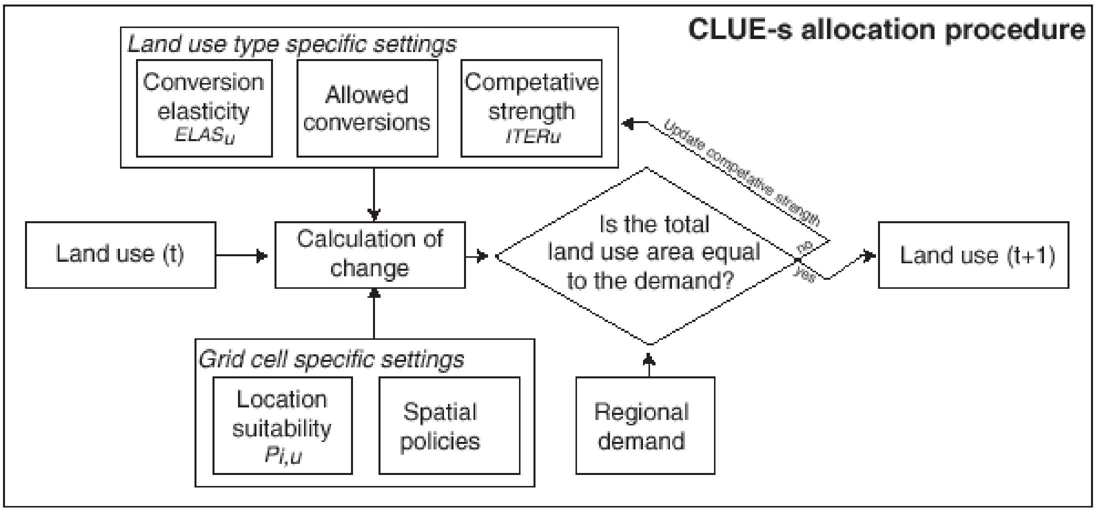
4.4.6 Calculating probability maps

The probability maps are calculated from the logistic regression results upon one of the CLUE software option. They are useful for testing whether the hypothesis for driving factors of each land use type was correct (The CLUE group, 2004). These maps can be imported by ArcGIS to see the result.

4.4.7 Running the model (allocation procedure)

After successful scenario specific setting of all parameters and processing of all entrance ASCII files mentioned above, it is possible to run the model. Overall procedure of allocation is indicated in the Figure No 15.

Figure No 15: Allocation module of the CLUE-S model (The CLUE group, 2004)



4.5 Processing of simulation results and display of data by ArcGIS

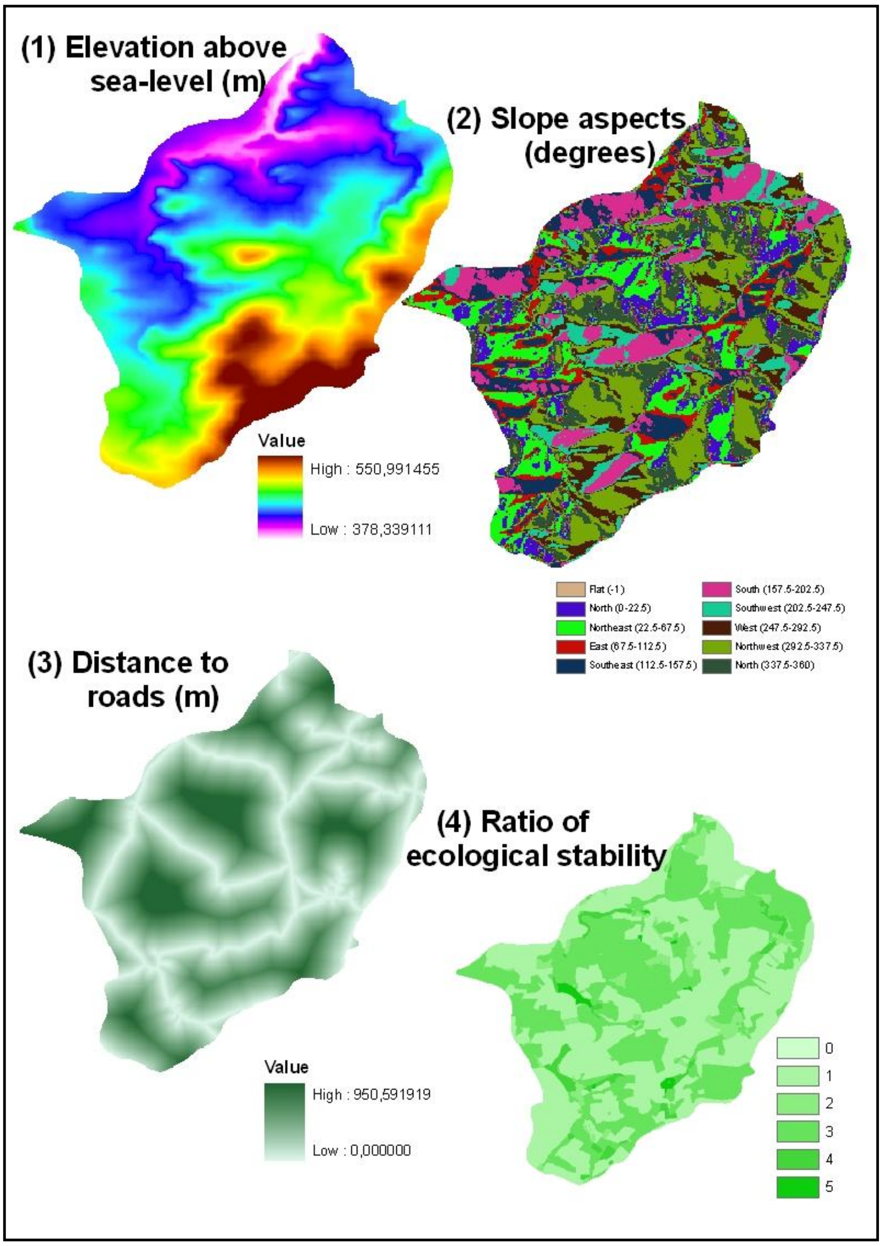
All simulation results are saved in ASCII files that contain the resulting land use type distribution individually for every year. Simulation results will be shown in graphs, tables and maps.

5 RESULTS

5.1 Landscape mapping and land cover change analysis

The initial land cover of the case study area was assumed from the landscape mapping conducted in summer 2005. The land cover change analysis was elaborated within my bachelor degree. That analysis brought set of potential drivers of land use change, which were supplemented by submitted driving factors of Eururalis project. Values of available factors were processed through geographic information systems (ArcGIS®). Examples of spatially explicit results can be seen in the Figure No 16.

Figure No 16: Examples of biophysical (attitude and slope), natural (ration of ecological stability) and external factors (distances to roads) that differentiate land covers



5.2 *Translation of scenarios*

5.2.1 Explanatory factors trends

For translation of Global Economy and Regional Communities scenarios from European to case study level explanatory factors trends and influences are explored and compared with their incidence at regional level (see Table No 6).

Table No 6: Explanatory factors trends derived from Eururalis (base) and at case study level (case)

Explanatory factor	A1 base	A1 case	B2 base	B2 case
Population	↑	↙	↗	↗
Employment	↑	↓	↗	↗
Macro-economic growth	↑	0	↗	0
Incomes	↑	↓	↙	↔
Subsidies	↓	↓	↔	↔
Introduction of new products	↑	↗	↙	↗
Agricultural yield	↑	↗	↗	↙
Influence of climate change (policy)	↗	0	↗	0
Market protection policy (CAP)	↙	↓	↗	↑
Income support policy (CAP)	↓	↓	↔	↗
Ambition of biofuels (Bio-energy	↗	↗	↗	↑
Influence of the Nitrate Directive	↗	↗	↗	↑
LFA concept	0	0	↔	↔
Spatial policies	↑	↔	↗	↗
Natura 2000	↔	0	0	0
Interest in biodiversity and natural	↔	↔	↗	↑
Interest in environmental quality	↗	↔	↗	↗
Interest in animal welfare	↗	↔	↗	↑
Interest in quality of life	↑	↔	↗	↗
Interest in cultural-historical values	↙	↙	↑	↑
Interest in competitiveness	↑	↗	↓	↓
Interest in self-sufficiency	↓	↙	↑	↑

0: faint, no influence; ↑: trend of (importance) increase; ↗: more likely trend of (importance) increase; ↓: trend of (importance) decrease; ↙: more likely trend of (importance) decrease; ↔: steady state.

5.2.2 Regression results and probability maps

In this chapter we will go through causalities of the case study area specific land cover pattern. Results of the land cover determinants testing by logistic regression can be seen in the Table No 7.

Table No 7: Resulting exp (β) values for land use pattern estimated by logistic regression

Driving factor	Build-up	Water	Forest	Orchard	Grassland	Arable
Constant	-3.1	-1.9	6.8	-5.7	2.4	-1.5
Distance to nearest town	*	0.027	0.012	*	0.014	0.004
Distance to nearest road	-0.001	*	*	*	-0.01	0.01
Buffer zone of villages	*	*	-1.267	*	-1.115	*
Buffer zone of brooks	*	*	*	*	0.816	*
Distance to nearest water body	*	*	-0.012	*	0.013	*
Distance to nearest fallow	*	*	*	*	*	0.022
Distance to nearest pathway	*	-0.044	-0.01	*	-0.01	0.079
Distance to nearest brook	-0.03	-0.081	-0.01	*	*	-0.02
Distance to district town	*	-0.058	*	-0.023	*	-0.014
Distance to nearest village	*	0.036	0.015	*	*	-0.025
Distance to nearest nature	*	-0.036	*	*	*	-0.015
Hydrology	*	*	-0.123	*	*	0.102
Hydrology2	*	*	*	*	*	-1.997
Orientation	*	*	*	*	*	0.061
Slope	*	*	*	*	*	-0.105
Attitude	-0.009	*	0.007	*	-0.009	0.022
Population density	-0.329	*	*	*	-0.171	*
Social facilities	*	*	*	*	*	*
Number of inhabitants	0.051	*	*	0.027	*	-0.005
Temperature	*	*	*	*	-0.83	*
Price of deprivation	*	*	*	*	-0.002	*
Ratio of ecological stability	*	*	*	*	0.17	*
Restriction (nature conservation)	*	*	0.699	0.789	*	-0.536
Precipitation	*	*	-0.015	*	*	*

*****Not significant, all other exp (β) values are significant at 0.05 level

An allocation of build-up area is determined by population and accessibility. Buildings and houses are constrained by residential, productive or serviceable use. Present villages maintain accessibility to surrounding by roads net. Most of buildings are located out of more densely populated plots and nearby passing brooks. One of bio-physical factor influences build-up areas location – altitude. In general, villages are located in lower elevation. Naturally, orchards are bound to residential (populated) areas. Another finding of statistical analysis is allocation of orchards nearby important landscape elements or bio-centres.

Forest allocation is determined by two bio-physical factors. Forest is common in the higher elevation and on the soil unfitting for agricultural production. Forests present hot-spots of the highest natural and ecological value. They are often far from villages and towns and attached to system of other natural enclaves - brooks, water bodies and enabled by pathways.

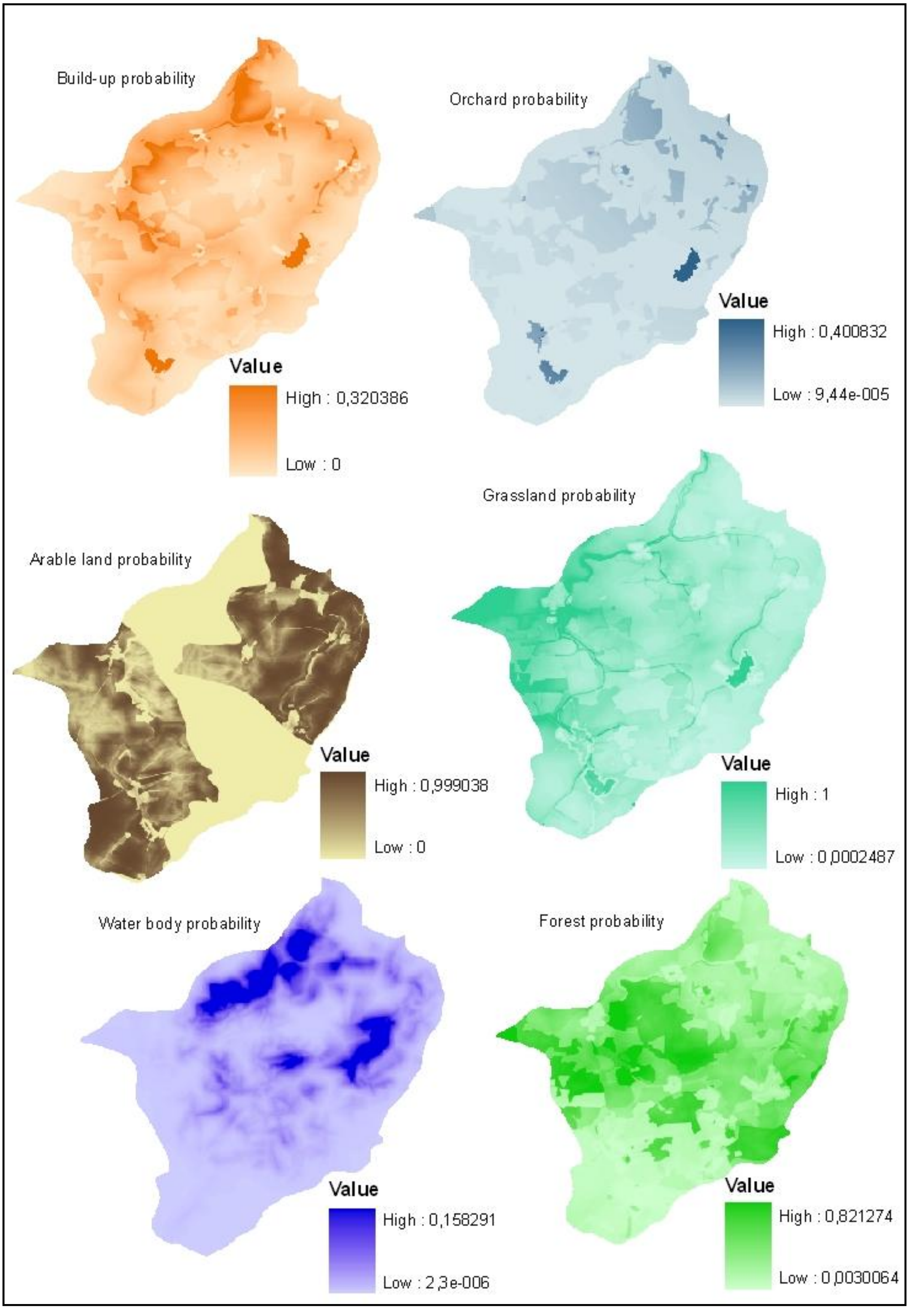
Allocation of water bodies is explained mainly by mutual position these bodies and villages and towns. Present ponds are located mainly on the edges of forests out of build-up area. Region specific water bodies' constitution within landscape is determined by closeness to pathways, natural areas and district towns.

Arable fields cover more than 50% of the case study area and are aggregated to large-scale fields fitting on the great deal of biophysical factors. Conclusive relation presents preference of higher altitude, orientation to southwest and northwest, lower slope and independency on hydrological favourable locations. Arable land pattern is demonstrated by accessibility.

Contrary to arable land, grasslands are presented in lower elevation, accompanied brook streams and mostly moderately hot climate region 2 with corresponding precipitation and temperature and lower population density. Grasslands do not go along residential area. Similarly like arable land, grassland pattern is demonstrated by "distance" factors.

You can explore the potential of the case study area for each of land cover type on the Probability maps on the Figure No 17.

Figure No 17: Probability maps



5.2.3 Translation of scenarios

General development philosophy of A1 scenario is emphasised on market-oriented solution, e.g., low taxes, free trade, an optimum balance between demand and supply of goods, services or environmental quality. Government interventions are limited as possible. They are focused on core responsibilities (education, health, security, competitive markets, law enforcement etc.) and market failures. In term of the case study region philosophy of A1 scenario is reformulated to rural development abolishing. It is indicated by governmental intervention phasing out, rural development support reduction, market support phasing out, farm payments decoupling and phasing out, Common Agricultural Policy (CAP) and Less Favoured Area (LFA) concept abolishing. Mentioned supports and payments reduction turns the scale contrary to biofuels cultivation. Under A1 scenario Bio-energy Directive stimulate development of bio-energy plants and solar collectors. Not urban sprawl, but spontaneous development of nature is expected.

General development philosophy of B2 scenario is emphasised on self-reliance, local dynamics, ecological stewardship and equity. Government interventions are necessary. Most striking in the B2 scenario is the global market decline and focus on local and regional markets and self-reliance in terms of resources. In term of the case study area an indispensable effect provides less favoured areas policy maintaining. Agricultural sector is focused on centralized dairy farming following animal welfare principles and environment-friendly management and additional cultivation of second generation of bio-energy crops. New pastures are maintained. Current large-scale arable fields are restored by landscape- and nature-friendly bio-agricultural principles. Only modest land abandonment follows B2 scenario.

5.2.4 Conclusions of questionnaire

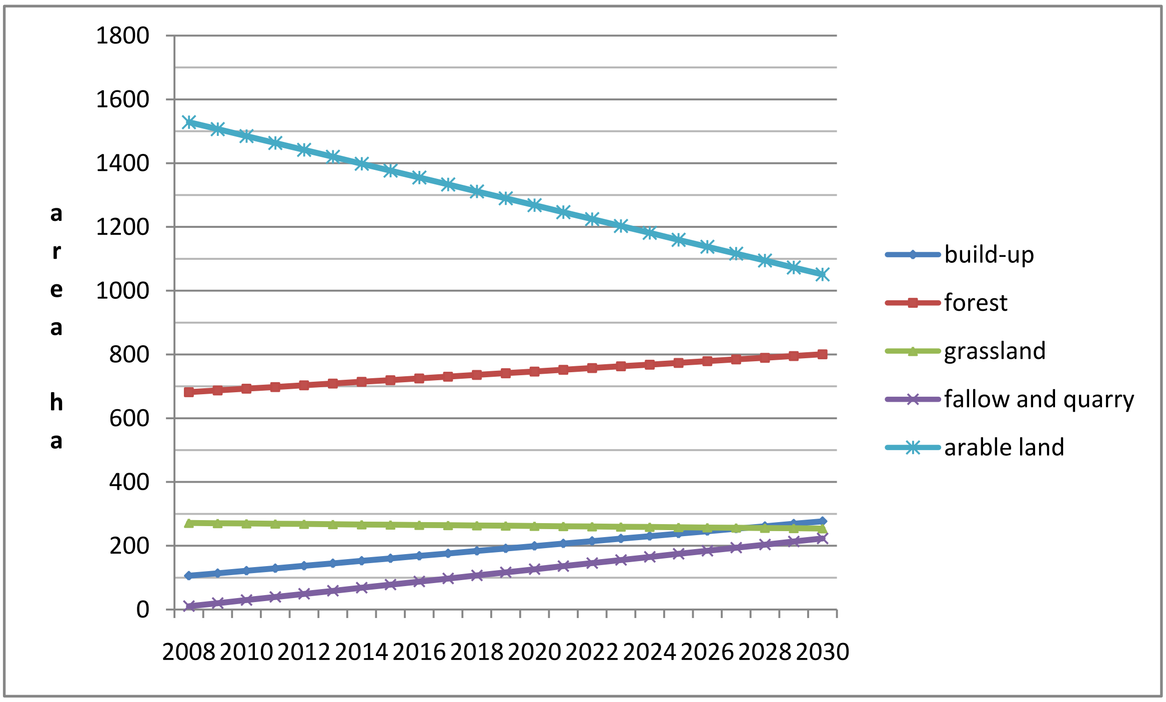
Results of questionnaire indicate that local inhabitants tend to philosophy of B2 scenario. In the respondents´ point of view the main problems of the case study area are traffic inaccessibility, unsatisfactory social facilities and worsening of aesthetical aspect of surrounding landscape. They considered water pollution, flush of fertilizers from arable fields and aesthetical aspect as main environmental problems. The think that future policies should improve forest management in term of nature conservation, diminish negative effects of industry and support agricultural use. Respondents were questioned about favourite development of the case study area. They could choose between support of agriculture, tourism and recreation, residential areas development and landscape diversity. Most of respondents preferred first option – support of agriculture in terms of suitable management. Hedgerows and pathways improving landscape clearness should be maintained and ratio of meadows and grasslands increase.

5.2.5 Scenario specific setting: land requirements, conversion setting, location specific preference setting and area restrictions

5.2.6 Land requirements

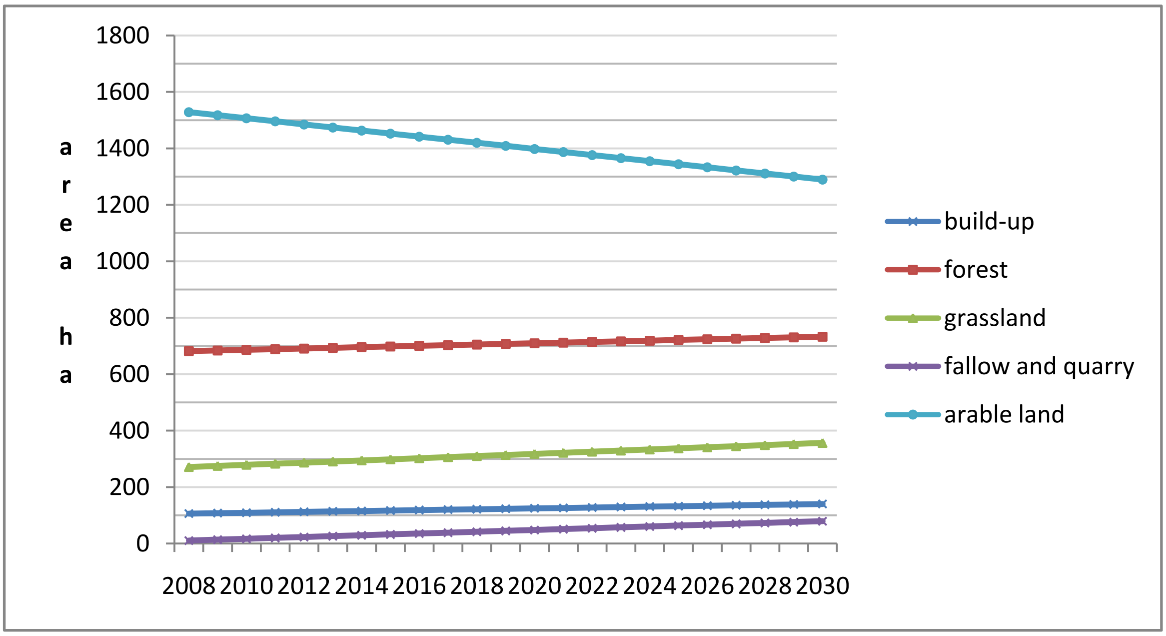
Situation under A1 scenario seems different. A share of bio-fuels is assumed at lower limit of 2.5% of the case study area (4.3% of arable land). From decrease of biofuels fields results 7.2% arable land abandonment (4.2% of the case study area). Due to governmental non-interference 40% of arable land and 0.5% of grassland is abandoned. Agri-tourism development countervails (by transition of 5% land to multifunctional agriculture) income decrease and retrenches land abandonment. Unutilized agricultural land is partly used for energetic plants building-up and agri-tourism services maintaining (+5% build-up area) and partly for forest development (+3.5% forest cover). Decline of agricultural production compensated by above mentioned land use will bring 14% abandonment. Under this scenario, total area of forest will increase its ratio coverage about 3.5 % as it was estimated by Eururalis study. Category of fallow and quarry cover will increase about 210 hectares between 2008 and 2030. In year 2030 share of quarries in total area presents 7 hectares due to filling and consequential building largest quarry up and contrary to this development maintaining new one for brick clay mining. Under A1 scenario area of orchards goes down to half of original area due to dying out of fruiters and absence of restoration. In the Figure No 18 you can see land requirements for each of land cover types under A1 scenario in time period 2008-2030.

Figure No 18: Main land cover types requirements under A1 scenario



Under B2 spatial severity of bio-agriculture, bio-fuels cultivation and focus on milk production will bring only 3% abandonment of arable land during next 22 years. A share of bio-energy crops at arable land will stay same. Second generation of these crops covers 6.7% of the case study area (11.5% of arable land). Arable plots for forage crops cultivating will be replaced by pastures. It indicates 2.5% increase of grassland coverage. Anti-erosion measurements along the brooks will finish, what brings 0.3% increase of grassland. Under B2 scenario grassland area will increase from 10 to 12.5% of the case study area. Build-up area under B2 scenario will rise in term of weak development of residential areas, weak growth of provincial towns Domazlice and Horsovsky Tyn and maintaining few of bio-agricultural farms. Build-up area development will not exceed 1% (26 hectares). Forest spreading keep the trend of 1.5% increase. The category of fallow and quarry will increase about 69 hectares between 2008 and 2030. Original share of quarries was 7.5 from 10.2 hectares, in year 2030 it presents only 3 hectares. Area of water bodies and orchards will stay equal as in the present. Under B2 scenario total area of orchards stays similar to the original coverage. Area of water bodies stays same under both A1 and B2 scenario. In the Figure No 19 you can see land requirements for each of land cover types under B2 scenario in time period 2008-2030.

Figure No 19: Main land cover requirements under B2 scenario



5.2.7 Conversion setting

The relative elasticity to change ranged from 0 (easy conversion) to 1 (irreversible change). Under the A1 scenario conversion elasticities were set up in the following sequence build-up area 0.2, water body 1, forest and orchard 0.1 and last three land covers grassland, fallow with quarries and arable land 0. Under the B2 scenario conversion elasticities a bit differ. They were set in the same sequence 0.2 1 0.1 1 0 0 0.

Specific conversion setting and its temporal characteristics are specified in the conversion matrix that is shown for both scenarios in the Figure No 20.

Figure No 20: Conversion matrixes (on the left for A1 scenario, on the right for B2 scenario)

A1	0	1	2	3	4	5	6	B2	0	1	2	3	4	5	6
0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0
2	0	0	1	0	0	0	0	2	0	0	1	0	0	0	0
3	1	0	1	1	0	1	0	3	0	0	0	1	0	0	0
4	1	0	1	0	1	1	0	4	1	0	0	0	1	0	0
5	1	0	105	0	0	1	0	5	1	0	105	0	105	1	0
6	1	0	1	0	1	1	1	6	1	0	1	0	1	1	1

0: build-up; 1: water body; 2: forest; 3: orchard; 4: grassland; 5: fallow and quarry; 6: arable land

5.2.8 Location specific preference addition

Under both of scenario, build-up area is preferred around existing residential areas. It is indicated by value 0.5. Fallow will take place at most arable land (under A1 scenario value 0.3 and under B2 value 0.6). In addition, under B2 scenario grasslands will take place at initial arable land.

5.2.9 Area restriction

The case study area is restricted by nature conservation policy inside the natural element Cerveny vrch. In addition, under the B2 scenario locations with highest value of ecological stability (for indication of ecological stability see Appendix) are restricted.

5.3 Simulation results

Under A1 scenario large scale arable land abandonment and consequential forest spreading and build-up area maintaining are the main factors of landscape structure adjusting (see Figure No 21). Open landscape will be closed by spontaneous succession of semi-natural aspects (solitaire trees and forest islands). Fallow land in the south part of the case study area works as a strong competitor rolling grasslands into the western tail of the area.

Under B2 scenario landscape structure gets mosaic (see Figure No 22). Weak and equal spreading of forest and residential areas defragmentises open agricultural landscape. Grassland development will bring increase of ecological stability (for indication of ecological stability see Appendix). Fallow is developing mainly in the south part of the case study area and along existing fallow and quarry land. Land abandonment continues in small units.

Figure No 21:

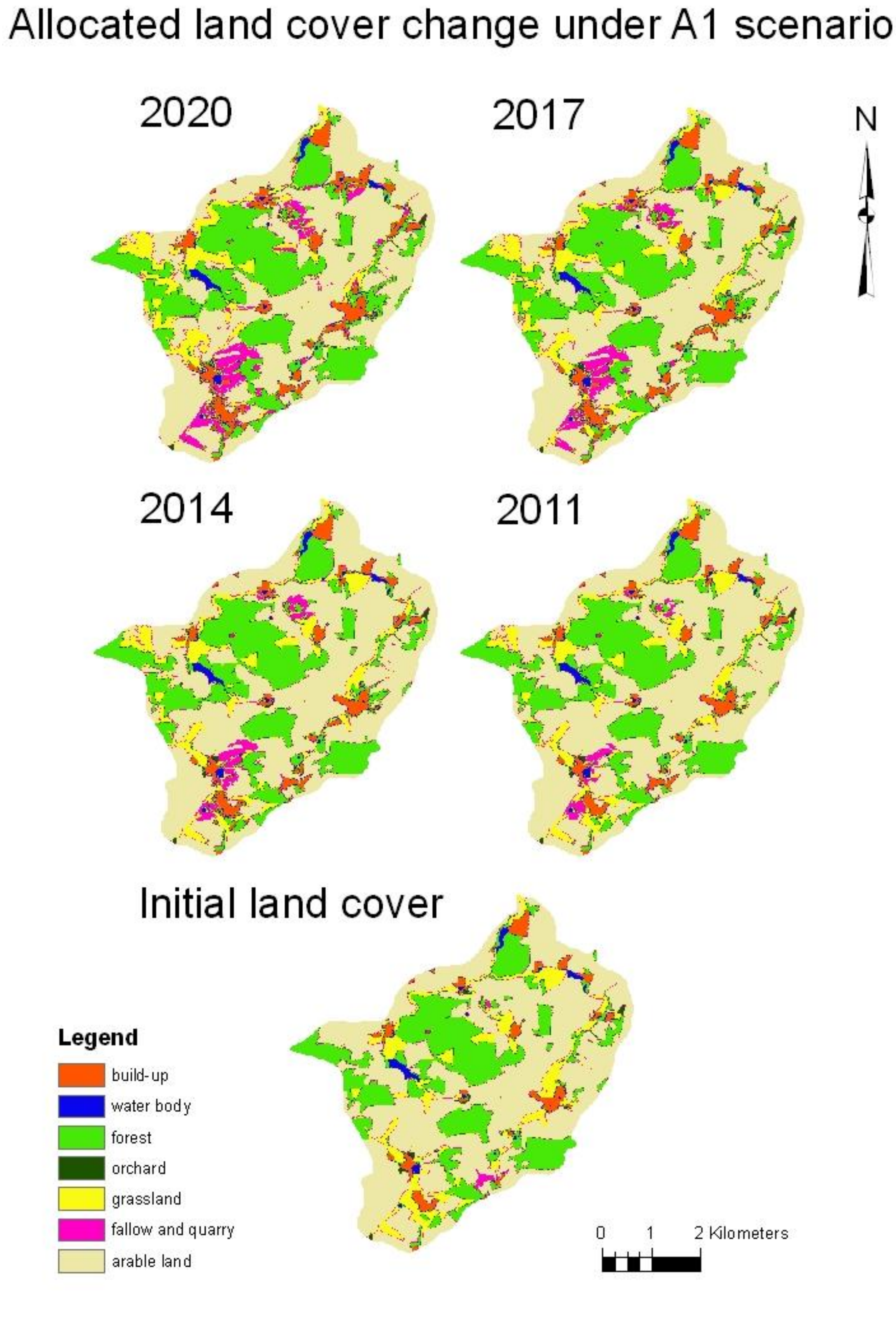
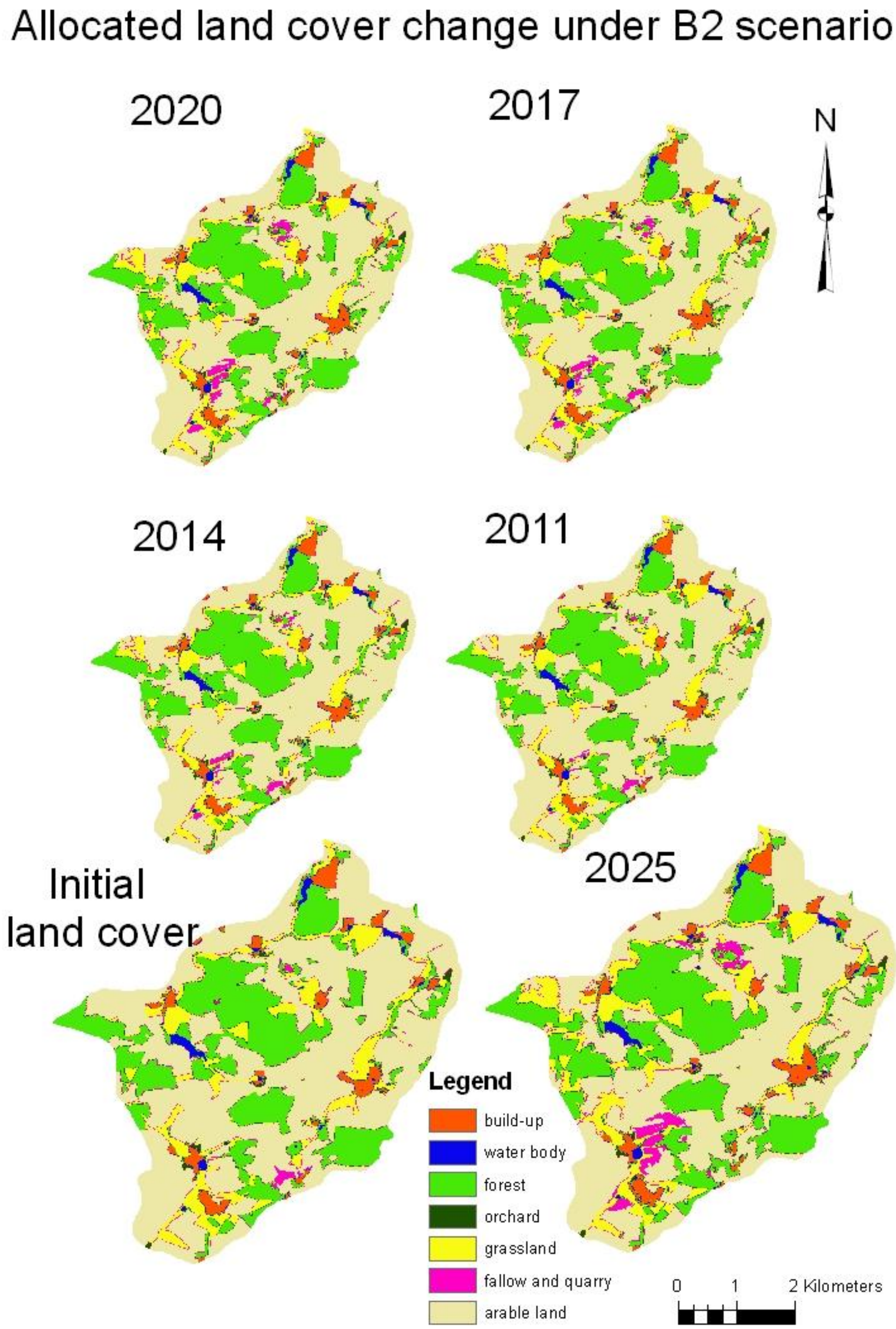

Allocated land cover change under A1 scenario
2020
2017
N
2014
2011
Initial land cover
Legend
build-up
water body
forest
orchard
grassland
fallow and quarry
arable land
0 1 2 Kilometers

Figure No 22:



Allocated land cover change under B2 scenario
2020
2017
N
2014
2011
Initial land cover
2025
Legend
build-up
water body
forest
orchard
grassland
fallow and quarry
arable land
0
1
2 Kilometers

5.4 *Allocation procedure results: deviation between demand and allocated change*

Resulting deviations between demand and allocated area within modelling procedure can be seen in the Table No 8. Negative values indicate under-allocation, positive values over-allocation.

Table No 8: Deviation between demand and allocated change under A1 and B2 scenario

A1	Build-up	Water b.	Forest	Orchard	Grassland	Fall. & q.	Arable l.
2009	-3.9	0.0	-0.4	-0.9	-1.0	-4.0	10.0
2010	-3.7	0.0	0.9	-2.9	-1.5	-1.9	9.2
2011	0.5	0.0	0.2	-2.6	-1.2	-2.9	6.1
2012	0.2	0.0	0.0	-2.2	-0.1	-3.9	6.2
2013	0.7	0.0	-0.3	-1.9	0.5	-3.7	4.7
2014	-1.4	0.0	-1.9	-1.6	0.0	-2.5	7.6
2015	-3.2	0.0	-0.7	-1.3	-2.8	-3.0	11.0
2016	-0.6	0.0	-1.3	-0.9	-0.4	-3.6	6.9
2017	-2.5	0.0	-2.3	-1.0	-1.7	-4.7	12.3
2018	-1.7	0.0	-0.9	-0.7	0.1	-1.8	5.2
2019	0.9	0.0	0.4	-2.0	0.0	-1.2	1.9
2020	0.3	0.0	3.0	-1.7	-0.6	-0.2	-0.8
B2	**Build-up**	**Water b.**	**Forest**	**Orchard**	**Grassland**	**Fall. & q.**	**Arable l.**
2009	-1.5	0.0	-1.3	0.0	-2.8	-1.4	7.1
2010	-1.3	0.0	-3.5	0.0	-1.0	-4.0	9.8
2011	-1.5	0.0	-3.1	0.0	-0.8	-4.0	9.4
2012	-3.1	0.0	-2.8	0.0	0.4	-3.9	9.6
2013	-0.6	0.0	-4.4	0.0	-1.4	0.4	6.0
2014	-1.7	0.0	-4.1	0.0	0.4	-3.4	8.8
2015	0.6	0.0	-4.3	0.0	0.3	-2.0	5.5
2016	-1.0	0.0	-2.6	0.0	-0.4	-2.2	6.1
2017	-0.1	0.0	-1.8	0.0	-1.2	-2.8	6.0
2018	0.6	0.0	-4.2	0.0	-0.1	-2.7	6.3
2019	-0.9	0.0	-4.6	0.0	-1.5	-0.7	7.9
2020	-2.5	0.0	-1.5	0.0	0.7	-3.1	6.3

6 DISCUSSION

6.1 Applicability of Eururalis scenarios at case study level

6.1.1 Translation of scenarios

In term of evaluating of EURURALIS scenarios applicability at tens-kilometres-large regions two contrasting storylines Global Economy (A1) and Regional Communities (B2) were chosen. A translation of storylines across scales is efficient for an applicability testing.

In order to A1 scenario conversion, we need to take into account dealing with rural agricultural land in the less favourable area, where agriculture presents key production sector. Milk production and interrelated nutritive crops cultivating are the major. When main philosophy of A1 scenario is described by market-oriented solution at global level, in term of the case study region, it should be reformulated to rural development abolishing. Decoupling and phasing of governmental intervention, rural development and market support, farm payments, Common Agricultural Policy (CAP) and Less Favoured Area (LFA) concept out is critical for agricultural development that is based on production of protected commodities in subsidised less favourable area. Although Eururalis supposes interest in biofuels cultivation on abandoned agricultural land, we cannot look forward to salvation of large arable fields by biofuels cultivation due to very fertile cropland absence and high transportation costs. Within the case study region, Bio-energy Directive creates opportunity for bio-energy plants and solar collector building up. Interest in tertiary sector can be quitted by maintaining of agri-tourism services. In addition, under A1 scenario EURURALIS study assumes a development of spatial policies to prevent urban sprawl, although the case study area is not located nearby so-called hot-spots of urbanisation (main cities or agglomerations). We deal with less accessible area with low population pressure, where spontaneous development of nature can be expected.

Contrary to A1 scenario, B2 philosophy is easily applicable at the case study region level. High priority of food quality and safety, viability of the countryside, biodiversity, landscape values, and reduction of nutrient and pesticide loads lead to restoration of current large-scale management at arable fields by certificated bio-agriculture principles. Focused on protected commodity, biofuels cultivation and support of bio-agriculture within LFA creates opportunities for weaker land abandonment than is awaited by original Eururalis study. Regional Communities show relative modest changes in landscape pattern. Nevertheless, local market protection and LFA policy probably does not completely save area under B2 scenario against land abandonment and does not fully compensate slow economic growth or its stagnation (Eururalis 2.0, 2007).

6.1.2 Scenario specific land requirements

Both of Eururalis scenarios Global Economy and Regional Communities assumed two-percent decrease of arable land during thirty-year period 2000-2030. It is true that just 46 percent of the EU coverage is used for agriculture. Two-thirds (28 percent) creates arable land and one-third (almost 13 percent) pastures. The case study area is constituted differently. We deal with landscape of prior agricultural use. In the most ascendant agricultural era (70´) arable land covers 59 percent and grassland 10 percent of the study region. Mainly post-revolutionary political changes of last twenty years caused three-percent decrease of agricultural land. Indeed, changing EU policies (Bio-energy directive or CAP) play key role nowadays.

Eururalis study assumed 4-6% share of bio-energy crops at agricultural land until 2010. This ratio contributes 5.75% target of EU Bio-energy Directive although an effect of bio-energy plants cultivation on future change of crop area is estimated as small (Eururalis 2.0, 2007). Indeed, let us look at the situation within the case study area. In 2008, rape (Brassica napus) is cultivated at 11.5% of arable land. This plant serves as an ideal energy crop of first generation or bio-fuel within potato growing agricultural region (Becka et al, 2007). Although other crops of the potato growing agricultural region are referenced because their energetic use (e.g., wheat Triticum aestivum, rye Secale cereale, maize or triticale), they do not reach relevant energetic yield (Weger, 2009). Thanks to EU and domestic stimulation under B2 scenario we can imagine replacement of whole 6.7% of the case study area (11.5% of arable land) by second generation of energetic crops. Another above mentioned opportunity under B2 scenario is a restoration of arable land by bio-agricultural principles that work with animal welfare, which indicates declination of cow number and partial compensation of cow-shed breeding by grazing. Arable plots for forage crops cultivating will be replaced by pastures. Decline of livestock production compensated by spatial severity of bio-agriculture, bio-fuels cultivation and focus on protected commodity will bring only 3% abandonment. Presenting ratio beats Eururalis presumption that is based on initial 28% coverage of arable land. Situation under A1 scenario seems differently. Biofuels from less favourable areas cannot be able to compete with import from climatic-favourable regions of Africa or Brazil. I assume share of bio-fuels under A1 scenario at lower limit. Major milk production connected with forage crops cultivation will undergo intensive change due to protected commodities income cancelling. Agri-tourism development partly countervails income decrease and retrenches land abandonment caused by governmental non-interference.

Eururalis study assumed pasture decrease between 0.8% (A1 scenario) and 2.1% (B2 scenario) of EU area. Contrary to that study area development of last ten years shows 0.3% increase due to CAP support (anti-erosion grass buffer zone along the brooks) and LFA (grasslands in the LFA). Thanks to focus on environmental topics within B2 scenario we can await doubling of these measurements (finishing of anti-erosion measurements along the brooks). Thanks to CAP, LFA and focus on animal welfare we can assume safeguarding of milk production at the farm in Meclov and consequential increase of pasture area. This rise will be supported by Nitrate Directive that makes claims to nutrients leaching. Under B2 scenario grassland area will increase from 10 to 12.5% of the case study area that presents almost 13% standard of EU agricultural land. Weak underestimation is caused by fact that the case study area deals with subnormal representation of grasslands and pastures within rural agriculture landscape. Existing grasslands could be used for grazing of horses (hobbyfarmers) or livestock (agri-tourism).

Agricultural land abandonment and forest maintaining are interrelated by succession processes (Eururalis 2.0, 2007). Between 1973 and 2008, expansion of forest from 26 to 27.3 % was observed in the case study area due to post-revolutionary forest edges spreading into abandoned arable land and rationalization of forest management. Especially scenario A1 offers space for forest edges spreading and spontaneous nature development. Timber production could supply loss of agricultural production function. Under this scenario total area of forest will increase its ratio coverage about 3.5 % as it was estimated by Eururalis study. Rise of forest under B2 scenario differs between Eururalis (increase about 4.3 %) and potential of the case study area, where similar development as in the recent past is assumed (+1.5% forest cover). Abandoned land without production or multifunctional use will be probably managed by governed succession to prevent forest spreading inside of rising meadow.

Build-up area under B2 scenario will rise in term of weak development of residential areas, weak growth of provincial towns Domazlice and Horsovsky Tyn and maintaining few of bio-agricultural farms. Although under A1 scenario rural landscape will be opened to recreation (hobby farming, horse-riding, biking, agri-tourism or cottage maintain) and various prospectus (energy-plant maintaining, light-industry or timbering). Absence of trade or industry cities and low accessibility does not bring transition of dominant agriculture to another production branch.

Under A1 scenario area of orchards goes down to half of the original area due to dying out of fruiters and absence of restoration. Under B2 scenario total area of orchards stays similar to original coverage due to inhabitants´ interest in cultural-historical values of village.

6.1.3 Transferability of Eururalis storylines across scales

A transferability of EURURALIS storylines and CLUE-s model configuration is prejudiced by operation of different drivers of land use change across European regions, countries and partial administrative units that have made variability in land use at that scales. Location factors differential such as climate, soil and historic socio-economic development have made Europe heterogeneous. It confirms Eururalis 2.0 team (2008) by creation of typology of European regions based on land use and economic significance of agriculture. It distinguishes peri-urban, nature, agri-high and agri-low regions that differ in individual drivers of land use change. The Czech Republic is falling into agri-low regions on account of

50% coverage of agricultural land that already inhibits economic growth. Thus most of Czech regional economy should be urban driven. Nevertheless, a registration of the case study area within agricultural Less Favoured Areas, focus on protected commodities, impossibility of strong industrial development within restricted Bohemian Forest and consequential subsidies have diminished economical defects of agriculture and kept it urban independent. Instead of population growth and urbanization, phasing of governmental intervention and market support out, and abolishing of Less Favoured Area concept present main drivers of land cover change under A1 scenario. Not urban sprawl, but abandonment of agricultural land and spreading of forest and serviceable buildings change pattern of study landscape. The same driving factor holds different trends across both European and Czech regions and affects a study system by different force level.

Similarly, B2 scenario illustrates different power of European policies between scales and study regions. Eururalis study considers effects of CAP (market protection and income support) and Bio-energy directive small. Contrary to that, within the study region, focus on livestock production, centralization of milk production, and shift to energy crops show strong influencing by mentioned policies. Under B2 scenario these policies work as main drivers of agricultural land preservation against abandonment.

As was mentioned before a location factor dependence on scale has not enabled simple reprinting of Eururalis study across scales. Both Eururalis storylines and consequential land use change simulation are case study specific. Contrary to EURURALIS scenario reprinting across scales, partial scenario invention at local unit seems more effective. It does not exclude global driving factors and European policies. Inhabitants and farmers are main stakeholders, who should play a key role in the formulation of research because they are the future users of the results (Stoorvogel and Antle, 2001).

6.1.4 Role of data availability

CLUE-s model (Veldkamp and Fresco, 1996; Verburg et al, 2002) was originally developed to simulate land use change using empirically quantified relations between land use and its driving factors in combination with dynamic modelling of competition between land use types. Due to unavailability of socio-economical (illiteracy, income etc.) and statistical (employment, migration etc.) data in spatial format, unsuitable extent and insufficient availability of complex biophysical (soil properties, water logging etc.) data modelling procedure is limited to quantification of relation between main land cover classes and primarily accessibility factors. Modelling of competition between land cover classes need to be supplemented by location specific preference addition.

The preference of a location for certain land cover is based more on neighbourhood characteristics and accessibility factors than on bio-physical and socio-economic determinants of land use change. Only three biophysical factors altitude, slope and orientation of plots could continuously cover whole area of rural region in fine resolution thanks to opportunity to derive them from data Zabaged® (CUZK, Prague). Hydrology and price of land deprivation derived from database of soil-ecological units so-called BPEJ are only relevant for agricultural land because of their original tasks of agricultural land validation. BPEJ validation scale could serve more for derivation of parameters for crop distribution simulation (CLUE group, 2004) than for land use change simulation. Available climate characterization derived from BPEJ divided the case study area into two climate regions with approximated values of temperature and precipitation. Micro-climatological characteristics are not necessary to explore for basic land cover change analysis that try to grasp possible future instead of attempting to give the best prediction (Verburg et al, 2008) although climate factors can influence speed of succession on abandoned land (Eururalis 2.0, 2008). Ratio of ecological stability (Vondruskova, 1994) and nature conservation policies derived from landscape mapping showed strong correlation with location of natural and semi-natural land covers (forest and meadows). A collection of all biophysical and ecological factors for land use change analysis through field observation is not pretty suitable due to time- and money-severity (Uran and Jansen, 2003).

Application of integrated scenario and modelling tools at the level of Czech regions has to be accompanied by data standards development in fine spatial resolution. It can enable to follow EURURALIS study´s goals. Eventual exploring of qualitative instead of quantitative or mixed scenarios can diminish overall demandingness of scenario assessment. Using of these tools has to be forgoing by extensive research of available methodology (Stoorvogel and Antle, 2001) and by interconnected persuasion of Czech politicians about immediate need of landscape planning tools (Semancikova et al, 2008).

6.2 Implication of Eururalis scenarios within the case study area

6.2.1 Implications: digestibility and contrast

Based on application of EURURALIS study at regional scale we can render a ratio of buildings development at abandoned agricultural land under A1 scenario, estimate a rate of forest spreading under both A1 and B2 scenarios or project a replacement of arable fields by grassland under B2 scenario. As mentioned before, Eururalis offered an opportunity to identify major processes and the range of possible future at regional scale, although reformulation of A1 scenario across scales reduced digestibility of storyline for users. Although main processes identified by Eururalis team were urbanization and nature development at abandoned land, at regional extent a population rate is limited by small residential potential of agricultural landscape, absence of jobs, services and well-working infrastructure. Second non-executed paradigm in addition to loss of digestibility caused by scenario reformulation across scales is to keep contrast between scenarios to make following discussion meaningful. Indeed A1 and B2 scenarios are more contrastive at regional scale in potential societal effects than land use change. Within both of the scenarios, abandonment of agricultural land play key role.

6.2.2 Role of uncertainty

Application of Eururalis scenarios at the case study region revealed strong dependency of current landscape pattern on European policies (Bio-energy directive, Common Agricultural Policy, Less Favoured Areas concept and partly Nitrate directive). A presumption of an inclination to animal welfare and bio-agricultural principles reduce negative effects of agriculture extensification under B2 scenario, what moderates changes within the landscape pattern. Sociological research should take place within perception of biofuels and biological agriculture that play important role within B2 scenario. To answer question if inhabitants interested in cultural value can tolerate new crops cultivation and different management is not possible without interdisciplinary group of researchers.

Role and intensity of environmental ideas within agricultural sector is insignificant under A1 scenario because agriculture is not kept in discussion. Vague description of regional development under Global Economy scenario by focus on core responsibilities, e.g., health or education, and market-oriented solution without governmental intervention does not give clear picture about the role of rural areas and lead to reduction of digestibility by scenario users. Similarly, rate of hobby-farming favour and agri-tourism services maintaining under A1 scenario is unreliable. These rates need to be reviewed by sociologists as same as succession speed at the abandoned arable field by succession experts, who will take into account soil conditions, climate factors or previous management.

In fine, there is only one certainty present if we compare futures with and without supporting European and domestic trade policies, the case study area future without mentioned support will bring huger abandonment of agricultural land and spontaneous nature development than future with these policies.

6.3 Discussion above methodological sequence

6.3.1 As accurate as we are able to describe a study area

Well-selected pixel size presents important factor for all land cover/use analysis (Tucek, 1998). One grid cell size was measured by area of the smallest defined land cover element (water body of 190 square meters) divided by the number of land cover classes (7). This assessment guaranteed minimal losses of data during digitalization and files conversion from vector to raster (Verburg et al, 2008), although simulation maps show large deviations between required and allocated change. Preciseness of entrance data was flushed away through broad configuration of iteration parameters of allocation procedure. In addition, preciseness of the procedure is influenced by strong differences between areas of land cover types and disproportionate allocation probability of land cover types. CLUE-s´ simulation result is as accurate as we know and are able to describe the case study area. It follows a description that the case study region is falling down thanks to inaccuracy of logistic regression that is based mainly on accessibility factors. Within the case study location specific setting presents only one solution for diminishing of statistical analysis insufficiency. Thanks to this parameter, a new build-up area is allocated around existing residential areas and forest is spreading along its edges. Another disturbance based on unfitting regression results is visible at simulating maps – fallow is stronger competitor in the southern part of the case study area and draw grassland from this area out. It is confusing in term of A1 scenario that is connected with decrease of grassland area, although new replaced plot is created on the western boundary creates. The point is that fallow is a land cover type for which the suitable location does not exist. Indeed regression results are needed as base for probability map calculation.

6.3.2 Methodological assessment within calculation of land requirements

In general, the calculation of land requirements is based on the range of methods, although the extrapolation of trends of the recent past into the near future is a common technique. Within submitted case study land demands were estimated partly by extrapolation of trends from 1973 to present and partly by interpolation of EU trends indicating within Eururalis 2.0 project (2008). Pure exploring of land cover change from 1973 to 2008 did not offer opportunity for trend extrapolation because of revolutionary year 1989 that completely changed drivers of these changes. Separation of pre- and post-revolutionary contribution to total land cover change was highly difficult. This hybrid method could be replaced by extrapolation of local trends 10 years apart (Verburg et al, 2007) although other background than aerial photographs need to be used for historical land use pattern indication. Just weak differentiation capability of aerial photographs does not enable fine resolution of permanent and temporary crops or intensive grasslands and (semi)natural meadows that is needed in all land use simulations (CLUE group, 2004). The simulation of individual crops makes easier comparison and discussion with agronomist, who are more oriented on individual commodities than land use types (Verburg and Veldkamp, 2001). In the environment of the Czech Republic data ZABAGED® (CUZK, Prague) or cadastral maps could be used. It eliminates time-consuming, spatial distortion and unsuitable resolution for land use type differentiation.

6.3.3 Multidisciplinary approach within methodological sequence

The discussion above illustrates need of specific methodological sequence for dynamic modelling of regional land cover/use change and scenario formulation. Within submitted case study land cover and use dynamics are explored, although strength of micro-level approaches is adherent to the explanation of the processes leading to behaviour differentiation (Verburg and Veldkamp, 2001). We did not explore employment, incomes, and willingness of local inhabitants or effects of climate changes. Indeed scenarios as part of integrated studies need to be divided by sociological, economical, geographical and ecological disciplines (Verburg and Veldkamp, 2001). An inaccurate simulation of forest spreading into abandoned land or insufficient insight into environmental and economical impacts of land cover changes need to be explored by specialists. In the next step, 3P indicators (People, planet and Profit) should be used for land cover change implication in spatial planning policies.

7 CONCLUSIONS

Eururalis scenarios application at 30-square-kilometers-large watershed helped to depict main land cover conflicts and synergies instead of exact grasp of contrasting futures and predictions. Under A1 scenario not urbanisation, but agricultural land abandonment and consequential building-up and forest spreading change landscape structure. The case study area is highly dependent on European subsided policies and governmental interventions. By comparison of futures with and without supporting European and domestic interventions and subsidies, we take the view of the case study area without mentioned support, which is bringing huger abandonment of agricultural land and spontaneous nature development than future with these policies. Under Global Economy an open landscape of arable fields will be closed by spontaneous succession, under Regional Communities gets mosaic structure.

A reformulation of scenarios across scales reduces digestibility of storylines for users and does not keep contrast for meaningful discussion. Each of different scenarios needs to be specified to the situation and to a case study region because different location factors and drivers operate across European regions, countries and Czech rural regions. Discussion with stakeholders may help to discover behaviour habits, explore scenario and suggest a storylines of potential development and determine the selection of concrete modelling tool. Results cannot be transferred to the users effectively without sophisticated selection of communication path and language.

Within application of scenarios at the case study area, the role of uncertainty is high. To answer questions if inhabitants interested in cultural value can tolerate new crops cultivation and bio-agriculture management or how deep hobby-farming and agri-tourism favour can be is not possible without interdisciplinary group of researchers and integrative effort. An integrative planning process using quantitative scenarios and dynamic modelling at the case area level need to be processed through solving of specific issues dealing with data unavailability, high punctuality, time-severity and interconnected cost intensity. During the development of methodologies, minimum data sets need to be defined and evolved.

8 REFERENCES

Abler, D., 2003. Adjustment at the Sectoral Level, An IAPRAP workshop on Policy Reform and Adjustment [online]. UK: The Wye Campus of Imperial College. Available at: http://agadjust.aers.psu.edu/Workshop_files/Abler_presentation.pdf, [cite 12-3-2009].

Alcamo, J., Ribeiro, T., 2001. Scenarios as Tools for International Environmental Assessments. Environmental issue report 24, p. 6-29.

Anderson, K., Valenzuela, E., 2007. Do Global Trade Distortions Still Harm Developing Country Farmers? Washington, D.C.: Development Research Group, The World Bank, 41p.

Antimiani, A., Conforti, P., Salvatici, L., 2008. Measuring Restrictiveness of Bilateral Trade Policies: A Comparison between Developed and Developing Countries. Review of World Economics 144(2), p.207-224.

Becka, D., Vasak, J., Zukalova, H., Miksik, V., 2007. Repka ozimna: pestitelsky radce. Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague. Publishing Kurent, s.r.o., 60p.

Berger, G., 1964. Phénoménologie du Temps et Prospective. Paris: Presses Universitaires de France.

Bertrand, G., Michalski, A., Pench, L., 1999. Scenarios Europe 2010: Five possible futures for Europe. Working paper of European Commission Forward Studies Unit [online]. Available at: http://ec.europa.eu/comm/cdp/scenario/scenarios_en.pdf, [cite 2007-9-5].

Brockmeier, M., Pelikan, J., 2008. Agricutural market access: A moving target in the WTO negotiations? Food Policy 33, p. 250–259.

Brown, S., Hall, M., Andrasko, K., Ruiz, F., Marzoli, W., Guerrero, G., Masera, O., Dushku, A., DeJong, B., Cornell, J., 2007. Baselines for land-use change in the tropics: application to avoided deforestation projects. Mitig Adapt Strat Glob Change 12, p. 1001–1026.

Buson, M., 2007. Scenario planning resources. In: What is scenario planning? [online]. Available at: http://www.well.com/~mb/scenario_planning/, [cite 2007-9-5].

Bouwman, A.F., Kram, T., Klein, G.K., 2006. Integrated modelling of global environmental change. An overview of IMAGE 2.4. Netherlands Environmental Assessment Agency (MNP), Bilthoven, the Netherlands. 228p.

Carpenter, S.R., Pingali, P.L., Bennett, E.M., Zurek, M.B., 2005. Ecosystems and Human Well-being: Scenarios, Volume 2: findings of the Scenario Working Group of the Millenium Ecosystem Assessment, 536p.

Castella, J.C., Verburg, P.H., 2007. Combination of process-oriented and pattern-oriented models of land-use change in a mountain area of Vietnam. Ecological modeling 202, p. 410-420.

Claessens, L., Hopkinson, C., Rastetter, E., Vallino, J., 2006. Effect of historical changes in land use and climate on the water budget of an urbanizing watershed. Water ResourcesResearch 42 (3), p. 1793-1801.

The CLUE Group, 2004. Manual for the CLUE-S model. The CLUE Modelling Framework, The Netherlands, 47p.

Crissman, C.C., Antle, J.M., Capalbo, S.M., 1998. Economic, environmental, and health tradeoffs in agriculture: pesticide and the sustainability of Andean potato production [online]. Kluwer Academic Publishers, Boston, USA. 281pp. Available at: http://books.google.com/books?hl=cs&lr=&id=2KuQpa_Rb_EC&oi=fnd&pg=PR15&dq=Economic,+environmental,+and+helath+tradeoffs+in+agriculture:+pesticide+and+the+sustainability+of+Andean+potato+production&ots=JjXNId8aJg&sig=lAvkRymoMKjL5XhAE_6A4QAW1X4, [cite 2009-13-1].

Culek, M., et al, 2005. Biogeograficke cleneni CR II. díl. Praha: AOPK ČR, 590p.

Culek, M., et al., 1995. Biogeograficke cleneni CR. Praha: Enigma, s.r.o., 347p.

Demek, J., 1987. Obecna geomorfologie. 1.vyd. Praha: Academia, 476p.

Dudak, 2005. Ceský les, priroda-historie-zivot. 1.vyd. Praha: Baset, 880p.

Echeverria, C., Coomes, D.A., Hall, M., Newton, A.C., 2008. Spatially explicit models to analyze forest loss and fragmentation between 1976 and 2020 in southern Chile. Ecological modelling 2 1 2, p. 439–449.

Eickhout, B., Van Meijl, H, Tabeau, A., Van Rheenen, R., 2006. Economic and ecological consequences of four European land use scenarios. Land Use Policy 24, p. 562–575.

Eickhout, B., Van Meijl, H, Tabeau, A., Stehfest, E., 2008. The Impact of Environmental and Climate Constraints on Global Food Supply. GTAP Working Paper No. 47, 49p.

European Comission, 1992. Development of framework for the evaluation of policy options to deal with the greenhouse effect. Brussel: Comission of the European Community, Directorate General for Environment, Nuclear Safety and Civil Protection, p.22.

European Comission, 2005. Winning the battle against global climate change. Communication from the Comission to the Council, the European Parliament, the European Economic and Social Comittee and the Comitee of Regions. Brussel: European Comission, p. 17.

European Environmental Agency (EEA), 2007. Land use scenarios for Europe: qualitative and quantitative analysis on a European scale. EEA Technical report 9, 76p.

EURURALIS 1.0, 2004. [online]. Available at: http://www.eururalis.eu/eururalis1.htm, [cite 20-1-2008].

EURURALIS 2.0, 2008. [online]. Available at: http://www.eururalis.eu/eururalis2.htm, [cite 4-3-2009].

Fahey, L., Randall, R.M., 1998. Using Scenarios for Strategic Planning. In: Learning from the future [online]. Available at: http://www.aphis.usda.gov/vs/cvb/scenarios/appendix.htm, [cite 2007-9-5].

Godet, M., 1987. Scenarios and Strategic Management. London: Butterworths.

Hall, C.A.S., Tian, H., Pontius, G., Cornell, J., 1995. Modelling spatial and temporal patterns of tropical land use change. Journal of Biogeography 22, p.753-757.

Havlikova, L., 2005. Protokol o analyze vody v koupalisti Podhaji. Horsovsky Tyn: Municipal office. 5p.

Hertel, T.W., 1997. Global trade analysis: modelling and applications. UK: Cambridge University Press, 402p.

Howe, D., 2004. Planning Scenarios: Executive Summaries, Created for Use in National, Federal, State, and Local Homeland Security Preparedness Activities [online]. Available at: http://cryptome.org/15-attacks.htm, [cite 2007-10-12].

IMAGE team, 2001. Implementation of the SRES scenarios: Climate Change scenarios resulting from runs with several GSMs. CD-ROM publication. The Netherlands: National Institute for Public Health and the Environment, Bilthoven.

Jilek, T., 2005. Dejiny in Cesky les, priroda-historie-zivot. Praha:Baset, 880p

Kahn, H., Wiener, A.J., 1967. The Year 2000. New York: MacMillan.

Kempen, T., ten Haaf, W., Stuiver, H. J., 2006. Introduction Geo-Information Science: Practical manual. Laboratory of Geographical Information Science and Remote Sensing, Centre for Geo-Information, Wageningen University, the Netherland, 182p.

Klijn, J.A., Vullings, L.A.E., van den Berg, M., van Meijl, H., van Lammeren, R., van Rheenen, R., Tabeau, A.A., Veldkamp, A., Verbung, P.H., Westhoeck, H., 2005. The EURURALIS study: Technical document. Alterra-rapport 1196. Alterra, Wageningen, 215p.

Kok, K., Winograd, M., 2002. Modelling land-use change for Central America, with special reference to the impact of hurricane Mitch. Ecological Modelling 149, p. 53-69.

De Koning, G.H.J., Veldkamp, A., Fresco, L.O., 1999. Exploring changes in Ecuadorian land use for food production and their effects on natural resources. Journal of Environmental Management 57(4), p. 221- 237.

Lesschen J.P., Verburg P.H and Staal S.J., 2005. Statistical methods for analysing the spatial dimension of change in land use and farming systems - LUCC Report Series 7. International Livestock Research Institute, Kenya and LUCC Focus 3 Office of Wageningen University, 80p.

LIU, C.K., KUO, N-F., HSEU, J.S., 2005. Effects of tariff liberalization on the global forest sector: application of the GTAP model. International Forestry Review 7 (3), p.218-226.

Lu, Y-C.,Teasdale, J.R., Huang, W-Y., 2003. An Economic and Environmental Tradeoff Analysis of Sustainable Agriculture Cropping Systems. Journal of Sustainable Agriculture 22(3), p.25-41.

Matthews, R.B., Gilbert, N.G., Roach, A., Polhill, J.G., Gotts, N.M., 2007. Agent-based land-use models: a review of applications. Landscape Ecology 22, p. 1447–1459.

Nakicenovic, N., Alcamo, J., Davis, G., de Vries, B., Fenhann, J., Gaffin, S., Gregory, K., Grubler, A., Jung, T.Y., Kram, T., La Rovere, E.L., Michaelis, L., Mori, S., Morita, T., Pepper, W., Pitcher, H.M., Price, L., Riahi, K., Roehrl, A., Rogner, H-H., Sankovski, A., Schlesinger, M., Shukla, P.,; Smith, S.J., Swart, R., van Rooijen, S., Nadejda, V., Zhou, D., 2000. Special Report onEmission Scenarios. IPPC Special Reports. NY: Cambridge University Press, p.599.

Nijkamp, P., Wang, S., Kremers, H., 2005. Modeling the impacts of international climate chase policies in a CGE context: The use of the GTAP-E model. Economic Modelling 22, p. 955– 974.

Novakova, B., 1991. Zemapisny lexikon CR, Obce a sidla. Praha: Academia, 604p.

Overmars, K.P., De Groot, W.T., Huigen, M.G.A., 2007. Comparing inductive and deductive modelling of land use decisions: Principles, a model and an illustration from the Philippines. Human Ecology 35, p. 439-452.

Pontius, R.G, Cornell, J.D., Hall, C.A.S., 2001. Modeling the spatial pattern of land-use change with GEOMOD2: application and validation for Costa Rica. Agriculture, Ecosystems and Environment 85, p. 191–203.

Pontius, r.G., Huffaker, D., Denman, K., 2004. Useful techniques of validation for spatially explicit land-change models. Ecological Modelling 179, p. 445–461.

Pontius, R.G., Schneider, L.C., 2001. Land use change model validation by an ROC method for the Ipswich watershed, Massachusetss, USA. Agriculture, Ecosystems and Environment 85, p. 239-248.

Quitt, E., 1971. Klimaticke oblasti Ceskoslovenska. 1.vyd. Brno: Geografický ústav ČSAV, 73p.

Rotmans, J., 1990. IMAGE: An Integrated Model to Assess the Greenhouse Effect [online]. Maastricht: Springer, 289 p. Available at: http://books.google.com/books?hl=cs&lr=&id=VSgJZVkKXrkC&oi=fnd&pg=PT9&dq=The+Integrated+Model+to+Assess+the+Global+Environment&ots=lcBR56qtkt&sig=b7BOfcazAQ2r2hXgICJcqCuOzts, [cite 2008-12-10].

Semancikova, E., Mach, J., Holcova, V., Liskova-Dvorakova, Z., Strakova, J., 2008. Vliv ridicich faktoru na vnimani krajinne problematiky a budouci vyuzivani uzemi. Unpublished.

Schoorl, J.M., Veldkamp, A., Fresco, L.O., 1997. The Conversion of Land Use and its Effects (CLUE-CR): a regression based model applied to Costa Rica (Pascal version 1.2). Quantitative approaches in Systems Analysis 8, p.1-53.

Stoorvogel, J.J., Antle, J.M., 2001. Regional land use analysis: the development of operational tools, Agricultural Systems 70, p. 623–640.

Stoorvogel, J.J., Antle, J.M., Crissman, C.C., Bowen, W., 2004. The Tradeoff Analysis Model: Integrated Bio-physical and Economic Modeling of Agricultural Production Systems. Agricultural Systems 80, p. 43-66.

Strakova, J., 2006. Vyvoj krajiny a analyza prostorove struktury v povodi Mracnickeho a Podhajskeho potoka. Bacchelor thesis. Fakulty of Biology, University of South Bohemia, 60p.

Tchir, T.L., Johnson, E.A, Miyanishi, K., 2004. A model of fragmentation in the Canadian boreal forest. Canadian-Journal-of-Forest-Research 34 (11), p. 2248-2262.

Tucek, J., 1998. Geograficke informacni systemy, Principy a praxe. Praha: Computer Press. 424p.

UNEP/RIVM, 2003. Quantifying Four scenarios for Europe. CPB Netherlands Bureau for Economic, CPB document 38, 67p.

Uran, O., Jansen, R., 2003. Why area spatial decision support systems not used? Some experiences from the Netherland. Computers, Environment and Urban Systems 27, p. 511-526.

Veldkamp, A., Fresco, L.O., 1996. CLUE: a conceptual model to study the Conversion of Land Use and its Effects. Ecological Modelling 85(2-3), p.253-270.

Verbung, P.H., Soepboer, W., Veldkamp, A., Limpiada, R. and Espaldon, V., 2002. Modeling the spatial dynamics of regional land use: the CLUE-S model. Environmental Management 30 (3), p. 391 - 405.

Verburg, P. H., Veldkamp, A., Bouma, J., 1999a. Land use change under conditions of high population pressure: the case of Java. Global Environmental Change 9(4), p. 303-312.

Verburg, P., Sonneveld, M., Stoorvogel, J., 2008. Multi Functional Land Use. Lecture notes LAD32306 of the Wageningen University, 408p.

Verburg, P., Veldkamp, T., Lesschen, J.P., 2007. Exercises for the CLUE-S model. The CLUE Modelling Framework, The Netherlands, 33p.

Verburg, P.H., de Koning, G.H.J., Kok, K., Veldkamp A., Bouma, J., 1999b. A spatial explicit allocation procedure for modelling the pattern of land use change based upon actual land use. Ecological Modelling 116, p. 45-61.

Verburg, P.H., van Eck, J.R., de Nijs, T.C.M., Dijst, M.J., Schot, P., 2004. Determinants of land use change patterns in the Netherlands. Environment and Planning 31, p. 125-150.

Verburg, P.H., Veldkamp, A., 2001. The role of spatially explicit models in land-use change research: a case study for cropping patterns in China. Agriculture, Ecosystems & Environment 85 (1-3), p. 177-190.

Verburg, P.H., Soepboer, W., Veldkamp, A., Limpiada, R., Espaldon, V., Mastura, S.S.A., 2002. Modeling the Spatial Dynamics of Regional Land Use: The CLUE-S Model. Environmental Management 30(3), p.391-405.

Vondruskova, H., 1994. Metodika mapovani krajiny. Praha: Ceský ustav ochrany prirody, 55s.

Weger, J., 2009. Rychle rostouci dreviny jako energeticke plodiny druhe generace a jejich potencial v CR a EU [online]. Available at: http://www.veda.cz/article.do?articleId=42320, [cite 2009-2-4].

Westhoek, H.J., van den Berg, M., Bakkes, J.A., 2006. Scenario Development to Explore the Future of Europe's Rural Areas. In: Agriculture, Ecosystems and Environment 114, p. 7-20.

Wikipedia, the free encyklopedia, 2006. Scenario planning [online]. Available at: http://en.wikipedia.org/wiki/Scenario_planning, [cite 2007-9-5].

Wollenberger, E., Edmunds, D., Buck, L., 1999. Using scenarios to make decission about the future: anticipatory learning for the adaptive co-management of community forests. In: Landscape and Urban Planning 47, p. 65-77.

Zahradnicky, J., Mackovcin, P., et al, 2004. Chranena uzemí CR XI., Plzensko a Karlovarsko. Praha: AOPK CR a Brno: EkoCentrum. 588p.

Indexes:

1: VGHUR, Dobruska= Military-geographical and -hydrometeorological department

2: CUZK, Prague= Czech geodesic and cadastral department

3: VUMOP, Prague= Research institute of amelioration and soil conservation

9 APPENDI

9.1 Water analysis in Podhaji pond and Mracnicky brook

9.1.1 Results of chemical analysis (Havlikova, 2005)

Location of sampling	**Podhaji pond - inflow**	**Podhaji pond - inflow**	**Podhaji pond - runoff**	**Podhaji pond - runoff**	**Mracnicky brook**
Date of sampling	**2.5.2005**	**30.5.2005**	**2.5.2005**	**30.5.2005**	**30.5.2005**
Ammonia (mg/l)	0,2	0,4	0,2	0,4	0,4
Nitrite (mg/l)	0,6	0,6	0,5	0,5	0,6
Nitrate (mg/l)	10	15	10	15	20
pH	8	8	8	8	8
Phosphate (mg/l)	0,25	0,5	0,3	0,3	0,3
Hardness of water (mmol/l)	1,3	1,9	1,3	1,9	2,2
Carbonate hardness (mmol/l)	1,2	1,8	1,2	1,9	2,2
Phenol	without smell	without smell	without smell	without smell	without smell
Mineral oil	absent	absent	absent	absent	absent
Anionic surfactants	without foam	without foam	without foam	without foam	without foam
Viseble pollution	medium	medium	medium	medium	medium

9.1.2 Interpretation of chemical analysis (Havlikova, 2005):

Quality of water falls into group of medium pollution exclude nitrates that are in the area of strong pollution. Values at the inflow and runoff of Mracnicky brook are almost equal. It follows that undesirable compounds are present already at inflow (in the Mracnicky brook)

9.2 Input data sources and data application

Input data	Application	Source of data
Historical land cover/use (build-up area, arable land, grassland, orchard, forest, solitaire trees, water body, fallow)	Formation of digital layer of historical land cover/use Extrapolation of land cover/use changes	Aerial photographs from 1973 (VGHUR=Military-geographical and -hydrometeorological department, Dobruska)
Present land cover/use	Formation of digital layer of current land cover/use Extrapolation of land cover/use changes Collecting of landscape characteristics Essential for all land use simulation	Orthographically rectificated aerial photographs (CUZK=Czech geodesic and cadastral department, Prague) *Landscape mapping (Vondruskova, 1994)
Current landscape structure and potential	Estimation of explanatory factors of land use allocation	*Landscape mapping (Vondruskova, 1994)
Geomorphology	Basic descriptor of geologic-pedologic-hydrologic- species distribution relationship and explanatory factor of land use allocation	Literacy review (Demek, 1987)
Geology	Explanatory factor of land cover/use allocation/change	Geological survey for documentation of regional system of ecologic stability
Pedology and physical properties of soil	Explanatory factor of land cover/use allocation/change Physical properties of soil essential for crop yield simulation Pedology essential for all simulation, choice depends on local conditions	Digital BPEJ map (VUMOP=Research institute of amelioration and soil conservation, Prague) Pedological survey for documentation of regional system of ecologic stability
Hydrology	Explanatory factor of land use change	CHMU(Czech hydrometeorological department, Prague)

Input data	Application	Source of data
	Essential for all simulation, choice depends on local conditions	Chemical analysis (Havlikova, 2005)
Climate (precipitation, temperature)	Explanatory factor of land cover/use allocation/change Essential for all simulation, choice depends on local conditions	Literacy review (Quitt, 1971) CHMU(Czech hydrometeorological department, Prague)
Topography (altitude, slope, aspect)	Explanatory factor of land cover/use allocation/change Essential for all simulation, choice depends on local conditions	Data ZABAGED (CUZK=Czech geodesic and cadastral department, Prague)
Geography (distance from city, road etc.)	Explanatory factor of land cover/use allocation/change Essential for all simulation, choice depends on local conditions	Land cover/use map, data ZABAGED (CUZK=Czech geodesic and cadastral department)
Biogeography	Basic descriptor of biogeographical relationships Explanatory factor of land cover/use allocation	Literacy review (Culek, 1995 and 2005)
Zoology	Basis for appropriate nature conservation and area restriction Essential for ecological stability simulation	Zoological survey for documentation of regional system of ecologic stability
Potential natural vegetation	Basis of naturalness and for appropriate nature conservation and area restriction Understanding of land cover/use allocation/changes	Geo-botanic map *Landscape mapping (estimating of naturalness of landscape units, Vondruskova, 1994)

Input data	Application	Source of data
	Essential for ecological stability simulation	
Nature and landscape conservation	Basis for appropriate area restriction	*Landscaper mapping (estimating of degree of ecologic stability, identification of important landscape units) Literacy review (Zahradnicky et al, 2004) Laws and public notices
History	Understanding of land cover/use changes	Archive materials Literacy review (Jilek, 2005 in Dudak, 2005)
Socio-economy (population density, labour force, illiteracy, incomes, rate of commuting, social facilities)	Explanatory factor of land cover/use allocation Understanding of land use changes Optional when considered important proxy for driving force	Archive materials Statistical datasets and year-books of FSU(Federal hydrometeorological department), CSU(Czech hydrometeorological department) **Questionnaire Literacy review (Novakova, 1991; Dudak, 2005)
Agricultural characteristic and development (fertilization, management)	Explanatory factor of land use allocation/change Understanding of land use changes Essential for crop yield simulation	Interview with leaders of agricultural company Year-books, archive materials

*Landscape mapping and **Questionnaire: see chapter Methodology

9.3 *Mapping clue*

9.3.1 Mapping clue for arable land, garden, grassland, forest and fallow

code **Value of Ecolo-gical stability**	**1-** **Arable land**	**2-** **Hop-garden** **Vineyard** **Garden**	**3-** **Orchard**	**4-** **Grassland**	**5-** **Forest** **Tree-grow cover** **Tree-grow edges**	**6-** **Fallow**
5				41- natural, alpine	51- natural and nature-close 52- nature-close, 60% of natural composition 57- natural edges	61.1- herbal 62.1- with trees 63.3- woody
4			31- small-scale, extensive Herbal horizon includes important, preserved or natural species of plants	42.1- natural and nature-closed with majority of natural species	53- semi-cultural, undeveloped societies, mixed stand 30-60% of natural species 58- edges, nature-closed	61.2- herbal 62.2- with trees 63.2- Woody, nature-closed, without ruder species
3		26- gardens Small-scale Grassed	32- small-scale, extensive Majority of natural plant species	42.2- nature-closed, poorer in species 43- semi-cultural, intensive, with few of natural species	54- cultural, monocultures 59- cultural edges, monocultural 59- degraded edges	61.3- herbal 62.3- with trees 63.3- woody, disturbed

code Value of Ecolo-gical stability	1- Arable land	2- Hop-garden Vineyard Garden	3- Orchard	4- Grassland	5- Forest Tree-grow cover Tree-grow edges	6- Fallow
2		22- small-scale vineyard 27- small-scale intensive gardens with arable land	33- large-scale, grassed, intensive	44- cultural, intensive, fertilized, poor in species	55- degraded, destroyed by imissions, with ruder species, cover of black locust 56- seed plantation	61.4- herbal 62.4- with trees 63.4- degraded, woody, with ruder species
1	11-basic 12-small-scale 13-disturbed by erosion	21- hop-garden 23-large-scale vineyards 24- small-scale with fruit-trees 25- large-scale with fruit-trees 28- gardens	34- large-scale, at arable land			61.5- without or almost without vegetation
0						

9.3.2 Mapping clue for line societies and solitaire trees, rocks, wetlands, brooks, residential and build-up areas and roads

KOD / SES	7- Line societies Solitaire trees	8- Rock and debris 9- Wetland	10- Water bodies	11- Water flows, brooks	12-Residential areas and objects out of towns	13- Roads, pathways, dumps
5	71.1- herbal 72.1- with trees 73.1- woody natural	8 01- natural 9 01- natural	10 01- natural 10 02- nature-closed, transient zone developed	11 01- natural, without management, well-developed societies		
4	71.2- herbal 72.2- with trees 73.2- woody, nature-closed, without ruder species	8 02- disturbed 9 02- disturbed	10 03- nature-closed, disturbed transient zone	11 02- natural, small-scale management, developed societies		
3	71.3- herbal 72.3- with trees 73.3- woody, semi-cultural 72.4- cultural 73.4- cultural	8 03- highly disturbed 9 03- highly disturbed	10 04- managed, modified transient zone	11 03- managed, small-scale disturbance of societies	12 01- gardens, parks, cemeteries 12 02- cottage camps 12 03- build-up area	13 01- nonconsolidated grassed pathways
2	71.4- herbal 72.5- with trees 73.5- woody, degraded, majority of ruder species 74- solitaire trees (ecological		10 05-man-made, without transient zone	11 04- managed, highly disturbed shore societies	12 04- build-up area of villages/towns (veget.20-50%) 12 05- cottage camps (veget. 20-50%)	13 02- nonconsolidated pathways with disturbed societies of plants

KOD **SES**	**7-** **Line societies** **Solitaire trees**	**8- Rock and debris** **9- Wetland**	**10- Water bodies**	**11- Water flows, brooks**	**12-Residential areas and objects out of towns**	**13- Roads, pathways, dumps**
	stability 2-4)					
1			10 06- man-made, betony-made	11 05- man-made, consolidated channel		13 03- nonconsolidated pathways without vegetation 13 08- dumps with growing-up vegetation
0					12 06- build-up area of towns 12 07- agricultural and serviceable buildings	13 04- consolidated pathways 13 05- roads of first class 13 06- roads of first class and highway 13 07- railway 13 09- dumps 14 00- consolidated areas

9.4 Classification clues

9.4.1 Hydrological range derived from landscape mapping

Code	Characteristic
0	Build-up areas
1	Flat dry or drying soil
2	Flat sandy soil
3	Normal soil
4	Waterlogging soil with contact with ground water
5	Wet soil a)running b)stagnant
6	Peat soils
7	Water bodies

9.4.2 Hydrological range derived from soil-ecological values (BPEJ)

Code	Main soil unit
7	Build-up areas
6	Water bodies
5	12, 43, 67, 69, 73 (waterlogging)
4	08, 39, 68 (unfavourable)
3	13, 23, 37, 40, 72 (dependent)
2	32, 64 (favourable)
1	11, 14, 29 (highly favourable)

9.4.3 Societal facilities

Code	Characteristic
0	Out of villages
1	Traffic unavailability, without shops, schools, services, medical centre
2	Nearby other village with services
3	With food shop
4	With food shop, services
5	With food shop, school, pre-school, services, medical centre
6	Towns

9.4.4 Climate

Climate region	Average temperature (code)	Average precipitation (code)
Moderately warm region 2	7-8 (code 7)	550-650 (code 600)
Moderately warm region 4	6-7 (code 6)	650-750 (code 700)

9.4.5 Topographic aspects

Code	Characteristic
1	Flat
2	North
3	Northeast
4	East
5	Southeast
6	South
7	Southwest
8	West
9	Northwest
10	North

9.4.6 Nature conservation (restriction)

Code	Characteristic
0	Without protection
1	Bio-corridor
2	Important landscape aspect
3	Important landscape aspect and bio-corridor or bio-centre
4	Important landscape aspect and nature monument

9.5 Questionnaire

1. Name of your village ....

2. Age

a) Less than 18

b) 19 - 30

c) 31-45

d) 46-59

e) More than 60

3. Gender

a) female

b) male

4. Education

a) primary school

b) vocational certificate

c) graduation

d) university

5. Job

a) employee

b) businessman

c) student

d) pensioner

e) unemployee

f) housework

g) worker

h) another choice..

6. Orientation of your job

a) agriculture
b) industry
c) state administration
d) services
e) nongovernmental
f) forestry
g) private business
h) another choice………………………………………………………………

7. How long have you lived in your village?

a) 1 – 5 years
b) 6 – 10 years
c) More than 11
d) I was born there

*** 8. Why did you decide to live in your village?**

a) nature and landscape

b) availability of housing

b) job

c) ancestry

d) another choice………………………………………………………………

9. Do you commute?

a) not
b) less than 15 km
c) more than 15 km …………….how much? …………..

10. Eventually, why do you move out?

a) because of better job
b) because of housing
c) because of commuting
d) because of absence of shops, medical care, culture and traffic unavailability
e) another choice………………………………………………………………

11. How did your village change during last years?

1 – gets better

2 – gets better a bit

3 – stays same

4 – gets worst a bit

5 – gets worst

12. Was surrounding landscape changed?

a) yes, how? ....

b) not

c) I do not think about that

13.Was opportunities to get job in your village improved from 1990?

a) no, it is same, I must commute

b) no, it is same, I do not have problem with work in my village

c) it is getting better

d) it is getting worst, I had to start commute

***14. For better environment in your surrounding need to be:**

a) change agricultural management

b) better care about forest

c) restore hedgerows, pastures and meadows

d) restrict negative effects of industry and human activity

e) education about nature-friendly behaviour

f) revitalise brooks

g) educate local inhabitants about relationship with landscape and nature

h) another choice ……………………………………….

***15. Worst problems of neighbourhooding environment (1-5, 5 means worst)**

a) water pollution

b) runoff from arable land

c) decrease of agriculture

d) air pollution by cars and industry

e) air pollution by dust

f) unavailable transit through landscape

g) uncontrolled building-up

h) decrease of aesthetical values

i) another choice……………………………………….

16. What type of development do you prefer?

a) ***Support of intensive agriculture***

b) ***Support of tourism and recreation – pathways, hotels...***

c) ***Village support – services, housing...***

d) ***Landscape support – hedgerows, revitalization of brooks...***

17. What would you like to change in your village?

...

18. If you move out, what would you lack?

...