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GIS ANALYSIS FOR THE DESIGN OF A TOURISTIC PRODUCT: LOCATING THE HIGHEST VILLAGE AND MUNICIPALITY OF SPAIN

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1. CURRENT STATUS. GEOGRAPHICAL TOURISM

Although not typified in the handbooks, there is a kind of tourism called geographical tourism. Amongst others, the highest places of a region or those in the Earth are visited, as well as the source and mouth of the most important rivers, river and countries conjunctions and some parallels and meridians.

Good examples of this kind of tourism are the Mount Everest, Mount Teide, the triple confluence of Brazil, Paraguay and Argentina, Finisterre, the sources of Ebro and Tajo rivers, the Equator, the North Pole Arctic Circle in Rovaniemi (Finland), or the Greenwich Observatory.

Although there are some of them that deserve remembrance, others are related to huge mistakes, becoming touristic points undeservedly. Cape North and the Cape of Good Hope are good examples. These geo-touristic errors are spread in the whole planet, and our country is not an exception. This is the case of Cape Touriñán in front of Finisterre, being the most occidental point of the Spanish Peninsula. Its singularity is recognized, however, no visits are received. In other cases, big controversies appear which are not solved or are difficult to solve.

Another controversy is the title of the highest village or municipality of Spain. Trévez (Granada) is defined as the highest village of Spain, according to a ceramic inscription existing in the village. On the other hand, Valdelinares (Teruel) is claimed to be the highest municipality of Spain.

The National Geographical Institute sheds light on this matter with its Geographic Nomenclature for Municipalities and Population Entities and points out to Valdelinares as the highest municipal core of Spain (1.695 meters). The same Nomenclature, however, includes 16 entities located over this height and at least 10 of them have population, according to the data provided by the National Institute for Statistics.

This study aims at providing new data to this question, making use of the systems for geographical information and the enormous quantity of material available from the application of the European directive INSPIRE. We pretend to make a distinction amongst municipality, population core and entity and to define not only the height from a specific point but also the average of the heights measured in villages and municipalities, entities with a surface, therefore represented by polygons instead of points.

2. DATA

There are many free data available at national level. A milestone for this availability was European directive Inspire, *Infrastructure for Spatial Information in Europe*. This directive marked the rules for the settlement of an infrastructure for spatial information in European Countries. The data used in this study show the enormous effort made from the application of the Inspire Directive.

Firstly, we have the digital model for land with a resolution of 200 meters, MDT200, available for the different provinces in the web page of the National Centre for Geographical Information. The MDT200 has been chosen so that the volume of data to handle for the over 500.000 square kilometres of Spanish territory was not excessive. However, it is compared with another digital model of the land, the ASTER GDEM. It is the unique digital model for elevations that covers the entire planet with high resolution. The mesh is 30 meters.

Regarding vector files, the limits for municipalities, provinces and autonomies have been obtained from the web site of the National Centre for Geographical Information. However, the determination of heights with these files showed a problem derived from distinct territorial entities that do not appear in the lists of municipalities for each province provided by the Statistic National Institute. To solve it, the vector files for administrative limits provided by the web page of ArcGIS have been used. These files have the advantage that each municipality has its province and autonomy assigned in the table for attributes, thus making unnecessary the union by location of their attributes.

Finally yet importantly, the nuclei of population provided by the web page of the National Centre for Geographical Information and have been used, completed, with data from the web page of the Environment, Food and Agriculture Ministry.

3. METHODS

The data have been treated and analysed by the software QGIS. In the beginning it was known as Quantum GIS, it started in 2002 and nowadays it is the leader system for geographical information of open source for desktop. It is a project of the *Open Source Geospatial Foundation* (OSGeo), fostered by volunteers that constitute a growing community of developers. Nowadays, the last version is the QGIS 2.12 Lyon.

The first step made with QGIS is the union of the different pages in order to generate a digital model of the land for the Peninsula and Balearic Islands on the one hand and Canary Islands by the other hand, as the data from the raster come from different coordinate systems. Later on, the digital models for the land as well as the vector files

are moved to a system of geographic coordinates for latitude and longitude that, compared with those from *Universal Transversal Mercator*, facilitates the representation of the Peninsula and the two archipelagos.

The average heights for the Spanish municipalities and for the population nuclei are acquired by means of the tool "Zone statistics". This tool provides several statistics of height for each municipality: the number of pixels included in each polygon, the municipalities and population cores, the sum of the values, the mean and the median, the standard deviation, the minimum, the maximum, the interval, the minority, the majority and the variety.

4. RESULTS

The first analysis focuses on the average of the municipalities. For the 31 municipalities with mean heights above 1.800 meters, the mean heights have been determined over a total of 106.649 points in the case of the Digital Model of the Land with a mesh of 200 meters and with more than 5 million points (5.623.297) in the model with a mesh of 30 meters. This data are more accurate than a simple and aleatory location point.

The results change the classification of the municipal height in a radical way with respect to the Geographic Nomenclature for Municipalities and Population Entities and show a clear domain of the tallest mountain ranges of Spain, the Pyrenees and the Betic mountains. 29 of these 31 municipalities are located in these mountain ranges. Only two of them do not belong to this domain, the Orotava in Santa Cruz de Tenerife and Valdelinares in Teruel, which is the last municipality of the table. Fifteen of them overcome the 2.000 meters, including, of course, those that are included in the podium: Trevélez and Capileira in Granada and Benasque in Huesca. The three of them have the benefit of counting totally or partially in their land with well-known peaks: the Mulhacén and the Aneto. In the same line, the unique canary municipality in the list, the Orotava, has the highest mountain of Spain, the Teide. Without any doubt, it is a singular municipality as it also includes coast, thus being the municipality with the highest drop of Spain.

With the aim of providing a bigger accuracy to the results, the mean values are recalculated with the most accurate digital model of the land, the ASTER GDEM. There are not significant changes in the main municipalities, thus confirming the reliability of the MDT200.

Regarding the towns, the heights of the population nuclei are calculated with the aid of the vector files extracted from the National Centre for Geographical Information and the Environment, Food and Agriculture Ministry and the Digital Model with 200 meters mesh.

The first 31 municipalities are those whose towns are located at a height above 1.435 meters. This number is similar to that shown for the municipalities, in order to help the spatial comparison. As was to be expected, the distribution is totally different. The hypsographic weight of the tallest peaks disappear, as the villages do not show hypsometry and prefer valleys and hillsides. Therefore, the biggest mountain ranges practically disappear of the map and the predominance is for the municipalities located in more modest units: Central and Iberian Mountain ranges. The population villages from Teruel are the most important, summing 14 both from the Aragon land and from the Castile land. The Central

Mountain range includes 11 population nuclei from Avila and Somosierra from Madrid. From the Pyrenees and the Penibetic area, only some villages are included in the ranking, in Girona, Huesca and Lleida, on the one hand, and in Granada, on the other hand. Regarding Canary Islands, no municipality has population nuclei above 1.435 meters.

This difference is well shown in the Honour Roll. In contrast with Trevelez from Granada, the highest village is Valdelinares in Teruel. The next villages also belong to Teruel, Griegos and Gúdar. Nothing to see with the municipal podium, shared by places from Huesca and Granada.

The comparative with the Geographic Nomenclature for Municipalities and Population Entities gives rise to small differences. The Nomenclature obtains only one height for the main population nuclei, in contrast with our system, which collects all the points for the population nuclei, showing some differences in the case of municipalities with disperse population or with an important topographic drop.

Once solved the confrontation between the highest village and municipality from Spain, we make profit of the availability of data to sign the highest villages and municipalities for each autonomy. As in the previous case, many differences are found when comparing them with the Nomenclature.

The data offer important clues for the Spanish relief. In the north, the less entity of the Pyrenees belonging to Navarra is observed in contrast with those belonging to Aragon and Catalonia, due to the lack of symmetry along the mountain range. The Basque limit, with the lowest height, gives rise to the Cantabrian range, which ends with the heights in Asturias, succeeded by the elevations in Galicia, which close the tableland of the Iberian Peninsula in the northeast. The vertebrates of Central Range mark the top heights of Extremadura, Castile – León and Madrid, whereas the Iberian Range is reflected in La Rioja, Castile – La Mancha and Valencian Community. Sierra Morena is shadowed by the biggest peaks of the Penibetic range. In Canary Islands, the Teide is dominant. Low values are provided by the Serra de Tramuntana in Balearic Islands and Northeast land of Murcia.

The data for the villages are less significant in identifying the relief, as traditional human occupancy does not follow any hypsographic trend. The differences are more considerable in the mountain ranges that suffered from glacial retouches and those whose hillsides show higher slopes. Therefore, the contrast in height between the peaks and the valleys where the populations are settled is bigger. According to this fact, the village located at the highest height in Aragon (and in Spain) is not placed in the Pyrenees but in the Iberian Range. The highest one from Catalonia is of the same level than that from Castile – Leon, located in Central Range, a unit with much less entity. The highest populations of Asturias and Cantabria have heights below 1.000 meters, in a similar way to Basque Country, in spite of the bigger size of its mountain range. Viniegra de Arriba, in la Rioja, far exceeds them.

5. CONCLUSIONS

This study takes advantage of the Open Source Geographical Information Systems and the availability of spatial data to solve a question, the highest municipality and village of Spain, that floods the forums and social networks although without any scientific reference and without any paper in relevant press.

Regarding the results, there is a marked spatial diversity. In the municipalities, the most important factor is the physical geography and therefore, the highest ones are located mainly in the two most important mountain ranges: Pyrenees and Betic Range. On the other hand, in the villages, human motivations appear and then the population nuclei escape from the biggest heights moving towards more modest mountain ranges.

In the end, the main municipalities disputing the honour of being the highest one of Spain, Trevélez and Valdelinares, or Valdelinares and Trevélez, have demonstrated to have their share of reason. According to this study, both can deserve the leading position, although the municipal authorities should correct the identification diplomas: the municipality should be Trevelez, the village, Valdelinares.

