PLUREL

Land Use Relationships
In Rural-Urban regions

Module 2

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

D2.4.3a

Land use projections based on Moland output

Part A: The Hague test case

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SIXTH FRAMEWORK PROGRAMME

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Abstract

Objectives

The objective of this test case series is to produce scenario runs for different test cases using the MOLAND land use model. Each test case is unique in its geography, society and policy choices. The land use model handles each test case independently with unique datasets as provided by Alterra. A list of common indicators was designed in order to ensure the inter-comparability of the eclectic set of cases. In this paper, a stand-alone draft for now, which will eventually be amalgamated with other test cases, we look at the behaviour of the South-Holland province (aka "The Hague test case", although many cities are a part of the test case area) according to three scenarios. Each of these scenarios is run on its own and with three "strategies" or policy alternatives, for a total of 12 model runs.

Methodology

Three scenarios were run for the South-Holland province (Netherlands) from 2004 to 2040: 'Business as usual', 'Peak oil' (B1) and 'Fragmentation' (B2). The parameters for the scenarios were set in collaboration with local stakeholders at several meetings spanning 2008-2010. Three of four strategies defined by the stakeholders were also run on top of these scenarios. Strategy 1 refers to 80% of new construction happening in already existing urban areas and is run by allowing construction of new residences inside of the already existing urban fabric. Strategy 2 is the "Discourse development" whereby making green space important is emphasized. This strategy is not included in the scenarios. The third strategy refers to green and blue services. This strategy is run using arbitrarily chosen parcels of a given percentage (stipulated by Alterra). The fourth and final strategy, referring to the Agrarian banking system, is also run using arbitrarily selected parcels as part of the incentives. The number of parcels used in this scenario was dependant upon the number stipulated by Alterra.

The methodological sequence included discussions with stakeholders, data acquisition and manipulation, ingestion into the Moland model and calibration; and scenario parameter setting and running. The final step was to extract statistics from the results and to prepare the data for export to allow stakeholders to perform their own analyses.

Results

Results in this report show the statistical differences between the three different baseline scenarios and their three "strategies", or policy alternatives. Only the differences in the baseline scenarios are shown spatially, but differences in all combinations are shown graphically.

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

Spatial scale for results: Regional, national, European	Regional
DPSIR framework: Driver, Pressure, State, Impact, Response	Driver/Pressure/State/Impact/Response
Land use issues covered: Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation	Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation
Scenario sensitivity: Are the products/outputs sensitive to Module 1 scenarios?	Yes
Output indicators: Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions	None
Knowledge type: Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks	GIS-based maps; tables and charts

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

1. Introduction

Moland is a land use modelling tool used within the PLUREL project context to model the dynamic urban expansion for selected case studies. Based on cellular automata, the model is able to capture the complexity and random nature of urban growth and its implications on peri-urban and rural land while being able to handle large geographical areas. The model is described in detail elsewhere (Barredo *et al*, 2003; Walsh & Twumasi, 2008; Petrov *et al* 2009).

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 1, the majority of the work occurs before the actual running of scenarios with the model.

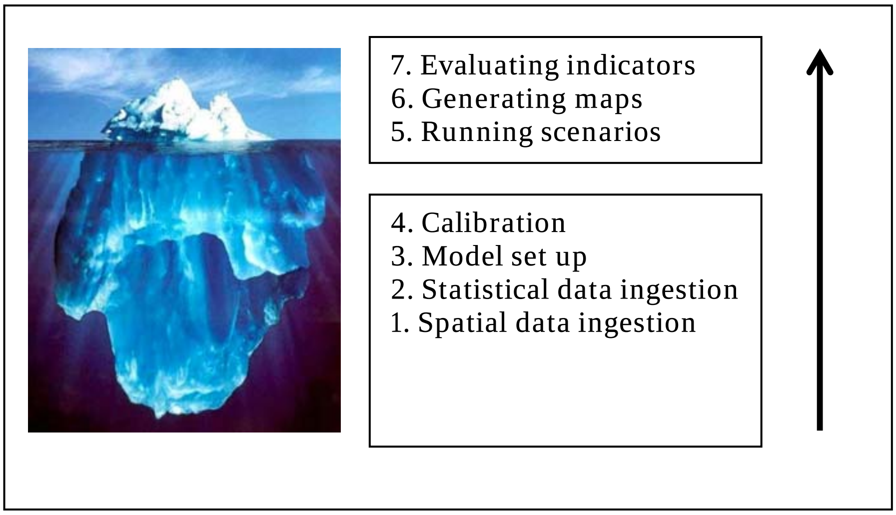


Figure 1. Representation of the underlying tasks behind running scenarios in Moland.

This report brings the reader through the various phases of modelling with Moland, with focus on The Hague case-study-specific details and analyses of results.

2. Study site

The Hague test case is one of six test case regions for the PLUREL project. This particular test case is a valuable learning tool for several reasons:

- The province is heavily zoned

- There are several ecologically sensitive areas, including around the Rotterdam harbour area
- The harbour has approved plans to expand westward, towards the water
- Some of the harbour area within Rotterdam centre are zoned to become for residential and workplaces in the near future
- There is a large region of glass greenhouses (Westland) whose purpose for now is to meet demands in the horticultural industry, but these demands fluctuate in the scenarios, causing abandonment and diversification in use
- The "services" sector of The Hague is not heavily influenced by the other economic sectors such as industry and commerce; but these three are amalgamated in the land use map
- There are several building restrictions due to low altitude, the canals and ecologically sensitive areas
- Dutch population awareness and consciousness about environment and conservation of natural, semi-natural and agricultural land: Conservation is regarded as a priority

The South Holland province is divided into six Nuts 3 regions and includes 95 settlements. Figure 2 shows the two main settlements of the province: The Hague and Rotterdam.

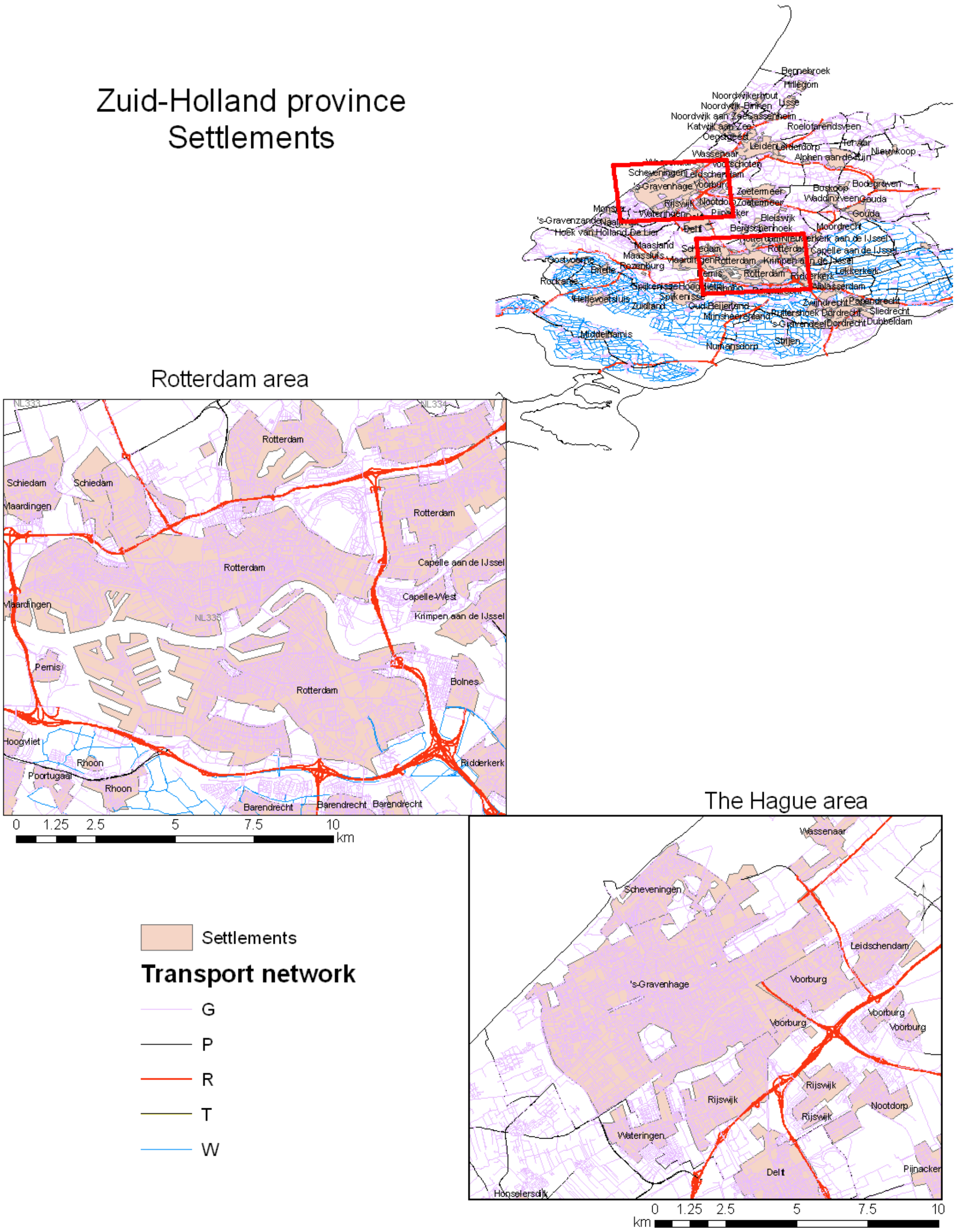


Figure 2. The two main settlements of the South-Holland province

2.1 Deviations from original plans

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. For this reason, and several others cited below, the spatial resolution was degraded from 25m to 100m. Other reasons include:

1. The study area had grown throughout the project to encompass the South-Holland province in its entirety, thus a 25m resolution would have been too fine for the model to manage;

2. The legend inconsistencies were less apparent when the land use maps were aggregated to a 100m resolution and the level of precision in the legend did not correspond to the level of spatial precision (i.e. a high spatial precision would require detailed information about the urban content. The legend contains only one urban class)

2.2 Legend

The legend applied for The Hague test case was agreed upon by the stakeholders during the workshop held in The Hague in December 2009. This legend was amended to suit the needs of the model. Table 1 details the legend and describes the reclassification scheme needed in order to calibrate and run the model. The main reasons for adjustments are due to inconsistencies in the classifications from the base year (1995) to the simulation start year (2004). The original land use classes for 1995 and 2004, which were provided to the JRC, are shown in section 3.1.1. The land use maps were converted from 25m to 100m resolution and reclassified as shown in table 1 with 14 classes + 1 ‘noData’ class.

Also in table 1 is the Moland land use category to which the class belongs. This is fundamental to the modelling process because it determines the behaviour of the cells within the model. Vacant classes can be built upon and may expand without explicit increase in land use demand; functional classes are the active classes with explicit land use demands assigned; and feature classes are unchanging unless the zoning maps or subsequent manual adjustments in the land use maps for any given time step are made.

Table 1. The land use legend for The Hague test case.

Original ID	Original description	Reclassified ID	Reclassified name	Moland Class
1	grass	**0**	pasture	vacant
78	pasture/farmland			
2	corn	**1**	arable	vacant
3	potatoes			
4	beets			
5	grains			
6	remaining agriculture plants			
9	orchard			
11	broad-leaved forest	**2**	ParkWoodland	feature
12	coniferous forest			
43	forest in marsh area			
77	Forest/orchard			
24	bald ground in bup in periphery	**3**	bare soil urban fringe	vacant
72	available land, harbour			
10	bulb	**4**	bulbs	function
8	greenhouse horticulture	**5**	greenhouse	function
88	work location	**6**	work location	function
18	urban area	**7**	urban	function
85	urban in port			
19	built-up in rural area	**8**	ruralResid	function
22	forest with dense bup	**9**	woodlandResid	function
26	bup in agrarian area	**10**	farmsteads	function
76	pier/dock/deposit	**11**	port	function
73	buildings in harbour			
79	pier/dock			
71	airport	**12**	airport	feature
20	broad-leaved forest in bup area	**13**	urban green	feature
21	coniferous forest in bup area			
23	grass in bup area			
25	head ways and rail ways	**14**	road and rail	feature
81	road			
31	open sand in coast area	**15**	sensitive water areas	features
46	bald ground in nature area			
30	tidal salt marsh			
32	open dune vegetation			
33	dense dune vegetation			
41	remaining marsh vegetation			
42	reed vegetation			
45	remaining open grown over nature area			
75	coastal zone			
16	sweet water	**16**	water	feature
17	salt water			
86	water			
35	dune heathland			
87	wetland			
		17	OUTSIDE	feature

3. Model set-up and calibration

The Moland regional model is appropriate if there are several competing centres of gravity (jobs, residence, economic sectors). For The Hague test case, the regional model was applied because of competing economic sectors. Ideally the area would have been divided into competing regions but insufficient statistics in economic sectors were available at a sub-provincial class thus the regional model was run, with all the added benefits of being able to configure economic sectors, but only one region was introduced in the model. Table 2 shows the general configuration of the model:

Table 2. The model parameter set up for The Hague test case.

Resolution		100m
# columns		925
# rows		758
Spatial reference		ETRS 1989 LAEA
Extent	Top	3261198.86497015
	Bottom	3185398.86497015
	Left	3895691.12465563
	Right	3988191.12465563
# regions		1
# vacant states		3
# functional states		8
# feature states		7
Economic sectors, job density associated		Industry, commerce and services
Economic sectors, no job density associated		• Dairy farming • Horticulture • Port
Population sector with population density associated		Residential

3.1 Data preparation

The data received from The Hague region is summarized in table 3:

Table 3. Data used for calibration of Moland urban land use model for The Hague region

Application	Description
Land use, First time step for calibration	Original: raster format 25m, t0=1995 (figure 3)
Land use, Second time step for calibration; first time step for simulation	Original: raster format 25m, t1=2004 (figure 4)
Regions map	Vector format
Digital elevation model, used in land use suitability mapping	Elevation model, 100m (figure 8)
National zoning	77 vector layers
Local zoning	Vector format (figure 5)
Transportation network	Vector format (figure 9)

3.1.1 Land use

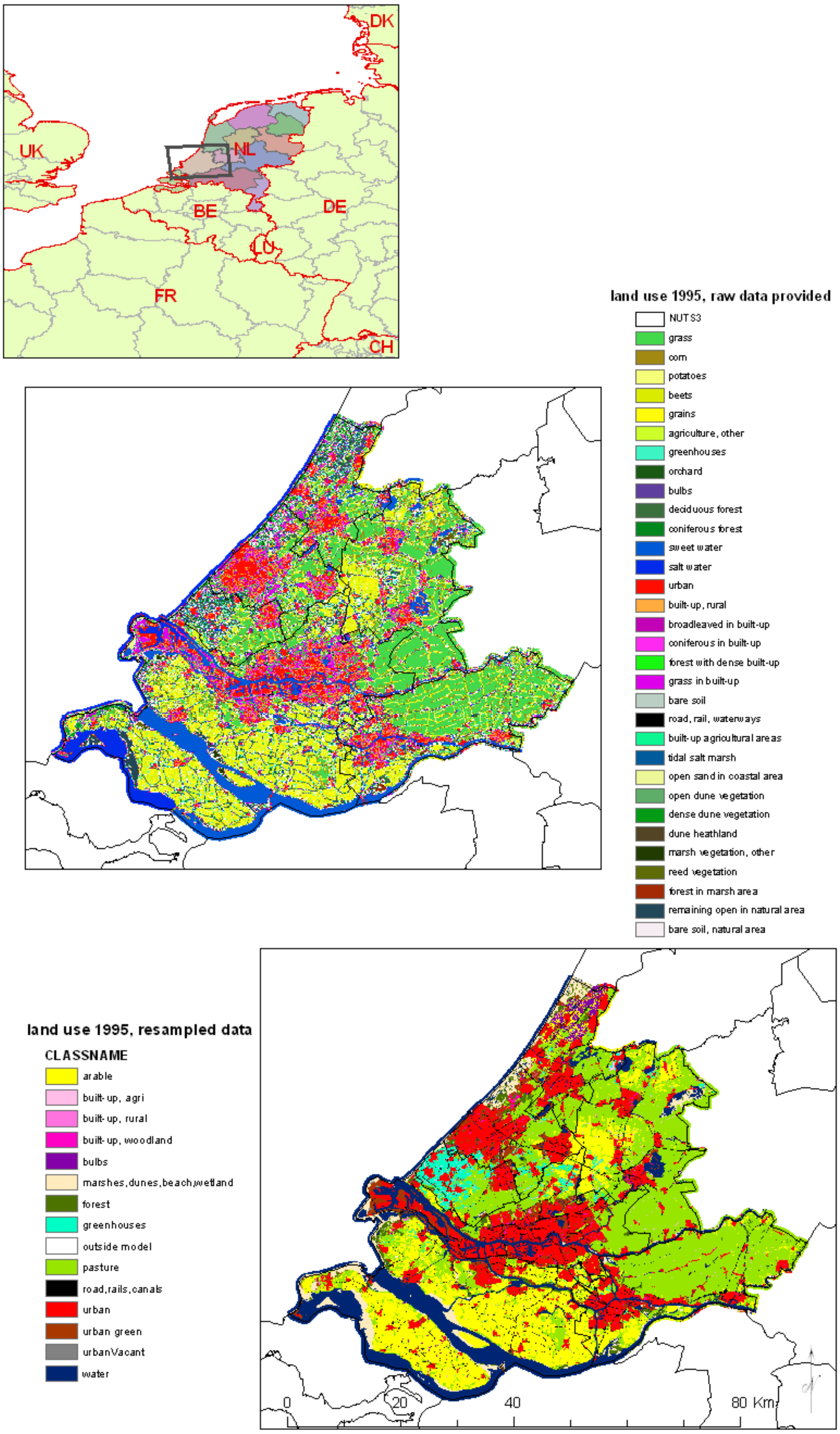


Figure 3. Raw data for 1995 provided was transformed to 100m resolution and with a shortened, aggregated legend.

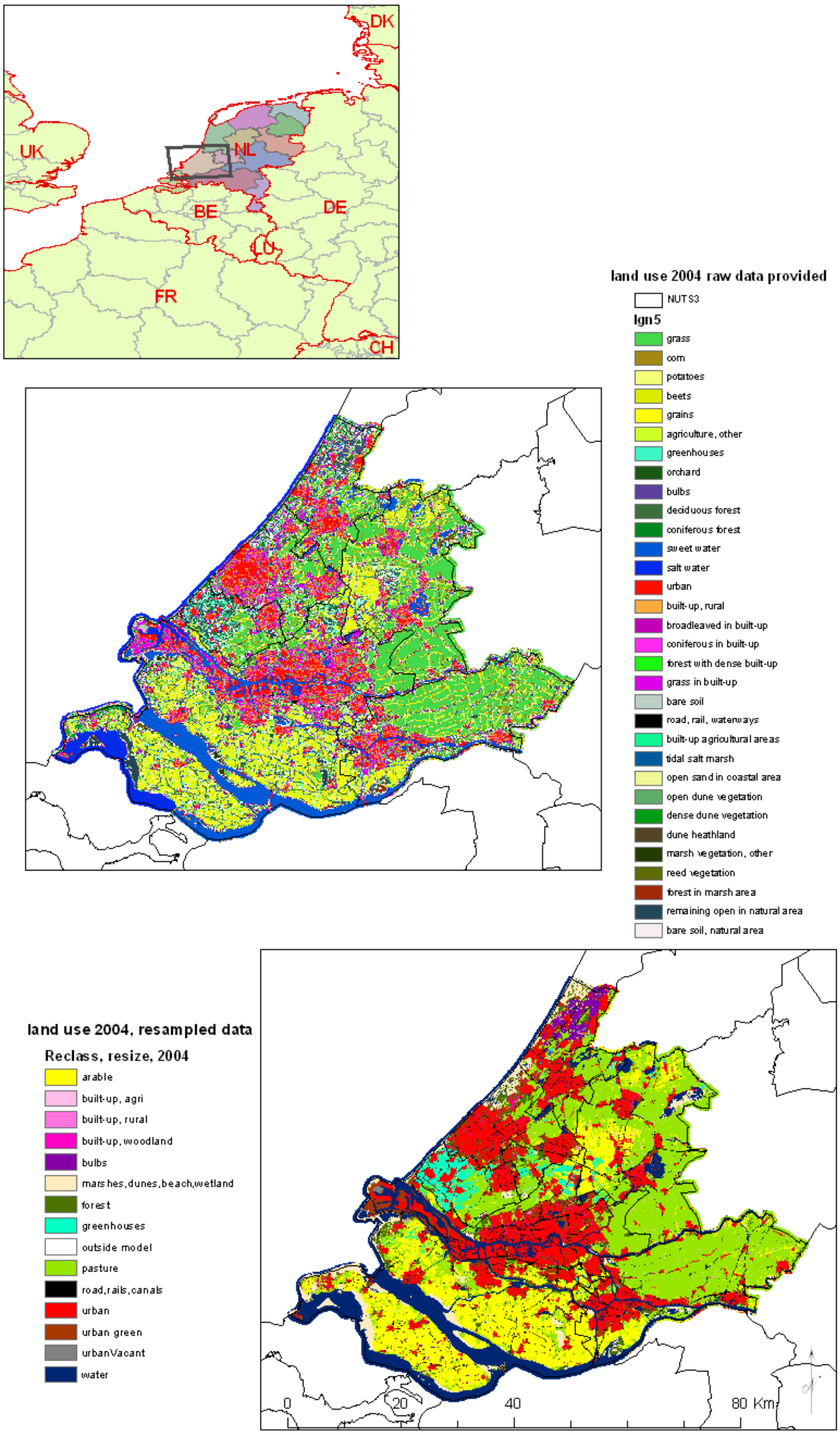


Figure 4. Raw data for 2004 provided was transformed to 100m resolution and with a shortened, aggregated legend.

3.1.2 Zoning

The zoning maps play an important role in the model. They determine whether or not a land use is allowed for a specific geographical location. Figure 5 shows the zoning map provided for the year 2004 until the end of the scenario runs. This zoning map was applied, upon request, to all three scenarios.

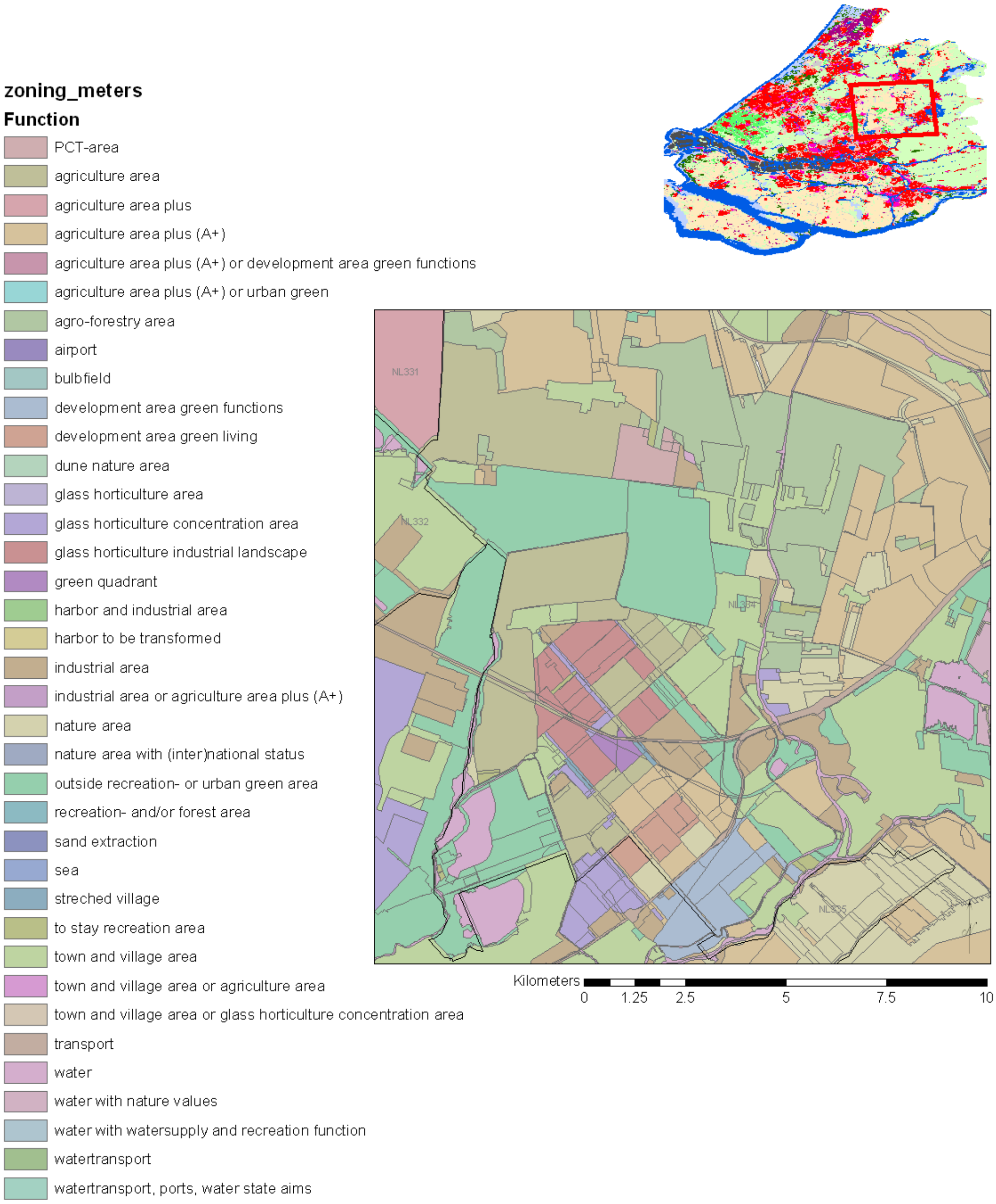


Figure 5. The zoning map provided for the South-Holland province.

The zoning map which was provided was amended in order to apply to specific land uses and to include the *actual* land use. This is important because otherwise the model reallocates land uses as of year 1 (2004). This is a problem for certain classes which are not usually allowed to change location, such as existing urban and port areas (see figure 6, for example) because these become re-allocated at time=0.

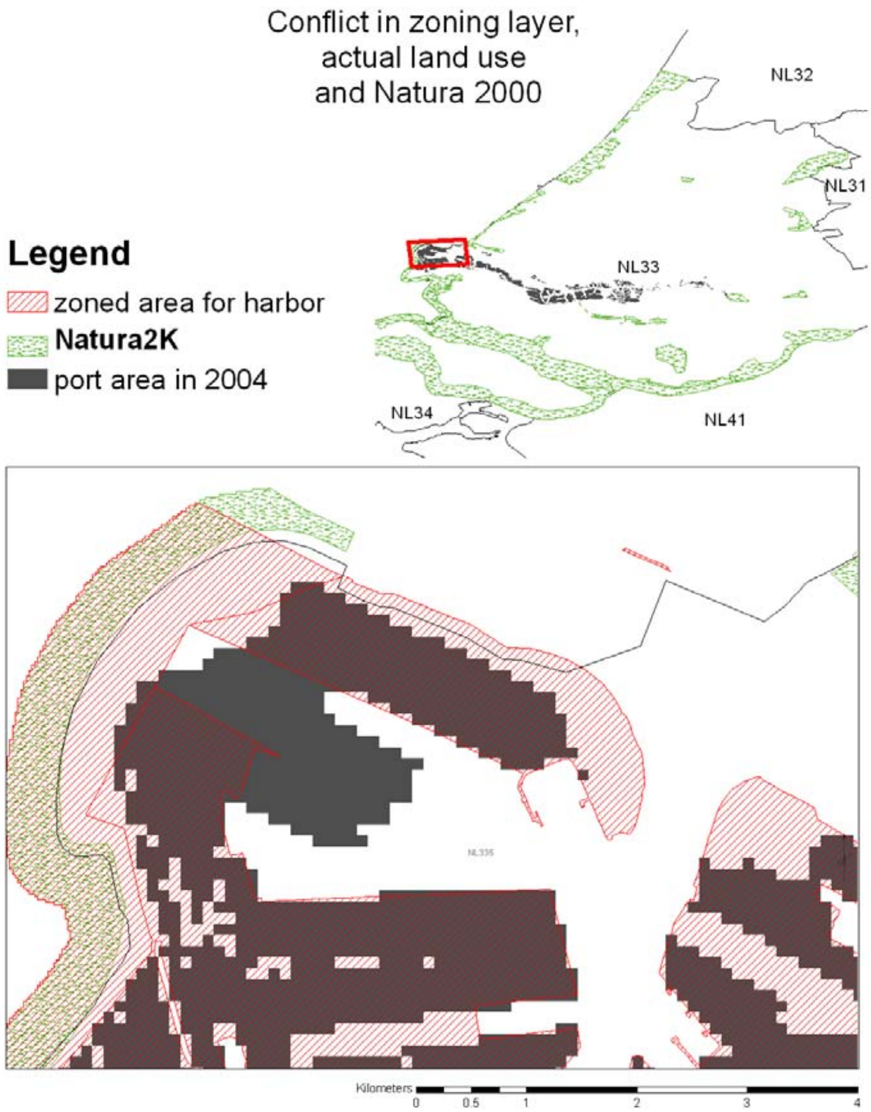


Figure 6. The conflict between different sources of data requires adjustment before ingestion into the model. In this example, the conflict between Natura 2000 designated areas, the zoning map for the post and the current land use for the port area.

Other transformations included zoning out Natura 2000 sites for building. This could not be applied to built up land use classes. A summary of the final zoning classes are listed in table 4:

Table 4. A summary of zoning map classes

Function	**Zoning: "Allowed" from T0 to end of simulation**	**Zoning: "not allowed" from T0 to end of simulation**
PCT-area	arable	
agriculture area	arable	
agriculture area plus	arable	
agriculture area plus (A+)	arable	
agriculture area plus (A+) or development area green functions	arable	
agriculture area plus (A+) or urban green	arable	
agro-forestry area	semi-natural and arable	
airport	airport	
bulbfield	bulbs	
development area green functions	semi-natural	
development area green living	semi-natural	
dune nature area		protected
glass horticulture concentration area	greenhouses	
glass horticulture industrial landscape	greenhouses	
green quadrant	semi-natural	
harbor and industrial area	port	
harbor to be transformed	Urban and port	
industrial area	workplaces	
industrial area or agriculture area plus (A+)	Workplaces and arable	
nature area	semi-natural	
nature area with (inter)national status		protected
outside recreation-or urban green area		
recreation- and/or forest area	semi-natural	
sand extraction		
sea		protected
streched village	urban	
to stay recreation area		protected
town and village area	urban	
town and village area or agriculture area	urban	
town and village area or glass horticulture concentration area	Urban and greenhouses	
transport	protected	protected
water with nature values	protected	protected

water with water supply and recreation function	protected	protected
water transport	protected	protected
water transport, ports, water state aims		

The protected areas, according to the zoning map provided and to Natura 2000 sites, were used to absolutely forbid building in these areas. In the cases where there were conflicts with the areas currently labelled as built up areas within protected areas, the built up areas were introduced manually but not allowed to expand. Figure 7 shows an example of such a case:

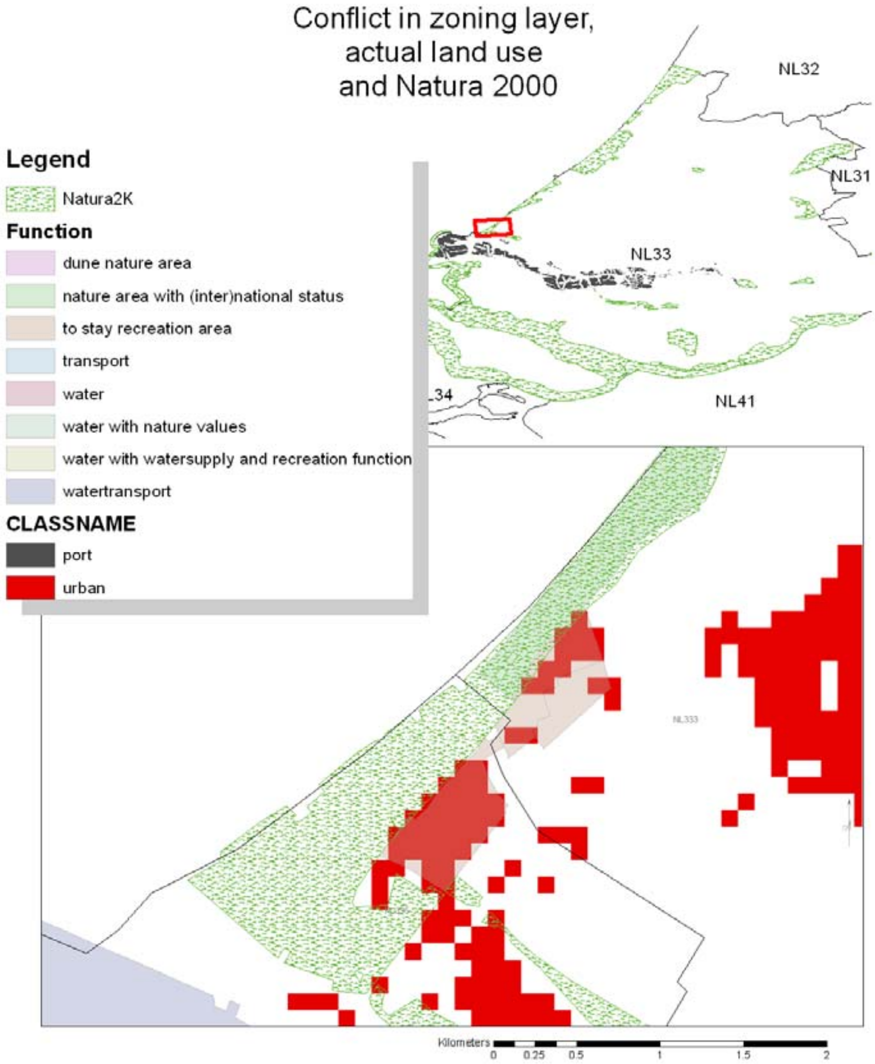


Figure 7. Areas which are urban according to the 2004 land use maps sometimes conflict with protected areas according to the zoning maps. In these cases, the urban areas are allowed to stay but not expand further into protected areas.

3.1.3 Suitability

Land use allocation for vacant classes is determined through “suitability maps”. Suitability maps express the physical suitability of a site for the land use classes. The suitability maps are created from a number of different layers, summarised in table 5:

Table 5. The layers integrated into the suitability maps.

Erosion risk	Soil erosion estimates (t/ha/yr), reclassified to 5 classes using Jenk’s Natural Breaks algorithm. High class value=high risk
Water shortage	Water deficit during the growing season (mm), reclassified to 5 classes using Jenk’s Natural Breaks algorithm. Low class value=high water deficit
Soil depth	Soil depth based on European soil database (cm), reclassified to 5 classes using Jenk’s Natural Breaks algorithm. Low class value = shallow
SWAP – water availability	Soil water availability to plants (mm), reclassified to 5 classes using Jenk’s Natural Breaks algorithm. High class value = high water availability.
Clay content	Soil clay content (%),values in jumps of 10% from 0-50%
Peat	Presence of peak in European soil database (y/n)
Elevation	Elevation above sea level (m), reclassified to 5 classes using Jenk’s Natural Breaks algorithm
Current land use	Land use in 2004

Each layer could be used in a different way for each of the different land use classes. For example, soil depth, clay content and peat concerned the arable land class but not the vacant urban class. All datasets, with the exception of the elevation (see figure 8) and land use were created and made available by the JRC.

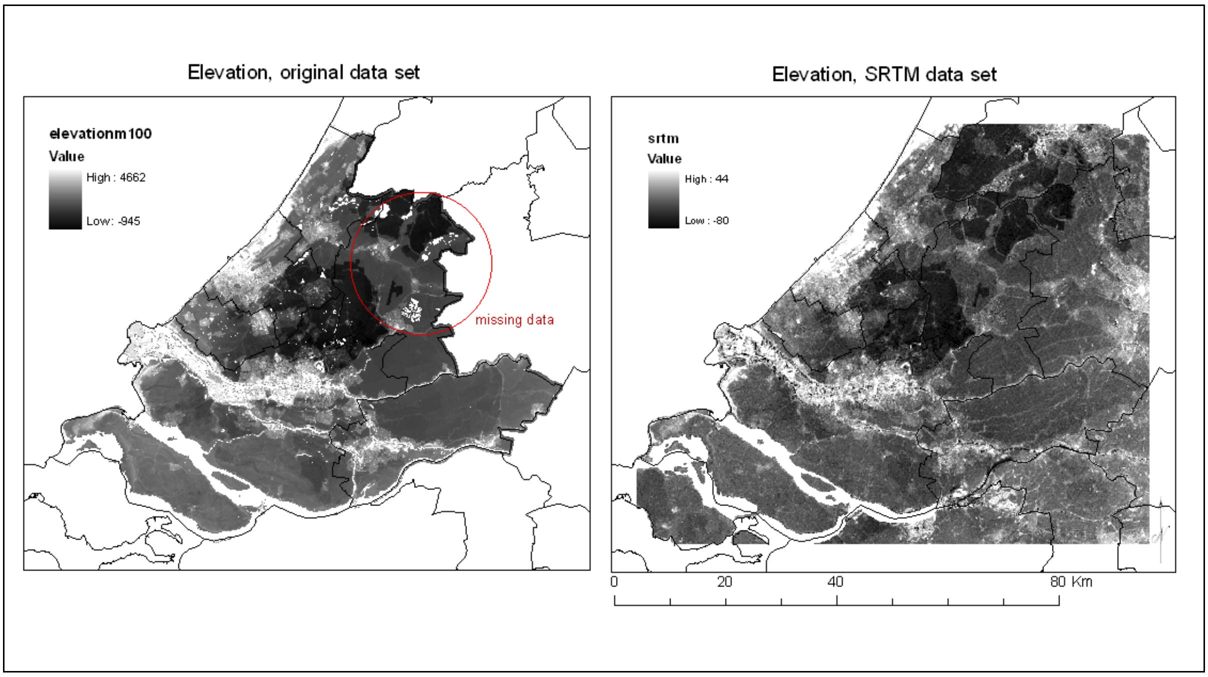


Figure 8. The digital elevation model provided (left) was replaced by the SRTM dataset (right).

Alterra improved the suitability map for arable land by adding local knowledge of the land use description and geographical area (figure 9):

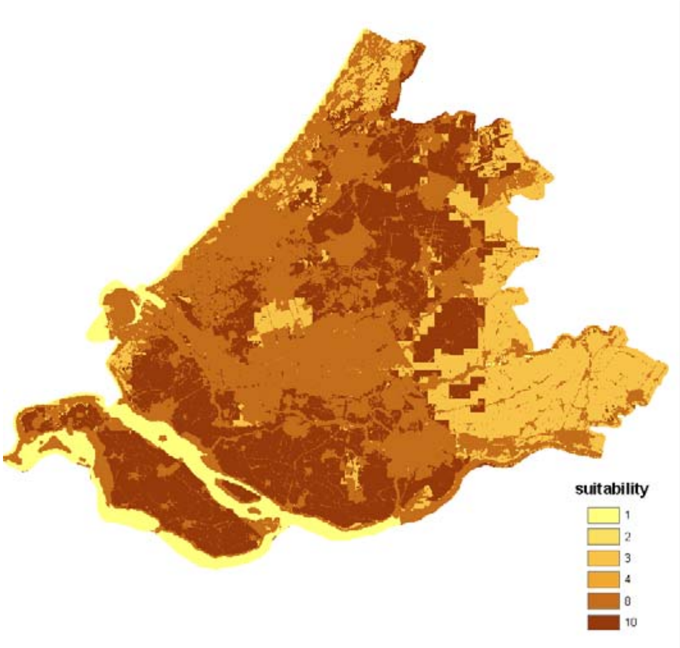


Figure 9. The suitability map for arable land provided by Alterra, whereby 1=least suitable and 10=most suitable.

3.1.4 Transportation and accessibility

The transportation network shapefiles were merged (roads, railway, waterways, railroad stations and airport) into a single shapefile (figure 10).

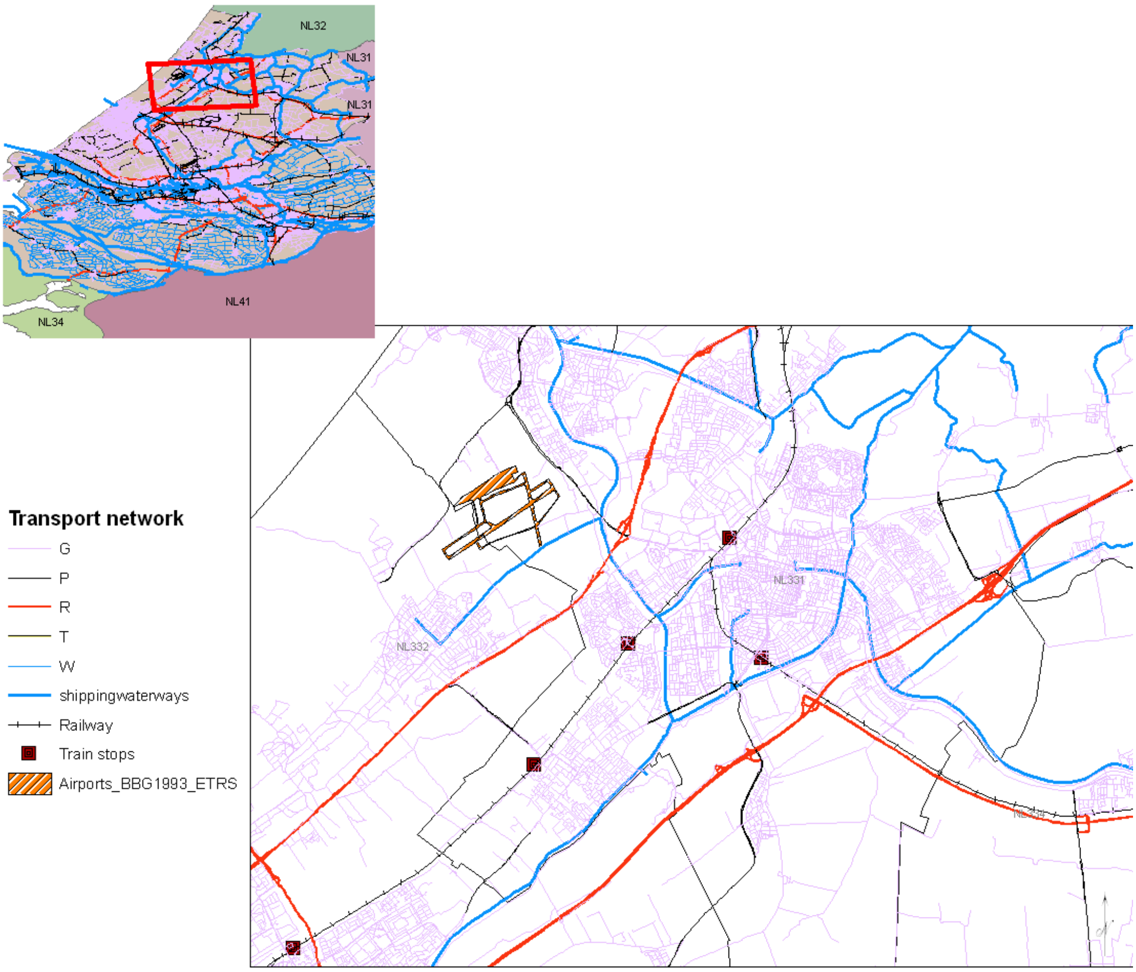


Figure 10. The transportation network for Leiden, a city within the test case area.

The airports were integrated into the land use map after a few minor changes: the vacant areas in between runways were filled in and labeled as part of the airport, otherwise other land uses could pop up between runways and two airports that are present in the 2004 land use maps were replaced with urban classes because they are no longer in use. The planned new highway between Rotterdam and Delft was added in 2015. From that date, the model takes this road into consideration as it would other highways.

3.2 Calibration

Suitability maps for vacant classes were created in Geonamica's Overlay tool and added were then checked and adjusted by Alterra. The output of suitability map making is a continuous grid from 0-10 whereby the increasing gradient indicates an increasing suitability (0= not suitable, 10=suitable).

The values assigned to the suitability maps were based on two things: expert knowledge and data behaviour. In order to assess data behaviour, the land use maps for both 1995 and 2004 were used to extract land use class statistics per suitability layer. This data was processed in a way which accounted for the relative size of each land use class as well as the relative size of each suitability class. Thus the percent land use occupying the percent suitability class was taken into consideration when assigning suitability levels per land use class. The data is shown in Annex A.

The following step was to verify the impact of the suitability maps on the calibration dataset. The land use allocation in the calibration run was compared with the true allocation. Based on this analysis, the overestimations and underestimations of the suitability maps per land use class are identified and are adjusted in small increments in order to arrive to a good fit with true data.

As described earlier, the transportation network was ingested into the model. Road, rail, airport and water transportation were all merged into the same shapefile and the necessary column "acctype" was created in the file dbf. The transportation maps can be updated at anytime during the simulation (this can be done either through uploading a whole new transport network or simply adding features on the existing transport network). The weight and spatial influence of each of the transportation types was described for each land use type. Table 6 shows the accessibility parameters for the baseline and B2 scenarios. The B1 scenario has different values due to the importance of oil prices. An example of the accessibility map for urban areas is shown in figure 11.

Table 6. Accessibility parameters used to build accessibility maps for calibration, the business as usual and the B2 scenarios.

		(importance/ Distance decay)				
Land use	**Implicit access to built-up/non-built-up**	*Highway*	*Major road*	*Rail*	*Train station*	*Water transport*
Bulbs	0.5/1	0.1/100	0.8/100	0/0	0.8/10	0.1/10
greenhouse	1/1	0.1/50	1/100	0/0	0.1/50	0.5/0.1
Work location	1/0.8	0.1/200	1/50	0.5/-2	1/50	0.4/5
urban	1/0.8	0.1/150	1/50	0.1/-5	1/50	0.9/5
Rural residence	0.8/1	0.1/200	0.9/50	0.3/-4	0.5/10	0.5/50
Woodland residence	0.8/1	0.1/200	0.9/50	0.3/-4	0.5/10	0/0
Farmstead	0.8/1	0.1/200	0.8/50	0.5/-4	0.5/10	0.8/50
Port	1/1	1/200	1/200	1/200	1/200	1/20

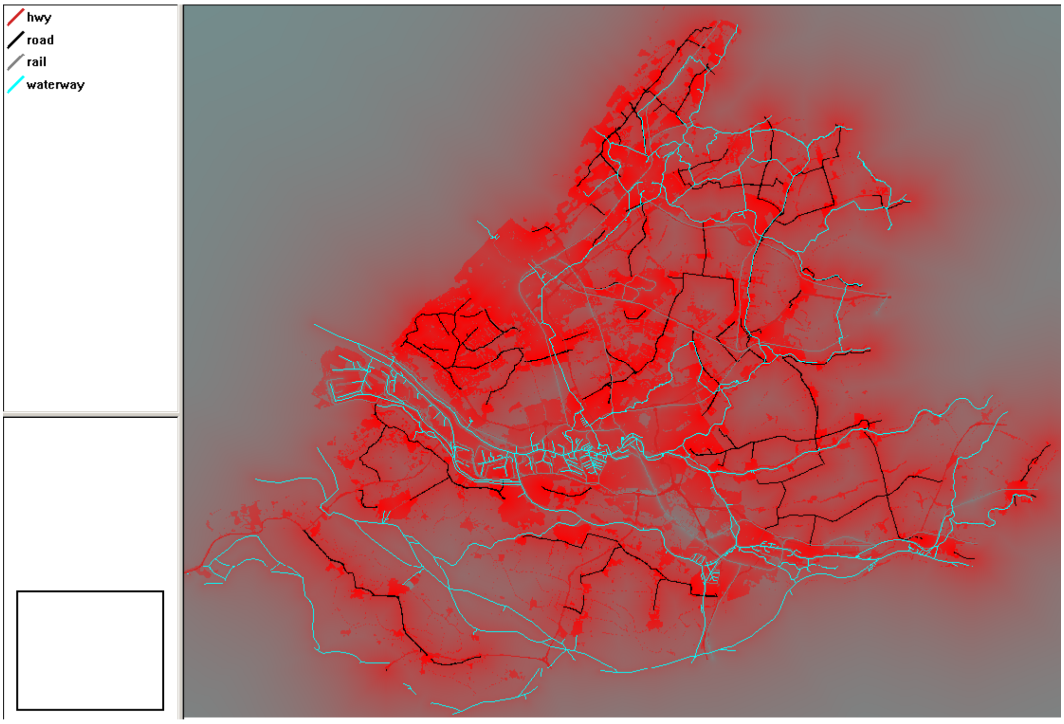


Figure 11. The accessibility map for urban areas, used for the calibration and the BAU and B2 scenarios.

Two bogus simulations were run in order to assess the calibration:

1. The "random constraint model", whereby the correct amount of land use change is allocated for T2 (2004), but in random locations (Hagen-Zanker and Lajoie, 2008[1]). For decreasing classes, pixels are taken away at

[1] Hagen-Zanker, A. and Lajoie, G. (2008) Neutral models of landscape change as benchmarks in the

random and replaced with LU classes that are increasing. Kappa statistics are computed from the random constraint.

2. The "no change model", whereby the initial land use map is used as the no change model to compare simulation results (Pontius and Malanson, 2005[2]). No change is typically more accurate than the simulation results (even if there is no simulation involved). The calibration is considered good when the model results are better than the null model results.

The actual calibration dataset, with suitability maps, accessibility maps and neighbourhood influence ingested was run and modified according to results given by the Kappa simulation model(van Vliet, 2009 – 12th Agile International Conference on GIScience "Assessing the Accuracy of Changes in Spatial Explicit Land Use Change Models" Hannover), a method which takes the total amount of change into consideration. This method was developed because it is known that Kappa accuracy is proportional to the number of changes occurring in an area. Thus fewer changes translate into higher accuracy, and since land use tends to persist rather than change over time, the models usually look very good. A sort of normalization of total changes can be made to assess the true accuracy of the calibration. According to the author of the paper, a value of 0.02 is good (personal communication, July 2009). Results are shown in table 7. Kappa values of -1 signify that the is no agreement at all; kappa values of 1 represents perfect agreement and a kappa value of 0 means that the agreement is exactly as can be expected by chance. The kappa value is computed from a contingency table of map A vs map B; in this case, map A=2004 true land use map and map b=2004 simulated land use map.

Table 7. Calibration results for two bogus runs and the calibration run.

Run	*Kappa (corr)*
Random constraint	-0.06329
No change model	-0.03706
Calibration	0.191345

A high degree of confusion which foils better statistics arises in the land use classes which are misclassified from one year to the next. This occurs for urban

assessment of model performance. Landscape and Urban planning 86 (3 – 4): 284 – 296.

[2] Pontius Jr., R.G. and Malanson, J. (2005) Comparison of the structure and accuracy of two land change models. International Journal of Geographical Information Science 19 (2): 243 – 265.

green in particular, whereby fields, even those within airport and port boundaries, are classified as “urban green” but more importantly, land use classified as “pasture” in 1995 are reclassified as urban green in 2004 if they border with urban areas. This kind of behaviour is either due to misclassification or a true conversion. If the latter case is true, then the land use class “urban green” should be used as a functional class and not as a feature.

The probability values for a given land use being converted to another is shown in Annex B.

3.3 Scenario descriptions

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 figure 12. A full description of the adapted scenarios can be found in the PLUREL deliverable 1.3.2.

Scenario framework – key variables

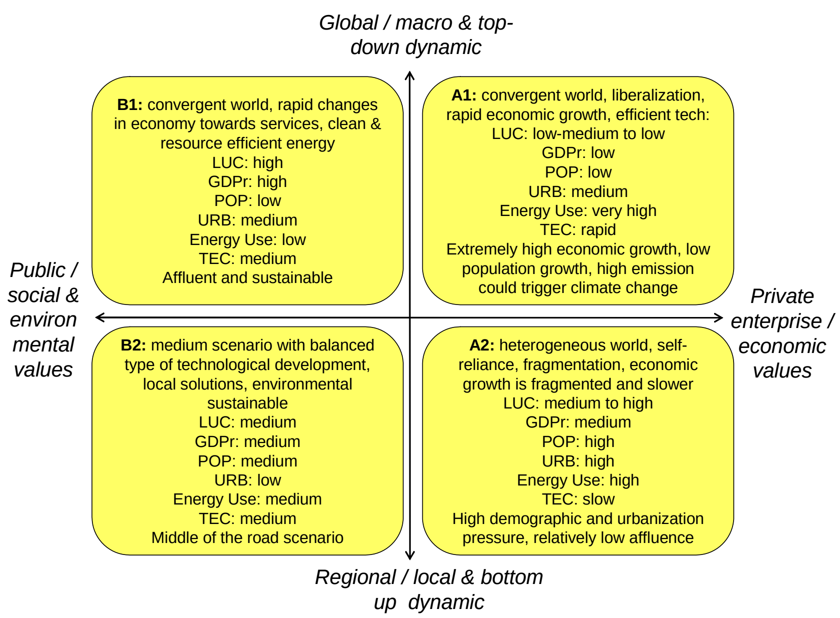


Figure 12. Adapted SRES[3] scenario key variables (taken from d1.3.2.)

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

According to the July 2009 version of the working paper WP 3.4 “PLUREL scenario workshop The Hague Region 11 and 12, May 2009”, two scenarios were retained for The Hague test case: Peak oil (B1) and Fragmentation (B2). The business as usual scenario was also run in addition to these two scenarios. A description of the B1 and B2 scenarios and their expected outcomes is detailed in the above-cited PLUREL working document. In this document, the original and detailed qualitative descriptions are summarised under the appropriate scenario heading.

All scenarios are to run to 2040. This means that the length of the run is 36 years. Although the reasons for this duration are clear and highly justifiable, it is important to note that such a long time frame increases uncertainty in the outcome. This is of course open for discussion. Since storylines are not meant to be predicative, and scenarios are based on storylines, uncertainty could be considered as being irrelevant. The philosophical debate can be left aside for now, however it is important for the reader to consider the possible implications of such a long temporal window for the model run.

3.3.1 Business as usual

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: National trends for the past decade according to the national statistics office CBS (http://www.cbs.nl) for population numbers and projections; and Eurostat for employment figures in the economic sectors.

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

- Non-linear extrapolation of horticulture sector trends from current statistics
- Non-linear extrapolation of population trends. The population reaches a peak in 2020 then is on a slight decline. For the Strategy 1 run, thus the density of living space is stable at 80 persons /ha until 2020 but is slightly lower after 2020 (74 persons/ha).
- Employment increase in port sector

- Dairy farming industry is steady
- As of 2008, the port had the go-ahead to expand by 20%; assuming this trend went ahead, the port was further expanded in 2030 by another 10%.
- Building of new individual houses is limited in the peri-urban and hinterland
- Densification along roadside and in current urban areas
- Small decrease in population, as forecasted by the national statistics office
- Accessibility: workplaces attracted to roads; individual houses such as farmsteads are not. These remain near the city centre
- Zoning: local zoning maps provided and Natura 2000 areas.

3.3.2 Peak oil

This scenario, as described by SRES, is characterised by a society whose priorities are in services and informatics rather than industry and production. Emphasis is placed on social issues and environmental sustainability. The population is described as reaching a peak growth and the decline after 2020. Building is restricted using the same zoning restrictions as for the BAU scenario.

The following is a brief description of the B1 scenario for The Hague test case.

- The services-based areas of The Hague and Delft prosper while Rotterdam is on the decline due to a slightly shrinking port, which in turn is due to the rising costs in petroleum and its derivatives
- The greenhouse industry suffers from increasing transportation costs, but does not collapse entirely
- Port activity remains somewhat steady, as for the BAU scenario, there is a shift towards the water from the city center of Rotterdam, thus leaving land available for other uses.
- Some housing appears in hinterland but growth is limited due to strong incentives to maintain “natural” areas such as agricultural areas, pasture and bulbs.
- New land. There is mention of new land being created using “sand supplements”. These are unfortunately not integrated into the model because the location of these areas is unknown and would probably not have an impact on land use changes because it occurs offshore.

3.3.3 Fragmentation

This scenario, as described by SRES, is characterised by what is described as being a "transition" period. The following is a brief description of the amendments to this scenario for The Hague test case:

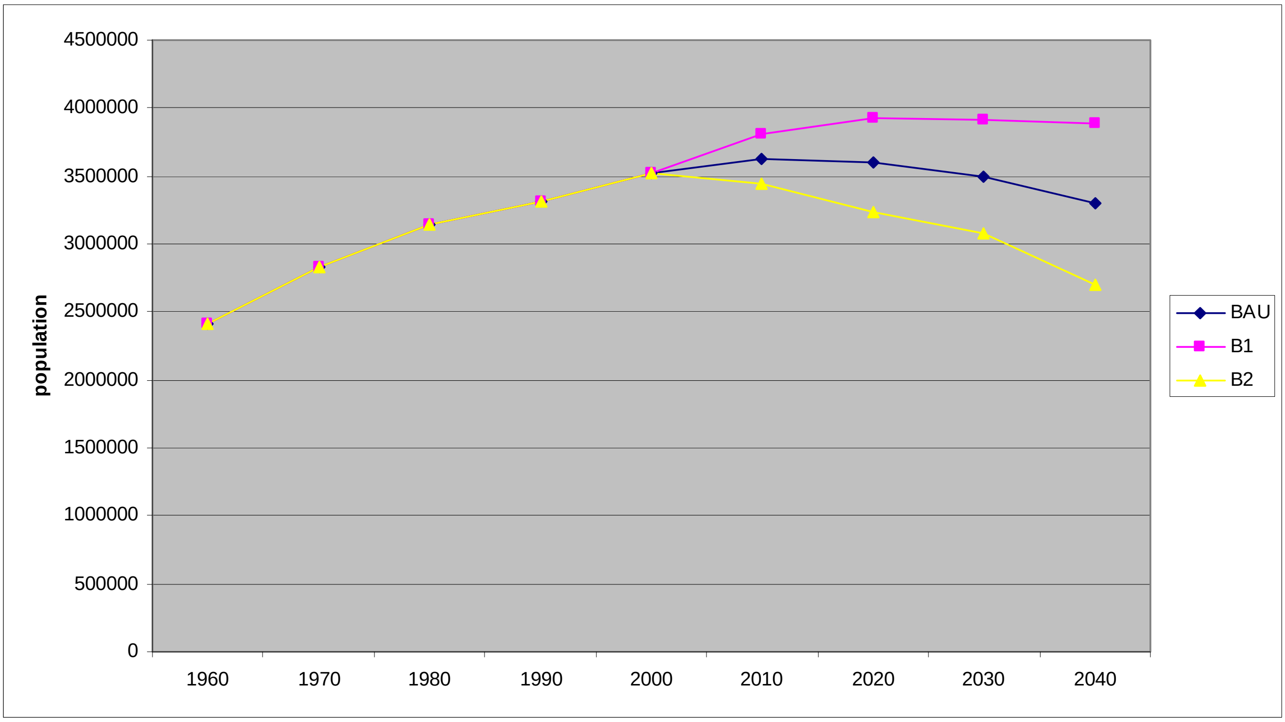
- Economically void scenario, whereby greenhouses are abandoned and, in some cases, filled with other functions but the port remains stable
- The Hague suffers decline but the Delft region is maintained intact due to good business in the technology and R&D.
- Gated communities arise in and near the Delft-Rijwijk-Nootdorp triangle (rural residential class)
- Only the Delft area is left intact in terms of work locations, other areas are desecrated

3.3.4 Baseline scenario configurations

The baseline scenarios, described in the July 2009 version of the working paper WP 3.4 "PLUREL scenario workshop The Hague Region 11 and 12, May 2009" and restructured during a meeting in Ispra in August 2010, were translated into terms the model could digest. Data was described on intervals of decades in order to configure the model. Table 8 shows the input used for the economic sectors and figure 13 shows the input for the population sector.

Table 8. Past and projected trends in employment per economic sector for South Holland province for the 3 baseline scenarios

		2004	2010	2020	2030	2040
Industry, commerce, Services /ha	BAU	12860	12900	13000	13100	13200
	B1	12860	12900	13260	13624	13992
	B2	12860	12800	12700	12600	12500
Port /ha	BAU	5834	6000	6200	6400	6400
	B1	5834	6000	6200	6400	6400
	B2	5834	6000	6200	6400	6400
Horticulture /ha	BAU	12978	12970	12975	13000	13200
	B1	12978	12970	12975	13000	13200
	B2	12978	10000	8500	7700	6489
Dairy farming /ha	BAU	1052	1052	1052	1052	1052
	B1	1052	1052	1052	1052	1052
	B2	1052	1052	1052	1052	1052



	1960	1970	1980	1990	2000	2010	2020	2030	2040
BAU	2407127	2831816	3145288	3318885	3517795	3625052	3600179	3490816	3296963
B1	2407127	2831816	3145288	3318885	3517795	3806305	3927795	3909714	3890416
B2	2407127	2831816	3145288	3318885	3517795	3443799	3236561	3071918	2703510

Figure 13. The trends in population for the test case used to configure the three baseline scenarios.

3.4 Strategies

Three different strategies were presented by the stakeholders. The purpose of running the so called "policy alternatives" in addition to the baseline scenarios, was to test the impacts of policy in three different contexts: business as usual, peak oil, or fragmentation. Two rules therefore had to be applied. The first is a horizontal rule whereby the method in which the strategies were configured should always be consistent and mutually exclusive. The second, vertical rule, involves the consistency in the demand set. This implies that the demand set for the economic and residential sectors remains consistent from the parent baseline scenarios to its child policy alternatives (figure 14).

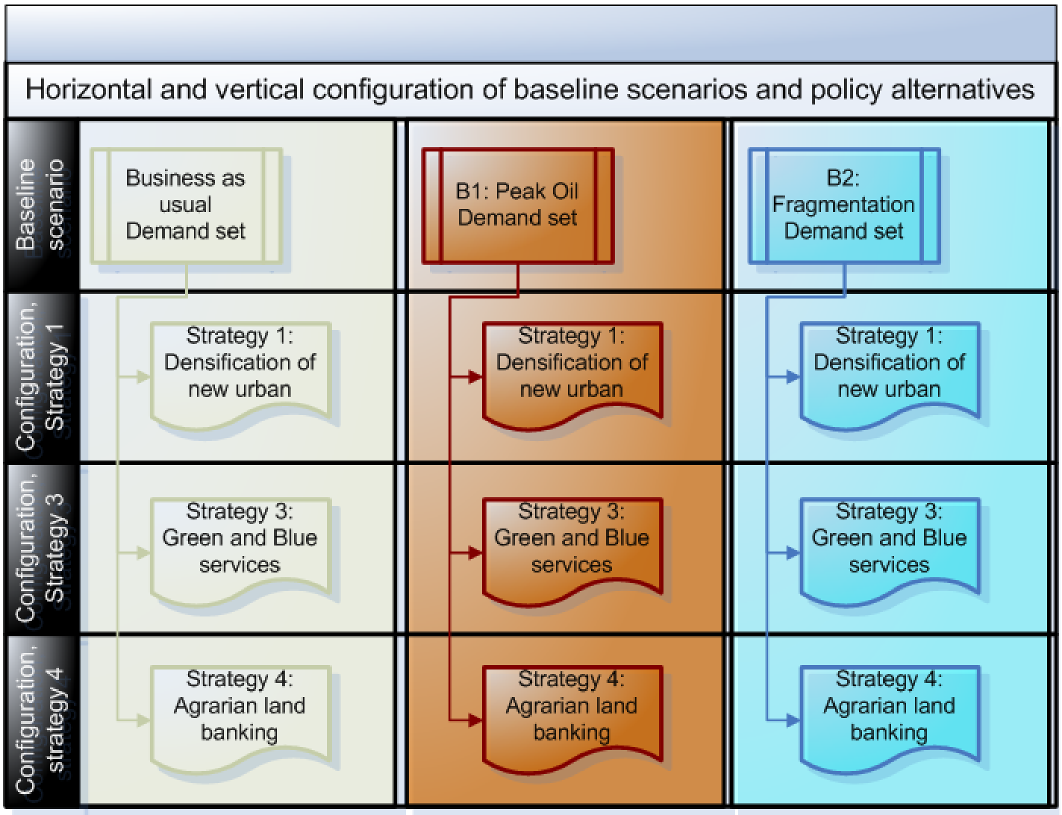


Figure 14. The horizontal and vertical configuration rules for three policy strategies.

3.4.1 Configuration, Strategy 1

"Strategy 1" involved increasing the density of the workplaces and residential areas (urban areas). In this strategy, at least 80% of new construction should take place within the urban fabric. At the initial state (t=0), the number of cells is read from the land use map and is cross-checked with the user-entered statistics of population and employees in the industry, commercial and services sector. Initial densities are assigned. For every simulation step thereafter, *W* is updated (Moland user's manual, p.34):

$$ {}^{t+1}W_{K,i} = {}^{t}\delta 1_{k}\,{}^{t}W_{K,i} \bullet {}^{t}Wreg_{K,i} \bullet {}^{t}Wcel_{K,i} \qquad \text{(eq. 1)} $$

where

Wreg is a term for densification at a regional level;

Wcel is a term for densification at a cellular level

δ1 is the absolute influence of the current land productivity

Wreg and *Wcel* each have a number of parameters allowing the model to be more or less influenced by the demand over supply, crowding, transition potential, suitability and zoning, accessibility and total capacity of the region. By manipulating these parameters for the Industry, Commercial and Services economic sector, we influence the land use class "workplaces". In order to influence the density of the workplaces, we can manipulate the influence of parameters "growth transition potential". Other parameters such as "crowding" and "demand over supply" play a role in influencing density at regional level.

The parameters are also influenced for the population sector, thus influencing the classes "urban" and the three residential classes (farmsteads, luxury homes and rural residences). It would be possible to calculate the densities of the population if the proportion of the population residing in the "residential" cells were known, but this is not the case. An assumption is therefore made with respect to the population densities: The urban class has a higher density than the residential farmsteads, luxury homes or rural residences. In this way, the model can be configured to allocate a growing population to fewer, high density cells rather than to distribute the population in the lower density residential classes. The change in the population density of the region is calculated as (Moland user's manual, p.37):

$$\Delta^t W_{p,i} = \ln({}^t W_{p,i}) - \ln({}^{t-1} W_{p,i}) \qquad \text{(eq. 2)}$$

where

${}^t W_{p,i} = density\ of\ population\ (p), at\ time\ t;\ for\ region\ i$

The actual allocation of population to cells is dependant on the amount of land available, but if cells are assigned different "holding capacities", it is possible to allocate the same demand into fewer cells. So for example, for the urban class, the amount of cells required for the allocation of the demand for residences is allocated as follows

$$ {}^t N_{urban,i} = {}^t \varepsilon_{urban,i} \bullet {}^t N_{p,i} \qquad \text{(eq. 3)}$$

where

${}^t \varepsilon_{urban,i}$ = the relative proportion of residential cells of type "urban" at time = t

$$ {}^t N_{p,i} = \frac{{}^t D_{p,i}}{{}^t W_{p,i}} \qquad \text{(eq. 4)}$$

where

D = demand; W = land productivity as in eq. 1; and N = number of cells required

The same is done for the less densely packed residential classes.

3.4.2 Configuration, Strategy 3

Strategy three was dealt with by allocating a percentage of total parcels, as defined by Alterra, to receive subsidies. Subsidies were defined as being received per hectare (thus the larger parcels received more subsidies). Table 9 shows the definition of this strategy for the three different scenarios as presented by Alterra.

Table 9. The stakeholder definition of the Green and Blue Services strategy (Strategy 3) in terms of parcels adhering to the initiative and subsidies received per hectare.

Green-Blue Services	BAU	B1	B2
% of total area	20	20	30
Number of parcels (of total 25363)	5073	5073	7609
Subsidies €/ha yr	1000	100	100
Chance of staying above normal	1.2	1.2	1.05

This table was translated to maps as follows: For 20% of the 25363 parcels of arable land and pasture potentially included in the strategy and thus eligible for subsidies, only a certain percentage adhere. This percentage differs depending on the scenario. For example, for the BAU scenario, 20% of parcels adhere to the strategy; for the B2 scenario, 30% of parcels are included in the strategy. In addition to this criterion, there is the multiplicative criterion set by Alterra which represents the likelihood of the land owners not adhering to the strategy initiative, will continue with their activities. For example, 30% of parcels adhere to the subsidies for the B2 scenario, but in any case, the remaining 70% are 5% more likely to remain pasture or arable with respect to the baseline scenario. In this schema, the larger parcels, assumed to belong to the same land owner, receive more money. For example whereas a parcel of 120 ha is worth 120 000 Euro according to the BAU scenario, a 1ha parcel is only worth 1000 Euro for the same scenario; and the non-subsidized parcels receive 0 Euro. This information is ingested into the land use model through the suitability map layers. Since the model handles values between 0-1, it was necessary, due to the large discrepancies between the large and small parcels (max = 129 ha; min = 1ha), to implement a non-linear rescaling method whereby the square root of the values were used to assign a value to a parcel to represent the likelihood of it remaining intact (likelihood = suitability). In order to bring the values between 0-1, the results are divided by the maximum value.

Different maps were generated to differentiate the situation between BAU and B1 scenarios and the B2 scenario. Figure 15 shows the map generated for the BAU scenario.

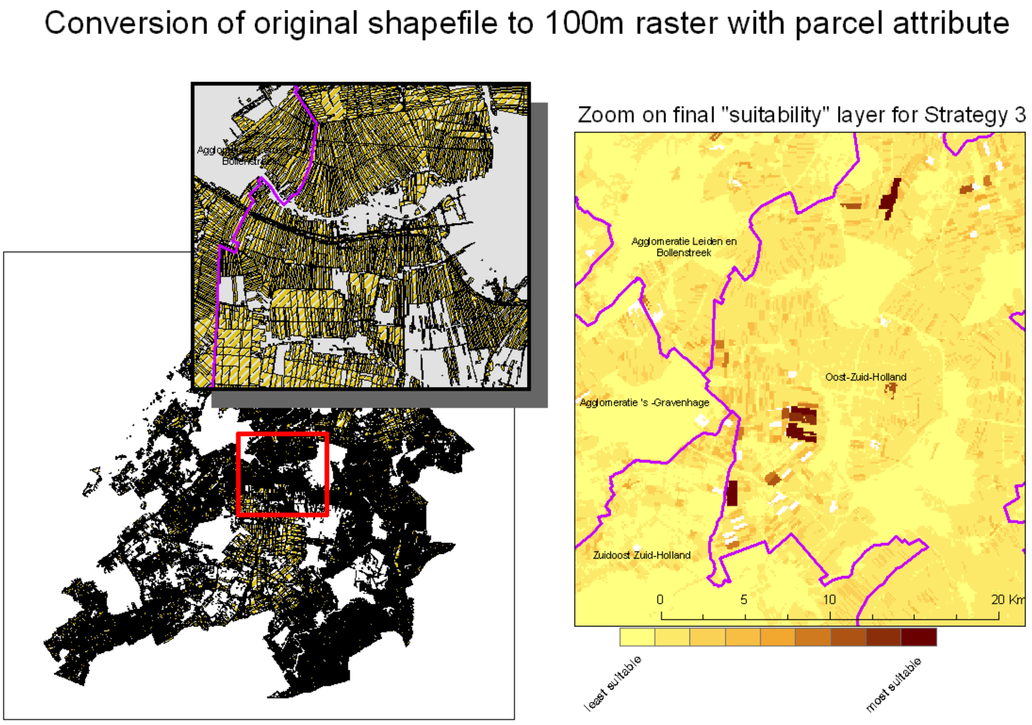


Figure 15. The map used to configure Strategy 3 represents parcels eligible for and receiving subsidies for the Green and Blue Services initiative for the BAU scenario.

3.4.3 Configuration, strategy 4

For “Strategy 4”, largely the same parcels were selected as for strategy three in order to make the strategies comparable. In this case, rather than the subsidies, the measure of success is in the percent of participating farmers. As shown in table 10, the percent of parcels adhering to the agrarian land banking system.

Table 10. The stakeholder definition of the Land banking strategy (Strategy 4) in terms of parcels adhering to the initiative and percent farmers adhering to the initiative.

Land Banking			
	BAU	B1	B2
% of total area	10	20	0
Number of parcels (of total 3574)	358	715	0
% farmers	50	80	0
Chance of staying above normal	1.5	2	0

Different maps were again generated to differentiate the situation between BAU and B1 scenarios (for the B2 scenario, no Agrarian Banking initiative was planned). Figure 16 shows the map generated for the BAU scenario.

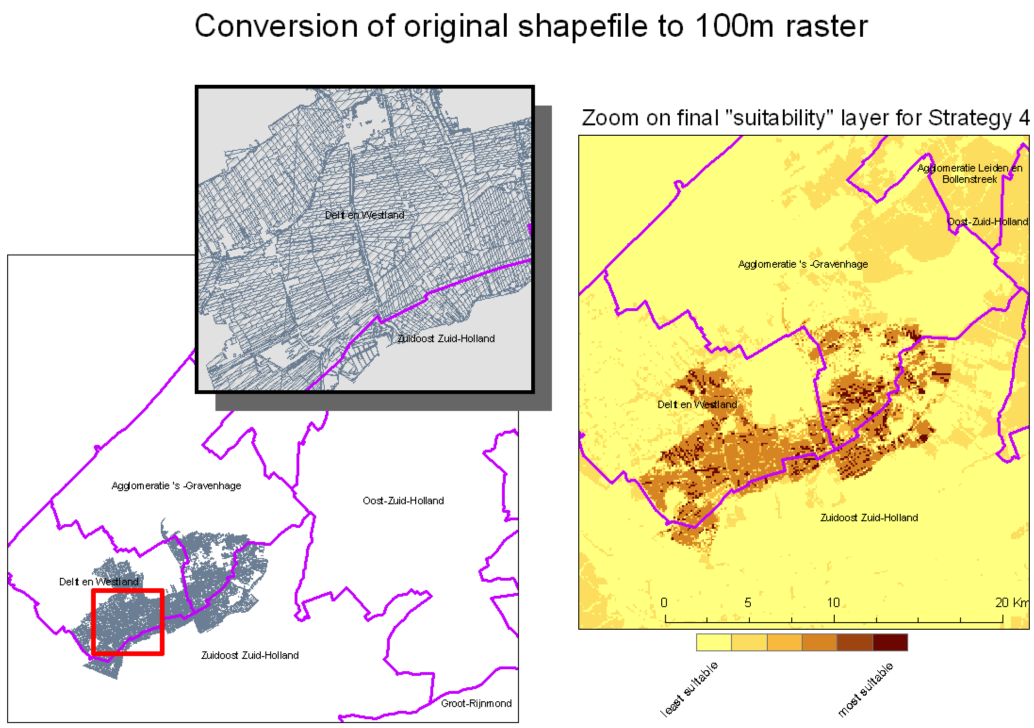


Figure 16. The map used to configure Strategy 4 represents parcels adhering to the Agrarian Banking System for the BAU scenario.

4. Results

Several indicators, which had been agreed upon by stakeholders for the different case studies, were calculated for The Hague test case. Some were not possible to calculate. For example, it was not possible to assess population numbers or population densities in the absence of statistics associated to densities for the residential land use categories urban, built-up rural, built-up woodland and built-up agricultural land (farmsteads). The following is a list of the indicators that could be calculated for The Hague, and a description of the interpretation for The Hague:

1. Total amount of new urban land. This includes the workplaces, the port, the airports and the urban land but not the "vacant" land because this class is also used to describe land vacated by the diminishing horticulture industry in the B2 scenario.
2. Amount of urban land by RUR typology (figure 30). See above for land use classes included in the calculations.
3. Amount of new urban land per new inhabitant. The density of residential classes is a parameter used to manipulate scenarios and is therefore not an indicator, but rather a driver.
4. Lost valuable nature. Based on discussions with stakeholders, "valuable natural lands" include forest, natural coastal areas and other natural and semi-natural waterfront areas; and water itself. The areas associated with water and its flora are protected in these scenarios and therefore do not change; the forest land use class is susceptible to change.
5. Lost farmland. "Farmlands" include pasture, arable and bulbs.

In this report, a small description of the outcomes of each of the scenarios is made and the maps are shown. The raw data, shown in Annex C, includes the statistical breakdown of land use classes for the RUR typology.

4.1 Business as Usual

Figure 17 shows the resulting land use map for the business as usual scenario, run until 2040.

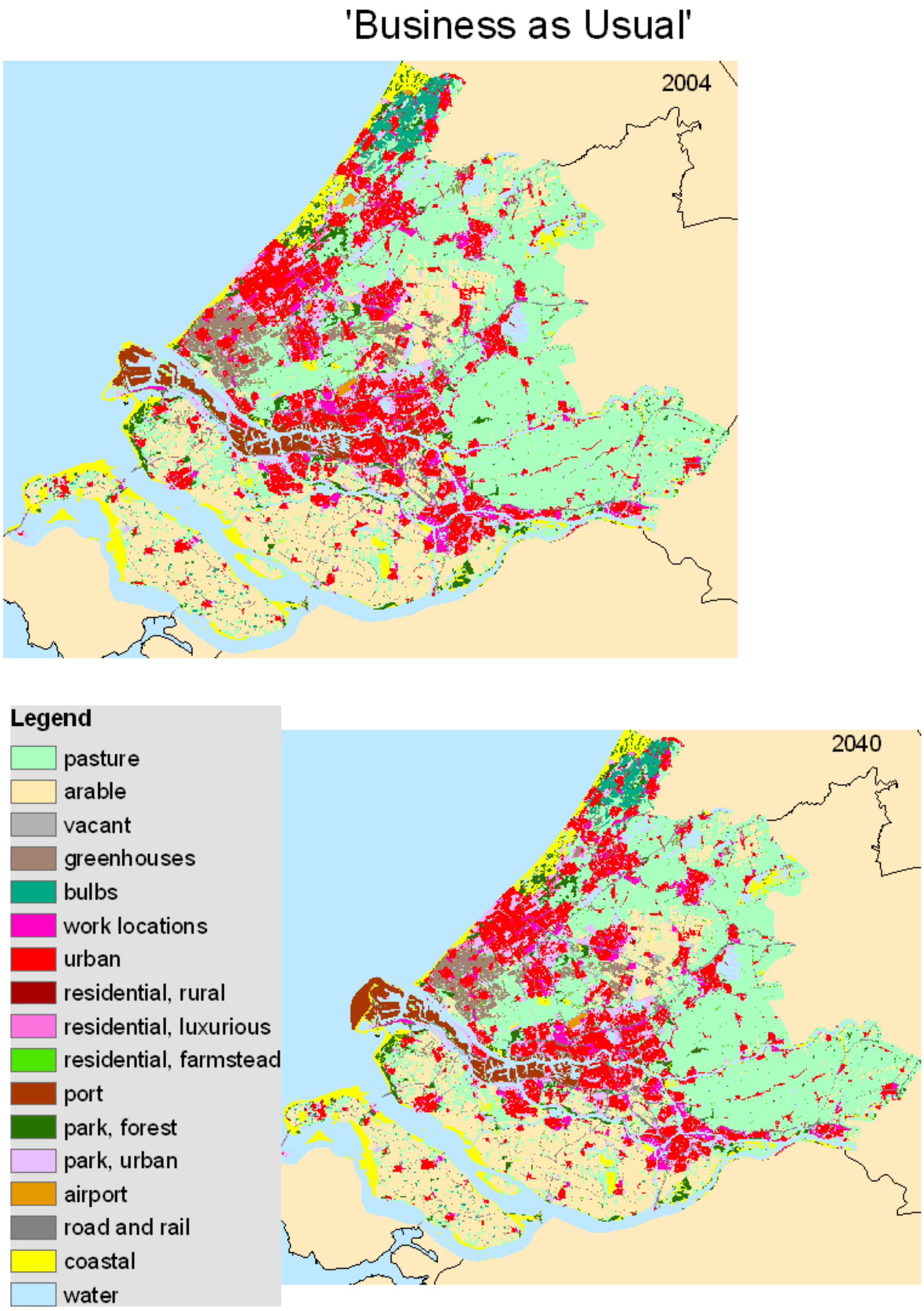


Figure 17. The original map from 2004 and the resulting land use map for the business as usual scenario for 2040.

Table 11 summarises the changes in land use for the province from 2004 to 2040 according to the BAU scenario:

Table 11. The changes in land use classes from 2004-2040 for the BAU scenario.

	2004	2040	Change %
pasture	104167	102759	-1.35
arable	60048	59754	-0.49
vacantUrban	874	2	-99.77
greenhouses	8950	9102	1.70
bulbs	4028	4098	1.74
workLocations	7432	7776	4.63
urban	45309	46764	3.21
ResidRural	600	621	3.50
ResidLuxury	1555	1603	3.09
Residfarmsteads	2105	2105	0.00
port	5834	6400	9.70
parkForest	7513	7513	0.00
parkUrban	17237	17236	-0.01
airport	270	270	0.00
roadsRail	10078	10078	0.00
ReedsSandMarsh	14688	14613	-0.51
Water	50087	50081	-0.01

Table 12 summarises the growth in cells with residential uses for the scenario and table 13 shows the non-residential urban land expansion.

Table 12. The expansion of residential areas for the BAU scenario between 2004 to 2040.

residential	lu2004 /ha	lu2040 /ha
90% of urban	40778.1	40897.8
ruralResidences	600	602
woodlandResid	1555	1570
50% farmsteads	1052.5	1052
TOTAL	**43985.6**	**44121.8**
Change in amount of new residential urban land	136.2 ha	0.31%

Table 13. The expansion of non-residential areas for the BAU scenario between 2004 to 2040.

non-residential urban land	lu2004 /ha	lu2040 /ha
workLocations	7432	7662
10% of urban	4530.9	4544.2
port	5834	6400
TOTAL	**17796.9**	**18606.2**
Change in amount of new non-residential urban land	809.3 ha	4.55%

The loss of farmland between 2004 and 2040 is -0.39% for the BAU scenario (table 14).

Table 14. The farmland land use changes for the BAU scenario for 2040.

Farmland	lu2004	lu2040
arable	60048	59946
pasture	104167	103605
bulbs	4028	4028
TOTAL	**168243**	**167579**
Change in amount of farmland	-664 ha	-0.39%

An in depth analysis was done on all baseline scenarios adopting the method presented by Pontius *et al* (2004[4]) whereby the net gain, loss and exchange of land types, which are regrouped into simplified thematic areas, are analyzed based on the frequency of exchange amongst themselves. The contingency table analysis shows that there is a no land "swapping" in this scenario, therefore all changes seen are net changes. Furthermore, when there is a gain of built-up land, it comes at the expense of vacant land (0.21% higher probability than in a random model). No other conclusions can be drawn from this scenario outcome when compared to the random model outcome. Table 15 summarises the gain, loss, swapping and net change in each land use meta-class:

Table 15. The results of the categorical land use change analysis for the BAU scenario, corrected for the probability factor in a random model

	gain	loss	total change	SWAP	abs value 'net change'
built-up	0.78	0.00	0.78	0.00	0.78
natural	0.00	0.00	0.00	0.00	0.00
farmed	0.00	0.51	0.51	0.00	0.51
vacant	0.00	0.27	0.27	0.00	0.27
total	0.78	0.78	1.56	0.00	1.56

[4] Pontius Jr., Shusas, E., McEachern, M (2004). Detecting important categorical land changes while accounting for persistence. Agriculture, Ecosystems and Environment 101: 251-268.

4.2 Peak Oil (B1)

The results for the B1 scenario are shown in figure 18.

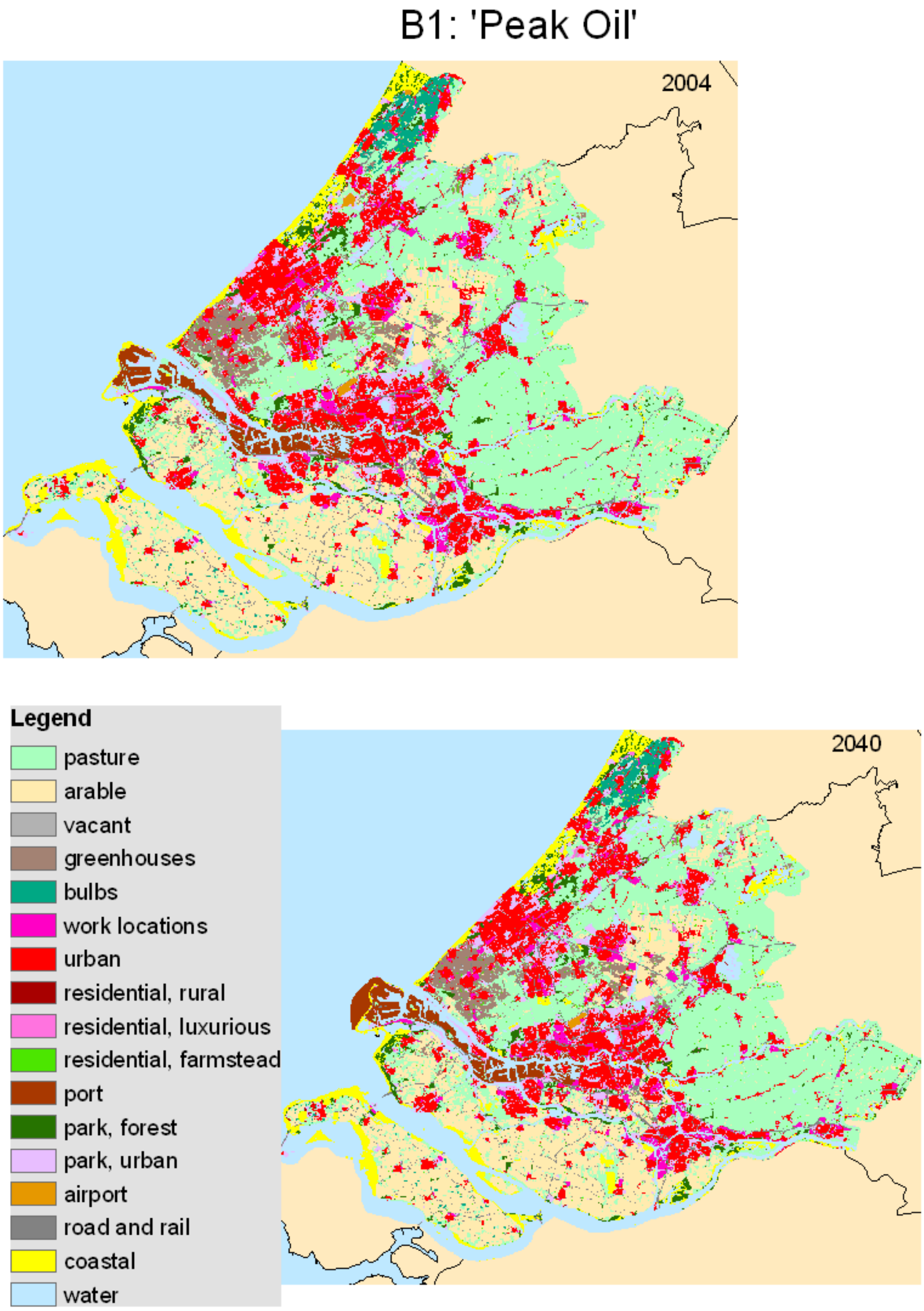


Figure 18. The resulting land use map for the peak oil (B1) scenario for 2040.

The changes from one land use class to another between 2004 and 2040 according to the B1 scenario are summarised in table 16.

Table 16. The changes in land use classes for the B1 scenario, from 2004 to 2040.

	2004	2040	Change %
pasture	104167	103596	-0.55
arable	60048	58577	-2.45
vacantUrban	874	82	-90.62
greenhouses	8950	9102	1.70
bulbs	4028	4098	1.74
workLocations	7432	8019	7.90
urban	45309	46751	3.18
ResidRural	600	626	4.33
ResidLuxury	1555	1628	4.69
Residfarmsteads	2105	2105	0.00
port	5834	6400	9.70
parkForest	7513	7513	0.00
parkUrban	17237	17236	-0.01
airport	270	270	0.00
roadsRail	10078	10078	0.00
ReedsSandMarsh	14688	14613	-0.51
Water	50087	50081	-0.01

Tables 17 and 18 summarise the main changes in residential and non-residential urban classes between 2004 and 2040.

Table 17. The changes in residential urban surfaces for the B1 scenario

residential urban land	**lu2004**	**lu2040**
90% of urban	40778.1	42075.9
ruralResidences	600	626
woodlandResid	1555	1628
50% farmsteads	1052.5	1052.5
TOTAL	**43985.6**	**45382.4**
Change in amount of new residential urban land	1396.8 ha	3.18%

Table 18. The changes in non-residential urban surfaces for the B1 scenario

non-residential urban land	**lu2004**	**lu2040**
workLocations	7432	8019
10% of urban	4530.9	4675.1
port	5834	6400
TOTAL	**17796.9**	**19094.1**
Change in amount of new non-residential urban land	1297.2 ha	7.29%

The loss of farmland is quantified as being -1.17% for this scenario (table 19):

Table 19. The changes in farmland for the B1 scenario

Farmland	**lu2004**	**lu2040**
arable	60048	58577
pasture	104167	103596
bulbs	4028	4098
TOTAL	**168243**	**166271**
Change in amount of farmland	-1972 ha	-1.17%

The net gain, loss and exchange of land types, which are regrouped into simplified thematic areas, are analyzed based on the frequency of exchange amongst themselves (Pontius *et al* 2004). The contingency table analysis shows that there is a no land "swapping" in this scenario, therefore all changes seen are net changes. Furthermore, when there is a gain of built-up land, it comes at the expense of vacant land (0.01% higher probability than in a random model). No other conclusions can be drawn from this scenario outcome when compared to the random model outcome. Table 20 summarises the gain, loss, swapping and net change in each land use meta-class:

Table 20. The results of the categorical land use change analysis for the B1 scenario, corrected for the probability factor in a random model

	gain	**loss**	**total change**	**SWAP**	**abs value 'net change'**
built-up	1.05	0.00	1.05	0.00	1.05
natural	0.00	0.00	0.00	0.00	0.00
farmed	0.00	0.68	0.68	0.00	0.68
vacant	0.00	0.37	0.37	0.00	0.37
total	1.05	1.05	2.10	0.00	2.10

4.3 Fragmentation (B2)

The fragmentation scenario was the most difficult to configure in that the economic drivers were difficult to identify. It appears that in this scenario, the main economic drivers of the region are on the decline. Yet some activity is still expected in the Delft region from the R&D sector. The scenario is characterized by degraded city centers and the appearance of "gated communities", a term which we took the liberty to interpret as meaning an increase in the rural and woodland residential classes. It was technically not possible to assign a different economic sector to greenhouses, as the scenario description implies, so this class results as vacated on the maps although in the scenario definition, the greenhouses are converted to other uses. Urban area was allowed to take over the greenhouses to a certain extent. Figure 19 shows the resulting land use map for this scenario:

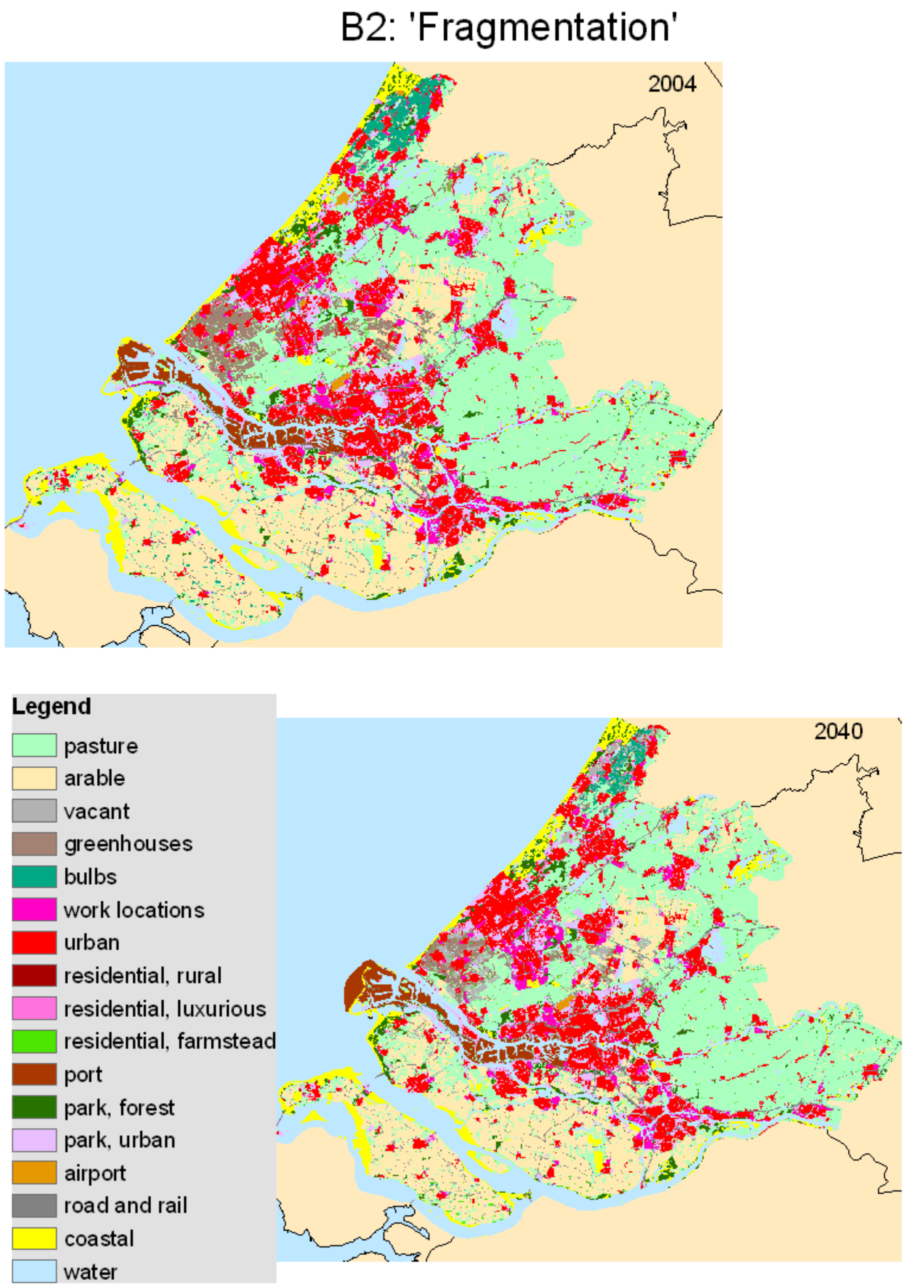


Figure 19. The resulting land use map for the fragmentation (B2) scenario for 2040.

Table 21 summarises the changes in land use for the province from 2004 to 2040 according to the B2 scenario. The increase in vacant areas is massive.

Table 21. The changes in land use classes from 2004-2040 for the B2 scenario.

	2004	2040	Change %
pasture	104167	103368	-0.77
arable	60048	58586	-2.43
vacantUrban	874	7351	741.08
greenhouses	8950	4478	-49.97
bulbs	4028	2011	-50.07
workLocations	7432	7575	1.92
urban	45309	46628	2.91
ResidRural	600	608	1.33
ResidLuxury	1555	1598	2.77
Residfarmsteads	2105	2381	13.11
port	5834	6400	9.70
parkForest	7513	7513	0.00
parkUrban	17237	17236	-0.01
airport	270	270	0.00
roadsRail	10078	10078	0.00
ReedsSandMarsh	14688	14613	-0.51
Water	50087	50081	-0.01

For the B2 scenario, the amount of new residential and non-residential urban land is summarised in tables 22 and 23:

Table 22. The expansion of residential urban surfaces for the B2 scenario between 2004 to 2040.

residential urban land	lu2004	lu2040
90% of urban	40778.1	41965.2
ruralResidences	600	608
woodlandResid	1555	1598
50% farmsteads	1052.5	1190.5
TOTAL	**43985.6**	**45361.7**
Change in amount of new residential urban land	1376.1 ha	3.13%

Table 23. The expansion of non-residential urban surfaces for the B2 scenario between 2004 to 2040.

non-residential urban land	lu2004	lu2040
workLocations	7432	7575
10% of urban	4530.9	4662.8
port	5834	6400
TOTAL	**17796.9**	**18638**
Change in amount of new non-residential urban land	840.9 ha	4.72%

The loss of farmland between 2004 and 2040 is -2.54% for the B2 scenario. (table 24):

Table 24. Change in nature and farmland classes.

Farmland	lu2004	lu2040
arable	60048	58586
pasture	104167	103368
bulbs	4028	2011
TOTAL	**168243**	**163965**
Change in amount of farmland	-4278	-2.54

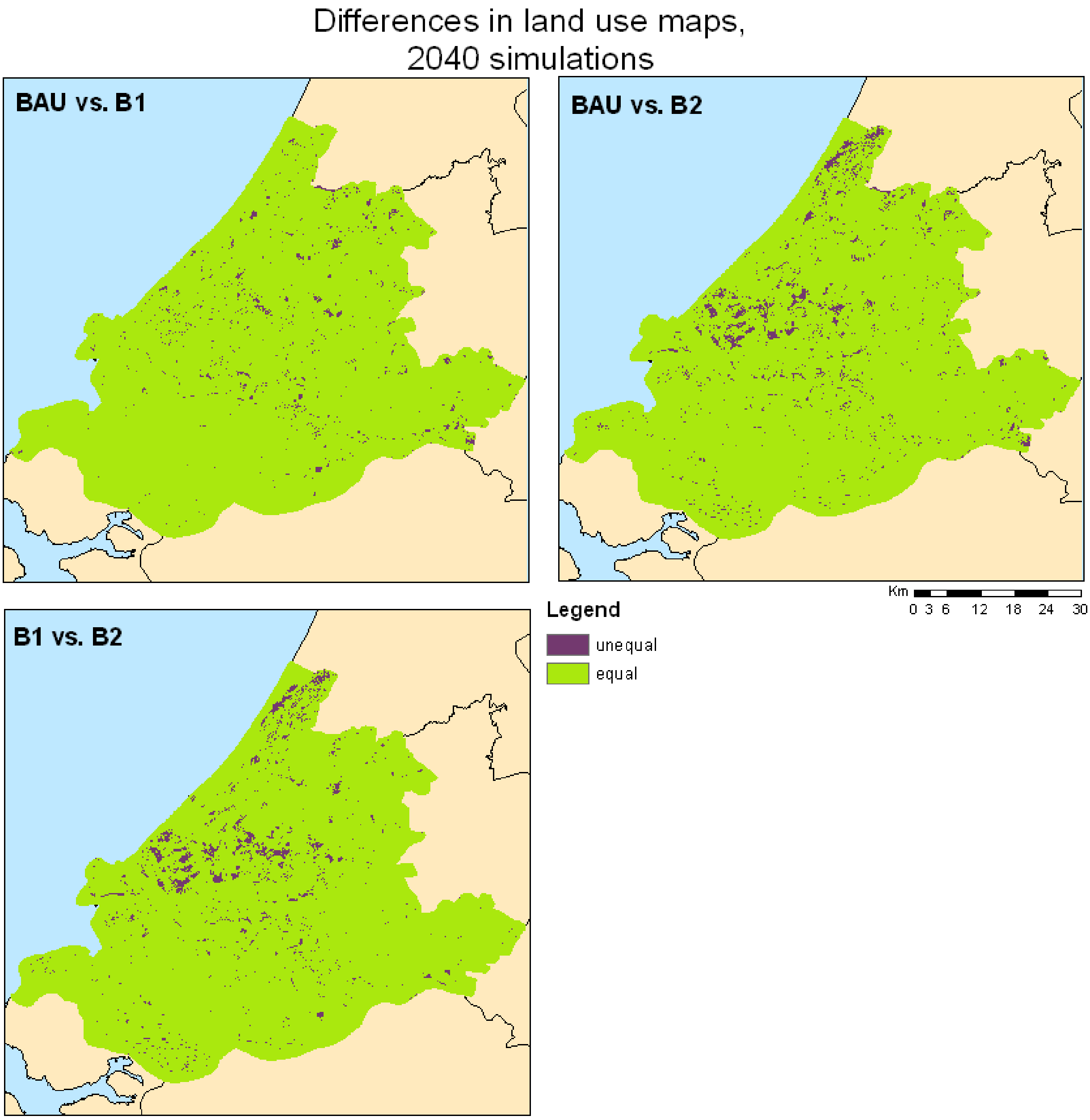
The advanced contingency table analysis shows that there is a bit of land "swapping" in this scenario within the built-up and vacant land meta-classes. The matrix also shows that when there is a gain of built-up land, it comes at the expense of vacant land (0.01% higher probability than in a random model); and vacant land will take over built up (0.27% more frequently than a random model) and farmed land (0.68% more frequently than a random model). Table 25 summarises the gain, loss, swapping and net change in each land use meta-class:

Table 25. The results of the categorical land use change analysis for the B2 scenario, corrected for the probability factor in a random model

	gain	loss	total change	SWAP	abs value 'net change'
built-up	1.33	0.28	1.61	0.55	1.06
natural	0.00	0.00	0.00	0.00	0.00
farmed	0.00	1.75	1.75	0.00	1.75
vacant	0.97	0.28	1.25	0.55	0.70
total	2.30	2.30	4.61	1.10	3.51

4.4 Scenario comparisons

When the scenario results are compared to one another in terms of the criteria set by the indicators, the differences in the outcomes are evident (figure 20).



	pasture	arable	vacant	greenhouses	bulbs	workLocations	urban	ResidRural	Luxury homes	farmsteads	port	overallKappa
b1 vs b2	0.98	0.99	0.05	0.64	0.66	0.69	0.98	0.99	0.52	0.87	0.95	0.95
bau vs b2	0.97	0.97	0.14	0.65	0.66	0.72	0.98	1.00	0.58	0.88	0.97	0.95
bau vs b1	0.98	0.97	0.02	0.89	0.97	0.86	0.98	0.98	0.61	0.97	0.97	0.97

Figure 20. The difference maps showing the areas that are equal and those that are unequal between the three baseline scenarios and associated kappa coefficients for each couple.

The following four figures show zooms or the areas most affected by changes (as indicated by figure 20). In the BAU scenario the area which was labeled as being an airport in 2004 is converted to greenhouses and some luxury house. In the B1 scenario, this same area is converted to urban and luxury residences, although some is still left vacant. In the B2 scenario, most of this land remains vacant, although a bit of urban land appears (figure 21).

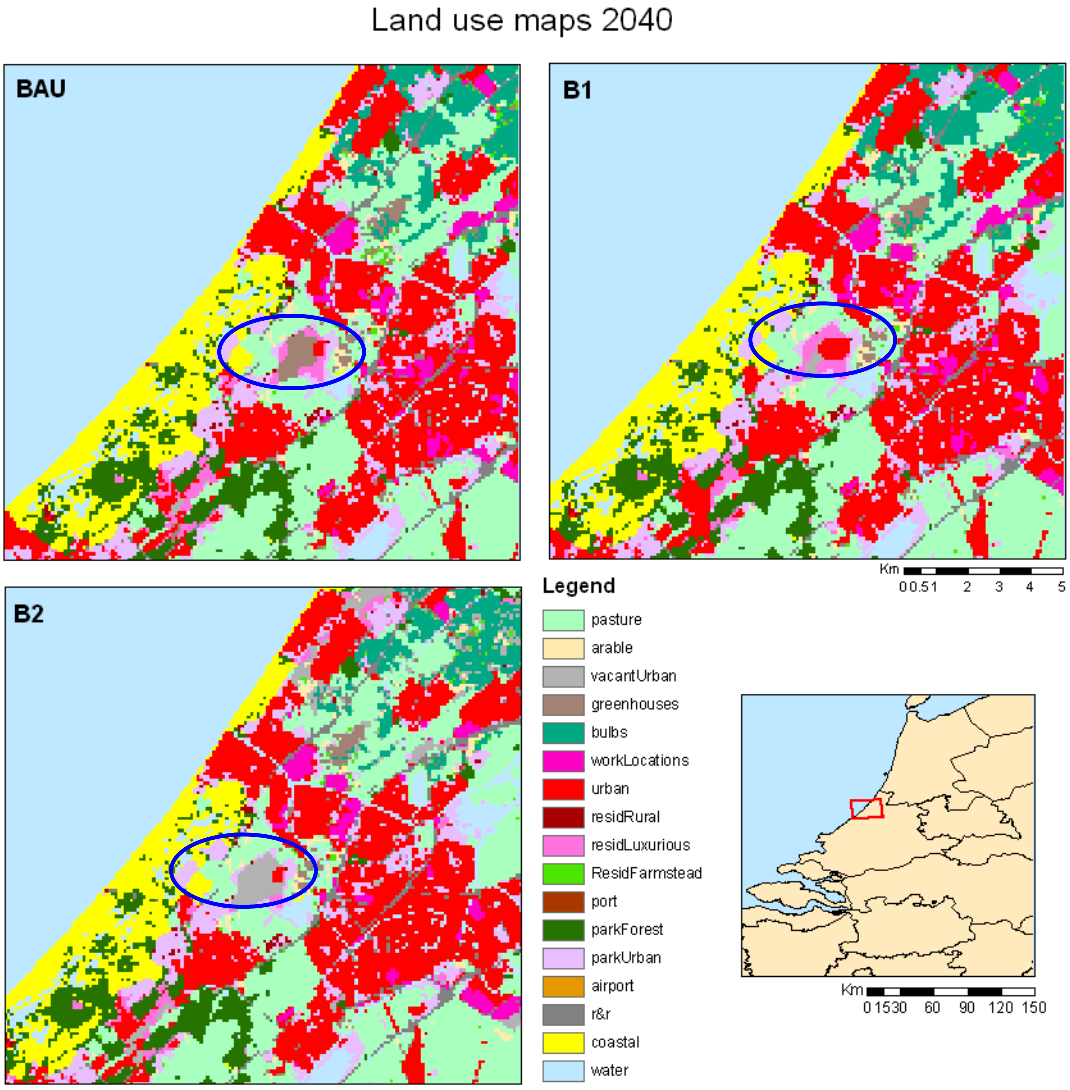


Figure 21. A zoom on the abandoned airport in the NW part of the province.

Figure 22 shows The Hague region zoom whereby the main differences are in the greenhouse densification in the B1 scenario and it's vacating in the B2 scenario; and differences in industrial area placements in all three scenarios

Land use maps 2040

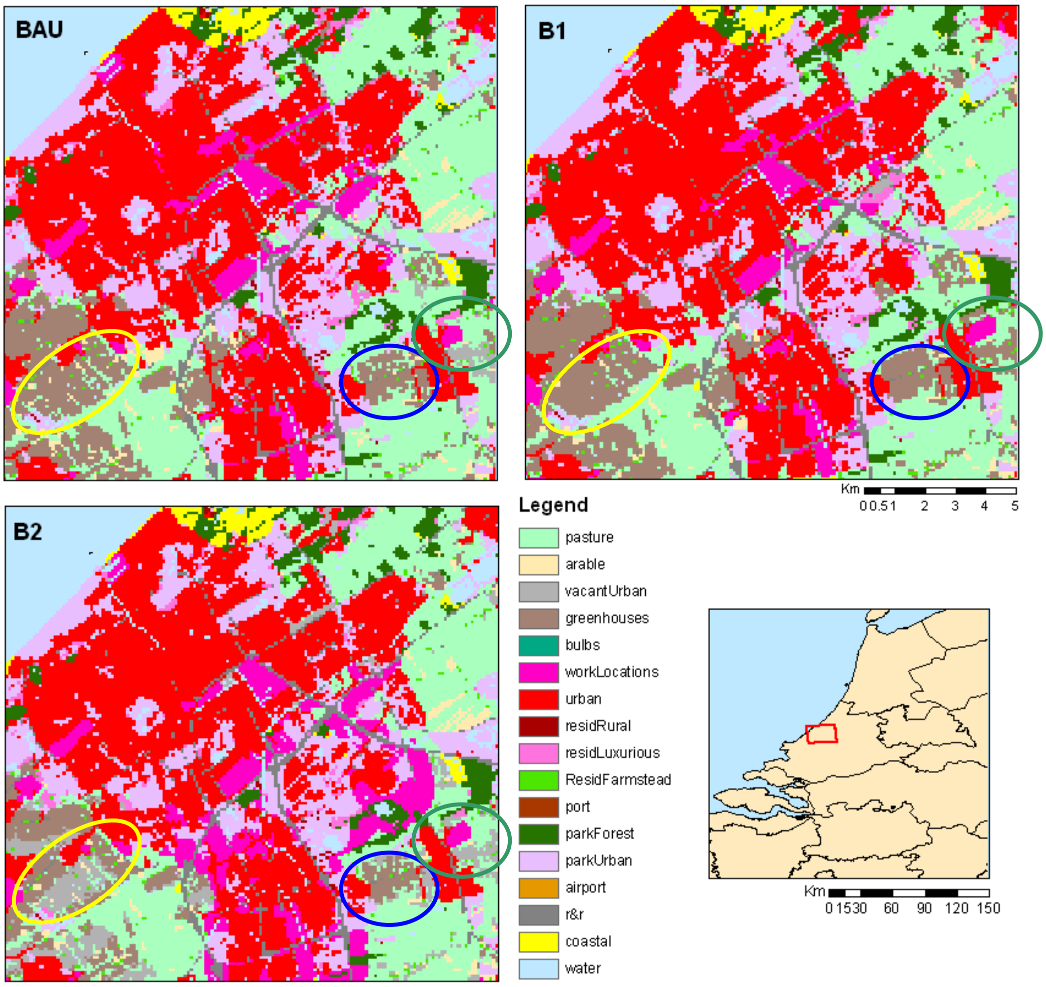


Figure 22. A zoom on The Hague region, differences in model outcome.

For the Rotterdam port area near the city center, there are differences in the way in which the progressively vacating port land is converted. In the BAU scenario, much of it is left vacant due to the decreasing population and thus the decreasing demand . A few greenhouse cells do pop up on the former port area for this scenario. For the B1 scenario, the area is converted to urban and industrial sites. The B2 scenario also shows this effect, but to a lesser degree (figure 23).

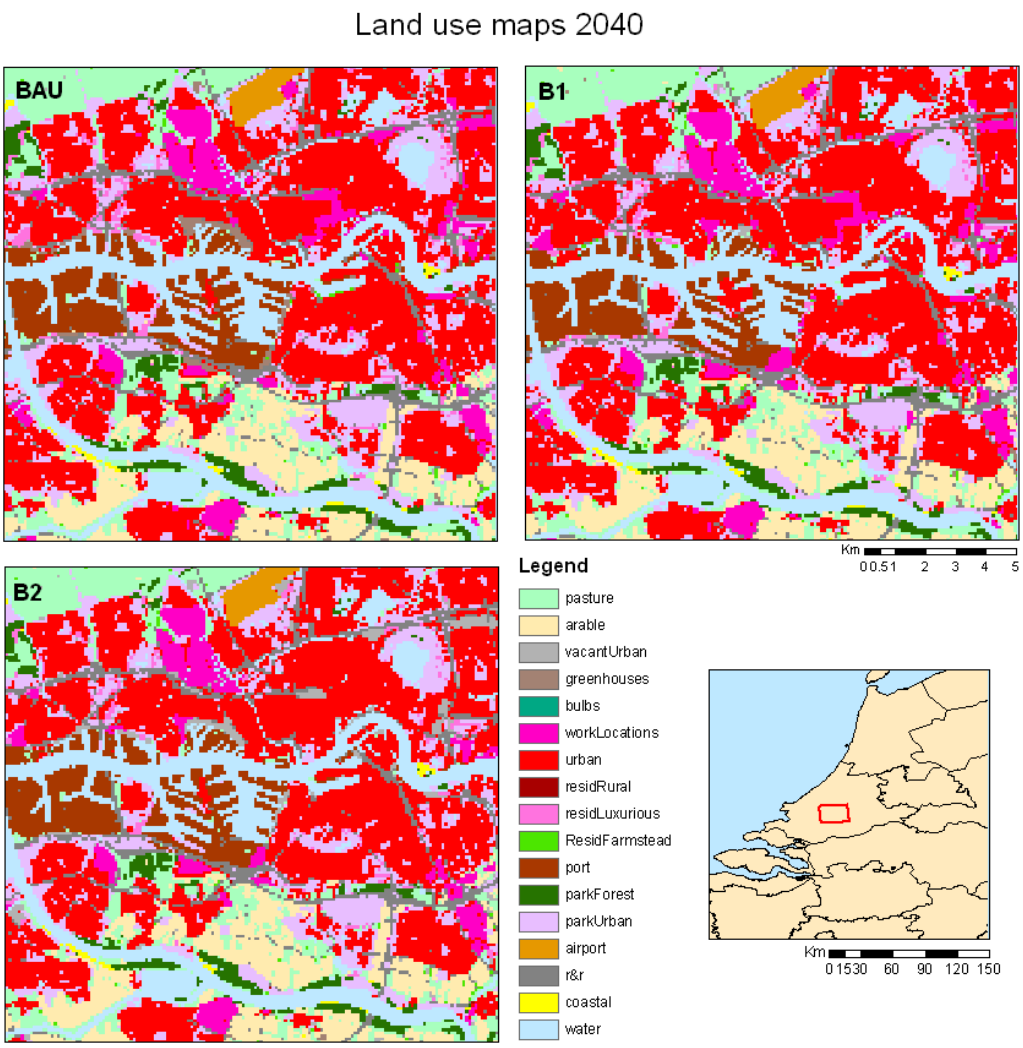


Figure 23. A zoom on the Rotterdam port region, differences in model outcome

As shown in figure 24, some changes occurring here and there are often difficult to see with the human eye, but appear in the statistics.

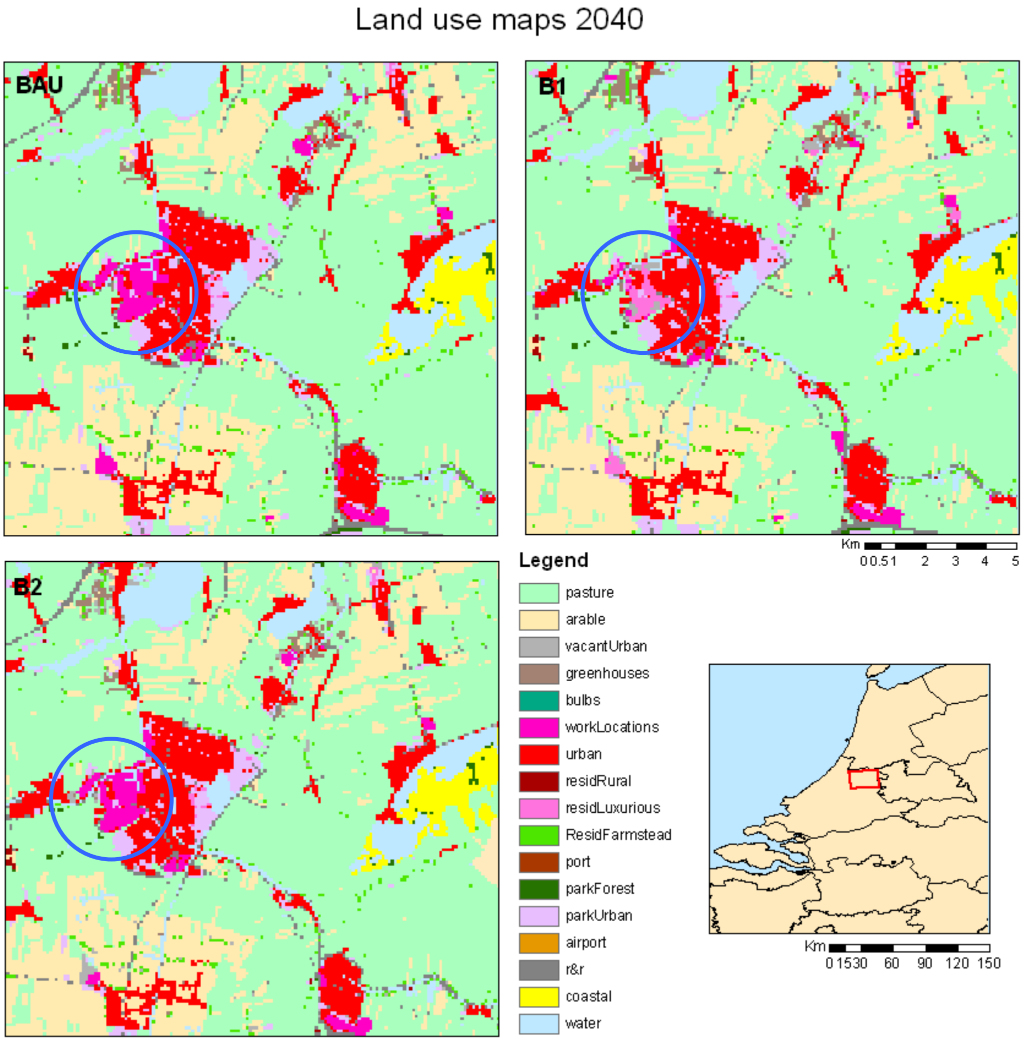


Figure 24. A zoom on the NNE part of the province, differences in model outcome

All scenarios used the same zoning restriction maps and the same suitability maps. The main differences are in the demand for land in the different scenarios and the decline in the port area in the B2 scenario. Workplaces and rural residential housing crop up in the Delft-Rijwijk-Nootdorp triangle and farmsteads appear in the B2 scenario. In terms of total land change, the B2 scenario shows drastic increase in vacant land. This can be rectified by using a more generous zoning map which allows the reallocation of land uses associated with declining economic sectors, namely the port and greenhouses. It is the zoning maps and lack of demand which prevents these areas from being reassigned. Table 26 shows the overall changes in land use for the three scenarios:

Table 26. The overall changes in land use classes for each of the scenarios.

Percent change in land use classes from 2004 to 2040

	BAU	B1	B2
pasture	-1.35	-0.55	-0.77
arable	-0.49	-2.45	-2.43
vacant	-99.77	-90.62	741.08
greenhouses	1.70	1.70	-49.97
bulbs	1.74	1.74	-50.07
workLocations	4.63	7.90	1.92
urban	3.21	3.18	2.91
ResidRural	3.50	4.33	1.33
ResidLuxury	3.09	4.69	2.77
Residfarmsteads	0.00	0.00	13.11
port	9.70	9.70	9.70
parkForest	0.00	0.00	0.00
parkUrban	-0.01	-0.01	-0.01
airport	0.00	0.00	0.00
roadsRail	0.00	0.00	0.00
ReedsSandMarsh	-0.51	-0.51	-0.51
Water	-0.01	-0.01	-0.01

Figures 25-29 show the differences between scenario outcomes for the most relevant land use classes. A more in-depth spatial analysis could be done with the ascii files of the scenario outcomes.

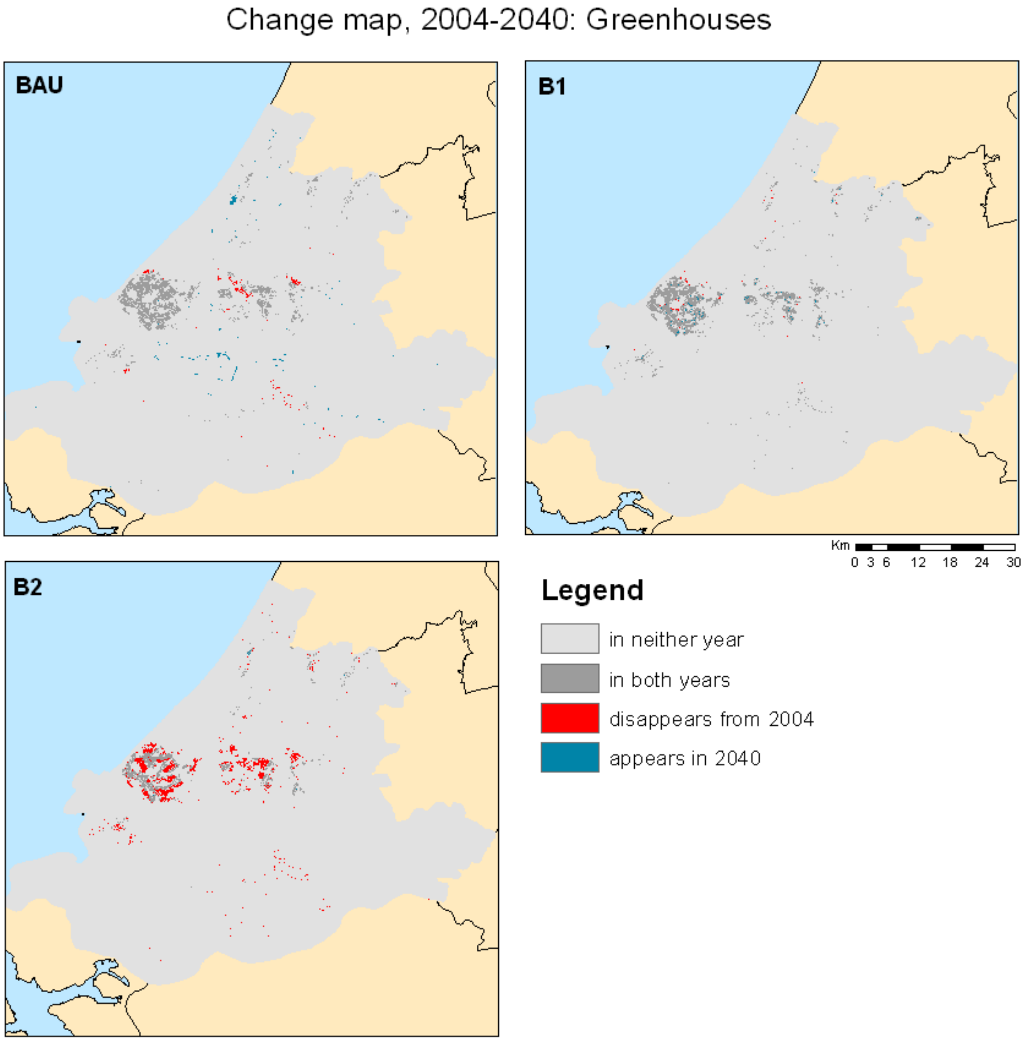


Figure 25. Differences in the greenhouses class for the three baseline scenarios.

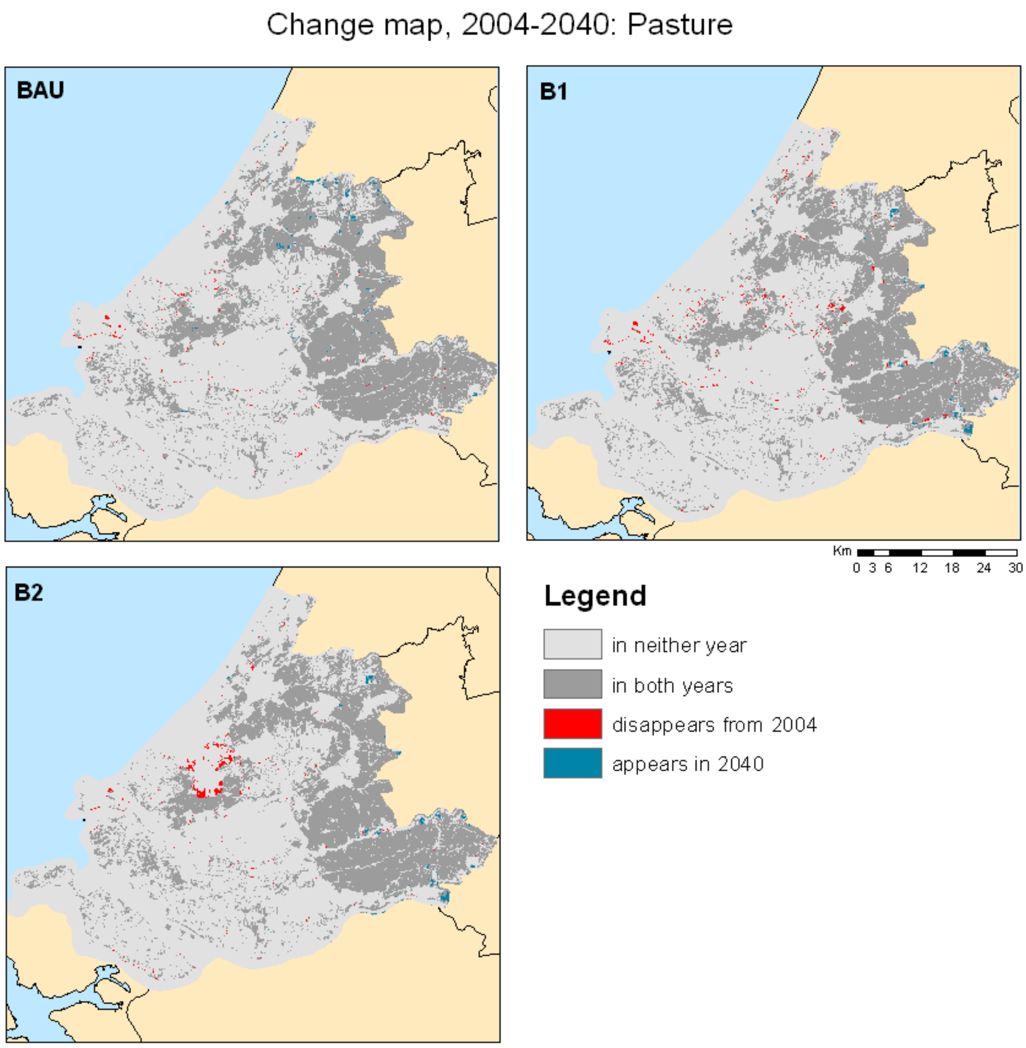


Figure 26. Differences in the pasture class for the three baseline scenarios.

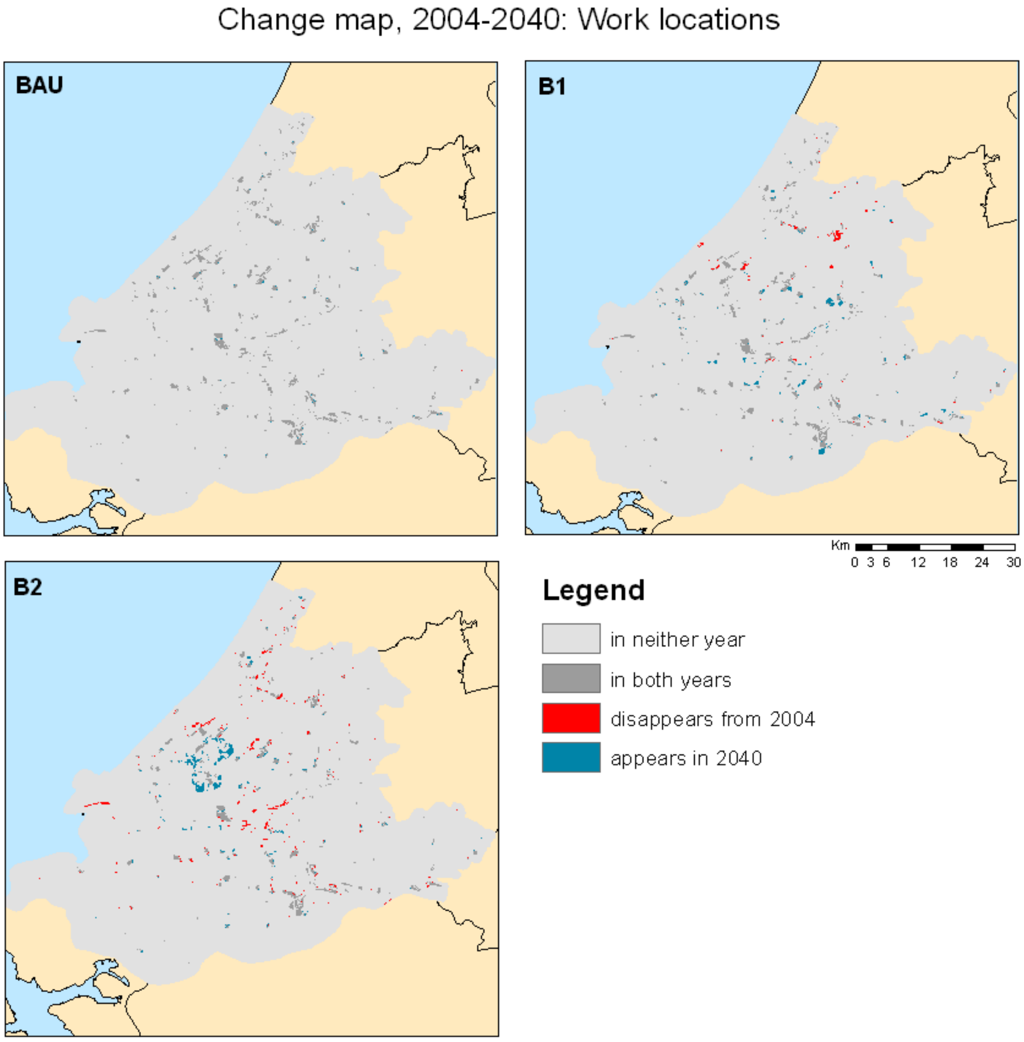


Figure 27. Differences in the work locations class for the three baseline scenarios.

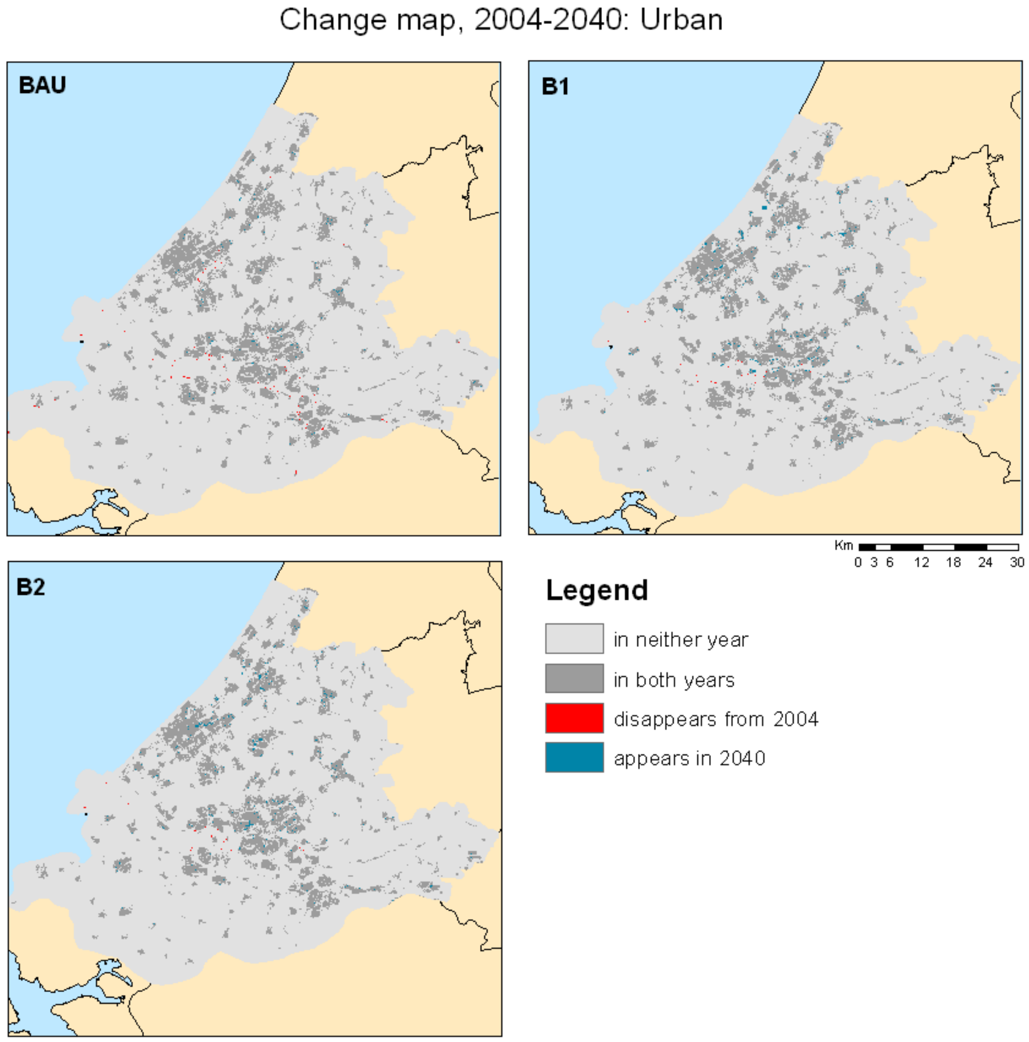


Figure 28. Differences in the urban class for the three baseline scenarios.

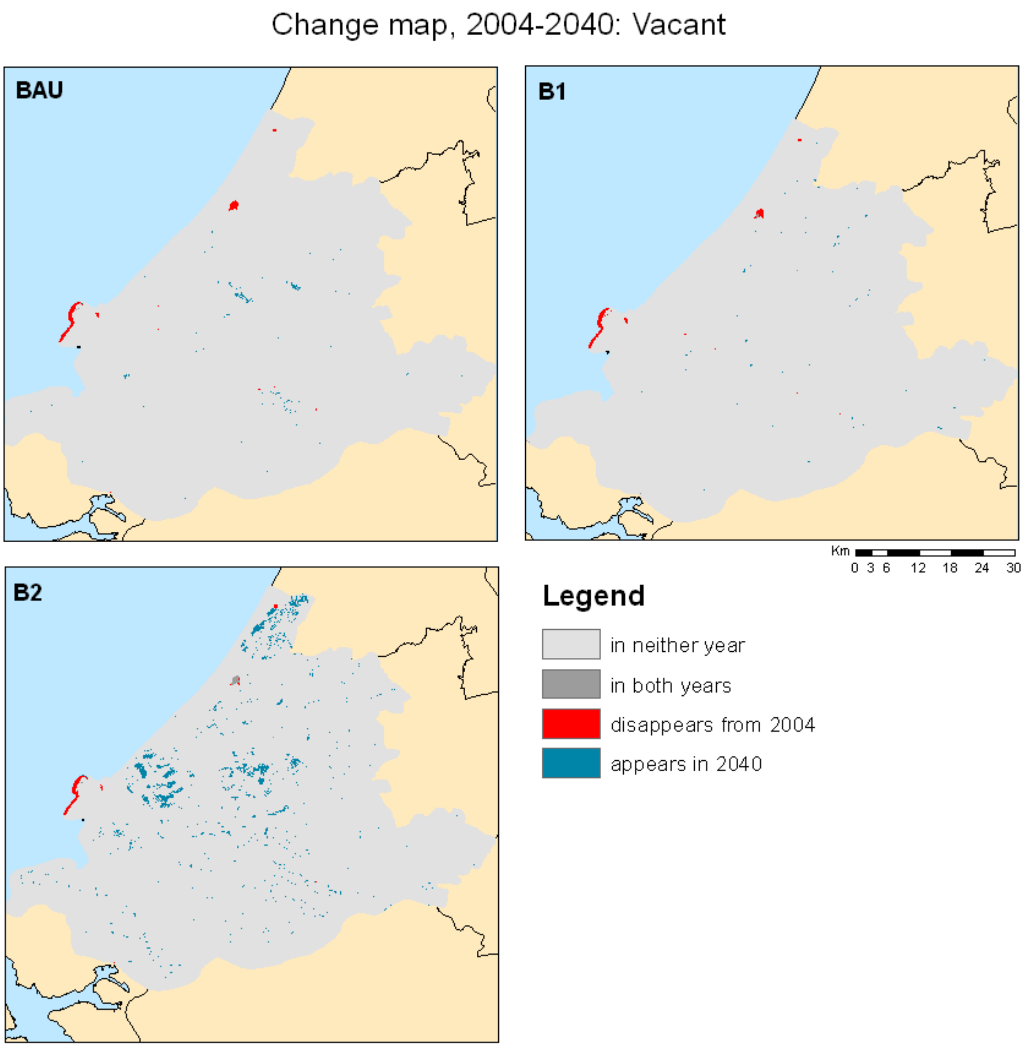


Figure 29. Differences in the vacant land class for the three baseline scenarios.

4.5 Change statistics for RUR divisions

Table 27 summarises differences in the land use changes in for the RUR divisions. These divisions are shown in figure 30:

Table 27. The percent change of grouped land use classes according to theme for the RUR divisions.

DIFFERENCES % change from 2004 to 2040 per scenario:			
2040 BAU	natural	farmland	built-up
protected	0.00	-9.05	3.98
urban	0.00	-5.17	0.10
peri-urban	0.00	-0.22	-0.06
rural	-0.75	-0.55	3.82
2040 B1	natural	farmland	built-up
protected	0.00	-9.51	3.78
urban	0.00	-10.69	0.10
peri-urban	0.00	-1.27	4.17
rural	-0.75	-0.99	5.82
2040 B2	natural	farmland	built-up
protected	0.00	-1.60	1.13
urban	0.00	34.00	-1.24
peri-urban	0.00	2.36	-6.62
rural	-0.75	-1.09	6.41

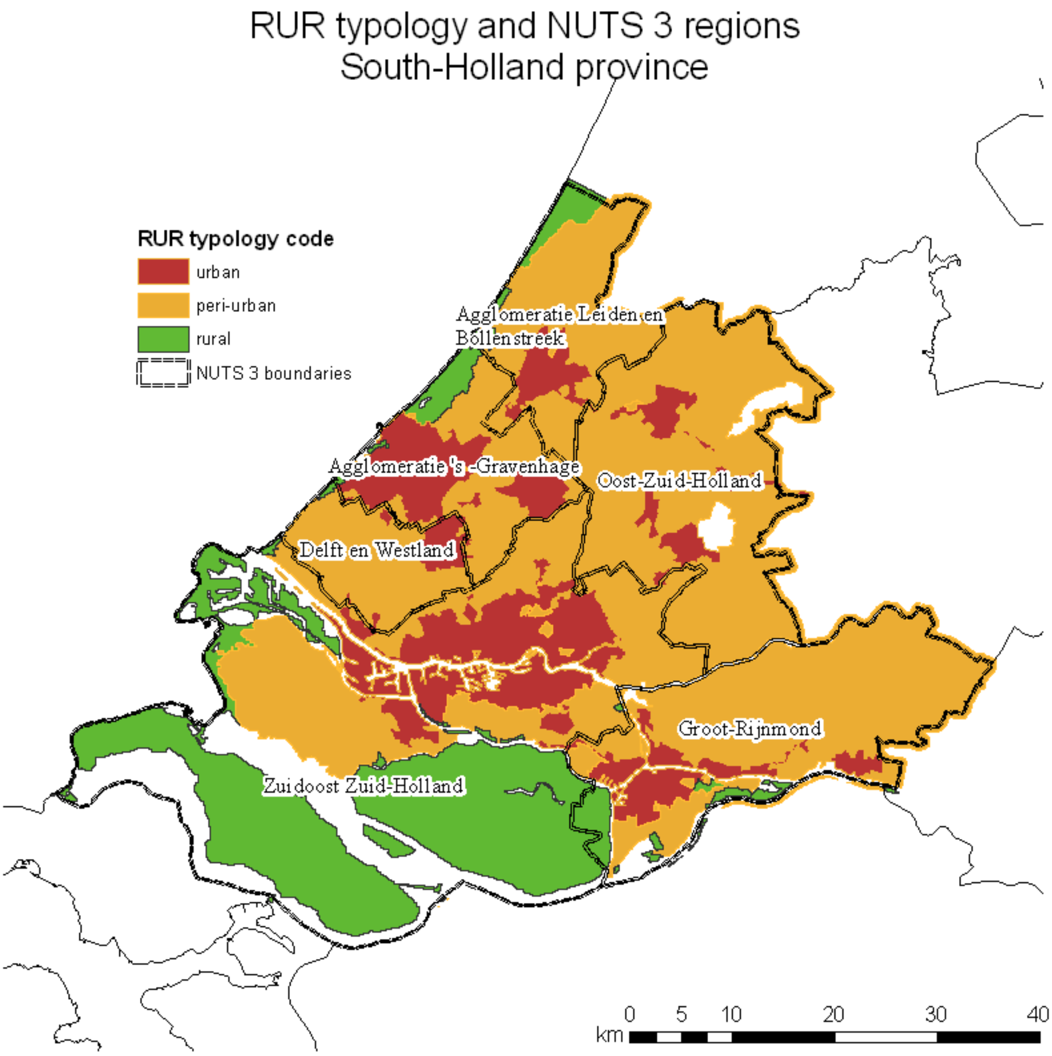


Figure 30. The RUR typology and NUTS 3 regions of the South-Holland province

4.6 Strategies (policy alternatives)

Although it is beyond the scope of this report to discuss the three strategies which were applied to each of the baseline scenarios, some statistics were extracted from the maps in order to provide a "quick view" of the effects of Strategies 1,3 and 4 on the three baseline scenarios. Figures 31-33 show the impacts of the strategies.

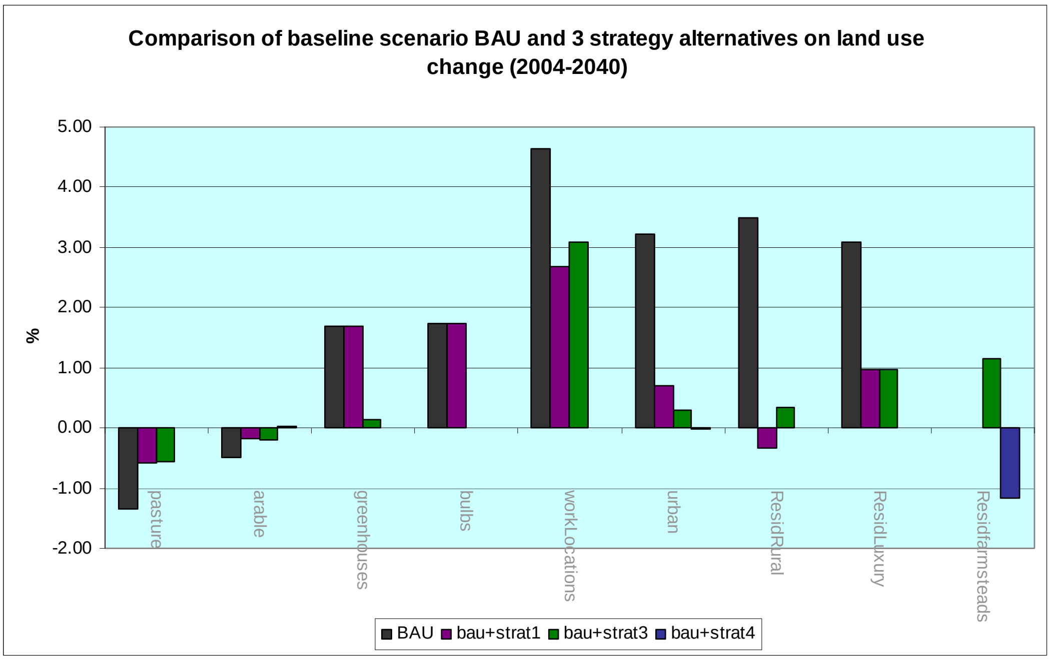


Figure 31. The differences for the BAU baseline scenario and the 3 strategies on land use for 2040.

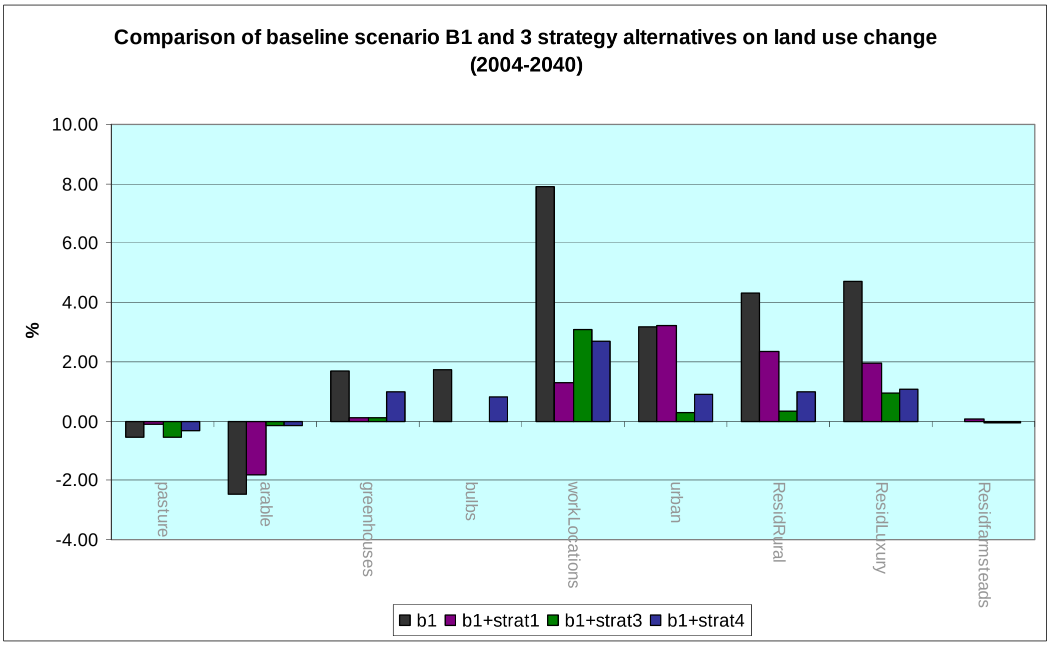


Figure 32. The differences for the B1 baseline scenario and the 3 strategies on land use for 2040.

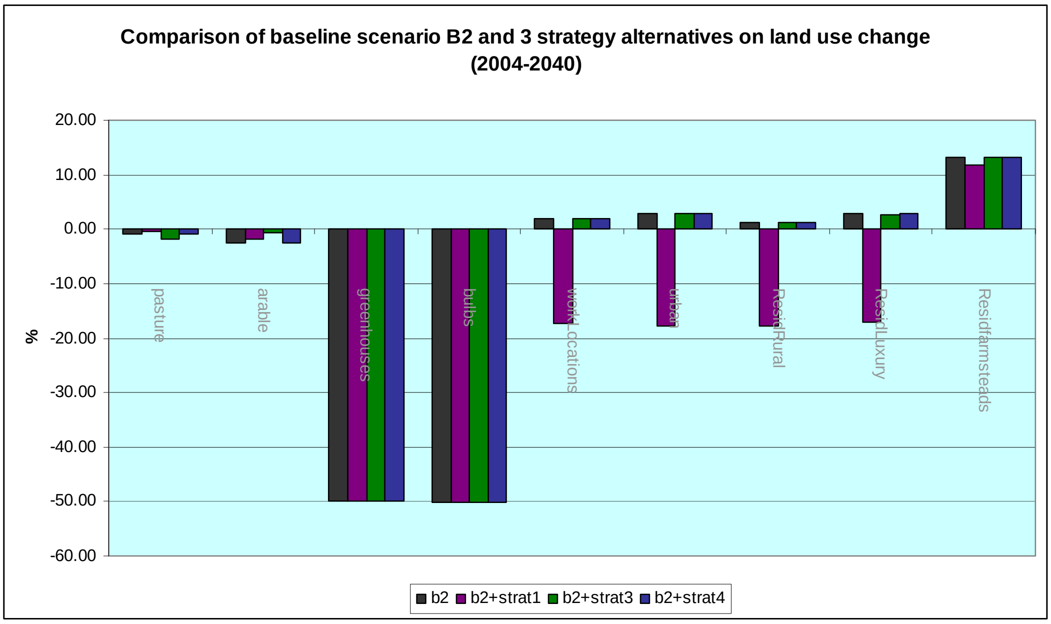


Figure 33. The differences for the B2 baseline scenario and the 3 strategies on land use for 2040.

Annex A

Table A1. The suitability layers are compared to the land use layers using a contingency table. The percent land use occupying the area of the suitability class (normalized by total area of that class) of the percent

	1995						2004				
Water availability	**class1**	**class2**	**class3**	**class4**	**class5**		**class1**	**class2**	**class3**	**class4**	**class5**
pasture%of%	2.37	8.79	9.22	1.64	6.02		1.98	8.91	9.35	1.28	5.62
arable%of%	1.47	0.01	0.15	16.42	0.22		1.42	0.01	0.09	15.54	0.21
forest%of%	0.66	0.08	0.34	0.32	0.06		0.69	0.06	0.32	0.50	0.07
urbanVacant%of%	0.00	0.00	0.02	0.02	0.00		0.00	0.00	0.12	0.01	0.00
bulbs%of%	0.01	0.00	1.62	0.01	0.00		0.01	0.00	2.24	0.02	0.01
SOIL DEPTH											
pasture%of%	0.01	13.57	6.25	0.09	7.18		0.01	13.04	6.31	0.09	6.24
arable%of%	0.10	1.04	0.01	0.00	14.56		0.08	1.15	0.01	0.00	13.26
forest%of%	0.06	0.01	0.87	0.00	0.84		0.07	0.02	0.76	0.00	1.04
urbanVacant%of%	0.02	0.00	0.00	0.00	0.03		0.00	0.00	0.00	0.00	0.07
bulbs%of%	0.00	0.00	0.01	0.00	0.81		0.00	0.00	0.01	0.00	1.24

WATER SHORTAGE										
pasture%of%	4.63	3.00	7.90	5.05	1.47		3.78	2.73	7.50	5.16	1.42
arable%of%	1.53	13.26	6.18	0.03	0.02		1.20	12.41	6.08	0.04	0.04
forest%of%	1.67	0.07	0.13	0.07	0.02		1.79	0.14	0.17	0.08	0.02
urbanVacant%of %	0.06	0.00	0.01	0.00	0.00		0.12	0.00	0.01	0.00	0.00
bulbs%of%	1.75	0.01	0.00	0.00	0.00		2.68	0.01	0.00	0.00	0.00
EROSION RISK										
pasture%of%	27.72	0.98	0.01	0.01	0.00		26.16	0.79	0.01	0.01	0.00
arable%of%	10.57	6.01	0.07	0.02	0.00		10.54	4.98	0.00	0.00	0.00
forest%of%	0.85	0.08	0.25	0.66	0.10		1.07	0.13	0.21	0.55	0.10
urbanVacant%of %	0.02	0.01	0.00	0.00	0.00		0.01	0.01	0.00	0.00	0.00
bulbs%of%	0.22	0.03	9.47	1.24	0.00		0.37	0.07	11.14	1.41	0.00
ELEVATION										
pasture%of%	4.23	22.95	2.65	0.10	0.00		3.85	21.90	2.36	0.07	0.00
arable%of%	3.02	8.88	3.49	0.02	0.00		2.66	9.07	2.98	0.01	0.00
forest%of%	0.00	0.02	0.19	1.09	4.62		0.01	0.06	0.25	1.05	4.10
urbanVacant%of %	0.00	0.01	0.01	0.02	0.00		0.00	0.00	0.01	0.06	0.01
bulbs%of%	0.00	0.10	0.58	0.03	0.00		0.00	0.15	0.91	0.04	0.00
grennhouses	0.47	0.35	1.16	0.01	0.00		0.69	0.42	1.10	0.01	0.00

urban	0.17	0.66	5.45	7.83	1.04		0.22	0.76	5.72	7.67	0.95
built-up, rural	0.01	0.01	0.05	0.05	0.01		0.03	0.01	0.05	0.06	0.01
built-up, woodla	0.01	0.03	0.12	0.21	0.20		0.01	0.02	0.11	0.20	0.22
built-up, agri	0.11	0.22	0.19	0.01	0.00		0.10	0.21	0.15	0.01	0.00

CLAY CONTENT

pasture%of%	9.12	0.40	3.76	12.05		9.30	0.38	3.03	11.55
arable%of%	0.06	0.15	18.89	0.17		0.09	0.03	18.04	0.17
forest%of%	0.01	2.67	0.28	0.13		0.02	2.39	0.47	0.14
urbanVacant%of %	0.00	0.05	0.02	0.00		0.00	0.28	0.00	0.00
bulbs%of%	0.00	4.29	0.01	0.00		0.00	6.11	0.02	0.00

PEAT

pasture%of%	9.25	12.13		8.28	12.39
arable%of%	9.64	0.05		8.88	0.09
forest%of%	0.97	0.01		1.13	0.01
urbanVacant%of %	0.03	0.00		0.04	0.00
bulbs%of%	0.42	0.00		0.64	0.00

Annex B

TableB1. Probability statistics of simulation results *i* given the original land use type *j*

	arable	forest	urban vacant	_bulbs_	_greenhouses_	_urban_	_built-up, rural_	_built-up, woodland_	_built-up, agri_
pasture	0.0197	0.0003	0.0000	0.0000	0.0015	0.0000	0.0000	0.0006	0.0008
arable	0.9777	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
forest	0.0330	0.9111	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
urban vacant	0.0091	0.2500	0.6955	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
bulbs	0.2687	0.0167	0.0000	0.6545	0.0000	0.0000	0.0000	0.0000	0.0000
greenhouses	0.0102	0.0004	0.0013	0.0000	0.8990	0.0000	0.0000	0.0000	0.0174
urban	0.0102	0.0011	0.0000	0.0003	0.0002	0.9569	0.0000	0.0015	0.0000
built-up, rural	0.0226	0.0353	0.0000	0.0028	0.0000	0.0000	0.8545	0.0000	0.0000
built-up, woodland	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
built-up, agri	0.0051	0.0005	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.9760

Table B2. Probability that actual land use is *i* given the original land use type is *j*

	arable	forest	urban vacant	_bulbs_	_greenhouses_	_urban_	_built-up, rural_	_built-up, woodland_	_built-up, agri_
pasture	0.0664	0.0004	0.0001	0.0015	0.0012	0.0002	0.0000	0.0003	0.0040
arable	0.8597	0.0001	0.0000	0.0053	0.0009	0.0007	0.0001	0.0001	0.0025
forest	0.0432	0.7920	0.0000	0.0003	0.0000	0.0001	0.0001	0.0001	0.0003
urban vacant	0.0084	0.0000	0.2311	0.0000	0.0000	0.3235	0.0000	0.0000	0.0000
bulbs	0.3985	0.0005	0.0000	0.5147	0.0005	0.0007	0.0010	0.0000	0.0064
greenhouses	0.0607	0.0000	0.0001	0.0003	0.8283	0.0004	0.0000	0.0000	0.0190
urban	0.0094	0.0003	0.0002	0.0004	0.0042	0.9488	0.0002	0.0019	0.0010
built-up, rural	0.0835	0.0014	0.0014	0.0014	0.0000	0.0438	0.7525	0.0014	0.0085
built-up, woodland	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.9911	0.0006
built-up, agri	0.0632	0.0005	0.0005	0.0074	0.0023	0.0037	0.0005	0.0005	0.6800

Table B3. Probability of agreement results between simulation and actual data for simulated year, given the initial land use

	arable	forest	urban vacant	_bulbs_	_greenhouses_	_urban_	_built-up, rural_	_built-up, woodland_	_built-up, agri_
pasture	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
arable	0.8405	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
forest	0.0014	0.7216	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
urban vacant	0.0001	0.0000	0.1607	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
bulbs	0.1071	0.0000	0.0000	0.3369	0.0000	0.0000	0.0000	0.0000	0.0000
greenhouses	0.0006	0.0000	0.0000	0.0000	0.7447	0.0000	0.0000	0.0000	0.0003
urban	0.0001	0.0000	0.0000	0.0000	0.0000	0.9080	0.0000	0.0000	0.0000
built-up, rural	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000	0.6430	0.0000	0.0000
built-up, woodland	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9911	0.0000
built-up, agri	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6637

Annex C

Table C1. Statistics for the Business as usual scenario for 2040 per RUR region (m^2)

BAU	protected	urban	peri-urban	rural
pasture	6230000	14260000	953720000	66730000
arable	1710000	2400000	249640000	334390000
vacantUrban	70000	560000	5620000	310000
greenhouses	390000	4770000	83520000	820000
bulbs	0	20000	35370000	4820000
workLocations	1700000	46270000	22290000	6090000
urban	3090000	279500000	144910000	26490000
ResidRural	250000	450000	4040000	1260000
ResidLuxury	100000	7200000	6840000	1470000
Residfarmsteads	330000	810000	17630000	2180000
port	6810000	25160000	680000	26130000
parkForest	4000000	3600000	32650000	32570000
parkUrban	6680000	71670000	73470000	19200000
airport	0	2670000	30000	0
roadsRail	1820000	32960000	47810000	17450000
ReedsSandMarsh	44760000	730000	19000000	65400000
Water	171610000	28650000	65640000	18380000

Table C2. Statistics for the B1 scenario for 2040 per RUR region (m^2)

B1	protected	urban	peri-urban	rural
pasture	6370000	13930000	943070000	65980000
arable	1530000	1760000	246480000	333390000
vacantUrban	150000	1560000	1750000	140000
greenhouses	90000	950000	89030000	930000

bulbs	0	20000	36080000	4790000
workLocations	1680000	42740000	29210000	6280000
urban	3480000	287070000	149580000	26830000
ResidRural	250000	450000	4240000	1300000
ResidLuxury	220000	7750000	6750000	1460000
Residfarmsteads	240000	900000	17400000	2430000
port	6670000	24270000	670000	27160000
parkForest	4000000	3600000	32650000	32570000
parkUrban	6680000	71670000	73470000	19200000
airport	0	2670000	30000	0
roadsRail	1820000	32960000	47810000	17450000
ReedsSandMarsh	44760000	730000	19000000	65400000
Water	171610000	28650000	65640000	18380000

Table C3. Statistics for the B2 scenario for 2040 per RUR region (m^2)

B2	protected	urban	peri-urban	rural
pasture	6540000	12590000	942920000	67270000
arable	1530000	1650000	249790000	330870000
vacantUrban	520000	9330000	58470000	4970000
greenhouses	0	190000	44340000	240000
bulbs	0	0	19500000	620000
workLocations	1140000	38980000	30680000	4750000
urban	3310000	286820000	148610000	26990000
ResidRural	250000	450000	4090000	1270000
ResidLuxury	80000	5890000	8060000	1880000
Residfarmsteads	270000	700000	17040000	5670000
port	7040000	24800000	760000	26160000
parkForest	4000000	3600000	32650000	32570000
parkUrban	6680000	71670000	73470000	19200000

airport	0	2670000	30000	0
roadsRail	1820000	32960000	47810000	17450000
ReedsSandMarsh	44760000	730000	19000000	65400000
Water	171610000	28650000	65640000	18380000

PLUREL

Land Use Relationships
In Rural-Urban regions

Module 2

August 2010

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

D2.4.3b

Land use projections based on Moland output

Part B: The Montpellier test case

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SIXTH FRAMEWORK PROGRAMME

Contents

Abstract

Objectives

The objective of the PLUREL test case series is to produce a set of scenario runs for different geographical regions using the MOLAND land use model. Each test case is unique in its geography, society and policy choices. The land use model handles each test case independently with unique datasets as provided by the stakeholders. A list of common indicators was designed in order to ensure the inter-comparability of the eclectic set of cases. In this paper, a stand-alone draft for now which will eventually be amalgamated with other test cases, we look at the behaviour of city and surroundings of Montpellier (France) according to three scenarios described by the local stakeholders.

Methodology

Four scenarios were run for Montpellier from 2000 to 2025: ‘Business as usual’, ‘Peak oil’ (B1) and two variants of the ‘HyperTech’ (A1). The parameters for the scenarios are described in the document entitled “Scenarios pour modèle Moland – Montpellier case study” by Jean-Paul Gambier and revised in collaboration with Françoise Jarrige and Jean-Pierre Chéry on 13 January 2010 (see annex 1).

The methodological sequence is as follows:

1. Consultation with stakeholders
2. Data acquisition and manipulation
3. Data ingestion into the Moland model and calibration
4. Scenario parameter setting and running
5. Compilation of resulting statistics

Results

The “business as usual” (BAU) scenario output for 2025 is midway between the two other extreme scenarios. The “Peak oil” (PO) scenario is very conservative in its new developments, especially in the peri-urban and rural areas. This is due to the rising oil prices and consequential energy crunch which slows the services sector linked to the port and airport; and decreases new construction of industrial areas. Discontinuous urban areas are subject to a densification and are consequentially converted to continuous urban areas. In the PO scenario, there is

also some incentive to “return to the land”. The land allocated to vineyards, pasture and arable land increase in this scenario. The opposite extreme to the PO scenario is the “Hyper Tech” scenario. In this scenario, construction is booming under planning control set by the SCoT zoning tools. Two variants have been elaborated for the HT scenarios, reflecting respectively the application of the zoning control only within the Montpellier Agglomeration (the original SCoT area) and a zoning control extended to the overall study area.

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

Spatial scale for results: Regional, national, European	Regional
DPSIR framework: Driver, Pressure, State, Impact, Response	Driver/Pressure/State/Impact/Response
Land use issues covered: Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation	Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation
Scenario sensitivity: Are the products/outputs sensitive to Module 1 scenarios?	Yes
Output indicators: Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions	None
Knowledge type: Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks	GIS-based maps; tables and charts

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

1. Introduction

Moland is a land use modelling tool used within the PLUREL project to model the dynamic urban expansion for selected case studies. Based on cellular automata, the model is able to capture the complexity and random nature of urban growth and its implications on peri-urban and rural land while being able to handle large geographical areas. 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. The model is described in detail elsewhere (Petrov *et al* 2009).

This report brings the reader through the various phases of modelling with Moland, with focus on the Montpellier case-study-specific details and analyses of results.

2. Geographical extent

Prior to compiling the data, the extent of the area to be modelled as well as the spatial resolution of the land use data has to be determined. Discussions were held in regards to definition of the study area. Three possibilities were considered: the functional urban area and two extended versions thereof (figure 1).

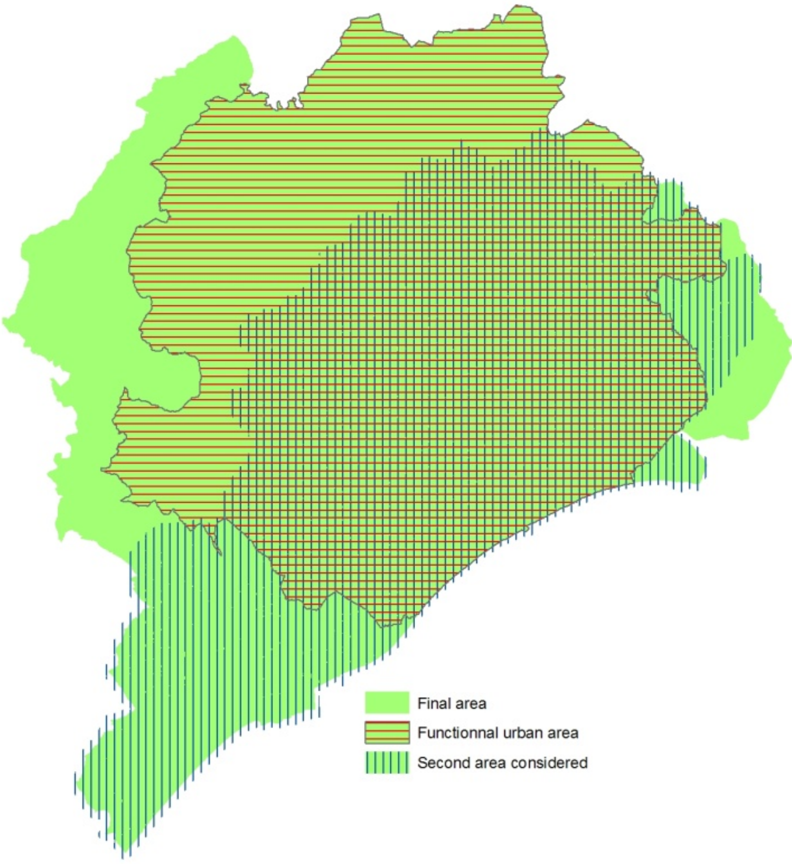

Figure 1. Montpellier areas considered for modeling

3. Model set-up and calibration

The Moland model can be run at two levels: Regional or local. The regional model has the capacity to contribute an additional economic stratum but is only appropriate if there are several competing centres of gravity (jobs, residence, economic sectors). For the Montpellier test case, the local model was applied because the city of Montpellier represents the only centre of gravity.

3.1 Legend

Different options were considered by Montpellier partners and Montpellier stakeholders. In the end, they opted for Corine data as these seemed the most reliable in terms of reported quality. Figures 2 and 3 show these data. Since Moland has already been successfully applied in many occasions using Corine data (including Leipzig case study in PLUREL project), this choice was seen as a way to facilitate comparison with other case studies. For this reason, for calibration purposes and in order to suit the needs implicitly expressed by the storylines, reclassification of original Corine layers was undertaken. Results of this reclassification are shown in figures 4 and 5.

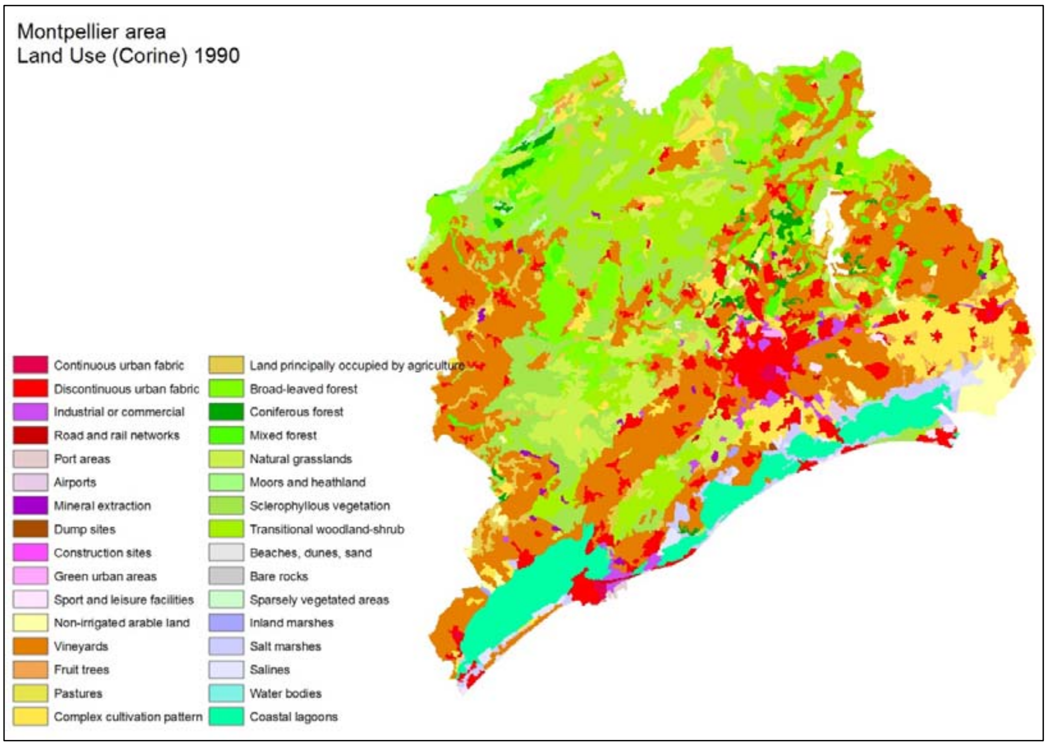

Figure 2. Original Corine data 1990. Montpellier area

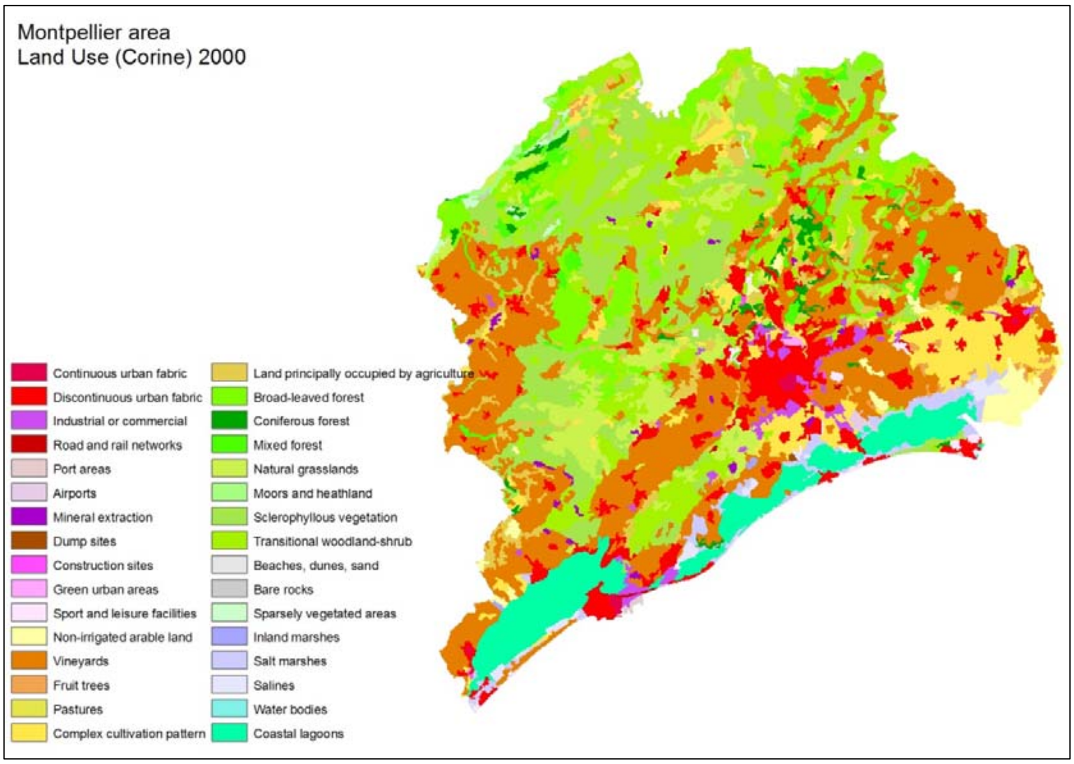

Figure 3. Original Corine data 2000. Montpellier area

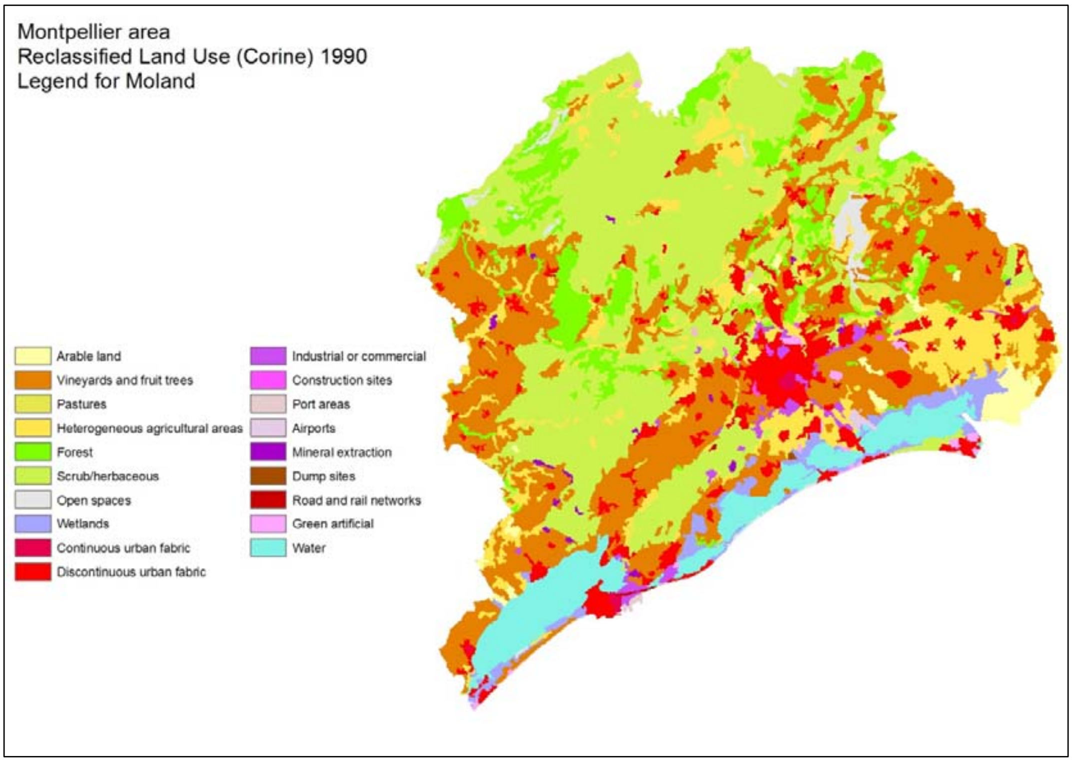

Figure 4. Reclassified Corine data 1990. Montpellier area

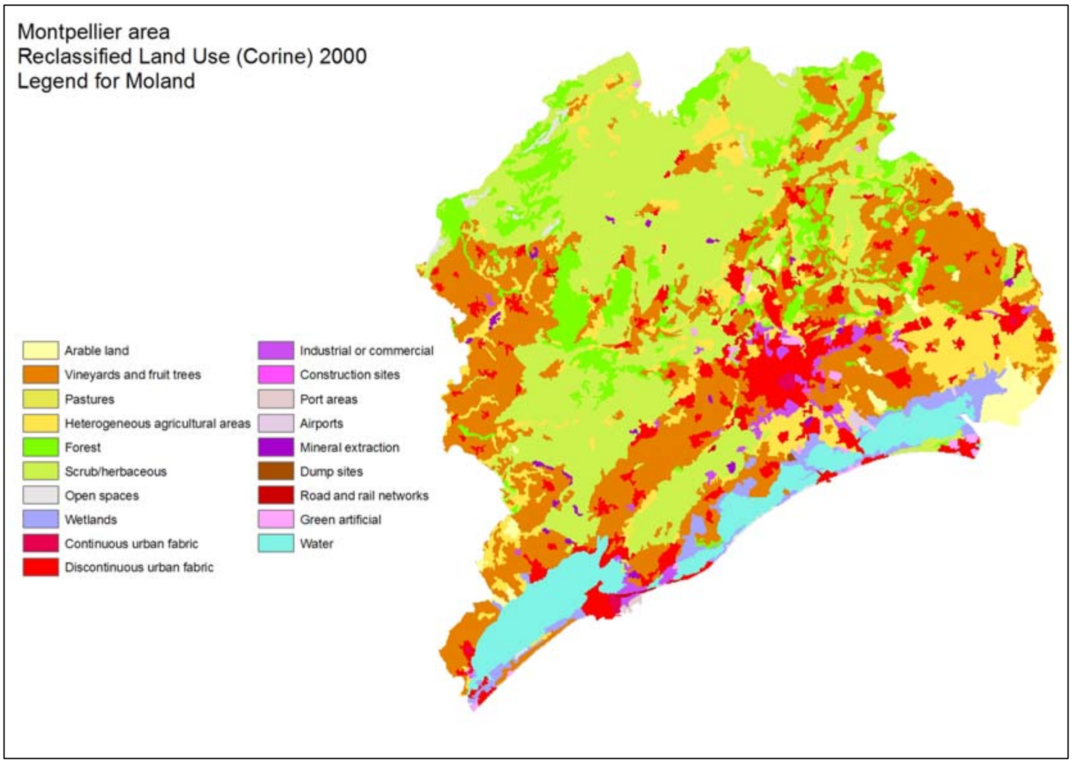

Figure 5. Reclassified Corine data 2000. Montpellier area

The reclassified Corine categories were ingested into Moland and grouped into vacant, functional and features classes, as required by the model (table 1).

Table 1. Montpellier land use legend and initial Moland parameters

Value	Category	Type
0	Arable land	Vacant
1	Vineyards	Vacant
2	Pastures	Vacant
3	Het. Agricultural	Vacant
4	Forest	Vacant
5	Shrub	Vacant
6	Sparsely vegetated	Vacant
7	Cont. urban fabric	Function
8	Discont. urban fabric	Function
9	Industrial/commercial	Function
10	Construction sites	Function
11	Port areas	Function
12	Airports	Function
13	Mineral extraction	Feature
14	Dump sites	Feature
15	Road and rail nets	Feature
16	Green artificial	Feature
17	Sand, dunes, rocks	Feature
18	Wetlands	Feature
19	Water	Feature

3.2 Land use 1990-2000

In the preliminary phases of the calibration process, the actual land use changes occurring for a determined window of time are examined in order to understand the dynamics of the region. Changes between 1990 and 2000 are summarized in table 2 and figure 6. Figure 7 shows the spatial distribution of areas have undergone changes. These trends in land cover change are used to drive the business as usual scenario.

Table 2. Changes in each category between 1990 and 2000

Category	1990 (ha)	2000 (ha)	Difference
Arable land	3155	3211	56
Vineyards	61225	60097	-1128
Pastures	110	89	-21
Het. Agricultural	22673	22516	-157
Forest	17492	18216	724
Scrub	72897	72564	-333
Open spaces	2800	1276	-1524
Wetlands	4905	4851	-54
Cont. Urban	453	453	0
Disc. Urban	15749	17220	1471
Industrial/comm.	2234	2821	587
Construction	151	128	-23
Ports	190	190	0
Airports	282	282	0
Mineral extraction	593	830	237
Dump sites	45	45	0
Road & Rail net.	162	171	9
Green artificial	938	1057	119
Water	13831	13868	37

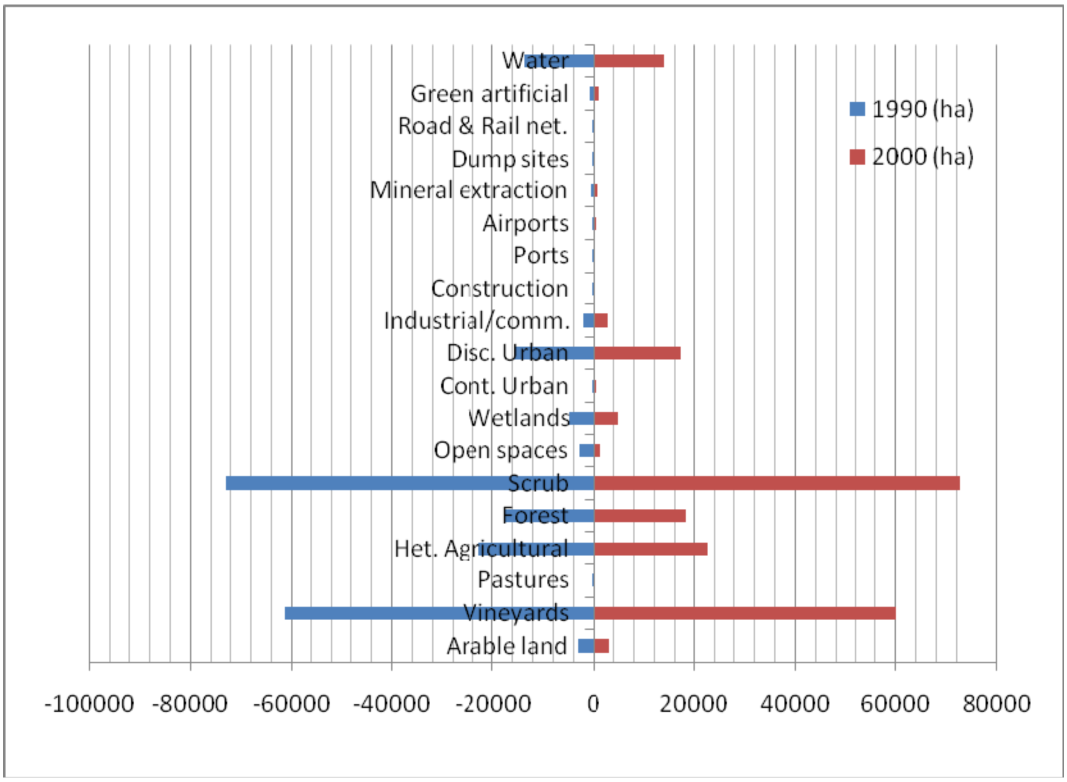

Figure 6. Land use changes (ha) between 1990 and 2000

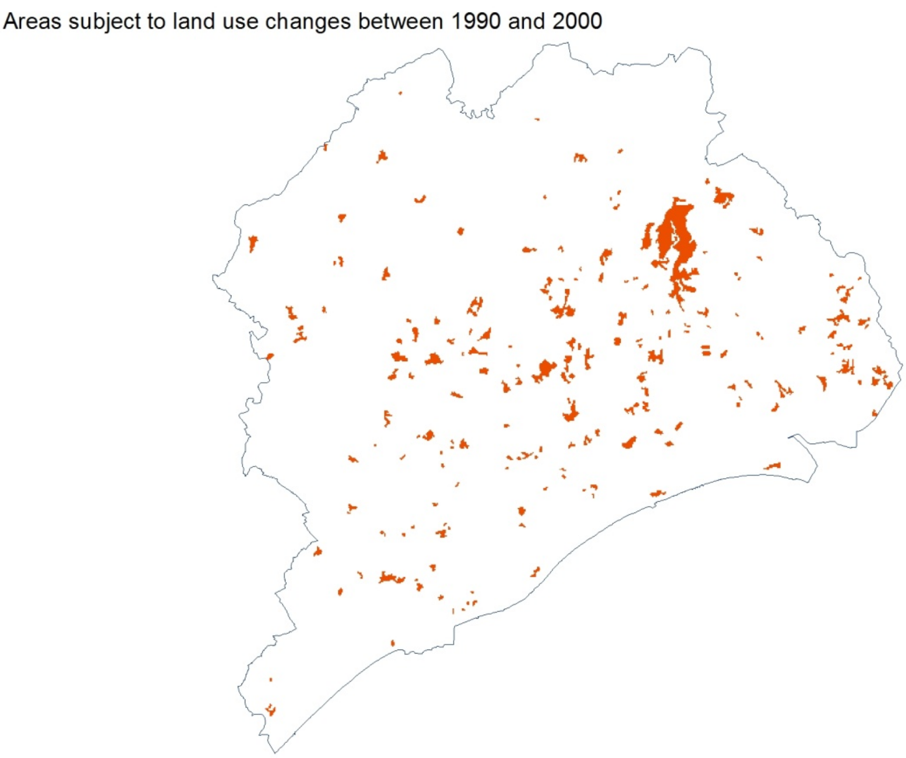

Figure 7. Areas experiencing land use changes between 1990 and 2000

The large area experiencing changes between 1990 and 2000 on the east side of the image corresponds to a bushfire. The area is covered in 2000 by scrub/herbaceous.

3.3 Transportation network

The transport layer used to compute accessibility maps is shown in figure 8. This layer contained motorways, main roads, railways and tramways

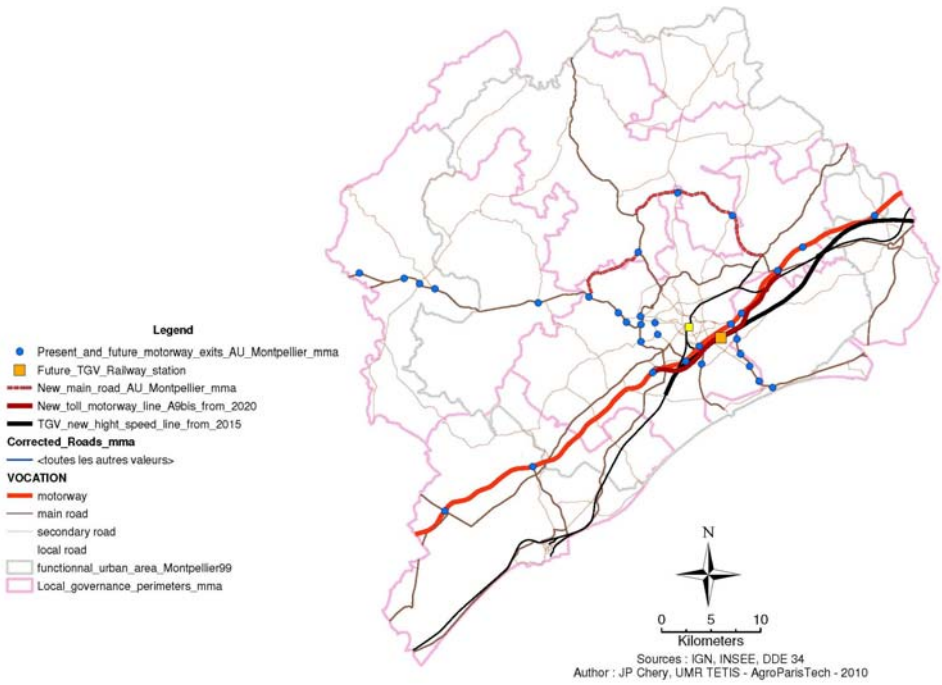

Figure 8. The transport network for the Montpellier test case

The following new extensions of were included in the simulation, according to the depicted storylines:

- Extension of tram line 3 – to be opened in 2015
- Extension of tram line 2 (West) – to be opened in 2015
- Extension of tram line 4 – to be opened in 2018
- Extension of tram line 2 (East) – to be opened in 2023
- Extension of tram line 5 - to be opened in 2023
- Settlement of the fast train connection TGV in 2015 (and relative station)
- New motorway A9bis from 2020

3.4 Zoning maps

The zoning maps play an important role in the model. They determine whether or not a land use is allowed.

Detailed zoning maps were provided for the Montpellier Metropolitan Agglomeration (referred to as MMA in this document) following the SCoT, territorial coherence scheme and were also assembled for the surrounding communes.

Figure 9 shows the zoning map for the overall study area. Figure 10 shows the delineation of the Montpellier Metropolitan Agglomeration (MMA).

The application of the zoning map followed the storylines depicted for each scenario.

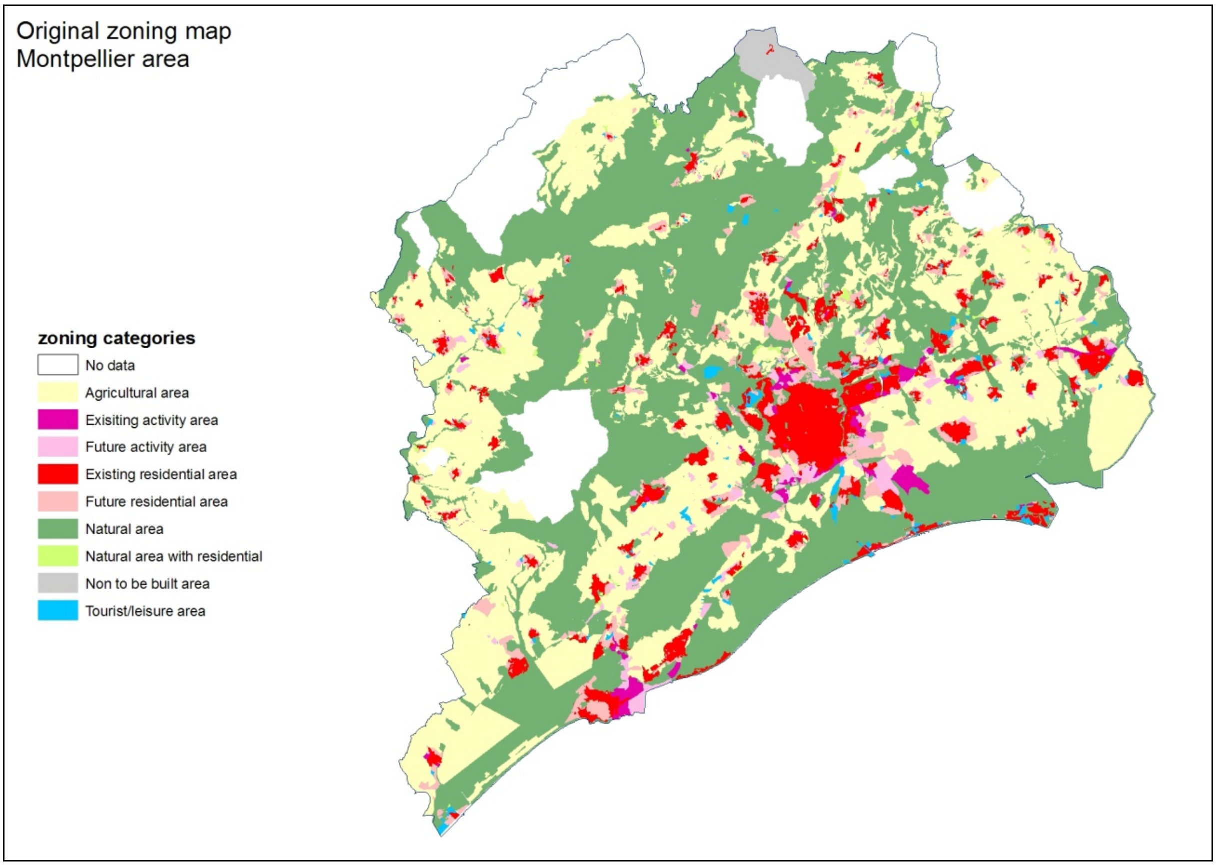

Figure 9. The zoning map for the overall Montpellier area

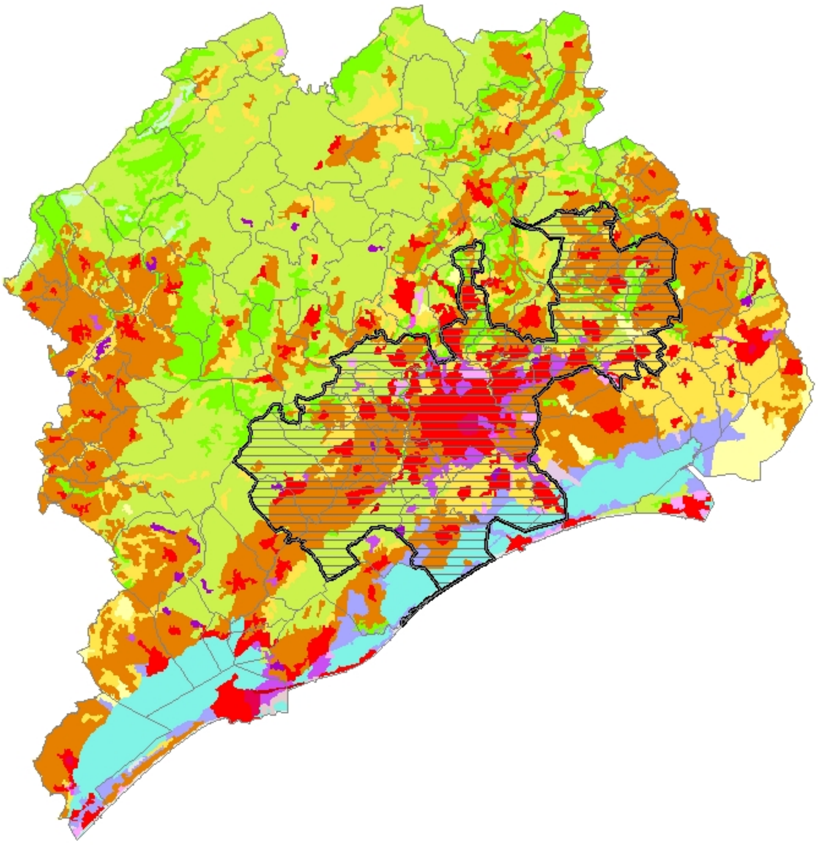

Figure 10 The Montpellier Metropolitan Agglomeration

Table 3 shows categories included in the original zoning map provided and the value assigned (1 –activity allowed- or 0 –activity not-allowed) to each of the functional classes.

Table 3. Assigned binary values to each of the functional classes based on original zoning map

	CUF	DUF	Airport	Port	Comm/ indust	Constr. site
Agricultural area	0	0	0	0	0	0
Existing activity area	0	0	1	1	1	1
Future activity area	0	0	1	1	1	1
Existing residential area	1	1	0	0	0	1
Future residential area	1	1	0	0	0	1
Natural area	0	0	0	0	0	0
Natural area with residential	0	1	0	0	0	0
Non to be built area	0	0	0	0	0	0

Tourist/leisure area	0	1	0	0	0	1

3.5 Suitability

Suitability maps in Moland represent natural-based areas where certain activities or land uses are better suited to expand while others are not. Moland requires a suitability map for each of the vacant classes in order to correctly allocate these classes. These maps range from 0 (least suitable) to 10 (most suitable). Tables 4-10 show parameters adopted for the production of each of the suitability maps and figures 11-17 show the maps produced.

Table 4. Parameters adopted for the production of a suitability map for “arable land”

	Slope (%)	Value assigned	Altitude	Value assigned	Land use	Value assigned
Arable land	0	0	< 0	0	Arable land	10
	0.01 - 3	10	0	0	Vineyards	3
	3 - 5	5	1 -1	2	Pastures	3
	> 5	0	1 - 2	8	Het. Agric	3
			2 - 50	10	Forest	0
			50 - 250	7	Shrub	3
			> 250	0	Sparsely	3
					All others	0

Suit_arable_land = INT [(slope + altitud + land_use)/3]<extract> built areas

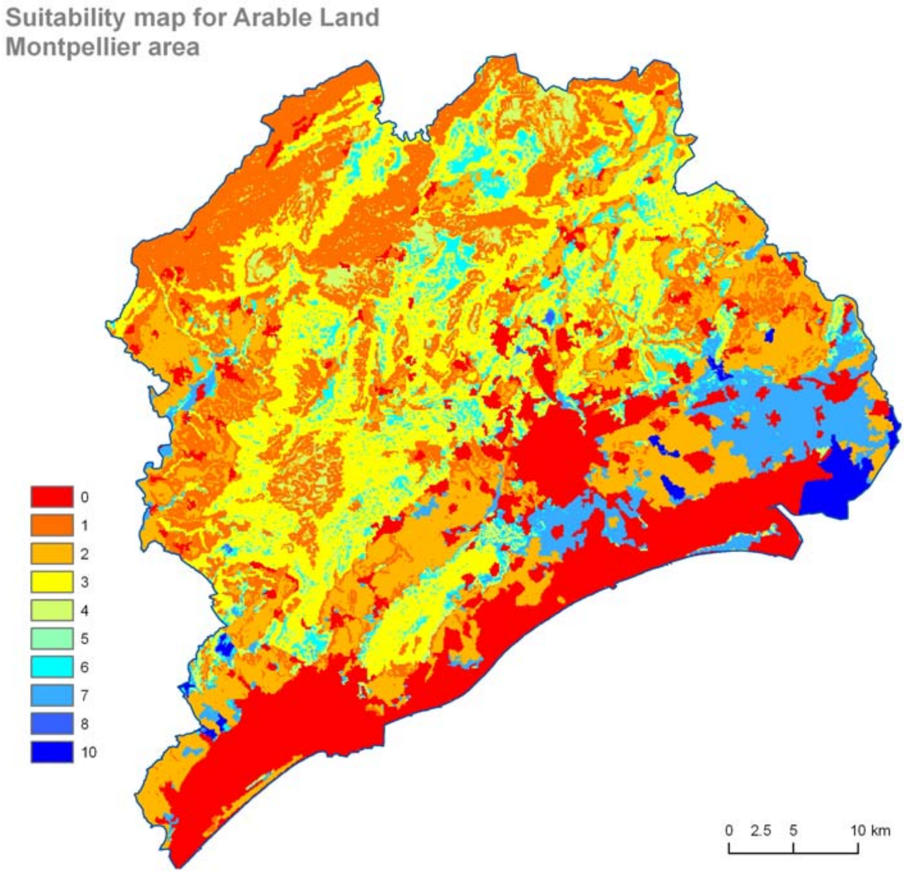

Figure 11. Suitability map for Arable land

Table 5. Parameters adopted for the production of a suitability map for "vineyards"

	Slope (%)	Value assigned	Altitude	Value assigned	Land use	Value assigned
Vineyards	0	0	< 0	0	All others	0
	0.01 - 3	10	0.01 - 50	10	Vineyards	10
	3 - 5	8	50 - 100	8		
	5 - 7	6	100 - 250	7		
	> 7	0	> 250	0		

Suit_vineyards = INT [(slope + altitud + land_use)/3]<extract> built areas

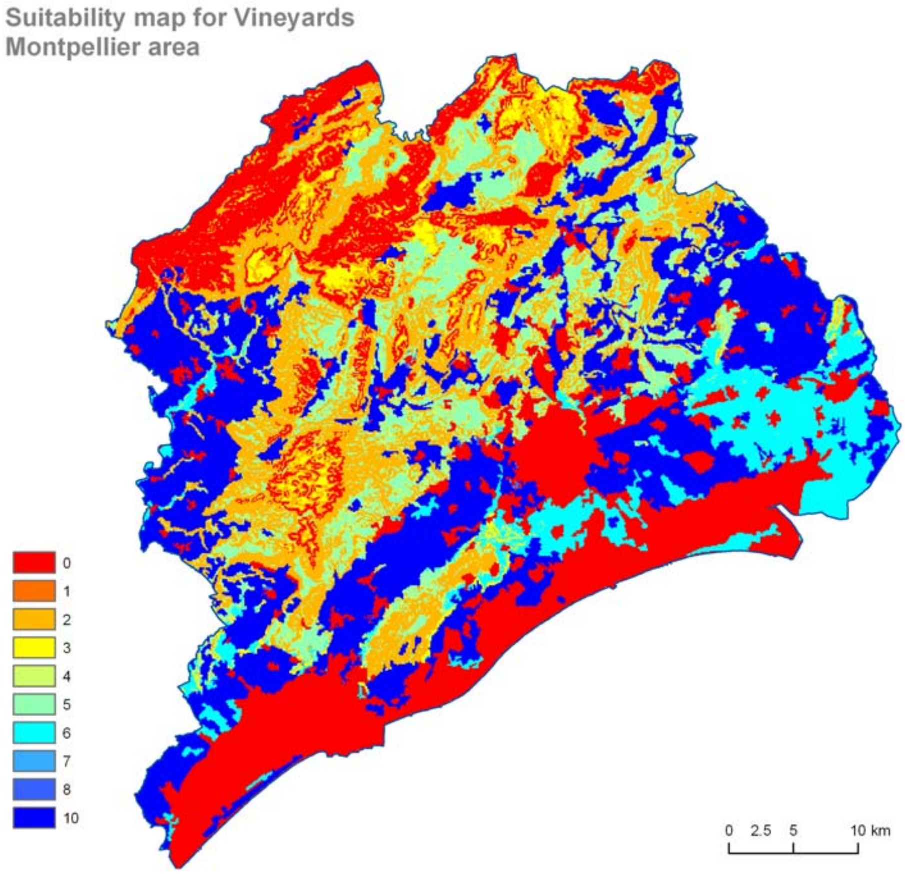

Figure 12. Suitability map for Vineyards

Pastures have a very limited presence in the area. Suitability map was produced by simply reclassifying land use classes according to the information provided in table 6.

Table 6. Parameters adopted for the production of a suitability map for "pastures"

Pastures

Land use	Value assigned
Arable land	6
Vineyards	6
Pastures	10
Het. Agric	6
Forest	6
Shrub	8
Sparsely	8
All others	0

Suit_pastures = Reclass 2000 land use

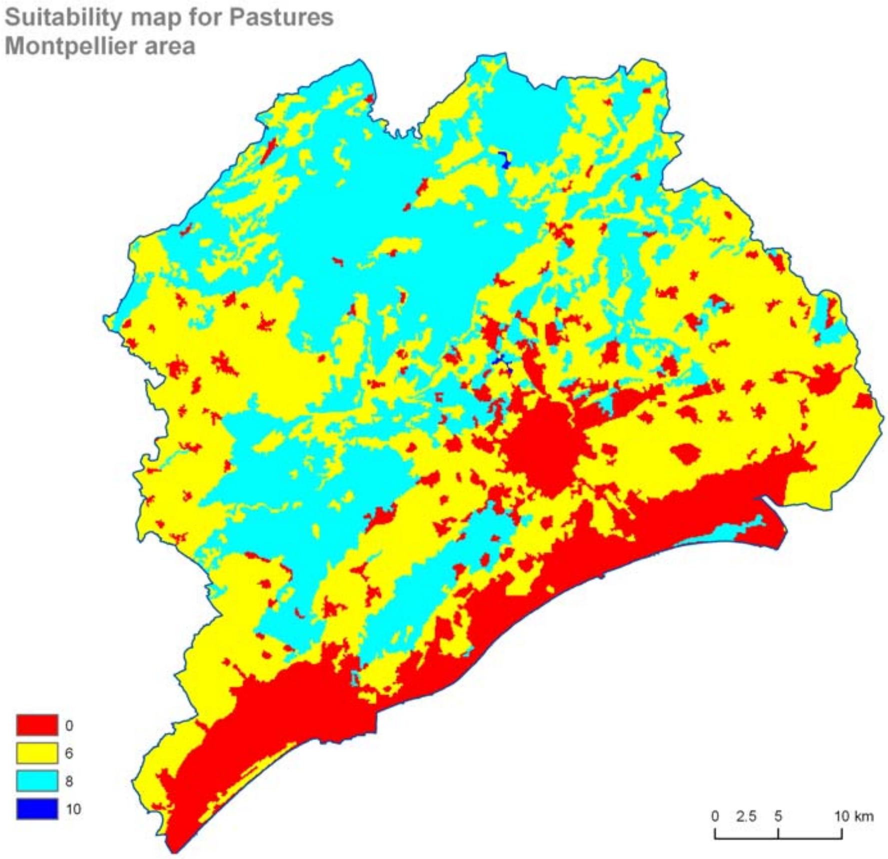

Figure 13. Suitability map for Pastures

Table 7. Parameters adopted for the production of a suitability map for “forests”

Forest

Land use	Value assigned
Arable land	4
Vineyards	4
Pastures	4
Het. Agric	6
Forest	10
Shrub	9
Sparsely	8
All others	0

Suit_forest = Reclass 2000 land use

-

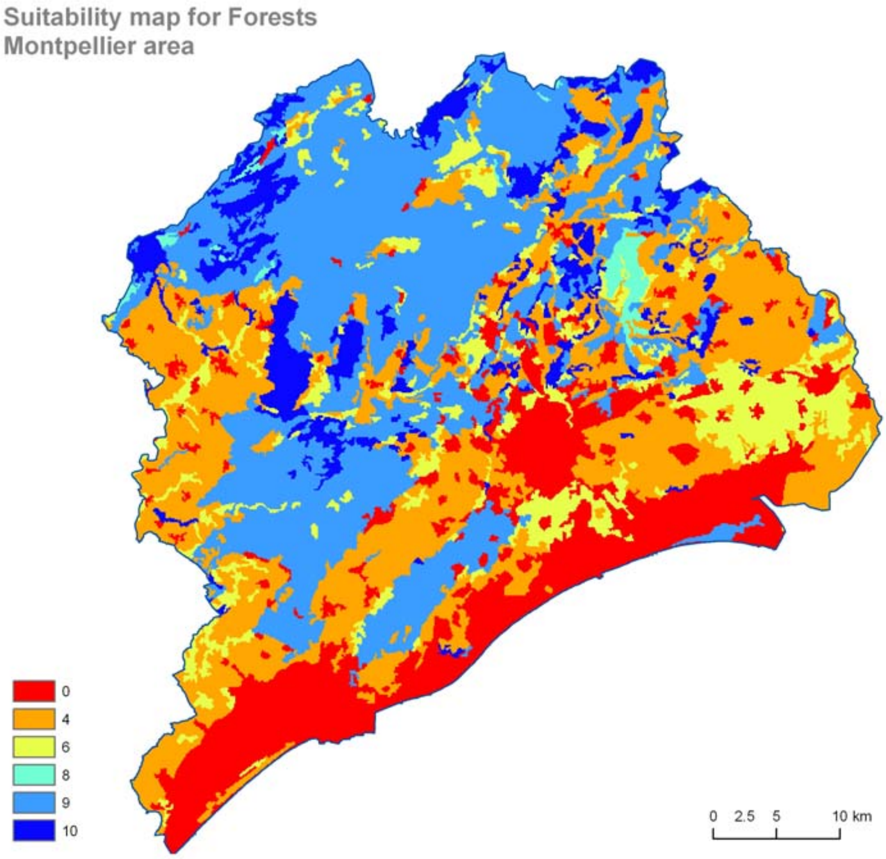

Figure 14. Suitability map for Forests

Table 8. Parameters adopted for the production of a suitability map for "heterogeneous agricultural areas"

Het. Agric

Land use	Value assigned
Arable land	8
Vineyards	8
Pastures	4
Het. Agric	10
Forest	2
Shrub	3
Sparsely	4
All others	0

Suit_het.agric = Reclass 2000 land use

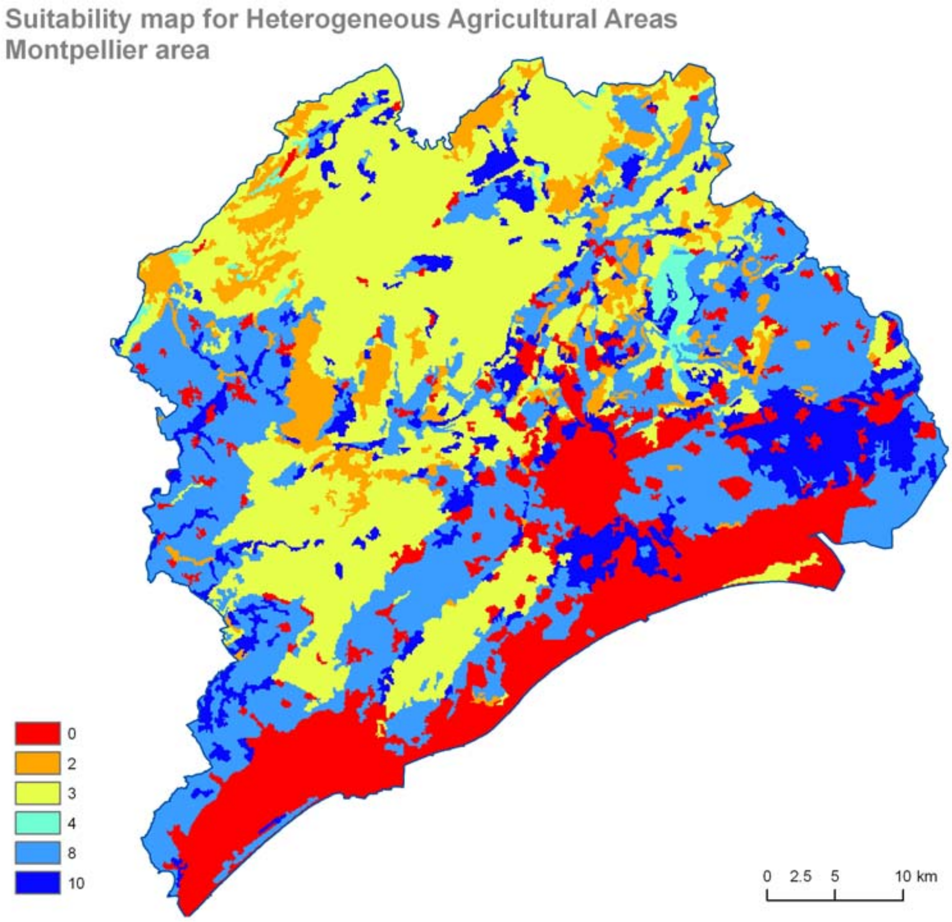

Figure 15. Suitability map for Heterogeneous Agricultural Areas

Table 9. Parameters adopted for the production of a suitability map for “shrub”

Shrub

Land use	Value assigned
Arable land	3
Vineyards	2
Pastures	5
Het. Agric	5
Forest	1
Shrub	10
Sparsely	8
All others	0

Suit_shrub = Reclass 2000 land use

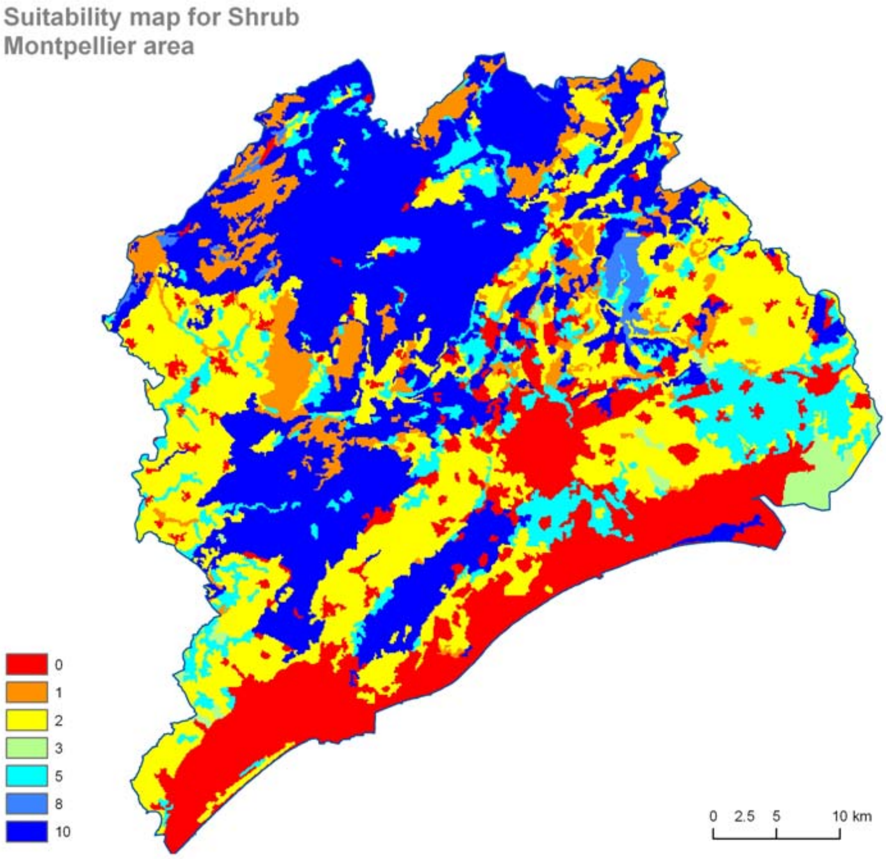

Figure 16. Suitability map for Shrub

Table 10. Parameters adopted for the production of a suitability map for “sparsely vegetated areas”

	Slope (%)	Value assigned	Altitude	Value assigned	Land use	Value assigned
Sparsely vegetated	0	0	< 25	0	Arable land	3
	0.01 - 3	1	25 - 100	2	Vineyards	0
	3 - 5	2	100 - 200	3	Pastures	5
	5 - 10	5	200 - 500	6	Het. Agric	2
	10 - 15	6	> 500	8	Forest	0
	15 - 25	7			Shrub	5
	> 25	10			Sparsely	10
					All others	0

Suit_sparsely = [INT (slope + altitud + land_use)/3]<extract> built areas

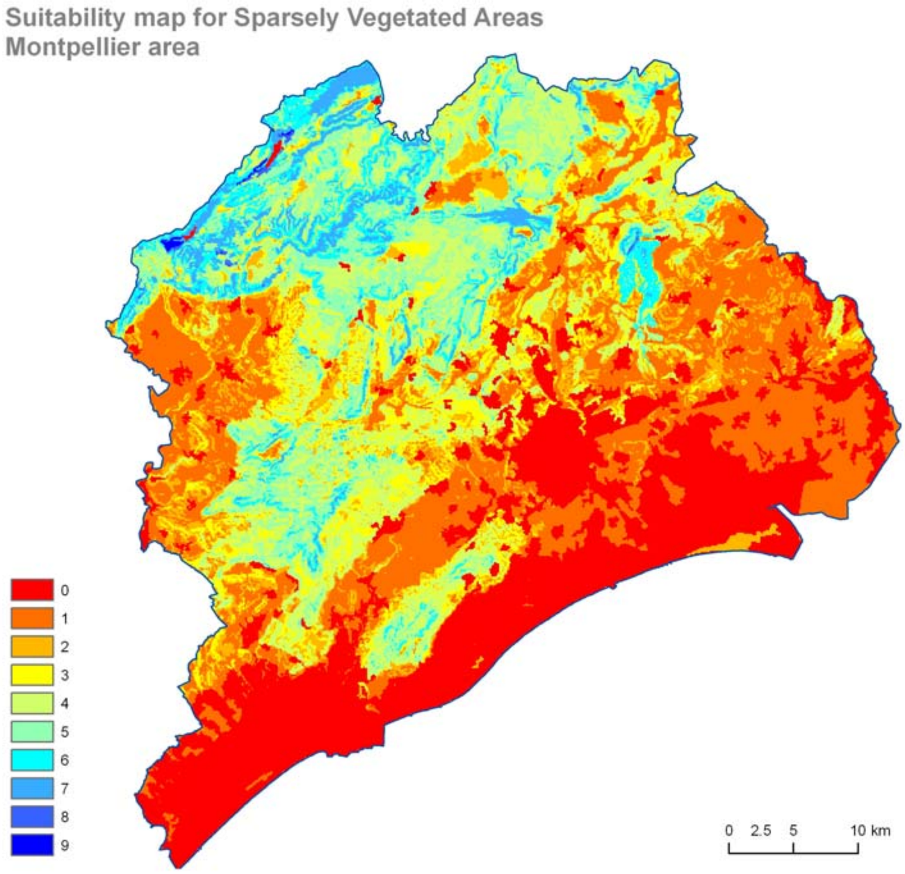

Figure 17. Suitability map for Sparsely Vegetated Areas

3.6 Calibration

Calibration was undertaken using the reclassified Corine layers of 1990 and 2000 shown in figures 4 and 5. Both suitability maps and neighborhood effects were included in the calibration process. The Kappa index results for the comparison between the Corine Land Cover 2000 and the simulated result using Moland for 2000 are shown in annex b (table b1).

4. Results

Several indicators were calculated for the Montpellier test case. The choice of these had been agreed upon by stakeholders for the different case studies during PLUREL workshops. Some indicators were not possible to calculate without ancillary data. For example, it was not possible to assess population numbers or population densities in the absence of statistics associated to densities for the residential land use categories continuous and discontinuous urban. Below is a summary of the statistics calculated for the Montpellier test case.

1. Total amount of new urban land.
2. Amount of urban land by RUR typology (figure 18).
3. Amount of new urban land per new inhabitant. The density of residential classes is a parameter used to manipulate scenarios and is therefore not an indicator, but rather a driver. This data is shown for the respective scenarios.
4. Lost farmland and / or valuable nature.

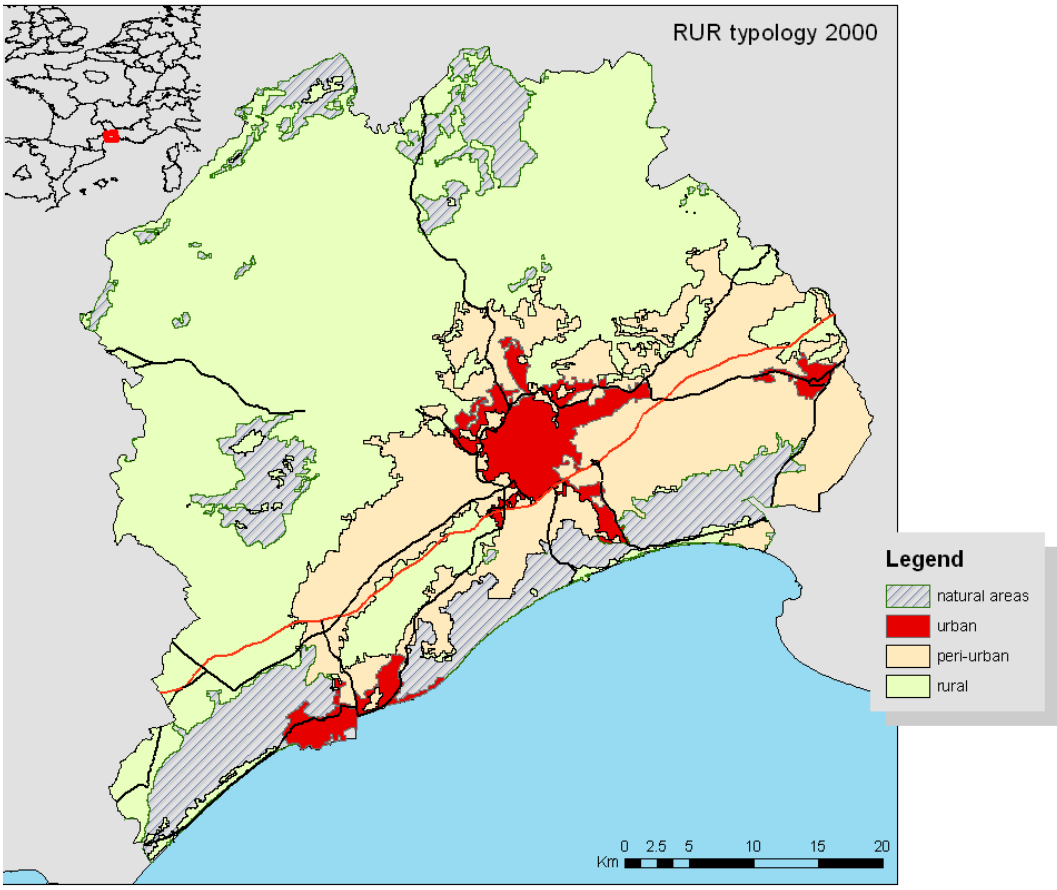

Figure 18. The RUR typology for the Montpellier test case

Table 11 summarises the categorization used in the calculations of the statistics.

Table 11. The statistical re-classification of the legend.

Class name	statistical category	statistical category
Arable land Vineyards & fruit trees Pastures Heterogeneous agricultural	farmland	
Forest Shrub Sparsely vegetated	natural	
Continuous urban fabric Discontinuous urban fabric Industrial and commercial	urban land	built-up
Construction sites Port Airport Mineral extraction Dump sites Road and Rail networks		built-up
Green artificial Sand, dunes, bare rocks Wetlands Water	unchanged	

One specific observation concerns the "construction sites" present in the Corine Land Cover map for year 2000. The transformation of this land use class is difficult to control (i.e. to be parameterised in the model) without prior knowledge of trends in construction class conversions (e.g.: zoning and suitability maps) and timeline (this is true for all scenarios). The model assumes that 'construction sites' are a transitional land use class whose dynamics is governed mainly by the stochastic perturbation coefficient which typically accounts for phenomena without specific transition rules and for the stochastic (or probabilistic) aspects of the land use evolution (for ex. : scatter in land use patterns, irregularities of spatial clusters etc.).

4.1 Business as Usual (old-BAU)

The main characteristics for this scenario (referred to as the 'back to the old business as usual' – see Annex I for details) are:

- abandonment of existing planning tool (SCoT) which means back to uncontrolled land business and urban sprawl, as experienced in the past in Montpellier city-region;
- demographic growth of 1.3 % per year
- A9 highway is doubled, TGV is built up and operated from 2020 – no additional public infrastructures are set up.

Figure 19 shows the resulting land use map for the business as usual scenario, run until 2025.

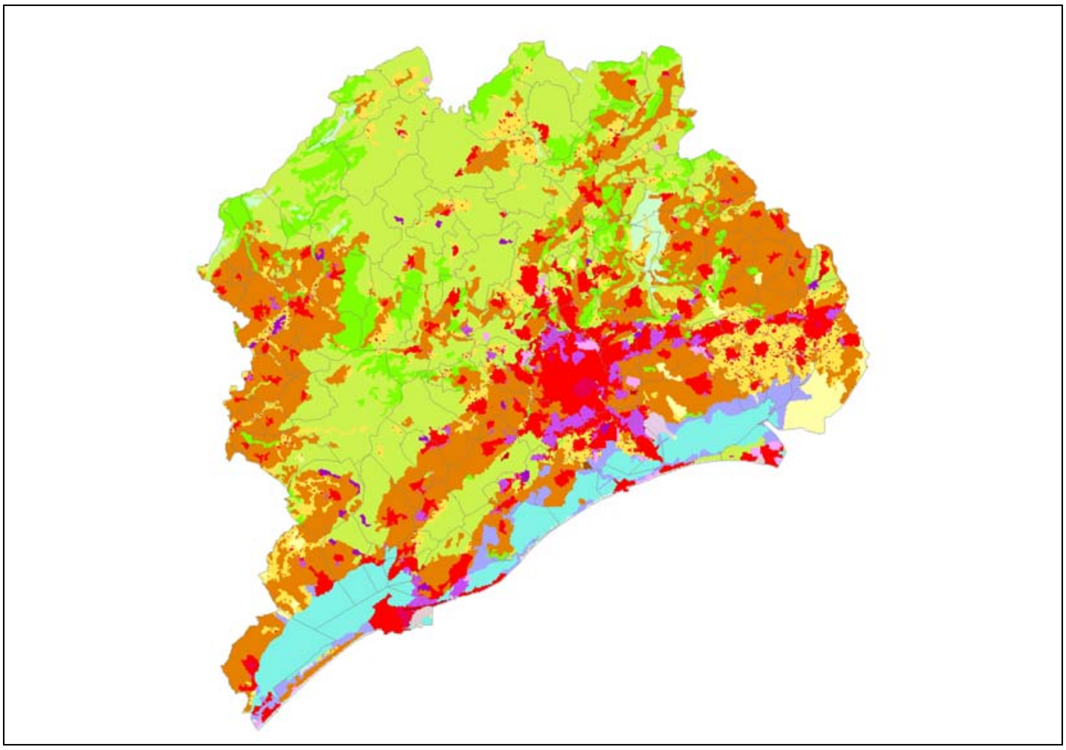

Figure 19. The output of the old-BAU scenario for 2025.

Table 12 summarises the changes in land use for the overall area from 2000 to 2025 according to the old-BAU scenario:

Table 12. Changes (ha) in land use classes from 2000-2025.

	2000 (ha)	2025 (ha)	%
Arable land	3211	3247	1.1%
Vineyards & fruit trees	60097	59310	-1.3%
Pastures	89	8	-91.0%
Heterogeneous agricultural	22516	17344	-23.0%
Forest	18216	17322	-4.9%

Shrub	72564	71118	-2.0%
Sparsely vegetated	674	2180	223.4%
Continuous urban fabric	453	650	43.5%
Discontinuous urban fabric	17220	22000	27.8%
Industrial and commercial	2821	4372	55.0%
Construction sites	128	250	95.3%
Port	190	260	36.8%
Airport	282	400	41.8%
Mineral extraction	830	830	0.0%
Dump sites	45	45	0.0%
Road and Rail networks	171	171	0.0%
Green artificial	1057	1057	0.0%
Sand, dunes, bare rocks	602	602	0.0%
Wetlands	4851	4851	0.0%
Water	13987	13987	0.0%

Figure 20 shows the differences between 2000 and 2025 for the continuous urban fabric class. This class includes housing density of type A (> 50 houses/ha) and B (> 30 houses/ha), as identified in the SCoT planning maps.

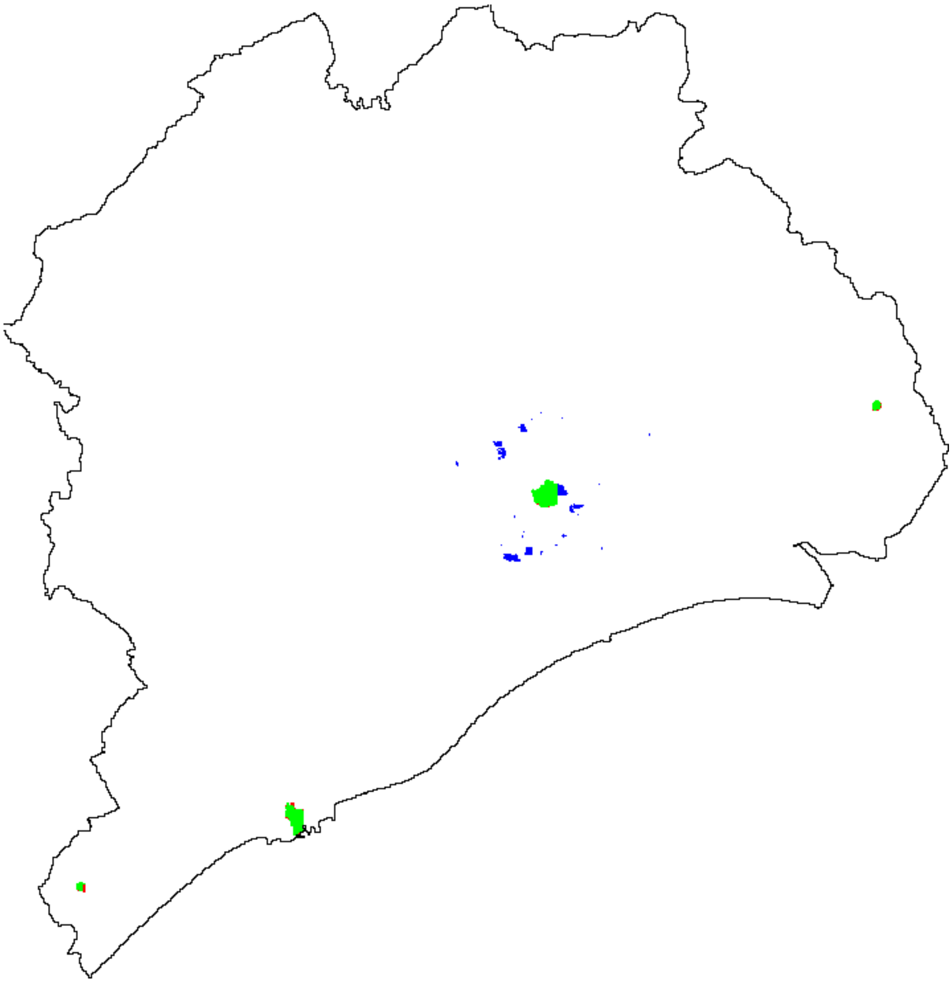

Figure 20. Growth of continuous urban fabric areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

Figure 21 shows the differences between 2000 and 2025 for the discontinuous urban fabric class. This class includes housing density of type C (> 20 houses/ha) and also sparse residential fabric – with less density. Phenomena of urban sprawl are clearly visible not only around the main urban area of Montpellier, but also along specific directions of development.

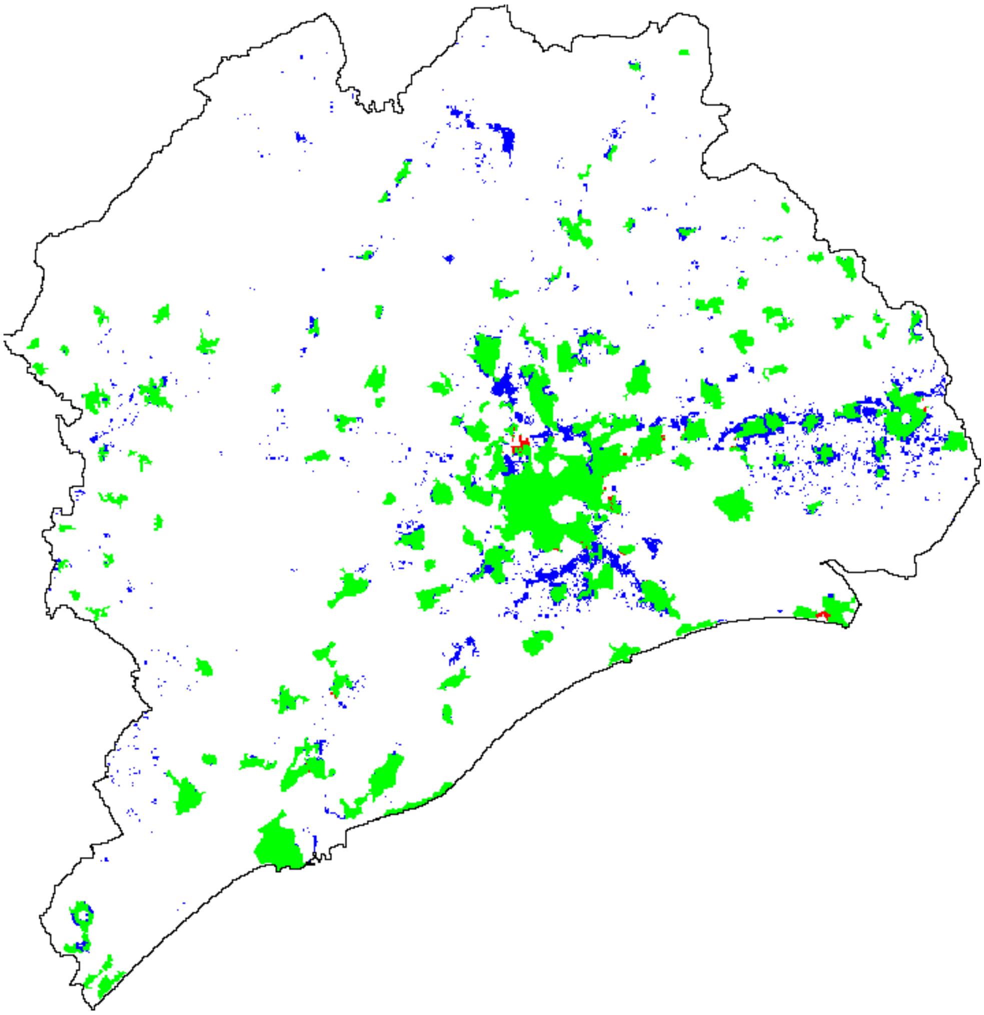

Figure 21. Growth of discontinuous urban fabric areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000.

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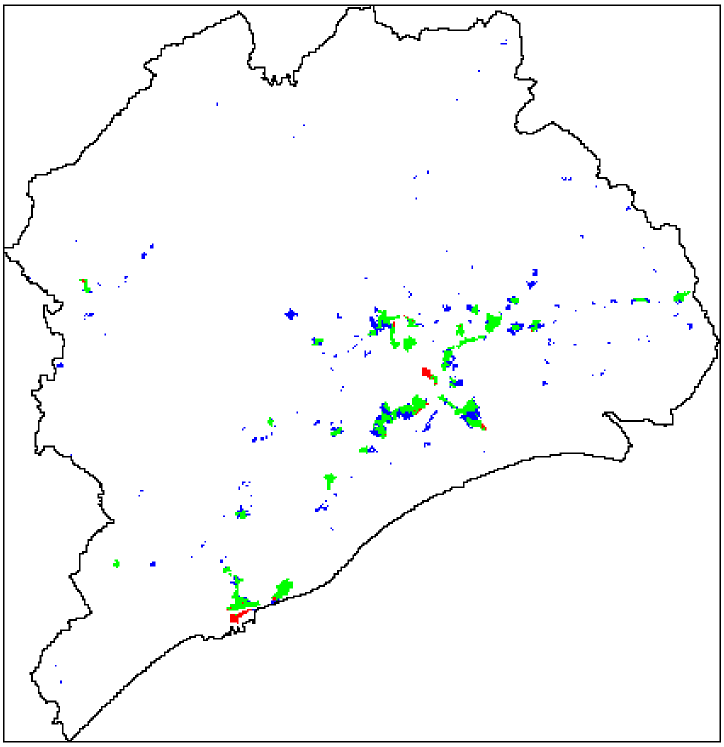

Figure 22 : Growth of industrial and commercial areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

The amount of new urban land was looked at as subdivided by the RUR typology. Table 13 summarises the growth in the RUR areas for urban land (defined as the sum of continuous fabric, discontinuous fabric and industrial/commercial areas). The decrease in urban land is due to the increase in port and airport surfaces.

Table 13. The expansion of urban and built up areas for the BAU scenario between 2000 to 2025.

Old-BAU	Change in amount of urban land (ha)		
	Urban	Peri-urban	Rural
URBAN LAND	**-85**	**+4832**	**+1732**

4.2 Hyper Tech (Long March Hypertech) (variant HT1)

The "long March Hyper Tech" HT1 scenario has been conceived by the stakeholders to represent the current planning situation The key planning instrument is the SCoT, which is extended beyond the Montpellier Agglomeration area.

The main characteristics for this scenario (referred to as the 'Long March or the advent of the hypertech metropolis' – see Annex I for details) are:

- Reinforcement of planning tool (SCoT), based on the reinforcement of the power of the local government, aiming towards high building density and precise urban limits.
- demographic growth of about 2% per year
- Technological and economic booming
- A9 highway is doubled, TGV is built up and operated from 2020
- new tramway network gradually put in service
- increased accessibility and mobility
- preservation of natural areas and agriculture

Figure 23 shows the output for the HT1 scenario for 2025.

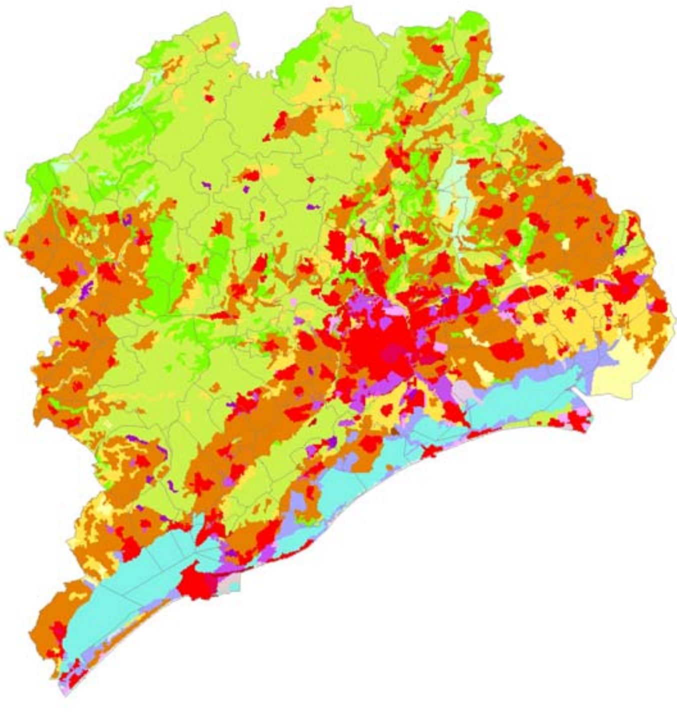

Figure 23. Land use map for the long March HT1 scenario for 2025.

The changes from one land use class to another form 2000 to 2025 according to the HT1 scenario are summarised in table 14.

Table 14. Land use changes in ha for the HT1 scenario, from 2000 to 2025.

	2000 (ha)	2025 (ha)	
%Arable land	3211	3215	0.1%
Vineyards & fruit trees	60097	56651	-5.7%

Pastures	89	71	-20.2%
Heterogeneous agricultural	22516	19988	-11.2%
Forest	18216	17238	-5.4%
Shrub	72564	70836	-2.4%
Sparsely vegetated	674	2180	223.4%
Continuous urban fabric	453	1000	120.8%
Discontinuous urban fabric	17220	22000	27.8%
Industrial and commercial	2821	4372	55.0%
Construction sites	128	250	95.3%
Port	190	260	36.8%
Airport	282	400	41.8%
Mineral extraction	830	830	0.0%
Dump sites	45	45	0.0%
Road and Rail networks	171	171	0.0%
Green artificial	1057	1057	0.0%
Sand, dunes, bare rocks	602	602	0.0%
Wetlands	4851	4851	0.0%
Water	13987	13987	0.0%

The increase of continuous urban fabric (+ 120%) is the key relevant spatial feature for this scenario. Figure 24 shows the development of high density housing mainly within the Montpellier agglomeration.

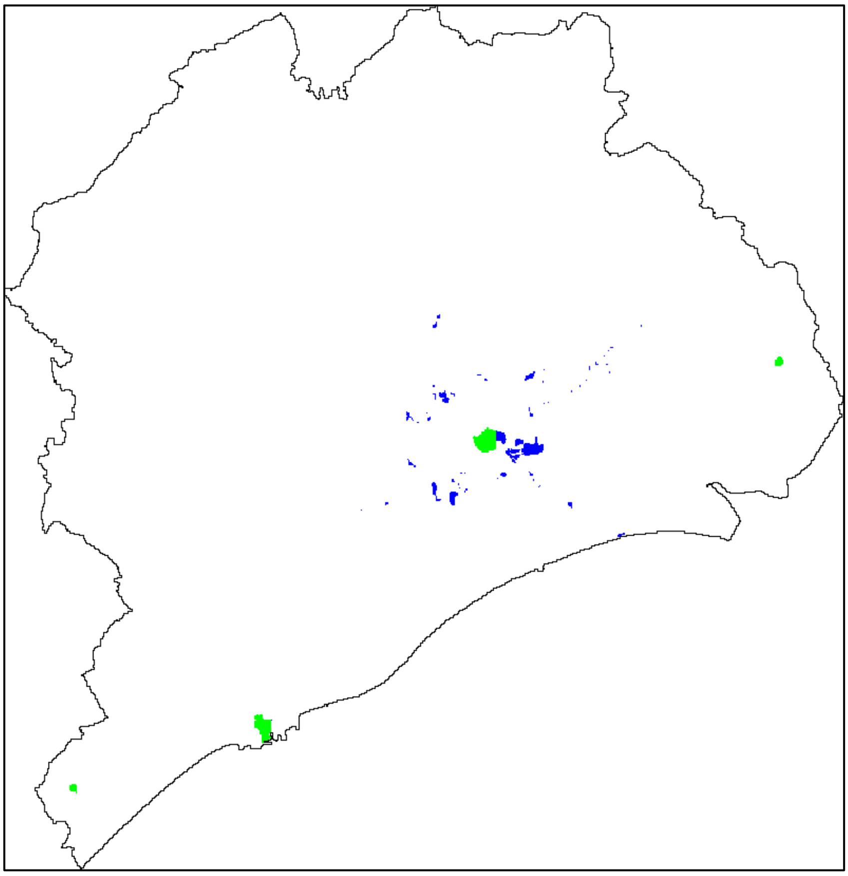

Figure 24 : HT1 Growth of continuous urban fabric areas. ■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

Commuting is encouraged by increasing mobility – but residential developments remain concentrated around main communication infrastructure. Figure 25 shows the increase of discontinuous urban fabric.

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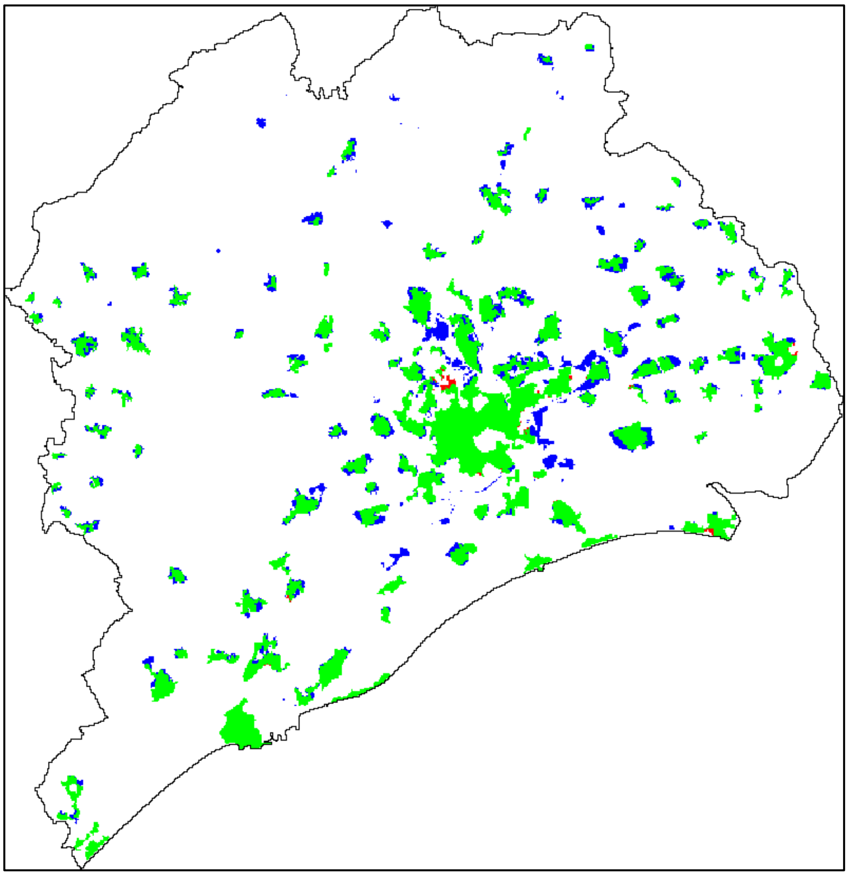

Figure 25 : HT1 Growth of discontinuous urban fabric areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

Industrial areas (Figure 26) are also developing along main transportation corridors. However, because of the economic set up for this scenario, new firms and commercial activities related to agriculture are represented by sparse developments all over the study area.

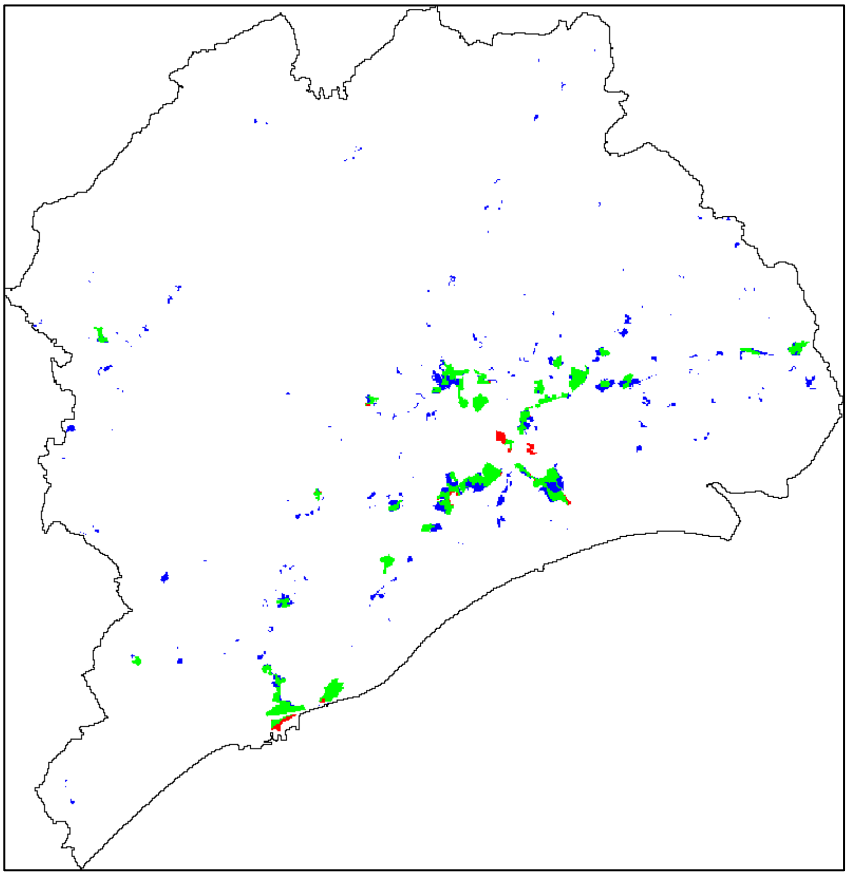

Figure 26 : HT1 Growth of industrial and commercial areas. ■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

The statistics relative to the RUR typology (Table 15) show a net increase of urban land (sum of continuous/discontinuous urban fabric and of industrial/commercial areas) in the peri-urban and rural areas. The decrease in the urban area is given by the transformation of industrial areas and discontinuous urban fabric in port and airport areas (red spots in figure 25 and 26).

Table 15. The changes in urban and impervious surfaces by RUR typology for the HT1 scenario

HT	Change in amount of urban land (ha)		
	Urban	Peri-urban	Rural
URBAN LAND	**-62**	**4402**	**2518**

-

4.2 Hyper Tech (Long March Hypertech) (variant HT2)

The "long March Hyper Tech" scenario has been conceived by the stakeholders to represent the current planning situation The key planning instrument is the SCoT, which is applied only within the Montpellier Agglomeration area.

The main characteristics for this scenario (referred to as the 'Long March or the advent of the hypertech metropolis' – see Annex I for details) are:

- SCoT is applied only within MMA. Constructions are permitted without limitation outside MMA
- demographic growth of about 2% per year
- Technological and economic booming
- A9 highway is doubled, TGV is built up and operated from 2020
- new tramway network gradually put in service
- increased accessibility and mobility
- preservation of natural areas and agriculture.

Figure 27 shows the output for the HT2 scenario for 2025.

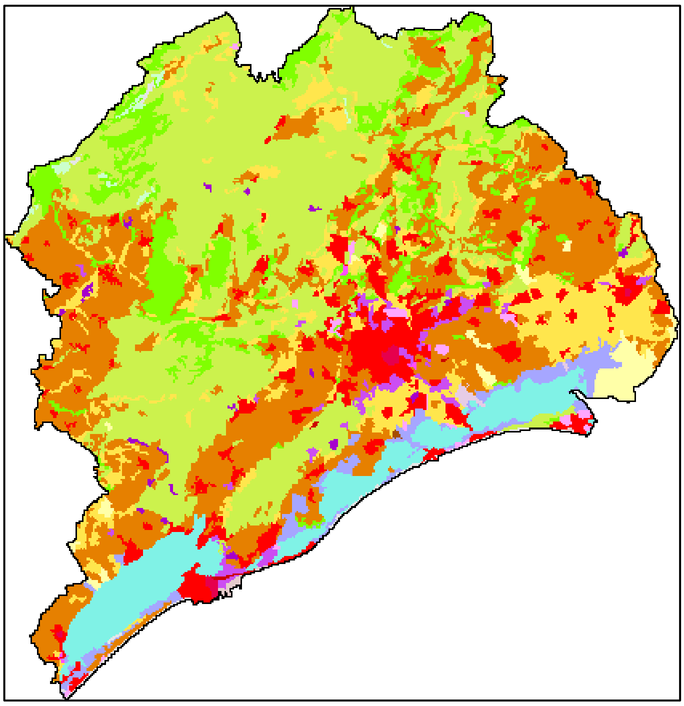

Figure 27. Land use map for long March HT2 scenario for 2025.

Land use changes for HT2 are given in table 14a

	2000 (ha)	2025 (ha)	diff (ha)	%
Arable land	3211	3211	0	0.0%
Vineyards & fruit trees	60097	56290	-3807	-6.3%
Pastures	89	74	-15	-16.9%
Heterogeneous agricultural	22516	20132	-2384	-10.6%
Forest	18216	17299	-917	-5.0%
Shrub	72564	70993	-1571	-2.2%
Sparsely vegetated	674	2180	1506	223.4%
Continuous urban fabric	453	1000	547	120.8%
Discontinuous urban fabric	17220	22000	4780	27.8%
Industrial and commercial	2821	4372	1551	55.0%
Construction sites	128	250	122	95.3%
Port	190	260	70	36.8%
Airport	282	400	118	41.8%
Mineral extraction	830	830	0	0.0%
Dump sites	45	45	0	0.0%
Road and Rail networks	171	171	0	0.0%
Green artificial	1057	1057	0	0.0%
Sand, dunes, bare rocks	602	602	0	0.0%
Wetlands	4851	4851	0	0.0%
Water	13868	13868	0	0.0%

Since the drivers (population and GDP) are identical – there are no major differences in the overall statistics between HT1 and HT2 – over the total area.

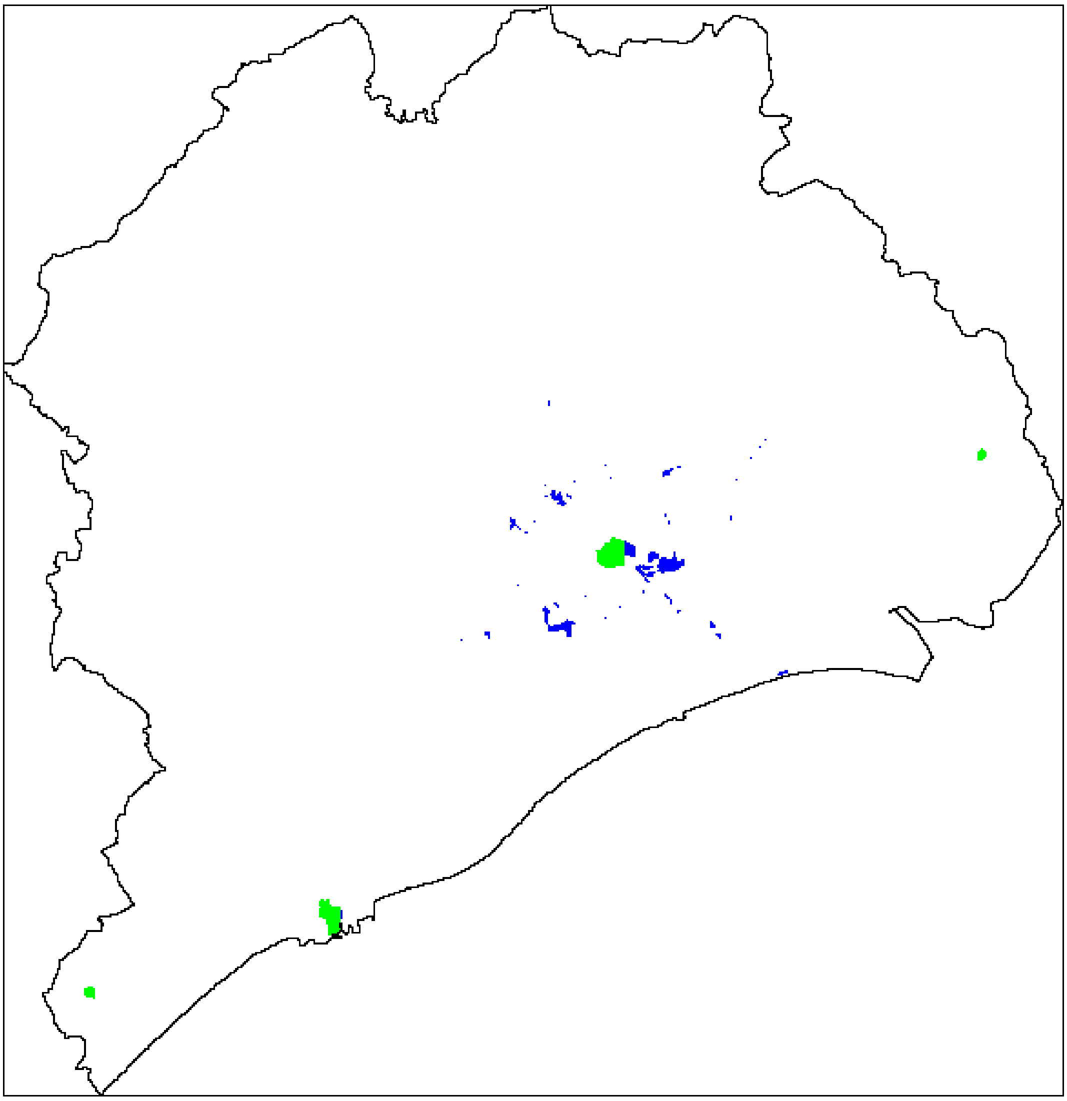

Figure 28 : HT2 Growth of continuous urban fabric areas. ■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

Commuting is encouraged by increasing mobility – but residential developments remain concentrated around main communication infrastructure. Figure 29 shows the increase of discontinuous urban fabric.

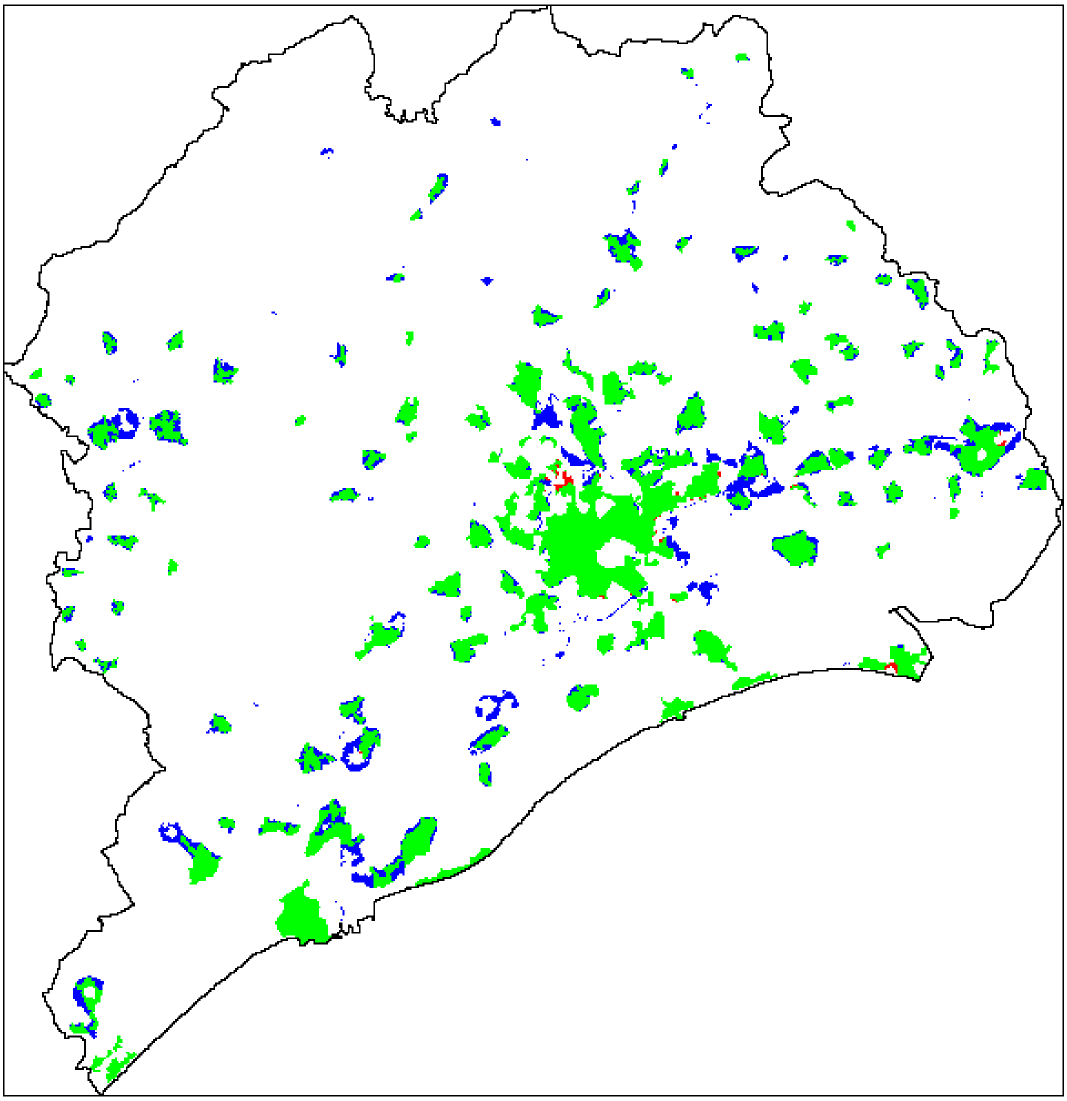

Figure 29 : HT2 Growth of discontinuous urban fabric areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

Industrial areas (Figure 30) are also developing along main transportation corridors. However, because of the economic set up for this scenario, new firms and commercial activities related to agriculture are represented by sparse developments all over the study area. Continuous urban fabrics (high density residential class) have taken over industrial/commercial areas in the core centre of the city of Montpellier.

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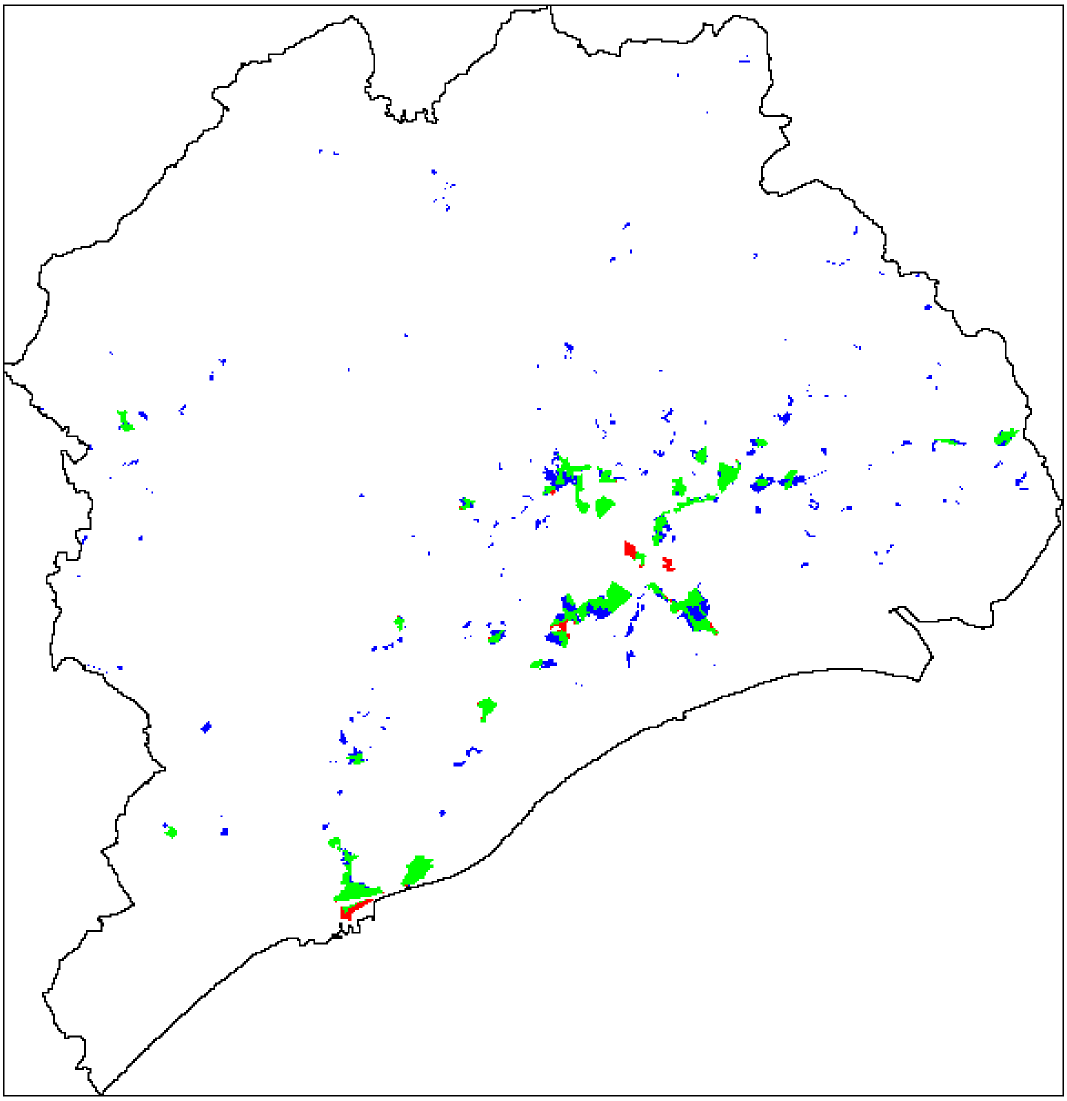

Figure 30 : HT2 Growth of industrial and commercial areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

The statistics relative to the RUR typology (Table 15a) show a net increase of urban land (sum of continuous/discontinuous urban fabric and of industrial/commercial areas) in the peri-urban and rural areas. The decrease in the urban area is given by the characteristics of the zoning measures which favour the building up outside the MMA.

Table 15a. The changes in urban and impervious surfaces by RUR typology for the HT2 scenario

HT2	Change in amount of urban land (ha)		
	Urban	Peri-urban	Rural
URBAN LAND	**-62**	**4329**	**2591**

4.3 Peak Oil (PO)

This scenario is identified by the stakeholders as the "Peak Oil and the technopolitan model decline" scenario. It is marked by a generic economic, social and demographic decline.

The main characteristics for this scenario (see Annex I for details) are:

- High cost of fossil fuels and consequent negative impact on economy;
- Demographic growth of 0.1 % per year
- New (limited) developments are developing along transport infrastructures.
- A9bisby bypasses Montpellier and the TGV is abandoned

Figure 31 shows the outcome of this scenario.

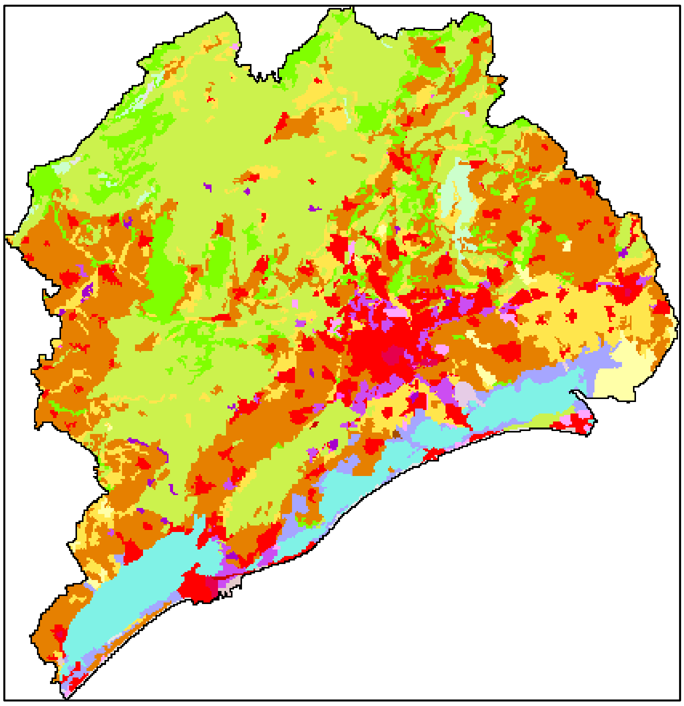

Figure 31. The resulting land use map for the PO scenario for 2025.

Table 16 summarises the changes in land use for the study area from 2000 to 2025 according to the PO scenario. The most obvious difference between this scenario and the others is the limited increase in built up classes.
Changes in continuous urban fabric, discontinuous urban fabric and industrial/commercial areas are represented in figures 32,33 and 34.

Table 16. Land use changes in ha from 2000-2025 for the PO scenario.

	2000 (ha)	2025 (ha)	%
Arable land	3211	3259	1.5%
Vineyards & fruit trees	60097	58565	-2.5%
Pastures	89	79	-11.2%
Heterogeneous agricultural	22516	20811	-7.6%
Forest	18216	17356	-4.7%
Shrub	72564	71338	-1.7%
Sparsely vegetated	674	2181	223.6%
Continuous urban fabric	453	650	43.5%
Discontinuous urban fabric	17220	20000	16.1%
Industrial and commercial	2821	3500	24.1%
Construction sites	128	250	95.3%
Port	190	190	0.0%
Airport	282	282	0.0%
Mineral extraction	830	830	0.0%
Dump sites	45	45	0.0%
Road and Rail networks	171	171	0.0%
Green artificial	1057	1057	0.0%
Sand, dunes, bare rocks	602	602	0.0%
Wetlands	4851	4851	0.0%
Water	13868	13868	0.0%

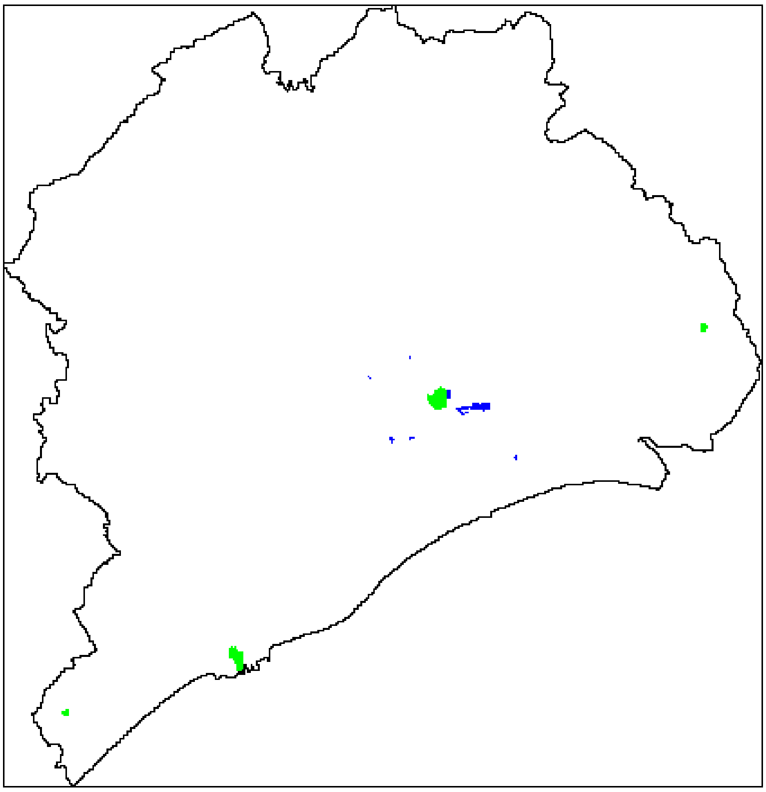

Figure 32: Growth of continuous urban fabric areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

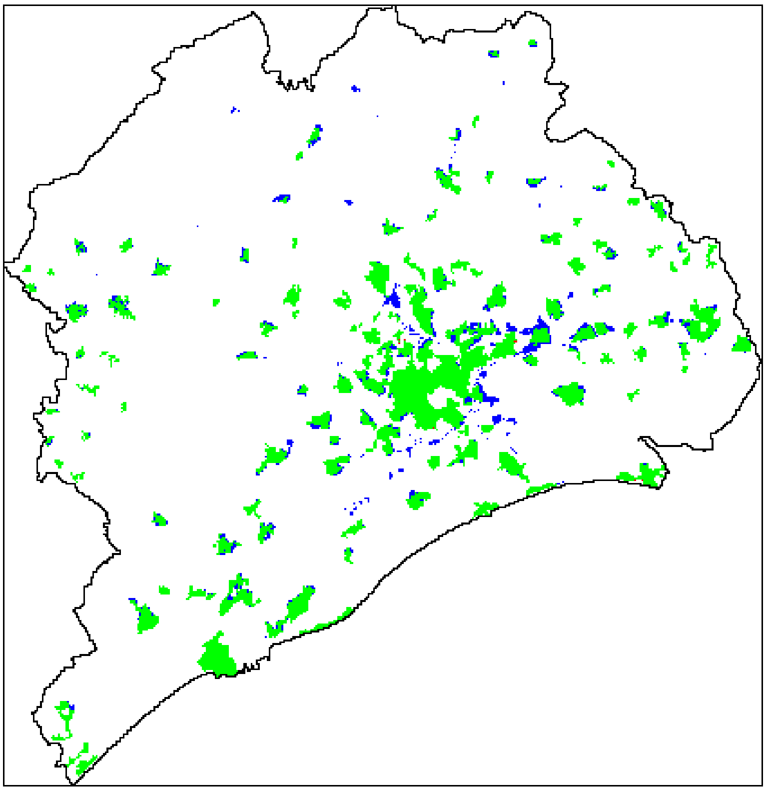

Figure 33 : Growth of discontinuous urban fabric areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

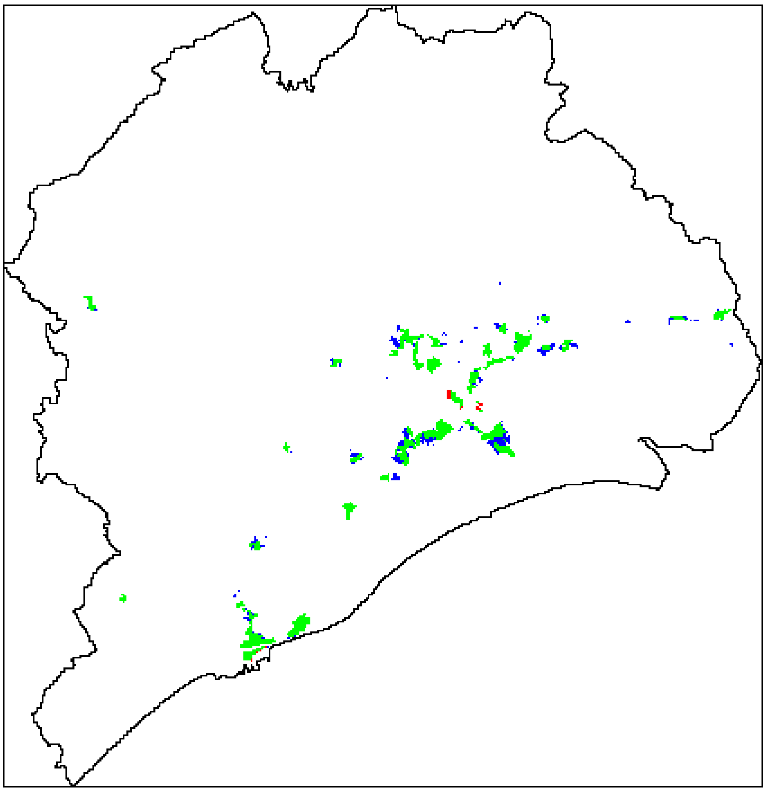

Figure 34 : Growth of industrial and commercial areas. .■ = Areas in 2000 and 2025; ■ = New areas in 2025; ■ = Areas only in 2000

As with all the scenarios, the amount of new urban land was subdivided by the RUR typology. Table 17 summarises the growth in the RUR areas for both urban areas and impervious surfaces.

Table 17. The expansion of urban and impervious surfaces for the PO scenario between 2000 to 2025.

PO	Change in amount of urban land /ha		
	Urban	Peri-urban	Rural
NEW URBAN	**-7**	**2604**	**1043**

4.4 Scenario comparisons

When the scenario results are compared to one another in terms of the criteria set by the indicators, the differences in the outcomes are evident. Table 18 shows the overall changes in land use for the three scenarios, as computed on the entire study area.

Table 18. The overall changes in land use classes for each of the scenarios.

Land use change, 2000-2025 (%)

	BAU	HT1	HT2	PO
Arable land	1.40%	0.09%	0.0%	1.78%
Vineyards & fruit trees	-1.23%	-5.71%	-6.3%	-2.58%
Pastures	-88.76%	-20.22%	-16.9%	-5.62%
Heterogeneous agricultural	-23.21%	-11.28%	-10.6%	-7.60%
Forest	-5.00%	-5.34%	-5.0%	-4.73%
Shrub	-1.97%	-2.39%	-2.2%	-1.67%
Sparsely vegetated	223.44%	223.29%	223.4%	223.89%
Continuous urban fabric	43.49%	120.75%	120.8%	43.49%
Discontinuous urban fabric	27.76%	27.76%	27.8%	16.14%
Industrial and commercial	54.98%	54.98%	55.0%	24.07%
Construction sites	95.31%	95.31%	95.3%	95.31%
Port	36.84%	36.84%	36.8%	0.00%
Airport	41.84%	41.84%	41.8%	0.00%
Mineral extraction	0.00%	0	0.0%	0.00%
Dump sites	0.00%	0	0.0%	0.00%
Road and Rail networks	0.00%	0	0.0%	0.00%
Green artificial	0.00%	0	0.0%	0.00%
Sand, dunes, bare rocks	0.00%	0	0.0%	0.00%
Wetlands	0.00%	0	0.0%	0.00%
Water	0.00%	0	0.0%	0.00%

The relevant increase (+220%) of ‘sparsely vegetated areas’ in all scenarios is due to the suitability maps built up for that class. The increase is due to a conversion from shrub and is located in a single area, north-east of Montpellier. It is the results of the suitability maps (see section 3.5) which are particularly effective for vacant land use classes, and of the calibration performed with the historical maop of 1990, when the area was indeed occupied by sparse vegetation, before being destroyed by a fire. It is therefore not due to zoning or planning policies.

The dynamics of artificial areas are the direct consequences of storylines and are therefore more interesting to remark. It is worth reminding that the three scenarios are driven by different demographic, economic and planning assumptions, which should always be considered in their comparisons.

Increase of urban fabrics (indeed these are residential areas) is typically driven by the demographic growth and by the urban planning strategies. It is therefore not surprising that the growth of continuous urban fabric is facilitated in the compact development depicted in the long March HT1/HT2 scenario. No particular assumptions were made for this class in the old-BAU and PO scenarios - therefore the similar increase.

Statistics for the discontinuous urban fabrics follow the same dynamics –here the main differences between old-BAU and HT1/HT2 is not numerical but rather in the spatial distribution.

Industrial and commercial areas evolve according to the economic storylines; rather positive for old-BAU and PO, while declining in PO.

The summary of statistics divided by the RUR typology is shown in table 20:

Table 20. The amount of new urban land and built-up surface per RUR typology for the four scenarios.

Amount of new urban land (ha)				
	BAU	HT1	HT2	PO
Urban	-85	-62	-62	-7
Peri-urban	4832	4402	4329	2604
Rural	1732	2518	2591	1043
Change in amount of built up surfaces (ha)				
	BAU	**HT1**	**HT2**	**PO**
Urban	-17	-10	-11	-15
Peri-urban	4970	4621	4547	2653
Rural	1844	2557	2633	1125

Changes in natural lands and farmlands, of the four scenarios, are given in table 21.

Table 21. Net change in farmland from 2000 to 2025 for the four scenarios.

Loss farmland	BAU	HT1	HT2	PO
ha	-6004	-5988	-6206	-3199
change %	-7.0	-6.9	-7.2	-3.7

Comparison between the HT1 and HT2 is of particular interest because; thou having the some socio-economic drivers the two scenarios differ in the application of the zoning restrictions. While the statistics computed on the overall study area are substantially similar, the spatial analysis of the two scenarios clearly reveals the different developments induced by the zoning characteristics.

The development of Continuous Urban Fabric (blue areas in figure 35) for the HT2 scenario presents a more scattered pattern than in HT1 – however the overall development is kept within the Montpellier Metropolitan Area. This is the consequence of the ‘attraction/repulsion’ rules which have the same setting in MOLAND for both scenarios.

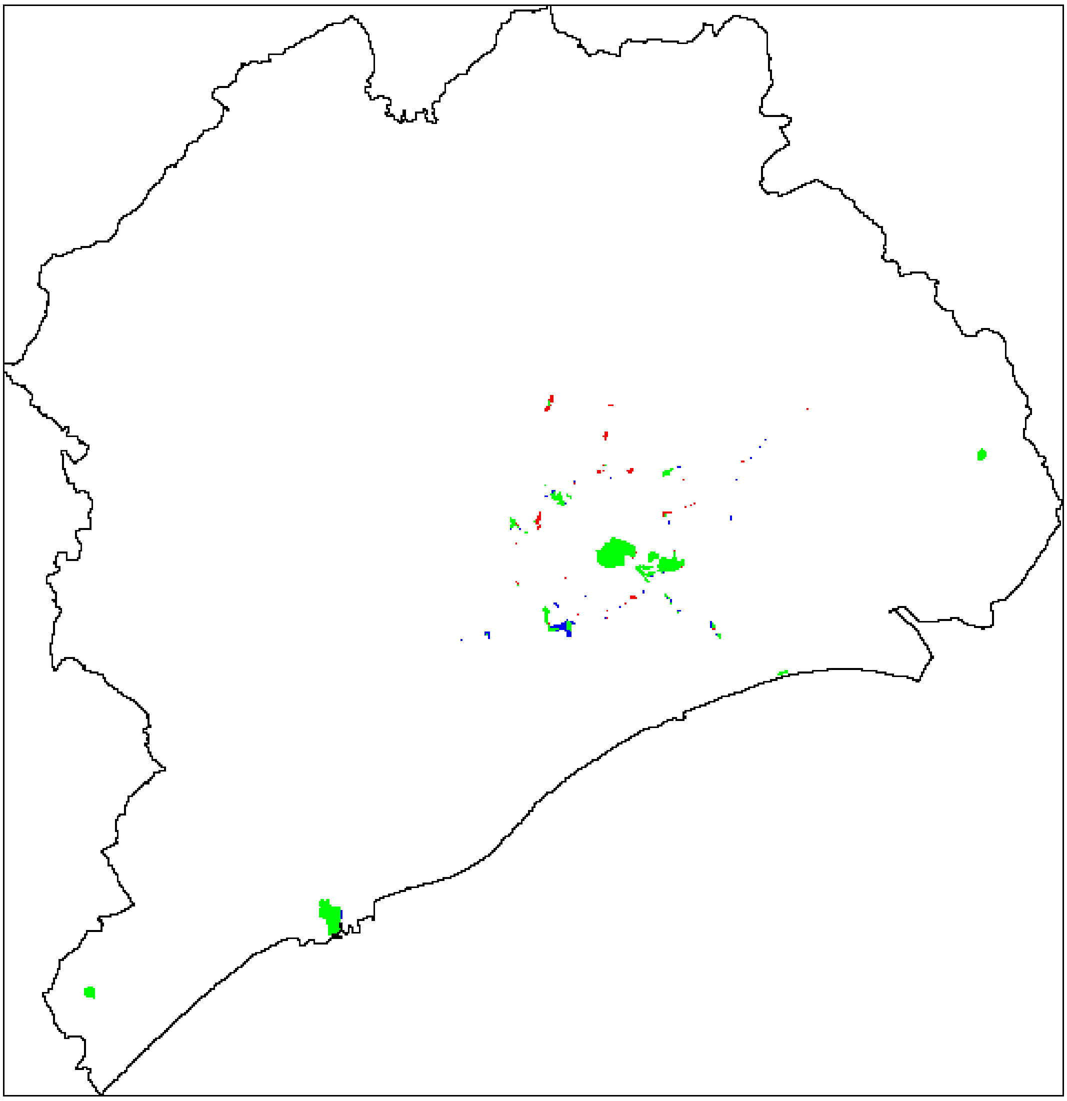

Figure 35: Continuous Urban Fabric in 2025: .■ = CUF Areas in HT1 and HT2; ■ = CUF areas only in HT2; ■ = CUF Areas only in HT1.

The development of discontinuous urban fabric (DUF) shows more clearly the impact of zoning restriction. Indeed, while for HT1 (red areas in figure 36) the DUF are growing mainly within the MMA, for HT2 (blues area in the figure) the DUF areas tend to spread also to the periphery of the overall study area. Attraction and accessibility play a key role in both scenarios.

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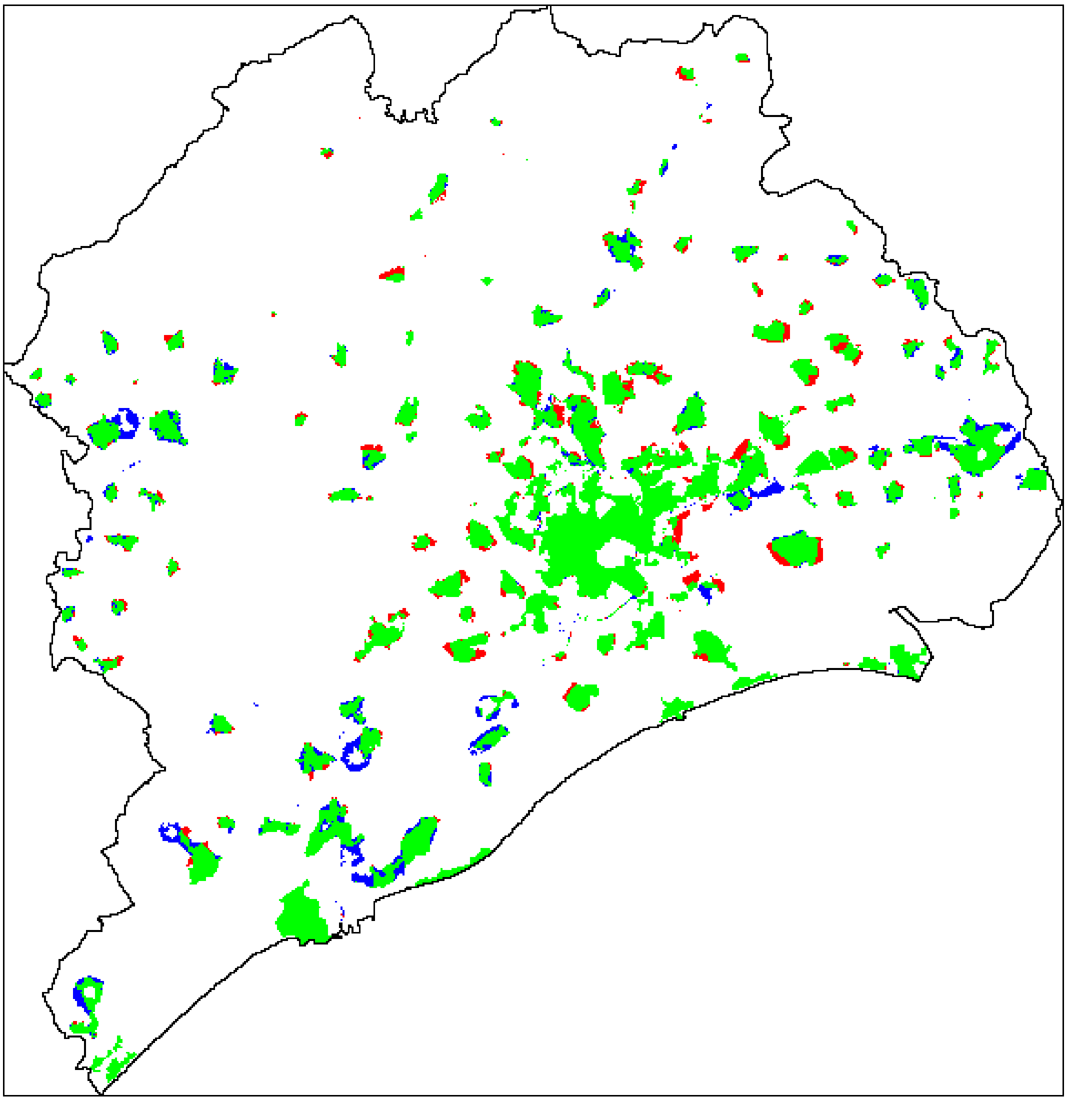
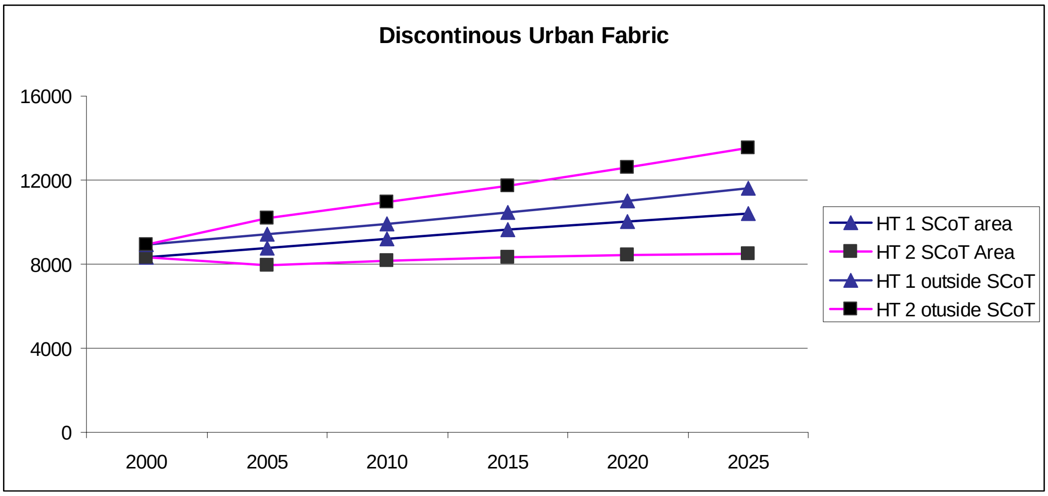


Figure 36: Discontinuous Urban Fabric in 2025: ■ = DUF Areas in HT1 and HT2; ■ = DUF areas only in HT2; ■ = DUF Areas only in HT1.

The graph below presents the evolution along time of the DUF surfaces for HT 1 and HT2, within and outside the SCoT area (which coincides with the MMA).
In the HT2 scenario, the increase of DUF outside the zoning area is evident.



5. Conclusions

Four simulations have been performed for the Montpellier study-area following the scenarios developed by local stakeholder.

The business as usual scenario assumes the abandonment of planning and zoning tools to allow market-driven developments. Sparse residential developments are the main spatial characteristics of this scenario.

The long-march HyperTech is the most realistic scenario for what concerns the application of planning and zoning policies. Two alternatives have been simulated for this scenario. Economic and demographic trends are positive for both alternatives. The resulting projected land use developments present compact urban and industrial patterns for the more controlled alternative (HT1) and a more sparse – although still aggregated around existing blocks – for the HT2 alernative.

The peak oil scenario represents a negative economic and demographic situation. The resulting developments are limited, as expected.

As final remarks, it is confirmed the decisive role of zoning maps in the modelling exercise as key drivers for spatial development. Despite the mismatch between the detailed maps - produced in the frame of the SCoT planning tool - and the coarse Corine Land cover/use does not allow precise thematic correspondence of the most important land use/cover classes (e.g. housing density classes), the simulation has allowed to distinguish main trends towards compactness or sprawl.

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Annex A.

Montpellier Agglomeration.
new approaches for territorial cooridnation in the peri-urban

Jarrige F. Chery JP. Buyck J. Gambier JP. 29/11/2010

Extract from Plurel Book. Chapter 8. Montpellier case study.

Executive summary

Due to the attractiveness of the Mediterranean coastal region where it is located, Montpellier presents a positive migration balance and population keeps on growing in the city-region. Urban sprawl caused deep changes in periurban landscapes during last decades, with individual housing plots spreading around all villages. New buildings took place where vineyards used to be the quasi-unique land-use as result of historical specialization in table-wine mass-production. This sector is more and more weakened by economic crisis, as most of other traditional agricultural sectors. Local economy now largely depends on tertiary activities, such as tourism, education, research, medicine, and new technologies.

These driving forces led to both large population mix and socio-spatial segregation, uncoordinated development and changing periurban landscapes – with an increasing per capita rate of space consumption - until the creation of a new local authority, Montpellier Agglomeration, at the end of 2001. This local government, gathering 31 municipalities, is in charge of several major public policies. Among these public policies formerly implemented by municipalities are: spatial planning (at regional scale), collective transport, water management and housing policy. The creation of Montpellier Agglomeration brought about deep changes in local governance and planning practices.

How does this new authority address the challenges of sustainable development at regional scale? What are the governance issues, and what development strategies have been established? What spatial planning tools are implemented? What contrasted scenarios can be drawn for future development? And what are the impacts of these scenarios when assessed against an integrated analysis in terms of sustainable development?

Lessons can be learned from the experience of Montpellier Agglomeration in the field of periurban land use relationships, and in order to share them with European partners, experts and stakeholders of periurban land use management, this chapter presents the following items:

- The local context is broadly presented through historical changes in land uses and demographic components in Montpellier city-region. Local governance issues are also analysed, as are the different steps of the construction of Montpellier Agglomeration. The new French system of land planning is then detailed regarding the issue of periurban land use.
- The SCoT (territorial coherence scheme) of Montpellier Agglomeration is analysed and assessed as an innovative experience of regional planning. Analysing the drawing and the implementation of this new tool of spatial planning policy gives an overview on major issues for periurban land use: policy directions and governance practices, solutions (or attempts) to contain urban sprawl. The SCoT of Montpellier Agglomeration stands out because of the attention paid to the protection of open spaces (either natural zones and farmland), and the use of landscape as major vector of urban planning. It also enacts strong development rules to intensify urban development and contain urban sprawl. Expectations are also put on farming as a tool to secure urbanization limits and guarantee the sustainability of periurban landscape.
- Four land use scenarios explore the future of the Montpellier Agglomeration, according to different types of territorial governance (following up the control strategy initiated with the SCoT, or back to uncontrolled land business and urban sprawl), and under different external pressures such as rising oil prices and climate change. How well do current development paths perform under these radically different conditions? What can be concluded for the future spatial planning in the peri-urban and instruments such as the SCoT from this exercise?

Four prospective scenarios to imagine the future of Montpellier Agglomération and assess present policies

Four scenarios have been elaborated to explore future land use patterns for Montpellier Agglomération, with a special concern to urban/rural relationships and sustainability of the urban system. These scenarios are based upon local/internal factors and global/external driving forces, more or less important according to scenarios.

From a local point of view, strategic parameters for future alternative scenarios are based upon major components of the strategy analysed in the SCoT:

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- Territorial governance: local political leadership and type of policies, stakeholders association and involvement
- Local economy: major leading activities, specially in innovative fields, and the future of farming, major land use in periurban areas
- Territorial perimeter: will Montpellier Agglomération remains at 31 municipalities or expand to gather cities in the north (Nîmes, Ales) and in the south (Sète, Thau)?

These local factors strongly beset the two first scenarios, 1) the "long March" or the advent of the hypertech metropolis, which can be considered as the following up the voluntary development policy and control strategy initiated by Montpellier Agglomération with the SCoT, and 2) back to old "business as usual", which means back to uncontrolled land business and urban sprawl, as experienced in the past in Montpellier city-region.

These scenarios showcase two radically different paths concerning local governance. The first one showcases the reinforcement of the power of the local government, renewing and enlarging the vision of local development coordinated at the scale of the entire city-region, socially and spatially integrated, and strengthened around Montpellier centre. This scenario follows through the virtuous choices initiated by Montpellier Agglomération with the SCoT. The second scenario showcases a weakening of local governance that will lead to a mitigation of urban sprawl control and an increase in socio-spatial segregation. "Back to old business" means free space for market forces and no or little public control on land use, as Montpellier city-region has experimented during three decades of demographic growth and urban sprawl before the creation of Montpellier Agglomération and the drawing of the SCoT.

The comparison of these two scenarios can be considered as an assessment of the relevance and the robustness of the tool of strategic planning of Montpellier Agglomération, the SCoT.

External driving forces are decisive in the two other scenarios, 3) Peak oil and the technopolitan model decline, and 4) Extrem water: Montpellier city-region victim of the Mediterranean see. These two scenarios have been drawn in a comparison perspective with other Plurel case studies. These two last scenarios are less sensitive to local changes in governance. Whatever the future development strategies may be, external drivers have major impacts. So these two scenarios put to the test development decisions and choices made nowadays in the SCoT.

These four scenarios are presented following the same items list: policy, economy, urban planning, infrastructures, agriculture and climate.

Scenario➢ Themes⮟	The "long March" or the advent of the hypertech metropolis	Back to old "business as usual"	Peak oil and the technopolitan model decline	Extrem water
Politics	The current President of Region Languedoc-Roussillon is re-elected at regional elections in 2010. Directly or indirectly, he controls regional public policies at all levels. This coordination is accelerated by the merger in a unique regional authority (nuts 2) of the 5 General Councils (Departements, nuts 3), after their bankruptcy following the reform of local governments and their taxation system (decrease of their tax resources). Montpellier Agglomeration becomes an Urban Community, with enlarged competences, and covers an extended metropolitan area from Sète in the south west to Nîmes and Ales in the north east. Unified political management allows achieving a balance between economic, social and environmental issues at the scale of the city-region, which now fits with the functional urban area. At the end of 2025, the capacity of local actors to come into negotiation with their neighbours holding different, thus complementary, resources, becomes essential. An integrated regional governance system is achieved.	The regional elections of 2010 put an end to the current President era at Regional Council. At national level, the same President is re-elected in 2012, and locally, the political majority of the city changes. Economic liberalism, either chosen or imposed because of lack of public resources following financial crisis, drives public policies. State disengagement carries on and social inequality raises. The poorest have little access to quality of life and live mostly in cities. The spirit of gated communities now also applies to inter-municipalities. Montpellier Agglomeration becomes an Urban Community competing with neighbouring territories: Communities of Thau lagoon, Pic Saint Loup and Pays de Lunel. Contrary to the unified and centralized situation at the scale of the city-region in scenario 1, in this case there is a "balkanization of territories".	The time of finite urban world started with the disappearance of oil. A law now prohibits any new urban development without integrated solution of collective transports. It marks the end of the period known as peri-urban which was born, in France, in the 1960s with the explosion of car market. The Minister of Social Cohesion and Territorial Solidarity launches a program to support new neighbourhoods of large peripheral housing estates inherited of the old urban sprawl and penalized by their isolation.	The politics is not in the heart of this scenario. Whatever the political options may be, they have little impact compared to global / natural / external factors which play a decisive role.

Scenario➢ / Themes⮛	**The "long March" or the advent of the hypertech metropolis**	**Back to old "business as usual"**	**Peak oil and the technopolitan model decline**	**Extrem water**
Demography	There is a record population growth: +1.7% to +2% per year. Through Local Housing Program, the population increase is absorbed without problems thanks to social and territorial solidarity in housing policy at the scale of the great metropolitan area. Long-distance commuters living part of the week in residential areas, dwellers in small towns and villages adjacent to the new centres, rural metropolitans: all newcomers have ways to take advantage of the new inter-territoriality.	Demographic growth is still high (1.3% per year), but spatially segregated with "social sorting". Social barriers and local identity are at the heart of conflicts between local "ghettoized" populations.	The high cost of fossil fuels imposes a halt to population growth (0.1%). Peri-urban housing, which implies individual commuting, has become a major trap for people who have no access to employment. High social tension is transferred to the city centre. Municipalities are trying to support their citizens with difficulty.	There is a very moderate demographic growth (0.3% per year) or even a population decline. This is due to two factors: the sea level rises of 1 or 2 meters (less room for new residents or for re-housing climate refugees) and Cevennes rain episodes are now very common (natural hazards also reduce land capacity for urban fabric).
Economy	The sector of personal services knows a record development in a "French California" type new economic metropolitan model ("Sud de France" University, coupled with Research and Development of local enterprises). New technologies are booming, from firms-nurseries like the public Montpellier International Business Incubator (MIBI).	The technopolitan model is questioned. Main economic activities are in the fields of personal services and residential economy. Most investments made in local economy come from offshore funds, in real estate and high-end services.	The announcement that the forecasts of oil reserve stocks were completely overestimated has the effect of a global tsunami. Transport becomes the largest household budget item. Local economy has to be completely reviewed: it is necessary to resolve the decline of the technopolitan economic model. Logistics hubs of the languedocian corridor close one after the other. There is a widespread conversion with great difficulty. Only new technologies make the most of this delicate situation. Alternative energies are developing (solar cells, wind mills).	Local economy follows the model of Agenda 21. All urban planning schemes are reviewed to put people out of risk. Tourism activities lose the seaside component since beaches have vanished, and most direct and indirect jobs linked to tourism disappeared. On the other hand, global warming allows taking advantage of hot winds that provide good generation power in addition to mass production of solar cells.

Scenario➢ / Themes⮟	The "long March" or the advent of the hypertech metropolis	Back to old "business as usual"	Peak oil and the technopolitan model decline	Extrem water
Urban planning	The SCoT gets into version 2: the perimeter of the SCoT is extended to the whole corridor of Languedoc (from Sète to Nîmes). **High building density and precise urban limits are generalised urban planning rules**. The establishment of a Local Public Urban Planning Society, in charge of urban planning, "in house" operator of municipalities, enables the implementation of public policies without the hazards of setting competition between developers. Tested in Montpellier, it has now extended jurisdiction over the entire metropolitan area as quasi-monopoly public service.	Urban planning is going out the window: the SCoT is put on ice. "Land hunting" is reactivated. Public planning tools are given up (deletion of land pre-emption rights and of landowning public establishments) due to litigation according to European law of free market in urban planning. This gives full place to private real estate monopolistic developer. Urbanization is opened to provide access to sites with high landscape value, dedicated to high income executives and retirees. City centres are impoverished: there is no more social housing programs. Socio-spatial segregation is reinforced with new gated communities.	Public transports, which pool the costs and are affordable, are at the heart of this scenario: the long phase of housing redistribution within sprawled urban areas seems to have stabilized along transport infrastructure and near services. Urbanisation refocuses in a sense of strong polarization on Regional Express Train (TER) and tramway. Through this prism, spatial segregation is reinforced. A "gerontocratic" atmosphere prevails in peri-urban villages where high income European pensioners, released from commuting, are concentrated.	New urban developments have to respect enlarged corridors for possible flooding. The SCoT is reviewed in this perspective. Concentration of risk-free housing is the priority. It leads to the expansion of urban areas to accommodate climate refugees who fled away from littoral municipalities. Land conflicts are exacerbated on the fringes of remaining spaces. The airport disappears under water. The topping out of High Speed Train Line is the frontline of the fight against the Mediterranean Sea.
Infrastructures	The Urban Transport Plan is completed in the whole new area of the great SCoT. Tramway network reaches Mèze in 2015. All major transport infra-structures planned are now built: highway A9bis, Nîmes-Montpellier High Speed Rail Line bypass, new TGV Rail station in 2020, single airport for the metropolitain area, Sète competitive harbour. Like new TGV station district, mobility hubs gained strategic values that help structuring new metropolitan urbanity.	Public transport infrastructures like tramways are given up because of lack of public funding. The A9 highway is doubled south of the Montpellier Agglomeration area. High Speed Railway (LGV) is built and the operating of the new TGV rail station is licensed in 2020 to a private company.	Public transport is strengthened but not enlarged: the peri-urban is neglected. Regional train network is maintained for the benefit of central cities. Municipalities have no means to pay for transport extensions such as new airport. A9bis highway bypasses and High Speed Train Line (LGV) project is abandoned. There are no water projects for agriculture.	The dream of the President of Region Languedoc-Roussillon and former mayor of Montpellier materializes, but it is not "Montpellier which goes to the sea", it is the reverse… Montpellier harbour has to be built as Sète became an island, and its harbour has been overwhelmed. The High Speed Train Line is along the coast. The building of the TGV rail station in the south-east of the city is compromised.

Scenario➢				

Themes⮟	The "long March" or the advent of the hypertech metropolis	Back to old "business as usual"	Peak oil and the technopolitan model decline	Extrem water
Agriculture	Since the demise of General Councils in France, the legal competence on natural areas has been devoluted to Regional Councils, and rural land development to urban authorities. Public supports contribute to farming activities, more and more considered as common heritage of new urban territories. In the Languedocian Metropolis, agriculture is now based on high-tech and high quality farming systems: organic crops, greenhouses,... with increasing local sourcing for food products. Some high tech vineyard remains, successfully achieving competitiveness in a globalized wine economy. Besides vineyard, multifunctional agricultural areas are dedicated to both production and recreational uses.	Horsification expands at the expense of farmland and vineyards. Owners of farmland massively turn to production equipment of solar energy. Accelerated disintegration of farming goes on because of globalized competition and the end of public support (from EU or local governments).	Although people from countryside feel they are the losers of development and spatial planning policies, "return to land" is a necessity. There is a boom in family food gardens, and for the movement "back to the land". The concept of agripark is developed. A problem remains for local food system if no solution is found to provide water for agricultural diversification.	Agriculture is delocalized in the northern rural districts of the region. Municipalities have to care and provide open space freed up to maintain public access to nature, for people in situation of ecological stress. There is a revival of some Mediterranean productions like sheep. But warming raises a problem with no possibility of irrigation: the issue of water and water for agriculture is deteriorating.
Climate	The climate is not decisive in this scenario.	The climate has no major impact in this scenario.	This scenario is sensitive to climate: warming limits the production capacity in the farm-to-fork system, imports have become expensive because of transport costs.	Sea level rises of 1 or 2 meters and the Cevennes rain episodes are more frequent and devastating. Temperatures are rising and with them the risks of sun exposure for people. The attraction of the seaside disappears, it is swarming with jellyfish and the beaches no longer exist: seaside tourism collapsed.

Annex B.

Table B1. Kappa statistics for the true land cover and simulated land cover for 2000

Method	Kappa
Map1	I:\ISPRA\PLUREL\PLUREL\Montpellier-june\land_use\land use map_2000-jan-01.rst
Map2	I:\ISPRA\PLUREL\PLUREL\Montpellier-june\mclc00rec5b.asc
Kappa	0.95181
KLocation	0.96097
KHisto	0.99047
Fraction corre	0.962

	Arable land	Vineyards & f	Pastures	Hetrogeneous	Forest	Shrub	Sparsely v	_Continuou	_Disconti	_Industria	_Constru	_Port_	_Airport_	Mineral e	Dump si	Road an	Green arti	Sand, du	Wetlands	Water	
Kappa	0.93293	0.97598	0.89443	0.91458	0.9617	0.96218	0.46525	1	0.91494	0.80322	-0.0006	1	1	0.99339	1	0.97295	0.94008	1	0.99245	0.99857	
KLoc	0.93426	0.97675	1	0.9292	0.9855	0.96253	0.9955	1	0.91494	0.80322	-0.0006	1	1	1	1	1	1	1	0.9981	1	
KHisto	0.99858	0.99921	0.89443	0.98427	0.9759	0.99963	0.46735	1	1	1	1	1	1	0.99339	1	0.97295	0.94008	1	0.99434	0.99857	
Map 1 \ Map	Arable land	Vineyards & f	Pastures	Hetrogeneous	Forest	Shrub	Sparsely v	_Continuou	_Disconti	_Industria	_Constru	_Port_	_Airport_	Mineral e	Dump si	Road an	Green arti	Sand, du	Wetlands	Water	Sum Map 1
Arable land	3003	0	0	21	61	102	3	0	0	30	0	0	0	0	0	0	0	0	0	0	3220
Vineyards & f	46	59014	0	432	0	0	0	0	424	89	23	0	0	0	0	0	0	0	0	0	60028
Pastures	0	0	89	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	110
Hetrogeneous	151	290	0	20497	0	0	0	0	749	109	31	0	0	0	0	0	52	0	9	0	21888
Forest	0	15	0	16	17194	188	0	0	11	2	0	0	0	0	0	0	0	0	0	0	17426
Shrub	0	263	0	354	956	70743	0	0	129	66	13	0	0	0	0	9	67	0	0	0	72600
Sparsely vege	0	0	0	36	0	1488	671	0	0	0	0	0	0	0	0	0	0	0	0	0	2195
_Continuous	0	0	0	0	0	0	0	453	0	0	0	0	0	0	0	0	0	0	0	0	453
_Discontinuou	11	388	0	673	5	12	0	0	15870	242	19	0	0	0	0	0	0	0	0	0	17220
_Industrial an	0	124	0	370	0	31	0	0	10	2273	13	0	0	0	0	0	0	0	0	0	2821
_Construction	0	3	0	106	0	0	0	0	9	10	0	0	0	0	0	0	0	0	0	0	128
Port	0	0	0	0	0	0	0	0	0	0	0	190	0	0	0	0	0	0	0	0	190
Airport	0	0	0	0	0	0	0	0	0	0	0	0	282	0	0	0	0	0	0	0	282
Mineral extra	0	0	0	11	0	0	0	0	0	0	0	0	0	830	0	0	0	0	0	0	841
Dump sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	0	0	0	0	0	45
Road and Rai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	162	0	0	0	0	162
Green artificia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	938	0	0	0	938
Sand, dunes,	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	602	0	0	602
Wetlands	0	0	0	0	0	0	0	0	18	0	8	0	0	0	0	0	0	0	4842	37	4905
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13831	13831
Sum Map 2	3211	60097	89	22516	18216	72564	674	453	17220	2821	128	190	282	830	45	171	1057	602	4851	13868	219885

Land Use Relationships
In Rural-Urban regions

Module 2

August 2010

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

D2.4.3c

Land use projections based on Moland output

Part C: Summary of effects of policy and summary of effects by the rural / periurban / urban subregions in Leipzig, Haaglanden, Montpellier and Koper

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SIXTH FRAMEWORK PROGRAMME

Contents

Abstract

The cellular-automata model Moland was applied to four case studies throughout Europe: Leipzig (DE), Koper (SI), South Holland (NL) and Montpellier (FRA) at variable spatial and thematic resolutions. The scenario description, the land use classes and the time frame were developed in collaboration with local stakeholders within the context of the project PLUREL, and therefore differ from one another. Qualitative scenario descriptions were laid out and translated into appropriate terms for the land use modelling exercise.

Firstly, this note presents the aggregated results for the land use simulations performed for the four PLUREL case studies, following the sub-regional subdivision defined in the RUR terminology: urban, peri-urban and rural areas. For each case study a brief description of the policy scenarios and of the achieved simulations is given.

Then, a more detailed analysis is performed for the scenario B1 which, although with many local variations, is common to all case studies. MOLAND simulated results are herein compared with a common European-wide simulation for the same baseline scenario.

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

Spatial scale for results: Regional, national, European	Regional/European
DPSIR framework: Driver, Pressure, State, Impact, Response	Driver/Pressure/State/Impact/Response
Land use issues covered: Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation	Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation
Scenario sensitivity: Are the products/outputs sensitive to Module 1 scenarios?	Yes
Output indicators: Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions	None
Knowledge type: Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks	Tables and charts

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

1. Introduction

The main aim of this note is to compare the outcomes of the four PLUREL test cases duly taking into account the dissimilarities amongst the cases and keeping present that it is not logically (nor technically) correct to directly compare the case studies to one another because of differences in legend, scale and input parameters between the test cases.

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).

At first, this note presents the statistics for the land use simulations for the four PLUREL Case Studies as performed the urban growth model MOLAND. Statistics are aggregated according to the sub-regions (urban, peri-urban, rural) subdivision defined in PLUREL. Then, a more detailed analysis is performed for the scenario B1 (common – although with many differences – to all case studies), comparing the MOLAND simulations with the land use projections provided by the European Land Use Model EUClueScanner.

2. The four PLUREL Case Studies

Within the context of the project PLUREL, the model Moland was applied to four case studies throughout Europe: Leipzig (DE), Koper (SI), South Holland (NL) and Montpellier (FRA) at 50 or 100m resolutions. The scenario description, the land use classes and the time frame were developed in collaboration with local stakeholders, and significantly differ from one another. Qualitative scenario descriptions were laid out and translated into appropriate terms for the land use modelling exercise.

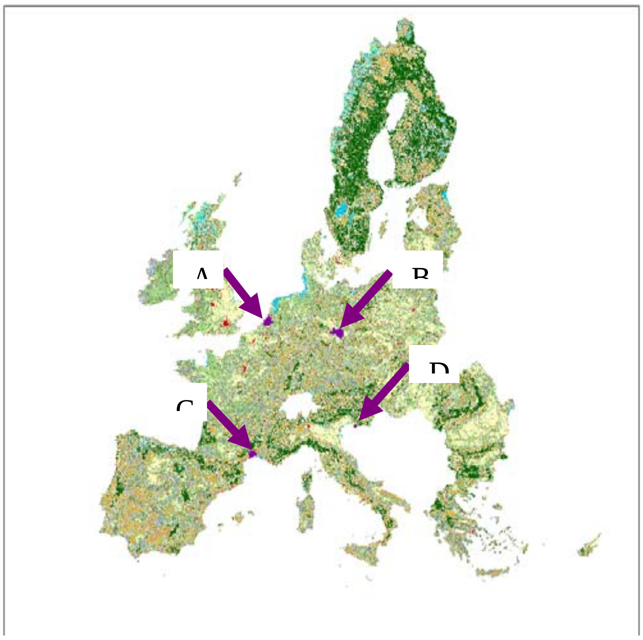

Figure 1. The test case areas for the PLUREL project

A. South Holland (NL)
B. Leipzig and Halle (DE)
C. Montpellier (FR)
D. Koper (SI)

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”.

Leipzig — Halle
Location: C. Germany
Economic profile: services
Scenarios run: BAU, A1, A2, B1, B2
Input LC map: Corine Land Cover 2000
Forecast: to 2025
Uniqueness: Agent-based modeling on Moland results
Scenario description:
BAU:increase in construction, industrial sites and discontinuous urban fabric (DUF) in S. Halle and S. Leipzig at expense of open and shrub lands
A1: Growth of industrial and construction sites, mainly due to the decline of arable land. Expansion of DUF shows a more polycentric pattern in S. Leipzig at expense of forest and agricultural land
A2: Expansion of continuous urban fabric (CUF), mainly in peri-urban areas, at the expense of pasture and shrub. Growth of industry and commercial areas is more common in rural areas
B1: densification of dense urban fabric (CUF); new clusters of DUF emerge close to or connected to industrial sites, mainly in peri-urban and rural areas
B2: modest growth in urban fabric; 40% increase in industry and commerce at expense of pasture, mixed agricultural and shrubs

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 which specifically requested to have the results for each scenario broken down to community level. Statistics per soil type classification were also requested and extracted in order to facilitate analysis of impacts of each scenario on quality soil.

Koper
Location: W. Slovenia
Economic profile: tourism, services
Scenarios run: BAU, A1, B1
Input LC map: Municipal maps, 2007
Forecast: to 2025

Uniqueness: Implementation of soil quality mapping for the B1 scenario; extrapolation of land use data on best soils
Scenarios description:
BAU:abandonment of agriculture and residential areas in hinterland, expansion of port and roadside expansion of built-up in peri-urban zones
A1: increase of tourist attractions and infrastructure; and commerce, residential and services at expense of permanent crop and pasture land. Competition for best soils results in loss of best soils to built-up
B1: growth in agricultural sector and subsequent valorization of hinterland with new residences and services appearing in those areas (taking pressure off the coastline). Best soils are used for agriculture

Three scenarios were run for the **Haaglanden** (South-Holland province (Netherlands)) from 2004 to 2040: 'Business as usual', 'Peak oil' (B1) and 'Fragmentation' (B2). The parameters for the scenarios were set in collaboration with local stakeholders at several meetings spanning 2008-2010. Three of four strategies defined by the stakeholders were also run on top of these scenarios. Strategy 1 refers to 80% of new construction happening in already existing urban areas and is run by allowing construction of new residences inside of the already existing urban fabric. Strategy 2 is the "Discourse development" whereby making green space important is emphasized. This strategy is not included in the scenarios. The third strategy refers to green and blue services. This strategy is run using arbitrarily chosen parcels of a given percentage (stipulated by Alterra). The fourth and final strategy, referring to the Agrarian banking system, is also run using arbitrarily selected parcels as part of the incentives. The number of parcels used in this scenario was dependant upon the number stipulated by Alterra.

Location: Haaglanden
Economic profile: horticulture, services
Scenarios run: Business as usual, B1, B2 + 3 strategies for each baseline scenario
Input LC map: Alterra, 2004
Forecast: to 2040

Uniqueness: Application of planning strategies to each scenario (Urban compactness, Green and Blue Services, Agrarian land banking)

Scenario description:

BAU: Limited extension of urbanization and limited loss of arable and pasture land. Residential development at cost of greenhouses. Rotterdam port is transferred from the city center to the sea; the eastern part of the port is replaced by housing and work places.

B1: Less urbanization than for BAU. Growth of greenhouses (used as alternative energy sources); Rotterdam port is transferred from the city center to the sea. Some of the vacated port land is transformed into residential.

B2: 50% of greenhouses and much of Rotterdam port are vacated. The only thriving area is near Delft because of the R&D sector

Four scenarios were run for **Montpellier** from 2000 to 2025: 'Business as usual', 'Peak oil' (B1) and two variants of the 'HyperTech' (A1). The main characteristics of the simulations were the role of the zoning plans: rather restrictive in the first variant of HyperTech (HT1), more permissive only outside the metropolitan agglomeration in the second variant (HT2), and almost fully relaxed for the other two scenarios, despite of different socio-economic drivers.

Montpellier

Location: S. France

Economic profile: tourism, services

Scenarios run: BAU, A1, B1

Input LC map: Corine Land Cover 2000

Forecast: to 2025

Uniqueness: Study of the implementation of the detailed ScOT regional planning tool

Scenario description:

BAU:abandonment of existing planning tool leads to uncontrolled urban sprawl, predominantly replacing pasture

A1:Key planning instrument in place; higher demographic and economic growth than for BAU.

B1:Economic and social decline leads to few improvements to infrastructure and very few changes in land use because of lack of demand for land

3. Aggregated results

Aggregated land-use simulation results according to the RUR classification are presented in the following table for all scenarios for each case study.

The following tables resume the statistics for the four case studies.

Table 1: Leipzig: the simulation of land use evolution (2000-2025), considered different scenarios developed by local stakeholders - "Business-as-usual", "Hyper-Tech", "Peak Oil" and "Fragmentation".

% change from 2000 to 2025 per scenario					
		BAU	*HT*	*PO*	*FR*
% change in built-up	*Urban*	3.27	1.93	1.84	1.44
	Peri-urban	23.85	34.05	18.81	13.49
	Rural	29.09	47.7	29.23	14.72
% change in farmland	*Urban*	-31.04	-16.9	-11.95	-13.5
	Peri-urban	-2.33	-3.09	-1.26	-1.1
	Rural	-1.01	-0.95	-0.34	-0.38
% change in natural	*Urban*	-29.05	-17.11	-16.32	-12.84
	Peri-urban	-3.4	-4.85	-2.68	-1.92
	Rural	-2.06	-3.37	-2.07	-1.04

Leipzig: The BAU scenario produces the highest impacts in the RUR-Urban area for what concern increase of built up areas and decrease in farmland and natural areas. The HT scenario results in the highest increase of urbanisation in both the peri-urban and rural areas. Farmlands are decreasing in the urban area, especially for the BAU scenario – with an analogous trend for natural areas. Farm/valuable land changes are more intense in Hyper-tech scenario and not so significant in Fragmentation scenario. On the opposite side, new urban land emerges mainly on Hyper-tech scenario, and Fragmentation register the smallest increase.

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", in Fragmentation scenario the emphasis is in the "high environmental protection: green ring map".

Table 2: Koper: Three scenarios were run for the Koper municipality from 2007 to 2025: Business as usual, Hyper-tech (A1) and Peak oil (B1).

% change from 2007 to 2025 per scenario				
		BAU	*HT*	*PO*
% change in built-up	*Urban*	7.83	12.4	10.77
	Peri-urban	26.3	33.43	12.71
	Rural	-21.6	-15	24.36
% change in farmland	*Urban*	17.78	-11.11	22.22
	Peri-urban	4.26	3.17	5.17
	Rural	2.51	2.48	2.61
% change in natural	*Urban*	-38.46	-55.56	-11.11
	Peri-urban	5.43	5.54	4.48
	Rural	5.24	5.53	5.25

Koper: The peri-urban area is the most impacted by all three scenarios in terms of increased urbanisation. Changes in extent of farmlands is rather limited, but in the urban area. It is worth noting the increase of farmland as result of policies for BAU and PO and a net decrease in the HT scenario. Natural areas are particularly 'suffering' in the BAU and HT scenario.

Table 3: Haaglanden - Three scenarios were run for the South-Holland province (Netherlands) from 2004 to 2040: 'Business as usual', 'Peak oil' (B1) and 'Fragmentation' (B2).

% change from 2004 to 2040 per scenario				
		BAU	*PO*	*FR*
% change in built-up	*Urban*	0.10	0.10	-1.24
	Peri-urban	-0.06	4.17	-6.62
	Rural	3.82	5.82	6.41
% change in farmland	*Urban*	-5.17	-10.69	34.00
	Peri-urban	-0.22	-1.27	2.36
	Rural	-0.55	-0.99	-1.09
% change in natural	*Urban*	0.00	0.00	0.00
	Peri-urban	0.00	0.00	0.00
	Rural	-0.75	-0.75	-0.75

Haaglanden: The relative land use/cover changes over the all zones are limited to less than 1%, apart for the loss in farmland in the urban area for all scenarios. The Fragmentation scenario produces increased urbanization only in the rural area.

Table 4: Four scenarios were run for Montpellier from 2000 to 2025: 'Business as usual', 'Peak oil' (B1) and two variants (HT1 and HT2) of the 'HyperTech' (A1).

		% change from 2000 20 2025 per scenario			
		BAU	HT1	HT2	PO
% change in built up	Urban	-0.2	-0.1	-0.1	-0.1
	Peri-urban	70	65.3	64.2	37.5
	Rural	39.8	55.1	56.8	24.3
% change in farmland	Urban	0	0	0	0
	Peri-urban	-12	-11	-10.9	-6.5
	Rural	-2.8	-3.8	-4	-1.6
% change in natural	Urban	0	0	0	0
	Peri-urban	-4.6	-12.1	-7.3	-2.1
	Rural	-0.8	-1.1	-1.1	-0.5

Montpellier: The business as usual scenario assumes the abandonment of planning and zoning tools to allow market-driven developments. Sparse residential developments are the main spatial characteristics of this scenario.

The long-march HyperTech is the most realistic scenario for what concerns the application of planning and zoning policies. The resulting projected land use developments present compact urban and industrial patterns for the more controlled alternative (HT1) and a sparser – although still aggregated around existing blocks – for the HT2 alternative. The peak oil scenario represents a negative economic and demographic situation. The resulting developments are limited, as expected. As final remarks, it is confirmed the decisive role of zoning maps in the modelling exercise as key drivers for spatial development. Despite the mismatch between the detailed maps - produced in the frame of the SCoT planning tool - and the coarse Corine Land cover/use does not allow precise thematic correspondence of the most important land use/cover classes (e.g. housing density classes), the simulation has allowed to distinguish main trends towards compactness or sprawl.

4. Interpretations of the B1 Scenario

Table 5 summarises the interpretations of the B1 scenario for each of the test cases. It is difficult to find a common thread in all test cases. Most emphasise environmental protectionism and urban compactness, there is also however a movement to valorise the agricultural sector, and this comes at the expense of farmland.

Table 5 : The different B1 scenario interpretations for the four Moland test cases in PLUREL

	Leipzig-Halle	Montpellier Agg	Haaglanden	Koper
General description	On the existing brown fields and empty redeveloped houses, new residential development inside of the city leading to. Existing old buildings are preserved or demolished leading to perforation. Services close to industry.	Finite urban world with the disappearance of oil. A law now prohibits any new urban development without integrated solution of collective transports.	Emphasis is placed on social issues and environmental sustainability	Society whose priorities are in services and informatics rather than industry and production. Emphasis is placed on social issues and environmental sustainability
Population	Increase of population due to in-migration of the young.	Halt to population growth (0.1%)	The population is described as reaching a peak growth and the decline after 2020 Some housing appears in hinterland but growth is limited due to strong incentives to maintain “natural” areas such as agricultural areas, pasture and bulbs	Peak growth and the decline after 2020 overall increase of 12% from 2000-2025

Economy	GDP is increasing. The industrial activity is reinforced. New investment in manufacturing, tourism and services. More employment in science.	Logistics hubs of the L*anguedocian corridor* close one after the other. Only new technologies make the most of this delicate situation. Alternative energies are developing (solar cells, wind mills).	The services-based areas of The Hague and Delft prosper while Rotterdam is on the decline due to a slightly shrinking port, which in turn is due to the rising costs in petroleum and its derivatives; The greenhouse industry suffers from increasing transportation costs, but does not collapse entirely	Economic incentives to agriculture sector; growth of this sector in hinterland
Infrastructure	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.	Public transports are at the heart of this scenario; housing redistribution within sprawled urban areas stabilizes along transport infrastructure and near services. Urbanisation refocuses in a sense of strong polarization on Regional Express Train (TER) and tramway. Public transport is strengthened but not enlarged: the peri-urban is neglected. Regional train network is maintained for the benefit of central cities.	Port activity remains somewhat steady, as for the BAU scenario, there is a shift towards the water from the city center of Rotterdam, thus leaving land available for other uses.	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
Environment	Moderate environmental intervention. High energy prices affect transport costs limiting commuting distances.	There is a boom in family food gardens, and for the movement “back to the land”. The concept of agripark is developed.	Emphasis is placed on environmental sustainability; new building is limited in hinterland	Conservation of quality soils; Respect soil fertility classification and Natura 2000 as zoned for no building; Eco-tourism emphasizes attractiveness of natural areas and inland areas

In order to compare the land use changes between the different scenario configurations and the baseline pan-European configuration, an approach detailed in Pontius et al (2004) is used. This method is adopted because it corrects for the persistence of land use classes, an annoying factor which is cause for bias and misleading results in the calibration process and comparative studies. In this method, the results are corrected for amount of change and persistent land use is not taken into consideration in the final statistics.

First, matrices for the percent changes in terms of net gains were produced for each of the test cases for the B1 scenario and for the European baseline B1 scenario, performed by the EUClueScanner model. Within these matrices, the values for the actual percent of the landscape, the expected percent of landscape if the change was random and the actual percent minus the expected percent are calculated. Finally, the difference between the expected change for the random model and the actual percent is divided by the expected change if the model were random. The exercise is repeated for the percent change in terms of net losses and the two main matrices, net gains and net losses, are summarised in a third matrix. Finally, the three resulting matrices are therefore re-scaled in order to make the test cases comparable to the pan-European baseline.

In order to make the case studies comparable and for the cross-tabulation matrix to be comparable in terms of total change in land use categories using net change and land use exchange; as well as net gains and losses in land use change, a few alterations were made to the original data:

1) The legends were all concentrated to four classes
    a. built-up
    b. natural
    c. farmland
    d. other
2) The output from the year 2025 was taken for all PLUREL scenarios
3) The PLUREL test case results for the simulated end year 2025 were compared with the European baseline simulation.

Three tables are shown for each of the test cases. In the first two tables, the percent gains and the percent losses, the values in bold refer to the percentage of the total landscape; the values in italics refer to the percent of the landscape expected in a random model; the values in red are the differences between the number in bold and the number in italics and the values in blue is the number in red divided by the number in italics. It is this number in blue which indicates a systematic process relative to the size of the category and it is therefore this number which is most telling if one were looking for systematic changes in the landscape. It is also this number which is used in the EU-wide study to establish which land use transformations are most systematic (i.e. statistically robust).

4.1. Koper

For the Koper test case, the B1 scenario is characterised by incentives for agricultural exploitation and strong zoning impediments result in a revival in the municipality's hinterland, even to the remotest rural areas. A growth in housing and services in these areas are the result of incentives to grow permanent crops. The peak B1 also results in an exploitation of best soils for agriculture, whereas moderate soils are reserved for housing. Tables 6 and 7 show the percent in gains and losses of the land classes. Table 8 shows the summary of these results.

Table 6 : Percent land changes in terms of gains

	built-up	natural	farmed	other
built-up	**1.50**	**0.49**	**0.69**	**0.24**
		1.52	*0.35*	*0.08*
		-1.03	0.34	0.16
		-0.68	0.96	1.86
natural	**2.80**	**53.11**	**7.57**	**1.21**
	4.86		7.83	1.88
	-2.05		-0.26	-0.67
	-0.42		-0.03	-0.36
farmed	**3.97**	**17.72**	**8.62**	**1.44**
	2.38	*16.47*		*0.92*
	1.59	1.24		0.51
	0.67	0.08		0.56
other	**0.52**	**0.12**	**0.00**	**0.01**
	0.05	0.18	0.08	
	0.47	-0.05	-0.08	
	9.56	-0.31	-1.00	
sum T1	**8.78**	**71.44**	**16.88**	**2.91**

Table 7: Percent land changes in terms of losses

	built-up	natural	farmed	other
built-up	**1.50**	**0.49**	**0.69**	**0.24**

		1.11	*0.26*	*0.05*
		-0.63	0.43	0.20
		-0.56	1.62	4.36
natural	**2.80**	**53.11**	**7.57**	**1.21**
	3.56		*2.35*	*0.40*
	-0.76		5.22	0.81
	-0.21		2.22	1.99
farmed	**3.97**	**17.72**	**8.62**	**1.44**
	7.11	*19.87*		*0.81*
	-3.14	-2.15		0.63
	-0.44	-0.11		0.78
other	**0.52**	**0.12**	**0.00**	**0.01**
	0.06	*0.47*	*0.11*	
	0.46	-0.35	-0.11	
	7.95	-0.74	-1.00	
sum T1	**8.78**	**71.44**	**16.88**	**2.91**

Table 8: Change in terms of percent landscape

	gain	**loss**	**total change**	**SWAP**	**abs value 'net change'**
built-up	7.29	1.42	8.71	2.85	5.86
natural	18.33	11.58	29.91	23.17	6.74
farmed	8.26	23.12	31.38	16.52	14.86
other	2.89	0.64	3.53	1.28	2.25
total	36.77	36.77	73.53	43.81	29.72

4.2. Haaglanden

Because of its configuration, the Haaglanden scenario sees the B1 scenario as negatively influencing the industry and commerce sectors but not the services sector upon which it is so heavily dependant. In this scenario, the only sector actually experiencing growth in terms of infrastructure is in the research and development sector in Delft, whereas the Rotterdam port and The Hague are stable. For this test case the main concern was with the conservation of pasture and arable land with the implementation of policy alternatives, called “Strategies”. Three strategies are tested on top of the B1 baseline scenario, testing the efficiency of each for the goal of conservation in mind.

Tables 9 and 10 show the percent in gains and losses of the land classes and Table 11 shows the summary of these results.

Table 9 Percent land changes in terms of gains

	built-up	natural	farmed	other

built-up	**16.13**	**3.12**	**6.74**	**3.41**
		5.45	*6.03*	*1.68*
		-2.33	0.71	1.72
		-0.43	0.12	1.03
natural	**0.50**	**2.32**	**1.24**	**0.33**
	0.37		*0.90*	*0.25*
	0.12		0.34	0.08
	0.34		0.38	0.31
farmed	**4.41**	**3.47**	**42.52**	**1.15**
	4.38	*9.55*		*2.95*
	0.03	-6.08		-1.80
	0.01	-0.64		-0.61
other	**1.09**	**11.12**	**1.95**	**0.50**
	1.25	*5.36*	*3.01*	
	-0.15	5.76	-1.06	
	-0.12	1.07	-0.35	
sum T1	**22.13**	**20.03**	**52.45**	**5.39**

Table 10 Percent land changes in terms of losses

	built-up	natural	farmed	other
built-up	**16.13**	**3.12**	**6.74**	**3.41**
		3.41	*8.94*	*0.92*
		-0.29	-2.20	2.49
		-0.09	-0.25	2.71
natural	**0.50**	**2.32**	**1.24**	**0.33**
	0.57		*2.28*	*0.23*
	-0.08		-1.04	0.10
	-0.13		-0.46	0.41
farmed	**4.41**	**3.47**	**42.52**	**1.15**
	2.50	*3.80*		*1.02*
	1.91	-0.33		0.12
	0.77	-0.09		0.12
other	**1.09**	**11.12**	**1.95**	**0.50**
	3.31	*3.00*	*7.85*	
	-2.22	8.12	-5.90	
	-0.67	2.71	-0.75	
sum T1	**22.13**	**20.03**	**52.45**	**5.39**

Table 11 Change in terms of percent landscape

	gain	**loss**	**total change**	**SWAP**	**abs value 'net change'**
built-up	6.00	13.27	19.27	11.99	7.28
natural	17.71	2.07	19.78	4.14	15.64
farmed	9.94	9.02	18.96	18.04	0.92
other	4.88	14.16	19.05	9.77	9.28
total	38.53	38.53	77.05	43.94	33.12

4.3. Leipzig-Halle

The Leipzig test case for the B1 scenario is characterised by an increase in population and a reshuffling of the economic sectors. The prohibitive costs associated with commuting leads to a densification of the already existing urban areas and vicinity of new urban areas to existing urban areas.

Tables 12 and 13 show the percent in gains and losses of the land classes and Table 14 shows the summary of these results.

Table 12 Percent land changes in terms of gains

	built-up	natural	farmed	other
built-up	**8.53**	**0.41**	**4.26**	**2.84**
		0.73	*4.26*	*0.58*
		-0.32	0.00	2.26
		-0.43	0.00	3.89
natural	**1.09**	**6.30**	**2.92**	**0.24**
	0.68		*2.80*	*0.38*
	0.41		0.12	-0.14
	0.60		0.04	-0.37
farmed	**4.07**	**2.41**	**64.41**	**0.46**
	4.60	*3.25*		*2.58*
	-0.53	-0.84		-2.12
	-0.12	-0.26		-0.82
other	**0.26**	**1.25**	**0.43**	**0.12**
	0.13	*0.29*	*0.55*	
	0.13	0.96	-0.12	
	0.96	3.26	-0.22	
sum T1	**13.95**	**10.37**	**72.01**	**3.66**

Table 13 Percent land changes in terms of losses

	built-up	natural	farmed	other
built-up	**8.53**	**0.41**	**4.26**	**2.84**
		0.91	*6.29*	*0.32*
		-0.49	-2.03	2.52
		-0.54	-0.32	7.88
natural	**1.09**	**6.30**	**2.92**	**0.24**
	0.66		*10.92*	*0.56*
	0.43		-8.00	-0.32
	0.64		-0.73	-0.57
farmed	**4.07**	**2.41**	**64.41**	**0.46**
	1.08	*2.57*		*0.91*

	2.99	-0.16		-0.45
	2.77	-0.06		-0.49
other	**0.26**	**1.25**	**0.43**	**0.12**
	0.28	*0.21*	*1.45*	
	-0.02	1.04	-1.02	
	-0.07	4.99	-0.70	
sum T1	**13.95**	**10.37**	**72.01**	**3.66**

Table 14 Change in terms of percent landscape

	gain	loss	total change	SWAP	abs value 'net change'
built-up	5.42	7.52	12.93	10.83	2.10
natural	4.08	4.25	8.32	8.15	0.17
farmed	7.61	6.94	14.55	13.89	0.66
other	3.54	1.94	5.48	3.88	1.60
total	20.64	20.64	41.29	36.75	4.54

4.4. Montpellier

The B1 scenario for the Montpellier test case is described as being a scenario with very conservative new developments due to rising oil prices, of which the services sector (port) is heavily dependant. As in the Koper test case, the inhabitants are somewhat encouraged to return to the hinterland to cultivate crops. For the Montpellier test case, there is a densification of the actual urban core, whereby discontinuous urban fabric is converted to continuous urban fabric.

Tables 15 and 16 show the percent in gains and losses of the land classes and Table 17 shows the summary of these results.

Table 15 Percent land changes in terms of gains

	built-up	natural	farmed	other
built-up	**6.71**	**1.46**	**3.53**	**0.43**
		2.98	*1.99*	*0.12*
		-1.52	1.53	0.31
		-0.51	0.77	2.72
natural	**0.65**	**36.88**	**6.41**	**0.19**
	1.55		*7.26*	*0.42*
	-0.90		-0.85	-0.23
	-0.58		-0.12	-0.55
farmed	**2.05**	**3.93**	**27.82**	**0.24**
	1.20	*8.36*		*0.32*
	0.85	-4.43		-0.08
	0.71	-0.53		-0.26
other	**0.39**	**8.34**	**0.91**	**0.07**

	0.34	*2.02*	*1.60*	
	0.05	6.32	-0.69	
	0.13	3.13	-0.43	
sum T1	**9.80**	**50.60**	**38.68**	**0.93**

Table 16 Percent land changes in terms of losses

	built-up	natural	farmed	other
built-up	**6.71**	**1.46**	**3.53**	**0.43**
		3.04	*2.32*	*0.06*
		-1.58	1.21	0.37
		-0.52	0.52	6.72
natural	**0.65**	**36.88**	**6.41**	**0.19**
	1.44		*4.58*	*0.11*
	-0.79		1.84	0.08
	-0.55		0.40	0.72
farmed	**2.05**	**3.93**	**27.82**	**0.24**
	1.23	*5.13*		*0.09*
	0.82	-1.20		0.15
	0.66	-0.23		1.56
other	**0.39**	**8.34**	**0.91**	**0.07**
	0.95	*4.92*	*3.76*	
	-0.57	3.42	-2.85	
	-0.59	0.69	-0.76	
sum T1	**9.80**	**50.60**	**38.68**	**0.93**

Table 17 Change in terms of percent landscape

	gain	**loss**	**total change**	**SWAP**	**abs value 'net change'**
built-up	3.09	5.41	8.51	6.18	2.32
natural	13.72	7.26	20.98	14.51	6.47
farmed	10.85	6.22	17.07	12.44	4.63
other	0.86	9.64	10.49	1.71	8.78
total	28.52	28.52	57.05	34.85	22.20

The following tables (Tables 17-20) show the numeric comparison between the pan-European B1 baseline scenario i (“EU” header) and the test case areas (“LOCAL” header).

Tables 17-20. The data related to the gains, losses, total changes, swapping between land uses and net change in land use class categories for both the pan-European baseline model and the case studies.

EU

Koper

	gain	loss	total change	SWAP	abs value 'net change'
built-up	0.94	0.00	0.94	0.00	0.94
natural	0.00	3.14	3.14	0.00	3.14
farmed	3.14	0.94	4.09	1.89	2.20
other	0.00	0.00	0.00	0.00	0.00
			LOCAL		
	gain	loss	total change	SWAP	abs value 'net change'
built-up	5.89	1.02	6.91	2.04	4.87
natural	20.91	8.23	29.14	16.45	12.69
farmed	5.57	25.72	31.29	11.14	20.15
other	2.64	0.05	2.70	0.10	2.59

S Holland

			EU		
	gain	loss	total change	SWAP	abs value 'net change'
built-up	6.47	0.00	6.47	0.00	6.47
natural	0.99	2.96	3.95	1.98	1.98
farmed	0.00	7.12	7.12	0.00	7.12
other	2.62	0.00	2.62	0.00	2.62
			LOCAL		
	gain	loss	total change	SWAP	abs value 'net change'
built-up	6.57	3.72	10.29	7.44	2.85
natural	4.44	1.94	6.38	3.88	2.50
farmed	2.10	8.50	10.60	4.19	6.41
other	3.61	2.56	6.16	5.11	1.05

Leipzig

			EU		
	gain	loss	total change	SWAP	abs value 'net change'
built-up	0.05	0.00	0.05	0.00	0.05
natural	0.49	0.86	1.34	0.97	0.37
farmed	0.00	0.53	0.53	0.00	0.53
other	0.86	0.00	0.86	0.00	0.86
			LOCAL		
	gain	loss	total change	SWAP	abs value 'net change'
built-up	2.14	0.03	2.18	0.06	2.11
natural	0.00	1.03	1.03	0.00	1.03
farmed	0.03	1.12	1.15	0.06	1.08
other	0.00	0.00	0.00	0.00	0.00

Montpellier						
	EU					
		gain	**loss**	**total change**	**SWAP**	**abs value 'net change'**
	built-up	0.40	0.00	0.40	0.00	0.40
	natural	0.30	1.05	1.35	0.60	0.75
	farmed	0.00	0.70	0.70	0.00	0.70
	other	1.05	0.00	1.05	0.00	1.05
	LOCAL					
		gain	**loss**	**total change**	**SWAP**	**abs value 'net change'**
	built-up	0.32	0.01	0.33	0.02	0.31
	natural	0.18	0.10	0.28	0.20	0.08
	farmed	0.10	0.49	0.59	0.20	0.39
	other	0.03	0.03	0.06	0.06	0.00

Figure 1 shows the differences in the results for the test case areas for the pan-European model. The figure demonstrates the differences in results for the test cases from the same model with a homogeneous configuration. The Haaglanden region experiences, according to this model output, a strong growth in built-up and farmed areas whereas Koper shows a strong growth in natural areas. Development in Montpellier and Leipzig is more restricted, with moderate growth in the 'other' land use categories.

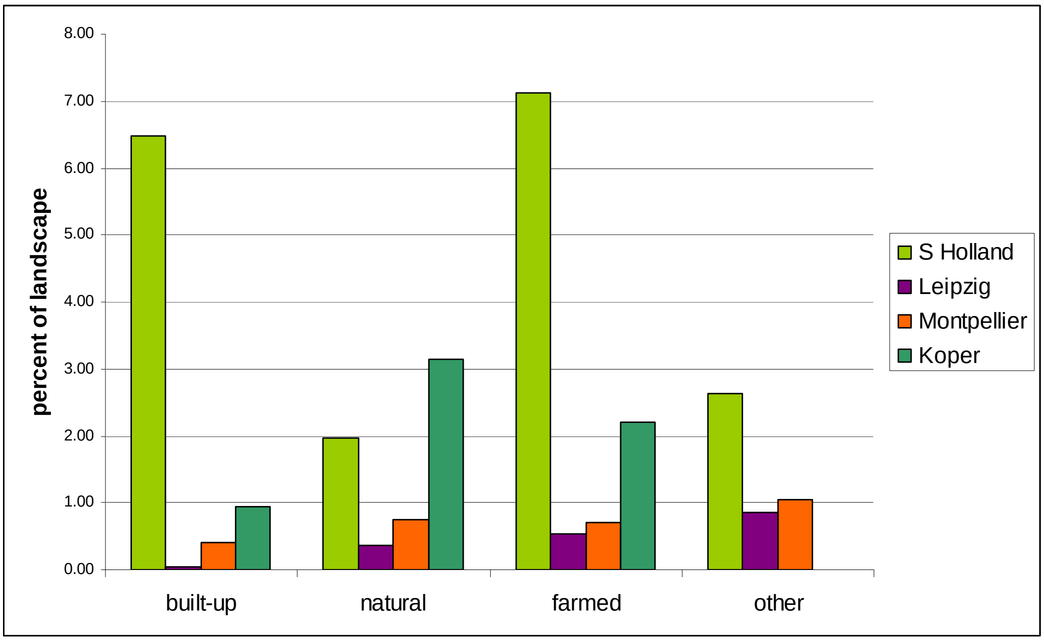

Figure 1 The percent net changes in landscape per land use category as resulting from the pan-European land use model with homogeneous configuration

4.5. Discussion of B1 simulations

The case study areas were first examined for systematic changes from the base year to 2025. By "systematic" we intend the definition as outlined in Pontius Jr *et. al.* (2004) whereby the true changes in the landscape are compared to the plausible changes in a random model and a conclusion is then drawn according to the total size of the land use class. We therefore formulate the outcomes in terms of: "If there is a demand for land use 'A' , what will it be most likely to replace?" or "If demand for land use 'A' is shrinking, what will it be most likely replaced by?" This information is extracted from the data in blue within the contingency tables from the base year to the final year of the simulation. We discuss these results in the following case-study-specific sub-sections below.

Koper

According to the results for the Koper test case, the main trends are a consistent transformation from 'other' to built-up and a loss of natural land to farmland. This case study was indeed configured to encourage a revival of the municipality's hinterland, with local incentives for agricultural products and it is in fact the increase in farmed land which is the most dominant in this test case. In the European baseline, general trends remain the same however this particular case study is penalised because of its small size. Thus the larger areas of the study site, the farmland and the natural areas, are given more emphasis than the marginal built-up areas. Most small settlements in the hinterland are swallowed up in the aggregation process. When compared to the results for the pan-European model, very different trends emerge. In the pan-European configuration, farmland areas are systematically taken over by built-up areas. This implies an opposite effect in the hinterland: its abandonment.

Haaglanden

In Haaglanden , the main trends are less evident. The strongest trend is a loss of 'other' land to natural land and from the loss of built-up 'other' due to vacated built-up areas, namely the port. The evidence for these trends is rather weak with a value of less than 3% for both conversion types (normalised for percent occupation in the landscape; i.e. the "blue values" in the matrices). This case study is more robust at European scale than is the Koper test case, namely because it is a bit bigger and also more urban. Built-up areas therefore tend to survive the aggregation procedure. Natural areas are slightly exaggerated if anything. When comparing the systematic changes from one class to another, the evident trend in the European baseline is from natural land to ‘other’ land classes. This is not the case in the local study because of the strong zoning maps imposed in the local model run.

Leipzig-Halle

Fairly strong persistent conversions are shown in this test case. When ‘other’ gains, it replaces built-up and when farmland loses, it is replaced by built-up. A If anything, the farmed land is under-represented in the low resolution version of the Moland output. Very different systematic changes are seen between the pan-European output and the locally configured output. In the pan-European version of the B1 scenario, the main conversion occurs between ‘other’ and the natural classes. Thus when ‘other’ gains, it replaces natural land. Furthermore, when farmed land loses, it is replaced by natural land and never by built-up or ‘other’ land.

Montpellier

The most prominent systematic changes in Montpellier according to the local Moland study are the conversions from other to built-up; and from natural to ‘other. Also, when ‘other’ loses, it is twice as likely to be replaced by farmland as by built-up land. The aggregation has an effect on the Montpellier test case, mainly for the built-up region and the natural areas. These tend to be exaggerated in the aggregation process because of their significant and un-fragmented presence in the land use map. For the pan-European study in Montpellier, the main persistent trends are in the conversion from ‘other’ to natural land and from farmed land to built-up land – there again not in line with the localised study results.

5. Conclusions

The application of the MOLAND model to four regions in Europe had a two-fold result:

- from one side it has demonstrated the flexibility of the modelling tool, as being able to translate local policies (in some cases these were stakeholders' wishes or visions) in concrete land use projections
- from the other side it has proven the difficulties of generalising processes and procedures such as land planning, which are – by nature – very local and geographically specific.

The application of the RUR sub-regional scheme is not always reflecting the actual characterisation of the area under study – this is partially due to the difference system of territorial government of each site – but also on the necessary generalisation of the definition of each RUR sub-region.

Zoning restrictions and planning regulations are – as largely expected – the most influential in the definition of future land use/cover patterns. The impact of infrastructure is also a key element for the dynamics. The model – because of its own configuration - does not capture social effects but reflects rather well economic drivers.

In conclusion – although it is not possible to make sensible comparisons amongst the case studies –it is certainly possible to adapt the interpretation of scenarios and storylines with local wishes and common visions. The new challenge in the research for land use/cover continental simulations is indeed in finding the right matching between wide European drivers and local ambitions.

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