PLUREL

Sustainability
Impact Assessment

Module 4

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

D4.4.4

Pan-European spatially–explicit model linking land-use change with socio-economic indicators

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SIXTH FRAMEWORK PROGRAMME

Contents

Abstract

Objectives/aims

This deliverable aims to provide data linking projected land-use changes and socioeconomic indicators, in the form of an interactive spreadsheet. This report aims to allow users to understand how the data was obtained and how it is structured.

Methodology

We used socio-economic (input) and land-use (output) data from the RUG model to produce an interactive spreadsheet. The study area includes all EU-27 countries except Bulgaria and Cyprus. Model projections are given for the four PLUREL scenarios and two time steps (2015 & 2025).

Results / findings / conclusion

Socio-economic and land-use variables are presented in a spreadsheet at NUTS 2 and NUTS 3 level. Because the RUG model is a "growth-only" model and GDP per capita increases in most projections, urbanisation is expected to increase, or at least remain constant, in most regions even though population may decrease. However, these can still be used to disaggregate population changes from NUTS 2 to NUTS 3 level.

Popular science description of main results

The main result of this deliverable is an interactive spreadsheet linking projected changes in socio-economic variables (population, GDP) to land-use change (artificial surfaces). The results are available for two time steps (2015 & 2025) and for all four PLUREL scenarios.

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	European, regional
DPSIR framework: Driver, Pressure, State, Impact, Response	Response
Land use issues covered: Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation	Housing
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	Socio-economic assessment criteria
Knowledge type: Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks	Tables

How many fact sheets will be derived from this deliverable:	**0**

Introduction

PLUREL WP4.4

The objectives of this workpackage are to develop and implement a methodology for the assessment internal and external costs for a set of social and environmental functions and services within Rural-Urban Regions.

Objectives of the deliverable

This deliverable aims to provide data linking land-use changes to socioeconomic indicators, in the form of an interactive spreadsheet. This report aims to allow users to understand how the data was obtained and how it is structured. It draws on the scenarios and data generated in WP1.1-3 & WP2.3 and on the methods developed in WP1.4.

Structure of the deliverable

The report is mainly a description of the data, consisting of:

- an introduction giving the context and background information;
- a description of the methodology;
- an overview of the available data.

Context

Peri-urban areas are by nature transitional and can be described as a complex mosaic of rural, urban and natural subsystems (Allen 2003; Dandy et al. 2009). As the interface between urban and rural areas, peri-urban are at the leading edge of the urbanisation process. Land-use change in peri-urban areas therefore depends largely on future patterns and distribution of artificial surfaces, which we define here broadly as “urban” land-use (CORINE level 2 land-cover classes 1 to 11).

Urbanisation results mainly from changes in household preferences (e.g. for proximity to green areas or public transport availability) in response to changing socio-economic conditions. The effect of these changes is mediated by institutional factors such as planning policies (Lambin et al. 2001; Veldkamp & Lambin 2001).

The RUG (Regional Urban Growth) model (Fontaine unpublished; see also D1.4.3) is a cellular automaton type model which calculates changes in artificial surfaces (CORINE land-cover level 1 class 1) as a consequence of projected changes in socio-economic factors, namely population and gross domestic product (GDP) per capita. The model parameters follow the PLUREL scenarios A1, A2, B1 & B2 (see D1.3.2). The projected proportions of artificial surfaces are therefore available for those scenarios, with two time steps: 2015 and 2025. The spatial resolution is a grid of 1 x 1 km square cells.

Methods

Projections of artificial surfaces per NUTS 2 region were calculated from projected values of population and GDP per capita for 2015 and 2025 (Reginster & Rounsevell 2006; see also D1.4.3). The population and GDP values were obtained from the work by KC *et al.* (KC *et al.* 2010) and the NEMESIS model (Brécard *et al.* 2006; Chevallier *et al.* 2006), respectively. The artificial surfaces at NUTS 2 level were used as input for the RUG model, which distributes them on a 1 x 1 km grid within each region according the scenario assumptions. For the purpose of this deliverable, the resulting values were then aggregated from the 1 x 1 km grid to NUTS 3 level.

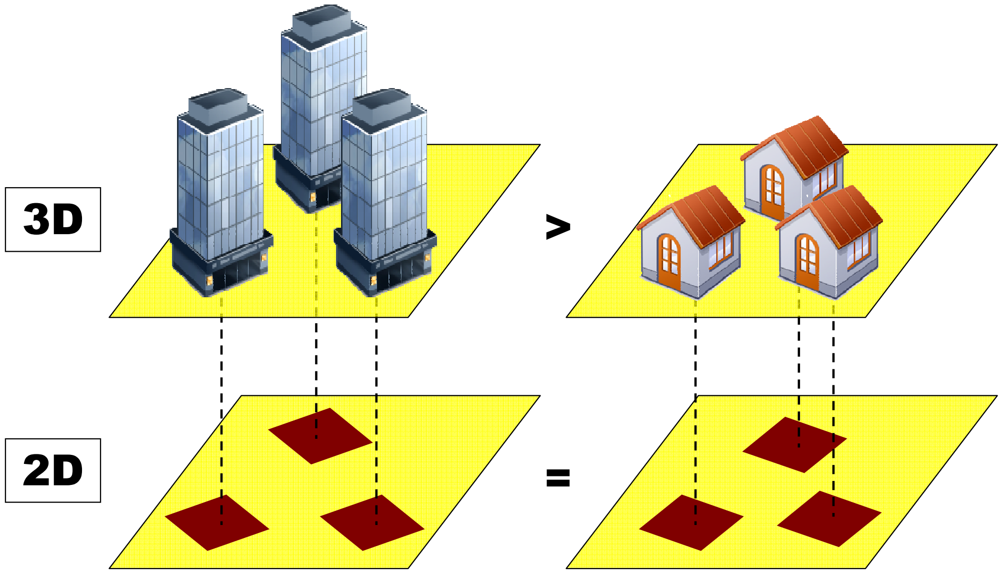


Figure 1. Diagram illustrating the difference between tri-dimensional (3D) and bi-dimensional (2D) artificial surfaces.

RUG allows the proportion of artificial surfaces on each grid cell to exceed 100%, which can be translated as increased pressure to build in the third dimension (Figure 1). This makes it a useful proxy for population, which we used to disaggregate population changes from NUTS 2 to NUTS 3 level, using the following equations:

$$\text{if } \Delta pop_{N2,t} > 0: \qquad \Delta pop_{N3,t} = \Delta pop_{N2,t} \cdot \frac{AS_{N3,t} - AS_{N3,t_0}}{AS_{N2,t} - AS_{N2,t_0}}$$

$$\text{if } \Delta pop_{N2,t} = 0: \qquad \Delta pop_{N3,t} = 0$$

$$\text{if } \Delta pop_{N2,t} < 0: \qquad \Delta pop_{N3,t} = \Delta pop_{N2,t} \cdot \frac{AS_{N2,t} - AS_{N2,t_0}}{\left(AS_{N3,t} - AS_{N3,t_0}\right) \cdot \sum_{N3=1}^{nN3} \left(\frac{AS_{N2,t} - AS_{N2,t_0}}{AS_{N3,t} - AS_{N3,t_0}} \right)}$$

This process is illustrated in Figure 2.

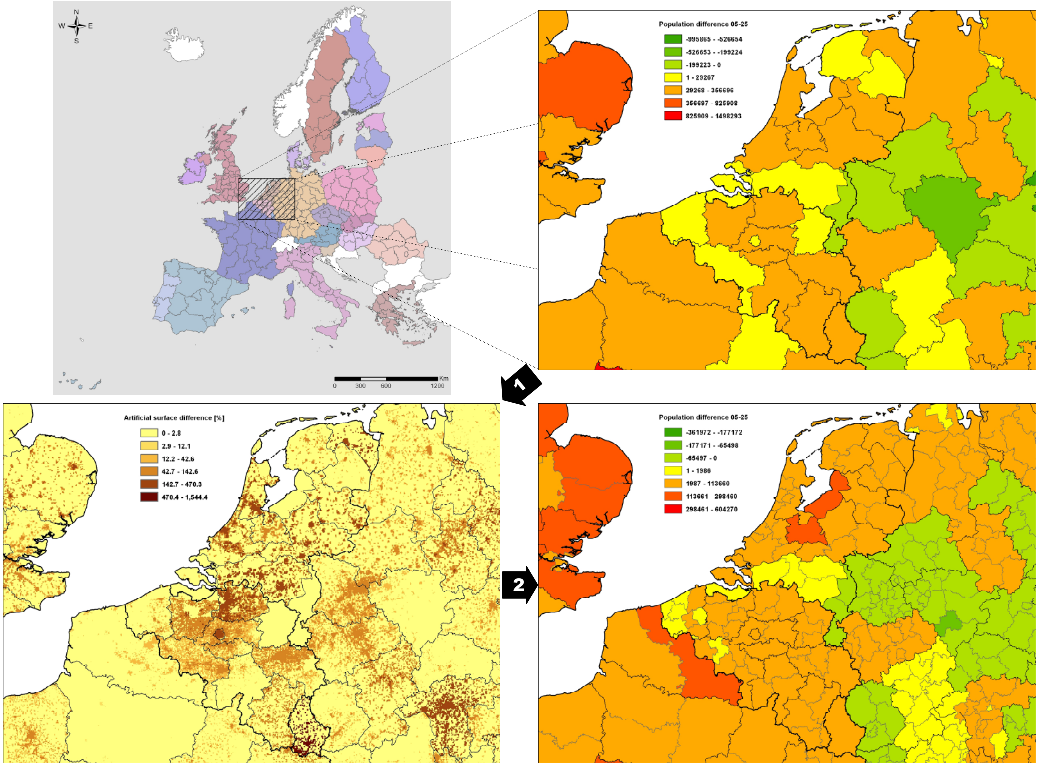
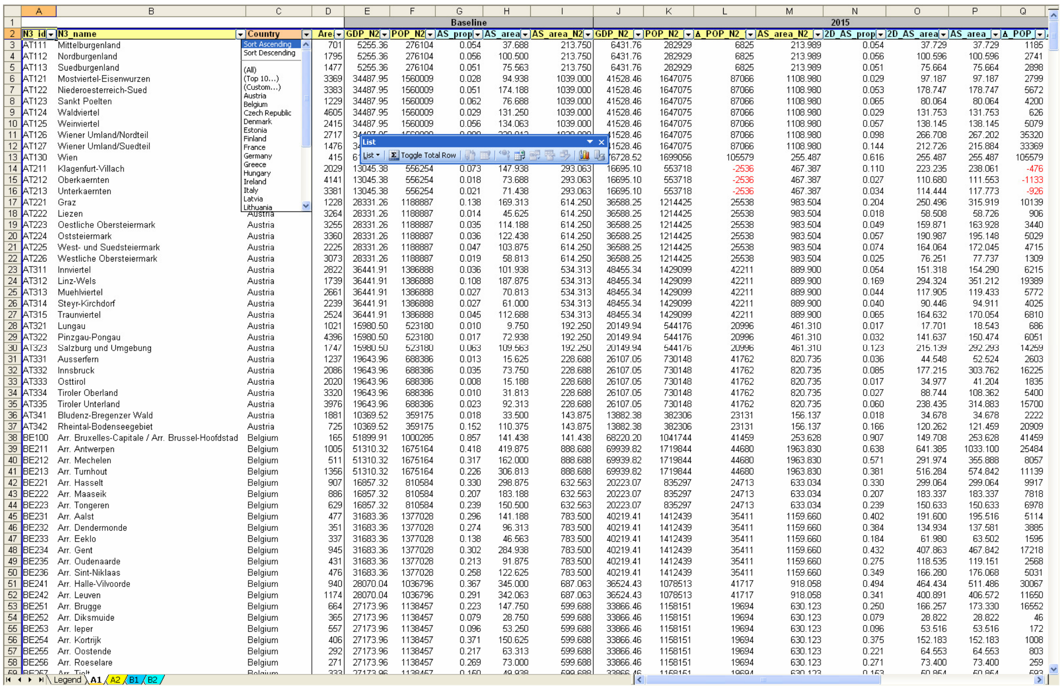


Figure 2. Diagram showing the RUG study area (top left) and an example of the processes involved for Benelux and surrounding areas. 1) The projected population changes at NUTS 2 level (top right) are one of the factors influencing the projections of changes in artificial surfaces (RUG output, bottom left). 2) The distribution of the new artificial surfaces is used to disaggregate the population change to NUTS 3 level (bottom right).

Although the 3D artificial surfaces are useful for some purposes, as seen above, the 2D ones are also necessary, for instance to calculate the amount of surface sealing. 3D values on the 1 x 1 km grid were therefore translated to 2D by rounding any values above 1 (100%) down to 1. This new grid was then aggregated to NUTS 3 level and added to the spreadsheet.

Data description

The data is available as an interactive spreadsheet containing data for the four PLUREL scenarios and two time steps (2015 & 2025), at NUTS levels 2 and 3 (Figure 3). The data includes socio-economic variables such as population and GDP, which are used as input for the RUG model, and land-use change variables (RUG output: artificial surfaces). Additionally, the projected population changes at NUTS 2 level are disaggregated to NUTS 3 on the basis of artificial surface projections (Figure 2). The variables are described in the "Legend" sheet of the spreadsheet (Figure 4).

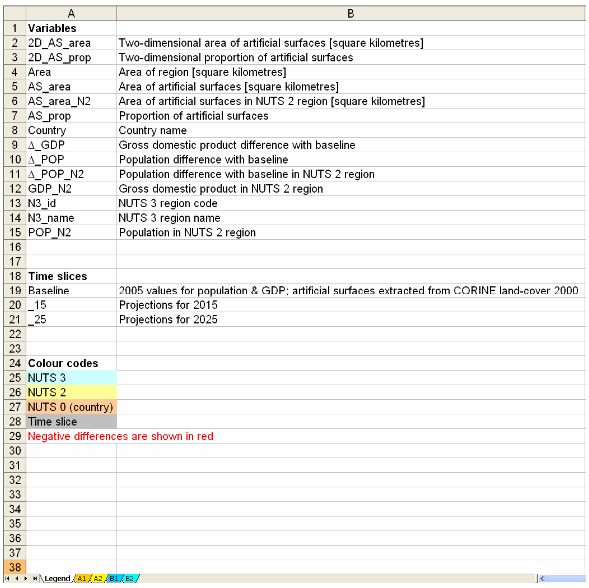


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1					Baseline					2015							
2	N3_id	N3_name	Country	Are	GDP_N2	POP_N2	AS_prop	AS_area	AS_area_N2	GDP_N2_	POP_N2_	Δ_POP_N2_	AS_area_N2_	2D_AS_prop	2D_AS_area	AS_area_	Δ_POP_
3	AT111	Mittelburgenland		701	5255.36	276104	0.054	37.688	213.750	6431.76	282929	6825	213.989	0.054	37.729	37.729	1185
4	AT112	Nordburgenland		1795	5255.36	276104	0.056	100.500	213.750	6431.76	282929	6825	213.989	0.056	100.596	100.596	2741
5	AT113	Suedburgenland		1477	5255.36	276104	0.051	75.563	213.750	6431.76	282929	6825	213.989	0.051	75.664	75.664	2898
6	AT121	Mostviertel-Eisenwurzen		3369	34487.95	1560009	0.028	94.938	1039.000	41528.46	1647075	87066	1108.980	0.029	97.187	97.187	2799
7	AT122	Niederoesterreich-Sued		3383	34487.95	1560009	0.051	174.188	1039.000	41528.46	1647075	87066	1108.980	0.053	178.747	178.747	5672
8	AT123	Sankt Poelten		1229	34487.95	1560009	0.062	76.688	1039.000	41528.46	1647075	87066	1108.980	0.065	80.064	80.064	4200
9	AT124	Waldviertel		4605	34487.95	1560009	0.029	131.250	1039.000	41528.46	1647075	87066	1108.980	0.029	131.753	131.753	626
10	AT125	Weinviertel		2415	34487.95	1560009	0.056	134.063	1039.000	41528.46	1647075	87066	1108.980	0.057	138.145	138.145	5079
11	AT126	Wiener Umland/Nordteil		2717	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1647075	87066	1108.980	0.098	266.708	267.202	35320
12	AT127	Wiener Umland/Suedteil		1476	[illegible]					[illegible]	1647075	87066	1108.980	0.144	212.726	215.884	33369
13	AT130	Wien		415	[illegible]					[illegible]	1699056	105579	255.487	0.616	255.487	255.487	105579
14	AT211	Klagenfurt-Villach		2029	13045.38	556254	0.073	147.938	293.063	16695.10	553718	-2536	467.387	0.110	223.235	238.061	-476
15	AT212	Oberkaernten		4141	13045.38	556254	0.018	73.688	293.063	16695.10	553718	-2536	467.387	0.027	110.680	111.553	-1133
16	AT213	Unterkaernten		3381	13045.38	556254	0.021	71.438	293.063	16695.10	553718	-2536	467.387	0.034	114.444	117.773	-926
17	AT221	Graz		1228	28331.26	1188887	0.138	169.313	614.250	36588.25	1214425	25538	983.504	0.204	250.496	315.919	10139
18	AT222	Liezen	Austria	3264	28331.26	1188887	0.014	45.625	614.250	36588.25	1214425	25538	983.504	0.018	58.508	58.726	906
19	AT223	Oestliche Obersteiermark	Austria	3255	28331.26	1188887	0.035	114.188	614.250	36588.25	1214425	25538	983.504	0.049	159.871	163.928	3440
20	AT224	Oststeiermark	Austria	3360	28331.26	1188887	0.036	122.438	614.250	36588.25	1214425	25538	983.504	0.057	190.987	195.148	5029
21	AT225	West- und Suedsteiermark	Austria	2225	28331.26	1188887	0.047	103.875	614.250	36588.25	1214425	25538	983.504	0.074	164.064	172.045	4715
22	AT226	Westliche Obersteiermark	Austria	3073	28331.26	1188887	0.019	58.813	614.250	36588.25	1214425	25538	983.504	0.025	76.251	77.737	1309
23	AT311	Innviertel	Austria	2822	36441.91	1386888	0.036	101.938	534.313	48455.34	1429099	42211	889.900	0.054	151.318	154.290	6215
24	AT312	Linz-Wels	Austria	1739	36441.91	1386888	0.108	187.875	534.313	48455.34	1429099	42211	889.900	0.169	294.324	351.212	19389
25	AT313	Muehlviertel	Austria	2661	36441.91	1386888	0.027	70.813	534.313	48455.34	1429099	42211	889.900	0.044	117.905	119.433	5772
26	AT314	Steyr-Kirchdorf	Austria	2239	36441.91	1386888	0.027	61.000	534.313	48455.34	1429099	42211	889.900	0.040	90.446	94.911	4025
27	AT315	Traunviertel	Austria	2524	36441.91	1386888	0.045	112.688	534.313	48455.34	1429099	42211	889.900	0.065	164.632	170.054	6810
28	AT321	Lungau	Austria	1021	15980.50	523180	0.010	9.750	192.250	20149.94	544176	20996	461.310	0.017	17.701	18.543	686
29	AT322	Pinzgau-Pongau	Austria	4396	15980.50	523180	0.017	72.938	192.250	20149.94	544176	20996	461.310	0.032	141.637	150.474	6051
30	AT323	Salzburg und Umgebung	Austria	1747	15980.50	523180	0.063	109.563	192.250	20149.94	544176	20996	461.310	0.123	215.139	292.293	14259
31	AT331	Ausserfern	Austria	1237	19643.96	688386	0.013	15.625	228.688	26107.05	730148	41762	820.735	0.036	44.548	52.524	2603
32	AT332	Innsbruck	Austria	2086	19643.96	688386	0.035	73.750	228.688	26107.05	730148	41762	820.735	0.085	177.215	303.762	16225
33	AT333	Osttirol	Austria	2020	19643.96	688386	0.008	15.188	228.688	26107.05	730148	41762	820.735	0.017	34.977	41.204	1835
34	AT334	Tiroler Oberland	Austria	3320	19643.96	688386	0.010	31.813	228.688	26107.05	730148	41762	820.735	0.027	88.744	108.362	5400
35	AT335	Tiroler Unterland	Austria	3976	19643.96	688386	0.023	92.313	228.688	26107.05	730148	41762	820.735	0.060	238.435	314.883	15700
36	AT341	Bludenz-Bregenzer Wald	Austria	1881	10369.52	359175	0.018	33.500	143.875	13882.38	382306	23131	156.137	0.018	34.678	34.678	2222
37	AT342	Rheintal-Bodenseegebiet	Austria	725	10369.52	359175	0.152	110.375	143.875	13882.38	382306	23131	156.137	0.166	120.262	121.459	20909
38	BE100	Arr. Bruxelles-Capitale / Arr. Brussel-Hoofdstad	Belgium	165	51899.91	1000285	0.857	141.438	141.438	68220.20	1041744	41459	253.628	0.907	149.708	253.628	41459
39	BE211	Arr. Antwerpen	Belgium	1005	51310.32	1675164	0.418	419.875	888.688	69939.82	1719844	44680	1963.830	0.638	641.385	1033.100	25484
40	BE212	Arr. Mechelen	Belgium	511	51310.32	1675164	0.317	162.000	888.688	69939.82	1719844	44680	1963.830	0.571	291.974	355.888	8057
41	BE213	Arr. Turnhout	Belgium	1356	51310.32	1675164	0.226	306.813	888.688	69939.82	1719844	44680	1963.830	0.381	516.284	574.842	11139
42	BE221	Arr. Hasselt	Belgium	907	16857.32	810584	0.330	298.875	632.563	20223.07	835297	24713	633.034	0.330	299.064	299.064	9917
43	BE222	Arr. Maaseik	Belgium	886	16857.32	810584	0.207	183.188	632.563	20223.07	835297	24713	633.034	0.207	183.337	183.337	7818
44	BE223	Arr. Tongeren	Belgium	629	16857.32	810584	0.239	150.500	632.563	20223.07	835297	24713	633.034	0.239	150.633	150.633	6978
45	BE231	Arr. Aalst	Belgium	477	31683.36	1377028	0.296	141.188	783.500	40219.41	1412439	35411	1159.660	0.402	191.600	195.516	5114
46	BE232	Arr. Dendermonde	Belgium	351	31683.36	1377028	0.274	96.313	783.500	40219.41	1412439	35411	1159.660	0.384	134.934	137.581	3885
47	BE233	Arr. Eeklo	Belgium	337	31683.36	1377028	0.138	46.563	783.500	40219.41	1412439	35411	1159.660	0.184	61.980	63.502	1595
48	BE234	Arr. Gent	Belgium	945	31683.36	1377028	0.302	284.938	783.500	40219.41	1412439	35411	1159.660	0.432	407.863	467.842	17218
49	BE235	Arr. Oudenaarde	Belgium	431	31683.36	1377028	0.213	91.875	783.500	40219.41	1412439	35411	1159.660	0.275	118.535	119.151	2568
50	BE236	Arr. Sint-Niklaas	Belgium	476	31683.36	1377028	0.258	122.625	783.500	40219.41	1412439	35411	1159.660	0.349	166.280	176.068	5031
51	BE241	Arr. Halle-Vilvoorde	Belgium	940	28070.04	1036796	0.367	345.000	687.063	36524.43	1078513	41717	918.058	0.494	464.434	511.486	30067
52	BE242	Arr. Leuven	Belgium	1174	28070.04	1036796	0.291	342.063	687.063	36524.43	1078513	41717	918.058	0.341	400.891	406.572	11650
53	BE251	Arr. Brugge	Belgium	664	27173.96	1138457	0.223	147.750	599.688	33866.46	1158151	19694	630.123	0.250	166.257	173.330	16552
54	BE252	Arr. Diksmuide	Belgium	365	27173.96	1138457	0.079	28.750	599.688	33866.46	1158151	19694	630.123	0.079	28.822	28.822	46
55	BE253	Arr. Ieper	Belgium	557	27173.96	1138457	0.096	53.250	599.688	33866.46	1158151	19694	630.123	0.096	53.516	53.516	172
56	BE254	Arr. Kortrijk	Belgium	406	27173.96	1138457	0.371	150.625	599.688	33866.46	1158151	19694	630.123	0.375	152.183	152.183	1008
57	BE255	Arr. Oostende	Belgium	292	27173.96	1138457	0.217	63.313	599.688	33866.46	1158151	19694	630.123	0.221	64.553	64.553	803
58	BE256	Arr. Roeselare	Belgium	271	27173.96	1138457	0.269	73.000	599.688	33866.46	1158151	19694	630.123	0.271	73.400	73.400	259

Legend / A1 / A2 / B1 / B2

Figure 3. Screen shot of the spreadsheet.

Figure 4. Screen shot of the variable description ("Legend" tab in the spreadsheet).



	A	B
1	**Variables**	
2	2D_AS_area	Two-dimensional area of artificial surfaces [square kilometres]
3	2D_AS_prop	Two-dimensional proportion of artificial surfaces
4	Area	Area of region [square kilometres]
5	AS_area	Area of artificial surfaces [square kilometres]
6	AS_area_N2	Area of artificial surfaces in NUTS 2 region [square kilometres]
7	AS_prop	Proportion of artificial surfaces
8	Country	Country name
9	Δ_GDP	Gross domestic product difference with baseline
10	Δ_POP	Population difference with baseline
11	Δ_POP_N2	Population difference with baseline in NUTS 2 region
12	GDP_N2	Gross domestic product in NUTS 2 region
13	N3_id	NUTS 3 region code
14	N3_name	NUTS 3 region name
15	POP_N2	Population in NUTS 2 region
16		
17		
18	**Time slices**	
19	Baseline	2005 values for population & GDP; artificial surfaces extracted from CORINE land-cover 2000
20	_15	Projections for 2015
21	_25	Projections for 2025
22		
23		
24	**Colour codes**	
25	NUTS 3	
26	NUTS 2	
27	NUTS 0 (country)	
28	Time slice	
29	Negative differences are shown in red	
30		
31		
32		
33		
34		
35		
36		
37		
38		

Legend / A1 / A2 / B1 / B2

References

Allen A. (2003) Environmental planning and management of the peri-urban interface: perspectives on an emerging field. *Environment and Urbanization* 15: 135-147.

Brécard D., Fougeyrollas A., Le Mouël P., Lemiale L. & Zagamé P. (2006) Macro-economic consequences of European research policy: Prospects of the Nemesis model in the year 2030. *Research Policy* 35: 910-924.

Chevallier C., Fougeyrollas A., Le Mouël P. & Zagamé P. (2006) A time to sow, a time to reap for the European countries: a macro-econometric glance at RTD National Action Plans. *Revue de l'OFCE* Special issue: Industrial dynamics, productivity and growth.

Dandy N., Ballantyne S., Moseley D., Gill R. & Quine C. (2009) The management of roe deer in peri-urban Scotland. Forest Research, United Kingdom.

Fontaine C. (unpublished) Modelling future urban growth at regional scale under explicit planning constraints.

KC S., Barakat B., Goujon A., Skirbekk V., Sanderson W. C. & Lutz W. (2010) Projection of populations by level of educational attainment, age, and sex for 120 countries for 2005-2050. *Demographic Research* 22: 383-472.

Lambin E. F., Turner B. L., Geist H. J., Agbola S. B., Angelsen A., Bruce J. W., Coomes O. T., Dirzo R., Fischer G., Folke C., George P. S., Homewood K., Imbernon J., Leemans R., Li X., Moran E. F., Mortimore M., Ramakrishnan P. S., Richards J. F., Skånes H., Steffen W., Stone G. D., Svedin U., Veldkamp T. A., Vogel C. & Xu J. (2001) The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change-Human and Policy Dimensions* 11: 261-269.

Reginster I. & Rounsevell M. (2006) Scenarios of future urban land use in Europe. *Environment and Planning B-Planning & Design* 33: 619-636.

Veldkamp A. & Lambin E. F. (2001) Predicting land-use change. *Agriculture Ecosystems & Environment* 85: 1-6.