PLUREL

Land use relationships in rural-urban regions

Module No. 2

August 2010

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

D 2.4.2

Procedures and protocols to upscale results from high-resolution spatially-explicit development scenarios that can be found in the PLUREL-case-studies or in MOLAND – simulations to a generic level of the three units of rural-urban regions: rural - peri-urban – urban

Leipzig and Koper case studies

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SIXTH FRAMEWORK PROGRAMME

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PLUREL

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Abstract

Objectives

Report D2.42 describes the application of MOLAND model to Leipzig and Koper regions. On the first case, simulation of land use evolution (2000-2025), considered different scenarios developed by local stakeholders - “Business-as-usual”, “Hyper-Tech”, “Peak Oil” and “Fragmentation”.

Three scenarios were run for the Koper municipality from 2007 to 2025: Business as usual, Hyper-tech (A1) and Peak oil (B1). The parameters for the scenarios were set in collaboration with local stakeholders at the Plurel meeting in Koper in March 2009. The results for each scenario are broken down to community level whereby statistics are retrieved. Statistics per soil type classification are also extracted in order to facilitate analysis of impacts of each scenario on quality soil. Spatial metrics are also applied to the results of all scenarios, and can be used as a measure for sustainability at the municipality level.

Results

In the PLUREL framework, global IPCC/SRES scenarios have been downscaled and refined with the involvement of stakeholders for the select study areas.
For Leipzig, simulation of land use evolution (2000-2025), considered different scenarios developed by local stakeholders - “Business-as-usual”, “Hyper-Tech”, “Peak Oil” and “Fragmentation”.

Three scenarios were run for the Koper municipality from 2007 to 2025: Business as usual, Hyper-tech (A1) and Peak oil (B1). The parameters for the scenarios were set in collaboration with local stakeholders at the Plurel meeting in Koper in March 2009. The results for each scenario are broken down to community level whereby statistics are retrieved. Statistics per soil type classification are also extracted in order to facilitate analysis of impacts of each scenario on quality soil. Spatial metrics are also applied to the results of all scenarios, and can be used as a measure for sustainability at the municipality level.

Local storylines driving land use evolutions (although identified by the same scenario names) and input data are profoundly different for the two study cases. This has therefore resulted in fairly different land use projections. Therefore, comparisons and overall statements on common land dynamics behaviours are not always appropriate. Certainly the land dynamics observed in Koper and Leipzig are strictly linked to specific local characteristics and can not be generalized at wider geographical scale.

Aggregated land-use simulation results for artificial classes (including: residential, industrial, commercial, services and port/transport areas) according to the RUR classification are presented in the following table for the three commonly named scenarios.

	Urban (%)		Peri-urban (%)		Rural (%)	
	Koper	**Leipzig**	**Koper**	**Leipzig**	**Koper**	**Leipzig**
BAU	7.83	3.27	26.30	23.85	-21.60	20.09
HT	12.40	1.93	33.43	34.05	-15.00	47.70
PO	10.77	1.84	12.71	18.81	24.36	29.23

The most evident difference is given in the projected decrease of artificial classes in the RUR rural zone in Koper for the BAU and HT simulations, whereas these classes are significantly increasing in Leipzig. The explanation resides in the assumptions of the BAU and HT scenarios which foresee abandonment of rural areas in Koper, while the PO scenario favours the promotion of the agricultural sector.

Artificial classes in the RUR urban zone have reduced increment for all scenarios in Leipzig as result of both local storylines and also of the structural polycentric development of the area. Urban development is encouraged in Koper for the three scenarios in the RUR peri-urban zone.
Developments in the RUR peri-urban zones show rather similar trends for the two study areas, likely because these zones are the most prone to new expansions.

Popular science description

Scenario development is a well known tool for the assessment of land use changes in a large number of studies. Scenarios are not predictions; they are an approach to help manage decisions based on interpretation of qualitative descriptions of alternative futures translated into quantitative scenarios. We can learn from the past by tracing analogies between historical and current situations. Different future possibilities can be illustrated and compared by using our imagination, intuition and creativity to question what could we do if the assumptions occur.

The MOLAND Model has been applied to two areas (respectively Leipzig and Koper) to evaluate the impacts of scenarios and storylines developed by local stakeholders.

Results show that future land use projection strongly depend on local characteristics and historical developments of the area under examination.

The outputs of the MOLAND allow the stakeholders to evaluate – in a spatially explicit dimension – the consequences of assumptions and desiderata.

Classification of results/outputs:

Spatial scale for results: **Regional, national, European**	**Regional**
DPSIR framework: **Driver, Pressure, State, Impact, Response**	**Driver: Demographic** **Pressure: urban sprawl (increase of artificial areas)** **State: land use** **Impact: land use changes, lost of natural areas** **Response:**
Land use issues covered: **Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation**	**Housing, Industrial and commercial areas, Agriculture, Natural areas, Water**
Scenario sensitivity: **Are the products/outputs sensitive to Module 1 scenarios?**	**Yes. They incorporate the storylines that were developed within module 1.**
Output indicators: **Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions**	**Land use structure**
Knowledge type: **Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks**	**GIS-based maps – spatial scenarios**

How many fact sheets will be derived from this deliverable:	**2**

1 Introduction

PLUREL integrates five interdependent research modules. The task developed by Joint Research Centre – Institute for Environment and Sustainability (Land Management and Natural Hazards Unit) contributes to "Module 2: Land use relationships in rural-urban regions", more precisely to the work package 2.4 – Spatial Development Strategies and Scenarios (planning policies options) (fig. 1). The main goal of this module consists in translating general trends (driving forces) into demands on land use, to assess changes in rural, peri-urban and urban areas.

In this sense, Joint Research Centre, as the partner responsible for simulate land use changes, for the next 25 years, by implementing MOLAND model, developed a methodology in order to test planning policy options, and to understand and evaluate urban and peri-urban relationships, and to fulfil the specific objectives of the project (Nilsson & Nielsen, 2008):

- "Models and strategies to enhance the understanding and handling of relationships between rural, peri-urban and urban land uses;
- Study and model the demands and competition for resources in Rural-Urban regions;
- Land-use scenarios for Rural-Urban regions in Europe".

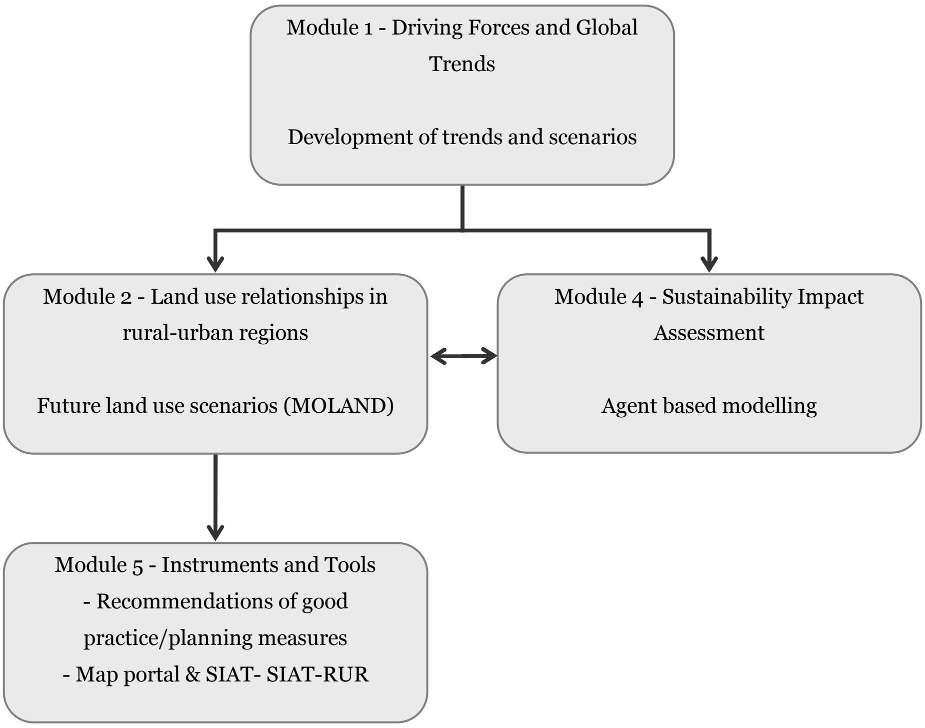


Fig. 1- Linkage between Moland model and other PLUREL modules

The present report aims to show the results of Leipzig and Koper case study, considering four scenarios – “Business-as-usual”, “Hyper-Tech”, “Peak Oil” and “Fragmentation”, and also provides a contribute to the production of PLUREL outcomes: “Data and map information portal”, and “Sustainability Impact Assessment Tool for Rural Urban Regions (SIAT-RUR)”.

The first part of this report shows a brief explanation about MOLAND model, followed by the methodology used to developed land use simulation, and then the results of Leipzig and Koper case-studies.

2 Moland model

MOLAND - is a powerful tool to help in the development of spatial planning policies, strategies and tools, by providing data related with land use dynamics.

Moland project began in 1998 (under the name of MURBANDY - Monitoring Urban Dynamics), with the aim to monitor the developments of urban areas and identify trends at European scale. In order to accomplish this goal several case studies across Europe were performed and some indicators were computed to access the impact of anthropogenic stress factors (Engelen, et al., 2007).

On the core of Moland is a cellular automata model, where "complexity emerges from interactions of very simple rules applied at local level in simple individuals i.e. cells. Hence the state of each cell in an array depends on the previous states of the cells within a neighbourhood, according to a set of transition rules" (Barredo, et al., 2005).

Considering that Moland was specifically developed for urban and regional simulation, and that its aims is to represent spatial dynamics, each cell corresponds to a different land use, and the change of the status of each cell depends on a set of parameters such as the inherent suitability for each land use, zoning restrictions, and accessibility of transport network, but also on the composition of the neighbourhood. To achieve this goal, the model incorporates several transition rules which establish the attraction or repulsion between different land uses (Lavalle, et al., 2004).

Moland requires a good knowledge of the principles driving the model in order to achieve a reasonable calibration as well as to drive scenarios realistically. As shown in figure 2, the majority of the work occurs before the actual running of scenarios with the model.

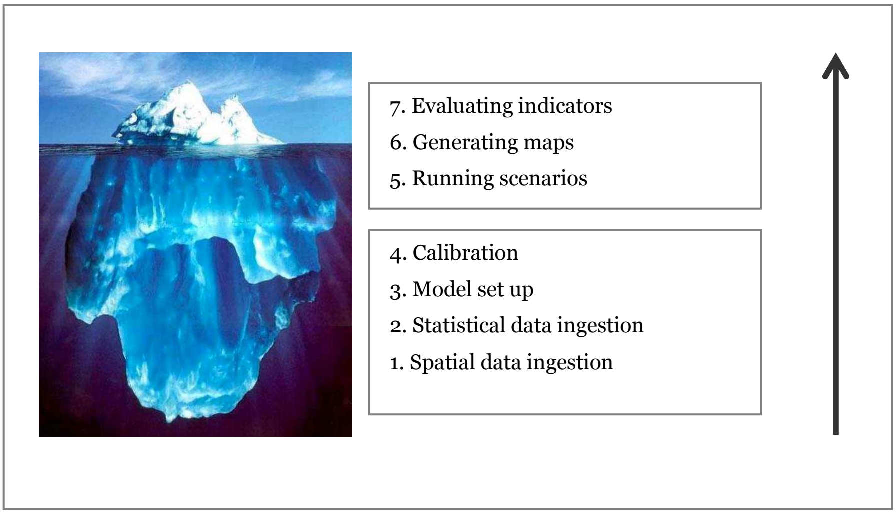


Fig. 2 - Representation of the underlying tasks behind running scenarios in Moland

A more detailed description of Moland framework was presented in the report D 2.1.4 (Petrov, et al., 2008).

3 Leipzig case study

3.1 Methodology

The methodological approach (fig. 3), used to simulate land use changes, was divided into the following steps:

1. Definition of scenarios by local stakeholders, based on IPCC-SRES scenarios (w.p.1);
2. Compilation of input data: land use (1990 and 2000), transport network (roads), zoning and suitability maps, statistical data (GDP and population);
3. Calibration of the model (using the period between 1990 and 2000);
4. Running of model, under different scenarios;
5. Production of outputs (land use maps and statistics);
6. Analyses of the output results.

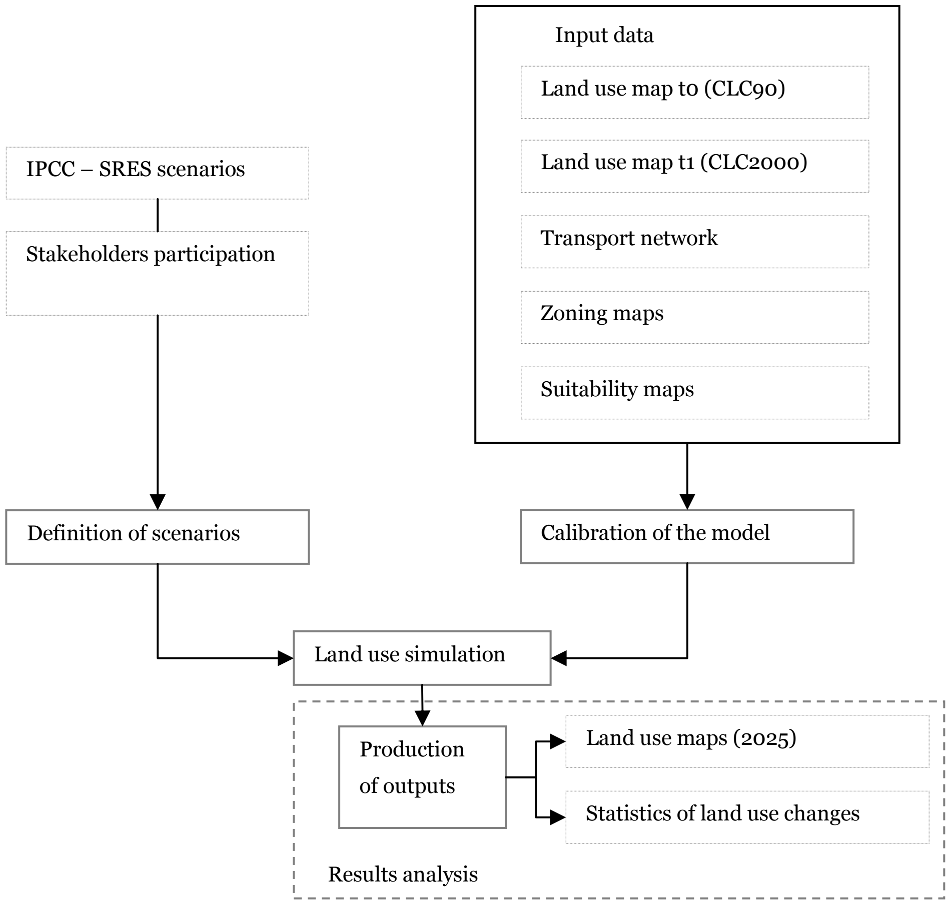


Fig. 3- Moland model approach

In the following sections, there is a description of these phases until the production of outputs, which will be presented on the next chapter.

3.1.1 Scenarios framework

As mentioned before, in order to compute land use projections (for a period of 25 years, between 2000-2025), a scenario[1] approach was developed using the four IPCC SRES scenarios as a basis, which were adapted to the case studies, with the support of local stakeholders (M1)[2]. Figure 4 shows PLUREL Scenarios framework which provides the context to the local scenarios. These scenarios cover the main driven-forces: demographic, economic trends, technology and transport, environmental change, and urbanization-spatial planning (Zasada, et al. 2007).

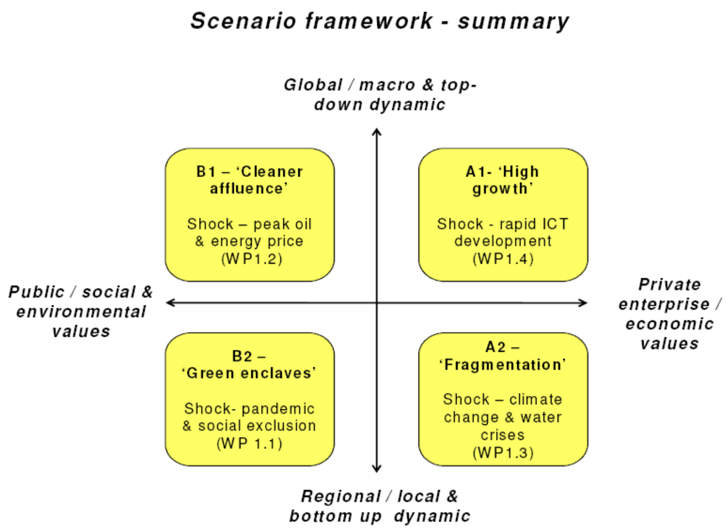


Fig. 4 - PLUREL Scenarios framework (source: PLUREL report No D1.1.1, August 2008)

Each one was modified into different narratives for Leipzig's region, and an extra-scenario (business-as-usual) was produced, as an extrapolation of trends observed during the period of 1990 to 2000.

[1] Within PLUREL project, a scenario is a narrative that describes a possible future.

[2] For more information see Deliverable Report D1.3.2.

Stakeholders' participation in this process was fundamental to produce storylines connected with Leipzig territory and that can represent possible futures, where these same stakeholders may have an active role. In addition, development of scenarios considered also statistics, such as demographic projections.

The following tables (1 to 4) show the narratives of scenarios (storylines) adopted in Leipzig case study.

Table 1 - 'Give-up shrinkage' scenario = 'Business as usual'

Population (fertility, mortality, in-migration, out-migration, peri-urban/rural growth)	Leipzig is characterized by steady decrease due to out-migration of the young, particularly woman; low rate fertility and ageing of population demography.
Economic trends (GDP)	GDP is slowly increasing. Moderate economic growth due to industrial activity and transport logistics (DHL, Amazon, UPS, Quelle distribution centre). Slow increase in manufacturing. Banks stable at a low level. Agriculture plays a minor role.
Urbanization/ Spatial planning	Increase of infrastructure construction (e.g. demolished houses replaced by partly housing and partly recreation/sports) however construction sites increase (inside of the city) due to lots of existing empty houses.
Transport	New investment in transport (e.g. link to motorway Chemnitz; fast railways to Munich, Berlin and Erfurt (ICE)).
'Shock' storylines and overall trends (politic, financial, etc)	Economic low increase. Low environmental protection. After 2013 Eastern Germany is no longer prior target area for EU structural funds and German Solidarity Fund stops 2019.

Table 2 - 'Scattered' scenario = A1 'hyper-tech'

Population (fertility, mortality, in-migration, out-migration, peri-	Leipzig is characterized by rapid increase of young population and increase of fertility rates.

urban/rural growth)	
Economic trends (GDP)	GDP is characterized by rapid growth. Invest more in: high-tech sectors (electronics, computers, pharmaceutical). Tourism is encouraged by a larger supply and diversification of offers. Also the service sector is reinforced, providing more employment. New policy to invest in education such as more research institutes.
Urbanization/ Spatial planning	Industrial developments are encouraged between Leipzig – Halle axis and other towns. Also new polycentric urbanization/residential are encouraged.
Transport	New transport investment (e.g. improvement of national roads and better links to the motorways; airport extensions).
'Shock' storylines and overall trends (politic, financial, etc)	Rapid technology advance – Economic growth. Passive management leading to peri-urbanization and 'metropo-lization' of rural area.

Table 3 - 'Managed shrinkage' scenario = B1 'Peak oil'

Population (fertility, mortality, in-migration, out-migration, peri-urban/rural growth)	Leipzig is characterized by increase of population due to in-migration of the young.
Economic trends (GDP)	GDP is increasing. The industrial activity is reinforced. New investment in manufacturing, tourism and services. More employment in science.
Urbanization/ Spatial planning	On the existing brown fields and empty redeveloped houses, new residential development inside of the city leading to 'town houses' (*Stadthauser*') for one or two families. Existing old buildings are preserved or demolished leading to perforation. Services close to industry.
Transport	Low transport investment due to high fuel costs

	and environmental concerns. There are encouraged the fast railways to Munich, Berlin and Erfurt (ICE)) and airport development.
'Shock' storylines and overall trends (politic, financial, etc)	Peak oil - Economic increase. Moderate environmental intervention. High energy prices affect transport costs limiting commuting distances.

Table 4 - 'Business as usual' scenario = B2 'Fragmentation'

Population (fertility, mortality, in-migration, out-migration, peri-urban/rural growth)	Leipzig is characterized by slight increase due to in-migration; low fertility rates and ageing of population.
Economic trends (GDP)	GDP is moderately increasing. Moderate economic growth due to tourism, service sector (e. g. public services, health care, accommodation, food and beverage, entertainment, etc) and transport logistics (DHL, Amazon, UPS, Quelle distribution centre). Slow increase in manufacturing. Banks stable at a low level. Agriculture plays a minor role.
Urbanization/ Spatial planning	Increase of infrastructure construction (e.g. demolished houses replaced by partly housing and partly recreation/sports).
Transport	Low investment in transport (e.g. link to motorway Chemnitz; fast railways to Munich, Berlin and Erfurt (ICE)).
'Shock' storylines and overall trends (politic, financial, etc)	Fragmentation, social exclusion. High environmental protection: Green ring map

3.1.2 Input data

Leipzig's region is represented, in Moland model, by a grid of 819,092 cells, with a spatial resolution of 1 ha (100x100m). The input data necessary to perform land use modelling and to generate spatial scenarios was:

- Corine Land Cover 2000 (CLC2000) – base year of land use modelling;

- Corine Land Cover 1990 (CLC90) – historical reference map, which was used to calibrate the model;
- Transport network infrastructure – classified as fast roads, national roads and other roads;
- Suitability maps – indicating which areas are better for each land use (vacant and active functions);
- Zoning maps – show spatial planning restrictions (produced by public authorities).

Considering that the focus of this work is on urban and peri-urban areas, *Corine Land Cover* legend was adapted, so that a more disaggregated level was used to distinguish artificial areas (3rd), and less detail was applied to natural areas (2nd level). In whole, eighteen land use classes were divided in three groups: vacant features (areas were expansion can happen), active functions (the most dynamic areas, which can determine urban growth) and fixed features (where land use change is constrained) (table 5).

Table 5 – Land use classes for Leipzig case study

Vacant features:	*Active functions:*	*Fixed features:*
arable land	continuous urban fabric	airports
permanent crops	discontinuous urban fabric	mineral extraction dump sites
pastures	industrial and commercial	road and rail networks
heterogeneous	construction sites	artificial non-agricultural
agricultural areas	port areas	water bodies
forests		
shrubs		
open spaces		
wetlands		

3.1.3 Calibration of the model

This process determines the accuracy of the results and ensures that model's behaviour will be realistic. The objective is to reproduce land use dynamics within a specific period. During calibration, spatial patterns of land use are analysed and transition rules are defined, according to the potential of each cell to change to another land use class. To accomplish this goal, in Leipzig were used land use maps of 1990 and 2000 (this last one, was used to compare with the simulated), but also suitability, accessibility and zoning. The stochastic parameter, which simulates the degree of stochasticity that is intrinsic to *most social and economic processes of urban areas*, was set at α = 0.83 (Petrov et al., 2007).

Validation of the model was done by comparing the simulated land use map with the real one (2000, in this case), and by checking the coincidence of these two land maps using a cell-by-cell comparison method and the associated statistics: kappa and fuzzy kappa (fuzzy-k) (Petrov et al., 2007). Table 6 presents the statistical results for the five active land use classes.

Table 6 - Coincidence matrix and Fuzzy-Kappa values for simulation 1990-2000 (Petrov, et al. 2007)

Leipzig : simulation 1990-2000

	Continuous urban fabric	Disconti-nuous urban fabric	Industrial& Commercial	Construc-tion sites	Port areas	Total cell number
Continuous urban fabric	888	0	3	0	0	891
Discontinuous urban fabric	0	36526	6	1	0	36533
Industrial & Commercial	0	0	7035	0	0	7035
Construction sites	0	0	0	49	0	50
Port areas	0	0	0	0	1	1
Total cell number	891	38183	9590	227	1	-
Added cells 1990-2000	0	2588	2555	177	0	-
Fuzzy-k	0.99	0.97	0.87	0.46	1	-

3.1.4 Running the model (spatial scenarios)

The storylines are expressed in a narrative way, creating the need to translate this qualitative data into quantitative data, so that the land use simulation can be performed and spatial scenarios produced. Therefore, after obtaining from the calibrated model the transition rules, which establish attraction and repulsion between different land use classes, it is also required to adjust other parameters in order to accomplish the aims of each storyline. Firstly, land use claims for the simulation period (25 years), must be set up

[3] Petrov, L. et al., 2007

to the entire region. This procedure, which defines the magnitude of land use demand within macro-model, applies only to the land use active functions (table 7).

Table 7 – Land use claims in macro-model, for different scenarios

land use function	2000	Business-as-usual	Hyper-tech	Peak-oil	Fragmen-tation
Continuous urban fabric	891	891	991	1050	900
Discontinuous urban fabric	38183	42308	43308	39950	39750
Industrial and commercial	9590	15977	18977	16200	13500
Construction sites	227	670	670	700	600
Port areas	1	1	1	1	1

However, this translation also depends on other parameters, which can be more related with spatial planning options. For instance, changes in accessibility (access of land use classes to different types of roads), suitability (e.g. ingestion of demolish areas taken from renewal plan, into the suitability map of discontinuous urban areas), zoning (e.g. green ring is no longer a constrain to the development of industrial and commercial areas) and in some cases this adjustment imply introducing new seeds (e.g. expansion of airport).

3.2 Results

In the beginning of 21st century, Leipzig's region has almost 500.000 inhabitants. This city has a tradition as centre of commerce (its Fair is considered one of the oldest trade fairs), but has also consolidated, during the last few years, its industrial importance due to the recent location of facilities of vehicle and automotive components industry (Porsche and BMW), and also as an international logistics node (European hub for DHL) (Kabisch, et al. 2008).

Since the end of World War II, Leipzig faces a long-term shrinkage process, with a surplus of housing stock and office buildings and, on the other side, a demographic decline. This phenomenon affects mostly the outskirts and working class neighbourhoods (Kabisch, et al. 2008). Demographic decrease was due to the high out-migration (mainly after 1990 to

Western Germany, and linked to an economic crisis), fall in the birth rate (and growth of deaths) and suburbanization (Banzhaf, et al. 2006; Kabisch, et al. 2008).

Although, in the beginning of this century, this process has slowed down, due to an increase of birth rate and in-migration from the surrounding areas and other East German regions, ageing is still a major issue in the development of this territory. Universities and research institutions have a key role in attracting young people (circa 37000 students in 2006/07) (Kabisch, et al. 2008), but the challenge is to convert part of them in long-term residents, even if there is a strategy to attract older people from other parts of Germany (e.g. Leipzig - *Gegen Mangel im Alter* campaign) (Kabisch, et al. 2008).

In order to cope with this situation, local authorities invested in three types of actions: "preservation of the architectural heritage, which is considered as a kind of trademark of the city, the creation of green spaces, which are supposed to replace destructed housing estates, and the support of hierarchic centres policies on a micro-scale" (Florentin, 2008).

According to RUR typology, Leipzig's region (which includes Leipzig and Halle urban areas), was classified as "urban polycentric metropolitan" (fig. 5). And, the priority land use issues are: land pressure due to housing, traffic, and sustainable integration of tourism (Nilsson, et al. 2008).

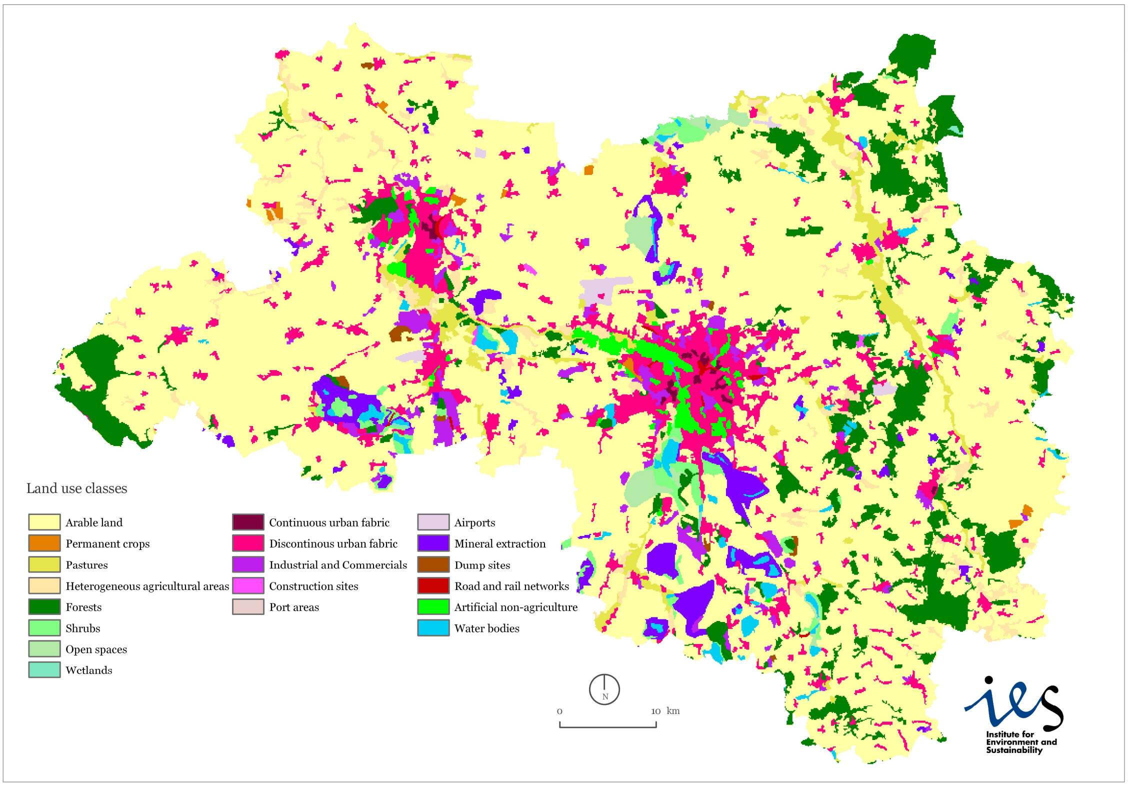


Fig. 5 – Leipzig, 2000: land use

In the next point, results of each land use simulation will be presented. These spatial scenarios are an interpretation of the storylines and represent possible futures, different pathways of development, but none of them is more probable to occur than other. They should be regarded as an instrument and a support to delineate strategies, in order to achieve a sustainable future. For Leipzig case study, land use scenarios were undertaken, using calibrated model, for a twenty-five years period (2000-2025).

3.2.1 Business-as-usual scenario

Results achieved with business-as usual scenario show that, assuming the extrapolation of trends from the period 1990 until 2000, we can expect that in 25 years the main changes will occur in construction sites (195%) and also in industrial and commercial areas (67%), followed by discontinuous urban areas (almost 11%) (fig.8). As we can see in figure 6, these changes are mainly in the South areas of Leipzig and Halle, or within this axe. The most affected areas are wetlands (-40%), shrub (-27%) and opens spaces (-19%).

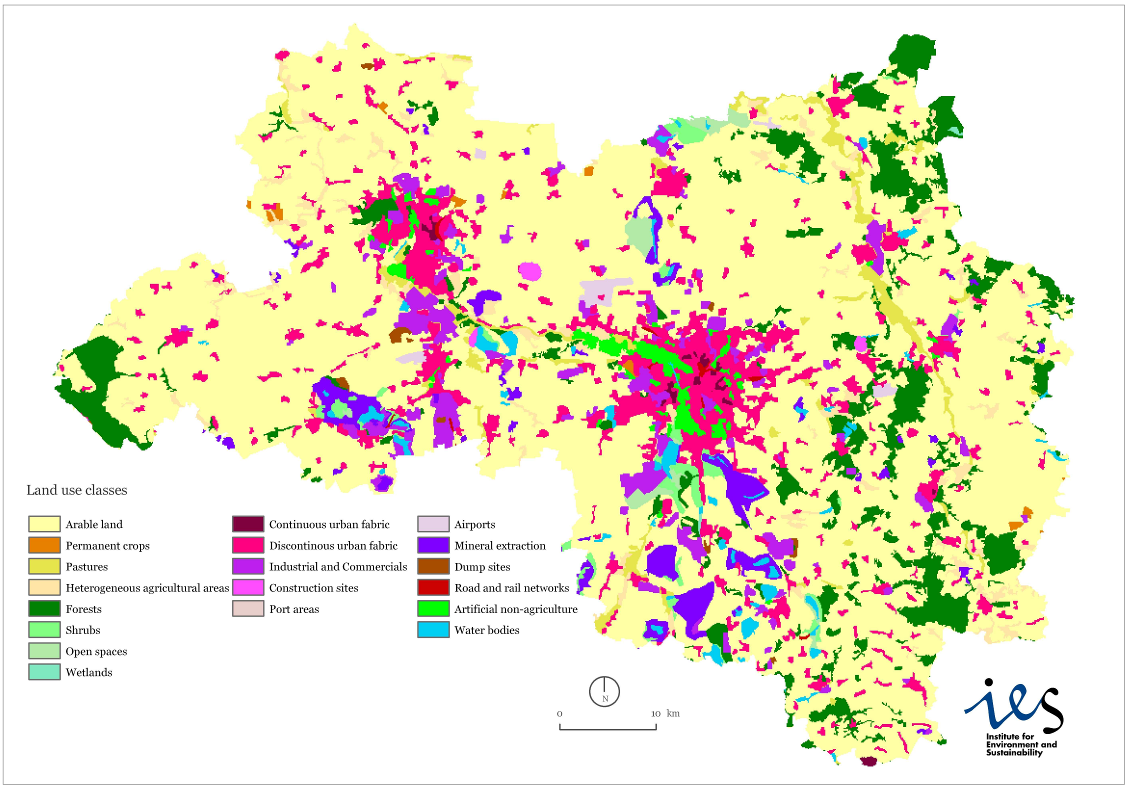
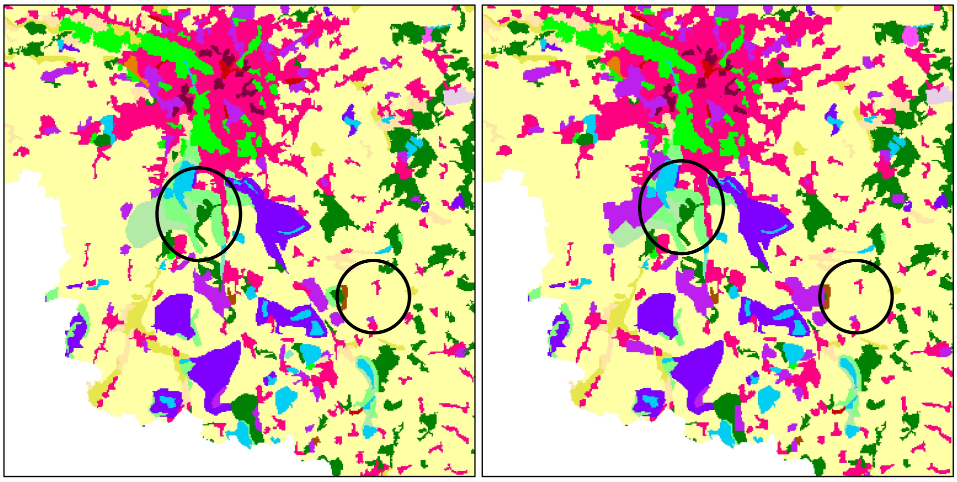


Fig. 6 – Leipzig, 2025: land use, considering business-as-usual scenario



Leipzig: Land use, 2000 Leipzig: Land use - Business as usual scenario, 2025

Fig. 7 –Business-as-usual: land use change in the south area of Leipzig

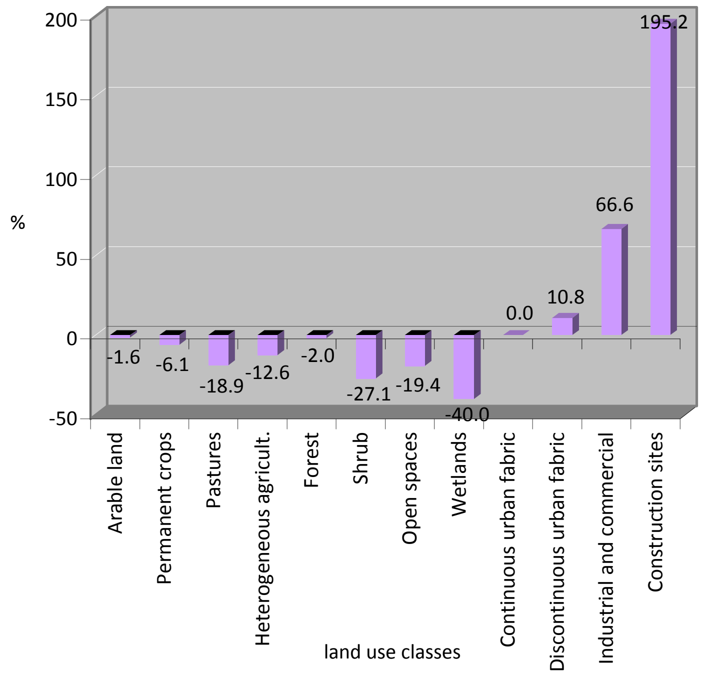


Fig.8 - Leipzig: land use changes, per category, considering business-as-usual scenario (2000-2025)

Using Map Comparison Kit (Research Institute for Knowledge Systems [RIKS], 2004) it is possible to compare visually the differences between land use maps and to know where main changes will occur. As expected, in this scenario, continuous urban areas will not growth, but the model reallocates some cells (a new cluster emerges on the south). Discontinuous urban areas register an increase of almost 11%, and it happens mainly next to previous discontinuous urban areas due to the decrease of arable land. The growth of industrial and commercial areas is mostly spread through the entire region, but it is always linked to discontinuous urban areas, and it takes land from pastures (1803 cells), shrubs (1387 cells), and arable land (1224 cells). Although in percentage terms, construction sites show the major increase, its spatial distribution is restricted to three small areas (two of them along Leipzig-Halle axe) (fig.9).

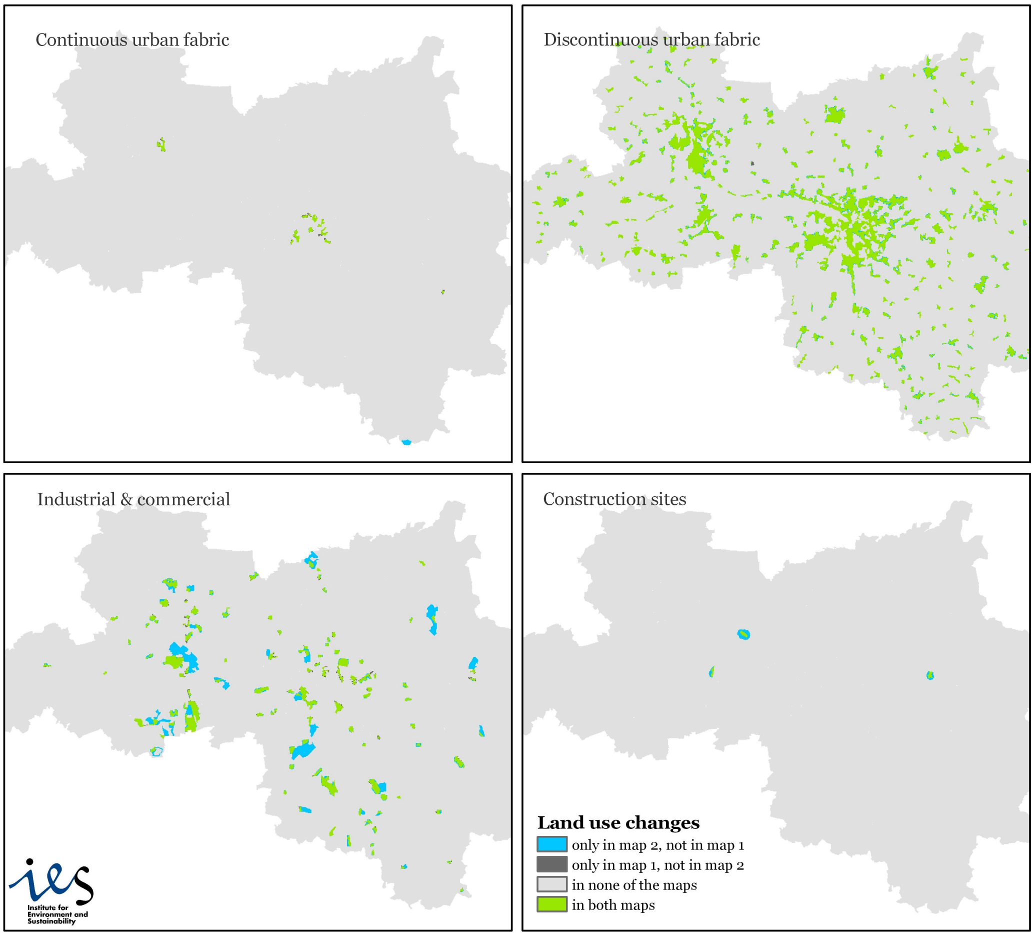


Fig. 9 - Business-as-usual: land use changes (2000-2025)[4]

3.2.2 Hyper-Tech scenario

This scenario emphasises a quick technology advance and the consequent economic growth. In 2025, land use patterns reflect that change (fig.10), due to the dynamism of industrial and commercial areas and construction sites (raise of 98% and 195%, respectively). In addition, the increase of young population and fertility rates can be felt in the enlargement of discontinuous urban areas (13%). Moreover, encouragement of polycentric urbanization/residential is visible in the allocation of these new urban areas, that emerge mostly in the South of Leipzig (fig.11). In order to embody investment on transport network, the size of Leipzig airport was slightly increase (608 cells), in 2010.

[4] In fig. 9, 13, 17, and 21, map 1 corresponds to land use 2000 and map 2 to land use 2025.

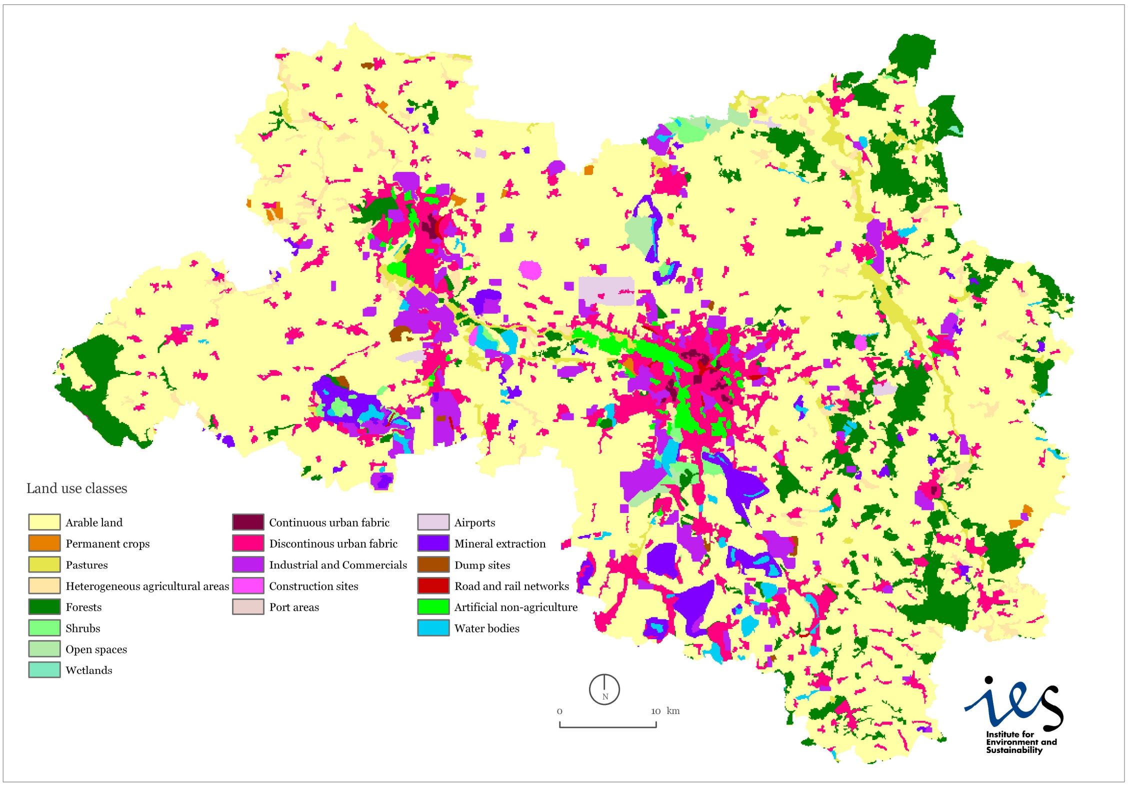
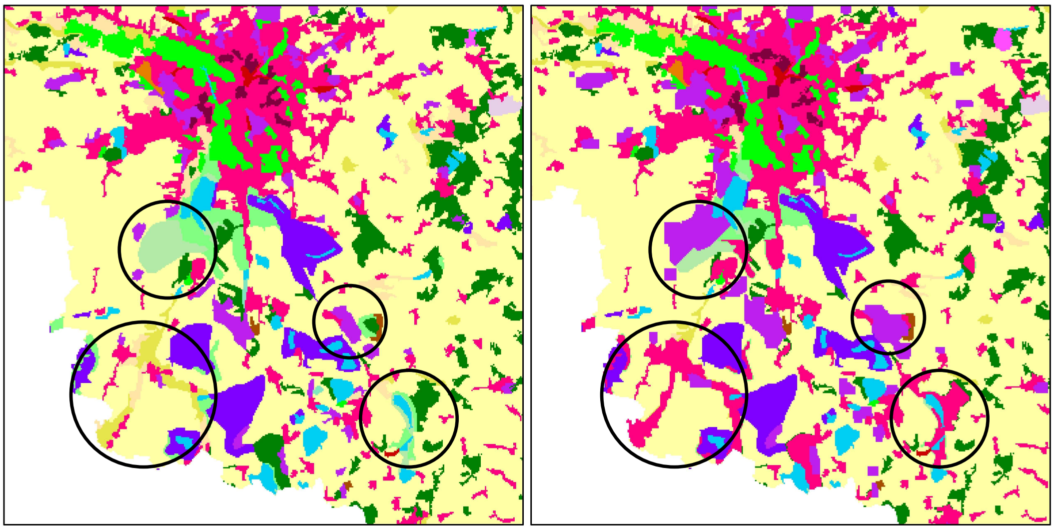


Fig. 10 – Leipzig, 2025: land use, considering hyper-tech scenario



Leipzig: Land use, 2000 | Leipzig: Land use - Hyper-tech scenario, 2025

Fig. 11 –Hyper-tech: land use change in the south area of Leipzig

As we can see in figure 13, land use pattern of continuous urban areas and construction sites is almost the same as in "business-as-usual" scenario, even if in this case, continuous urban areas increase 11% (fig. 12). However, a new land use pattern of discontinuous urban areas comes into view. It is no longer predominantly in the margins of pre-existent discontinuous urban areas but, as mentioned before, as new clusters in the South part of Leipzig's region, and close to industrial and commercial areas. This expansion occupies mainly forest (1907 cells), heterogeneous agricultural areas (1194 cells) and shrub areas (1163 cells). Once again, industrial and commercial growth is disseminated through the entire region, but it registers a greater expansion near Halle (the second most important urban core) and in the peri-urban area, located south from Leipzig. Within this scenario, industrial and commercial areas almost duplicate their areas, and mainly due to the decline of arable land (3381 ha), pastures (1738 ha) and heterogeneous agricultural areas (1423 ha).

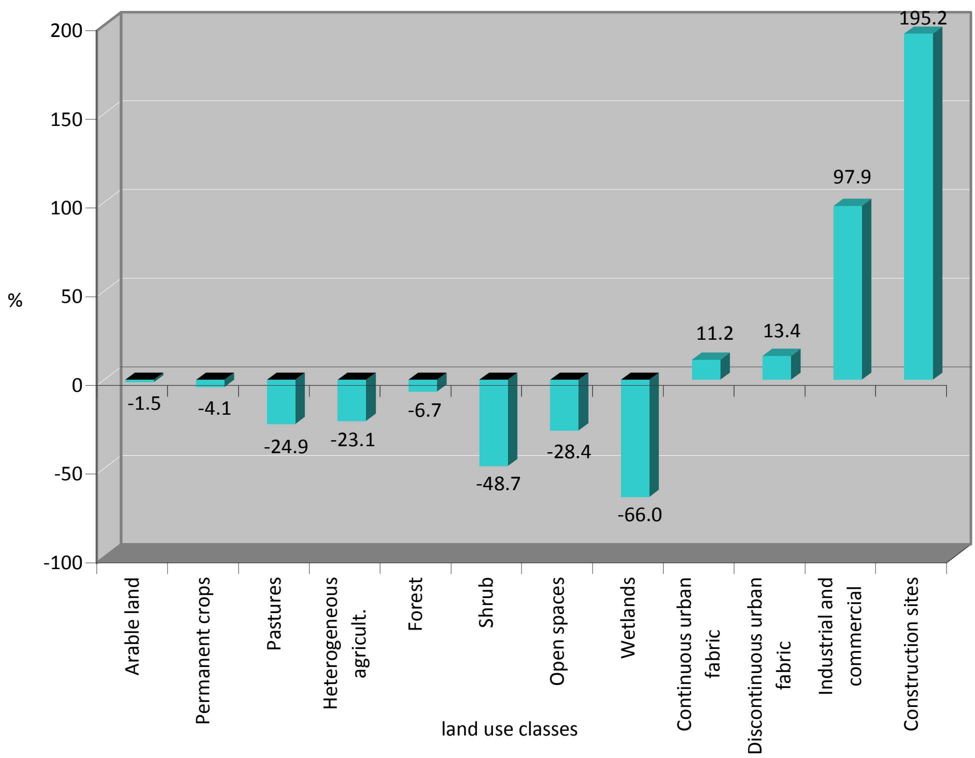


Fig 12 - Leipzig: land use changes, per category, considering hyper-tech scenario (2000-2025)

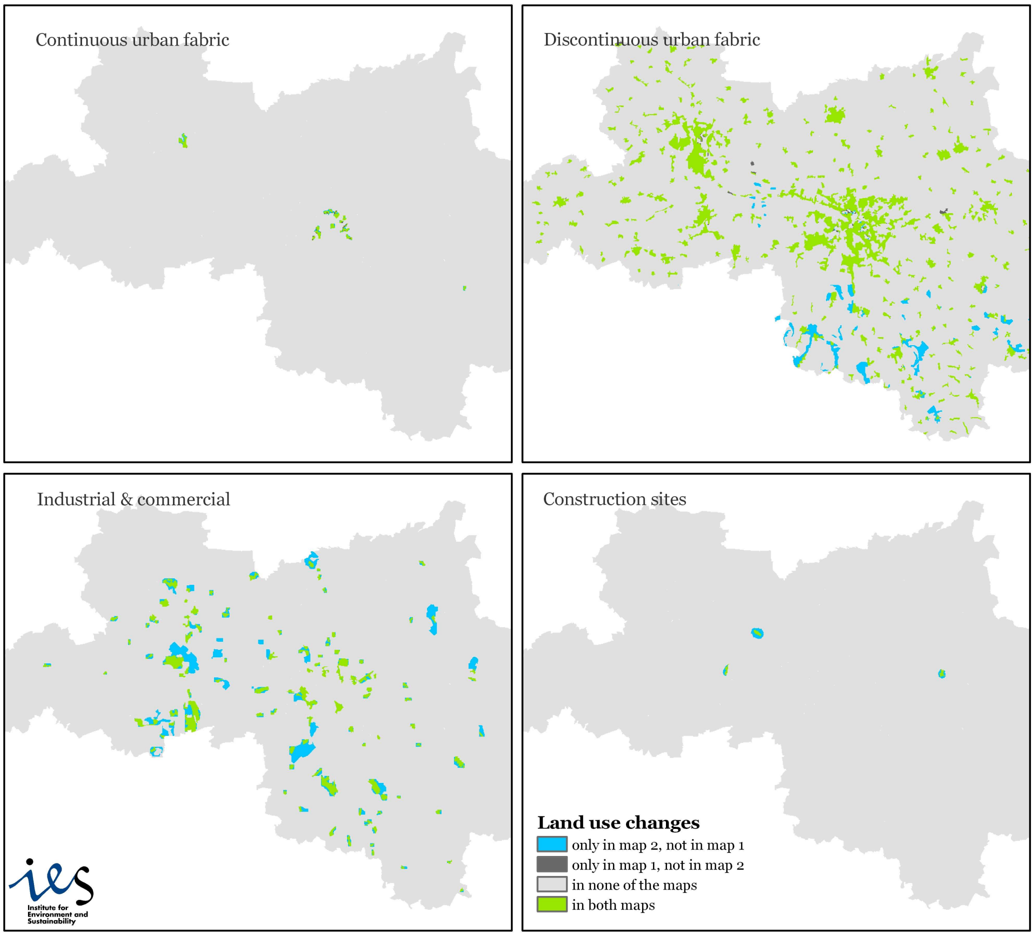


Fig. 13 - Hyper-tech: land use changes (2000-2025)

3.2.3 Peak oil scenario

In this scenario, land use changes are constrained by high energy prices. Although GDP increases, the allocation of economic activities is affected by the inherent costs of energy. An increase of population due to in-migration of young people contributes to the expansion of residential areas, which raise 18% in continuous urban areas (*Stadt hauser*), showing a consolidation/densification of urban fabric. New clusters of discontinuous urban areas emerge close or connected with industrial and commercial areas, which may contribute to reduce commuting distances (fig. 14 & 15). In fact, the attraction between these two classes is very intense within this scenario, and it is coherent with low transport investment (even though airport development occurs in 2011, to support investment in tourism).

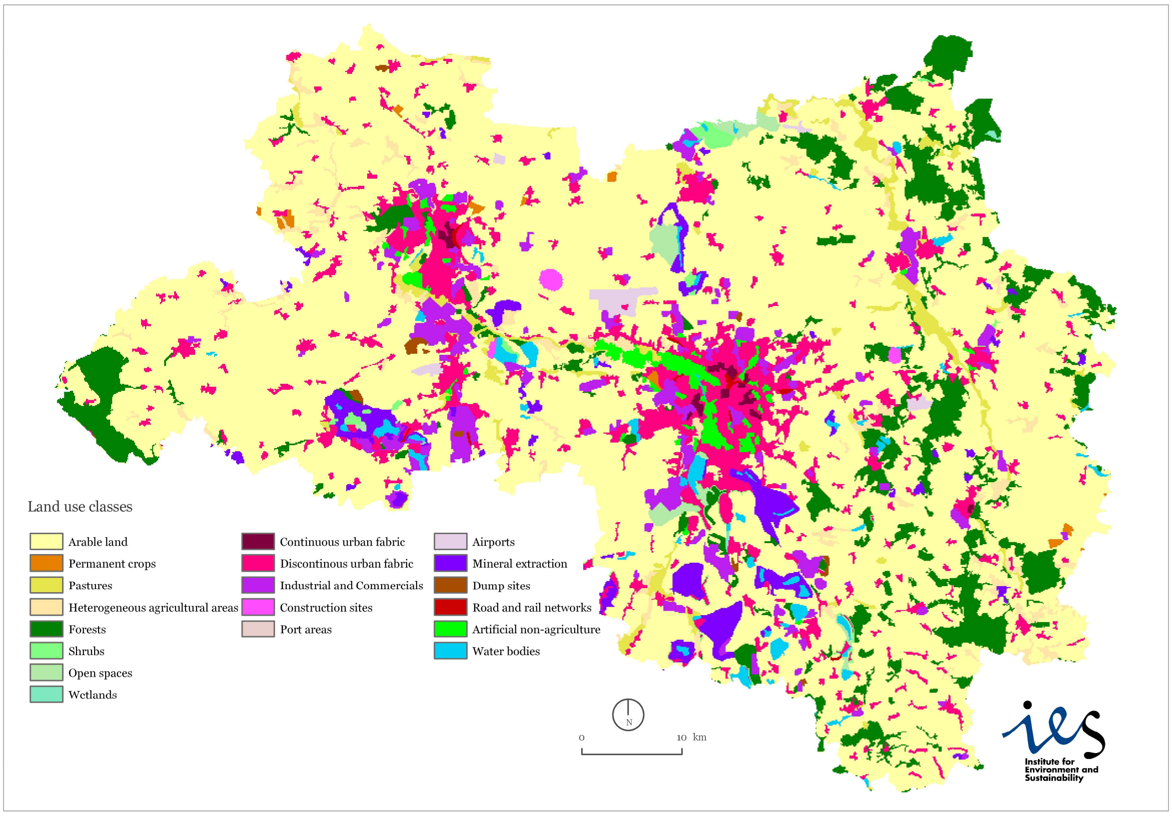


Fig 14 – Leipzig, 2025: land use, considering peak oil scenario

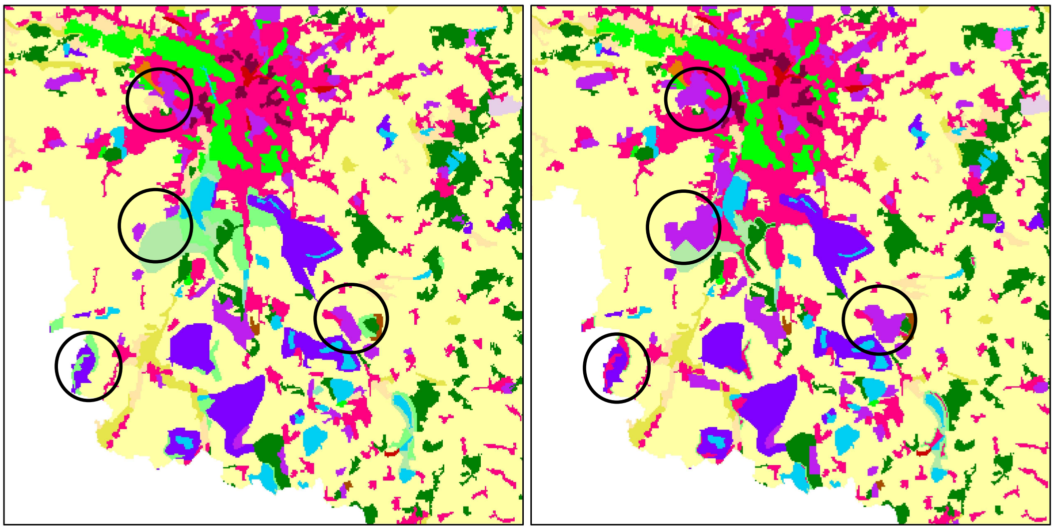


Fig 15 – Peak oil: land use change in the south area of Leipzig

The growth of discontinuous urban fabric (5%) occurs mainly in shrub areas (loses 2171 ha to this class), and the expansion of industrial and commercial areas (69%) is mostly in pastures (1790 ha), heterogeneous agricultural areas (1229 ha) and arable land (1224 cells). Even if the major increase is registered in construction sites (208%), industrial and commercial areas are the most dynamic (fig. 16).

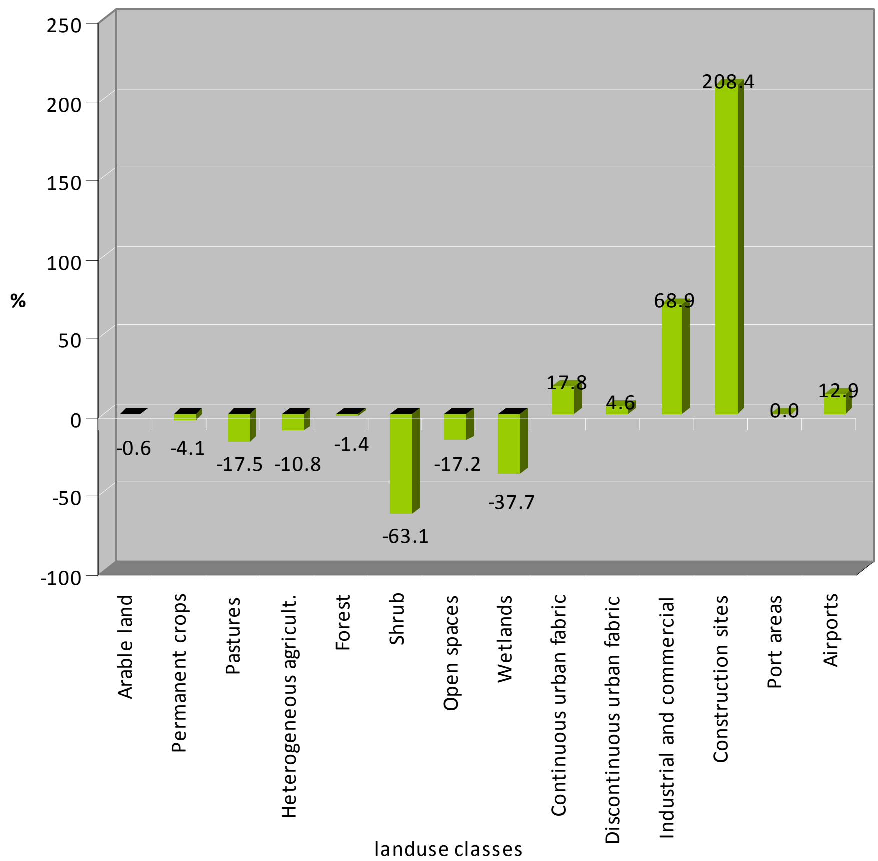


Fig 16 - Leipzig: land use changes, per category, considering peak oil scenario (2000-2025)

Continuous urban fabric evolution happens on the edge of previous continuous areas. As it can be seen in figure 17, the land use pattern of construction sites, in 2025, is very similar to the Business-as-usual and Hyper-tech scenarios. The impact of the growth of industrial and commercial areas is mostly felt in peri-urban and rural areas.

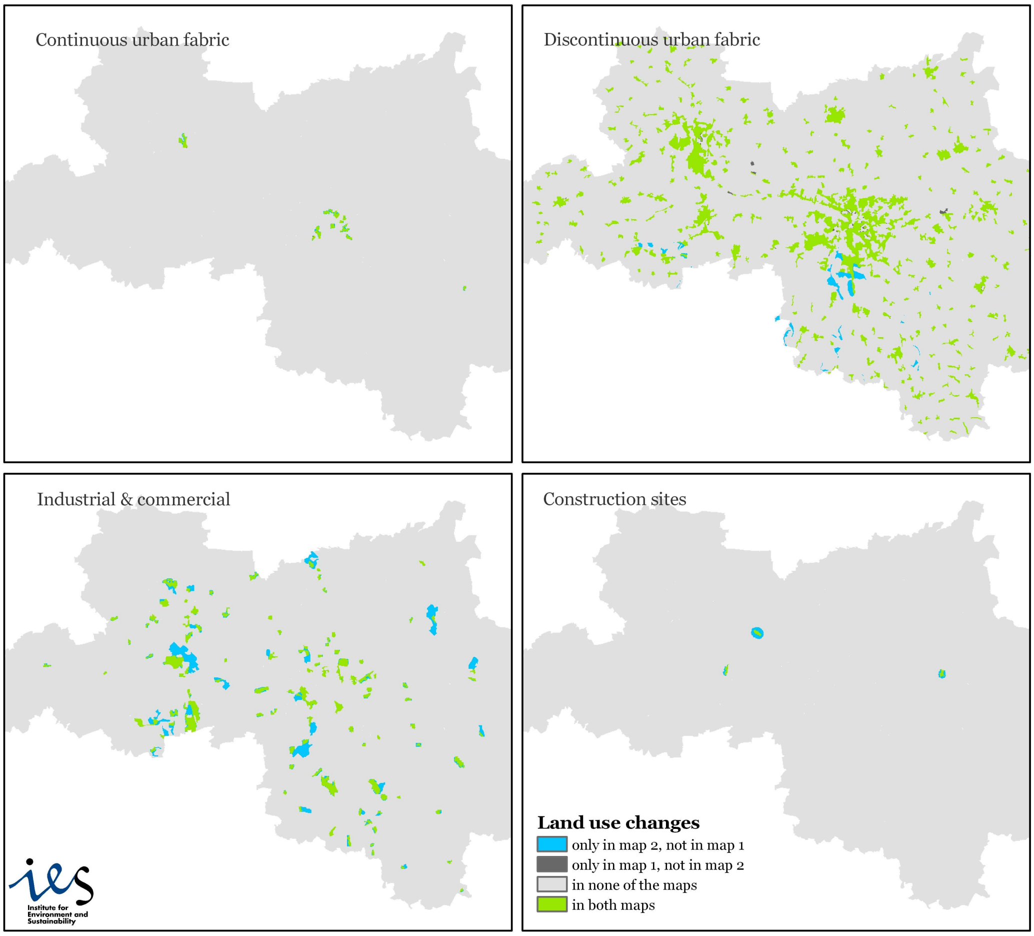


Fig 17 - Peak oil: land use changes (2000-2025)

3.2.4 Fragmentation scenario

The assumptions for this scenario follow, in a certain way, the urban shrinking process, i.e. population is almost stable, due to low fertility rates, ageing of population and in-migration, but built sector contributes to the expansion of urban areas. As a consequence, construction sites increase 164%, thanks to the loss of arable land (272 cells).

Although continuous and discontinuous urban fabrics have a modest growth of 1% and 4% respectively (fig. 20), economic growth is moderate (intensifying shrinking process). Tourism, service sectors and transport logistics have a role in land use dynamics, making industrial and commercial areas register a growth of 40%. In fact, the increase of this class depends on the decline of pastures (1462 cells), heterogeneous agricultural areas (1051 cells), and shrub (932 cells) (fig.19).

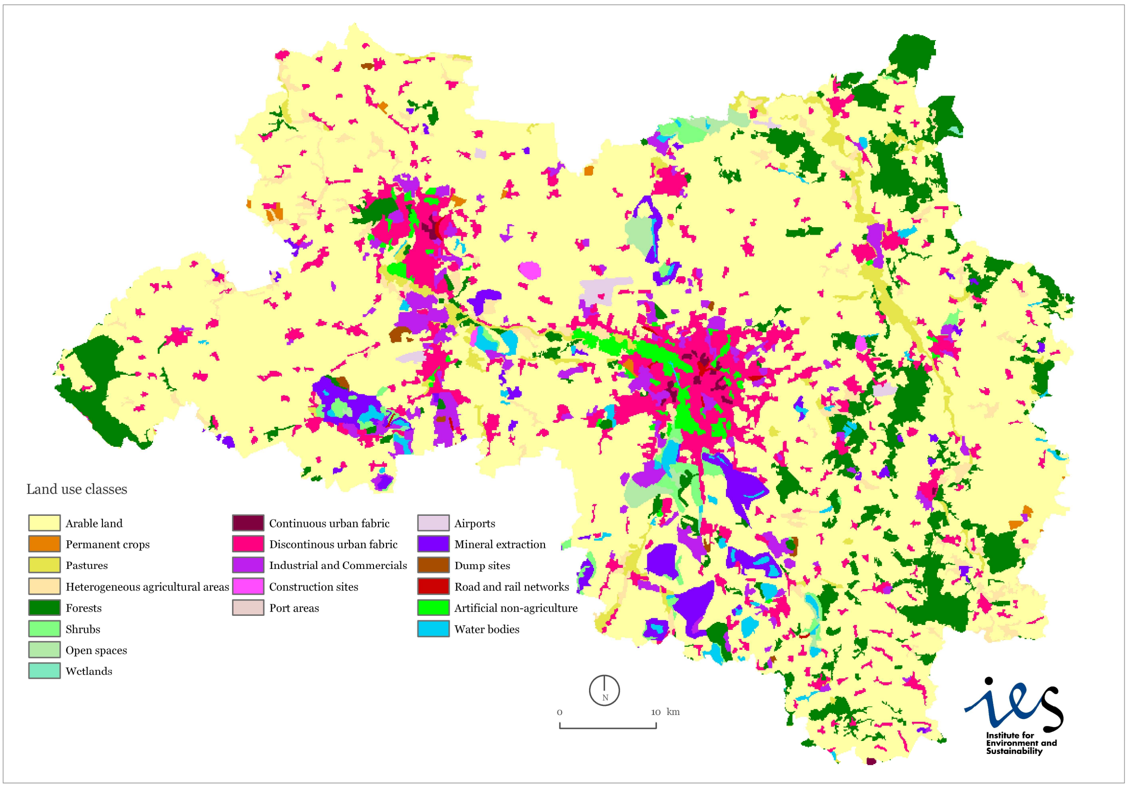


Fig 18 – Leipzig, 2025: land use, considering fragmentation scenario

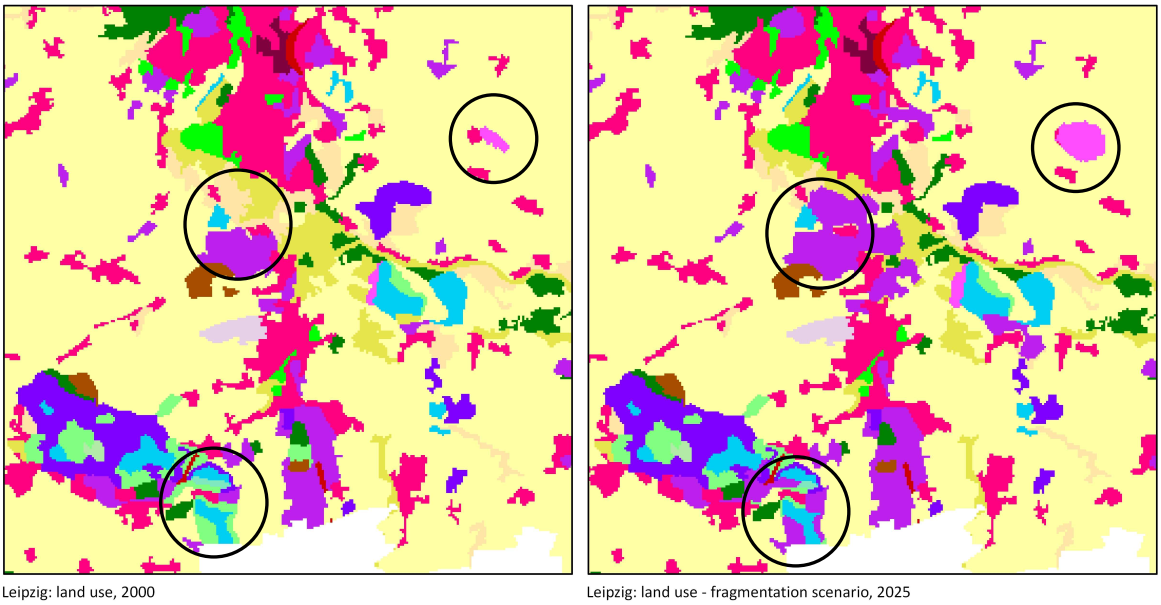


Fig 19 –Fragmentation: land use changes in south area of Halle

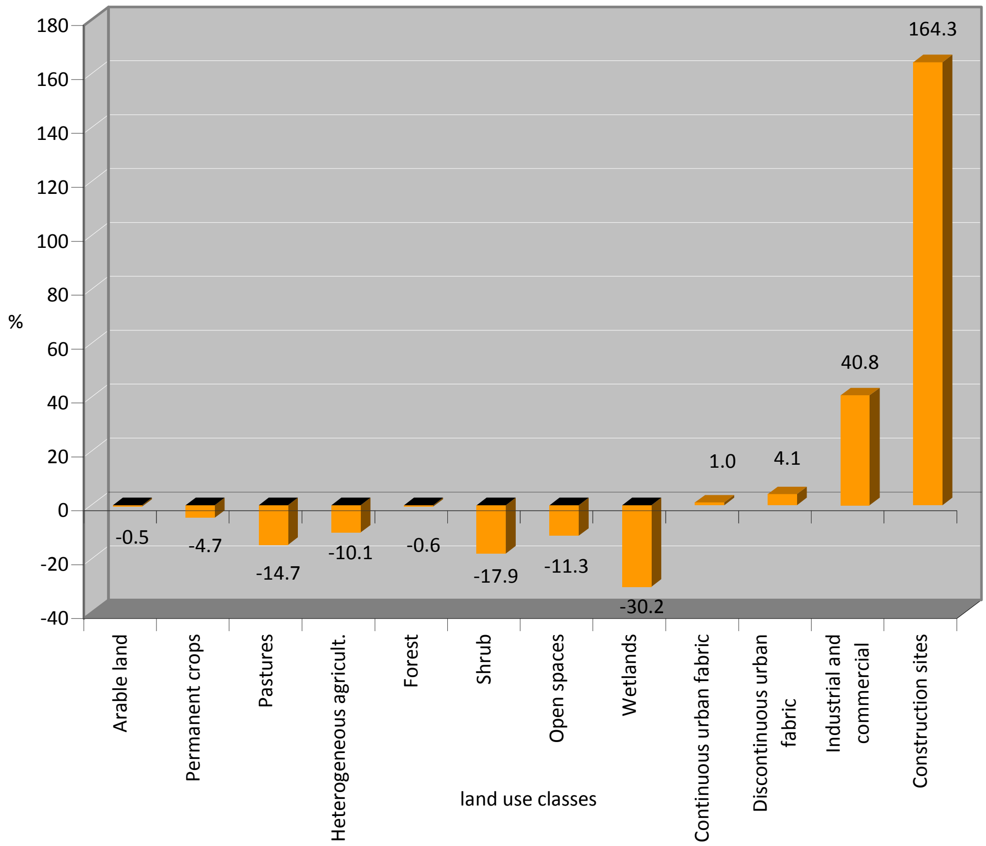


Fig. 20 - Leipzig: land use changes, per category, considering fragmentation scenario (2000-2025)

Land use patterns in 2025 are in fact very similar to 2000. The exception goes to construction sites, whose expansion occurs in the same places as in previous scenarios, and industrial and commercial areas, whose expansion is more spread through the region.

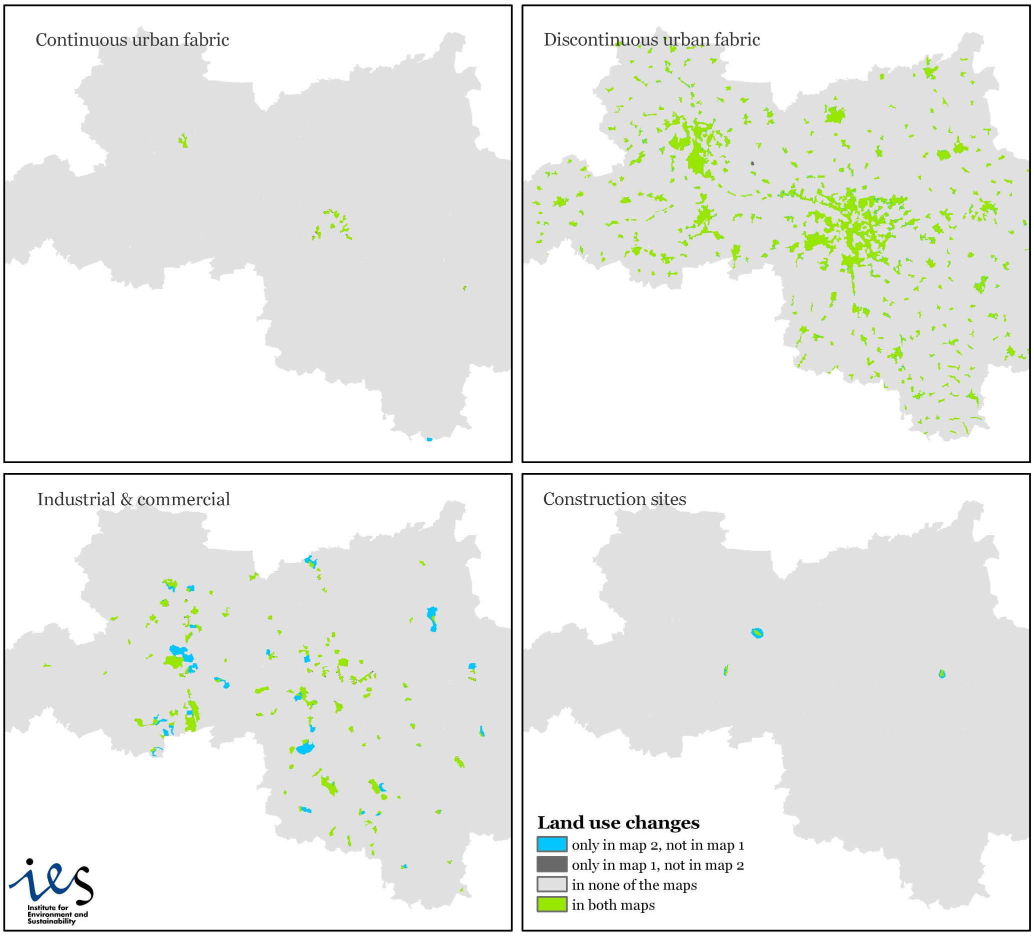


Fig. 21 - Fragmentation: land use changes (2000-2025)

3.2.5 Comparing scenarios

Different spatial scenarios are a consequence of diverse storylines, but also represent distinct options of spatial planning. In this sense, it is fundamental to compare the results between scenarios, so that strategies can be adjust, in order to minimize possible impacts, on landscape.

By comparing scenarios results (fig 22 & 23), it can be seen that farm/valuable land changes are more intense in Hyper-tech scenario (-4%) and not so significant in Fragmentation scenario (-1.6%). On the opposite side, new urban land emerges mainly on Hyper-tech scenario (23%), and Fragmentation register the smallest increase (8.7%).

These results must be analyzed considering the “shock” storylines and overall trends introduced in each scenario. If in Hyper-tech scenario, there is a “passive management leading to peri-urbanization and metropolization of rural area” (which is expressed in the values achieved), in Fragmentation scenario the emphasis is in the “high environmental protection: green ring map” (table 2 & 4). However, Fragmentation scenario results do not express a major problem: social exclusion.

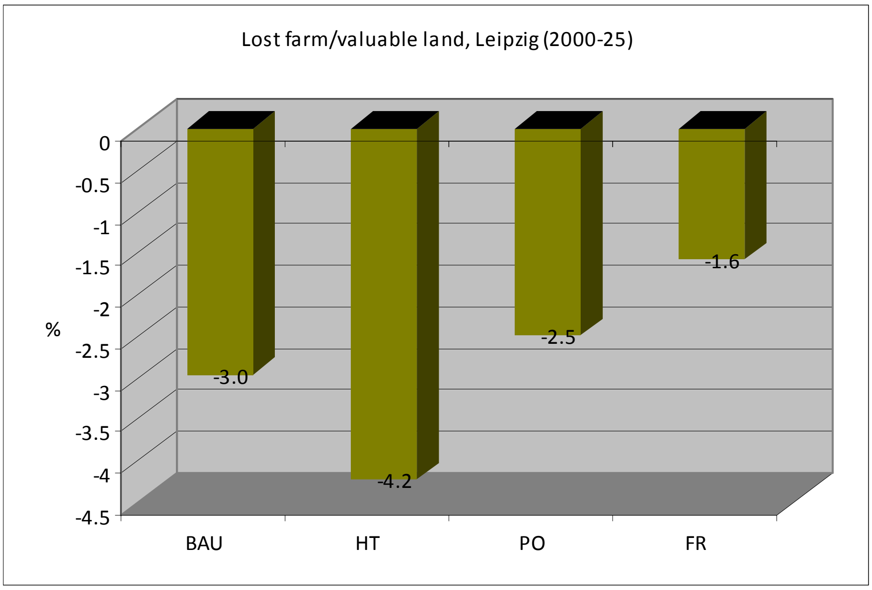


Fig. 22 – Leipzig: farm or valuable land changes (2000-2025)

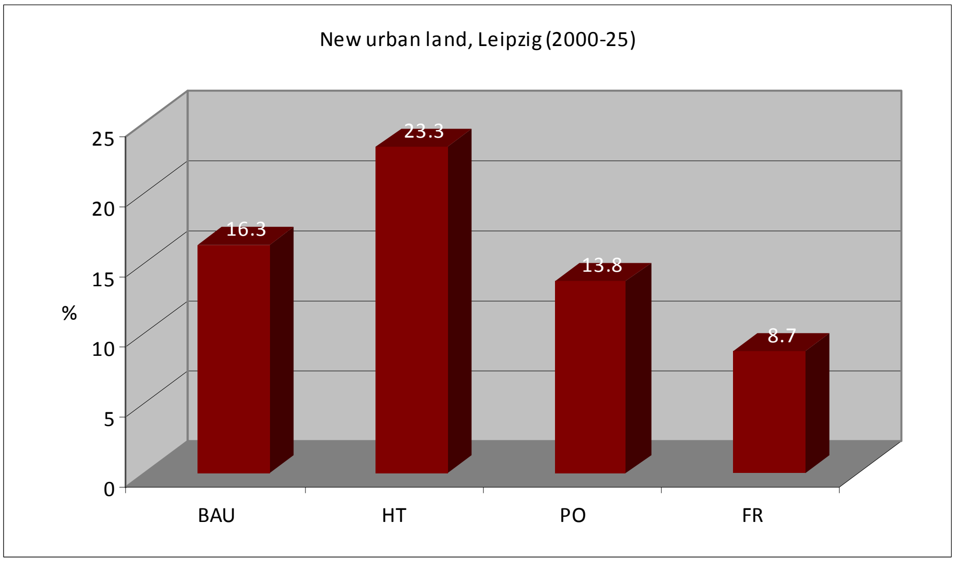


Fig.23 – Leipzig: urban land changes (2000-2025)

3.2.6 Application of RUR typology

Within PLUREL project was defined a RUR typology, which takes into account land use in 2000, and also population density[5]. In Leipzig's region, there are six urban cores, but Leipzig and Halle, are the most important (fig. 24).

In order to identify how RUR areas evolve under these scenarios, it would be necessary to have the same typology applied to each spatial scenario. Although it is not possible (yet) to have a RUR classification to the year 2025 (according to each scenario), it was done an exercise to see how land use dynamic could be different in these areas.

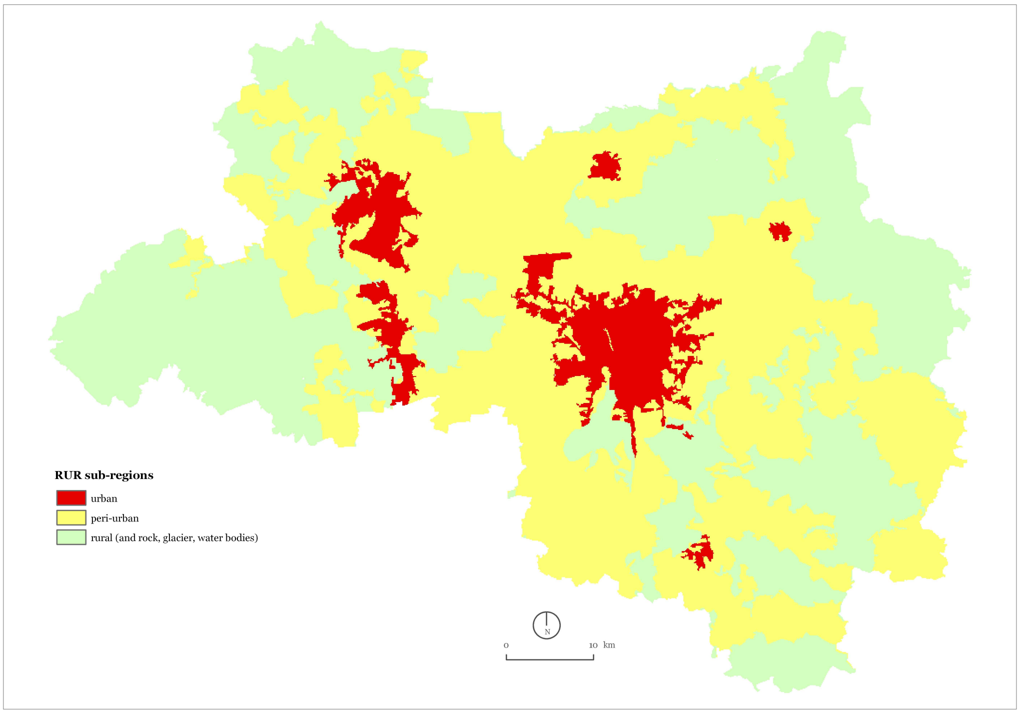


Fig. 24 – Leipzig: RUR typology

By comparing behaviour of foreseen discontinuous urban fabric and industrial and commercial areas in "business-as-usual" (BAU), "hyper-tech" (HT) and "peak oil" (PO) scenario, it is possible to verify that what are considered rural areas in 2000, evolve in a more dynamic way than urban or peri-urban areas (table 8).

[5] See Loibl W. and Köstl M. (2008).

Table 8 - Leipzig:land use changes (2000-2025) within RUR areas

RUR areas	Continuous urban fabric	Discontinuous urban fabric	Industrial & commercial
HT urban	10.27%	-0.62%	11.03%
HT peri-urban	-	17.07%	134.79%
HT rural	35.29%	37.62%	368.44%
BAU urban	-14.59%	6.19%	0.37%
BAU peri-urban	-	15.65%	87.94%
BAU rural	367.65%	11.68%	304.11%
PO urban	17.50%	-0.36%	8.73%
PO peri-urban	-	3.60%	91.67%
PO rural	26.47%	17.71%	269.44%

However, in absolute terms, the most affected areas will be what is considered in 2000 as peri-urban areas (fig. 25 & 26).

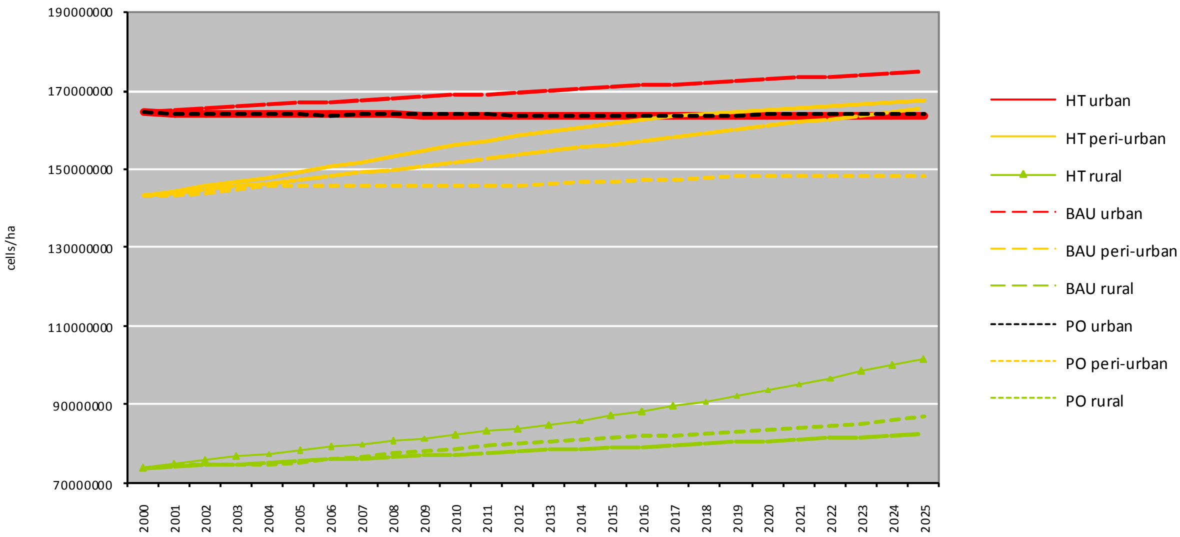


Fig. 25 – Leipzig: changes in discontinuous urban fabric considering different scenarios (2000-2025)

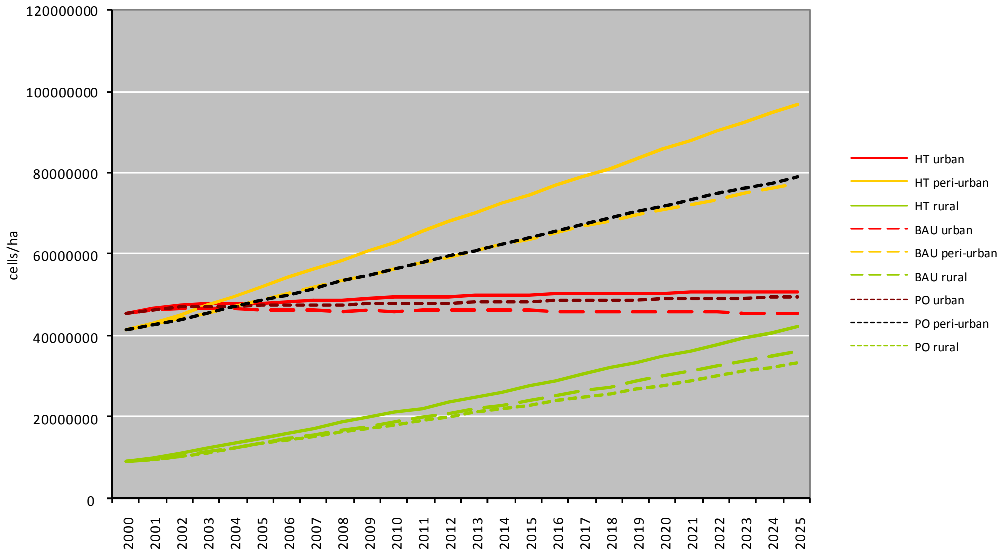


Fig. 26 – Leipzig: changes in industrial and commercial areas, considering different scenarios (2000-2025)

4 Koper case study

The Koper test case is one of six test case regions for the PLUREL project. Details of the area, as well as an in depth analyses of the impacts of regional planning on the peri-urban area, are detailed in D 3.3.5 (Perpar et al. 2008).

The Koper test case is a valuable learning tool one for several reasons detailed in Perpar et al. (2008):

- There is a historical city center where development is limited;
- The peri-urban fringe to this historical center is dynamic and currently undergoing massive change;
- Because of its location, there is competition for the best agricultural land between the agricultural sector and building.
- More than one third of the municipality are Natura 2000 areas.
- The peri-urban area has diverse land use and large vacant areas;
- The municipality is Slovenia's outlet to the sea. There is a port which occupies a significant land mass and economic role in the municipality as well as country;
- The main bulk of the municipality consists of rural hinterland whereby inhabitants are struggling to conserve the way of life of time ago; this is encouraged by economic incentives.

The municipality is in an evolutionary phase. According to the report produced by Perpar *et al*, three development strategies are currently under works for the municipality.

While Moland is a tool that can assist in regional planning because the impacts of scenario parameters can be seen on the surrounding area's land use; it is not an urban planning tool to be used to assist in the detailed plans within the confines of a city.

Variation to agreements met in Koper

Regional divisions for modelling. During the meeting we decided upon the RUR typology of divisions to run the regional model (figure 27). It was originally planned that each of the three divisions (rural, peri-urban, urban) would drive the regional model.

4.

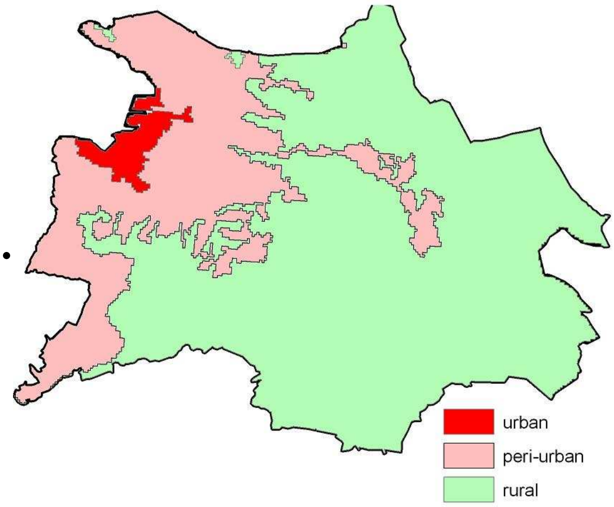


Fig. 27 - RUR typology divisions for Koper, created within PLUREL's Module 2.

This typology for the regional model was scrapped due to the dynamic nature of the typology: It will vary in accordance to land use changes and is therefore a volatile boundary. Since the change in delimitation of the RUR border was identified as an output indicator, it would be incorrect to include this in the regional model. The model was therefore run with only one region: the municipality.

4.2 Methodology

4.2.1 Legend

The legend applied for the Koper test case was determined by the stakeholders. Table 9 details the legend and describes the classes. The land use class refers to the original legend; the land use class category refers to the group to which the land use belongs. This was applied throughout the analysis of the results but not for processing within the model. The Moland land use category determines the behaviour of the cells within the model and is fundamental to the modelling process.

Table 9 - The land use legend for Koper

Code	*Land use class / category*	*Description*	*Moland legend category*
0	Arable /natural	abandoned agriculture	vacant
1	Forest /natural	stunted, no associated economic revenue	
2	Pasture /natural		
3	openSpace /natural	rocky, sparse vegetation, no economic revenue	
4	vacant	Vacant urban areas to be built upon first	
5	permanCrop /economic	Olive trees & vineyards, associated economic revenue	function
6	continuous urban fabric /economic	city core	
7	Services /economic		
8	Commercial /economic		
9	infrastPubUtilities /economic	power plants	
10	turistic objects /economic	Mainly marina, but also agrotourism in scenarios	
11	special residential buildings /residential	student & worker dormatories; housing for elderly	
12	multi-dwelling buildings /residential	apartment blocks	
13	individHouses /residential	most desired living space	
14	industryProd /economic		
15	Port /economic		
16	parking that can be built upon	Levels could be added but no expansion is foreseen	feature
16	parking		
16	parking house		
17	road		
18	rail		
19	leisureGreen		
20	cultural heritage	churches, old protected houses	
21	graveyard		
22	mineralExtr		
23	Wetland		
24	Water		
25	no data		

Soil quality legend

The University of Ljubljana provided data on soils quality divisions for the municipality as follows:

Class (SMU)*	*Description*
7 - 25	Very small soil production capability
26 - 39	Small soil production capability
40 - 57	Medium soil production capability
58 - 75	High soil production capability
76 - 100	Very high soil production capability

*SMU – Soil Map Units

This data was used to extract statistics per soil type.

4.2.2 Model set-up

The model was set up as follows (table 10):

Table 10 - The model parameter set up for the Koper test case

Resolution	*50m*
# columns	521
# rows	421
Spatial reference	MGI transverse Mercator False easting: 500000 False northing: -5 000 000 Central meridian: 15 Scale factor: 0.99999 Origin latitude: 0 Datum: D_MGI Top= 52430.6272213 Left=396354.421276 Unit: meters
# regions	1
# vacant states	5
# functional states	11
# feature states	10

The data available for Koper is summarized in Table 11.

Table 11 - The data used to run the Moland model

Input	***Source***
Land use 2000	Koper municipality
Land use 2007	Koper municipality
Administrative divisions map	Koper municipality
Zoning map	Koper municipality & refined at JRC
Digital elevation model	SRTM
Roads 2000	Koper municipality
Roads 2007	Koper municipality
Rail	Koper municipality
Suitability*	Developed in JRC
Statistical data on population and jobs	Slovenia statistical office

* Suitability maps are defined according to the following criteria: - Presence of land use in 2000 & 2007; - data-driven slope and altitude criteria; - soil quality for agricultural classes.

4.2.3 Calibration

Explicit parameters applied for this particular case study can be requested from the author.

Accuracy tests were run during various phases and with different experimental parameters.

A high degree of error in the vacant classes was present during the calibration phase. In order to account for this, all of the natural and semi-natural land uses accounting for the vacant classes were merged so that the calibration could proceed for the functional classes. Figure 28 shows the improvement of the results when the model is calibrated using this generic, merged, natural & semi-natural vacant land use class. The lessons learnt from the calibration with these abridged land use maps improved the calibration of the original data. The model parameters were applied to the full dataset. Once the original legend was restored, the vacant classes were concentrated upon with the manipulation of suitability maps. The no change model was compared to the newly calibrated dataset, also seen in figure 28.

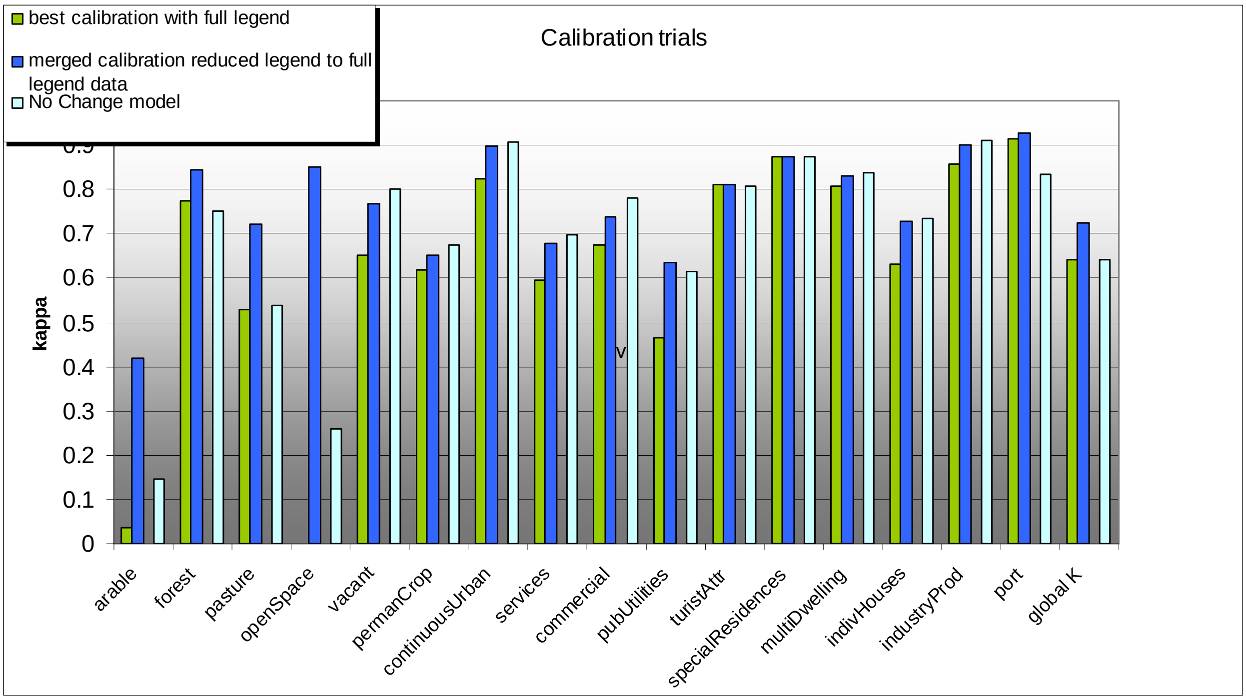


Fig. 28 - Improvements in calibration on the full dataset (with full legend) using macro-model automated calibration parameters derived from the legend based on merged semi-natural and natural vegetation classes and improvements on sustainability maps for natural land use classes.

4.2.4 Validation

A May 2009 land use map was used to validate the calibration. These maps are updated by the Slovenian government several times a year and are publically available[6]. These datasets are particularly useful for the natural and semi-natural vegetation classes, and especially for the crops. The built up classes are amalgamated, which restricts this dataset's potential for urban classes but results can be gauged by comparing the simulated overall shape of sprawl in the study area with the true shape as shown in the validation data.

[6] Ministrstvo Za Kmetijstvo, Gozdarstvo in Prehrano (http://rkg.gov.si/GERK/), consulted in July, 2009.

Natural and semi-natural areas

The calibration parameters were run from 2007 to 2009 (table 12). The port was not expanded and the permanent crop figures were taken from the true data extracted from the land use maps of Koper Municipality. The other economic sectors were entered as continuing the trend shown from 2000 to 2007.

Table 12 - Trends in sectors entered for the 2007 2009 simulation.

sector	2007 (number cells)	2009 (number cells)
Port	1134	1134
Agriculture	15367	16198
Services	274	302
Industry	824	831
population	4046	4161

The classes in both the simulated and validation dataset had to be changed so that they were comparable; many classes were merged. Table 13 shows the results of the validation procedure for semi-natural and natural vegetation, permanent crops, and built up (urban) areas.

Table 13 - Confusion matrix of simulated 2009 land use and ground truth 2009 land use maps (validation)

Confusion Matrix
Overall Accuracy = (108480/113364) 95.6918%
Kappa Coefficient = 0.9283

Ground Truth (Percent)

Class	forest	pasture	crop	urban
forest	98.46	3.93	0.15	0.82
pasture	0.27	90.85	0.73	2.16
crop	0	0.21	91.61	2.26
urban	1.27	5	7.51	94.68

Ground Truth (Percent)

Class	Total
forest	58.28
pasture	16.72
crop	12.86
urban	11.79

Class *(Percent)*	Commission *(Percent)*	Omission *(Pixels)*	Commission *(Pixels)*	Omission
forest	1.45	1.54	960/66063	1017/66120
pasture	2.94	9.15	557/18949	1852/20244
crop	2.01	8.39	293/14574	1308/15589

urban	22.92	5.32	3065/13370	579/10884

4.2.5 Scenarios

Four scenarios are outlined within the PLUREL module 1 (taken from PLUREL deliverable 1.3.2):

- ***A1-techno***, rapid development in ICT leading to reduced commuting and transport needs, with no constraints on the location of new build (WP1.4),
- ***A2-climate* -** climate change reaches a tipping point leading to impacts including rapid sea level rise, flooding and water resource constraints (WP1.3).
- ***B1-econ*,** an energy price shock leading to rapidly increasing energy and transport costs and consequent changes in mobility and trade flows (WP1.1),
- ***B2-demog*,** a pandemic disease leading to major population declines and behavioural shifts within society (WP1.2),

These scenarios were adapted to suit the mandate of the PLUREL project as shown in Fig. 29. A full description of the adapted scenarios can be found in the PLUREL deliverable 1.3.2.

The scenarios were presented and discussed with the Koper Stakeholder committee and two scenarios were retained for the Koper test case: Hyper Tech (A1) and Peak oil (B1). The business as usual scenario was also run in addition to these two scenarios.

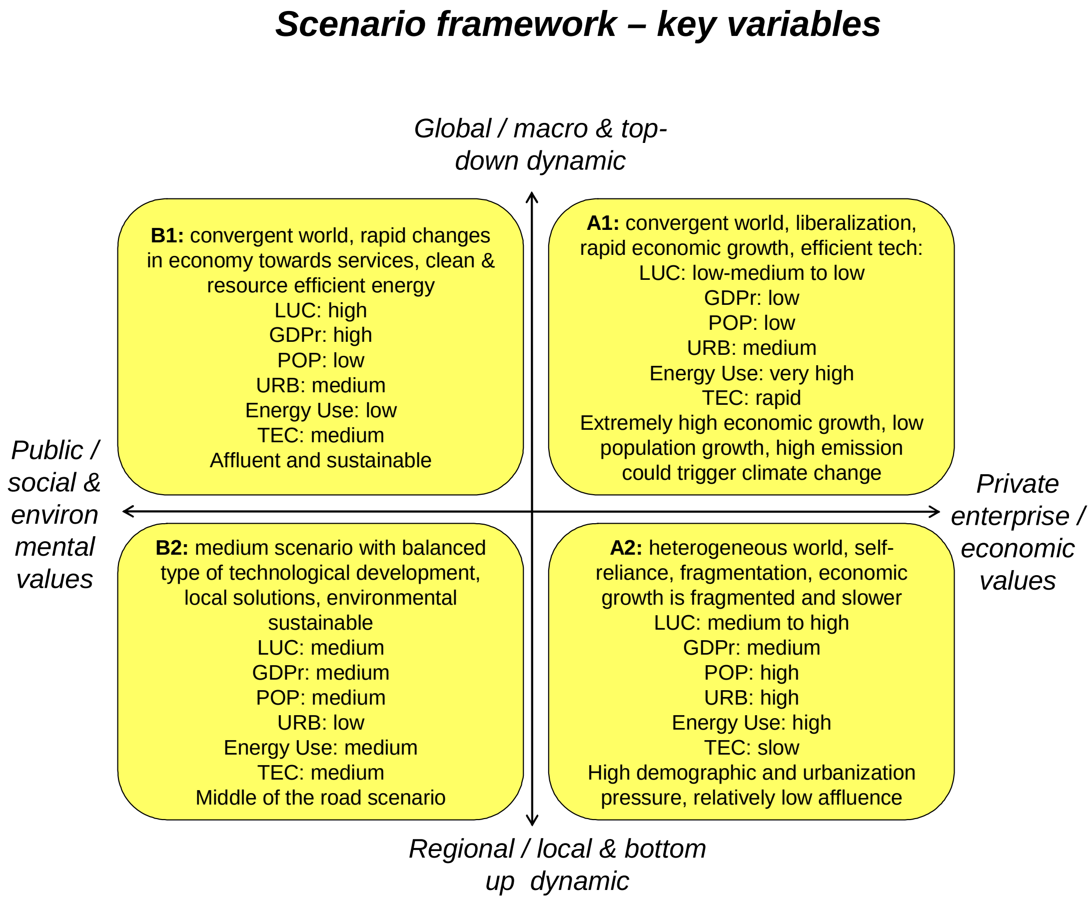


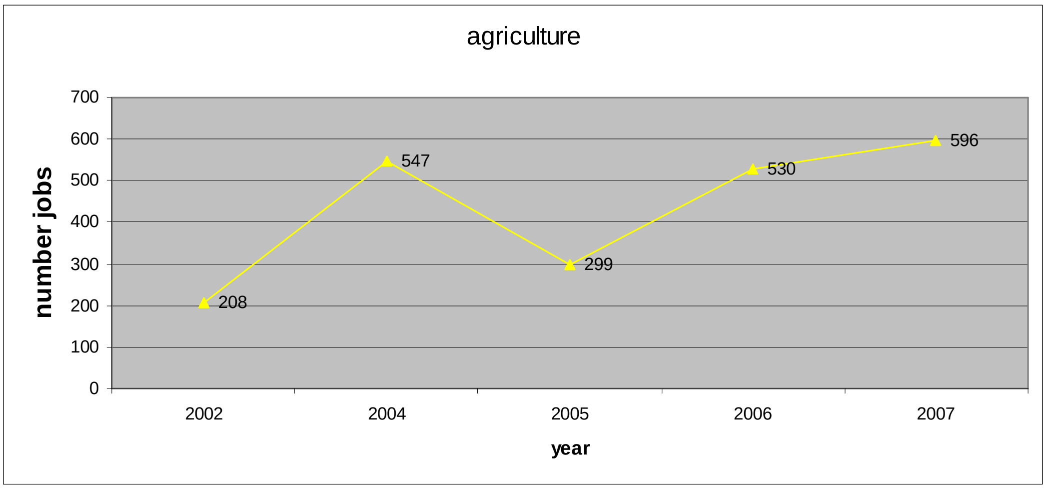
Fig. 29 - Adapted SRES[7] scenario key variables (taken from d1.3.2.)

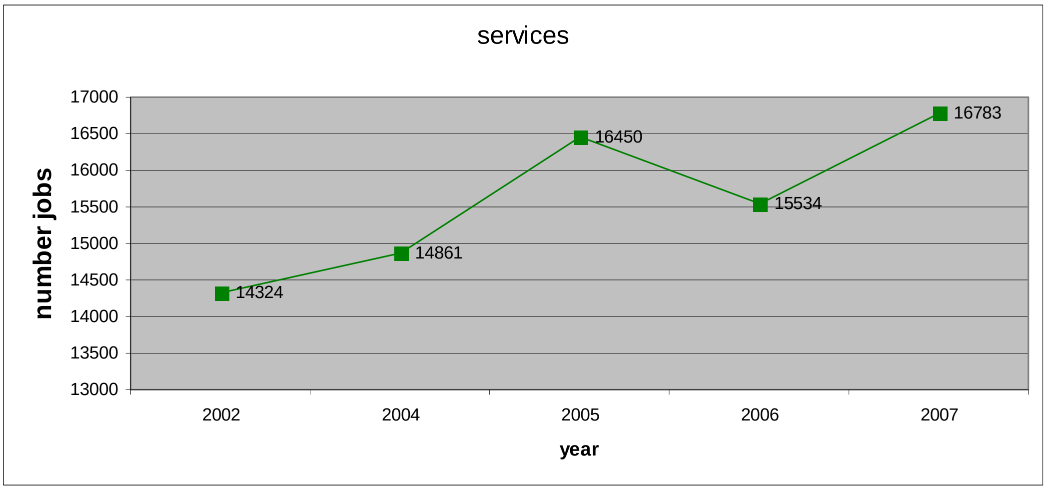
4.2.5.1 Business as usual scenario

The "Business as usual" scenario is run in order to test the calibration robustness and to eventually tweak the trends observed for the calibration period. Two sources were used in the set up of the BAU scenario:

1) National trends for the past decade and future projections according to Eurostat (annex a) and national statistics bureau (figures 30)

[7] SRES: "Special report on Emissions Scenarios". A report prepared by the Intergovernmental Panel on Climate Change.





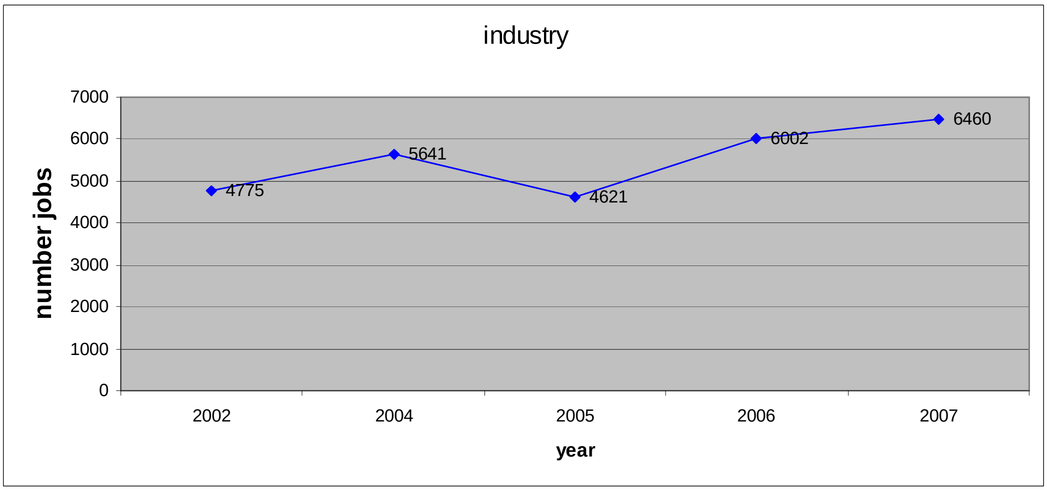


Fig. 30 - Municipality trends for economic sectors agriculture, services, industry (source: Statistical office of the republic of Slovenia http://www.stat.si/eng/index.asp)

2) Observed trends in land use changes from 2000 to 2007 based on land use maps provided by the municipality.

The following is a brief description of the parameters used to run this scenario for Koper:

- Economic sector trends (table 14),
- Employment increase in services sector,
- Industry steady,
- Energy production on the rise,
- Employment in agriculture steadily increasing, land area for this sector is decreasing (overall increase in density).

Table 14 - Past and projected trends in population and employment per economic sector

	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2025*
Population	*47415*	*47475*	*47848*	*48022*	*48147*	*48519*	*49039*	*49303*	*49682*	*49836*	*54885*
Jobs, agriculture	*286*		*208*		*547*	*299*	*530*	*596*		*625*	*1783*
Jobs, port	*830*		*924*	*918*	*924*	*950*	*963*	*1070*	*1081*	*1073*	*1557*
Jobs, industry & commerce	*3570*		*4775*		*5641*	*4621*	*6002*	*6460*		*7024*	*11583*
Job, services	*13241*		*14324*		*14861*	*16450*	*15534*	*15713*		*1997*	*23391*

- Housing trends:
  - Individual houses in the peri-urban and hinterland,
  - Densification along roadside,

- o Coast is also attractive for building condominiums and apartment buildings,
- o Significant increase in individual housing (25%) converted from vacant urban, pasture and permanent crop,
- o Small increase in block housing (2%),
- o Large increase in residence buildings (58%).
- Small decrease in continuous urban (3%)
- Population steadily growing
- Accessibility: housing attracted to roads; commerce and services not. These remain near the city centre (creation of dormitory towns without services or commerce; people travel to Koper centre)
- Zoning: only for Natura 2000 areas.

Table 15 - Trends in sectors entered for the 2007-2025 business as usual simulation.

sector	2007 (number cells)	2025 (number cells)	2007 (number jobs)	2025 (number jobs)
Port	1134	1200	1070	
Agriculture	15367	15000	596	
Services	274	525	15713	16500
Industry	824	831	6460	6500
population	4046	5083	49303	54900

4.2.5.2 Hyper Tech scenario

This scenario, as described by SRES, is characterised by very high economic growth. The population is described as reaching a peak growth and the decline after 2020. There is avid building within this scenario, with few (if any) zoning restrictions in order to emphasize absence of planning (table 17).

The following is a brief description of the amendments to this scenario for the Koper test case:

- Economically driven plan with concentration on the tourism sector. Increase in hotels and associated infrastructure.
- Decrease in zoning of natural areas near coastline.
- Decrease in zoning for built up classes; building is unrestricted.
- Port grows inland
- Roads: New access to port; new highway to Izola and selected variant for the motorway from Koper to Dragonja
- Rail: New access to the port; railway to Trieste

- Various: Seeds planted by municipality for new infrastructure (table 17, figure 31)

Table 16 - Trends in sectors entered for the 2007-2025 hyper tech simulation.

sector	2007 (number cells)	2025 (number cells)	2007 (number jobs)	2025 (number jobs)
Port	1134	2000	1070	
Agriculture	15367	15000	596	
Services	274	700	15713	30000
Industry	824	1500	6460	9000
population	4046	5080	49303	55000

Table 17 - The new buildings entered into the Moland model as "seeds" at the prescribed year, and their relative attraction and repulsion properties.

ID	Seed	year	Attracts	Repulses	Economic impact
1	ŠRC Ankaran, sports complex	2011	tourism, housing, services, commerce	industry, agriculture, forestry	stimulates growth in touristic revenue; stimulates growth in services revenue (non-touristic); stimulates growth in commerce; diminishes revenue from agriculture (destroyed farmlands)
2	GORC Sermin: Industrial park (under category "commercial")	2010	services, industry, commerce	housing, agriculture, forestry, tourism	increased revenue from services, industry and commerce (economy of scale); diminished revenue from agriculture (destroyed farmlands); lessened appeal for tourism (nearby Škocjan inlet); increased traffic from and to location
3	Marina	2014	tourism, services, commerce	housing, agriculture, forestry, industry	increased revenue from tourism and services;
4	Public swimming pool	2010	tourism, services	industry, agriculture, forestry	increased revenue from tourism and services;
5	Football stadium	2010	tourism. services	industry, agriculture, forestry, commerce	increased revenue from tourism and services; increased traffic from and to location;
6	"Tuš" - large shopping mall	2010	commerce, services, tourism	housing, industry, agriculture,	increased revenue from commerce; high increase in traffic flows around area

	forestry

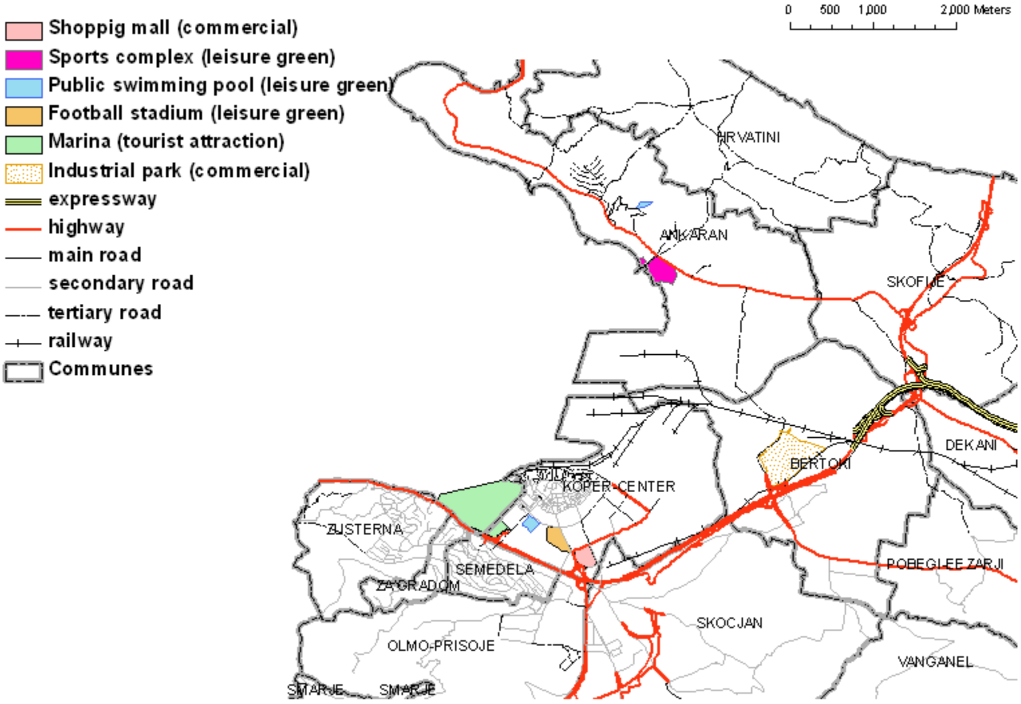


Fig. 31 - The building plans implemented in the hyper tech scenario.

4.2.5.3 Peak oil scenario

This scenario, as described by SRES, is characterised by a society whose priorities are in serves and informatics rather than industry and production (as in the A1 scenario). Emphasis is placed on social issues and environmental sustainability. As is the case for the A1 scenario, the population is described as reaching a peak growth and the decline after 2020. Building is restricted using strong zoning restrictions within this scenario.

The following is a brief description of the amendments to this scenario for the Koper test case (table 18):

- Emphasis on protection of natural resources,
- Respect soil fertility classification and Natura 2000 as zoned for no building,
- Economic incentives to agriculture sector; growth of this sector in hinterland,
- Eco-tourism emphasizes attractiveness of natural areas and inland areas,

- Densification within the areas of the port but port does not spread,
- Encouragement of housing in hinterland, relieve pressure on coastline,
- Rail: branching rail of hinterland to Koper; Koper to Izola.

Table 18 - Trends in sectors entered for the 2007-2025 peak oil simulation.

sector	2007 (number cells)	2025 (number cells)	2007 (number jobs)	2025 (number jobs)
Port	1134	1300	1070	
Agriculture	15367	25000	596	
Services	274	700	15713	27000
Industry	824	1000	6460	8000
population	4046	5083	49303	54900

Note on zoning map: The zoning map did not always correspond to the actual land use in 2007. The zoning map was therefore adjusted to include all CURRENT land uses as "allowed". Otherwise unrealistic results occur: Certain land uses disappear from 2007 to 2008 because they are forbidden according to the original zoning maps.

4.3 Results

This section is divided into three main parts. First, the land use change results are discussed scenario by scenario for

- the municipality
- per commune
- per soil typology
- per RUR typology (see Annex C for raw data)

Second, the scenario results are compared. Third, selected indicators are shown for the municipality, including an analysis of built-up area patterns for the municipality.

4.3.1 BAU scenario

4.3.1.1 Municipal land use changes

The municipality shows a net increase in arable land between 2007 and 2025 following the business as usual scenario, while permanent crop, pasture and vacant urban land shrink. The most important growth among functional classes occurs within the individual housing class and port area (figure 32).

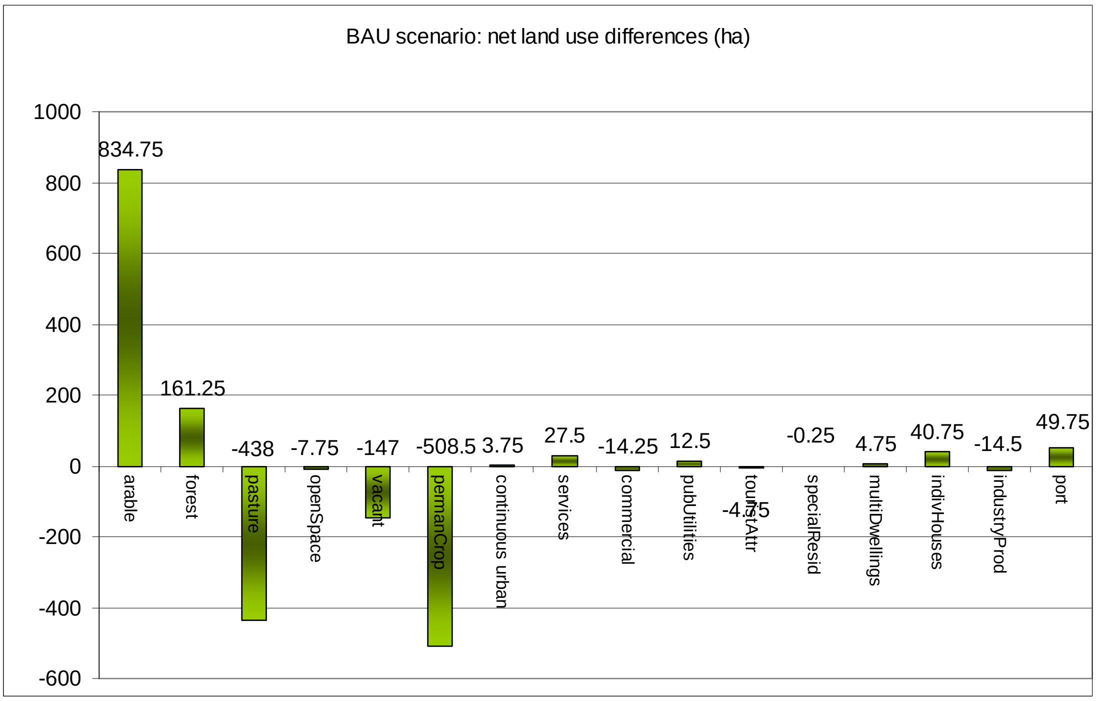


Fig.32 - Net land use differences over 18 years (from 2007 to 2025) for Koper municipality, following the "Business as usual" scenario

Changes from 2007 to 2025 for all land uses take place in throughout the municipality at differing degrees depending on the scenario run. Figure 33 illustrates the locations of the areas most affected by land use changes according to the business as usual scenario.

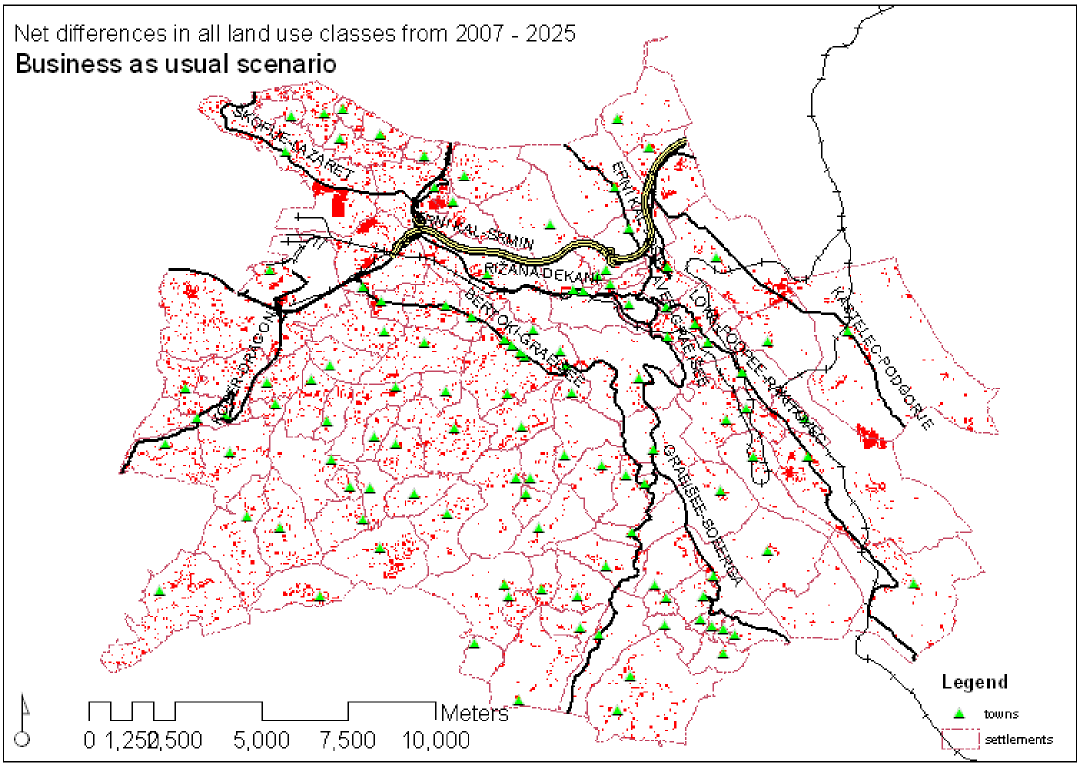


Fig. 33 - Areas where land use changes occurred from 2007 to 2025 for the business as usual scenario

For the business as usual scenario, the main changes are in individual housing, services and the port area. The port area is foreseen to expand northeast; the services increase in the peri-urban area; the individual houses are abandoned in some rural areas but not all, and are foreseen to increase along the Bertoki-Graeisse main road from Koper center to the hinterland (figure 34).

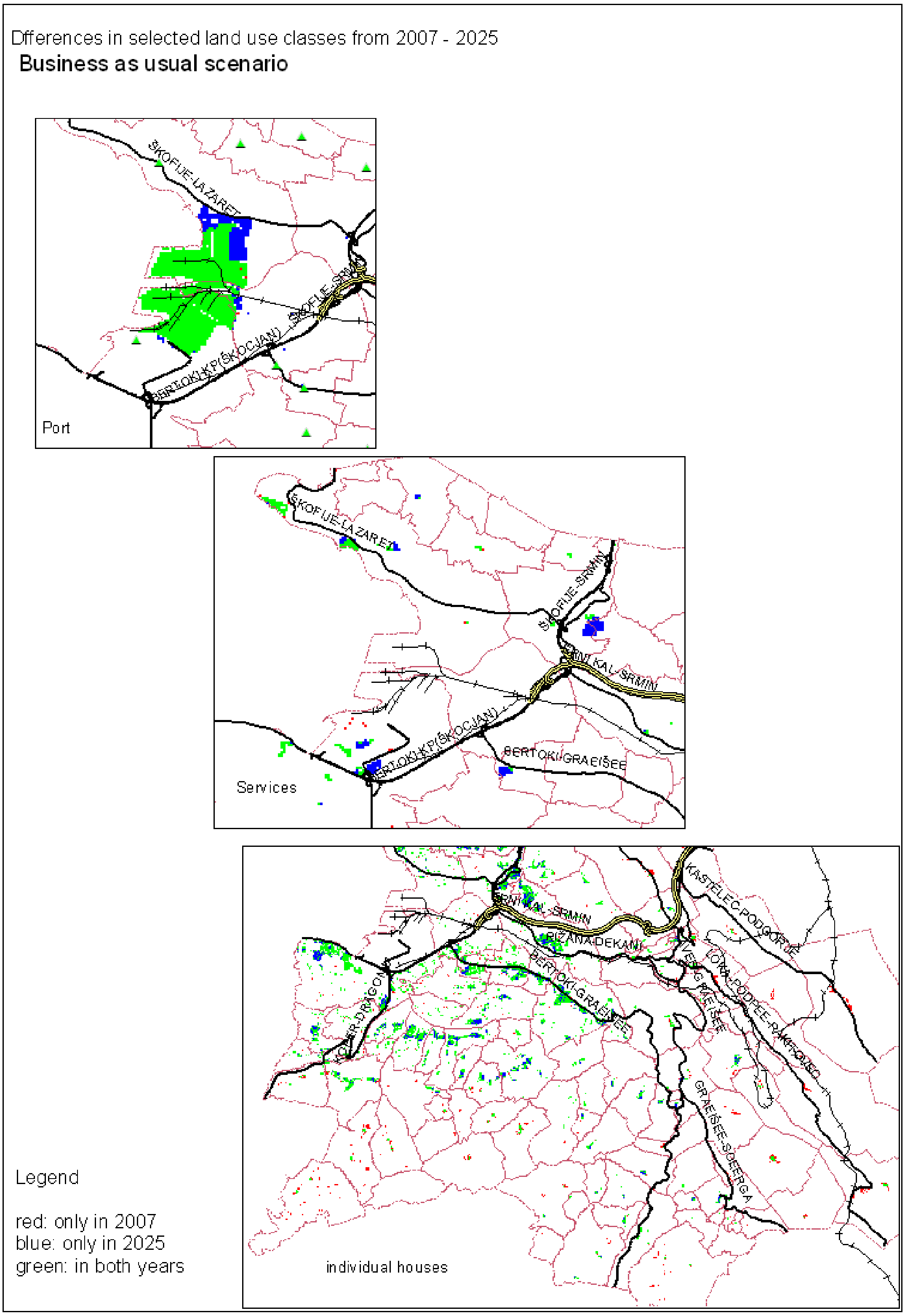


Fig. 34 - Land use changes for port, services and individual housing as the result of the business as usual scenario run for 2025.

4.3.1.2 Community land use changes

The communities are affected differently by the business as usual scenario in 2025, according to the Moland projections. The residential area grows in five communes but remains stable in most. There is a decrease in residences in seven communes. As far as economic activity is concerned, its increase is mainly prevalent in the communes where residential areas are on the decline. Where economic and residential areas decline in 2025, natural areas take over (figure 35). Figure 36 shows the numeric details of these figures.

![PLUREL logo]

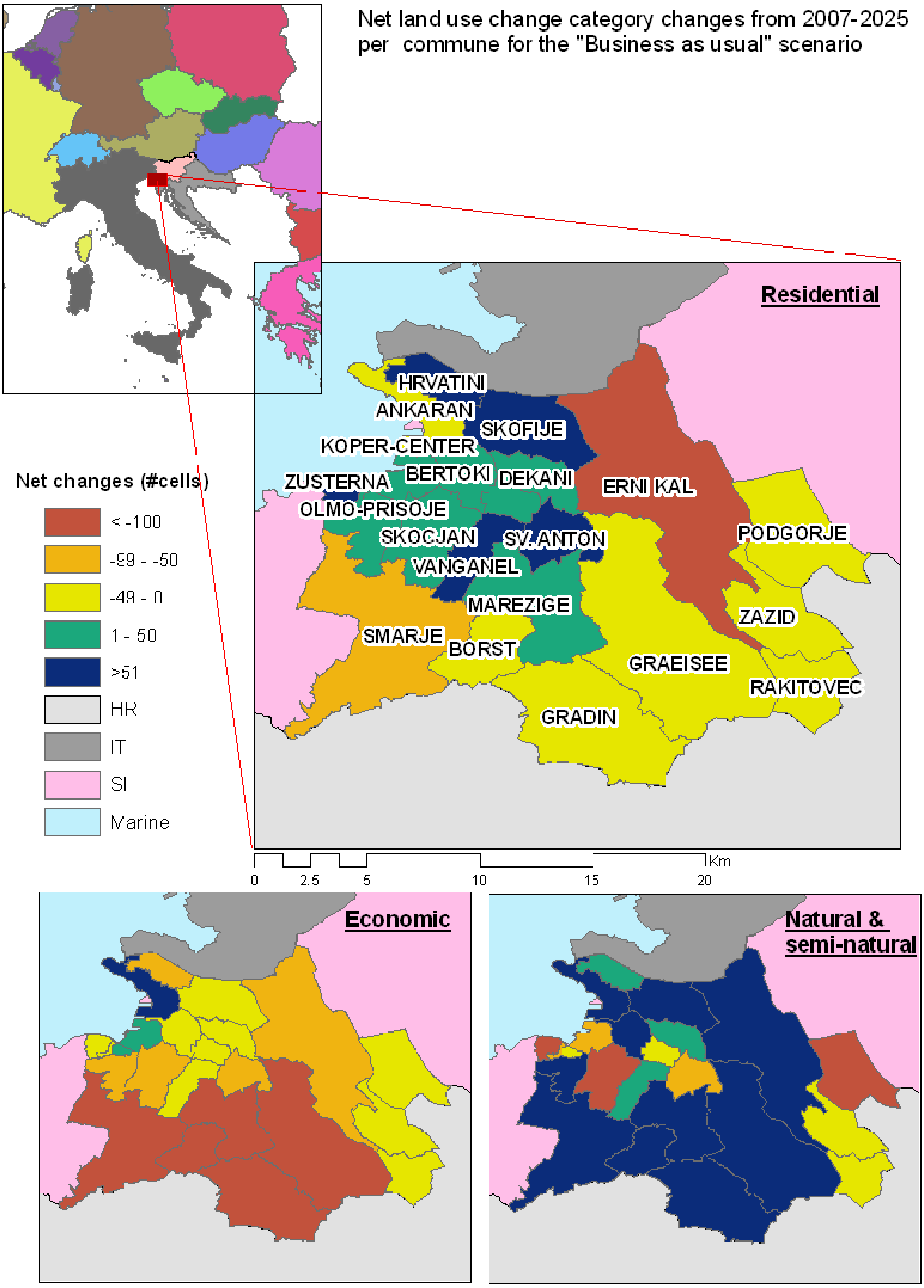


Fig. 35 - An overview of the trends in residential, economic and natural and semi-natural land use classes at a commune level for the BAU scenario projections for 2025.

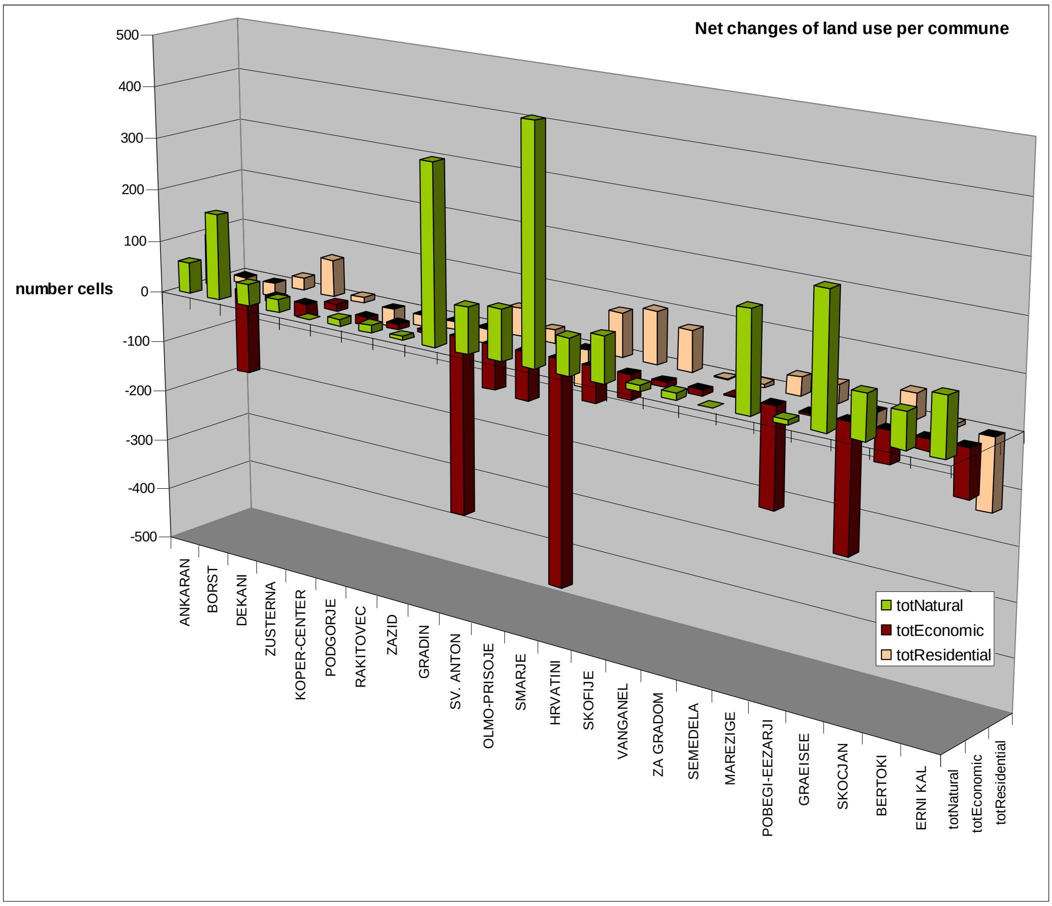


Fig. 36 - Details of land use class changes for the BAU scenario per commune in Koper

4.3.1.3 Soil typology land use changes

According to the results of the business as usual scenario, the main soil type competed for among the three land use categories is the richest soil. This makes sense since the economic interest includes the agricultural sector. Residential areas increase in the best soil categories, as shown in figure 37:

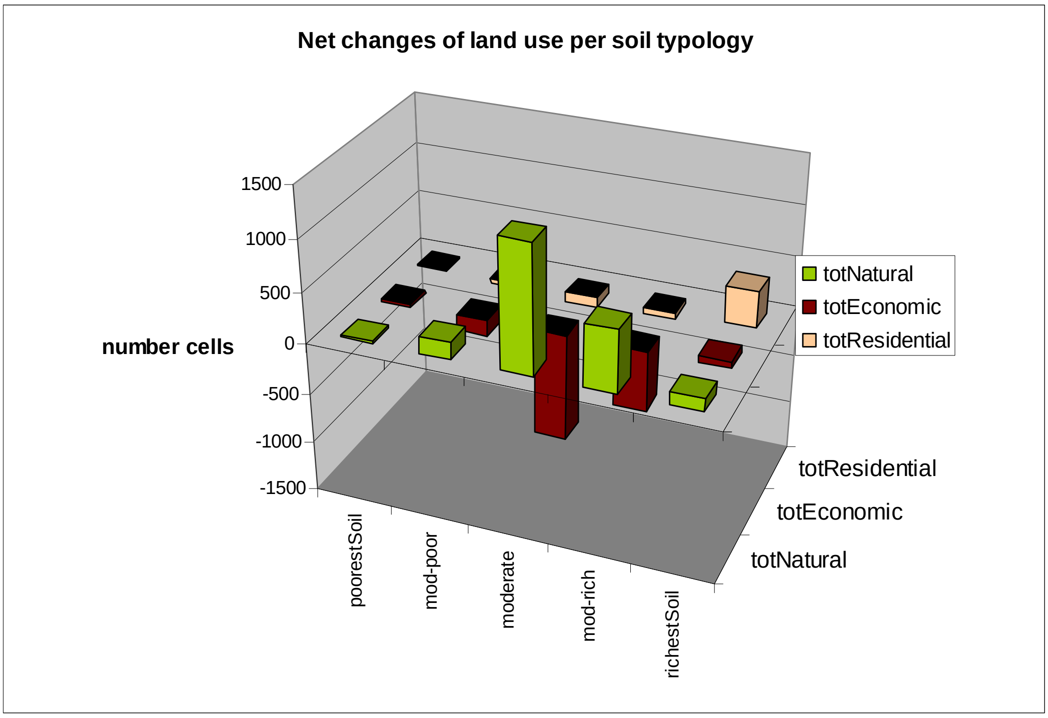


Fig. 37 - The net changes of land use categories per soil type.

4.3.1.4 RUR typology

According to the results of the business as usual scenario, the most important changes in built-up areas from 2007 to 2025 are in the periurban areas: Percent increase in urban areas is 7.83%; percent increase in periurban areas is 26.30% and percent increase in rural areas is -21.60%.

4.3.2 Hyper tech scenario

4.3.2.1 Municipal land use changes

At the end of the processing period for the hyper tech scenario, a net decrease in permanent crop, pasture land and vacant land prevail. There is a net increase in tourist attraction, commerce and services, and in residential buildings (figure 38).

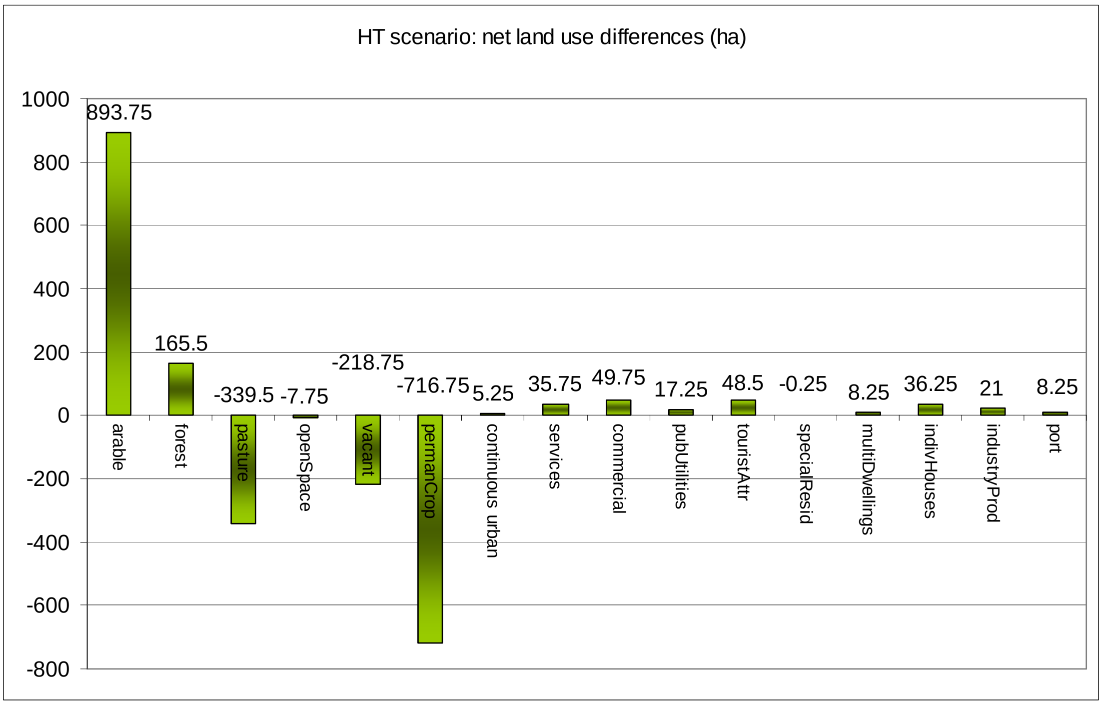


Fig. 38 - Net land use differences from 2007 to 2025 according to the HT scenario.

The main differences in the hyper tech scenario are related to the seeds which were implemented (see table 17, figure 31). The leisure green, commercial and tourist attraction classes were altered by seeds. Figure 39 shows the net changes for all land use classes for this scenario.

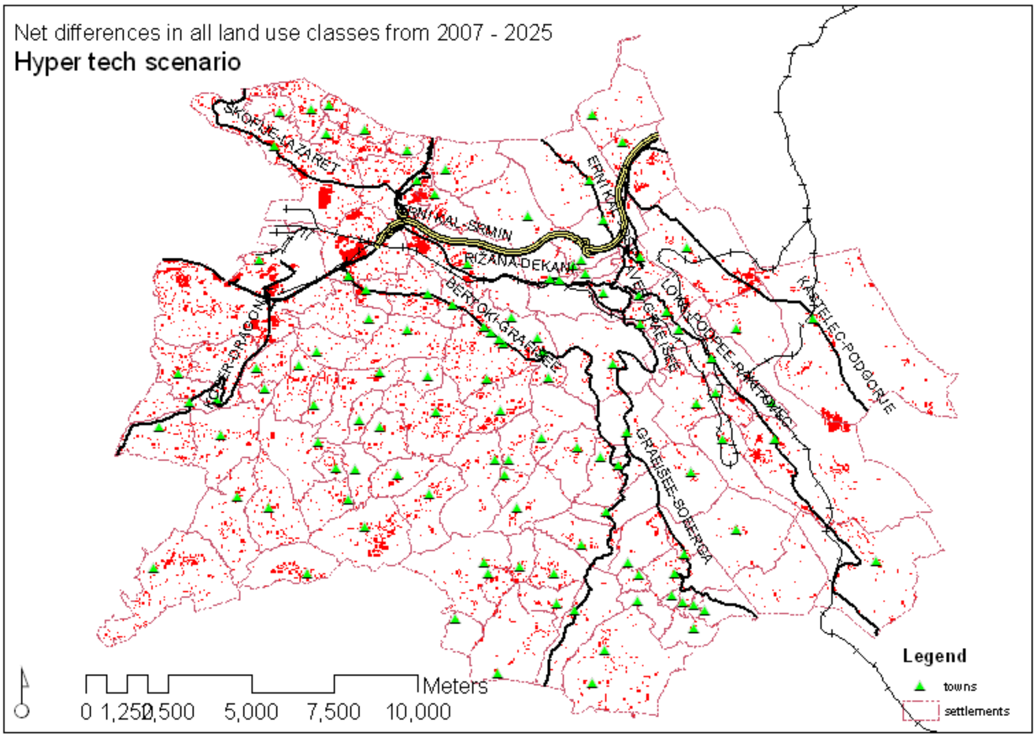


Fig. 39 - Net changes for all land use classes between 2007 and 2025 for the hyper tech scenario.

The impact on the area concerned and surrounding the "forced growth" of these classes is shown in figure 40.

4.3.2.2 Commune land use changes

At a community level, as shown in Fig. 41, changes occur in all communities. In terms of residential activity, there is an important increase in Skofije and Hrvatini on the Italian border while Erni Kal experiences a decrease in residential activity. From an economic perspective, several communities undergo a slight increase, including rural communities. Smarije is an exception to these trends: this community experiences an increase in natural and semi-natural land use classes, and a decrease in economic and residential activities. The simulated construction of the new marina and the sports facilities impacts the associated communities on the coast.

Figure 42 shows the detailed breakdown of the land use class changes for Koper.

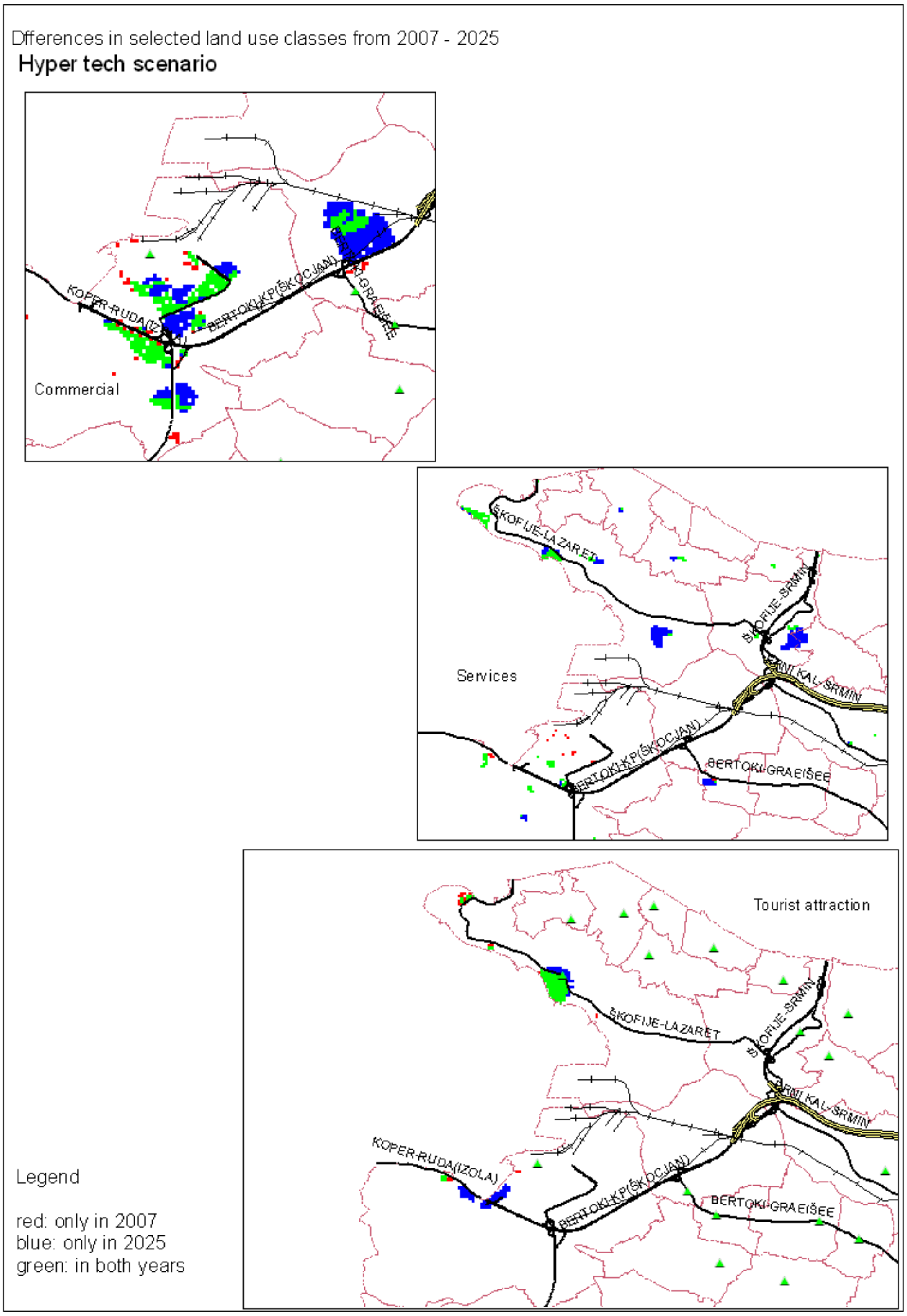


Fig. 40 - The differences in land use between 2007 and 2025 for the hyper tech scenario for three land use classes: commercial, services and tourist attraction

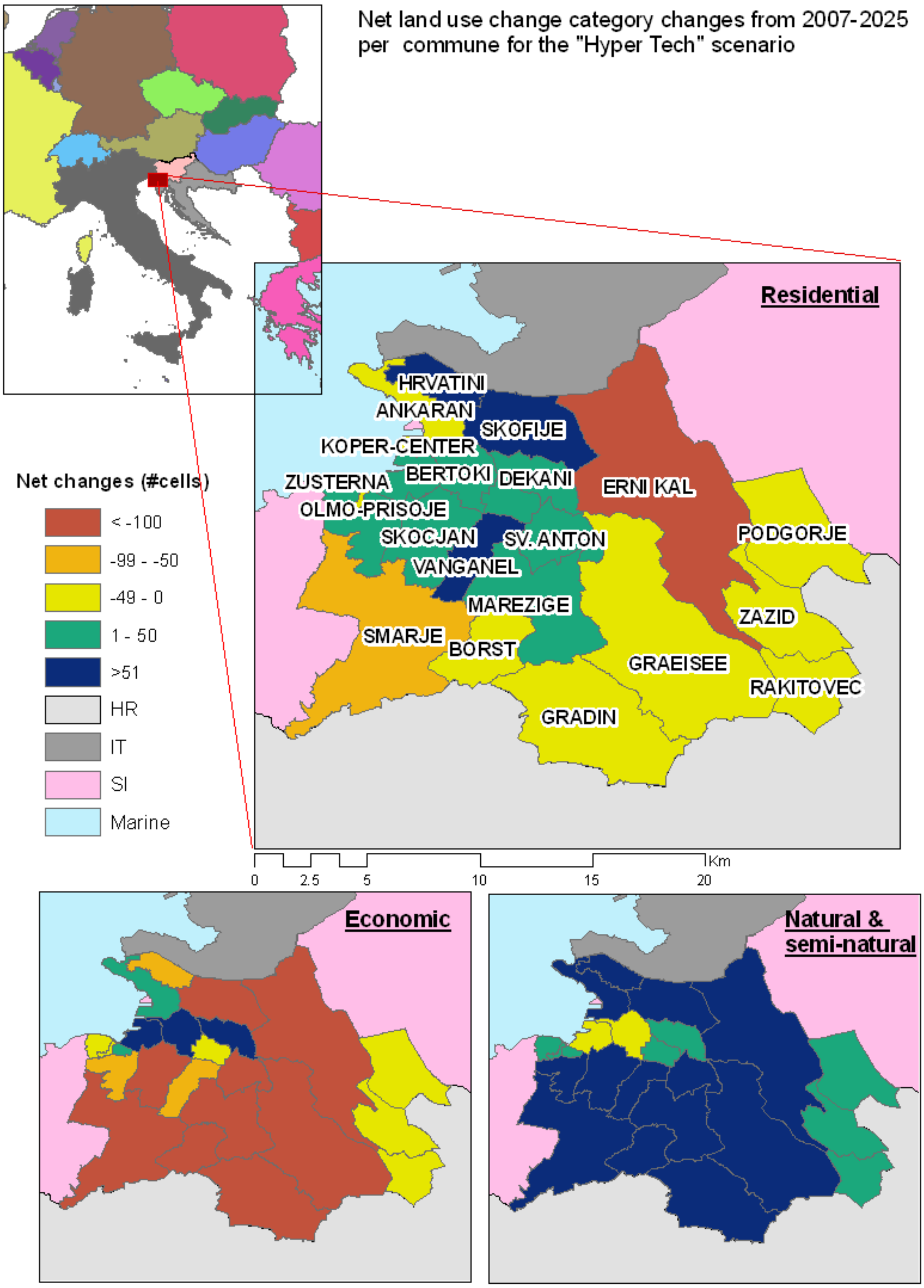


Fig. 41 - An overview of the trends in residential, economic and natural and semi-natural land use classes at a commune level for the HT scenario projections for 2025

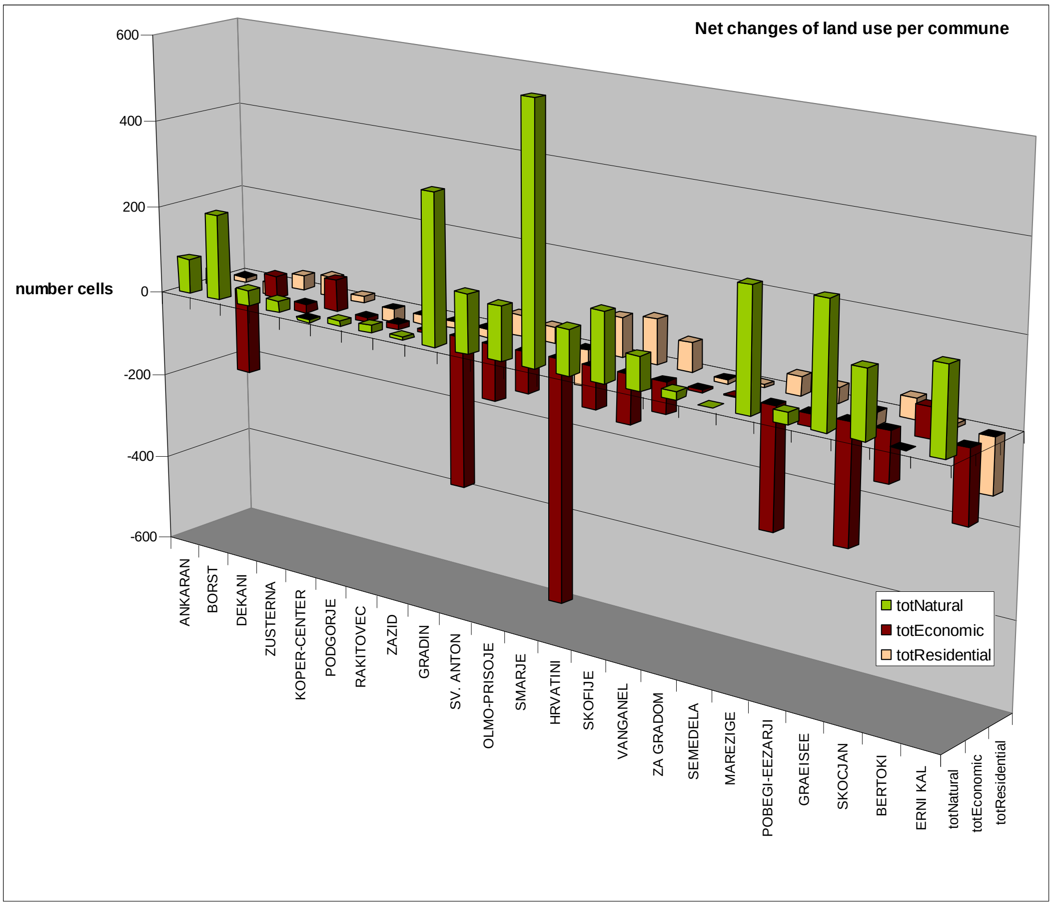


Fig. 42 - Details of land use class changes for the HT scenario per commune in Koper

4.3.2.3 Soil type land use changes

As figure 43 shows, there is competition for the richest soil between the natural land use and the residential land use categories. The natural land use category dominates the moderate to rich soil categories.

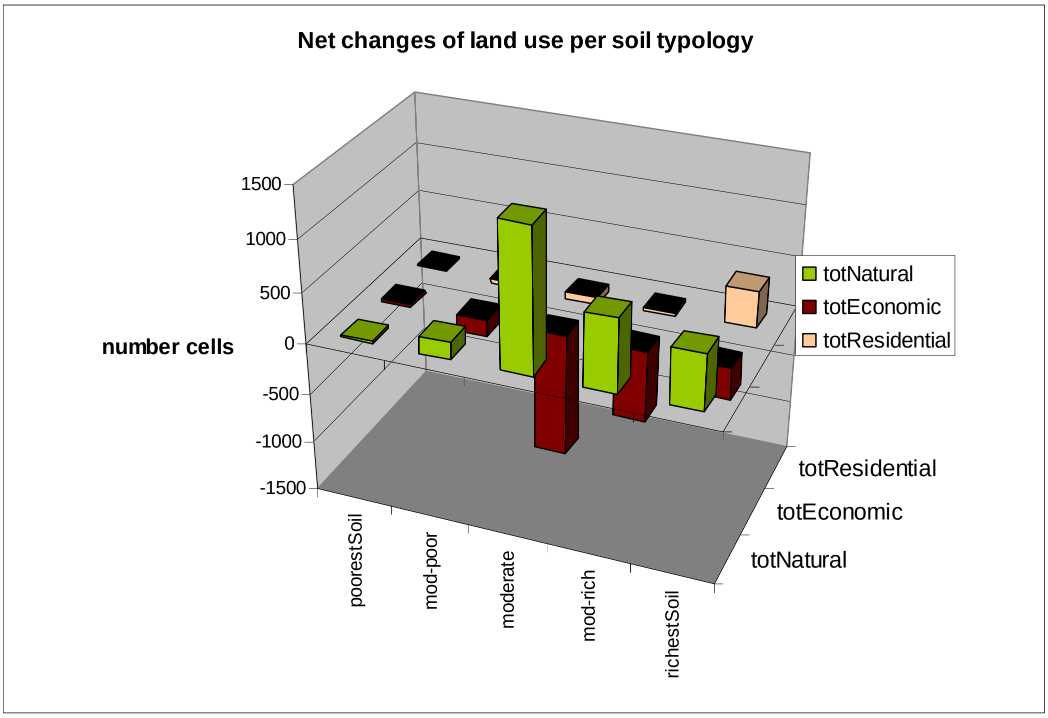


Fig. 43 - The land use category changes per soil type for the 2025 projections according to the HT scenario.

4.3.2.4 RUR typology

According to the results of the hyper-tech scneario , the most important changes in built-up areas from 2007 to 2025 are in the periurban areas: Percent increase in urban areas is 12.40%; percent increase in periurban areas is 33.43% and percent increase in rural areas is -15.00%.

4.3.3 Peak oil scenario

4.3.3.1 Municipal land use changes

The peak oil scenario shows an important decrease in pasture land, and relative stability in other vacant land use classes. The main land use that experiences an increase is permanent crop. Other land uses experiencing increases are associated with the services sector and individual housing (figure 44).

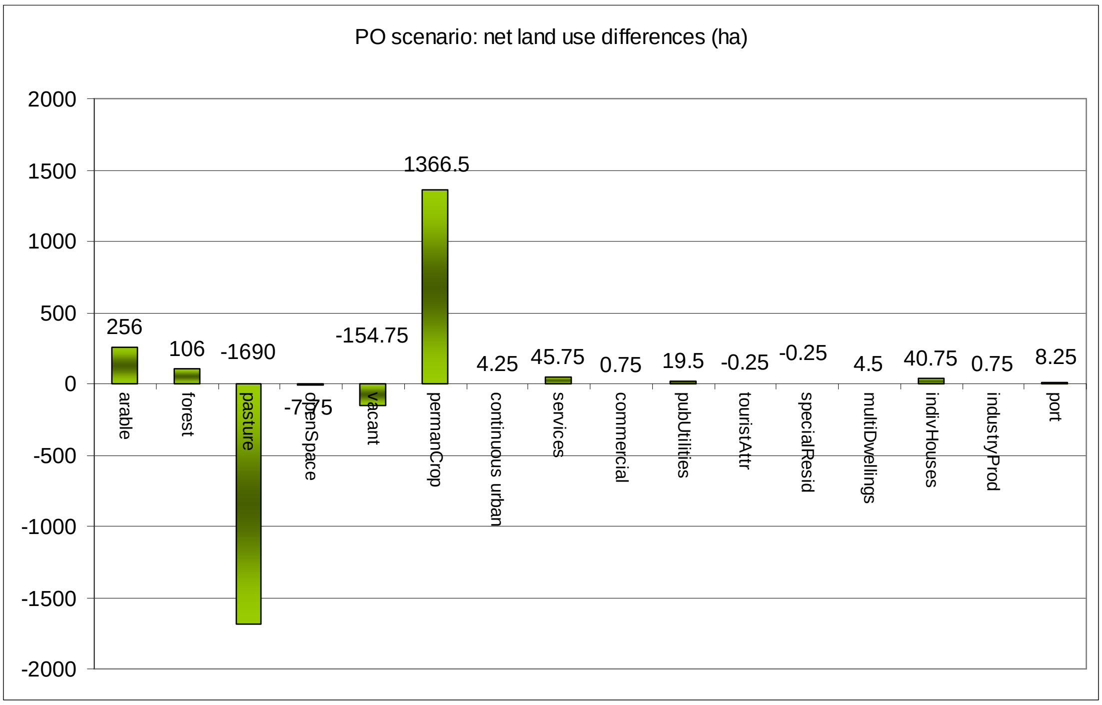


Fig. 44 - Net land use differences per class for the PO scenario projections for 2025

The net changes in land use from 2007 to 2025 due to the parameters set for the peak oil scenario are shown in figure 45.

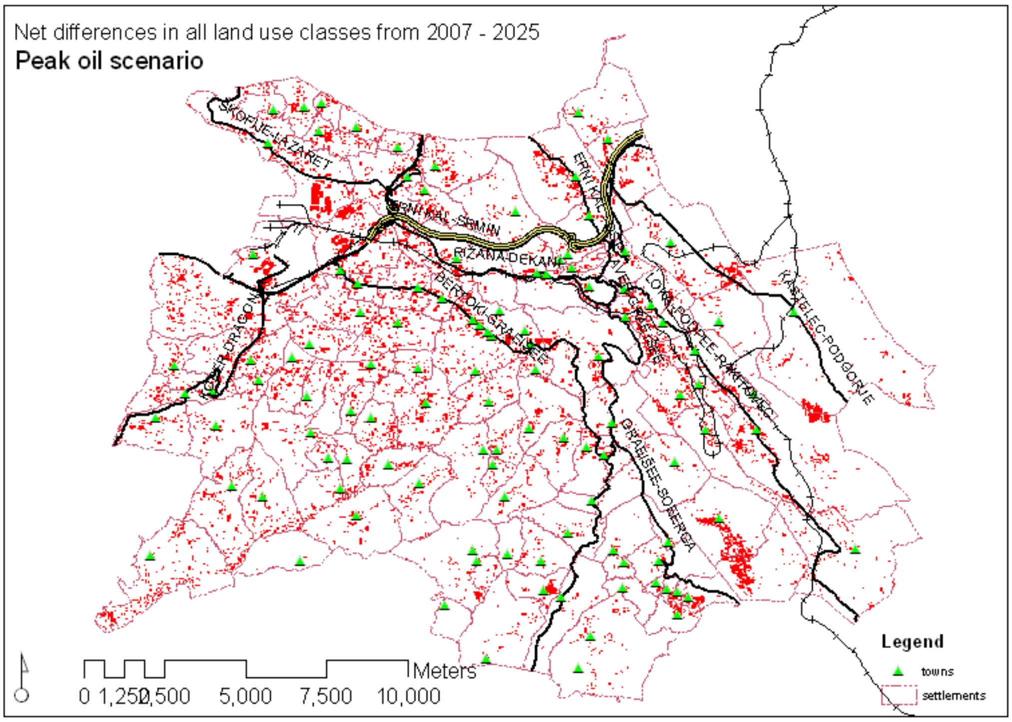


Fig. 45 - Net changes for all land use classes between 2007 and 2025 for the peak oil scenario

The main feature that characterizes the peak oil scenario is the growth in the agriculture sector. There is notable increase in permanent crop land use class. This affects the location of individual houses and services. These two classes remain intact and grow in the rural hinterland as a result of maintaining incentives for growing permanent crops. In addition to this, new tourist attractions crop up in the heart of the agricultural land (figure 46). This does not occur for the other two scenarios.

4.3.3.2 Commune land use changes

The net increase in the permanent crop class predominantly benefits Koper's rural areas. Erni Kal and Graeisse are significantly impacted by this scenario for the economic land use category at the price of their natural and semi-natural land use classes. Areas with significant residential activity increases are Skofje and Graeisse (figure 47).

The land use category net change breakdown per community is detailed in figure 48.

4.3.3.3 Soil type land use changes

The main change in occupation of the three top richest soil categories is within the economic sector (figure 49). This occurs at the expense of natural land use classes.

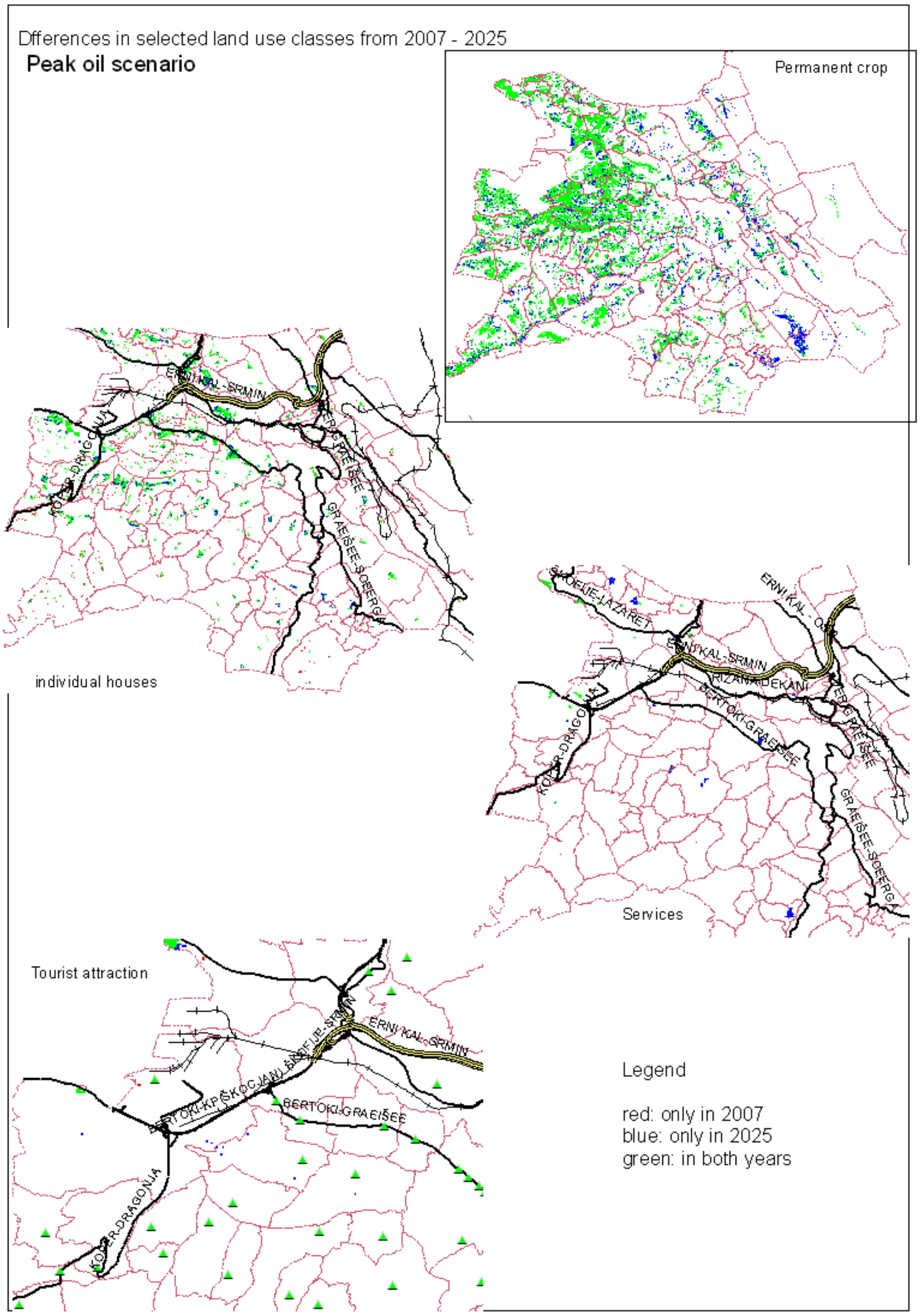


Fig. 46 - The results of the peak oil scenario on selected land use classes

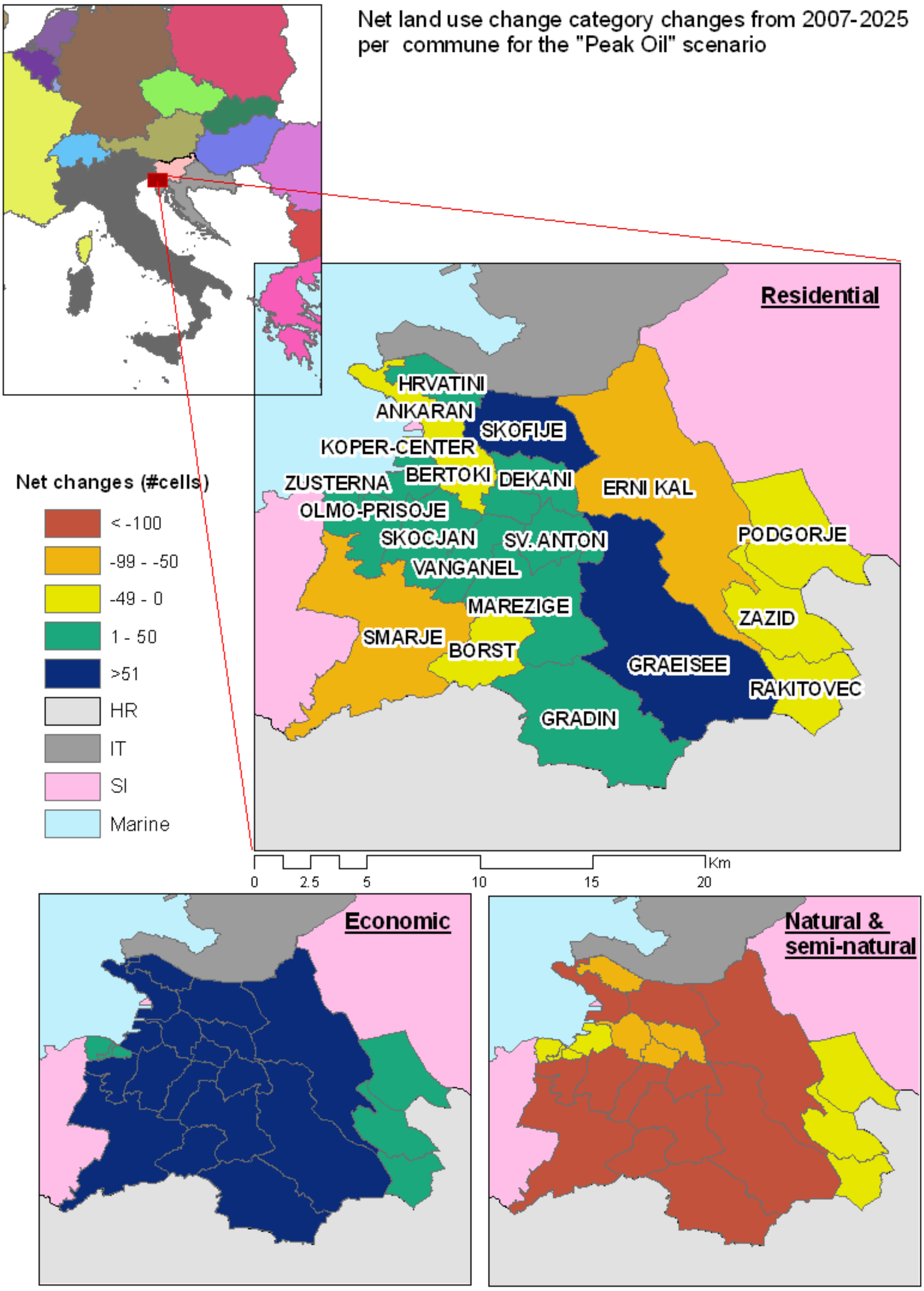


Fig. 47 - The overview of trends for the PO scenario on a community level per land use category.

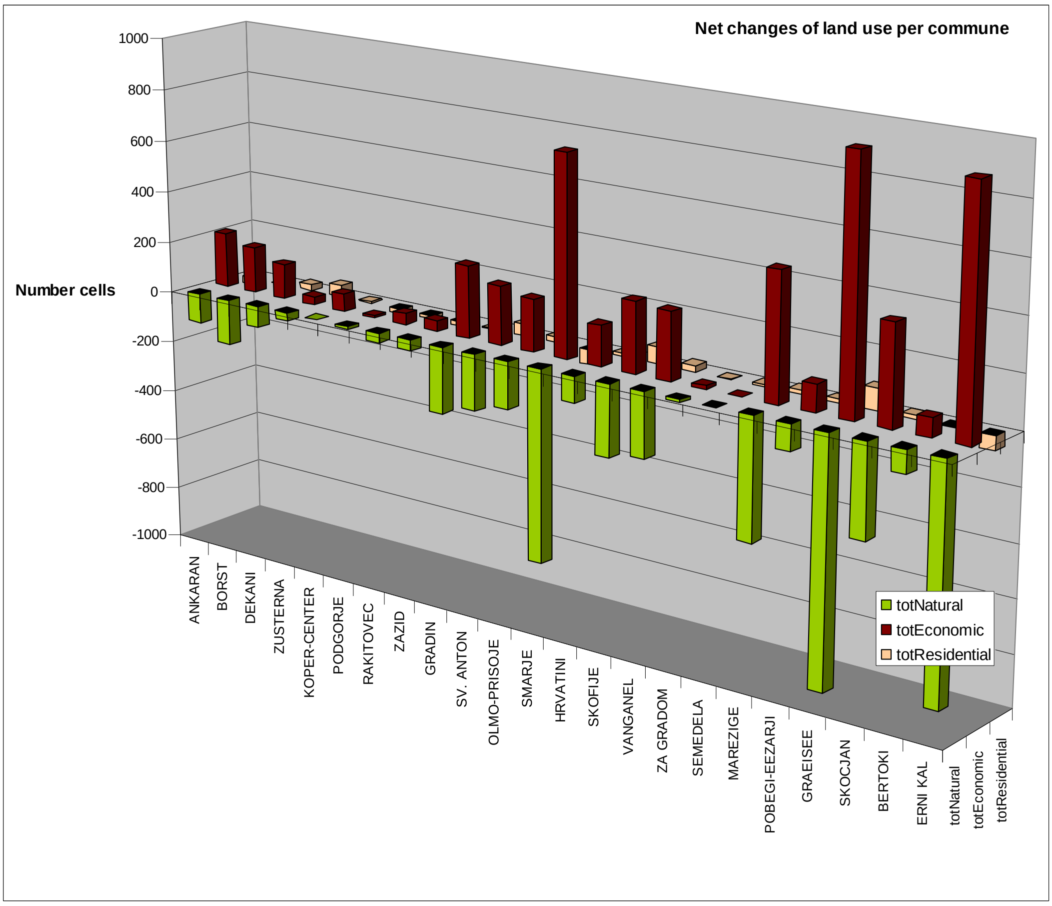


Fig. 48 - The breakdown of the land use category net changes from 2007 – 2025 for the PO scenario per commune.

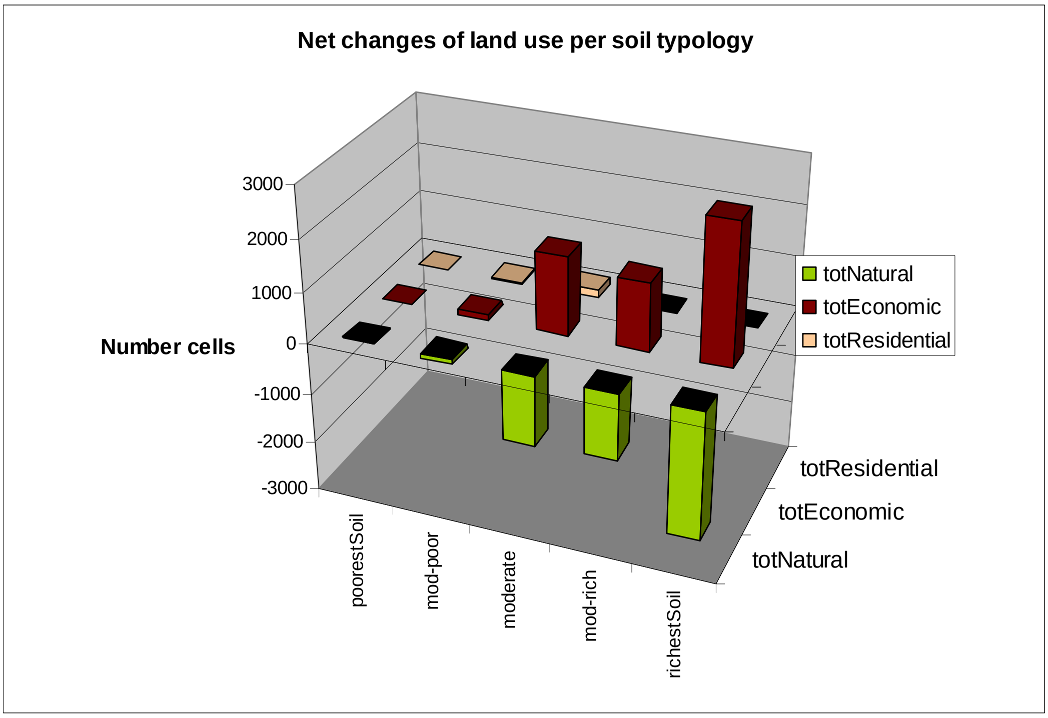


Fig. 49 - The land use category changes per soil type for the 2025 projections according to the PO scenario

4.3.3.4 RUR typology

According to the results of the peak oil scenario, the most important changes in built-up areas from 2007 to 2025 are in the rural areas: Percent increase in urban areas is 10.77%; percent increase in periurban areas is 12.71% and percent increase in rural areas is 24.36%.

4.3.4 Comparing scenario results for 2025 projections

4.3.4.1 Net land use demand changes

As figure 50 shows, the hyper tech and business as usual scenarios do not differ very much from one another: built up classes grow at the expense of vacant urban and pasture. The peak oil scenario differs mainly because of the land use demand for agricultural land. The preference for good soils for this land use class, reflected in the zoning maps, results in crops predominantly replacing the pasture land use class.

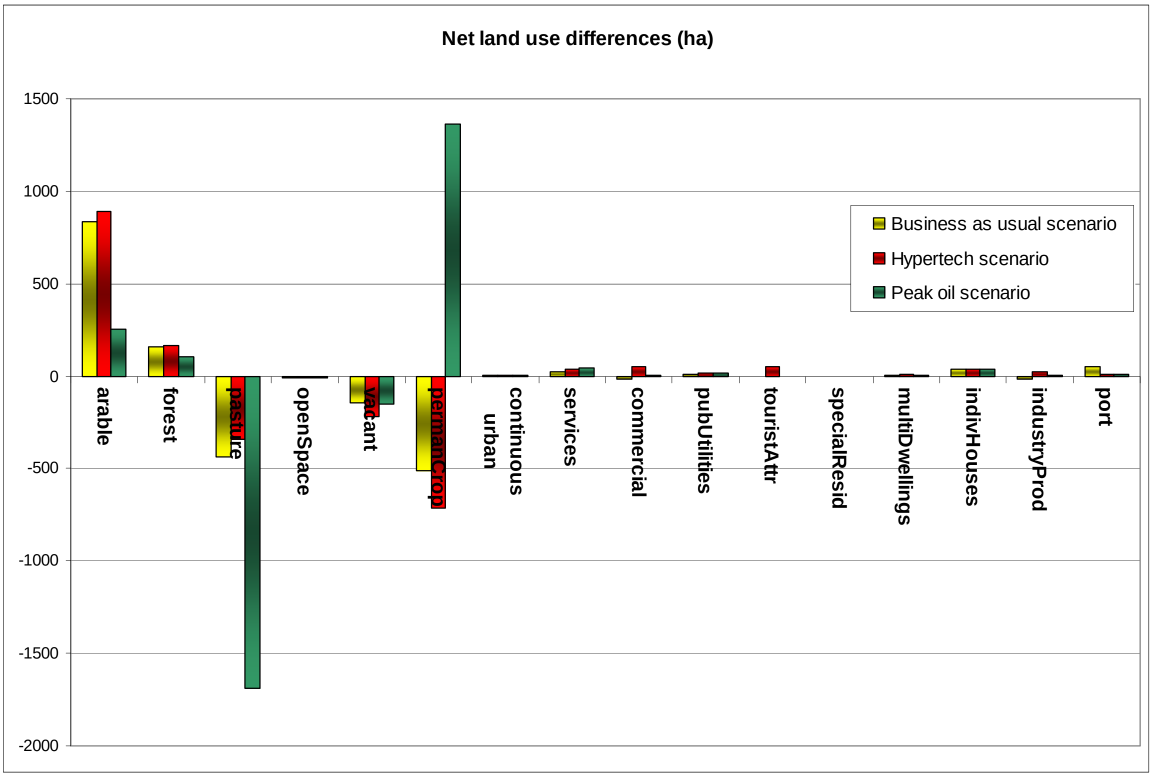


Fig. 50 - Net changes for land use classes between scenarios projections for 2025.

Tables 19 a-c shows the distribution of land use categories residential, economic and natural & semi-natural; per communities.

Tables 19 - Land use category changes in hectares for the Koper municipality communities for three scenario projections for 2025.

a. The residential category.

RESIDENTIAL/ ha			
	BAU	**HT**	**PO**
ANKARAN	-3.00	-3.00	-7.00
BORST	-6.50	-7.25	-0.75
DEKANI	5.75	8.25	5.75
ZUSTERNA	17.75	11.00	11.00
KOPER-CENTER	2.50	3.50	1.50
PODGORJE	-8.75	-7.75	-4.50
RAKITOVEC	-5.25	-5.25	-2.50
ZAZID	-3.50	-3.50	-3.50

GRADIN	-7.00	-5.00	0.75
SV. ANTON	13.25	12.00	11.25
OLMO-PRISOJE	6.25	9.00	5.00
SMARJE	-18.00	-20.50	-14.00
HRVATINI	20.75	22.50	3.50
SKOFIJE	24.75	25.25	16.25
VANGANEL	19.25	16.25	6.25
ZA GRADOM	0.50	-2.00	0.50
SEMEDELA	1.75	1.75	2.00
MAREZIGE	8.25	10.25	4.25
POBEGI-EEZARJI	8.50	8.75	3.25
GRAEISEE	-9.00	-7.50	20.50
SKOCJAN	12.00	11.50	3.50
BERTOKI	2.00	2.25	-0.75
ERNI KAL	-33.25	-31.00	-13.00

b. The economic category

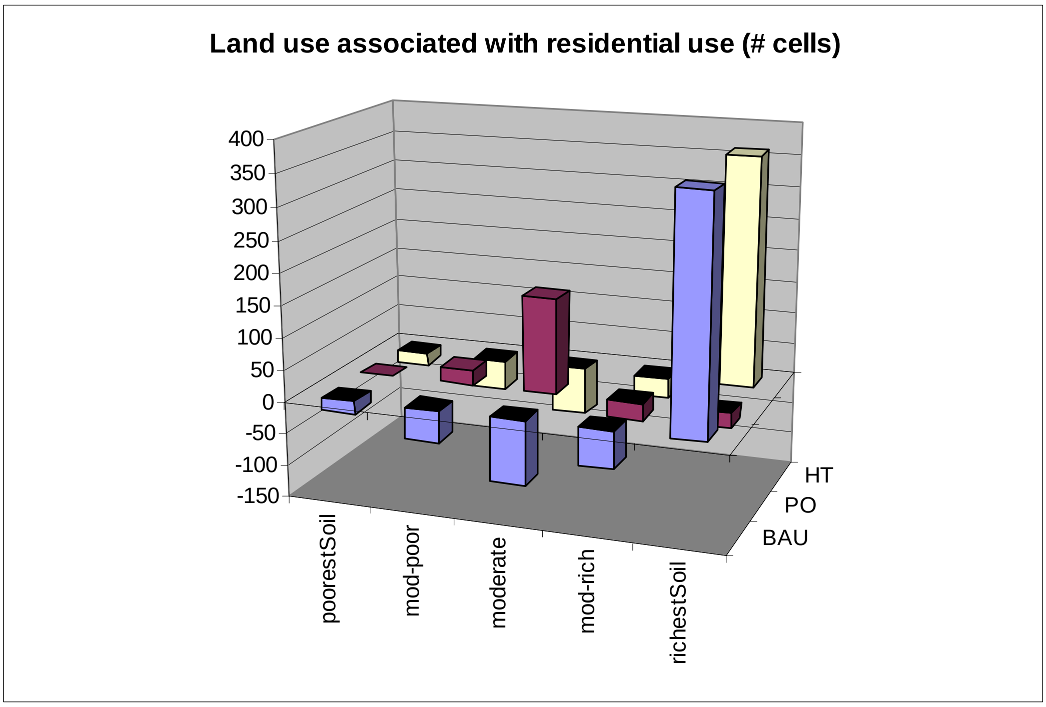
ECONOMIC /ha			
	BAU	**HT**	**PO**
ANKARAN	24.00	9.00	53.00
BORST	-40.75	-48.50	44.50
DEKANI	-2.25	12.75	33.75
ZUSTERNA	-6.50	-5.00	8.00
KOPER-CENTER	3.25	18.00	17.25
PODGORJE	-3.75	-2.75	2.25
RAKITOVEC	-2.50	-3.00	10.50
ZAZID	-1.75	-1.75	10.25
GRADIN	-85.25	-86.25	69.00
SV. ANTON	-21.25	-32.00	56.00
OLMO-PRISOJE	-23.00	-23.25	50.00
SMARJE	-108.25	-139.00	191.00
HRVATINI	-16.75	-23.75	38.50
SKOFIJE	-11.75	-27.75	67.25
VANGANEL	-2.50	-17.75	64.50
ZA GRADOM	-2.50	-1.50	3.50
SEMEDELA	0.50	0.25	0.25
MAREZIGE	-47.00	-68.50	120.50
POBEGI-EEZARJI	-1.00	-7.00	26.25
GRAEISEE	-59.50	-67.00	235.50

SKOCJAN	-14.75	-28.00	94.00
BERTOKI	-5.25	16.75	18.50
ERNI KAL	-22.25	-40.75	226.50

c. The natural and semi natural category.

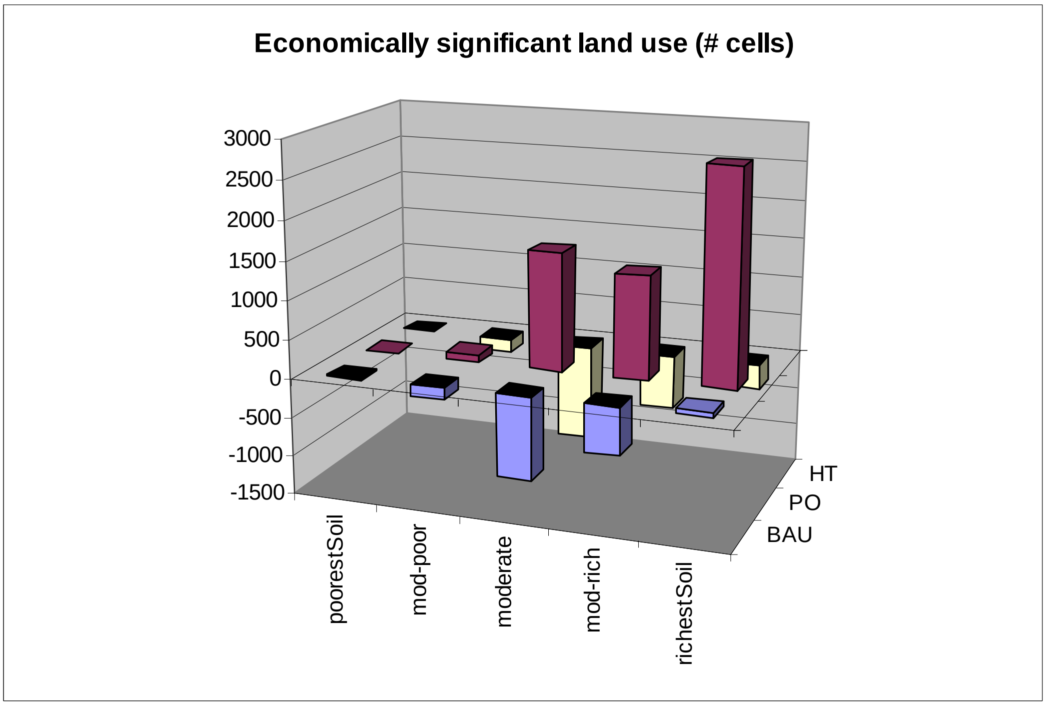
NATURAL & SEMI NATURAL /ha			
	BAU	**HT**	**PO**
ANKARAN	15.00	20.25	-29.00
BORST	41.50	49.50	-44.00
DEKANI	10.75	9.25	-20.50
ZUSTERNA	6.50	6.75	-7.50
KOPER-CENTER	0.00	-1.75	0.00
PODGORJE	3.25	3.25	-2.75
RAKITOVEC	3.75	4.25	-9.25
ZAZID	1.75	1.75	-10.25
GRADIN	85.75	86.25	-63.75
SV. ANTON	22.00	33.75	-54.00
OLMO-PRISOJE	24.25	30.75	-45.00
SMARJE	112.00	146.25	-184.25
HRVATINI	17.75	26.00	-24.75
SKOFIJE	22.00	39.50	-68.25
VANGANEL	3.25	19.25	-62.00
ZA GRADOM	3.25	4.75	-3.00
SEMEDELA	0.25	0.25	-0.25
MAREZIGE	47.00	68.75	-115.50
POBEGI-EEZARJI	2.00	6.75	-24.75
GRAEISEE	62.00	69.25	-234.00
SKOCJAN	20.75	38.00	-88.75
BERTOKI	16.75	-0.25	-22.00
ERNI KAL	27.25	48.00	-222.25

Figures 51 a-c show the land use classification under the different soil types and the associated data in hectares. The peak oil scenario shows a change in occupation of moderate quality soils by residential buildings, whereas the hyper tech and business as usual scenarios show residences dominating the best soils. Since permanent crop is part of an economic sector – agriculture – the peak oil scenario shows the best soils as being dominated by economically significant land use. Poor soils are not built upon; this is because these soils are in areas which are unsuitable for building. They remain fairly stable throughout all of the scenarios.



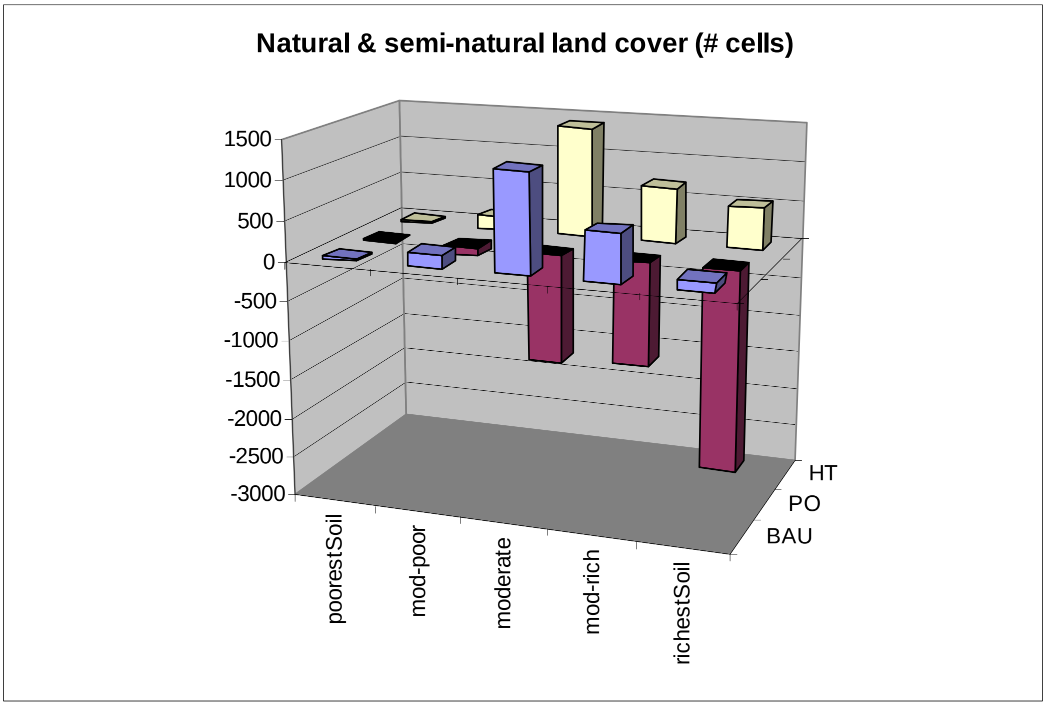
a.

RESIDENTIAL /ha			
	BAU	**HT**	**PO**
poorestSoil	-5	-5	0
mod-poor	-12.5	-11.75	6
moderate	-25.25	-18.5	37.75
mod-rich	-14.5	-8.25	-6.75
richestSoil	90.5	90.5	-5.75



b.

ECONOMIC /ha			
	BAU	**HT**	**PO**
poorestSoil	-5.5	-5.5	4.25
mod-poor	-39.5	-40.5	25
moderate	-265.5	-306.25	381.25
mod-rich	-150	-175	332.25
richestSoil	16.25	-78.5	687



c.

NATURAL & SEMI-NATURAL /ha			
	BAU	**HT**	**PO**
poorestSoil	5.75	6	-4.25
mod-poor	41.5	41.75	-24.25
moderate	312.75	351.25	-344.5
mod-rich	151.75	177.5	-326.5
richestSoil	31	134.75	-636

Fig. 51 - Distribution of land use categories on different soil types for different scenarios

a. Residential;

b. Economic;

c. Natural & semi-natural.

4.3.4.2 Land use demand location

Although net changes are interesting, it is the spatial distribution of the land use classes which are the value added by the Moland model. This section focuses on the differences between scenario outputs for 2025 for selected land use classes.

Principal findings:

- The “Peak Oil” (PO) scenario favours the distribution of jobs and services throughout the region through the promotion of the agricultural sector (figure 52-b).

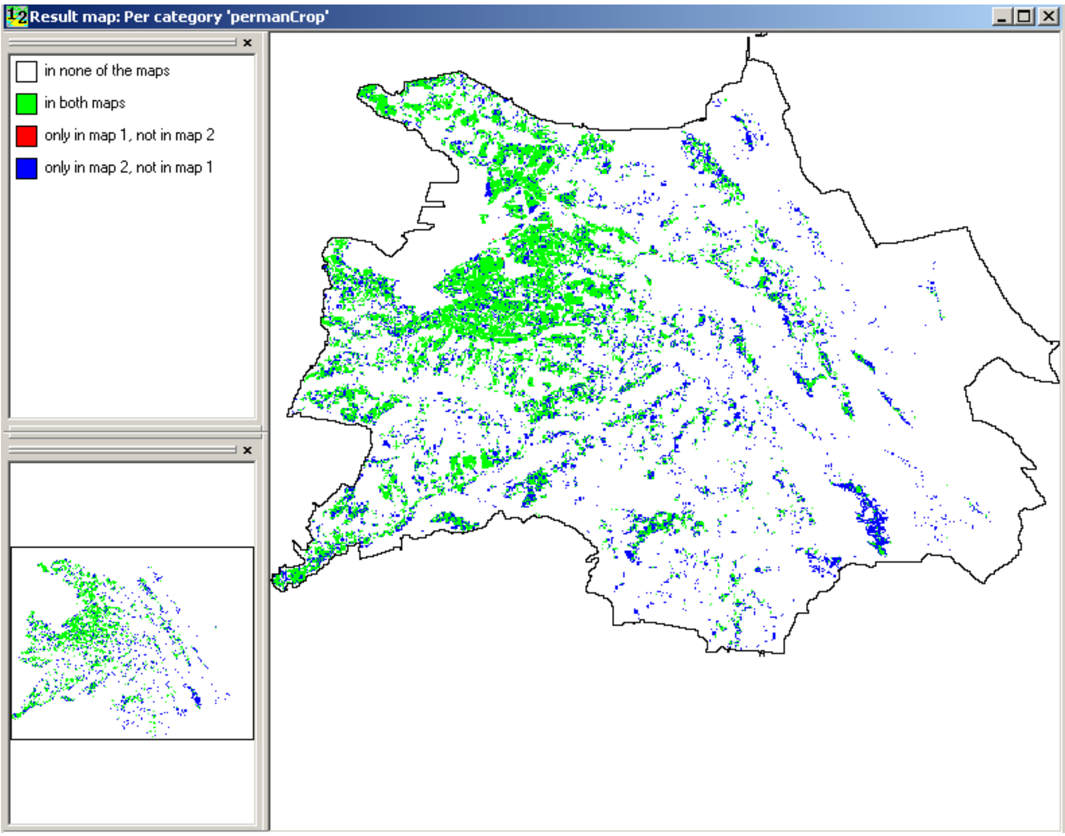


Fig. 52a - Comparison of the "Permanent Crop" land use category projected for 2025 for two different scenarios: Business as usual and Peak oil. The area in blue shows the results for the latter scenario: more abundant and distributed in less centralized communities

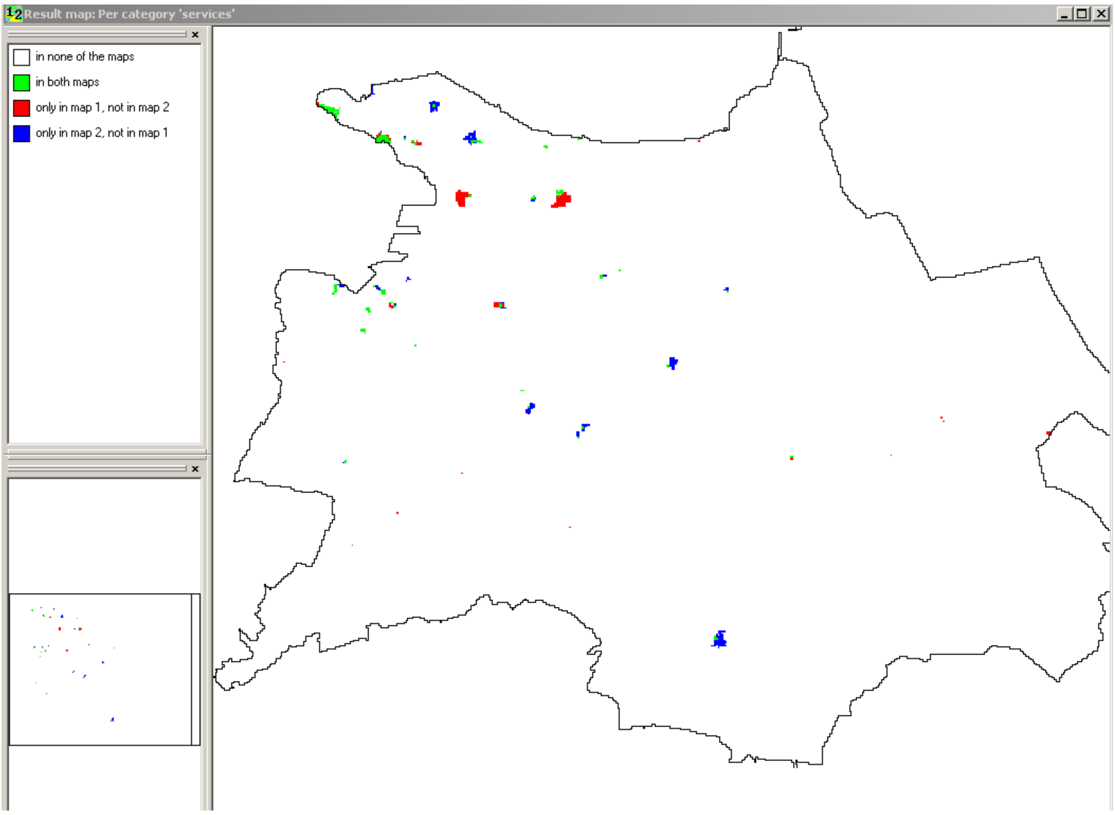


Fig. 52b - Comparison of the "Services" land use category projected for 2025 for two different scenarios: Hyper tech and Peak oil. The area in blue shows the results for the latter scenario: distributed services in less centralized areas

- The "Hyper Tech" (HT) scenario results in fewer large agglomerated vacant areas in the peri-urban zone, but more vacant areas in the rural zone (figures 53 a-b).

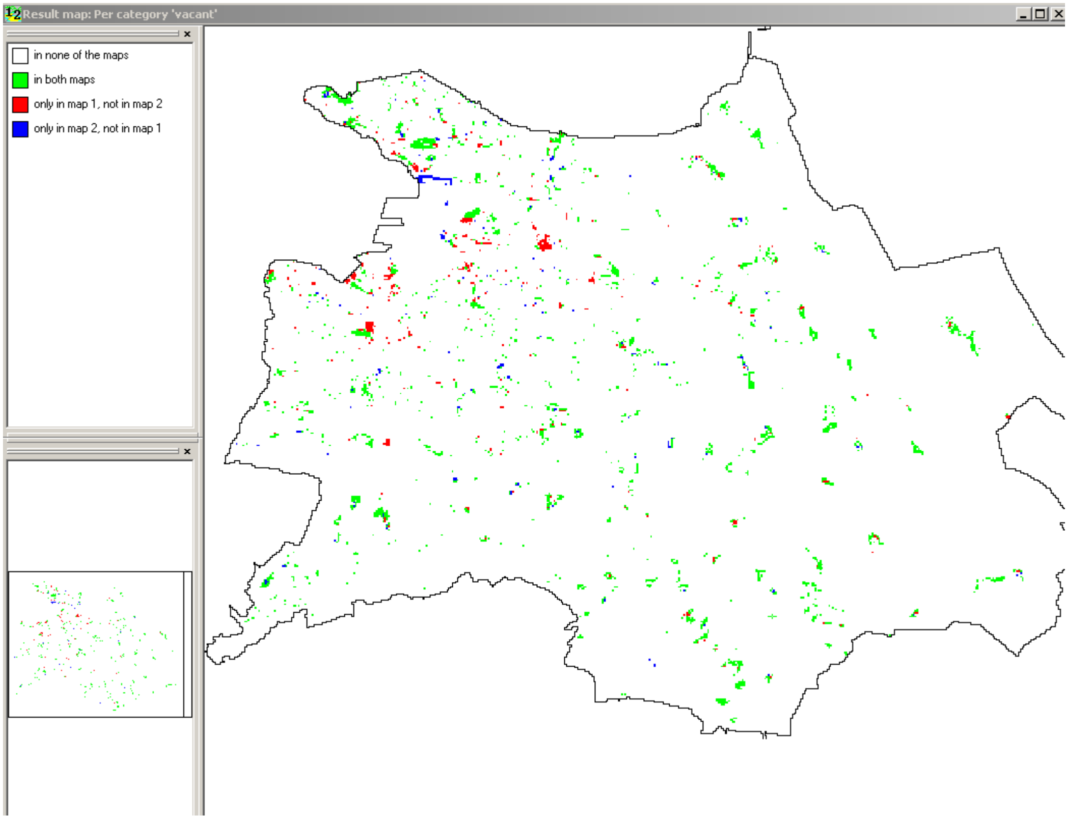


Fig. 53a - Comparison of the "Vacant" land use category projected for 2025 for two different scenarios: Business as usual and Hyper tech. The area in red shows the results for the first scenario: more vacant urban land for the BAU scenario.

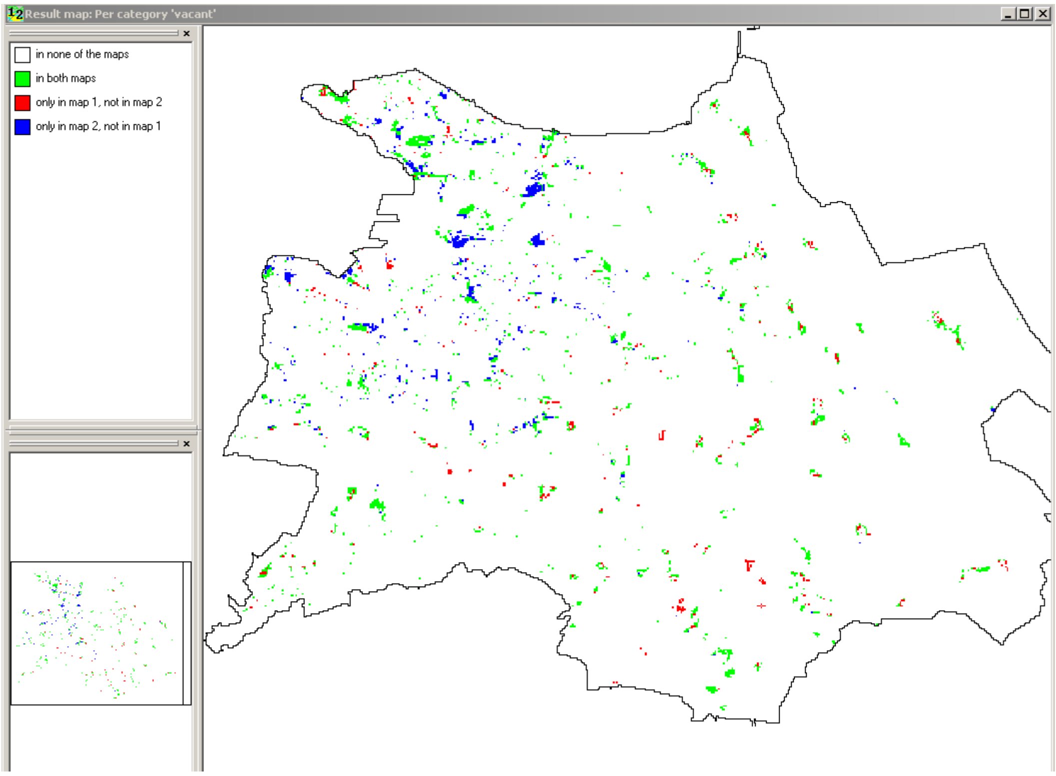


Fig. 53b - Comparison of the "Vacant" land use category projected for 2025 for two different scenarios: Hyper tech and Peak oil. The area in blue shows the results for the second scenario: more vacant urban land for the PO scenario.

The Peak oil scenario restricts building of housing in the peri urban area but encourages this growth in the rural hinterland (figure 54)

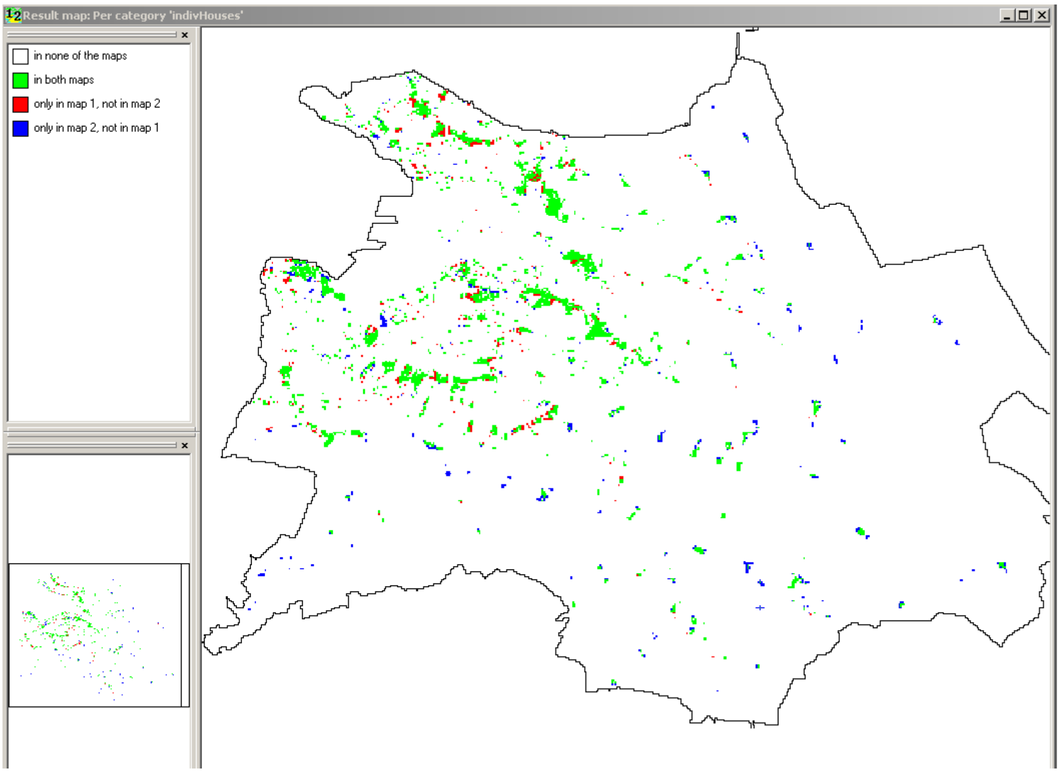


Fig. 54 - Comparison of the "Individual houses" land use category projected for 2025 for two different scenarios: Hyper tech and Peak oil. The area in blue shows the results for the second scenario: a higher distribution of individual houses in the rural hinterland for the PO scenario.

4.3.5 Probability maps

Monte Carlo runs show the probability of a certain land use class appearing on a given cell. The Monte Carlo exercise was run 99 times for the final year only (Herold *et al.*, 2003). The resulting maps can therefore be interpreted as the probability that a land use will occupy a cell in 2025.

The probability maps for each land use class with more than 150 cells attributed are included in appendix A for the BAU scenario.

The Monte Carlo probability maps were also used to verify the stability between the land use projected with the model and the degree of probability according to Monte Carlo. Monte Carlo probability from 95-100% for each land use was compared to projected land use. Nearly one hundred percent of all projected land uses (worse result = 99.68%) fell under the 95-100% probability masks.

According to the Moland user's manual, it is the highly volatile cells, those areas with low land use probabilities, which are to be concentrated upon. This is especially true if the current land use is a vacant class, of value and at risk of disappearance (ex. Valuable forested area). Since there is no pressing issue regarding the encroachment of sensitive areas, this possible index was not investigated further.

4.3.6 Spatial Metrics Indicators

Urban growth patterns

Binary built-up / non-built-up maps were run through the FRAGSTATS software, a public domain spatial metrics program made available by the University of Massachusetts (http://www.umass.edu/landeco/research/fragstats/fragstats.html). This software provided the change in the total number of hectares of built-up land use classes for each scenario projection for 2025 (table 20).

Table 20 - Net changes in built up areas (ha) from 2007 to 2025 for the three scenarios.

Scenario, year	Built up area change since 2007 (ha)
Business as usual, 2025	+ 105.25
Peak Oil, 2025	+ 124
Hyper Tech, 2025	+ 150.75

Compactness. Several authors describe fragmentation vs. compactness as an indicator for sustainable urban growth. In this case study, the FRAGSTATS software was used to derive the level of compactness for each scenario through dividing the number of patches above the threshold of 5 by the total number of patches. This parameter measures the level of aggregation of built-up areas in this application. The index is proportional to the level of compactness (table 21).

Table 21 - Net changes in built up areas (ha) from 2007 to 2025 for the three scenarios.

Scenario, year	Compactness (/%)
Business as usual, 2025	0.47
Peak Oil, 2025	0.51
Hyper Tech, 2025	0.41

Although the Fragstats software provided several spatial metrics indices, the location of the changes could be more readily viewed using the GUIDOS software. The GUIDOS software, a mathematical morphology based software originally developed for forestry sector (http://forest.jrc.ec.europa.eu/download/software/guidos), was applied in this instance for evaluating changes in patterns for built up areas. The binary maps representing built-up and non-built up were created for 2000 and 2007. These maps were then ingested into GUIDOS. The software output is a typology of the built-up area; relative to the shape, relative position and area of the built up pixels. The classes are outlined in table 22, the descriptions are detailed in Soille & Vogt, 2009:

Table 22. The GUIDOS software classes and descriptions:

MSPA class	Description
Core	Foreground pixels whose distance exceeds n pixels from the background, (n=1 in this application)
Islet	Foreground connector components not containing any core pixels
Loop	Connector pixels from same core connected component
Edge	Outer boundaries of core
Perforation	Inner boundaries of core
Branch	Pixels that do not belong to any other pre-defined categories
Bridge	Connector pixels from two or more core connectors

Figure 55 helps to explain the differences in the built up area spatial metric classes. The example used in this figure is for the changes occurring between 2000 and 2007.

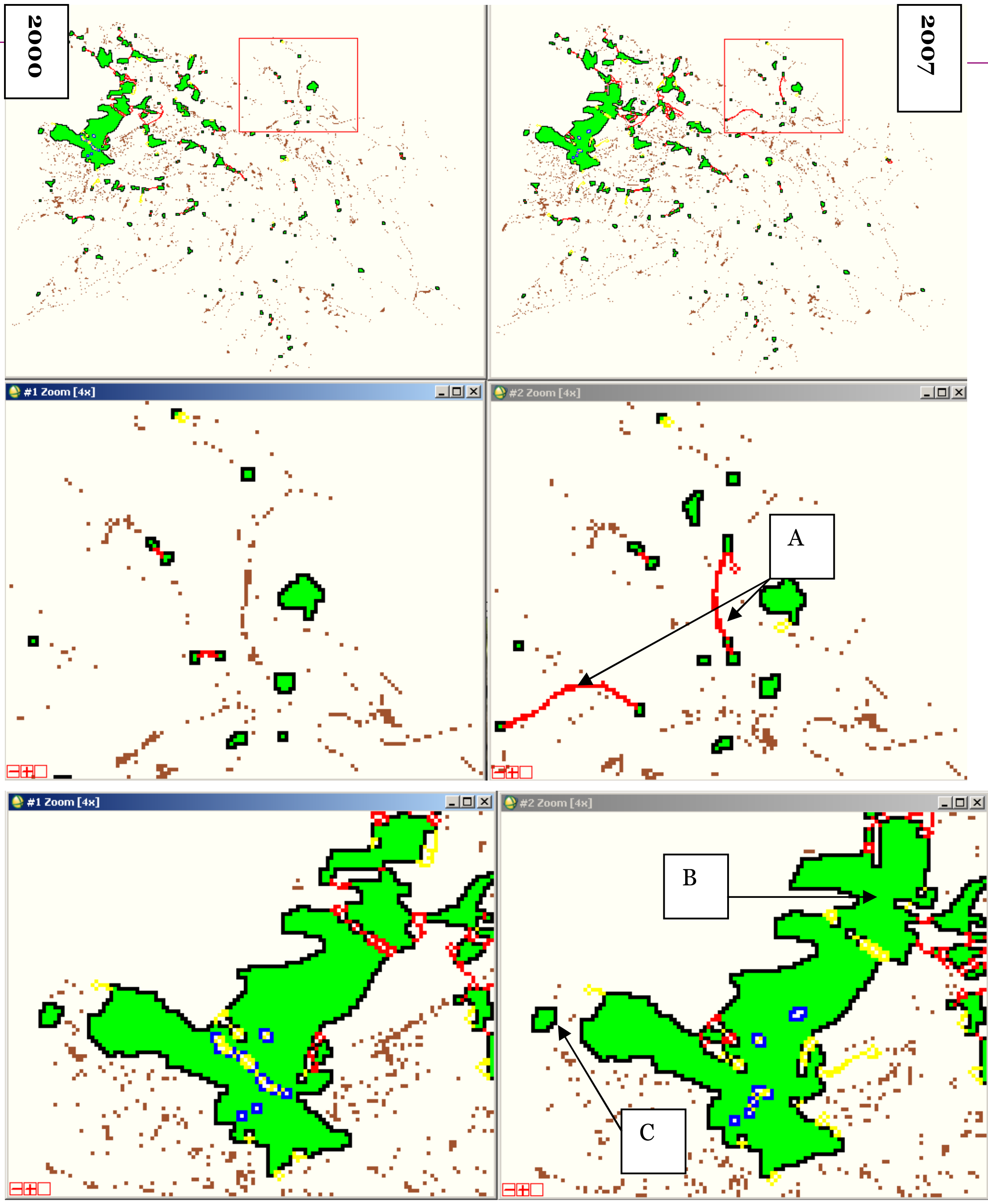


Fig. 55 - Interpreting changes in built up area spatial metrics using GUIDOS software. A= branching appearing in 2007; B= growth in core areas; C= transformation of islets to core areas.

The results of the MSPA run for each scenario are shown in figure 56 and the statistics are shown in figure 57.

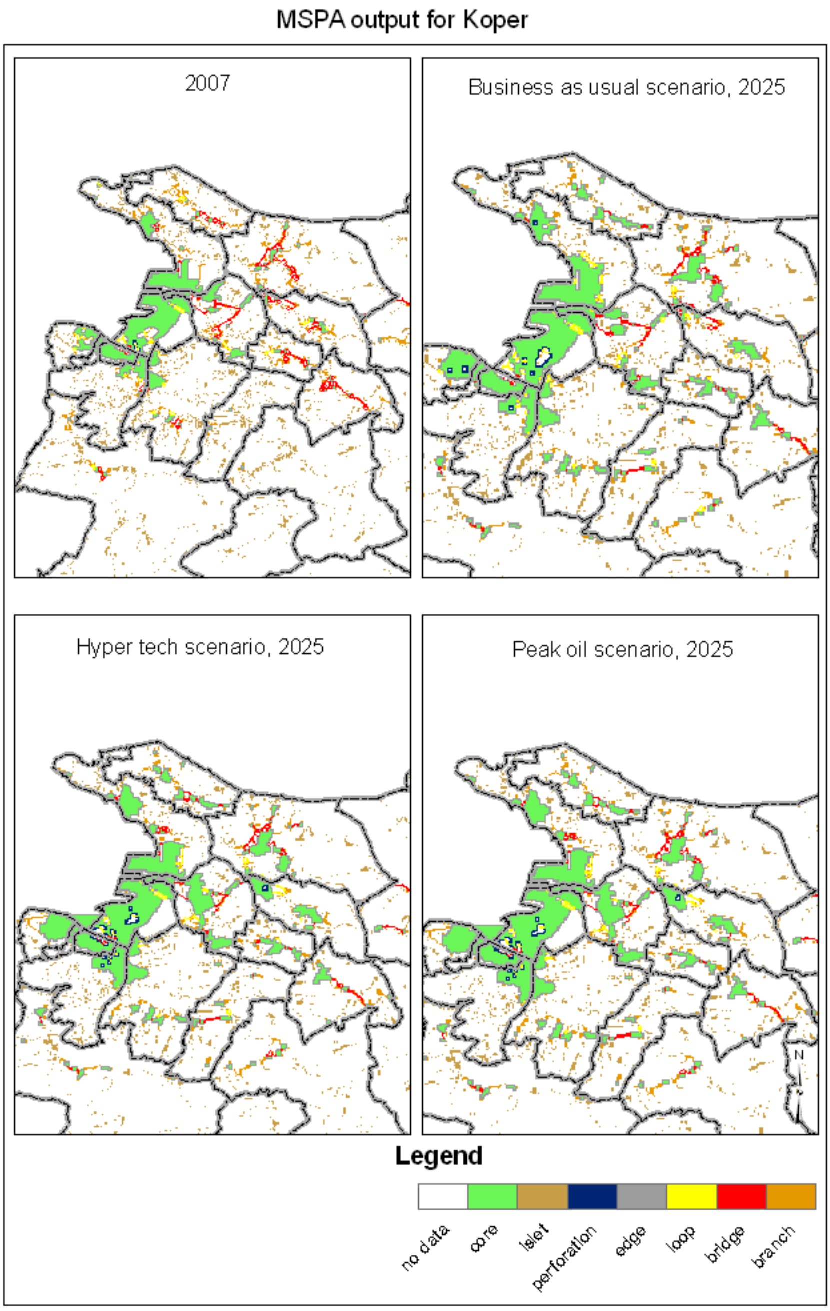


Fig. 56 - The results of the MSPA analysis for the 2007 image and the three scenario runs to 2025.

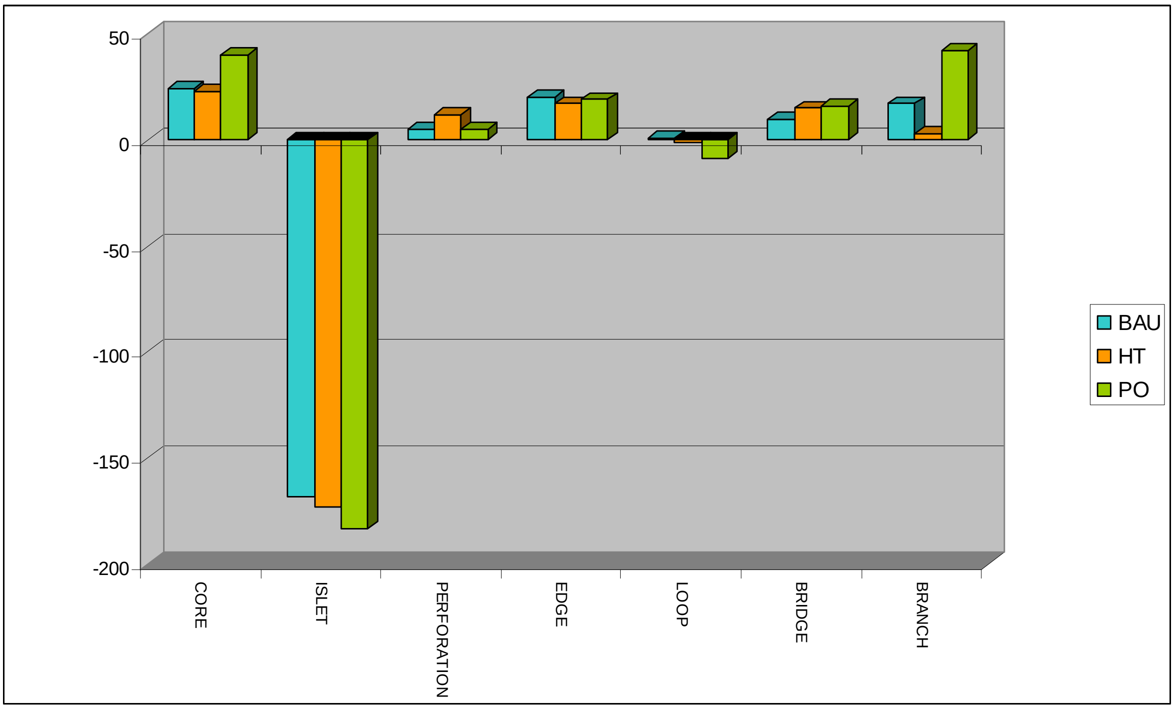


Fig. 57 - The difference in number of pixels belonging to each MSPA class from the baseline year (2007) to the projected year (2025) for three scenarios: BAU, HT, PO.

An increase in core areas and number of loops indicates a densification in the simulated built up class. The decrease in the number of islets, the number of edges and the number of branches and bridges implies an increasing fragmentation.

5 Conclusions

This report describes the application of the MOLAND model to two regions surrounding respectively the city of Leipzig and Koper.

Moland was specifically developed for urban and regional simulation, with the aim of representing spatial dynamics. Each cell in the input/output maps corresponds to a different land use, and the change of the status of each cell depends on a set of parameters such as the inherent suitability for each land use, zoning restrictions, and accessibility of transport network, but also on the composition of the neighbourhood. To achieve this goal, the model incorporates several transition rules which establish the attraction or repulsion between different land uses.

The manipulation of input parameters and transition rules allows the definition of 'ad-hoc' scenarios of future land use developments.

Scenario development is a well known tool for the assessment of land use changes in a large number of studies. **Scenarios are not predictions**; they are an approach to help manage decisions based on interpretation of qualitative descriptions of alternative futures translated into quantitative scenarios. We can learn from the past by tracing analogies between historical and current situations. Different future possibilities can be illustrated and compared by using our imagination, intuition and creativity to question what could we do if the assumptions occur (Petrov, 2009).

In the PLUREL framework, global IPCC/SRES scenarios have been downscaled and refined with the involvement of stakeholders for the select study areas.

For Leipzig, simulation of land use evolution (2000-2025), considered different scenarios developed by local stakeholders - "Business-as-usual", "Hyper-Tech", "Peak Oil" and "Fragmentation".

Three scenarios were run for the Koper municipality from 2007 to 2025: Business as usual, Hyper-tech (A1) and Peak oil (B1). The parameters for the scenarios were set in collaboration with local stakeholders at the Plurel meeting in Koper in March 2009. The results for each scenario are broken down to community level whereby statistics are retrieved. Statistics per soil type classification are also extracted in order to facilitate analysis of impacts of each scenario on quality soil. Spatial metrics are also applied to the results of all scenarios, and can be used as a measure for sustainability at the municipality level.

Local storylines driving land use evolutions (although identified by the same scenario names) and input data are profoundly different for the two study cases. This has therefore resulted in fairly different land use projections. Therefore, comparisons and overall statements on common land dynamics behaviours are not always appropriate. Certainly the dynamics observed in Koper and Leipzig are strictly linked to specific local characteristics and can not be generalized at at wider geographical scale

Aggregated land-use simulation results for artificial classes (including: residential, industrial, commercial, services and port/transport areas) according to the RUR classification are presented in the following table for the three commonly named scenarios.

	Urban (%)		Peri-urban (%)		Rural (%)	
	Koper	**Leipzig**	**Koper**	**Leipzig**	**Koper**	**Leipzig**
BAU	7.83	3.27	26.30	23.85	-21.60	20.09
HT	12.40	1.93	33.43	34.05	-15.00	47.70
PO	10.77	1.84	12.71	18.81	24.36	29.23

The most evident difference is given in the projected decrease of artificial classes in the RUR rural zone in Koper for the BAU and HT simulations, whereas these classes are significantly increasing in Leipzig. The explanation resides in the behavior consequent to the assumptions of the BAU and HT scenarios which foresee abandonment of rural areas in Koper, while the PO scenario favours the promotion of the agricultural sector.

Artificial classes in the RUR urban zone have reduced increment for all scenarios in Leipzig as result of both local storylines and also of the structural polycentric development of the area. Urban development is encouraged in Koper for the three scenarios in the RUR peri-urban zone.

Developments in the RUR peri-urban zones show rather similar trends for the two study areas, likely because these zones are the most prone to new expansions.

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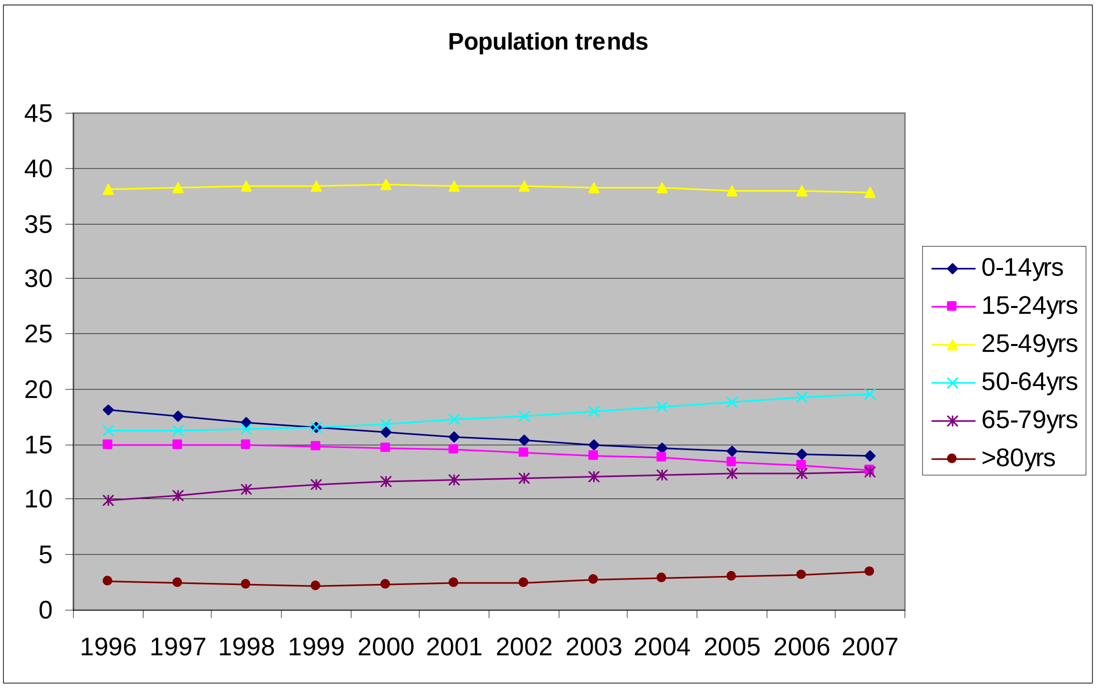
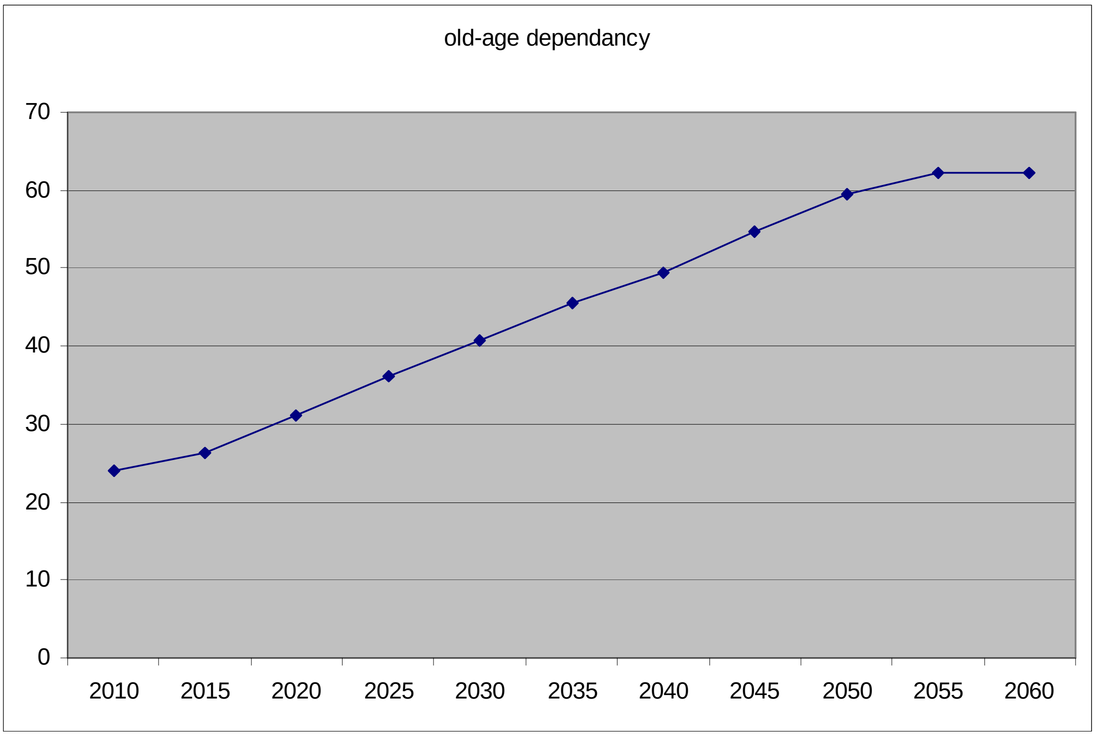
7 Annex A. Koper national trends in statistics

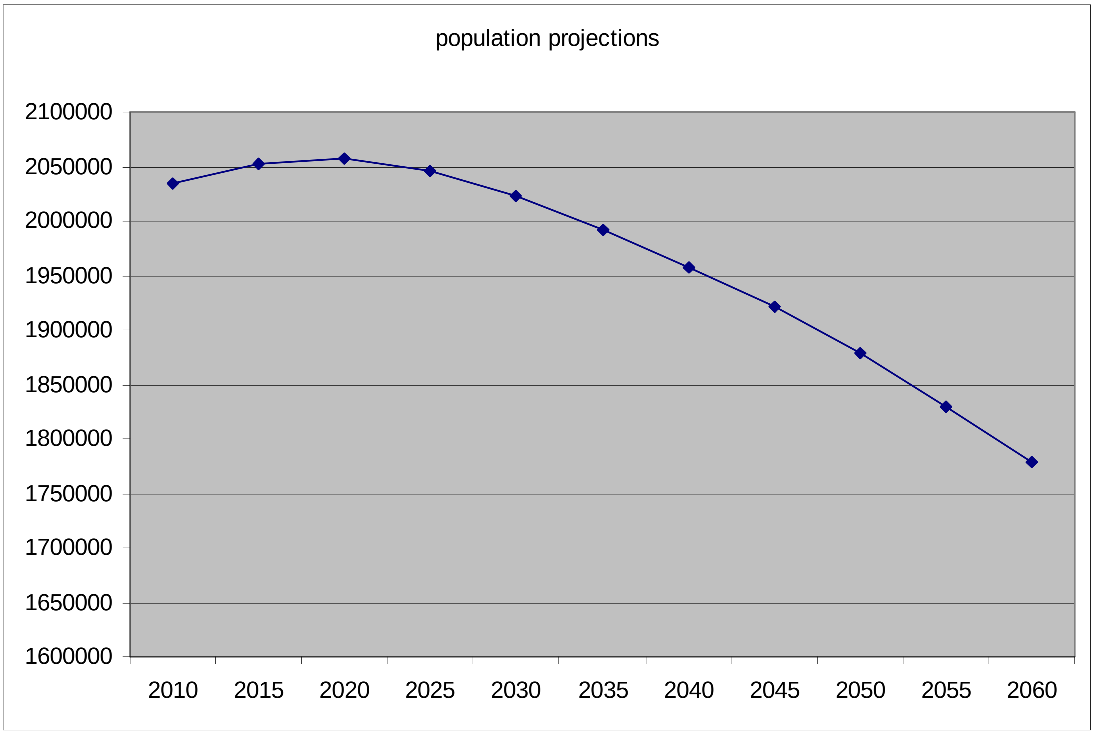
(source: Eurostat for Slovenia)

Ageing population

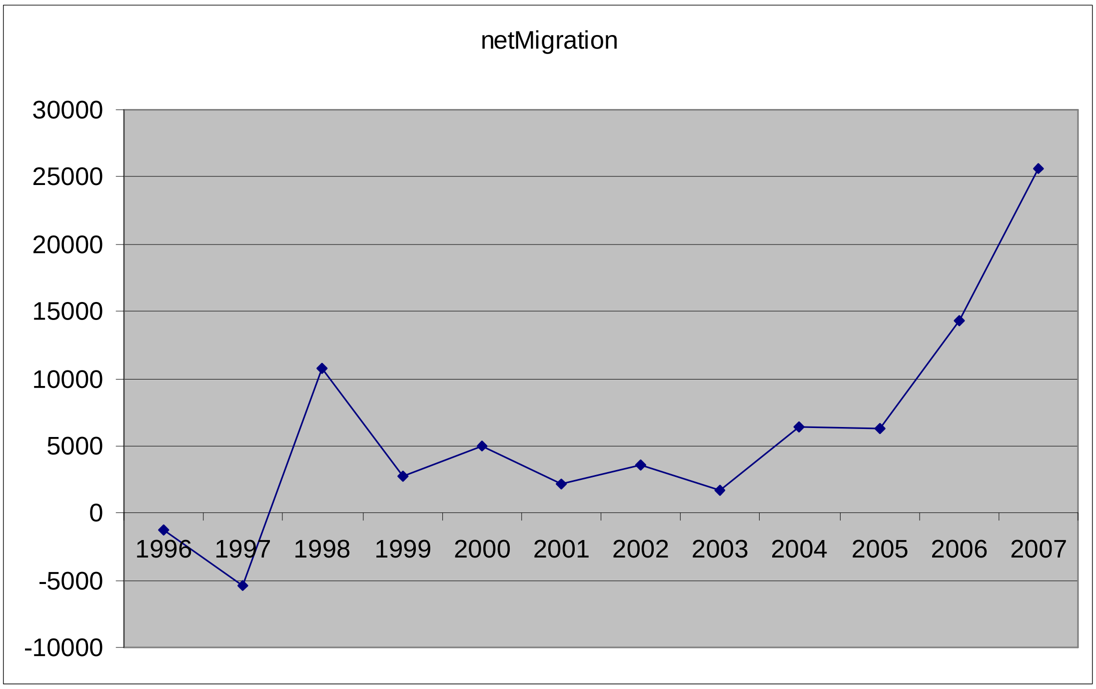




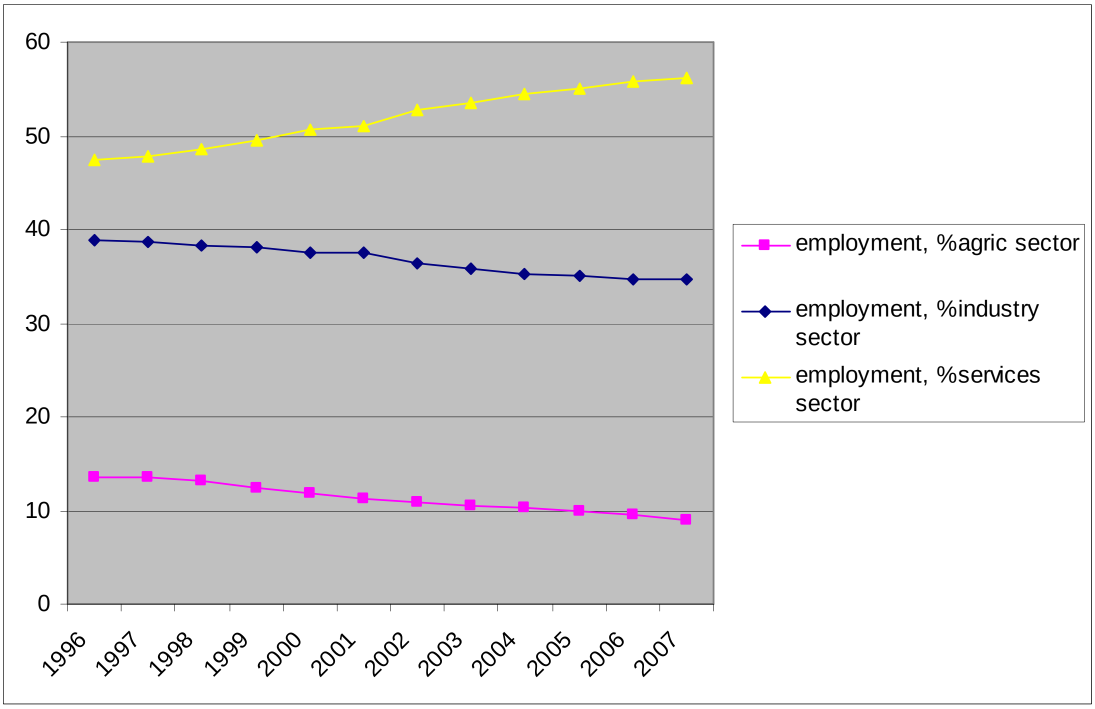
Decrease in population



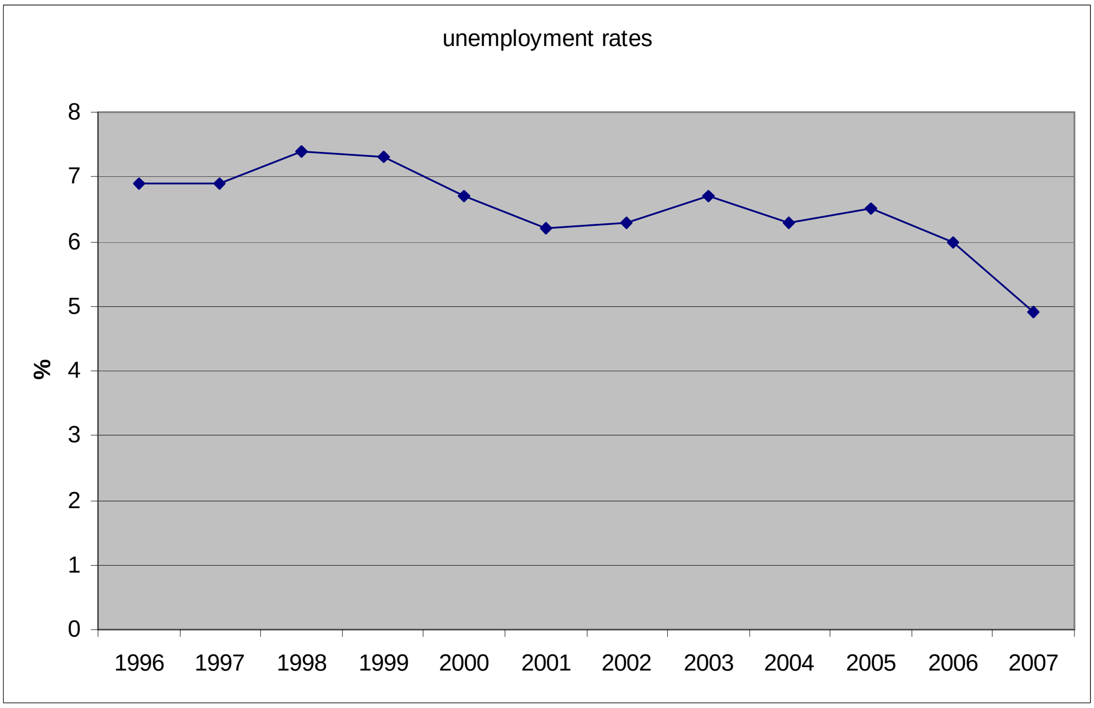
Immigration on the rise (or emigration on the decrease)



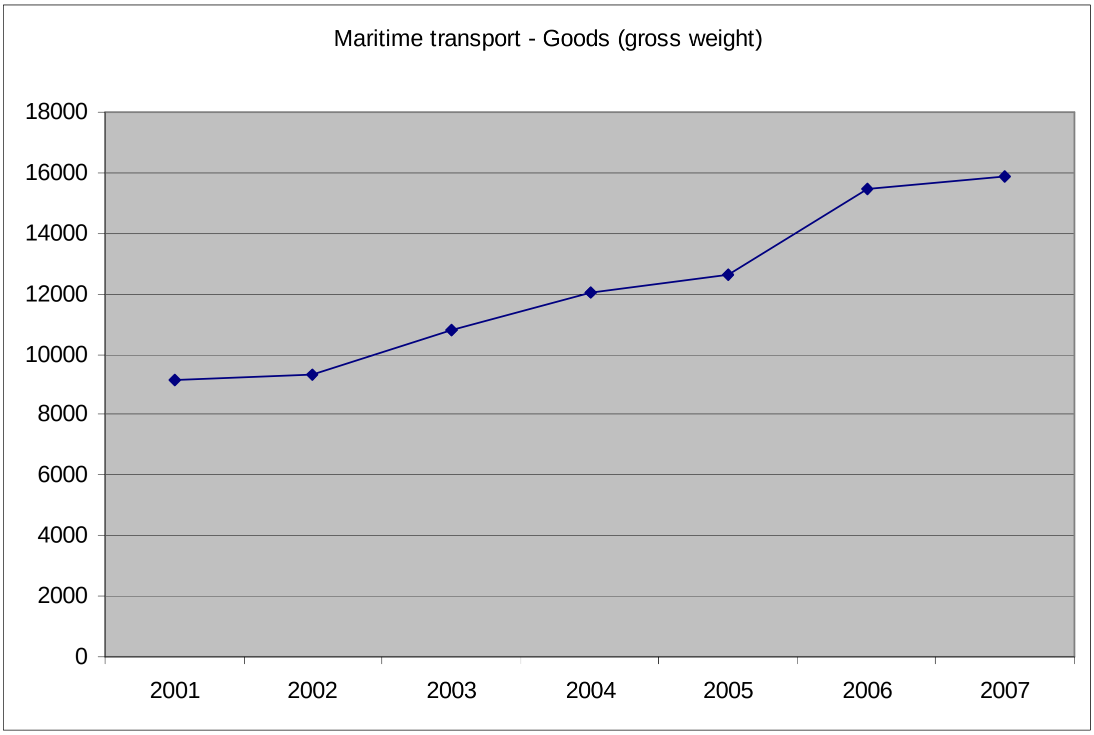
Employment rate increasing in services sector (decreasing in agriculture and industry sectors)



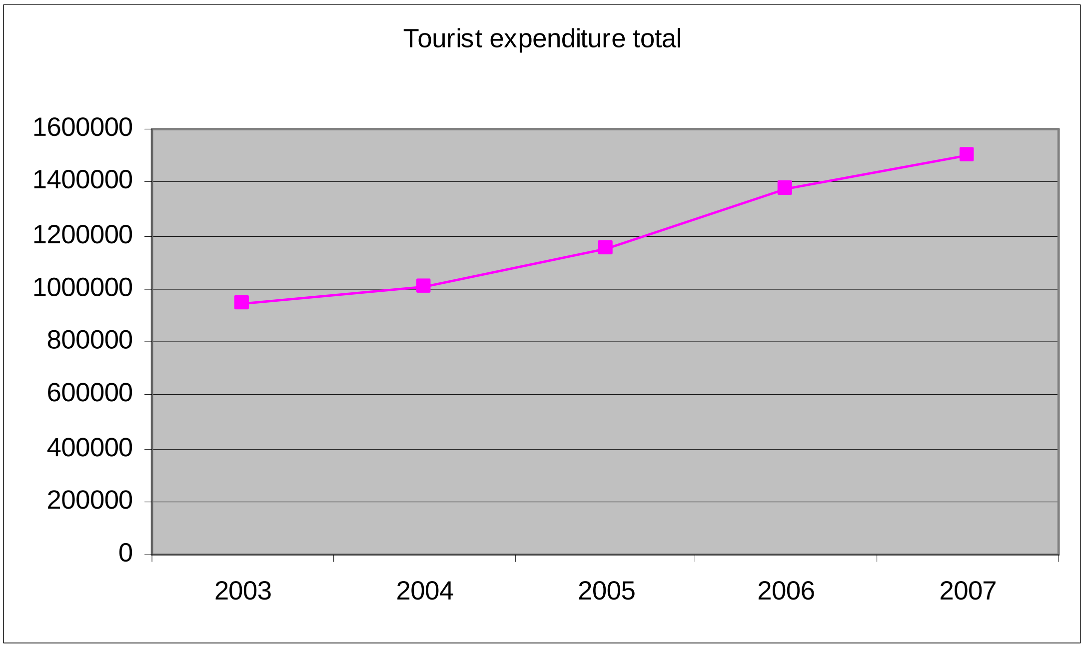
Unemployment rate decreasing

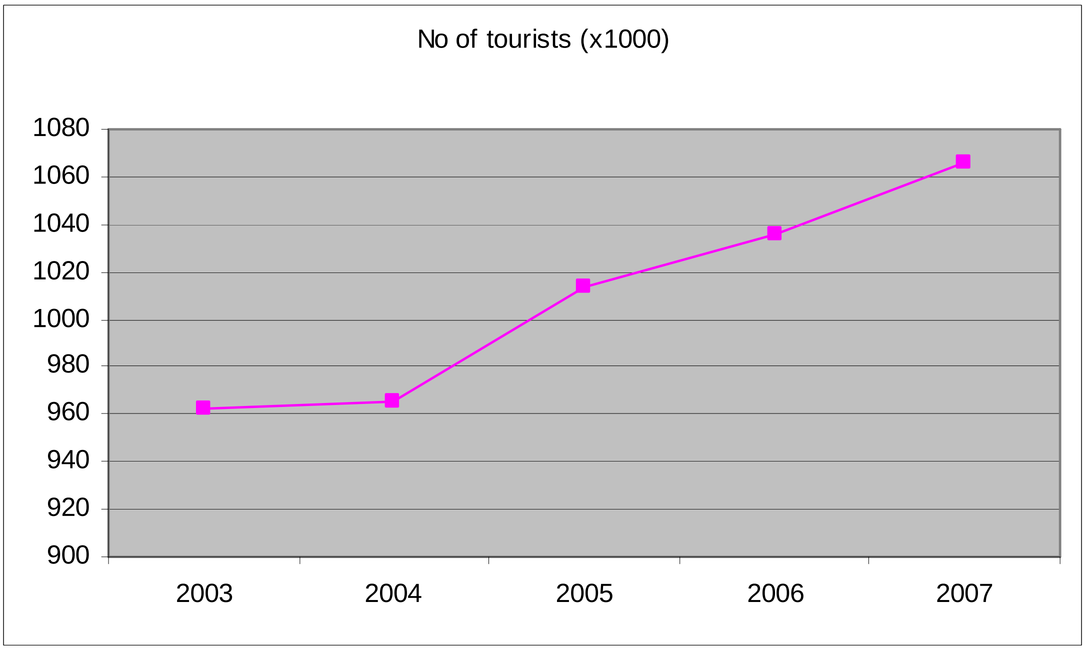


Increase in maritime traffic

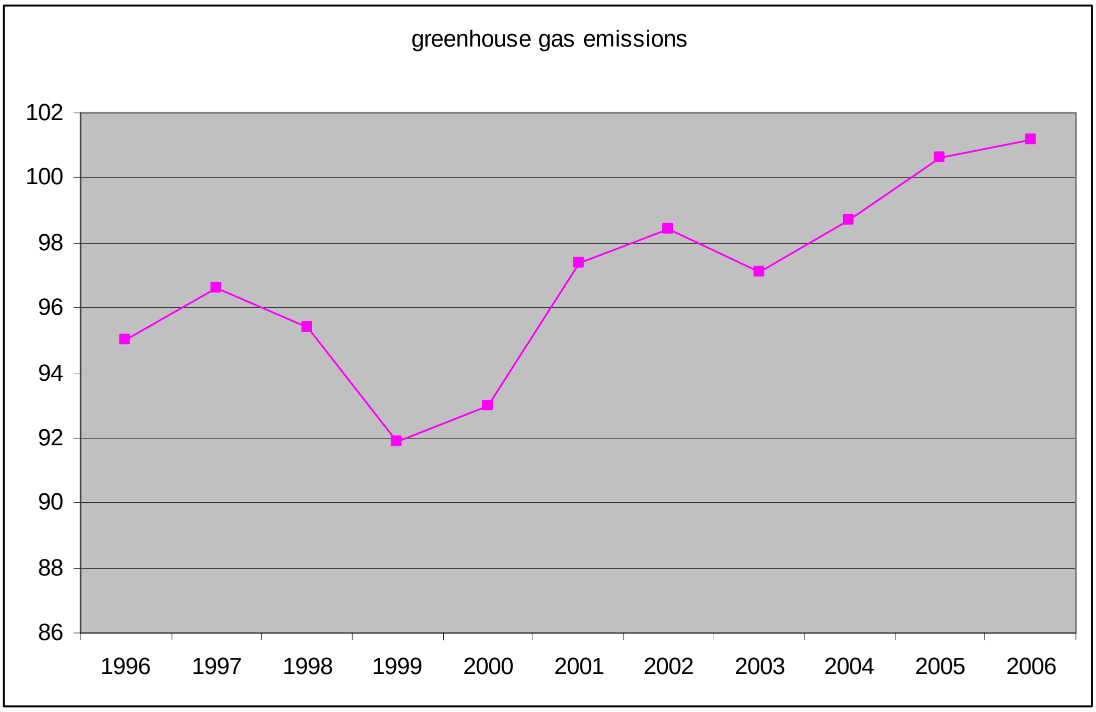


Increase in tourism





Increase in energy consumption


greenhouse gas emissions
102
100
98
96
94
92
90
88
86
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006

8 Annex B. Koper: Monte Carlo probability maps

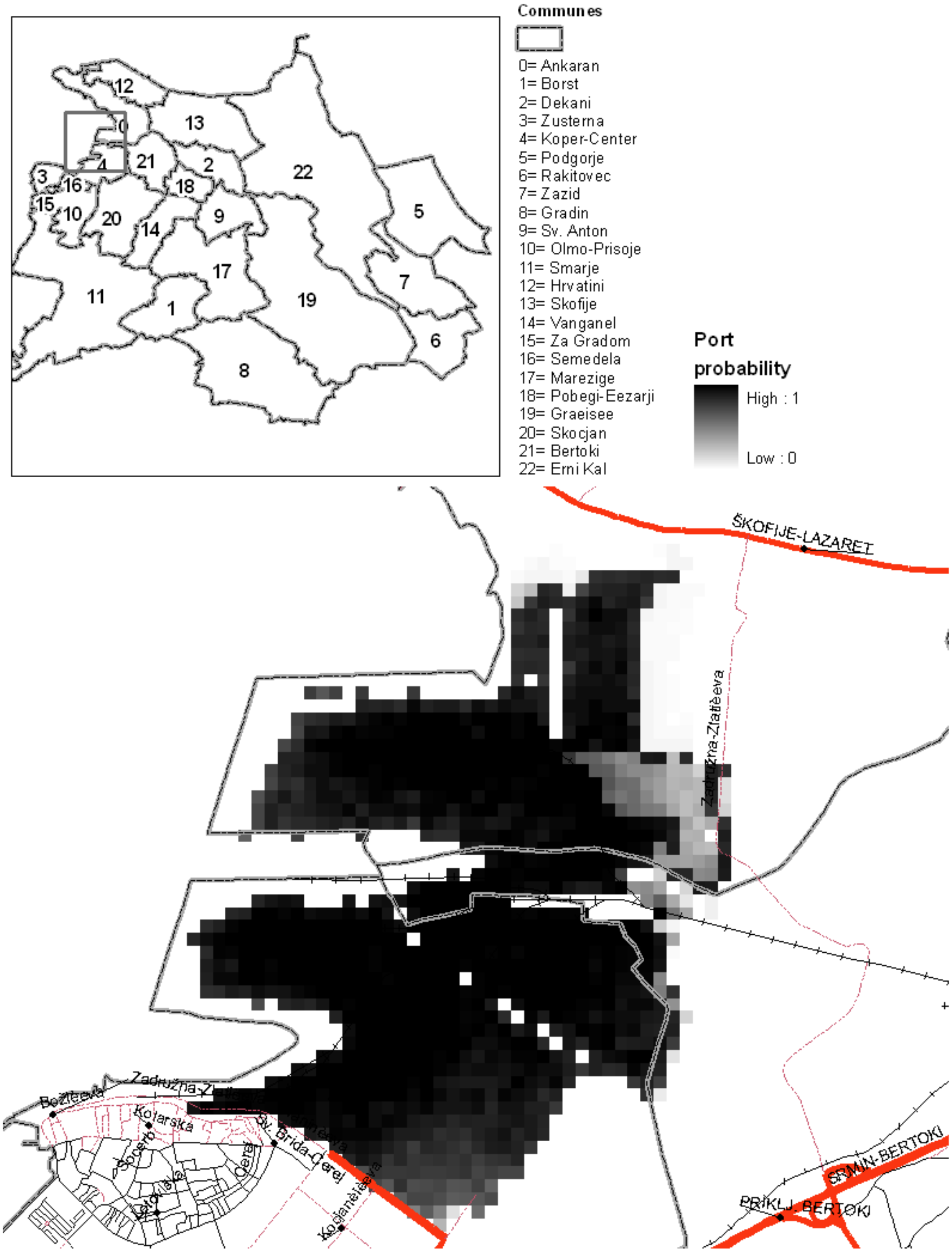
The probability maps per land use class for the "Business as usual" scenario; as generated by 99 Monte Carlo runs. These maps represent the probability of a land use occupying a cell because they are the result of several runs despite slight variations in parameters as defined by the user. Thus if a cell is labelled as 100% probable of being occupied by a certain land use, it is labelled as such despite a given variance in model parameters.

With the Monte Carlo runs, the model runs repeatedly with slightly different parameter values. The parameters that are varied in the runs are user-defined. For this case study the Monte Carlo runs were performed incorporating the following parameters:

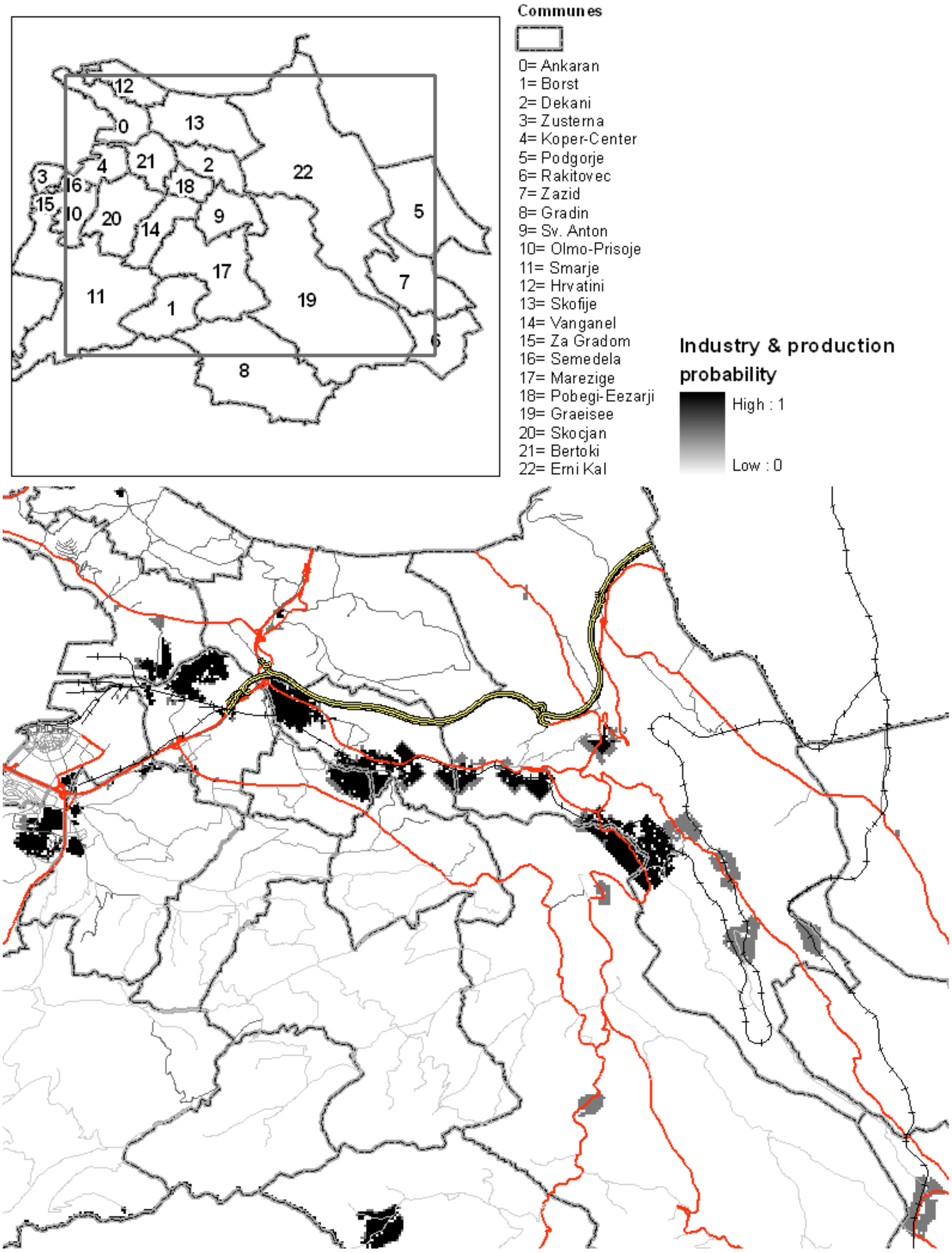
NrSectors	5					
BB	Number	Value	Minimum	Maximum	Sector	[Name]
1	7	0.1	0.001	2	-1	b, selfdistance multiplier
22	1	1.020492	0.975	1.025	2	delta(1), influence current land productivity
22	2	0.981786	0	1	2	delta(3), exponent 'demand over supply'
22	3	1	0	2	2	delta(5), exponent crowding
22	4	0	0	2	2	delta(7), exponent growth transition potential
22	5	0	0	2	2	delta(8), exponent growth accessibility
22	6	1	0	2	2	delta(9), exponent growth suitability
23	1	1.025	0.975	1.025	3	delta(1), influence current land productivity
23	2	0.999993	0	1	3	delta(3), exponent 'demand over supply'
23	3	1	0	2	3	delta(5), exponent crowding
23	4	0.832816	0	2	3	delta(7), exponent growth transition potential
23	5	0	0	2	3	delta(8), exponent growth accessibility

23	6	0	0	2	3	delta(9), exponent growth suitability
24	1	0.978607	0.975	1.025	4	delta(1), influence current land productivity
24	2	0.842969	0	1	4	delta(3), exponent 'demand over supply'
24	3	1	0	2	4	delta(5), exponent crowding
24	4	1.25	0	2	4	delta(7), exponent growth transition potential
24	5	0	0	2	4	delta(8), exponent growth accessibility
24	6	0	0	2	4	delta(9), exponent growth suitability

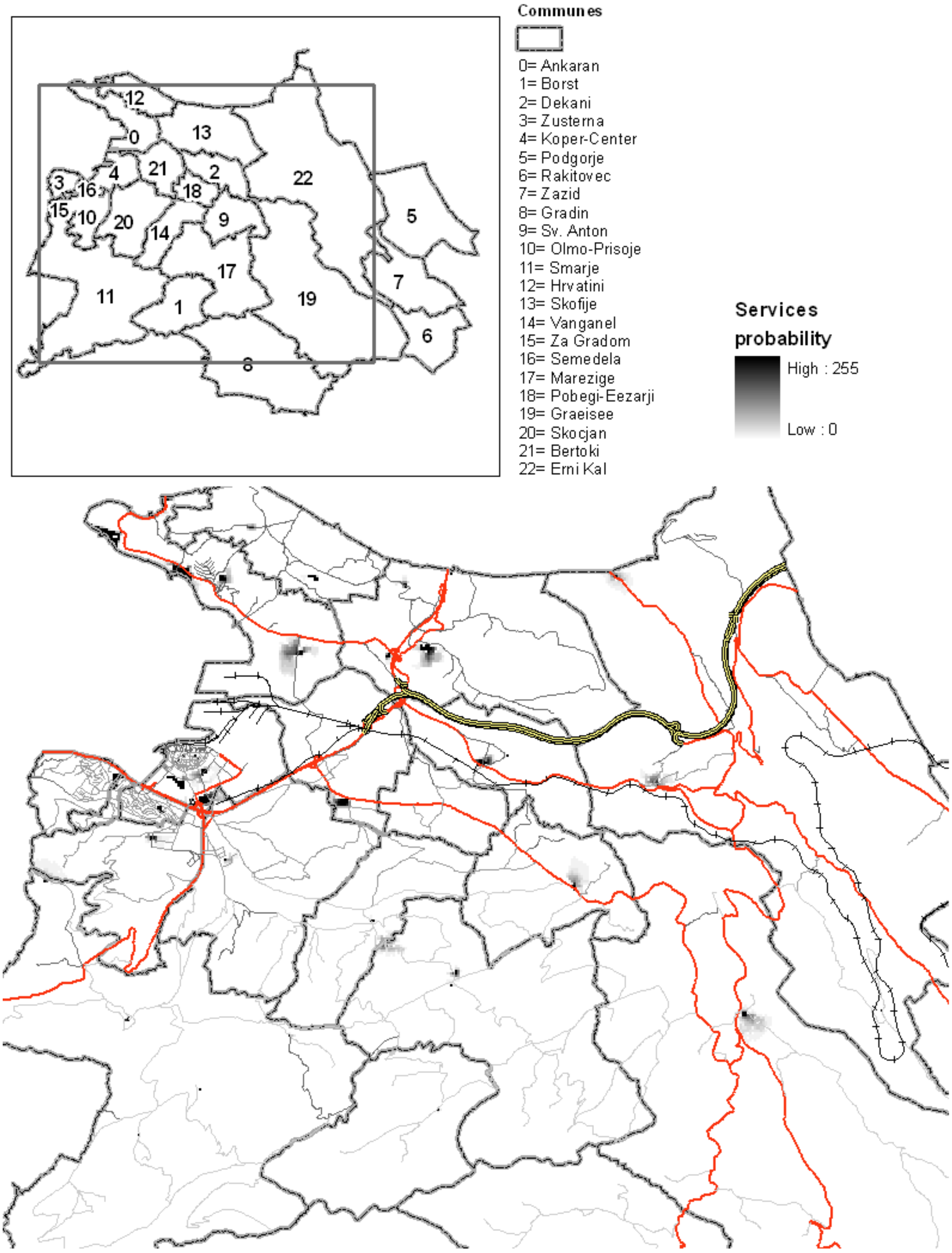
Probability of port land use class appearing by 2025



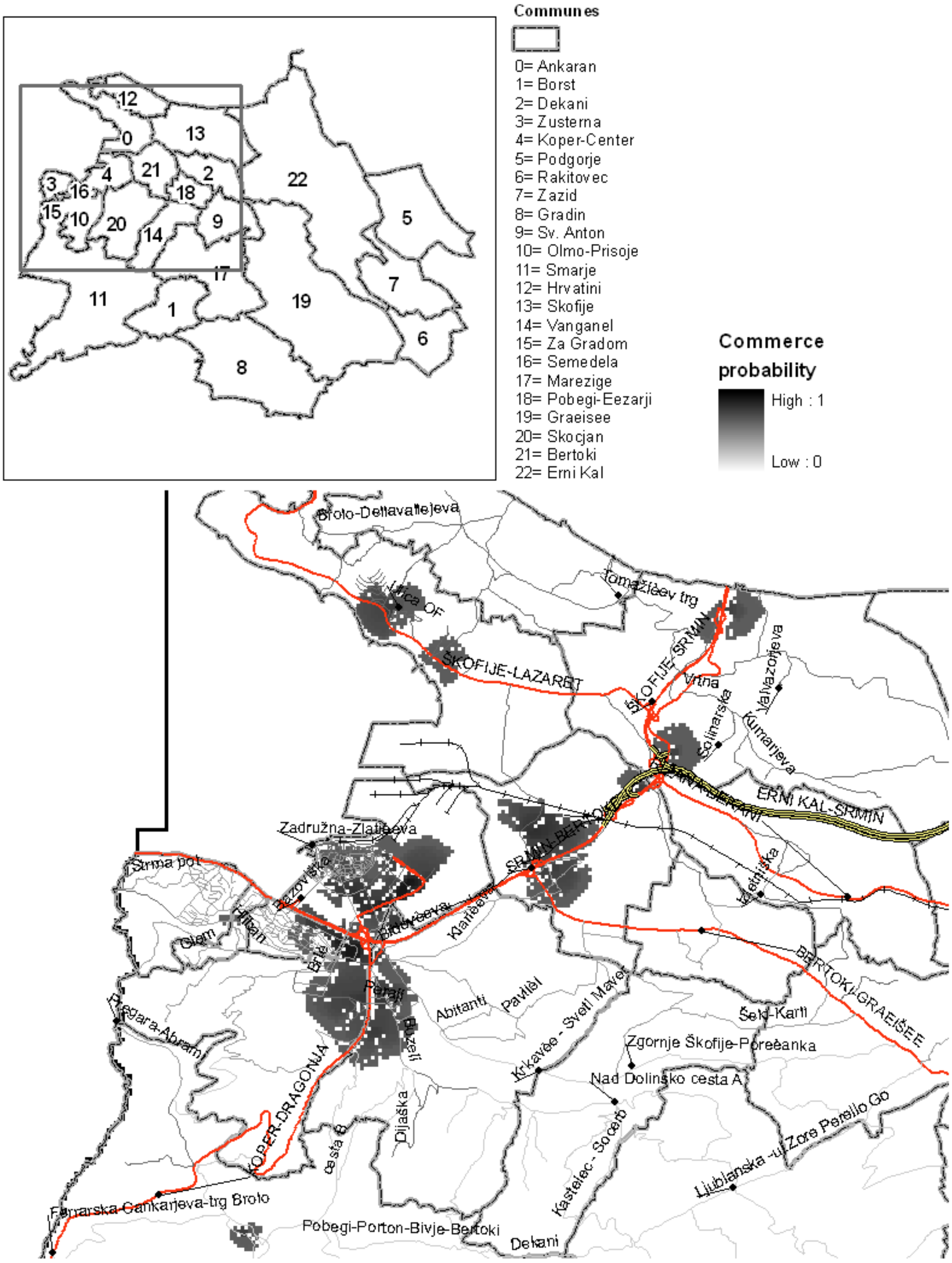
Probability of industry & production land use class appearing by 2025



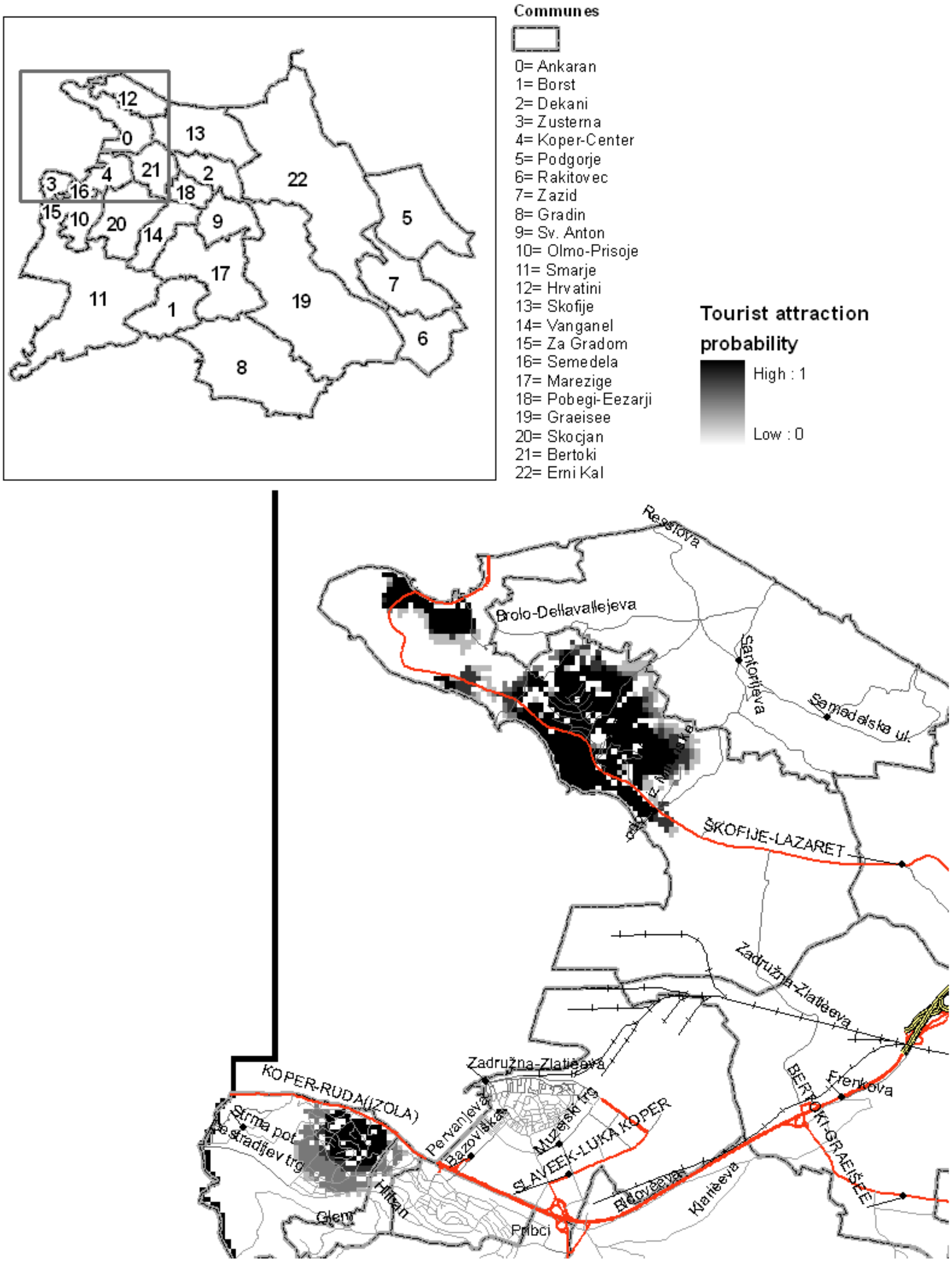
Probability location of services appearing by 2025



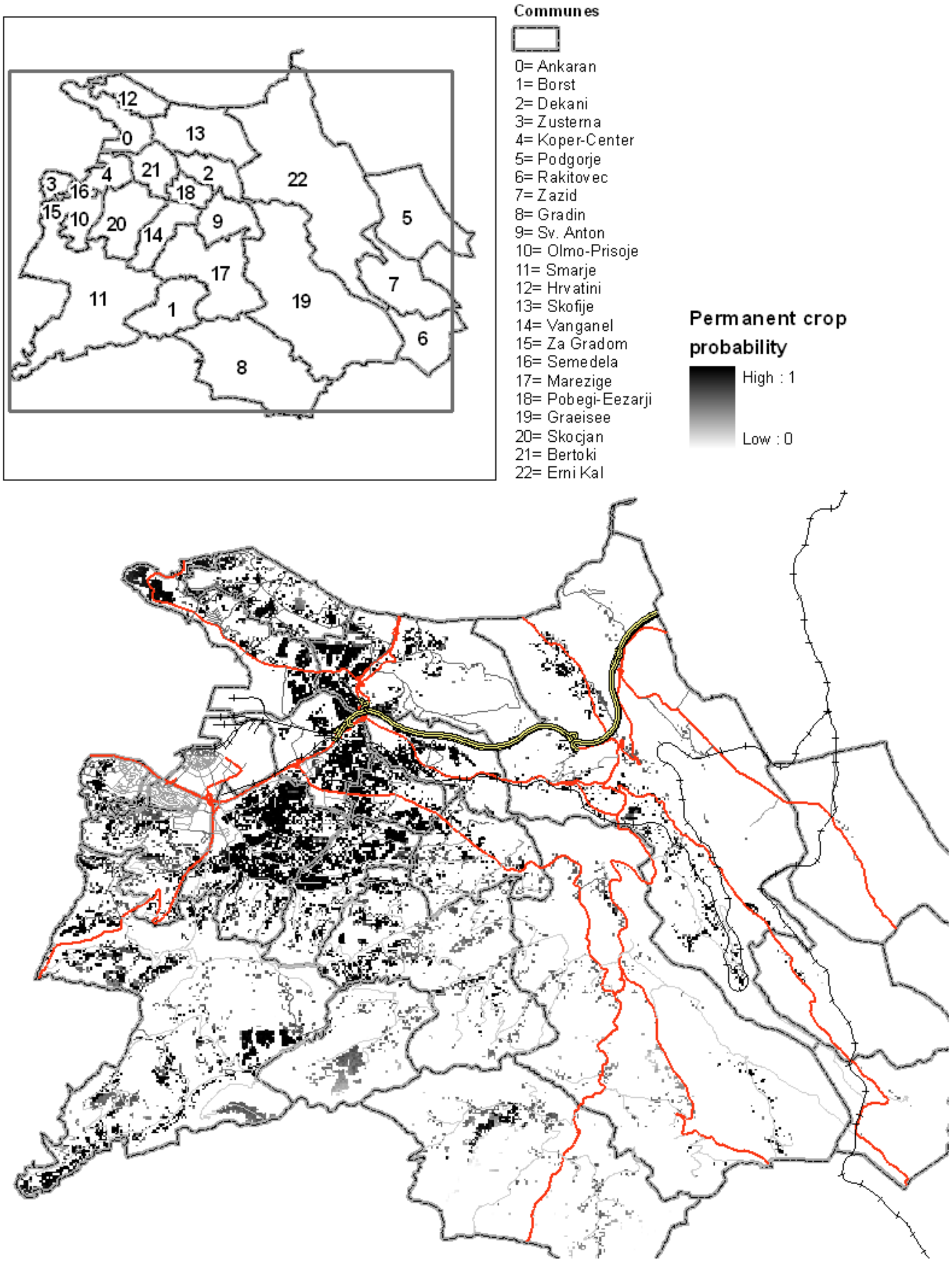
Probability location of commerce appearing by 2025



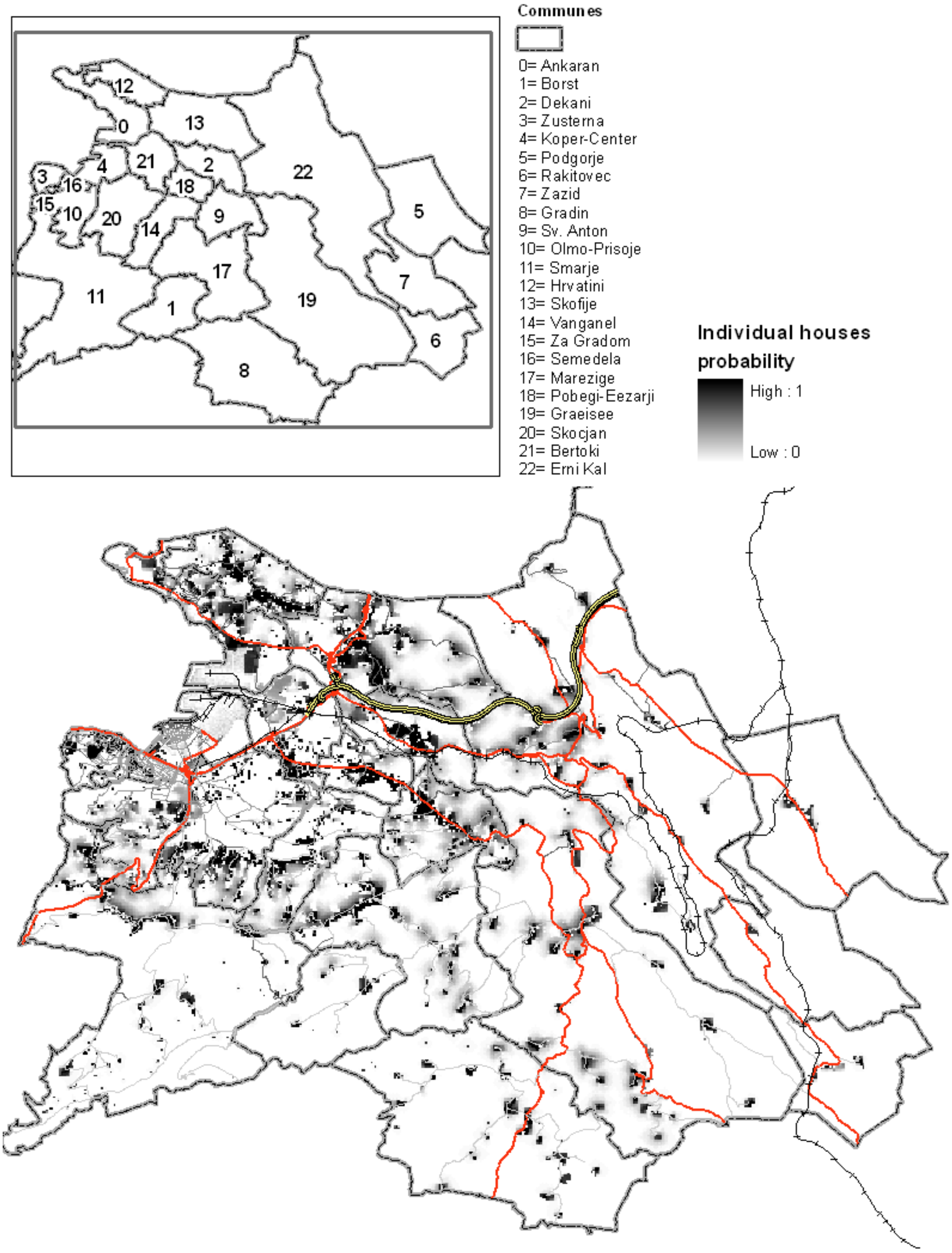
Probability location of tourist attractions appearing by 2025



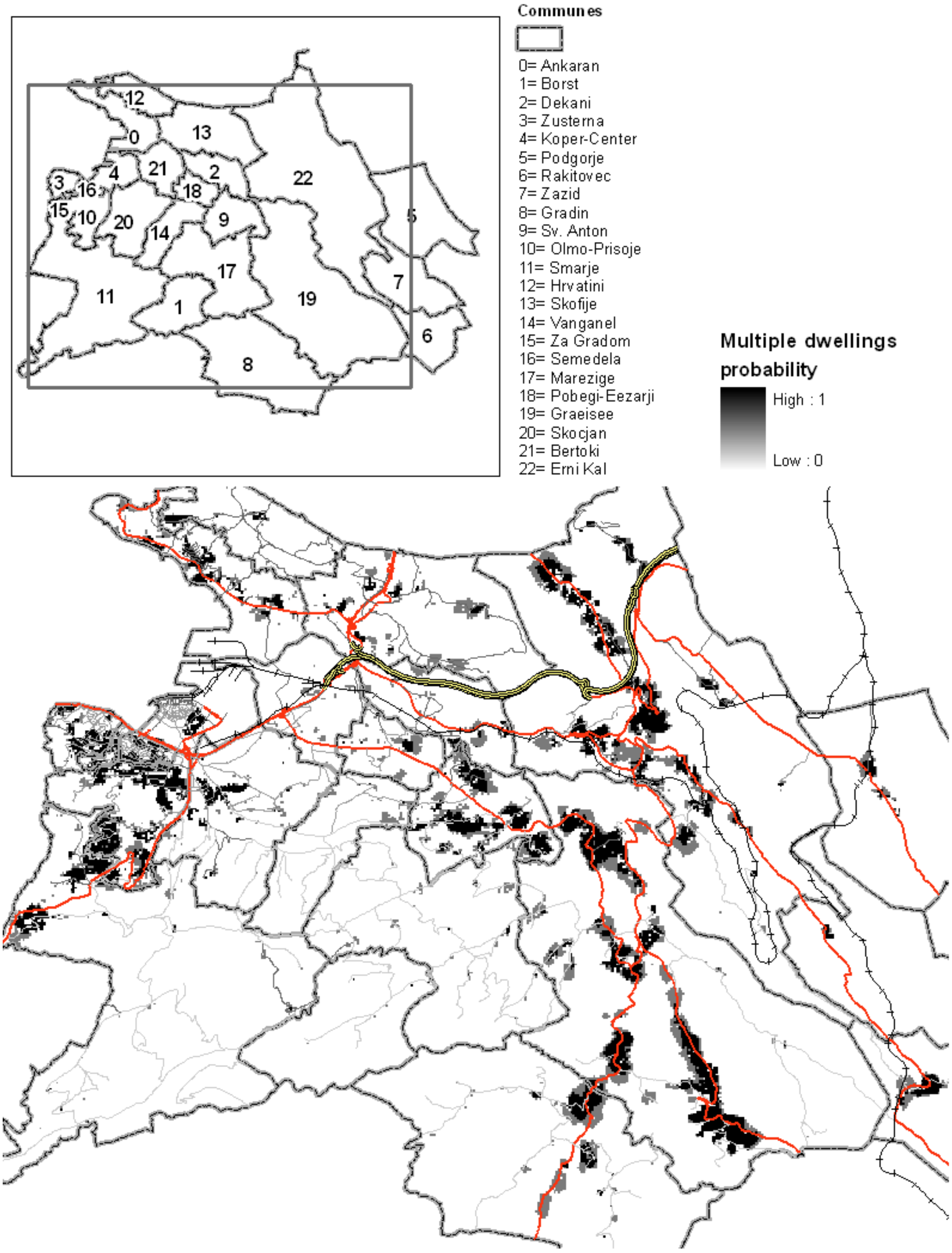
Probability location of permanent crops appearing by 2025



Probability location of individual houses appearing by 2025



Probability location of multiple dwellings appearing by 2025



9 Annex C. RUR statistics for land use changes

9.1 Liepzig: RUR statistics for land use changes

	DISCONTINUOUS		CONTINUOUS		Industrial and commercial	
	2000	2025	2000	2025	2000	2025
HT urban	164530000	163510000	8570000	9450000	45610000	50640000
HT peri-urban	143210000	167650000			41280000	96920000
HT rural	73970000	101800000	340000	460000	9000000	42160000
BAU urban	164530000	174710000	8570000	7320000	45610000	45780000
BAU peri-urban	143210000	165620000			41280000	77580000
BAU rural	73970000	82610000	340000	1590000	9000000	36370000
PO urban	164530000	163940000	8570000	10070000	45610000	49590000
PO peri-urban	143210000	148370000			41280000	79120000
PO rural	73970000	87070000	340000	430000	9000000	33250000

9.2 Koper: RUR statistics for land use changes

VALUE	CONTINUOUS	SERVICES	COMMERCIAL	INFRASTPUB	TURISTIC	RESIDENCES	MULTI_DWEL	INDIVIDHOU	INDUSTRYPR	PORT	ALLUrban
HT2025											
urban	332500	97500	802500	10000	127500	15000	745000	460000	417500	2160000	5167500
periurban	0	617500	557500	232500	277500	5000	302500	7045000	642500	657500	10337500
rural	0	40000	0	117500	30000	0	0	1797500	12500	0	1997500
PO2025											
urban	322500	137500	722500	10000	15000	15000	722500	545000	462500	2140000	5092500
periurban	0	427500	137500	145000	207500	5000	287500	6447500	397500	677500	8732500
rural	0	300000	5000	227500	30000	0	0	2347500	12500	0	2922500
BAU2025											
urban	317500	202500	550000	10000	10000	15000	730000	515000	417500	2190000	4957500
periurban	0	480000	167500	225000	185000	5000	277500	7117500	287500	1040000	9785000
rural	0	10000	0	77500	22500	0	5000	1712500	15000	0	1842500
2007											
urban	270000	125000	532500	10000	20000	20000	645000	452500	467500	2055000	4597500
periurban	0	217500	245000	77500	182500	2500	255000	5877500	345000	545000	7747500
rural	0	32500	12500	90000	30000	0	0	2160000	25000	0	2350000

	%increase of urban in urban	%increase of urban in periurban	%increase of urban in rural
BAU	7.26	20.82	-21.60
HT	11.03	25.05	-17.65
PO	9.72	11.28	19.59