The rapid growth of developed land (DL) on the Spanish coastal territory in the last years has been strongly criticized by environmentalists and ecological institutions, both on European and national level. Despite this, Spanish coast only occupies a total area of DL 3% (coastal provinces 143.457 km²), so the problems over this issue focus on three main aspects, developed land is concentrated in the first kilometers of the coast line, secondly, rapid rate of growth of low-density residential expansion in the last few years and finally, the driving forces that have led to this expansion, most notably tourism and real estate speculation.

Relating to this, this paper makes a balance of the growth of developed land in the provinces bordering the Spanish coast of the peninsula, whose objective is to evaluate the model or pattern of growth and expansion of the DL and to explore if there has been a similar trend of expansion in the coastal provinces as well. The data used for the analysis is taken from the data bases of the Corine Land Cover for 1990 and 2006, and the patterns of population for the same years.

Work is divided into three parts, the first part shows a descriptive diagnosis of the territory in 2006, the second part applies urban indicators which identify if a pattern or common model in the expansion of DL exists, and the third part consists of comparison between the expansion of developed land through studied period and applied urban indicators.

The first results show that the model of expansion of coastal land does not have a pattern or related model, where there are provinces with a strong increase in developed land and at the same time, do not show a significant increase in population, or the opposite, provinces with significant population growth and a moderate increase in DL. There are also very populated provinces with little expansion of developed land, or highly populated provinces which also have high expansion of developed land.
1. **CASE STUDY AREA**
Case study area comprises of 19 provinces which correspond to the Spanish coastline (without the islands), which covers the area of 143,457 km², equivalent to 28% of Spain territory. According to the census, in the year 2006 this area had a population of 23,498,314 inhabitants, which represented 53% of the total Spanish population.


![Map of Spain with provinces highlighted](image)

Source: Own elaboration

2. **DATA BASES**
The information used for this research basically comes from two sources: 1) the Corine Land Cover (CLC), for the years 1990 and 2006, and 2) the municipal register of inhabitants for the years 1991 and 2006. The CLC is a European project managed by the National Geographic Institute in order to make an inventory of land use from photo interpretation of Landsat TM images in 1990, Landsat7 in 2000 and SPOT4 pictures in 2006. On the other hand, the census is managed by the National Institute of Statistics and provides information on population numbers.

The data of land cover corresponds only to the categories within artificial surfaces:

1. Continuous residential land
2. Disperse residential land
3. Industrial and commercial
4. Roads and areas of communication
5. Harbors and airports
6. Construction sites, landfills and dumps
3. INTRODUCTION
Recent rapid expansion in urban areas nowadays is a matter of major debates in the context of the European Union, which expresses a significant concern for potential damage from uncontrolled growth which could occur in the environment, because of a negative perception of the loss of rural land and the transformation into a developed land which is increasingly permeable.

Although, historically the growth of cities has been linked to the increase of population, today this trend has changed significantly. There are various factors influencing the expansion and development of urbanization, attributed mainly to the pursuit of improved quality of life, which causes displacements to less congested areas.

The 59 Technical report “Towards spatial and territorial indicators using land cover data” of the EEA, exposes the DPSIR as a causal chain around land use and presents a series of socio-economic drivers in addition to population change, among other aspects, there are Transport Development, Expansion in Tourism, etc.

Image 1. DPSIR scheme for Land Cover

The Spanish territory has not been exempt from growth of urbanization in recent years around the world, in general terms, the amount of developed land on Spanish territory is largely moderate, where in 2006 according to the CLC only 2% of the territory was developed land; however, growth rate that has been noted in the last years is of a major concern.
The following table describes the changes in land cover in the Spanish territory in the years 1990, 2000, and 2006, which was an increase of developed land between 1990 and 2000 of 1658 km² (2.3% per year) and between 2000 and 2006 the increase of 1373 km² (2.6% annually). It reveals a dramatic increase of developed land over the period of 16 years (42%).

**Table 1. Land Cover Accounts Based on CLC1990, CLC2000, and CLC2006**

<table>
<thead>
<tr>
<th>Land cover 1990</th>
<th>Artificial areas</th>
<th>Arable land &amp; permanent crops</th>
<th>Pastures &amp; meadows</th>
<th>Forested land</th>
<th>Semi-natural vegetation</th>
<th>Open space/bare soils</th>
<th>Wetlands</th>
<th>Water bodies</th>
<th>TOTAL [hundreds ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7277</td>
<td>158806</td>
<td>94566</td>
<td>137605</td>
<td>91116</td>
<td>12865</td>
<td>1092</td>
<td>2884</td>
<td>506211</td>
</tr>
<tr>
<td>Land cover 2000</td>
<td>8935</td>
<td>158707</td>
<td>95047</td>
<td>137877</td>
<td>88540</td>
<td>12758</td>
<td>1111</td>
<td>3236</td>
<td>506210</td>
</tr>
<tr>
<td>Land cover 2006</td>
<td>10308</td>
<td>158285</td>
<td>95128</td>
<td>137873</td>
<td>87824</td>
<td>12393</td>
<td>1108</td>
<td>3292</td>
<td>506210</td>
</tr>
</tbody>
</table>

**Source:** EEA 2010

Of the 10,308 km² of developed land on Spanish territory, 47% is located in the provinces bordering the coast line (excluding islands), as it is shown in Chart 1, more than 70% is located in the first 20 km from the coastline, where provinces like Pontevedra and Malaga highlight respectively 81% and 75% of urbanized land from its surface in the first 4 km.

**Chart 1. Developed Land distribution in the first 20Km from the coast**

![Chart 1](chart1.png)

**Source:** Own elaboration

Under this background in 2006 the EEA published a report which highlights that Mediterranean coastal areas are under a great pressure from urbanization, not only the Iberian Peninsula, but the entire European Union. With this approach in academic circles several papers have been published giving a warning about the situation on the coast, highlighting the study made by the Ministry of Housing in 2007/2008 whose aim was to investigate development of certain Spanish areas in the second half of the XX
century. This paper shows a set of interactive flights where it is visible that, over a period of 50 years, some coastal areas such as Mallorca, Valencia, Alicante, Cartagena, Cadiz and Malaga have been transformed.

This communication takes place in the framework of this project in order to detect on a global scale (provinces) how was the growth of developed land spreading in the provinces bordering the Spanish coast from 1990 to 2006 and to determine whether a similar pattern of growth occurred in this period.

The chapter is divided into two parts: the first part presents an overview of the development that has had the developed land on the Spanish territory during the period of 1990, 2000 and 2006, which provides an overview on provincial-level development and distinction between the areas which have more developed land and those who have been exposed to major changes during this period. In the second part a set of urban indicators are applied in order to identify development model of each province and compare them to indicate if there is a relation between the results obtained for each indicator in the 19 studied provinces, particularly related to the degree of expansion of each province.

LAND CONSUMPTION ON THE SPANISH COAST

Changes in the Spanish coast coincide with a global situation that occurs in the transition from the fifties to the sixties, where the European economy after World War II begins to recover, the Spanish tourist market since its opening becomes an international phenomena with several positive economic impact. This international opening is associated with the new image that was created outside the country, promoted as an exotic destination with low prices.

On the other hand it offered economic investments, which were initially associated to the hotel industry and subsequently to real estate. Finally, there was a new and modern model of social structure using this as a new economic engine, thanks to interaction with the outside world that contributed to new customs. Further on, in the sixties tourism is no longer seen as a suitable phenomena and becomes an independent activity for the modernization and progress of the country. This situation combined with the rise of private car use and development of communications starts to generate the greatest imbalance in the progress between the interior and the coast. Therefore, this period marks the beginning of exponential urban growth along the entire Spanish coast. De Lacour, 2011

In the 19 provinces bordering the coast there is a developed land area of 4782 km² (47%). This surface is higher in proportion than the one of all of the country. The surface area corresponding to the coast is classified according to the structure of the territory into three parts: 3% of the land is artificial from urbanization, 27% is protected area (according to Red Natura 2000) and the remaining 70% is not developed. This
indicates that as well as on national level the percentage of developed land is moderate on provincial level.

Chart 2. Conformación de la estructura del territorio de las provincias de la costa

Despite the fact that at the provincial level moderate growth of developed land is denoted, disturbs the fact of rapid growth of developed land which occurred in the period between the year 1990 and 2006 and recorded an increase of 976 Km2, where at the same time, significant loss of forest land is noted in this period with a record of 1256 km2 and the transformation of agricultural land into developed land with an increase of 695 km2 located in particularly provinces of Almeria and Huelva, and its reduction of about 346 km2. (See Chart 3)

Chart 3. Relation between changes of use of land cover according to the CLC

Source: Own elaboration
Artificial land surface is varied between provinces, highlighting the highest values in the provinces of Barcelona with 17.7% of the total, with 10.3% Alicante, Valencia 9.6% and Murcia 7.2%.

**Map 2. Percentage of Developed Land in 2006**

![Map 2](image)

**Source:** Own elaboration

In the period from year 1990 to 2006 developed land in the coast experienced an increase of 976 km², just as disturbing is the large disparity between the growth of artificial land produced by the 19 provinces where the provinces of Barcelona, Tarragona and Girona only denote a growth rate of 10%, quite the opposite from the provinces of Castellón de la Plana with 46%, Murcia and Alicante 54% to 63% (see map 3). These data demonstrate the significant change denoting especially the provinces concentrated in the strip from Castellon to Murcia.

**Map 3. Expansion index of developed land 1990 a 2006**

![Map 3](image)

**Source:** Own elaboration
Meanwhile, expansion of developed land in relation to its different land uses, is distributed very diversely along the coast, where most of developed land increased between the years 1990 and 2006 corresponds to land for residential use with 47% and 34% of this land corresponds to discontinuous urban land.

**Table 2. Grow up developed land 2006**

<table>
<thead>
<tr>
<th>Urban Continuo</th>
<th>Urban Disc.</th>
<th>Industria</th>
<th>Vias</th>
<th>Puertos y Aipor</th>
<th>Construcción</th>
</tr>
</thead>
<tbody>
<tr>
<td>129</td>
<td>330</td>
<td>295</td>
<td>5</td>
<td>16</td>
<td>202</td>
</tr>
<tr>
<td>13%</td>
<td>34%</td>
<td>30%</td>
<td>1%</td>
<td>2%</td>
<td>21%</td>
</tr>
</tbody>
</table>

**Source:** Own elaboration

In order to understand the degree of specialization of each province a location quotient analysis is made through the increase of developed land between the period 1990 to 2006, which obtained a division into six categories for developed land use: Residential continuous land, residential disperse land, industry, roads, harbors and airports, construction sites, landfills and dumps.

The next set of thematic maps represents by ranges the results for each province according to the location factor analysis:

Map 4. Thematic maps according to the location coefficient for artificial uses

**Source:** Own elaboration
The map A describes provinces with greater expertise in the continuous residential land, with these increased by 13%, which highlights the provinces of Granada, Cadiz and Huelva, the map B describes the provinces with the most expertise in presenting these disperse residential land increased by 34%, emphasizing mainly the provinces of Girona, Alicante and Cadiz on the map C describes provinces with the highest specialization in industrial land expansion presenting it with 30%, where the provinces of Barcelona, Tarragona, Castellon de la Plana and Guipuzcoa stand out, the map D describes provinces with the highest expertise in the road areas which have a 1% increase, highlighting the provinces of Malaga, Granada and Almeria, the map E represent the provinces with greater expertise in harbors and airports with an increase of 2%, with the first rank in the province of Cantabria, and finally, the map F describes provinces experienced by greater specialization in construction sites, landfills and dumps, registering an increase of 21% where higher percentages occur in the provinces of Huelva, Lugo and Asturias.

As a significant result of this analysis stands out the fact that there is no relation between the provinces with greater specialization in industrial areas and the development of roads, on contrary, road areas show a relation to the expansion of disperse residential land.

Growth of developed land registered in the coastal provinces in recent years does not occur at the same time with the growth of the population. It hasn’t been noted a balance between growth of population and growth of developed land. They note that provinces like Lugo, Vizcaya and Asturias have negative population movement and, at the same time, an increase of developed land up to 20%. On the other hand, provinces of Barcelona, Girona, Tarragona and Almeria recorded a greater increase of population than of the developed land, in the rest of the provinces there has been recorded a greater increase of developed land than the population, especially in the provinces of Alicante, Murcia, Castellon de la Plana, Valencia and Cadiz Cantabria (See chart 4).

**Chart 4.** Percentage growth of land and population in the coastal provinces

Source: Own elaboration
4. METHODOLOGY
The methodology consists of two parts. First, urban indicators in identifying the pattern or model of each province are applied, and second, a comparison between the expansion of developed land in the studied period and urban indicators that have been applied in the first part, with which is to be obtained a conclusion if there is a similar trend among them.

- **Land Occupation**
With regard to the size of the artificial surface defined by each urban area, the land consumption $O_s$ [1] was calculated as the proportion of urbanised land $3$ (Sup.Urb.) and the municipal area according to the spatial administrative boundaries $4$ (Sup.Ter.). A ratio between $m^2$ and $m^2$ then expressed as a percentage of urban land over free surface.

$$O_s = \frac{S_{up\text{Urb}}}{S_{up\text{Ter}}} * 100 \quad [1]$$

- **Population Density**
To calculate the spatial distribution of the population in urban landscapes, ie, whether the weight of all persons on a specific territorial area, we have used two indicators of population density, gross [2] and net [3].

Population Density - Gross

$$D_g = \frac{Pob}{S_{up\text{Ter}}} \quad [2]$$

Population density - Net

$$D_n = \frac{Pob}{S_{up\text{Urb}}} \quad [3]$$

- **Expansion**
Expansion, or the formation of ‘endless’ cities: has measured by the increase over time of the total built-up area.

- **Descongestion**
Decongestion or the decline of urban densities: has measured as the decline over time of the ratio of the total urban population and the total built up area it occupies.

- **Fragmentation**
The analysis of fragmentation measures the degree of breakdown in more parts of an urban structure. It is based on the concept of entropy provides a measure of segmentation depending on the number of polygons and their weights, with respect to the surface [4].

$$SE = \frac{-1}{\ln n} \sum [F_i (\ln F_i)] \quad [4]$$

- **Consumption**
To calculate the ratio of urban land area for each person, we used the consumption indicator, calculated as the ratio $M^2$ of developed land divided by the population.

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3 CORINE Land Cover and CPSV database
4 Tele-Atlas 2004
5. RESULTS

In general terms, the analysis shows that the provinces of the Spanish coast during the studied period have had a markedly different development in which hasn’t been identified a pattern or a model of defined growth, and where only in 7 from 19 studied provinces 71% of land development from 1990 to 2006 is located.

The applied indicators reflect a territory with a model of many inequalities; where provinces with high land development have densities similar to provinces with low or medium expansion, or high occupancy provinces have the same density and fragmentation as provinces with lower occupancy rate (See Table 3).

The variability between the resulting values among all the provinces is also quite significant, going from an expansion in some provinces less than 20 km² to expansions of more than 120 km² or from density of 10,000 inhabitants per km²DL to densities less than 2,000 inhabitants per km²DL, emphasizing Barcelona and Alicante provinces with 8% and 11% of occupancy, values far above the average of all provinces (3%).

Although there has not been observed a model for the expansion of DL, provinces can be divided into three groups (see Table 3) with similar characteristics: the first group consists of provinces with high expansion, low or medium net density and high or medium fragmentation, the second of provinces with an low or medium expansion, low or medium net density and high or medium fragmentation and the third of provinces with low expansion, high net density and low fragmentation.

Table 3 Outcome Indicators

<table>
<thead>
<tr>
<th>PROVINCIAS</th>
<th>EXPANSION</th>
<th>LAND OCUP.</th>
<th>NET DENSITY</th>
<th>GROSS DENSITY</th>
<th>DESCONGESTION</th>
<th>CONSUMO</th>
<th>FRAGMENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alicante</td>
<td>202</td>
<td>8%</td>
<td>3615</td>
<td>307</td>
<td>50</td>
<td>277</td>
<td>2.0</td>
</tr>
<tr>
<td>Murcia</td>
<td>140</td>
<td>3%</td>
<td>3982</td>
<td>121</td>
<td>16</td>
<td>251</td>
<td>2.7</td>
</tr>
<tr>
<td>Valencia</td>
<td>139</td>
<td>4%</td>
<td>5357</td>
<td>228</td>
<td>22</td>
<td>187</td>
<td>1.6</td>
</tr>
<tr>
<td>Barcelona</td>
<td>99</td>
<td>11%</td>
<td>6278</td>
<td>685</td>
<td>65</td>
<td>159</td>
<td>1.4</td>
</tr>
<tr>
<td>Málaga</td>
<td>65</td>
<td>4%</td>
<td>5100</td>
<td>204</td>
<td>26</td>
<td>196</td>
<td>2.2</td>
</tr>
<tr>
<td>Granada</td>
<td>60</td>
<td>1%</td>
<td>5836</td>
<td>69</td>
<td>5</td>
<td>171</td>
<td>1.0</td>
</tr>
<tr>
<td>Castellón de la Plana</td>
<td>55</td>
<td>2%</td>
<td>3774</td>
<td>84</td>
<td>11</td>
<td>265</td>
<td>1.6</td>
</tr>
<tr>
<td>Asturias</td>
<td>43</td>
<td>2%</td>
<td>5414</td>
<td>101</td>
<td>0</td>
<td>185</td>
<td>1.9</td>
</tr>
<tr>
<td>Tarragona</td>
<td>37</td>
<td>4%</td>
<td>2626</td>
<td>116</td>
<td>19</td>
<td>381</td>
<td>1.4</td>
</tr>
<tr>
<td>Cádiz</td>
<td>35</td>
<td>3%</td>
<td>4603</td>
<td>160</td>
<td>8</td>
<td>217</td>
<td>2.1</td>
</tr>
<tr>
<td>Almería</td>
<td>34</td>
<td>1%</td>
<td>4883</td>
<td>73</td>
<td>12</td>
<td>205</td>
<td>1.7</td>
</tr>
<tr>
<td>La Coruña</td>
<td>29</td>
<td>3%</td>
<td>5459</td>
<td>141</td>
<td>3</td>
<td>183</td>
<td>1.3</td>
</tr>
<tr>
<td>Cantabria</td>
<td>27</td>
<td>3%</td>
<td>3780</td>
<td>107</td>
<td>6</td>
<td>265</td>
<td>1.5</td>
</tr>
<tr>
<td>Huelva</td>
<td>26</td>
<td>2%</td>
<td>2861</td>
<td>49</td>
<td>3</td>
<td>350</td>
<td>1.3</td>
</tr>
<tr>
<td>Girona</td>
<td>20</td>
<td>4%</td>
<td>2713</td>
<td>116</td>
<td>18</td>
<td>369</td>
<td>1.2</td>
</tr>
<tr>
<td>Pontevedra</td>
<td>18</td>
<td>3%</td>
<td>6278</td>
<td>209</td>
<td>6</td>
<td>159</td>
<td>1.2</td>
</tr>
<tr>
<td>Lugo</td>
<td>16</td>
<td>1%</td>
<td>6631</td>
<td>36</td>
<td>-1</td>
<td>151</td>
<td>0.9</td>
</tr>
<tr>
<td>Vizcaya</td>
<td>12</td>
<td>5%</td>
<td>10403</td>
<td>514</td>
<td>3</td>
<td>96</td>
<td>1.1</td>
</tr>
<tr>
<td>Guipúzcoa</td>
<td>8</td>
<td>4%</td>
<td>8117</td>
<td>350</td>
<td>6</td>
<td>123</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Source: Own elaboration
The following thematic maps describe the results of the analysis of urban indicators in 2006: net density, congestion, gross density and fragmentation.

**Map 5.** Net density 2006, Index of Congestion 1990 to 2006, Gross density, Index of fragmentation.

Source: Own elaboration

The net density indicator for 2006 reflects significant differences among all the provinces, where only Girona, Tarragona and Huelva have low population density per surface of developed land, on the contrary only the provinces of Vizcaya and Guipuzcua have a high population density having with more than 10000hab/km², and the 14 remaining provinces are in categories of medium density. In another sense the congestion indicator shows that provinces with the greatest loss in the intensity of population are located on the Mediterranean coast, where particularly the provinces of Barcelona and Alicante are emphasized, thus this indicator reflects great inequality among all provinces as well.

The gross density indicator shows that the provinces of Barcelona and Vizcaya are the highlights of the 19 studied provinces in relation to their proportion of population and
surface of the province, at the same time being provinces with less free surface of their administrative area, followed by the provinces of Valencia, Alicante, Malaga and Pontevedra. Regarding to the index of fragmentation, the provinces with the highest degree of fragmentation are Girona, Tarragona and Huelva, at the opposite pole are the provinces of Barcelona, Vizcaya, Guipuzcuia, Lugo and Pontevedra. This analysis shows that most of the coastal provinces have a high development rate of fragmentation since only 4 of the 19 provinces have low rates of fragmentation.

6. EXAMPLE OF EXPANSION MODEL OF DEVELOPED LAND

Finally, a sample of urban typology was selected which was developed in the provinces with the greatest expansion of DL. These examples emphasize that the area that has developed in these zones during the studied period is a territory characterized by low density, of touristic use, therefore is the common denominator in the expansion of coastal land.

Map 6. Examples of urban typology model of the Spanish coast

Source: Own elaboration
7. CONCLUSION

The provincial level analysis has shown a quite complete diagnosis of the structure of urban sprawl in different parts of the Spanish coast, which permits to identify which areas are most significant in the model followed over 16 years under review. Provinces located from Castellón de la Plana to Murcia are highlighted, for its higher growth in comparison to other provinces, and therefore these are to be studied in a detailed scale. Significantly, results that the expansion of land developed during the studied period in most provinces is not in a direct relationship with population growth, indicating that there are other drivers who have driven to this important development.

It hasn’t been noted that 19 provinces have urban development model with similar characteristics. The applied analysis shows that there is a marked inequality in both the expansion occurred during the study period and the values resulting in different applied indicators.

The fact that the existing databases do not classify or distinguish more detailed the different uses of urban land, especially land for touristic development, can not accurately assess the real influence of other factors which are significant in the expansion of developed land.

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