HYDROLOGICAL AND MORPHOMETRICAL PARAMETERS ACQUISITION USING GIS FOR PRELIMINARY HAZARD MAPPING IN A MEDITERRANEAN BASIN

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Abstract

Taking a Digital Elevation Model and Landsat images as mainly input data, different hydrological and morphometrical basin parameters were acquired through Geographical Information System analysis operations, and applied to a basin in the South of Spain. The objectives were to generate a preliminary classification map, based on the different hydrological response of the basin subcatchments, combining the parameter maps with the "rational method" formula, and to compare the results generated by different pixel resolutions. A percentual average error appears on results of low resolutions maps, decreasing its percentage when analyzed return period discharge diminishes. A pre-classification of the subcatchments was determined with the peak discharge results converted into discharges by unit area, showing different grades of hazard susceptibility.

Keywords: hazard susceptibility, pixel resolution, GIS, cartography.

1 Introduction

With the development of Geographical Information Systems, cartography has advanced quickly allowing in an easy way the combination of different information for the generation of a map. For this reason, GIS has become a main instrument for environmental management. With them, changes on land can be modelized and optimized, and risks can be controlled and diminished in a considerable way. This is special important in Mediterranean areas where due to their torrential precipitations, floods often occur.

The use of GIS needs special attention on the input information. GIS operations will always present a resulting map, although it can be completely unrealistic. That is why in the present work a comparative study of different pixel resolutions is done.

The main objectives of this work are two:

1. To analyze the error of using a wrong pixel resolution.
2. To generate a *preliminar flooding hazard susceptibility* map in a quick way in order to determine which subbasins are more dangerous and need a deeper study.

1.1. *Area of study*

The area of study chosen is the Guadalteba basin. It is a small/medium-size river basin located in the south-east of Spain, in the province of Málaga. Its catchment area is 200 km^2 and most of it is under agricultural land use. This fact together to a dam located at its outlet involve the need of a flooding study.

2. METHOD

The method applied in this work in order to get the different grades of hazard susceptibility is the "rational method", modified by Témez [6]:

$$Q=\frac{CIA}{3.6}*k \tag{1}$$

where,

Q - peak runoff rate (m^3/hr)
C - runoff coefficient
I - average maximum intensity during time of concentration period
A - drainage area (m^2)
k - uniformity coefficient

With this formula, a peak discharge is acquired for each subbasin, and all of them have been converted to discharge by unit area. This has been done in order to be able to compare the different subbasin results. The application of the rational method was done with the "Cálculo Hidrometeorológico para Pequeñas y Medianas Cuencas (CHC)" programme, developped in the Centro de Estudios Hidrográficos (CEDEX). Its parameters were acquired through different sources.

On a first step, these sources were:

1. Toposheet 1:50.000. From it, the basin was divided in 11 homogeneous subcatchments. They were digitized and rasterized each one as a unit of study. This map was used for obtaining data per subbasin, and to know the area parameter. At the same time, all the outlet points of each subbasin were saved in a point file and rasterized.

   A digital map of the drainage system gave the channel indicator. Applying a GIS operation (distance) to this map the river length to the outlet parameter was also acquired.

2. Digital Elevation Model. Due to the small size of the basin, contour lines every 20 m were digitized, and rasterized with a pixel size of 10 m from a toposheet with scale 1:50.000 [2]. This resolution was chosen considering that is the highest resolution admited by this scale, taking into account the general cartographic error of 0.2 mm. From this map, maximum and minimum altitudes of each subcatchment were obtained and the slope was generated by the above mentioned CHC programme. Nevertheless, the slope parameter can be achieved directly by appling some formula or a GIS function on the Digital Elevation Model.

3. Landsat TM images corresponding to three different periods of the year: November 1990, and January and May 1991. A classification of them with some photointerpretation was done to obtain a land use map [2]. This parameter was used to obtain runoff coefficient with the Soil Conservation Service [5] and Témez tables [6]. This kind of tables need data about slope, hydrological conditions, type of soil and

a general classification of land use. For this reason, land use map was grouped into eight units: wheat, legume or sunflower crops, olive orchards, forest, grassland, rock outcrops, water and urban areas.

4. Field work observations. Soil types present slow infiltration rates, with a moderately fine to fine texture.

5. Proposal presented by Temez[7]. The coefficient I1/Id was determined as 8 for all the subcatchments according to the national value map proposed by Témez to modify the Spanish administrative Instruction 5.2 - IC [4].

6. Precipitation data. Areal precipitation data for different return period precipitations were calculated: 2, 5, 10, 25, 50, 100, 200 and 500 years, based on a regional study for all Spain [3].

In case the above mentioned programme would have been not available, combination of length river to the outlet and slope parameters would have allowed to obtain the time of concentration (Tc) and indirectly the uniformity coefficient (k) with the following equations:

$$Tc=0.3*\frac{L^{0.76}}{J^{1/4}} \tag{2}$$

where, Tc, time of concentration
L, length
J, slope

and,

$$k=1+\frac{Tc^{1.25}}{Tc^{1.25}+14} \tag{3}$$

These formulas as well as those ones for runoff coefficient and for average maximum intensity variable during the time of concentration period are described by Témez [6].

In order to be able to compare among the different subbasins, the resulting peak discharges were converted into discharges by unit area (mm).

On a second step, and following this methodology, a second group of results were achieved using source maps with a pixel resolution of 1 km.

3 Results

Based on the scale input map (1:50.000), it is considered that maps with 10 m pixel resolution give more detailed and realistic information than those ones acquired from 1 km pixel resolution. Analyzing their percentual error, there is a diminishing average percentual error towards a higher return period:

T (years)	Average percentual change on discharge peaks
5	7
25	5
100	4
500	3

Although these values are not very high, it is remarkable that analyzing the subbasin results, these percentages achieved sometimes more than 10 % of error. This means that to study subbasin hazard susceptibility, results hide real data with small pixel resolution (1 km).

For the second objective, to determine which subbasins are more susceptible of being flooded, 500-year return period discharge has been analyzed. This return period has been chosen because on the Spanish water law, it is taken to delimit the flooding areas.

Discharges by unit area values move from 600 to 1300 mm. This range is not very large due to the similar conditions of all subbasins, but it is representative enough to determine differences on their hazard behaviour. These results are presented on a choropleth map being grouped on different hazard susceptibility units.

4 Conclusions

Input data is one of the most important decisions when GIS cartography is being used [1]. There must be a good correlation between the scale input maps and pixel resolution, although it does not need a maximum resolution as the chosen in this study. A wrong determination of this last element can involve a high error (more than 10 %), what can mean high amount of economical and human losses in flood hazard. This error will be higher in non-homogeneus land use areas.

Besides that, GIS presents a perfect methodology to achieve through an easy formula a quick hazard susceptibility cartography. It is recommended to use it for medium-large basins were the variability of precipitation, land use, etc. is high among the different subbasins. Although it is preferable that run off results are presented on an isoline map [8], due to the aereal components of the rational method variables, in this kind of studies it is better to present them on a choropleth one.

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