WP 3 – Environmental Evaluation

Built-up and associated land area increases in Europe

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Acronyms

BUILT+	Built-up and associated land
CLC2000	CORINE Land Cover 2000
GFCF	Gross Fixed Capital Formation
GINFORS	Global INterindustry FORecasting System – Economic model
LRC^{BUILT+}	Land resource coefficient for BUILT+ defined as ratio of annual increases in BUILT+ and annual GFCF expenditure
MOSUS	'Modeling opportunities and limits for restructuring Europe towards sustainability' – EU project
UAA	Utilized agricultural area

Abstract

This study estimates for European countries current and potential future consumption of 'built-up land and associated land', termed BUILT+. It is defined as the land area occupied for residential, commercial, industrial, and infrastructure purposes including both built-up land and associated vegetated areas. For the EU25 there are an estimated 26.6 million hectares BUILT+, which corresponds to 7% of total land area or 591 m^2 per capita with wide variations among countries.

Future BUILT+ areas estimates depend on economic development and land use policies. 'Gross Fixed Capital Formation' (GFCF) at constant prices, is chosen as driver for economic development. Future GFCF expenditure for individual countries were taken from the economic model GINFORS. Land use policies are subsumed in the development of a land resource coefficient LRC^{BUILT+} defined as the ratio of annual increases in BUILT+ and annual GFCF expenditure. By decreasing LRC^{BUILT+} we can reflect developments in land use policies aiming at lowering annual BUILT+ area consumption over time.

For a total of 22 countries including EU15 estimates show by the year 2020 increases in BUILT+ between 5 and 7 million hectares, i.e. a 20 to 28% increase compared to the year 2000 BUILT+ area. From sustainability point of view a decoupling of BUILT+ and investment, here expressed as GFCF, is desirable. Study results call for better monitoring of BUILT+ increases.

1 Introduction

Rising standards of living combined with economic and societal structural changes has led to a continuous increase in land used for residential, industrial, commercial, and infrastructure purposes. Built-up land but also man-made vegetated areas such as green urban areas, leisure facilities or green grassland or shrubs associated with transportation networks are spreading across Europe and increasing much faster than the population. Further expansion is likely to be caused by factors such as decreasing household size, which increases the number of households; growing demand for roads; and the depopulation of rural areas, leading to an influx of people into already built-up urban areas. Such land use changes may be of major significance from an environmental and sustainability point of view.

First, increases in built-up and associated land are by and large irreversible processes. Most new areas have been created at the expense of agricultural land, but are also encroaching on forested land. Since historically cities have been developed in the most fertile regions, it is among the best agricultural soils that are being irreversibly converted. Removing the built surface would not restore the soil to a useful resource. This has implications for soil as a resource for future generations.

Second, the growth of built-up areas associated with its land sealing process is of concern because of consequent effects including fragmentation of the landscape, loss of habitat for fauna and flora, microclimate, and reduction in soils' water retention capacity with subsequent consequences for ground water and flood prevention.

The European Union has included built-up area in its list of sustainable development indicators. It is defined as the percentage of built-up land in total land area (EC, 2005).

Despite most countries today acknowledge the importance of the further development of growth in built-up areas, and spatial development plans from the local to the supranational level call for a more controlled spread of urban and infrastructure development, comprehensive data on both current areas as well as historic increases in built-up and associated land area are very sparse.

The aim of this paper is to contribute to this discussion in the European context by discussing potential future developments. The focus is on the entire land area occupied for residential, commercial, industrial, and infrastructure purposes including both built-up land and associated vegetated areas. Henceforth the sum of these areas is termed 'built-up land and associated land' with the acronym BUILT+.

First we introduce 'best estimates' of current area of BUILT+ for European countries (Chapter 2) and summarize available data of historic increases (Chapter 3). This study is part of a wider European project entitled 'Modeling opportunities and limits for restructuring Europe towards sustainability (MOSUS[1])'. An economic simulation model GINFORS[2] (Lutz et al., 2005; Meyer at al., 2004) is applied as the basic simulation tool to study different scenarios until 2020. GINFORS calculates numerous socio-economic indicators. One of them is 'Gross fixed capital formation' (GFCF). This study proposes to apply GFCF as a driver for future increases in built-up and associated land areas (Chapter 4). Finally Chapter 5 presents scenario results for future BUILT+ areas for selected European countries including EU15 member countries.

2 Current area of built-up and associated land

Before projecting future developments an accurate as possible estimation of BUILT+ as defined above is necessary. A detailed accounting of this category is difficult because of a lack of European-wide information.

Air-borne derived land cover maps cannot be used for large-scale accurate estimates of artificial areas, as requested for nation wide analysis, because the mapping scale is not detailed and the thematic accuracy not high enough. Due to the heterogeneity of the landscape these maps generally tend to underestimate disperse land cover classes like urban and infrastructure land. In contrast statistical databases are predominantly based on surveys and thus provide a relatively accurate accounting of the land area that is used in a certain land use category. While statistics of agricultural and forest land are generally available and quite accurate, surveys on built-up land areas are less common and difficult to compare due to differences in nomenclature and scope of the survey.

By and large BUILT+ corresponds to the land cover category 'artificial surfaces' in CLC2000 (EEA, 2005) and a land use category termed 'built-up and related land' in EUROSTAT (Table 1). While EUROSTAT's responsibility lies with collecting European wide statistical databases, CLC2000 is certainly the best available geographically explicit land cover database.

[1] See www.mosus.net for more information
[2] **G**lobal **IN**terindustry **FOR**ecasting **S**ystem

Table 1. Built-up and associated land categories included in EUROSTAT and CLC2000

EUROSTAT: **'Built-up and related land'**	***CLC2000 (CORINE Land Cover):*** **1. Artificial Surfaces**
• Residential land • Industrial land • Land used for quarries, pits, mines, etc. • Commercial land • Land used for public services, excluding transport, communication and technical infrastructure • Land of mixed use • Land used for transport and communication • Land used for technical infrastructure • Recreational and other open land	1.1 Urban fabric 1.1.1 Continuous urban fabric 1.1.2 Discontinuous urban fabric 1.2 Industrial, commercial and transport units 1.2.1 Industrial or commercial units 1.2.2 Road and rail networks and associated land 1.2.3 Sea ports 1.2.4 Airports 1.3 Mine, dump and construction sites 1.3.1 Mineral extraction sites 1.3.2 Dump 1.3.3 Construction sites 1.4 Artificial, non-agricultural vegetated areas 1.4.1 Green urban areas 1.4.2 Sport and leisure facilities

Factors influencing BUILT+ area utilization include a country's bio-geographical characteristics, population density, economic development status, and legislative provisions for land use planning. The approach chosen here to estimate BUILT+ for European countries is described below and results are summarized in Table 2.

If possible published data sources were used. EUROSTAT reports for the year 2000 for ten countries area data for the category 'built-up and associated land'. In addition for Great Britain, Sweden, and Switzerland published data describing approximately the BUILT+ category were available (Swiss Federal Office for Spatial Development 2001 and 2003; Statistics Sweden 2005; R.H. Haines-Young 2000). The remaining countries were divided into three geographical zones: Scandinavia, Western Europe and Eastern Europe.

In Scandinavia the low population density of only 15-20 people per m^2 causes a higher per capita consumption of BUILT+. In particular infrastructure requirements are higher compared to more densely populated countries. Available statistics for Sweden were applied to Norway and Finland, namely a per capita consumption of 1530 m^2.

The rational to separate Eastern and Western Europe is their different economic development status. As expected available data indicate a somewhat lower per capita BUILT+ consumption for Eastern Europe compared to Western Europe.

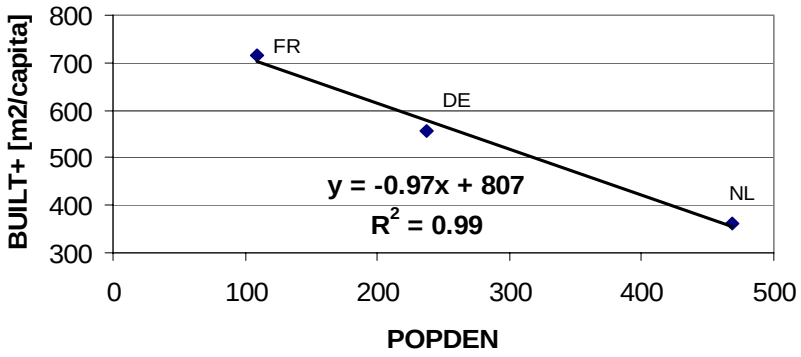
In Western Europe for three countries, Netherlands, Germany and France there is an obvious linear trend between population density and per capita BUILT+ consumption (Figure 1).

Outliers from this trend are Austria, Switzerland, Belgium and Great Britain. The lower BUILT+ per capita consumption in Austria and Switzerland may well be explained by the country's mountainous character. Belgium's comparatively high BUILT+ consumption (i.e. it lays above the

trend line of the three countries) is confirmed by CLC2000. This satellite derived data produce 620,000 hectares artificial land area, a value even higher than the 564,000 ha reported by EUROSTAT. The reverse is true for Great Britain. Its lower per capita BUILT+ consumption may stem from a relatively high agglomerated structure of urban development.

We apply the linear trend shown in Figure 1 to six countries (see 'estimWE' in the source column of Table 2). This was not possible in the case of Italy and Malta due to land area constraints. Here a default of 500 m^2/capita was used to estimate BUILT+ (recorded as 'estim500' in Table 2). For Italy applying the trend outlined in Figure 1 would calculate BUILT+ areas covering nearly all the remaining land area besides forest and arable land. An explanation for a lower per capita BUILT+ consumption could, as in the case of Great Britain, be a highly agglomerated urban fabric. Malta with its high population density is a special case.

Figure 1. Relation between a countries population density and per capita area consumption of BUILT+ for France, Germany and Netherlands



Source: EUROSTAT

In Eastern Europe only two countries, Poland and Latvia, were chosen to form the base for a relationship between population density and BUILT+ per capita consumption. Countries where 'estimEE' is given as Source in Table 2 apply this trend. BUILT+ in Romania is very low considering its population density[3] and Slovenia may rather be compared with mountainous countries.

[3] The direction of the trend is reversed, when we would chose Poland and Romania as base countries for the trend estimate. I.e. despite the lower population density in Romania compared to Poland its per capita BUILT+ consumption is lower.

Table 2. Year 2000 built-up and associated land (BUILT+) areas estimates

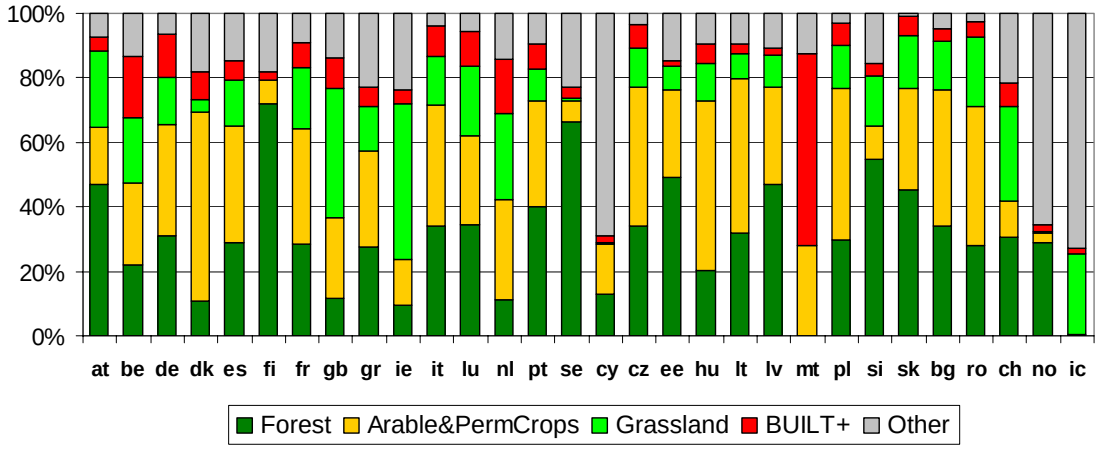
CC	Country	land area	BUILT+	Source**	Share total*	Share Other*	POP	POP DEN	BUILT+
		1000 ha	1000 ha		%	%	Mio.	p/sqkm	m2/capita
at	Austria	8252	382	Eurostat	4.6	39	8.0	97	477
be	Belgium	3030	564	Eurostat	18.6	58	10.2	338	551
de	Germany	34613	4573	Eurostat	13.2	67	82.2	237	557
dk	Denmark	4239	366	estimWE	8.6	32	5.3	126	686
es	Spain	50055	2919	estimWE	5.8	28	40.0	80	730
fi	Finland	30454	791	estim1530	2.6	13	5.2	17	1530
fr	France	54148	4210	Eurostat	7.8	46	58.7	108	717
gb	Great Britain	24088	2292	UKStat	9.5	41	59.6	248	384
gr	Greece	13076	793	estimWE	6.1	21	10.9	83	727
ie	Ireland	6890	285	estimWE	4.1	15	3.8	55	755
it	Italy	29412	2846	estim500	9.7	72	56.9	194	500
lu	Luxembourg	258	28	estimWE	10.8	67	0.4	168	645
nl	Netherlands	3388	575	Eurostat	17.0	55	15.9	468	363
pt	Portugal	9105	713	estimWE	7.8	45	10.2	112	699
se	Sweden	40843	1352	SWStat	3.3	13	8.9	22	1526
cy	Cyprus	916	21	Eurostat	2.2	3	0.7	75	297
cz	Czech Rep.	7728	543	estimEE	7.0	66	10.3	133	528
ee	Estonia	4187	79	estimEE	1.9	11	1.4	33	574
hu	Hungary	9093	550	estimEE	6.0	39	10.2	112	538
lt	Lithuania	6267	198	Eurostat	3.2	25	3.5	56	564
lv	Latvia	6222	136	estimEE	2.2	17	2.4	38	572
mt	Malta	32	19	estim500	59.4	83	0.4	1188	500
pl	Poland	30435	2053	Eurostat	6.7	69	38.7	127	531
si	Slovenia	2016	80	Eurostat	3.9	20	2.0	99	400
sk	Slovak Rep.	4810	290	estimEE	6.0	86	5.4	112	538
bg	Bulgaria	10895	455	estimEE	4.2	48	8.2	75	555
ro	Romania	22949	1021	Eurostat	4.4	62	22.5	98	455
ch	Switzerland	3916	287	CHStat	7.3	25	7.2	183	400
no	Norway	30625	685	estim1530	2.2	3	4.5	15	1530
ic	Iceland	9024	145	Eurostat	1.6	2	0.3	3	5197

* Share-total = Share of BUILT+ in total land area; Share-other = Share of BUILT+ in 'other' land area, i.e. total land minus forest and utilized agricultural area

** *Source: see text*

Depending on population density the share of BUILT+ in total land area ranges between 2 and 18% (except Malta). Land use statistics for all major categories including BUILT+ are summarized in Annex 1 and Figure 2 shows the distribution shares of the individual land use categories.

Figure 2. Distribution of land area categories for the year 2000 for European countries



3 Historic increases in built-up areas

Built-up areas in Europe have grown dramatically over the past hundred years. In Western Europe, the 1960s and 1970s were periods of rapid suburbanization and decline of city centers, while in Central and Eastern Europe there was massive urbanization. Suburban growth is now starting to gain momentum in parts of Central and Eastern Europe where economic transformation is enabling wealthy people and the growing middle classes to buy suburban family houses and commute to work by car.

Comprehensive data on historic increases in built-up land area are very sparse. Only recently, some countries have made efforts to monitor their expansion rates of urban and infrastructure areas. Usually it is then only a rough estimate what can be provided due to the varying results derived from different data sources. Comparisons between countries are even more difficult. However on a case study basis, impressive illustrations of the speed and extent of urban growth are available. For example, the MURBANDY project (http://murbandy.sai.jrc.it) monitors urban growth of several European cities by comparing land cover data in different years from satellite data interpretation.

Table 3 and 4 summarize countries for which relatively reliable data for increases in BUILT+ areas were found. However, differences in per capita consumption of current BUILT+ area as well

as per capita increases indicate that not all data may be comparable. Data from Austria, Switzerland, and Germany suggest annual increases in settlement and transport areas of around five m^2 per person per year (Table 3). In the case of Germany there is apparently a decreasing tendency since the beginning of the 1990s, which may be related to the general decline in economic growth. EUROSTAT includes industrial and commercial areas and reports higher values of over 8 m^2/person/year (Table 4).

Table 3. Increases in settlement and transport area for selected countries

		ha/y	m2/person/y
Austria	settl.+transp. 1971-1991 of which transp.	5475 – 9125 2117	7 – 12 2.6
Switzerland	settl.+transp 1979/85-1992/97 of which transp.	2750 653	3.9 0.9
Germany	settl.+transp in 2001 settl.+transp avg. 1993-1997 settl.+transp avg. 1997-2000 settl.+transp avg. 1993-2001 of which transp.	42705 43550 47200 45400 8463	5.2 5.3 5.7 5.5 1.0
Netherlands	residential 1989-2000	1900	1.2
England	Residential	5500 - 6500	

Source: A-Federal Environment Agency 2002; CH – Bundesamt für Statistik 2001; D-Federal Statistical Office Germany 2003

Table 4. Built-up and related land (BUILT+) for 1995 and 2000 and derived variables

	Total	BUILT+		BUILT+			POP		BUILT+		
	land	1995	2000	increase			2000	PDEN	1995	2000	increase
	1000 ha			1000 ha	%	ha/y	mio.	p/sqkm	m2 per Capita		m2/p/y
BE	3033	534	564	30	5.7	6083	10739	354	506	525	5.7
DE	34895	4218	4573	355	8.4	71038	82344	236	517	555	8.7
FR	54148	3916	4210	295	7.5	58900	59278	109	673	710	10.0
NL	3388	561	575	15	2.6	2920	15898	469	363	362	1.9
DK	4239	666	729	63	9.4	12533	5340	126	1275	1365	23.7
AT	8243	341	382	41	11.9	8140	8096	98	424	471	10.1
LT	6267	176	198	22	12.7	4480	3500	56	485	567	12.6
PL	30435	2037	2053	16	0.8	3260	38649	127	528	531	0.8
SK	4810	372	368	-4	-1.0	-720	5400	112	694	682	-1.3
CH	3916	279					7167	183	399		
PT	8879		1637				10225	115		1601	
RO	22971	1023	1021	-2	-0.2	-480	22117	96	451	462	-0.2
SL	2014	60	80	19	31.6	3820	1967	98	308	404	19.4

Source: EUROSTAT + own derived variables

4 Methodology for scenario development

Economic development and policies related to land use planning will be decisive factors for the development of built-up and associated land areas as defined for this study. Economic development drives investment including construction activities. Land use planning policies differ among countries but usually involve some kind of zonation planning including a determination of areas eligible for construction activities.

Besides these, developments in other sectors may indirectly influence BUILT+ area growth. They include agricultural policy, nature conservation or cultural heritage concerns. Abandoned agricultural land is subject to increased pressure towards land cover conversion, in particular densely populated and economically booming areas conversion demands from the residential and commercial sector will be substantial. Nature or landscape conservation concerns work in the other direction. They may restrict accelerated decreases in agricultural land areas. Moreover the vegetated associated land part of BUILT+ may be developed in an environmentally sound way.

From a methodological point of view we therefore aim for future BUILT+ estimates to mirror economic development on the one hand and land use planning on the other. This study proposes to use ‘Gross Fixed Capital Formation’ (GFCF) to reflect BUILT+ increases due to economic development. GFCF is a measure for investment (private or public) as one driver of economic growth. It accounts for around 20 per cent of final expenditure on GDP in most OECD Countries. Emerging markets, and transition economies in particular, need a higher intensity of investment activitz and their share of GFCF in GDP can reach as much as 35%.

GFCF includes machinery and equipment as well as construction and civil engineering. EUROSTAT comprise expenditure for the following sub-categories:

- Construction
- Dwellings
- Non-residential construction and civil engineering
- Equipment
- Metal products and machinery
- Transport equipment

The first three of those directly relate to increases in our definition of residential, commercial and infrastructure land areas. Their share in total GFCF is fairly similar among European countries, mostly around 50-55%.

We define a land resource coefficient (LRC) as the ratio of annual increases in BUILT+ and annual GFCF expenditure. Its acronym henceforth is termed LRC^{BUILT+}.

$$LRC_j^{BUILT+} = \left(BUILT_j - BUILT_{j-1}\right) / GFCF_j \qquad \text{[ha/EURO]}$$

BUILT	BUILT+ land area [ha]
GFCF	Gross Fixed Capital Formation [EURO]
LRC^{BUILT+}	Land resource coefficient
j	year

LRC^{BUILT+} describes annual new developments of BUILT+ land areas per billion EURO spent on GFCF and can be interpreted as an expression of a country's land use policies. A low LRC indicates land use policies that avoid urban sprawl and tend to restrict land area taken for infrastructure, commercial or residential developments. The higher the LRC the more land is consumed to achieve a similar level of economic development, or more precisely GFCF expenditure. From a sustainability point of view a decoupling of increases in BUILT+ and GFCF is desirable, i.e. a decreasing LRC^{BUILT+} coefficient.

As was pointed out above data on historic increase in BUILT+ area are sparse. Table 5 summarizes those countries for which comparable annual increase rates for approximately the period 1995 to 2000 were found. These are used to calculate LRC^{BUILT+} as well as per capita increases in built-up and associated land areas. Currently European countries appear to develop an annual 40 to 250 hectares BUILT+ land per billion € spent on GFCF. In per capita terms BUILT+ increases were mostly between 2 and 10 m^2 per person per year (compare also Table 3). BUILT+ increases in Denmark as reported in EUROSTAT seem quite high[4].

Figure 3 highlights an obvious linear relationship between LRC^{BUILT+} and population density for four European countries, namely France, Belgium, Germany and Netherlands. Such a function confirms common sense as it suggests higher area consumption for BUILT+ per spent € GFCF (a higher LRC^{BUILT+}) in less densely populated areas and vice versa. In other words a high population density seems to favor construction expenditure rather on existing built-up area than new developments. The reverse is true for countries with lower population densities.

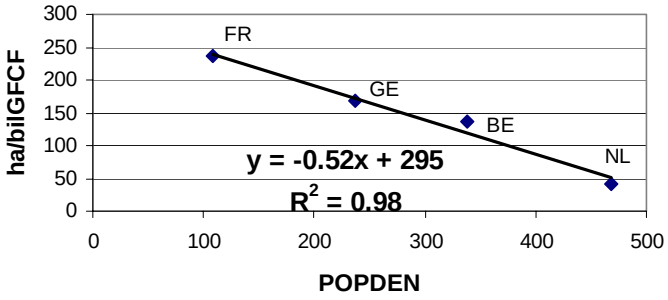
[4] Either there was a more significant increase in BUILT+ area compared to other Western European countries or (more likely) there are definition inconsistencies.

Table 5. Recent increases (approximately 1995 to 2000) in BUILT+, GFCF expenditure and population density and derived variables in selected European countries

	Increase in BUILT+	GFCF AVG95-00	**LRC^{BUILT+}** (Incr.BUILT+/GFCF)	Population Density	per capita BUILT+ increase
	ha/y	billion EURO	ha/billion GFCF	p/sqkm	m^2/p/y
NL	2920	71	41	469	1.8
BE	6083	44	137	354	6.0
DE	71038	424	168	236	8.6
FR	58900	249	236	109	10.0
AT	8140	44	187	97	10.1
DK	12533	30	415	126	23.7
PL	3260	20	161	127	0.8
CH	2750	53	52	183	3.9

Source: Increase in BUILT+ from EUROSTAT except Switzerland (see Table 4); GFCF average 1995-2000 from GINFORS results (Lutz et.al 2005b).

Figure 3. Relationship between population density and area increases in BUILT+ per billion EURO GFCF expenditure (LRC^{BUILT+}) for France, Germany, Belgium and The Netherlands



The other countries listed in Table 5 do not fall on the trend line shown in Figure 3. Data for Denmark seem unreliable. Austria and Poland are positioned somewhat below this trend line. Thus for their population density they consume less BUILT+ area compared to the four countries. For Austria its mountainous character may well explain this. Switzerland has a substantially lower LRC^{BUILT+} as would be expected from the trend line. However Switzerland's relatively high population density (twice as high as Austria) combined with its mountainous character may well explain such low increases in BUILT+ per GFCF expenditure. The case of Poland highlights the advantage of using GFCF for country comparison as opposed to per capita increases in BUILT+. Poland's LRC^{BUILT+} coefficient compares much better than the per capita increases.

For the scenarios described in this paper the function depicted in Figure 3 is used to calculate an initial LRC^{BUILT+} for European countries lacking historic BUILT+ increase data. The function was

therefore applied to all countries except Austria, Switzerland, Netherlands, and Great Britain, for which a lower initial LRC^{BUILT+} was used based on published sources.

Using future estimates of a country's GFCF expenditure together with assumptions on the development of the LRC^{BUILT+} allows calculating future consumption levels of built-up and associated land areas.

5 Scenarios until 2020

Quantification of future developments with little data on historic increases in BUILT+ area and even relatively uncertain data on current BUILT+ areas certainly is more a basis for further discussion and has no forecast character. The estimates presented in this study rely on GFCF to describe economic development. All issues related to land use planning subsume in the development of the LRC^{BUILT+} coefficient. For the latter no historic time series are available. Consequently we can only 'guess' how the coefficient may develop and at least get some quantitative boundaries for a possible development under the defined conditions. Because of all these uncertainties essentially only two scenarios are run assuming a different development of the LRC^{BUILT+} coefficient.

Future GFCF expenditure

GINFORS model results determine future GFCF expenditures (at constant prices). Initial LRC^{BUILT+} estimates were developed from BUILT+ area increases per GFCF spent in the monetary currency EURO. GINFORS country models calculate in local currency. For reasons of inflation it was not possible to calculate comparable GFCF values in EURO for certain Eastern European countries.

We've scrutinized all three GINFORS model results run in the MOSUS project. GFCF developments until 2020 are fairly similar for all three scenarios. The highest absolute deviations are found in France and Spain, where GFCF in the 'High Sustainability Scenario' is some 18 € above the baseline results of 401 and 213 billion € respectively. In the context of this study we utilize only MOSUS Baseline Scenario results. Table 6 presents GFCF as well as GDP on a per capita basis until 2020.

Studies on urban growth often rely on GDP to reflect economic development. GINFORS results highlight that GFCF growth is apparently not fully coupled to GDP growth. In Luxembourg, Switzerland, Greece, Ireland, Poland and Slovakia the share of GFCF in GDP varies over time (Table 6). Economic sectoral developments with relevance for BUILT+ area increases are therefore better reflected by GFCF than by GDP.

Table 6. Per capita GFCF and GDP at constant prices from 2000 to 2020 (MOSUS Baseline Scenario Results)

	GFCF per Capita [1000 EURO]					GDP per Capita		GFCF in GDP [%]		Annual Growth	
cnt	***2000***	***2005***	***2010***	***2015***	***2020***	***2000***	***2020***	***2000***	***2020***	**GDP**	**GFCF**
at	5.8	5.9	6.3	6.9	7.8	24.3	33.3	24	23	2.1	2.0
be	4.7	4.8	5.2	5.7	6.5	22.6	32.4	21	20	2.6	2.2
lu	9.4	9.1	8.6	8.1	7.7	42.7	55.7	22	14	3.6	0.2
dk	6.6	6.8	7.3	8.1	9.0	29.0	42.2	23	21	2.8	2.3
fi	4.4	4.6	5.2	5.7	6.3	23.3	34.7	19	18	3.1	2.8
fr	4.6	4.8	5.2	5.7	6.2	22.3	29.1	21	21	2.5	2.6
de	5.4	5.2	5.2	5.4	5.7	24.0	31.0	22	18	1.8	0.4
gr	2.0	2.6	3.4	4.1	4.6	8.7	14.1	23	33	3.4	7.1
ie	4.7	4.5	4.2	4.0	3.8	22.1	32.6	21	12	4.2	0.3
it	3.6	3.8	3.9	4.1	4.3	17.6	23.2	21	19	1.8	1.1
nl	5.1	4.8	4.9	5.3	5.9	22.8	28.0	22	21	1.6	1.1
pt	2.7	2.7	2.6	2.6	2.6	9.6	13.7	28	19	2.5	0.1
es	3.3	3.4	3.7	4.2	4.9	13.2	17.1	25	29	2.5	3.8
se	4.9	4.6	5.5	6.5	7.8	27.8	41.0	18	19	3.1	3.7
gb	4.3	3.8	4.5	5.4	6.4	23.2	31.3	18	21	2.3	3.1
cz	1.3	1.7	2.0	2.3	2.7	4.0	8.0	33	34	5.3	5.3
hu	0.6	0.9	1.1	1.2	1.3	2.6	5.9	25	22	6.8	5.2
pl	0.7	0.6	0.6	0.6	0.6	2.6	5.6	26	12	5.5	-0.3
sk	0.9	1.0	1.0	1.0	0.9	3.0	5.9	29	16	4.6	0.4
no	6.7	6.1	7.4	9.2	11.4	30.7	47.8	22	24	2.2	3.6
ch	7.8	7.6	7.9	8.1	8.3	35.5	64.7	22	13	4.5	0.5

Source: GINFORS model results (Lutz et.al, 2005b)

Land use planning (Development of the land resource coefficient LRC^{BUILT+})

Besides economic development and population density land use planning and policies are major determinants for increases in built-up and associated land areas. Europe includes densely populated areas and arguably its land is among the most intensely used. In recent decades the rise of the service economy and the need for food security, together with vastly improved standards of living, changes in societal values, increased personal mobility and increasing demands for housing, have lead to widespread conflicts over the use of land.

Land use and other diverse development plans determine potential changes in land use in a particular region. Such plans exist on different regional levels, with varying degrees of enforcement power. Allocation space for urban, commercial and infrastructure development, or the delineation of specific risk zones with restricted land uses are common elements of such plans. While the general plans on a higher administrative level, such as the European Spatial Development Perspective (EC, 2001) call for a reduction of urban sprawl and transport demand, economic and societal pressures and demand on the local level may well counteract these goals.

It then depends on the legal planning framework of a particular country, how much enforcement power resides on the local level.

The European Commission advocates a common European spatial planning perspective that provides a framework for national, regional, and local levels. Moreover, recent catastrophic climatic events, including flooding and avalanches, triggered discussions on potential inappropriate land uses and may shift land use planning decisions away from the local to a higher regional level.

In the European context key questions that will determine the extent of increases in built-up and associated land areas include: How strong is the economic development? What is the value of farmland surrounding cities? Do land use plans aim to limit land sealing and can they be enforced?

The scenario estimates presented below reflect all issues related to land use planning and policy, but also indirect effects from devaluing farmland, in the development of the land resource coefficient LRC^{BUILT+}.

Scenario estimates of future BUILT+ areas

There are practically no historic data from which we can derive any trend in annual increase rates of BUILT+. Therefore, with respect to the development of the LRC^{BUILT+} coefficient we can only speculate. The scenario run presented in Annex II assumes a decrease of the initial year 2000 LRC^{BUILT+} coefficient by 40% in the year 2020. In this way total increases in BUILT+ for the 22 countries included in the analysis amount to 5.7 million hectares. For comparison an assumption to keep the initial year 2000 LRC^{BUILT+} constant over he next 20 years calculates a total increase in BUILT+ by 7.5 million hectares. This value may represent the higher end of potential growth.

Due to significant differences in absolute GFCF values between Western and Eastern Europe, increase rates in Eastern Europe are much lower compared to Western Europe. In addition in Poland, Slovakia and Slovenia there is no growth of GFCF until 2020. The approach applied in this study may however be misleading for Eastern European countries. LRC^{BUILT+} estimates are based on historic data in EURO. We simply convert the respective currency of an Eastern European country into EURO. Taking into account lower wages and commodity prices in Eastern Europe, one EURO of spent GFCF may be used for more extensive construction activities resulting in higher land area conversions compared to Western Europe.

Following general trends in land use changes in Europe during the past decades, it is likely that a large share of newly developed land is converted from former agricultural land, in particular grassland. Provided that in the EU15 all increases in BUILT+ would be converted from agricultural land, by 2020 UAA would have decreased by 4% from its level in 2000. This ratio varies among countries (see right column in Annex II). However for the forest rich Scandinavian

countries larger conversions of forestland into BUILT+ are more likely than BUILT+ land development on agricultural land.

For comparison in the year 2000 total utilized agricultural area in the EU15 was 130 million hectares. According to FAOSTAT between 1960 and 2000 the EU15 lost 24 million hectares of UAA. In many countries the decrease accelerated after 1990 and was strongest in the sub-category permanent pasture. A certain fraction of UAA was converted to forests. The EU15 scenario estimates of some 0.3 mio ha annual increases on BUILT+ therefore correspond to less than half of historic UAA decreases of 0.6 mio ha per year. The calculated BUILT+ increases seem reasonable or maybe even moderate.

6 Conclusions

Despite most countries today acknowledge the importance of the further development of growth in built-up areas and call for a more controlled spread of urban and infrastructure development, comprehensive data on both current areas as well as historic increases in built-up and associated land area are very sparse. This study estimates for European countries current and potential future consumption of 'built-up land and associated land', termed BUILT+. It is defined as the land area occupied for residential, commercial, industrial, and infrastructure purposes including both built-up land and associated vegetated areas.

Relatively reliable data for current BUILT+ areas (representing the year 2000) are available for 13 European countries. For another 16 countries BUILT+ was estimated based on population density, a regionalization into Scandinavia, Western and Eastern Europe and by comparing resulting BUILT+ areas with available non-agricultural or forestry land. For the EU25 we calculate 26.6 million hectares BUILT+, which corresponds to 7% of total land area or 591 m^2 per capita. Per capita BUILT+ consumption and share in total land varies widely among countries.

Future BUILT+ areas estimates depend on economic development and land use planning and policies in a wider sense. A macro-economic variable for investment, namely 'Gross Fixed Capital Formation' (GFCF) at constant prices, is chosen as driver for economic development. Land use policies are subsumed in the development of a land resource coefficient LRC^{BUILT+} defined as the ratio of annual increases in BUILT+ and annual GFCF expenditure. Year 2000 LRC^{BUILT+} coefficients were determined for each country. For a few countries it could be calculated from published sources of historic BUILT+ increase rates. For the rest a linear function dependent on population density was applied.

GFCF expenditure until 2020 was taken from the economic model GINFORS. Because of country disparities in the share of investment (GFCF) in GDP and over time, we argue that economic sectoral developments with relevance for built-up area increases are better reflected by GFCF than by GDP. By decreasing LRC^{BUILT+} over time we mimic developments in land use policies.

Scenarios until 2020 were run for a total of 22 countries including EU15 and the major EU10 countries and Norway and Switzerland. For those countries BUILT+ increases are between 5 and 7 million hectares, i.e. a 20 to 28% increase of the year 2000 BUILT+ area. A comparison with historic decreases in agricultural area suggests the estimated BUILT+ increases for the EU15 as likely or even conservative. Results for Eastern Europe should be treated with caution because of methodological problems related to currency conversion.

Taking into account that in Europe the owner of every square meter of land is well documented for legislative reasons it should be possible to derive fairly accurate estimates on the extent of BUILT+ land areas. From a sustainability point of view a decoupling of BUILT+ and investment expressed as GFCF is desirable, i.e. a decreasing LRC^{BUILT+} coefficient. In consequence investment in construction will occur rather on existing built-up and associated land areas than developing virgin soil resources. In order to achieve this monitoring of BUILT+ increases is recommended.

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Annex I. Year 2000 land use categories for European countries (1000 ha)

CC	Country	total land	forest	arable*	grass	other	BUILT+	BUILT+ Source	BUILT+ in total land %	POP mio.	POPDEN p/km^2	BUILT+ m^2/captia
at	Austria	8252	3886	1446	1943	595	382	Eurostat	4.6	8.0	97	477
be	Belgium	3030	672	769	614	411	564	Eurostat	18.6	10.2	338	551
de	Germany	34613	10740	12010	5048	2242	4573	Eurostat	13.2	82.2	237	557
dk	Denmark	4239	455	2488	166	765	366	estimWE	8.6	5.3	126	686
es	Spain	50055	14370	18189	7183	7394	2919	estimWE	5.8	40.0	80	730
fi	Finland	30454	21935	2190	26	5512	791	estim1530	2.6	5.2	17	1530
fr	France	54148	15341	19324	10341	4932	4210	Eurostat	7.8	58.7	108	717
gb	Great Britain	24088	2794	6029	9693	3280	2292	UKStat	9.5	59.6	248	384
gr	Greece	13076	3599	3896	1789	2999	793	estimWE	6.1	10.9	83	727
ie	Ireland	6890	659	962	3339	1645	285	estimWE	4.1	3.8	55	755
it	Italy	29412	10003	11030	4439	1094	2846	estim500	9.7	56.9	194	500
lu	Luxembourg	258	89	71	56	14	28	estimWE	10.8	0.4	168	645
nl	Netherlands	3388	375	1059	902	477	575	Eurostat	17.0	15.9	468	363
pt	Portugal	9105	3666	2952	903	871	713	estimWE	7.8	10.2	112	699
se	Sweden	40843	27134	2608	372	9377	1352	SWStat	3.3	8.9	22	1526
cy	Cyprus	916	117	143	4	632	21	Eurostat	2.2	0.7	75	297
cz	Czech Rep.	7728	2632	3318	961	274	543	estimEE	7.0	10.3	133	528
ee	Estonia	4187	2060	1134	299	615	79	estimEE	1.9	1.4	33	574
hu	Hungary	9093	1840	4803	1051	849	550	estimEE	6.0	10.2	112	538
lt	Lithuania	6267	1994	2992	497	586	198	Eurostat	3.2	3.5	56	564
lv	Latvia	6222	2923	1874	611	678	136	estimEE	2.2	2.4	38	572
mt	Malta	32	0	9		4	19	estim500	59.4	0.4	1188	500
pl	Poland	30435	9047	14330	4083	922	2053	Eurostat	6.7	38.7	127	531
si	Slovenia	2016	1107	204	314	312	80	Eurostat	3.9	2.0	99	400
sk	Slovak Rep.	4810	2177	1514	780	49	290	estimEE	6.0	5.4	112	538
bg	Bulgaria	10895	3690	4636	1615	500	455	estimEE	4.2	8.2	75	555
ro	Romania	22949	6448	9908	4949	623	1021	Eurostat	4.4	22.5	98	455
ch	Switzerland	3916	1199	437	1144	849	287	CHStat	7.3	7.2	183	400
no	Norway	30625	8868	883	157	20032	685	estim1530	2.2	4.5	15	1530
ic	Iceland	9024	31	7	2274	6567	145	Eurostat	1.6	0.3	3	5197
	EU25	38355	13961	115344	55414	46527	26658		7.0	451	118	591

* includes permanent crops

Annex II. Built-up and related land (BUILT+) area increases in 2020 for an assumed decrease of LRC^{BUILT+} by 40%

		Year 2000 land area					LRC^{BUILT+}		Year 2020				
Country	Total land	FOR	UAA[1]	Other	BUILT+		2000	2020	BUILT+		BUILT+ increase		Loss in UAA[3]
		1000 ha			1000 ha	%[2]	ha/GFCF		1000 ha	%*	1000 ha	%	%
Austria	8252	3886	3389	595	382	4.6	180	108	530	6.4	**148**	39	4.4
Belgium	3030	672	1383	411	564	18.6	120	72	667	22.0	**103**	18	7.4
Luxembourg	258	89	127	14	28	10.8	208	126	42	16.1	**14**	49	10.8
Germany	34613	10740	17058	2242	4573	13.2	172	104	5746	16.6	**1173**	26	6.9
Denmark	4239	455	2654	765	366	8.6	230	139	512	12.1	**146**	40	5.5
Spain	50055	14370	25372	7394	2919	5.8	254	153	3563	7.1	**644**	22	2.5
Finland	30454	21935	2216	5512	791	2.6	287	173	914	3.0	**122**	15	(5.5)
France	54148	15341	29665	4932	4210	7.8	239	144	5435	10.0	**1225**	29	4.1
Great Britain	24088	2794	15722	3280	2292	9.5	100	60	2734	11.3	**442**	19	2.8
Greece	13076	3599	5685	2999	793	6.1	252	152	936	7.2	**144**	18	2.5
Ireland	6890	659	4301	1645	285	4.1	267	161	362	5.3	**77**	27	1.8
Italy	29412	10003	15469	1094	2846	9.7	195	118	3536	12.0	**690**	24	4.5
Netherlands	3388	375	1961	477	575	17.0	31	19	616	18.2	**41**	7	2.1
Portugal	9105	3666	3855	871	713	7.8	238	143	816	9.0	**103**	14	2.7
Sweden	40843	27134	2980	9377	1352	3.3	285	171	1582	3.9	**230**	17	(7.7)
Czech Rep.	7728	2632	4279	274	543	7.0	227	137	614	7.9	**71**	13	1.7
Hungary	9093	1840	5854	849	550	6.0	237	143	587	6.5	**37**	7	0.6
Poland	30435	9047	18413	922	2053	6.7	230	138	2138	7.0	**85**	4	0.5
Slovenia	2016	1107	518	312	80	3.9	245	147	95	4.7	**15**	19	2.9
Slovak Rep.	4810	2177	2294	49	290	6.0	237	143	309	6.4	**19**	6	0.8
Switzerland	3916	1199	1581	849	287	7.3	35	21	318	8.1	**31**	11	2.0
Norway	30625	8868	1040	20032	685	2.2	288	174	851	2.8	**165**	24	(16)
mio.ha									*mio.ha*				
SUM	400	143	166	65	27	6.8			32.9	8.2	**5.7**		3.5
EU15	312	116	132	42	23	7.3			28.0	8.9	**5.3**	23	4.0

1 Utilized Agricultural Area; 2 Percentage in total land area; 3 Share of total BUILT+ increases between 2000 and 2020 in UAA of year 2