The urban transformation of Italy's Adriatic coastal strip: Fifty years of unsustainability

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ABSTRACT

The study regards the processing of data on urban land conversion along the Italian Adriatic coast in the last 50 years. The results obtained show different aspects of the phenomenon: values were obtained for the average annual speed of transformation of the coastal strip; clustering, dispersion and statistical concentration of the data obtained were studied, which has made it possible to show unparalleled threshold values in the present levels of urbanization; geostatistical surveys were conducted to determine the distribution changes of urban concentration over time; analyses have been developed to point out what landscape and morphological elements have emerged, and are tendentially confirming greater sensitivity to land artificialization; a number of comparisons based on specific indicators were produced that show the typological and geographic variations of development taking place in the time period studied; important information has emerged on the different territorial policies implemented by the regions over the long-term. This research has made it possible to investigate one of the largest and most intense land transformation phenomena in Italy which has led to the construction of an urban organism extending along more than 1470 km of coast with very few breaks which, together with railroad and motorway infrastructural elements, forms the longest urban stretch in southern Europe and one of the most extensive in the entire continent. A further result of the work carried out concerned the extraction of data on the remaining coastal stretches, i.e. those not yet affected by urban transformation and thus of extreme importance for policies focused on the preservation of community habitats and the preservation of coastal landscape. In conclusion, it has been possible to draw a map of management responsibilities at the municipal and regional levels for the revision of future urban planning trends in terms of sustainable governance.

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Introduction

The study discussed in this paper has produced the interesting processing of data on the quantitative and qualitative development of land urbanization along the Italian eastern coast from the post-war period (1949–1962) to the Noughties, analyzing modalities, extent and environmental impact of this phenomenon on this fragile and vulnerable geographical area.

Over the past years growing attention has been paid to land use as a harmful environmental factor (Lambin et al., 2001; Sala et al., 2000; Ellis and Ramankutty, 2008), but its effects on ecosystems and coastal landscapes are particularly significant and have been neglected throughout the Mediterranean basin for a long time (Catalán et al., 2008).

There are not many studies in international literature on the Italian case (Bonifazi and Heins, 2001; Capello, 2001) and more detailed data on long-term development in some geographical areas of the country have been published only recently (Pileri and Maggi, 2010; Romano and Zullo, 2012; Salvati et al., 2012).

Very few regions (only 4 out of 20) have vector information on land use over the past 50 years, but there are also very few cases in which data on shorter periods of time are available (1970–2000), regarding both the overall extent of urbanization and statistically significant historical series. Furthermore, no coordinated survey activities have been planned by local authorities (regions, provinces and municipalities).

The negative aspects of this phenomenon are still only marginally considered by scientific agencies and in communication and land governance (Grubler, 1994; Heilig, 1994) and only in 2013 did this issue appear for the very first time on the political agenda, one of the candidates in the last national political election unlike other countries, where actions, data and publications are far more numerous (Hall et al., 1973; Mellor, 1983; Yanitsky, 1986; Irwin and Bockstael, 2007; Zaninetti, 2006; Garcia-Call, 2011; Hauri et al., 2006; Illy et al., 2009). Only recently has the need emerged to set up mechanisms to monitor urban transformation dynamics, but we

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are still far from having systematic and consistent data collection that would make credible comparisons and assessments possible (Sharma et al., 2012; Lowry, 1990).

One of the most recent initiatives to this regard is the one taken by the National Land Use Observatory, set up by the Milan Polytechnic and INU (Urban Planning National Institute) (http://www.inu.it/attivita_inu/ONCS_2.html) which however makes use of relatively recent information bases (end of the 1970s) and has very little data available. Towards the end of the 1980s, other authors highlighted landscape change modalities using large-scale national databases (1:250,000) (CNR-IPRA, 1988; Astengo and Nucci, 1990) or European standards such as CLC (Corine land cover) (Bossard et al., 2000; APAT, 2005; Comber, 2008) derived from satellite remote sensing on a nominal scale of 1:100,000 (Falcucci and Maiorano, 2008). Some international organizations, such as the European Environmental Agency (EEA, 2006), have estimated, in the case of Italy, that approximately 8000 ha per year were artificialized between 1990 and 2000, again based on CLC satellite remote sensing.

All these data have in common an insufficient level of detail, which creates, mismatches between assessments and actual conditions and at the same time, a difference in estimates that varies from one geographical area to the other depending on the type of settlement (Romano and Zullo, 2013).

In Italy, a great deal of attention is being paid to the issue of land use nowadays and in many cases estimated data are disseminated in various ways, but with a reduced level of reliability and lacking satisfactory statements regarding sources and methods.

A few years ago, one of the first examples mentioned on many occasions consisted of the information extracted from the databases of the National Institute of Statistics (ISTAT), according to which, between 1990 and 2005, approximately 3 million ha were urbanized. In reality, this area, accounting for 10% of the national territory, is farmland used for agriculture (used agricultural land – UAL), which has changed use in the 15 years considered. It has been converted into urban areas only in part, while most of it has been either abandoned or has become wild, degraded or forestal.

If we take into account that current overall urban areas, calculated using the most recent regional land use maps on a 1:10,000 scale and ISTAT estimates, range between 2 and 3 million ha (even if this figure excludes the road network), the mismatch between actual conditions and UAL data is very evident.

Numerous inaccuracies in the production of land use data may be found even among institutional research agencies which, in applying the statistical estimates based on partial sample data, has calculated land use in Italian regions at 2010 with huge tolerances varying between two and four percentage points, that is to say in many cases greater than the actual figures. As mentioned earlier for the present-day values of urbanized land, it is not very useful to produce “estimates” since almost all the Italian regions have reliable data based on land use maps derived from photo-interpretation at 10,000 updated between 2002 and 2007.

What is missing for the post-war period is a homogenous picture of the entire country reconstructed on the basis of standard data for the entire territory and backed by measurements with a sufficiently high level of accuracy that makes it possible to compare land transformation between the various regions on a level playing field.

The aim of this paper is to provide a contribution to this regard, by focusing on a significant area of the country in terms of features and problems, and is broken down as follows: the specific features of the Adriatic coast – an area subject to strong transformation pressure for many decades – are highlighted in the description of the study area; the section on methodology describes the origin of the data and the data extraction techniques used; the results section illustrates the settlement conditions in the study area in the 1950s and then sets out in detail the changes that have occurred from the post-war period to the post-2000 years, describing the various aspects differentiating the territories studied; the conclusions set out the current conditions, environmental criticalities and margins for the recovery of extremely compromised territorial conditions that even today receive scarce attention from local and central institutions.

Study area

The Italian Adriatic coast is an extremely significant sample territory to analyze the phenomenon of urban land conversion in Europe. As a matter of fact, together with the southern coast of France, the south-west coast of Spain and the south-west coast of the Balkans up to Greece, its morphology and climatic conditions are very appealing to settlements in the Mediterranean area (Vallega, 1995; Cori, 1999; Bellot et al., 2007). However, as evidenced by satellite night vision, the Italian eastern coast is undoubtedly the most densely urbanized one in the entire Mediterranean basin (Fig. 1).

This paper refers to data and assessments relating to two geographical units (Fig. 2): the first is formed by a selection of coastal municipalities of the Adriatic sea (CM), while the second is formed by a 500 m wide coastal belt (CB). Along the Adriatic coastline this belt coincides on average with the coastal plain and includes all those areas tied to the sea economy, crossed historically by national infrastructure and then affected by the massive phenomenon of mass tourism.

The coastline studied extends for about 1472 km and accounts for 6% of the overall length of coasts around the Mediterranean sea and 17% of the Italian section. The Adriatic coastal regions are 8 out of the total 20 with 121 municipalities. These municipalities, which form the CM, are numerically only 2% less than the entire Italian municipalities and cover only 3.2% of the entire national territory with 9589 km². However, the CM includes almost 6% of the entire Italian population censused in 2011 (over 3,476,800 residing inhabitants) and concentrates as far as 20% of the approximately 17,634,000 inhabitants residing in coastal regions (Source: ISTAT data, http://demo.istat.it)

The regions included in this study are Friuli Venezia Giulia, Veneto, Emilia Romagna, Marche, the Abruzzi, Molise and Puglia.

Fig. 1. Satellite night vision of the Mediterranean basin highlighting the intense urbanization of the Italian Adriatic coast.

Source: Google Earth, 2012.
The territories of these regions are encompassed in the Adriatic coastline to a highly differing extent, as evidenced in Table 1, with the CM, which cover 10% of total regional territories.

From a morphological viewpoint, the Adriatic coast is rather uniform, with few promontories and with almost 70% of the entire CM territory consisting of flat formations (wetlands and different types of coastal plains), low and sandy beaches and a flat or low-hill hinterland, which over time has facilitated the building of infrastructure and manufacturing and residential settlements. The construction of the railway line occurred very early, between 1863 and 1872, and was the first link between southern and central-northern Italy. The Adriatic highway (A14), instead, was completed between 1966 and 1975, and today is the second longitudinal artery in the Italian peninsula, 743.4 km in length. The presence of these two fast arteries, together with the first historical road (state road no. 16 – the Adriatic, which extends for over 1000 km and is the longest state road in the national network) has favored the growth of all the towns situated along it.

### Table 1
Study area characteristics.

<table>
<thead>
<tr>
<th>Regions</th>
<th>Area (km²)</th>
<th>No. of coastal municipalities</th>
<th>Municipal areas (km²)</th>
<th>Coastal municipal area ratio (%)</th>
<th>Length of coastal line (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friuli Venezia Giulia</td>
<td>7859.93</td>
<td>8</td>
<td>403.24</td>
<td>5.13</td>
<td>165.13</td>
</tr>
<tr>
<td>Veneto</td>
<td>18,424.00</td>
<td>10</td>
<td>1656.53</td>
<td>8.99</td>
<td>163.68</td>
</tr>
<tr>
<td>Emilia Romagna</td>
<td>22,123.24</td>
<td>14</td>
<td>1520.45</td>
<td>6.87</td>
<td>149.28</td>
</tr>
<tr>
<td>Marche</td>
<td>9749.54</td>
<td>23</td>
<td>959.96</td>
<td>9.85</td>
<td>226.84</td>
</tr>
<tr>
<td>Abruzzo</td>
<td>10,830.16</td>
<td>19</td>
<td>635.16</td>
<td>5.86</td>
<td>125.34</td>
</tr>
<tr>
<td>Molise</td>
<td>4461.03</td>
<td>4</td>
<td>259.94</td>
<td>5.83</td>
<td>37.94</td>
</tr>
<tr>
<td>Puglia</td>
<td>19,533.86</td>
<td>43</td>
<td>4153.86</td>
<td>21.26</td>
<td>604.45</td>
</tr>
<tr>
<td>Total and average</td>
<td>92,981.76</td>
<td>121</td>
<td>9589.15</td>
<td>10.31</td>
<td>1472.66</td>
</tr>
</tbody>
</table>
Unlike the Tyrrenian coast, for historical and climatic reasons, there are not many vast cities along the Adriatic line, as the largest ones are Trieste (204,000 inhabitants), Venice (270,000), Ancona (103,000), Pescara (123,000) and Bari (320,000); significantly smaller than the Tyrrenian metropolitan areas, such as Naples (almost 1 million inhabitants), Roma (2,800,000) or Genoa (600,000).

At any rate, the Adriatic for years has been one of the national areas with the highest development trend, especially regarding production and commercial locations, as it can rely on 11 commercial harbors with over 30 minor and mostly tourist ports, on several cities of international historical interest (Trieste, Venice and Bari) and a multitude of important tourist and seaside resorts at European level (almost 60 million visitors estimated in 2006).

Over the past 50 years, the foregoing features have produced an extraordinary transformational thrust, which has turned this coastline, together with the Po valley, into one of the most artificialized and congested places in Italy. Today, less than 30% of its waterfront is free from urbanization and is plagued by significant issues of territorial organization, but also of control and recovery of its residual ecosystem and landscape qualities.

Methodology

In this paper, urbanized areas in the 1950s have been extrapolated from homogenous maps of the entire country using an appropriate GIS technique, in order to obtain comparable values for all Italian regions. The data produced have required almost four years of studies and we expect to obtain reference data for the entire country in another three years.

As mentioned previously, in order to develop a reliable national evolutionary picture of urban conversion of land from the second post-war period to the present day, it is necessary to use cartographic bases that are homogenous for the period across the entire country and with a sufficient scale of detail to highlight even the most scattered and fragmented urbanized parts.

This is why, in the study presented in this paper we used Italian maps published on a scale of 1:25,000 by the Italian Military Geographical Institute (IGMI) between 1949 and 1962 (Fig. 3). These maps are part of the 25V Series, plotted on a scale of 1:20,000, organized in 3545 elements (tables) 7°30’ longitude and 5° latitude in size, in Gauss’s conformal representation and part of the national geodetic system (international ellipsoid oriented to Rome Monte Mario – ED40) with a kilometric grid in the Universal Transverse of Mercator conformal projection (ED50 European data).

From these maps, available in raster version, it is possible to extrapolate urbanized areas in the 1950s, formed by areas covered by buildings plus all ancillary areas (parking areas, streets within neighborhoods, goods storage and handling areas and various other structures).

Within the framework of this study, we developed a GIS technical procedure capable of semi-automating vector extraction of urbanized areas from historical raster maps (Romano and Zullo, 2010). Then, the overall parts corresponding to urban functions (built and ancillary areas) were isolated and tested using additional topological devices. The results obtained from this study on 1:25,000 maps were then compared with those of urbanized areas available in vector format from regional maps generally derived from photo interpretation on a nominal scale of 1:10,000 or 1:5000, updated between 2002 and 2007.

By “urbanized soil” we mean soil belonging to type b among the following different forms of transformed soil:

(a) Built-up land Surfaces covered by buildings and identifiable through the ground projection of the perimeter of the latter. Natural soil has been removed completely in order to build foundations.

(b) Urbanized soil Land used for urban functions, involving the replacement or retention of natural soil: it includes built-up land and land used for ancillary settlement functions, such as public and private gardens, sports facilities, unpaved roads and other service areas, either permeable or impermeable to water.

![Fig. 3. Detail of the representation of the Adriatic coast on the IGM 1:25,000 map of the 1950s.](image-url)
(c) Artificial land Areas where the natural layer has been replaced by other materials, either permeable or impermeable to water, to allow different uses: it includes parts of built-up land, but also streets, squares and parking lots (paved or permeable), as well as sports fields or excavation areas.

(d) Sealed soil Surfaces covered by layers of impermeable material preventing the absorption of surface water. It includes built-up land and land used for other purposes that require paving, such as streets, squares and parking lots and all those cases where the natural soil layers are removed entirely and replaced by other materials that improve the stability and indeformability of surfaces.

Results

Urbanization in the 1950s

Urbanization along the Adriatic coast, assessed on the basis of the CM, in the second post-war period is definitely limited (Table 2) as overall it is less than 28,000 ha (more or less equal to a square of 16 km per side) with an average density below 3% of the total municipal surfaces concerned. In the northern part of the CM, this value ranges between 3 and 4%, with the exception of Friuli where it as high as 14%. This is undoubtedly due to the combined effect of the reduced municipal coastal area in Friuli (approximately 40,000 ha) and the presence of the conurbation of Trieste. However, Table 2 shows that already back in the 1950s this region had an average urbanization density higher than that of other coastal regions. More specifically, at the time, this value, in excess of 4%, was among the highest in Italy and equal to that of Lombardy. There are several reasons for this, tied to the many military bases, the settlement customs of many cultures, the forms of agricultural organization and land reclamation, the harbor of Trieste, the earlier industrialization compared to other Adriatic regions and the development of strong handicraft production areas since the post-war period. As a matter of fact, the historical settlement database of Friuli shows that about one seventh of urbanized areas (5220 ha out of almost 34,000 ha in total) are formed by commercial, industrial and limited-access military areas (the latter account for as much as 3600 ha out of the total 5220 ha).

The urban density values in the CM of the other northern regions, always relatively high, may be ascribed to various reasons. In the case of Veneto, it may be ascribed to economic interests tied to fishing and trade (Venice harbor), although limits to coastal urbanization should also be attributed to the presence of lagoons and fluvial estuaries. Since the years of Fascism, the coast of Emilia already witnessed early tourist-seaside development, while the hilly coastal hinterland of Marche, historically part of the Papal State, was already used intensively in terms of farming. Moreover, the Ancona harbor has always been one of the most important in Italy for fishing and communications.

The conditions in the southern regions are different and the economic interests tied to the coast more limited. Beach tourism was not yet so significant (it became significant in the 1960s and 1970s) and the harbors (Pescara, Termoli and, in part, Bari) are historically less important than those in the northern Adriatic and only recently have they been greatly developed.

In the years immediately after the war, urbanization density in the Adriatic regions was very low: just over 2% on average, but with minimum peaks of 5 or 7% in Molise and the Abruzzi.

In this highly differentiated setting, the CM, accounting for 10% of the entire area of the regions, already plays a significant role, as it accounts for almost 15% of total urbanized areas. This threshold is clearly exceeded in Marche and Puglia (over 26%). At any rate, already back in the 1950s per capita urbanization in some regions
(Emilia Romagna and Molise) was about 200% higher than the mean value in respective regions (Tables 2 and 3).

A particularly fragile area of the coast is the strip comprising the beach and historically the sandy dunes in the coastal hinterland. Considering the previously defined CB with a mean width of 500 m from the waterline and an expanse of about 62,000 ha in total, in the fifties urbanization density was 12%, and this strip accounted for over a quarter of the total urbanization of coastal municipalities (Table 3). Particularly high density values, for the reasons mentioned earlier, have been found in Friuli, Emilia and Marche. A particularly interesting element is the linear expanse of urbanization-free coast: in the 1950s almost 1000 km out of the total 1472 km (64%) of the Adriatic front lacked constructions and other ancillary facilities – a coastal landscape now unimaginable. If we exclude Marche (with only 21% free coast), Friuli had almost 50%, while Veneto, Emilia and the Abruzzi reached almost 70% free coast. In the case of Molise and Puglia over 80% of the coast was entirely free from urbanization (Fig. 4).

**Comparison between the 1950s and the year 2000**

Between the 1950s and 2001 the population in coastal municipalities (CM) increased by almost 720,000 inhabitants (by just below 27%), while, over the same period, the population increase in respective regions (from 14,955,651 to 16,736,666) amounted to 12% and in Italy to 20% (Table 2).

CM urbanization density increased four-fold, reaching the current value of over 11% and, while in the 1950s the standard deviation of these data compared to mean values was of 1.60, it dropped to 0.46 in 2000, thus evidencing that values along the coast are far more similar across all the regions (Table 2). In particular, in the Abruzzi, in Molise and Puglia urbanization increases between eight and ten-fold, compared to five-fold in Emilia and three-fold in Veneto (again taking the presence of coastal lagoons in the latter case into due account). The southern regions have obviously "caught up" with the northern ones (Fig. 5a), by encouraging intensive forms of construction of holiday homes for tourist use which, already at the end of the 1980s, had reached the levels of saturation of coastal areas visible today. The remaining interstitial areas were later filled by commercial, sports and tourist services facilities very widespread along the coast.

Fig. 6a again shows that, from the 1950s to 2000 coastal urbanization density differs significantly from regional mean values in all the regions considered, excluding Puglia.

Table 2 again shows that, if in the 1950s urbanized areas along the coast (CM) covered approximately 27,000 ha, after 2000 this figure soars to over 106,000 ha.

Substantial changes have occurred along the coastal belt (CB) which, in the 50 years considered, has witnessed a 300% increase in urbanization (from 12% to 34%) and, in this case, Veneto with 400% and the southern regions Abruzzi, Molise (with about 500%) and Puglia with 400% (Table 3) are at the top of the list.

The estimate of per capita urbanization is also very interesting, as it has risen from 103 m²/inhabitant in 1951 to the present-day 3163 m²/inhabitant (Table 2), but with peaks of 500 m²/inhabitant in Emilia Romagna and Molise. This value is lower than the current mean value of coastal regions (421.8 m²/inhabitant), or even the Italian and European mean value, which is of about 350 m²/inhabitant (Romano and Zullo, 2013). However, it should be taken into account that the CM population has increased by 27% in the past fifty years, compared to 12% in respective regions. Moreover, in the hinterland areas of these regions, which are all either

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**Table 3**

CB data.

<table>
<thead>
<tr>
<th>Region</th>
<th>CB area (ha)</th>
<th>CB Urbanized area (ha)</th>
<th>CB Urbanization density (%)</th>
<th>Land uptake speed (m²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1950s</td>
<td>Noughties</td>
<td>1950s</td>
<td>Noughties</td>
</tr>
<tr>
<td>Friuli Venezia Giulia</td>
<td>5378.60</td>
<td>1726.73</td>
<td>2475.87</td>
<td>0.32</td>
</tr>
<tr>
<td>Veneto</td>
<td>7772.33</td>
<td>570.51</td>
<td>2246.42</td>
<td>0.07</td>
</tr>
<tr>
<td>Emilia Romagna</td>
<td>6907.85</td>
<td>1349.16</td>
<td>3857.24</td>
<td>0.20</td>
</tr>
<tr>
<td>Marche</td>
<td>8405.08</td>
<td>1412.01</td>
<td>3641.99</td>
<td>0.17</td>
</tr>
<tr>
<td>Abruzzo</td>
<td>6026.20</td>
<td>288.38</td>
<td>1468.73</td>
<td>0.05</td>
</tr>
<tr>
<td>Molise</td>
<td>1782.70</td>
<td>5987.02</td>
<td>272.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Puglia</td>
<td>25,889.35</td>
<td>7196.61</td>
<td>7204.77</td>
<td>0.07</td>
</tr>
<tr>
<td>Total and average</td>
<td>62,252.11</td>
<td>7323.27</td>
<td>21,167.04</td>
<td>0.12</td>
</tr>
</tbody>
</table>

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**Fig. 4.** Urbanization-free coast rate 1950s – noughties per region.
alpine or Apennine excluding Puglia, there has been, in general, a significant phenomenon of depopulation that has impacted the per capita index.

The speed of land transformation has been extremely considerable: urban land conversion may be estimated to be over 4 ha/day in CM, and about 0.7 ha/day in the CB. For CM, this figure has to be compared to the average 2849 ha/day of coastal regions (Table 2), but also the 88 ha/day estimated for Italy. In the case of the CB especially, if we consider the development of the linear front of the coast, the speed of urbanization has been of almost 10 km/year from the post-war period to the present day (Table 4).

A chi squared test (with Office Excel Tools) has been performed on the data of Table 4 and Fig. 4, to verify the possible coherence on the evolution of coastal urbanization between 50s and noughties of all the studied regions. The average decrement of urban free coast is 50.66%. On the base of this rate, for each region the expected value at noughties has been computed, and compared with the actual value at the same time. The result of the \( \chi^2 \) test (5%) shows that there is no relation among the values. This fact is obvious, because there are no national rules for the coordination of the regional urban policies. Further attention should be paid to the geographic modalities through which these changes have occurred in the past 50 years.
To this end, the Urban Dispersion Index (UDI) may be useful and is calculated as follows:

$$\text{UDI} = \frac{N_{uc}}{A}$$

where $N_{uc}$ = number of urbanized nucleus, $A$ = municipality area (ha).

The UDI (Romano and Zullo, 2012) increases, if new urbanization is scattered in the territory and not geographically interconnected, while it decreases if the new parts are joined and linked to existing ones. Fig. 5b shows fairly clearly that in the coastal belt (CB) these urbanized fronts have been significantly connected from 1950s to 2000, especially in central Italy, in the south of the Marche and, in particular, in the northern Abruzzi, while urban density variations have been mid-sized. In the other regions, excluding one example in Veneto, the structure of urban continuity has essentially remained unchanged and has an UDI variation value always of around zero, even when urban density has increased very significantly (Emilia Romagna). In Salento, the southern tip of Puglia, between the municipalities of Tricase and Gagliano del Capo, a considerable increase in territorial dispersion can be observed instead, while changes in urbanization density have been rather limited. A similar situation suggests an increase in urban sprawl compared to the 1950s due mainly to the formation of small urban aggregates and scattered housing, a widespread phenomenon in most of the country.

The continuity of urbanization near beaches is a phenomenon that adversely impacts coastal ecosystems, especially for those species whose habitats range from the hinterland to the sea. Furthermore, it causes significant damage to the integrity of sandy shores, as it eliminates dunes, inhibits natural sand replenishment with consequences in terms of tourist attractiveness and funds needed to protect coasts (Rust and Illenberger, 1996; Curr et al., 2000; Nordstrom, 2000; Griggs, 2005; Defeo et al., 2009; Buffa et al., 2012).

**Conclusions**

Urbanization on the Italian Adriatic coast over the past 50 years has evidenced a clear lack of planning and the prospects for the reversal or control of this phenomenon are rather dismal. The most significant data emerging from this study are those concerning the dynamics of the approximately 400% growth of urbanization density in coastal municipalities (CM), and in particular the 300% growth of the coastal belt (CB). In the latter study area, we have clearly observed that in the 1950s approximately two thirds of the 1472 km of the coastline were free from buildings and other structures, while this value drops drastically to less than one third
after 2000 (466 km), with an amazing average speed of advancing urbanization equal to about 10 km per year (just less than 30 m per day).

Today, as shown in Fig. 5a, some coastal municipalities are over 40% urbanized, with peaks of 50% and even 80%, but there are numerous municipalities (about 1/6 of the 121 in total) that exceed 25%. If we shift our attention to the coastline, only one municipality can boast that it is 100% free after 2000, but it is actually a very short section of less than 700 m in terms of linear development. The other municipalities (at any rate less than ten) with high rates of free coast are those situated in Veneto and in northern Emilia and comprise broad lagoon or estuary strips. The remaining free coasts are found in some sectors with very steep or rocky promontories (the Conero in Marche, Punta d’Erci in the Abruzzi and Gargano in Puglia) or alternating sections of sand, raised rocky coast and deep seabed (several cases in Puglia). On the sand and dune shore—line, the coastal sections free from constructions or other forms of urbanization within a 500 m belt from the waterline are very few and generally do not exceed a few kilometers in length (Fig. 6).

Moreover, it is important to stress that the data used in this study...
generally date back to the early Noughties, but the phenomenon of the urbanization of coasts has continued in the past decade too and therefore the current situation is probably even more severe (Fig. 7).

On the other hand, the dynamics tied to constructions have boosted the entrepreneurial market of the Adriatic coast considerably which, as a result of this, in addition to the better connections with the rest of the country, has been a strong demographic and services attractor for years. It is extremely difficult to correlate the growth dynamics of urbanized areas to economic factors owing to the lack of data, but Fig. 8 shows that there is a positive, albeit rather light ($r^2 = 0.11$), correlation between per capita income in coastal municipalities and the intensity of urbanization in the past 50 years.

The price paid to obtain these benefits has undoubtedly been very high from the standpoint of environmental sustainability and the costs incurred by communities to counter coastal erosion and the narrowing of beaches, which are the resources that have supported tourism and real estate interests. Just a little more attention would have been enough to avoid the issues we face today (Fig. 9):

- focus on hotel accommodation rather than holiday homes;
- reduced occupation of land by increasing construction indices;
- moving back buildings from dunes and the coastline;
- the non-occupation of the riparian zones of rivers and streams.

This behavior would have made it possible to obtain huge benefits in terms of preservation of the environmental quality of the ecosystems concerned (Sargolini, 2010) and of hydrogeological safety.

In fact, hydraulic risks in these areas are huge and occur through catastrophic phenomena with a recurrence rate of a few years (even two or three), thereby causing significant economic damage and sometimes human casualties in extremely sealed areas with an excessively elevated density (the latest serious events date back to 2010). The greatest risk derives from the strong variations in the flow rate of water courses coming from mountain ranges in the hinterland and the instability of the argillaceous slopes of hills in the coastal hinterland.

The study conducted allows us to plot an accurate map of possible different actions to be undertaken by the CM local governments that still have free coasts and can avoid total occlusion of the coastal front. In this respect, the Italian government should take action by adopting tax incentive policies vis-à-vis municipalities for the conservation of residual free coast, using instruments that are already in the process of being tested in some European countries (Henger and Bizer, 2010), but also through the systematic implementation of environmental rehabilitation projects using, for example, abandoned areas. As a matter of fact, in these cases, especially when dealing with the rather numerous abandoned production sites, it would be a good idea to proceed with the total removal of derelict structures and the recovery of dunes and environmental continuity between sea and hinterland. This type of action, aimed at recovering, at least in part, the greater sustainability expressed in Fig. 9, to date seems to be the only possible one to improve the ecological-environmental conditions and mitigate hydrogeological risks for the Adriatic coasts, now saturated by buildings.

References
