Flood risk assessment in a Spanish Mediterranean catchment

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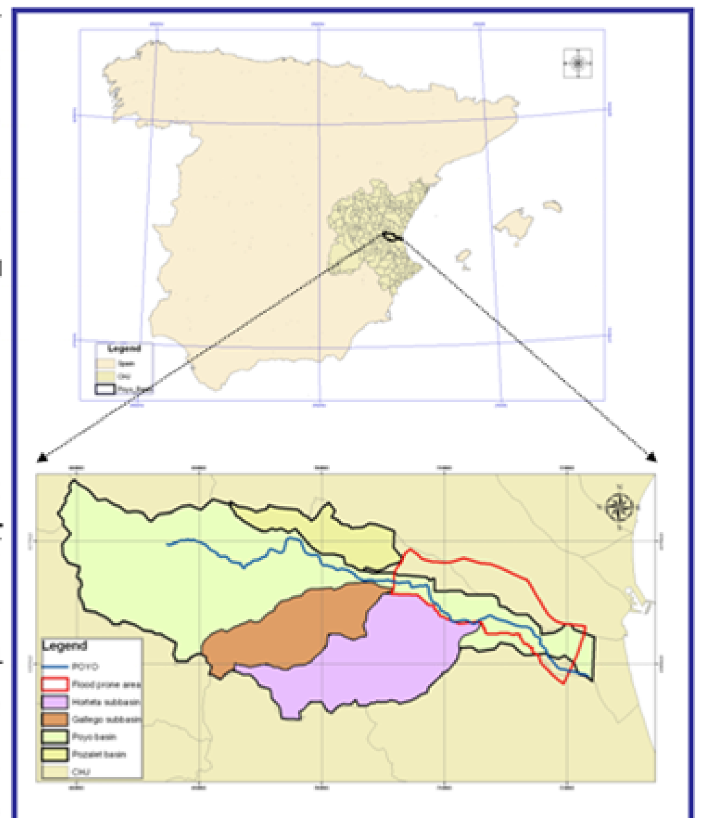
OBJECTIVE

This poster describes a multidisciplinary approach for the risk assessment and its application to analysing the effects of extreme flood events on the Mediterranean catchment called "Rambla del Poyo" in Valencia (Spain).

CASE STUDY

This catchment located in the East coast of Spain has an area of 380 km2 and is clearly open to the Mediterranean Mesoscale Convective Storms. The climate is semiarid, and the flow regime is typically ephemeral, but with highly frequent flash floods, with peak flows in the order of 500 m3/s. Recently, in 2000 and 2002 the area was severe flooded.



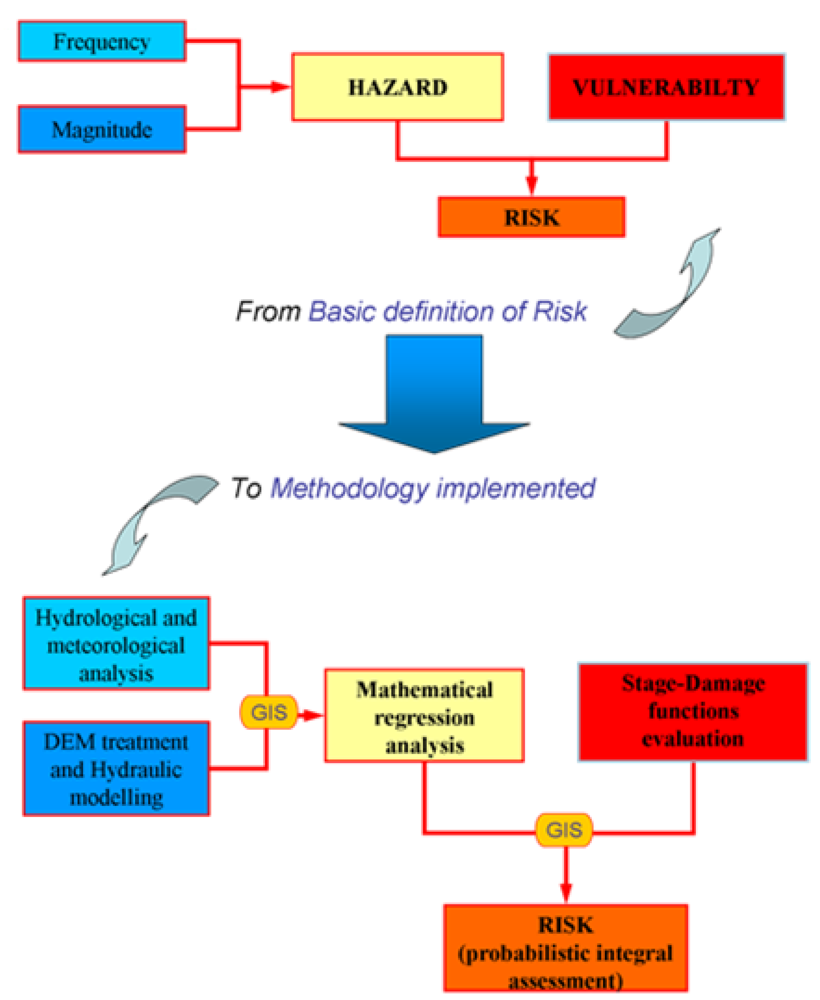
Location of Rambla del Poyo basin

The flood prone area is located in the lower part of the basin, with an important concentration of different urban centres and industrial and commercial areas (including part of the Valencia International Airport). For this reason, the analysis of damages of residential, industrial and commercial urbanized areas is essential for the prevention of damages with a proper flood risk management.

METHODOLOGY

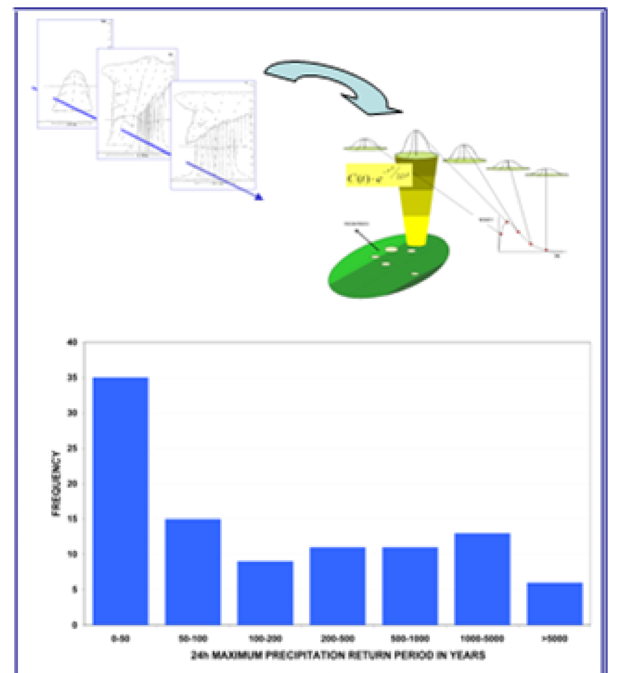
The approach is based on three main steps.

1. The first step entails, on one hand, a detailed hydrological analysis (parameter estimation, calibration-validation and simulation) using a distributed rainfall-runoff model called TETIS and synthetic rainstorms generator called RAINGEN, and, on the other hand, a flood frequency analysis.
2. The main objective of second step is the hydraulic modelling and the flood hazard estimation using a mathematical regression analysis on GIS.
3. The third step is the flood risk assessment using GIS tools to evaluate the probabilistic integral of the combination of flood hazard and land use vulnerability.

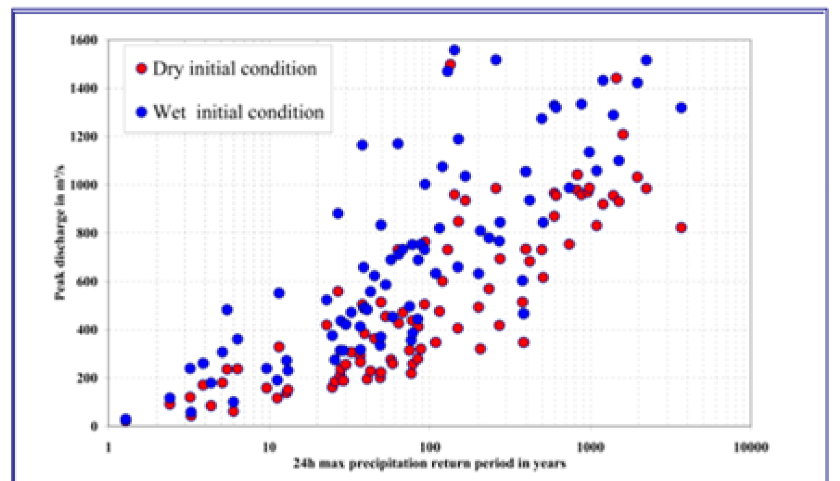


1. Hydrologic modelling and flood frequency analysis

In the case study, on one hand, high temporal resolutions rain gauge data are scarce, because of this, in addition to a small number of historic events, 100 synthetic rainstorms were generated using the multidimensional stochastic model called **RAINGEN**, which adequately represents the main structural properties typical of intense convective storms, including occurrence of raincells in space and time and the generated intensities. An equivalent daily maximum precipitation Pd was estimated for each synthetic event, thus allowing a return period assignment using the known statistical distribution of Pd in the region.



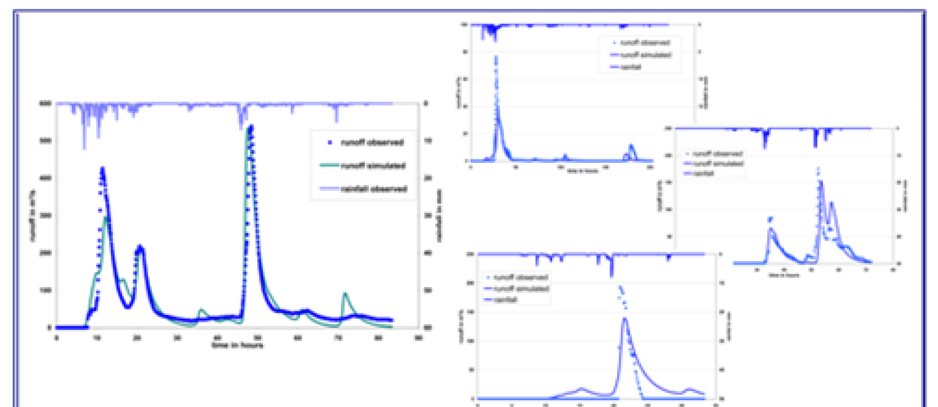
a) Basic conceptualization of the rainfall intensity field and; b) Return period of the 100 selected synthetic events generated with RAINGEN model



Influence of the temporal and spatial variability of precipitation (100 synthetic storms) and initial soil moisture conditions (two initial states)

On the other hand, the initial soil moisture condition can have a strong influence in the runoff production, for this reason, long term daily simulation has been done in order to asses the probability distribution of the initial situation before the extreme flood events (dry and wet conditions).

For all combinations of precipitation inputs and initial conditions, 200 hydrological simulations with TETIS model has been done in order to obtain the input hydrographs for the hydraulic model.

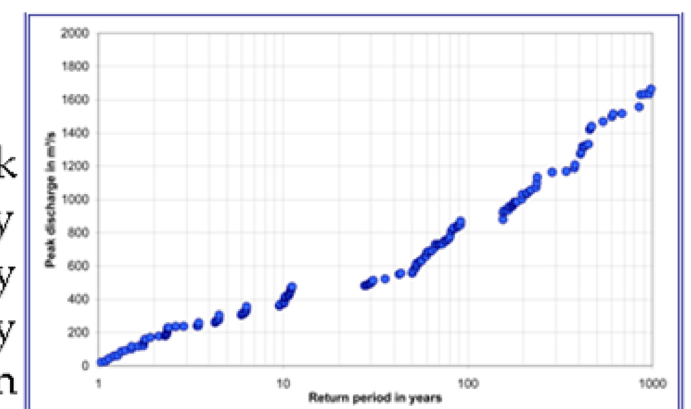


a) Calibration (left) and b) Validations (right); with TETIS model

Finally in this step, a frequency analysis to obtain the non exceedence probability of the peak discharges has been developed using the annual maximum daily precipitation and the initial soil moisture condition with this expression:

$$F_X(x)=\int_{-\infty}^{\infty} F_{X|r}(x|r)\, f_R(r)\, dr$$

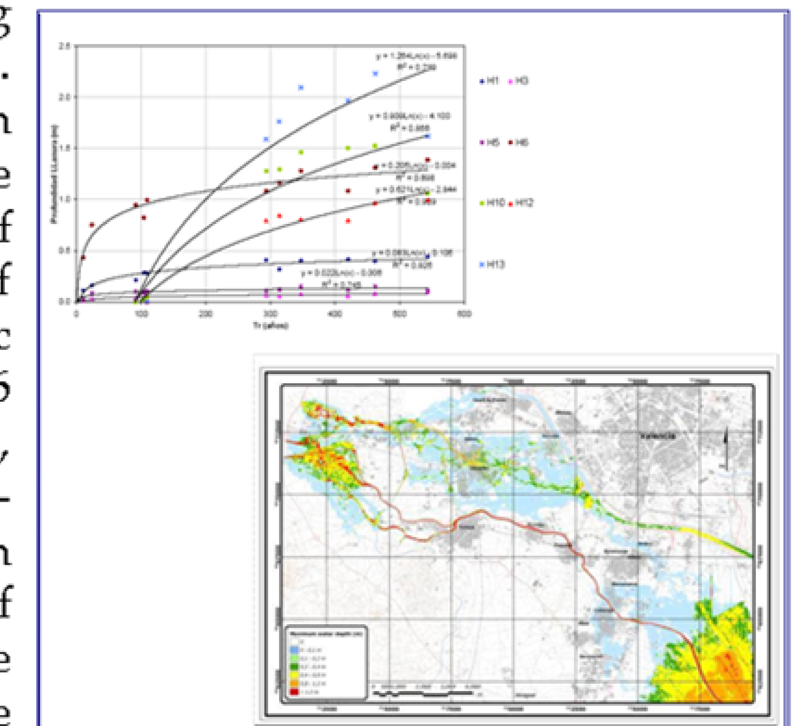
where: X= random variable of interest (peak discharge), R= annual maximum daily precipitation, f_R (r)= probability density function of R, F_X = r(x/r)= conditional density function of X given r obtained from simulations.



Plotting positions in Rambla del Poyo

2. Hydraulic modelling and flood hazard estimation

The hydraulic modelling has been developed using the coupled computing version of Sobek 1D/2D. In this task, the treatment of DEM calculation can be a key task depending on the scale of work. The introduction of buildings, walls, the opening of drainage works. . . Improving the quality of results in areas with high anthropogenic influence; in our case has been made 6 simulations with 3 different resolutions, after all, the model has been done with a model one-dimensional (1D), logging throughout the stretch to two-dimensional (2D) grid with the parent of 30x30 metres, except for its passage through the urban, commercial and industrial land uses in the flood prone area where it connects with the child grid of 10x10 metres. Unfortunately, for reasons of computer time, the hydraulic model has not been run for the 200 available events. However, 20 events have been carefully select trying to cover the best probabilistic interest spectrum for this study (from two to one thousand years of return period). From the 20 selected flooding maps it has been developed a GIS computational tool for calculating a regression between the independent variable (maximum water depth) and the dependent variable return period transformed into natural logarithm. Using this methodology have been generated the hazard maps for the return periods of interest.

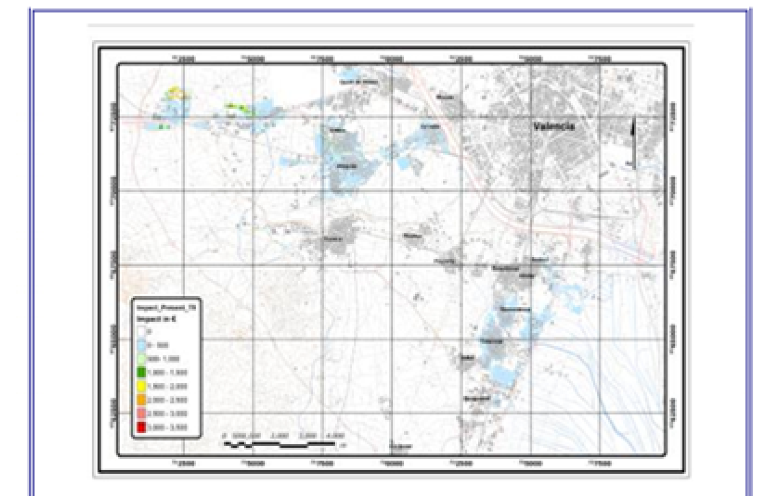


a) Mathematical regression analysis, and b) Hazard mapping

3. Flood Risk Assessment

Finally, the third step concerns to the flood risk, which was defined as probabilistic integral of the combination of flood hazard and land use vulnerability:

$$D = \int_0^{\infty} V(h)\, f_H(h)\, dh$$



Risk map

Where: R is the flood risk, V(h) is the land use vulnerability, h is the flood magnitude and fH(h) is its probability density function. The land use vulnerability is expressed in terms of stage-damage functions for urban, commercial and industrial land uses. Both, flood hazard and land use vulnerability are defined in terms of magnitude (water depth). This integral has been solved in discrete form using a GIS tools.

CONCLUSION

The flood risk assessment by a resolution of 10 meters in size cell in the flood prone area of the "Rambla del Poyo" has been done. With this useful methodology, we believe that a complete flood risk analysis is needed in order to objectively compare different future scenarios that can affect either the flood hazard and/or the vulnerability in the flood prone

NOTE: This work has been done in the ERANET-CRUE into the project "Efficiency of non-structural flood mitigation measures: "room for the river" and "retaining water in the landscape"