Models of Urban Land Use in Europe: Assessment Tools and Criticalities

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ABSTRACT

The aim of this paper is to examine available homogenous data on urban conversion of land in Western European countries and determine whether they are suitable to make an international comparison between land policies and management behaviour at the local level. This paper provides some results obtained from currently available information, but it stresses major data production criticalities which hinder the performance of comparable and reliable overall statistical studies. Conclusions stress the need for greater detail in the production of primary data on the features and magnitude of territorial urbanisation in Europe, as the EEA is doing for main cities. Moreover, this paper includes some remarks on the contents of the preliminary documents of EU soil directive. In particular, it focuses on the issue of urban transformation thresholds over time, a topic that has already been tackled by some northern European countries, however using techniques which cannot be applied as they are to all other countries.

Keywords: Land Uptake, Land Use Change, Soil Consumption, Urban Sprawl

INTRODUCTION

The issue of excessive urban conversion of natural land has been raised at European level only in recent years, mainly through initiatives undertaken by the European Environmental Agency (EEA, 2004. 2006) to analyse this phenomenon and its consequences.

Furthermore, it is worth recalling that the European Commission, based on a need to tackle soil productivity, risks to human health and environment, and to provide opportunities for climate mitigation and adaptation as well as stimulating business opportunities for soil remediation, proposed a Soil Framework Directive in 2006, which amends directive 2004/35/EC (on environmental liability with regard to the prevention and remedying of environmental damage) and reaffirms the status of “non-renewable resource” for this particular territorial component and the need for its conservation. The European Parliament adopted its first reading on the proposal in November 2007 by a majority of about two thirds. During

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March 2010 Environment Council, a minority of Member States blocked further progress on grounds of subsidiarity, excessive cost and administrative burden. No further progress has since been made by the Council. The proposal remains on the Council’s table.

The 2006 EEA report states:

All available evidence demonstrates conclusively that urban sprawl has accompanied the growth of urban areas across Europe over the past 50 years. This is shown from a recent European perspective. The areas with the most visible impacts of urban sprawl are in countries or regions with high population density and economic activity (Belgium, the Netherlands, southern and western Germany, northern Italy, the Paris region) and/or rapid economic growth (Ireland, Portugal, eastern Germany, the Madrid region). Sprawl is particularly evident where countries or regions have benefited from EU regional policies.

The aim of this paper is to examine available homogenous data on urban conversion of land in Western European countries and determine whether they are suitable to make an international comparison between land policies and management behaviour at the local level. Our paper provides some results obtained from currently available information, but it stresses major data production criticalities which hinder the performance of comparable and reliable overall statistical studies.

BACKGROUND

The EEA study, the most advanced in this field at EU level, focuses a great deal on urban development, sprawl drivers and their multiform impacts, providing extensive data on the growth of some sample cities and territories, of which an example is shown in Figure 1.

From this EEA research it can be inferred that average European land uptake between 1990 and 2000 amounts to about one million hectares. For many years, some European countries have implemented policies to curb land uptake caused by urbanisation, while other countries have faced the problem more gradually, such as Switzerland or the Netherlands (Datec, 2005; Zonneveld, 2007).

In other continents, signs that risk thresholds, tied to various economic and territorial “diseases”, had been crossed, emerged much earlier and various authors wrote papers to this regard over a time span of almost seventy years. In the United States, China, India and Latin America, the emergence of ”sprawl” (the encroachment of urban land upon the countryside with new suburbs) has now reached alarming proportions in some cases, in relation to coinciding favourable economic, social and physical-climatic conditions (Ewing, 1994). Studies performed in the United States over the past fifty years have mainly focused on the adverse effects that urban sprawl has on the quality of an urban area in terms of community, mobility and energy consumption (Altshuler, 1977; Buttenheim & Cornick, 1938; Dowling, 2000; Flint, 2006; Gaffney, 1964; Gordon & Wong, 1985; Haskell & Whyte, 1958; Hess, 2001; Jenks et al., 1996; Mumford, 1961; Rodwin, 1956). More recently undertaken studies focus on environmental integrity in a broader meaning of the term (Irwin & Bockstael, 2007; World Watch Institute, 2007).

In Europe, the debate has been lively with regard to political stances and has involved many social and territorial governance issues, as well as issues concerning participation in planning processes (Barlow, 1995; Cheshire, 1995). Investigation of the issues of the city-region and the sustainable development of this type of settlement is invaluable in this debate (Hesse, 2007; Herpsberger & Bürgi, 2009; Krueger & Savage, 2007). There are a number of interesting studies that consider urban sprawl as a territorial “disease” for which curbing and mitigating actions and measures need to be studied (Brett-Crowther, 1985; Clarke, 2008; Couch et al., 2007; Dietzel & Clarke, 2007; Johnson, 2001; Kasanko et al., 2006), including the cited work carried out by the EEA (2006).
which examined urban development in various European countries using a land uptake index.

Land transformed by urbanisation may be defined in different ways and in the studies and diagnoses of this phenomenon, it is important to establish which of the definitions, data and considerations are referred to built-up land, urbanised land, artificial land and sealed soil (Figure 2).

In Figure 2 shapes a), c) and d) are subsets of the urbanised land category b) which is the most widespread and homogenous data at European level (CORINE Land Cover). Often geographically more detailed technical maps within the various countries include also data on built-up land and sealed soil (defined as “non evapotranspiring soil”).

According to consolidated scientific opinions, land use caused by urbanisation is one of the main causes of political and social conflicts (Plotkin, 1987) and altered environmental quality of land (Ellis & Ramankutty, 2008; Sala et al., 2000).

The aspects involved, either directly or indirectly, in urban conversion of land include the following ones:

**Economic and energetic field:**
- Diseconomies in transport;
- Waste of energy;
- Reduced agricultural production.

**Hydro-geo-pedologic field:**
- Geological destabilization;
- Irreversible use of land;
- Alteration of underground and surface watercourses.

*Figure 1. Annual growth of built-up areas from the mid-1950s to the late 1990s, selected European cities (source EEA 2006 from MOLAND (JRC) and Kasanko et al., 2006)*
Physico-climatic field:

- Increased thermal reflection and climate change;
- Reduced emission absorption capacity;
- Effects on carbon sequestration;
- Spatial propagation of physico-chemical disturbances.

Eco-biological field:

- Physical erosion and destruction of habitats;
- Ecosystem fragmentation;
- Dystrophy of ecological and biological processes;
- Penalization of the ecosystem services of the environment;
- Reduction in overall ecological “resilience”.

The foregoing effects occur to a varying extent depending on landform types, highly differentiated by sprawl, and may be grouped into two main models depending on their dynamics: aggregate growth and “metastatic-like” growth (Fina & Siedentop, 2009).

In the first case, city centres expand over time always retaining, however, their seamless fabric and close-knit shapes without interstitial gaps. In the second case, urban expansion occurs through the multiplication of many small groups of buildings or isolated buildings which sometimes are joined in linear shapes along roads (Figure 3).

For example, assuming that all other impacts are the same, the second model leads to...
greater inefficiencies in transport, higher expenses for power distribution and the operation of grid services, and more severe consequences for the fragmentation of ecosystems.

SIZE OF THE PHENOMENON IN EUROPEAN COUNTRIES

Recently, responsibility for planning and the pathology of land uptake is becoming more and more important for the public opinion. Therefore we believe that future planning tools should curb these trends, by imposing rules to fight or mitigate land uptake. The control action should be effective mainly when urban sprawl concerns broad agricultural flat areas, with loss of crop production and ecosystem services (Eigenbrod et al., 2011; Harrison, 2011; Maes, 2011; Murgante & Danese, 2011; Scolozzi et al., 2012). Moreover, urban sprawl has serious effects on soil sealing, with a devastating hydrogeological impact on settled human communities (Jaeger et al., 2010; MEA, 2005).

Some European countries, that are more sensitive to the foregoing consequences, have already adopted regulations to curb this phenomenon and one of the most significant experiences is the German one (Bundesregierung, 1985, 2002, 2004; Henger & Bizer, 2010; Illy et al., 2009). The German government has also introduced some daily land uptake limits fixed at 30 ha per day for 2020, with the prospect of bringing this phenomenon down to zero by 2050 (Siedentop, 2007).

There are few studies in international literature on the Italian case (Bonifazi & Heins, 2001; Capello, 2001; Salvati et al., 2012; Romano & Zullo, 2012, 2013) and not many regions (only 4 out of 20) have vector information on land use over the past 50 years on their institutional geportals. There are also very few cases in which data covering a shorter time span is available (1970s - 2000), regarding both overall magnitude of urbanisation and statistically significant historical series and there are no coordinated survey activities among local governments.
(regions, provinces and municipalities). The negative aspects of this phenomenon are still only marginally considered by scientific, communication and land governance agencies.

In other countries, such as the United Kingdom, the Netherlands, France, Switzerland and Spain information and publications are far more numerous (Garcia-Call, 2011; Hall et al., 1973; Hauri et al., 2006; Irwin & Bockstael, 2007; Mellor, 1983; Yanitsky, 1986; Zaninetti, 2006;). The need to set up mechanisms to monitor urban transformation dynamics has emerged only recently, but we are still far from having systematic and consistent data collection that would make credible comparisons and assessments possible (Batty, 2008; Lowry, 1990; Sharma et al., 2012).

The more recent analytical data, homogenous for all Western European countries, come from CLC (CORINE Land Cover) 2006 satellite remote sensing and some of the results are shown in Table 1 (EEA, 2004).

Table 1 shows some information of considerable interest concerning, first and foremost, the urbanisation rate in the countries considered, which amounts to almost 4.5%. However, what are even more significant to this regard are the differences in behaviour of the various countries, with a standard deviation of the mean of 126%. On the other hand, Table 1 clearly shows that the urbanisation rate in Western Europe is marked by varying peaks: 20% in Belgium, 14% in the Netherlands, 8% in Germany, just over 7% in Denmark and the UK, down to the absolute lowest rate of 0.8% in Norway.

These differences in urbanisation rates can be easily ascribed to a mix of various factors, such as historical differences in economies, cultural relationships with land and type of agricultural productivity.

Further information may be gathered by examining per capita urbanisation index obtained from the relationship between total urban coverage and number of inhabitants. In Table 1 this index is organised in increasing order of values, and countries falling within given thresholds (300, 400 and 500 m²/inhabitant) have been identified. In this case, the standard deviation of the mean (53%), albeit considerable, is far lower than the one obtained for urbanisation.

Table 1. Data on urbanisation in Western Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>Country Area (ha)</th>
<th>Urbanized Area (ha)</th>
<th>Urbanization rate</th>
<th>Inhabitants 2006</th>
<th>Urbanization per capita (mg/inhab)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>50609075.18</td>
<td>1002896.26</td>
<td>0.020</td>
<td>43758250</td>
<td>229.19</td>
</tr>
<tr>
<td>Italy</td>
<td>30102535.61</td>
<td>1473899.45</td>
<td>0.049</td>
<td>58751711</td>
<td>250.87</td>
</tr>
<tr>
<td>Portugal</td>
<td>9211369.22</td>
<td>308869.80</td>
<td>0.034</td>
<td>10659952</td>
<td>292.22</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>24577702.95</td>
<td>1804418.38</td>
<td>0.073</td>
<td>58785246</td>
<td>306.95</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3589797.71</td>
<td>508349.09</td>
<td>0.142</td>
<td>16334210</td>
<td>311.22</td>
</tr>
<tr>
<td>Germany</td>
<td>35769393.80</td>
<td>3002445.95</td>
<td>0.084</td>
<td>82437995</td>
<td>364.21</td>
</tr>
<tr>
<td>Irish Republic</td>
<td>7003471.37</td>
<td>158211.18</td>
<td>0.023</td>
<td>4208156</td>
<td>375.96</td>
</tr>
<tr>
<td>France</td>
<td>54945628.48</td>
<td>2815240.06</td>
<td>0.051</td>
<td>63229635</td>
<td>445.24</td>
</tr>
<tr>
<td>Austria</td>
<td>8403572.55</td>
<td>408518.16</td>
<td>0.049</td>
<td>8254298</td>
<td>494.92</td>
</tr>
<tr>
<td>Norway</td>
<td>32386159.76</td>
<td>258813.01</td>
<td>0.008</td>
<td>4640219</td>
<td>557.76</td>
</tr>
<tr>
<td>Denmark</td>
<td>4526802.42</td>
<td>320252.39</td>
<td>0.071</td>
<td>5427459</td>
<td>590.06</td>
</tr>
<tr>
<td>Belgium</td>
<td>3067339.91</td>
<td>630879.33</td>
<td>0.026</td>
<td>10511382</td>
<td>600.19</td>
</tr>
<tr>
<td>Finland</td>
<td>33695580.20</td>
<td>476226.76</td>
<td>0.014</td>
<td>5255580</td>
<td>906.14</td>
</tr>
</tbody>
</table>

Western Europe 297888429.15  13169019.83  0.044  372163733  353.85
rate, thus evidencing that most countries have conformed to the need for urban spaces of social communities. This aspect is particularly evident in some Scandinavian countries where the number of inhabitants is lower, but production and industrial sites, of either European or global importance, are large.

To this regard, it is interesting to examine the same data related to some Eastern European countries that overall have a per capita index that is 25% higher than that of Western Europe (over 466 versus almost 354 m²/inhab.). Furthermore, we can see that some countries which, as we all know, are facing economic difficulties (e.g. Hungary and Romania) have per capita indices similar to those of very advanced countries in Western Europe, such as Denmark and Belgium. In these cases, land transformation driven by policy and government-related events in the Eastern block, despite significant economic inequalities within society in individual terms, has probably led to extensive changes in settlements prompted by public initiatives which persist even today, albeit with different drivers, in the attempt to bridge the development gap.

Some of these data suggest that urban conversion of land in the post-World War II years should be ascribed more to behavioural aspects of national societies, rather than their actual average economic conditions.

In fact, the diagram in Figure 4 shows that there is no significant dependence in the relationship between urbanised land and per capita GDP, even if we include in the diagram the Eastern European countries listed in Table 2.

At European level, it is very difficult to obtain homogenous data on the course of urbanisation for the various countries broken down for specific time periods. The only information available today to this regard is still the previously mentioned CLC data and their updates in 1990, 2000 and 2006. Table 3 shows that, in the 15 years spanning from 1990 to 2006, urban surfaces in the Western European countries examined, excluding the Scandinavian peninsula, have increased by almost one and a half million hectares (slightly less than the size of an Italian region like Sardinia) at the speed of 450 ha per day (almost 20 ha per hour). However, it is important to mention that, between 2000

**Figure 4. Correlation between per urbanisation and per capita GDP in the Western and Eastern European countries considered**
and 2006, the pace has slowed down a little thanks to Germany which has complied with its limit of 30 ha per day set in 2000. Table 3 also highlights that the increase in urban areas between 1990 and 2006 has occurred almost exclusively to the detriment of agricultural areas, with a mean incidence of 83% in these areas. In countries, such as Germany, Italy, the Netherlands, the UK, Ireland and Denmark, 90% of new urbanisation concerns agricultural areas, while only Portugal has a figure below 70%. This is a problem that is taking on its own distinctive features and is tied to the significant loss of agricultural production, and is therefore considered one of the major impacts of land consumption. The issue has been raised in the recent paper by the European Commission COM (2012) 46 (“The implementation of the Soil Thematic Strategy and ongoing activities”) which based on the same sources of data used in Table 3, states that:

In the period 1990-2006, 19 Member States lost a potential agricultural production capability equivalent to a total of 6.1 million tonnes of wheat, with large regional variations. This is a far from insignificant figure, given the levelling off of agricultural productivity increases that has already been experienced and the fact that, to compensate for the loss of one hectare of fertile land in Europe, it would be necessary to bring into use an area up to ten times larger in another part of the world.

### VALIDATING THE RELIABILITY OF EUROPEAN DATA

Going back to the information in Table 1, mean urbanisation rate in Western Europe amounting to some 358 m²/inhabitant for all 13 considered countries deserves specific attention. An almost identical result has emerged recently from a study carried out on the Italian territory and in the process of being concluded (Romano & Zullo, 2012). This study has shown that the threshold ranging between 350 and 400 m²/inhabitant in per capita urbanisation is characteristic of many Italian regions too, both individually and in different geographical aggregations.

Table 4 shows the urbanisation data of 12 Italian regions taken from more detailed cartographic sources than CLC, that is to say regional land use maps obtained by means of photo-interpretation on a 1:10.000 scale. In the considered territory, which covers over half of the country, the mean urbanisation rate is 6%, while per capita urbanisation amounts to about 370 m²/inhabitant. Moreover, the latter figure is fairly consistent across all the regions considered, since the standard deviation of the mean is 30%.

The comparison of these data with those relating to Italy included in Table 1 shows that there is approximately a 1% difference in urbanisation rate and this can be ascribed to at least two reasons. The first is tied to the present-day incompleteness of data about Italy included
Table 3. Agricultural land uptake between 1990 and 2006 in some countries of Western Europe

<table>
<thead>
<tr>
<th>Countries</th>
<th>Urbanized surfaces difference 1990-2006 (ha)</th>
<th>Daily land uptake 1990-2006 (ha per day)</th>
<th>Urbanized agricultural areas between 1990-2006 (ha)</th>
<th>% incidence of agricultural areas over total urbanized surfaces (90-06)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>317961,28</td>
<td>54,45</td>
<td>223419,66</td>
<td>0,703</td>
</tr>
<tr>
<td>France</td>
<td>225628,10</td>
<td>38,63</td>
<td>191966,74</td>
<td>0,851</td>
</tr>
<tr>
<td>Germany</td>
<td>274949,24</td>
<td>47,08</td>
<td>249419,48</td>
<td>0,907</td>
</tr>
<tr>
<td>Italy</td>
<td>133465,97</td>
<td>22,85</td>
<td>125732,28</td>
<td>0,942</td>
</tr>
<tr>
<td>Netherlands</td>
<td>121923,11</td>
<td>20,88</td>
<td>116833,86</td>
<td>0,958</td>
</tr>
<tr>
<td>Portugal</td>
<td>96856,24</td>
<td>16,58</td>
<td>54182,33</td>
<td>0,559</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>60129,14</td>
<td>10,30</td>
<td>55186,73</td>
<td>0,918</td>
</tr>
<tr>
<td>Irish Republic</td>
<td>52622,94</td>
<td>9,01</td>
<td>50873,45</td>
<td>0,967</td>
</tr>
<tr>
<td>Denmark</td>
<td>24193,28</td>
<td>4,14</td>
<td>22761,66</td>
<td>0,941</td>
</tr>
<tr>
<td>Belgium</td>
<td>22908,52</td>
<td>3,92</td>
<td>18643,49</td>
<td>0,814</td>
</tr>
<tr>
<td>Total and average</td>
<td>1330637,83</td>
<td>227,85</td>
<td>1109019,68</td>
<td>0,833</td>
</tr>
</tbody>
</table>

Table 4. Urbanisation data of some Italian regions updated at 2001

<table>
<thead>
<tr>
<th>REGIONS</th>
<th>Regional area (km²)</th>
<th>N. Inhabitants 2001</th>
<th>Urbanization rate</th>
<th>Urbanization per capita (mq/inhab.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umbria</td>
<td>8461,07</td>
<td>853676</td>
<td>0,036</td>
<td>352,88</td>
</tr>
<tr>
<td>Molise</td>
<td>4461,03</td>
<td>347628</td>
<td>0,027</td>
<td>346,00</td>
</tr>
<tr>
<td>Puglia</td>
<td>19533,85</td>
<td>3856870</td>
<td>0,066</td>
<td>332,37</td>
</tr>
<tr>
<td>Abruzzo</td>
<td>10826,99</td>
<td>1328832</td>
<td>0,034</td>
<td>276,48</td>
</tr>
<tr>
<td>Sardegna</td>
<td>24083,61</td>
<td>1589541</td>
<td>0,032</td>
<td>491,10</td>
</tr>
<tr>
<td>Marche</td>
<td>9727,7</td>
<td>1469826</td>
<td>0,052</td>
<td>344,12</td>
</tr>
<tr>
<td>Valle d'Aosta</td>
<td>3260,92</td>
<td>135001</td>
<td>0,014</td>
<td>348,84</td>
</tr>
<tr>
<td>Lazio</td>
<td>17206,403</td>
<td>5089737</td>
<td>0,077</td>
<td>259,50</td>
</tr>
<tr>
<td>Liguria</td>
<td>5405,9</td>
<td>1571783</td>
<td>0,057</td>
<td>197,53</td>
</tr>
<tr>
<td>Emilia Romagna</td>
<td>22123,24</td>
<td>3809294</td>
<td>0,093</td>
<td>541,75</td>
</tr>
<tr>
<td>Lombardia</td>
<td>23863,86</td>
<td>9034007</td>
<td>0,141</td>
<td>371,80</td>
</tr>
<tr>
<td>Friuli V. G.</td>
<td>7859,92</td>
<td>1209804</td>
<td>0,089</td>
<td>576,29</td>
</tr>
<tr>
<td>Total and average</td>
<td>156814,49</td>
<td>30295999</td>
<td>0,060</td>
<td>369,89</td>
</tr>
</tbody>
</table>

in Table 4 (only half of the national territory has been analysed so far) and, as a result, there is still some uncertainty regarding the overall figure. It is reasonable to believe that, since high urban density regions, such as Piedmont, Tuscany, Campania and Sicily, have not yet been included in the computation of urbanisation rate, the final value will be closer to 6-7%.
The second and most important reason for the difference between these two figures is tied to the primary data which they were obtained from: in the case of the European comparison in Table 1 urbanised areas were taken from the CORINE Land Cover (CLC) 2006 satellite remote sensing, while in the case of the Italian study, as mentioned earlier, the same surfaces were obtained from regional land use maps, plotted between 2002 and 2008, by means of photo-interpretation on a scale of considerable detail (1:10,000 – 1:5,000).

As it is well known, CLC data are on a nominal scale of 1:100,000, with a legend including 44 items divided into three hierarchical units, and are referred to homogenous spatial units with elementary zones belonging to the same class, clearly distinguishable from surrounding units. For these reasons, CLC data have many shortcomings in the accuracy of measured urbanised areas, since the minimum mappable unit is 25 hectares (equivalent to a square of 500 m per side) and the minimum width of polygons that can be surveyed is 100 m. This makes it impossible for CLC to capture urban aggregates with boundaries below 100 metres (sprinkling housing and small villages), while secondary roads (state, provincial and municipal roads) cannot be considered for the same technical reasons. The previously mentioned studies (Romano & Zullo, 2012) on Italian regional samples have ascertained that urbanisation values derived from CLC data greatly underestimate the magnitude of this phenomenon compared to technical maps on regional land use on a 1:10,000 scale (Table 5).

Differences between CLC data and real life, better reflected by regional land use maps, in the best cases amount to 30%, but are even larger when urbanisation is more scattered, with many isolated houses in agricultural areas and numerous tiny urban aggregations consisting of a few buildings. The aforementioned differences near or exceed 100% in regions, such as

Table 5. Differential test based on the surveys of urbanised areas taken from Corine Land Cover (CLC) and those obtained from technical maps or regional land use maps (CUS) after 2000

<table>
<thead>
<tr>
<th>REGIONS</th>
<th>Urbanized area CLC 2000 (ha)</th>
<th>Urbanized area CUS 2000 (ha)</th>
<th>Difference %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abruzzo</td>
<td>23250,13</td>
<td>36740</td>
<td>0,58</td>
</tr>
<tr>
<td>Campania</td>
<td>71145,88</td>
<td>101163,93</td>
<td>0,42</td>
</tr>
<tr>
<td>Emilia-Romagna</td>
<td>97985,00</td>
<td>206369,06</td>
<td>1,11</td>
</tr>
<tr>
<td>Friuli-Venezia Giulia</td>
<td>49529,01</td>
<td>69719,61</td>
<td>0,41</td>
</tr>
<tr>
<td>Lazio</td>
<td>88415,77</td>
<td>132078,31</td>
<td>0,49</td>
</tr>
<tr>
<td>Liguria</td>
<td>18900,41</td>
<td>31047,42</td>
<td>0,64</td>
</tr>
<tr>
<td>Lombardy</td>
<td>215942,87</td>
<td>304765,8</td>
<td>0,41</td>
</tr>
<tr>
<td>Marche</td>
<td>38634,30</td>
<td>50580,37</td>
<td>0,31</td>
</tr>
<tr>
<td>Molise</td>
<td>4286,21</td>
<td>12028,05</td>
<td>1,81</td>
</tr>
<tr>
<td>Puglia</td>
<td>71797,89</td>
<td>128190,03</td>
<td>0,79</td>
</tr>
<tr>
<td>Sardinia</td>
<td>54130,35</td>
<td>78061,88</td>
<td>0,44</td>
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<td>Umbria</td>
<td>23989,49</td>
<td>30124,74</td>
<td>0,26</td>
</tr>
<tr>
<td>Valle d’Aosta</td>
<td>3237,94</td>
<td>4709,3591</td>
<td>0,45</td>
</tr>
<tr>
<td>Veneto</td>
<td>132041,36</td>
<td>246298,58</td>
<td>0,87</td>
</tr>
<tr>
<td>Total</td>
<td>893286,63</td>
<td>1431877,14</td>
<td>0,60</td>
</tr>
</tbody>
</table>
Emilia Romagna, Molise, Puglia and Veneto, where urban sprawl is highly fragmented. When these forms of urbanisation are very common, as in the case of Italy, European estimates are significantly altered (Figure 2). If, in Table 1, the more realistic urbanisation rate, ranging between 6 and 7%, were attributed to Italy, instead of the CLC-based rate of 4.9%, per capita urbanisation would exceed 330 m²/inhabitant and thus be more consistent with that of Northern European countries and the Western European average. As a matter of fact, it is very likely that CLC data on urbanisation are far more consistent with the real-life situation in Northern European countries, such as Germany, the Netherlands, the UK and Scandinavian countries where urbanised areas are generally far more close-knit and aggregated in large patches, unlike what occurs in Italy, Spain, Portugal and Denmark.

The examples shown in Figure 5, obtained by overlapping the 2006 CLC urbanised areas with the aerial photos of Google Earth, clearly highlight the huge differences in data reliability in the case of countries with large and close-knit urbanised areas (Germany and the UK) compared to countries with many small towns scattered throughout the territory.

**TECHNICAL RECOMMENDATIONS**

The study presented in this paper, on one hand, sets out some comparative results relating to various Western European countries, including Italy, but on the other hand, inevitably makes us think about some of the critical aspects tied to available data and, in some cases, their partial reliability.

Taking into account that these are the only data available to date for all Europe (Western and Eastern), it is a fact that the amount of urbanisation evidenced by means of CLC remote sensing diverges from the real-life situation sometimes by well over 50% as shown in the

*Figure 5. An example of the differences in the mapping of urbanised areas between the Corine Land Cover (CLC) and regional land use maps (CUS) on a 1:10,000 scale in an area of Central Italy.*
example in Table 5 for Italy and in Figures 5 and 6 for other European countries. This leads to the awareness that available information is still too inaccurate and, above all, geographically inhomogeneous, to conduct scientifically robust analyses.

It therefore seems necessary that the competent European agencies work more on methods and technologies to set up databases with a higher resolution than current ones, in order to make comparisons and diagnoses based on realistic measurements. Increased accuracy of primary data on land use features on a continental scale is absolutely essential to collect information on the development of this phenomenon. This information should be tied to the determination of significant thresholds that may be useful in identifying mechanisms to control and gradually reduce urban sprawl similar to the ones adopted in Germany.

Some signs in this direction can be found in recent EEA works updated to 2007 (http://www.eea.europa.eu/data-and-maps/data/urban-atlas) which make data on urban coverage available on a 1:10,000 nominal scale (European Commission 2011), but for the time being limited to the main European cities with over 100,000 inhabitants (Figure 7).

Figure 6. Examples of the reliability of CLC perimeters of urbanised areas and actual layout of urbanised areas in the Western European countries studied: Germany (top left), UK (top right), Denmark (bottom left) and Italy (bottom right) (Aerial photo source: Google earth 2006)
Greater levels of detail, for example, would make it possible to confirm or recalibrate the previously mentioned interesting and recurrent result of 350-400 m²/inhabitant in per capita urbanisation as the standard value adjusted to the average requirements of contemporary Western European society, which is the product of spontaneous convergence over a time span of over half a century.

However, the considerations contained in this paper, based on urban development models illustrated in Figure 5, highlight that mechanisms to control territorial transformation cannot rest solely on quantitative limits, like the ones used in the German case.

For countries like Italy, Spain and Portugal (which the previously mentioned EEA 2006 report depicts as threatening cases for European coasts), the mere constraint of a maximum admissible quantity of artificial land per year is not sufficient to warrant minimum quality of outcomes.

In these cases, in fact, if the rise in urbanised areas is the same as in countries with close-knit urban shapes, infrastructure density would increase significantly and, as a result, the effects on energy waste, inefficiency of public services, chemical-physical environmental disturbances and the fragmentation of ecosystems (Figure 3) would also increase.

Moreover, it is far more difficult to implement strategies for the management, control and direction of land use, since you cannot be sure about features that the settlement will take on, owing to the weakness of rules governing it.

It is therefore clear that land uptake control in Europe, and the initiative prompted by the draft directive by the European Parliament and Council COM(2006) 232 (which introduces a framework for soil protection and amends
directive 2004/35/CE), will have to take these aspects into due account and be modulated adequately. Almost certainly, the prospective directive resulting from the 2006 proposal will not contain indications limiting urbanisation, since the same proposal states that:

Most of the recommendations from the Working Groups as well as concerns expressed in the Internet consultation have been taken on board. Abundant calls for mandatory restrictions on urban and touristic developments have not been endorsed as the Community has limited competences on restricting land use.

This is why, despite the fact that proposal COM (2006) 232 mentions soil sealing as one of the key soil-related issues in Europe (erosion by water or wind, organic matter decline brought about by a steady downward trend in the organic fraction of the soil, soil contamination, salinisation through the accumulation in soil of soluble salts, compaction through an increase in bulk density and a decrease in soil porosity, landslides brought about by the downslope, moderately rapid to rapid movement of masses of soil and rock material), it only explicitly mentions the phenomenon of urbanisation once (13-Sealing is becoming significantly more intense in the Community as a result of urban sprawl and increasing demand for land from many sectors of the economy, and this calls for a more sustainable use of soil) and fails to insist further on this point in the sections on risk prevention, mitigation and restoration.

The subsequent document COM (2012) 46 (The implementation of the Soil Thematic Strategy and ongoing activities) goes back to the issues of contamination, desertification and degradation, but remains rather superficial regarding the responsibility of urbanisation for the adverse consequences of soil sealing.

These concise remarks make it desirable that the text of the “soil directive”, if adopted, be greatly amended and reviewed, by clearly attributing to urbanisation the role it deserves as an activator of territorial and environmental diseases.

For reasons of EU competence, it seems evident that only National States are directly responsible for the control of urban conversion of soil, which for the previously mentioned reasons, will have to independently identify tailor-made sets of suitable parameters to monitor and limit the growth of urban coverage.

CONCLUSION

From this paper, it may be inferred that for many countries it will not be sufficient to introduce only quantitative limits to the admissible increase in urbanised areas, but additional parameters will be needed, such as the shape of such areas, territorial dispersion indices and density and types of transport networks.

It should be added that many countries currently lack accurate information on the dynamics of urban use of land, as well as technical and administrative systems to track this phenomenon using adequate and homogeneous details for the entire country and over a shorter period of time than that usually needed (five or ten years) to update present-day regional maps.

Unlike the USA, where many in-depth studies on sprawl have been carried out, some of which have been mentioned earlier (Brueckner, 2000, 2001; Glaeser & Kahn, 2001; Nechyba & Walsh, 2004), there are still relatively few similar studies in Europe (Patacchini et al., 2009) and they are generally broadly affected by data uniformity issues, which this paper has tried to bring to the surface with regard to the territorial sector.

Owing to the lack of information platforms (land registers) and Regional Observatories (communicating with government entities capable of compiling overall data) on land and types and size of abandoned areas, it will be almost impossible to manage forms of checks and balances of this phenomenon both at sub-national and national level.
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