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Session 5 – Poster presentation

FLOODING AREAS AND RISK ANALYSIS OF CATALONIA (INUNCAT PLAN)

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INTRODUCTION

The geographic location and the complex orography of Catalonia, gives origin to an irregular rainfall taking place in some cases, torrential rains, that they have caused, throughout history, catastrophic flash floods, between which it emphasizes the one of the 25th of September of 1962, which it caused more than 700 dead and numerous physical damages. The fluvial network corresponds to a length of 70,500 km (fig. 1).

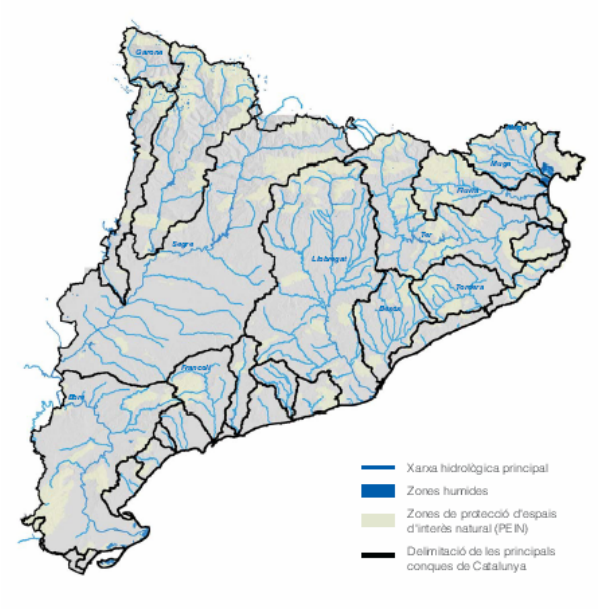

Figure 1 - Hydrologic basins of Catalonia.

The special plan of floods emergencies of Catalonia (INUNCAT) must face as main objective the flood emergencies in the territorial Catalonia (DGEiSC). Thus, the warning system, the organization and the procedures of performance in case of flood are defined. All its previous quantification and location of the fundamental aspects for the risk analysis, between which they emphasize the hazard analysis and the establishment of the recurrence times, the vulnerability, the zonation and the location of conflicting points.

HAZARD ANALYSIS

The documentary source used in the analysis has involved different cartographic information of resolution and scales. The methodology of the hazard study of the fluvial network includes the delimitation of the flooding zones according to geomorphogic and hydraulic criteria for different reccurrence periods (50, 100 and 500 years) and the determination of the intrinsic hazard of each river basin, diferentiating for each sections its discharge response.

The information on hazard has been complemented with the information available of the identification of the conflicting points, geologic hazards, the flooding zones by possible breakage of dams and the capacity of the urban drainage.

For those fluvial streams where still it is not available the hydraulic information (that it allows to determine the probability of occurrence) has been used the geomorphologic information that it synthesizes well-known the maximum historical thresholds.

So, the extension of the potentially flooding zones from the Quaternary terraces, the floodplains, the alluvial fans, the deltas and coastal plains has been deliniated. Moreover, the geologic hazard for those slopes that are displaying a high probability to reactivate mass movements in the case of exceptional flooding events have also been considered.

The base information used for the delimitation of the flooding zones (fig 2) includes the following sources:

- Detailed geomorphology, scale 1:5.000 (ACA).
- Inuncat geomorphology, scale 1:50.000 (ACA).
- Digital elevation model of Catalonia, of 15 m spacing (ICC).

- Fluvial network and river basins, scale 1:50.000 scale (ICC).
- Geologic maps, scales 1:50.000 and 25.000 (ICC).
- Geologic hazards, scale 1.50.000 (ICC).

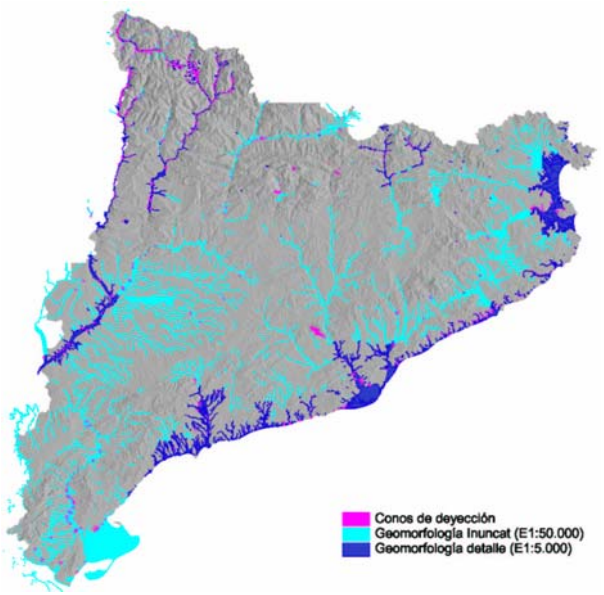

Figure 2 - Flooding areas shown following according geomorphologic criteria.

The boundary of the alluvial fans has allowed to evaluate the urban nucleus and lifelines susceptible to suffer damages by floods (1038 identified cones of which 584 affect 231 Catalan municipalities). The greater number is located in the context of the Pyrenean area of Lleida (fig 3), and in fact, only 7 of the 41 regions are not affected by these phenomena.

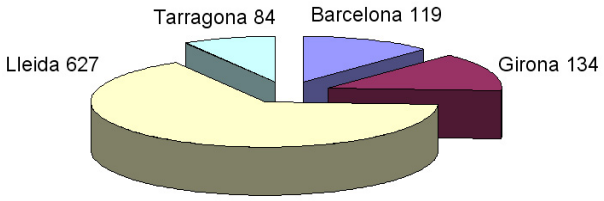

Figure 3 - Identified number of alluvial fans.

The hydrologic-hydraulic analysis has consisted on the determination of the associated stream flow of rivers through recurrence periods, later to make the hydraulic model for the periods of return of 50, 100 and 500 years. With the information of the hydraulic model, an output draught or water column cover has been generated for each one of the recurrence periods (fig. 4).

The identified conflicting points have several origins, mainly from the ACA and Fire Department. In the case of the Department of Autonomic Police, 1852 points have been recorded until the present writing of the Inuncat Plan. Basically, they correspond to four types: structures, infrastructures, hydraulic and morphodynamics.

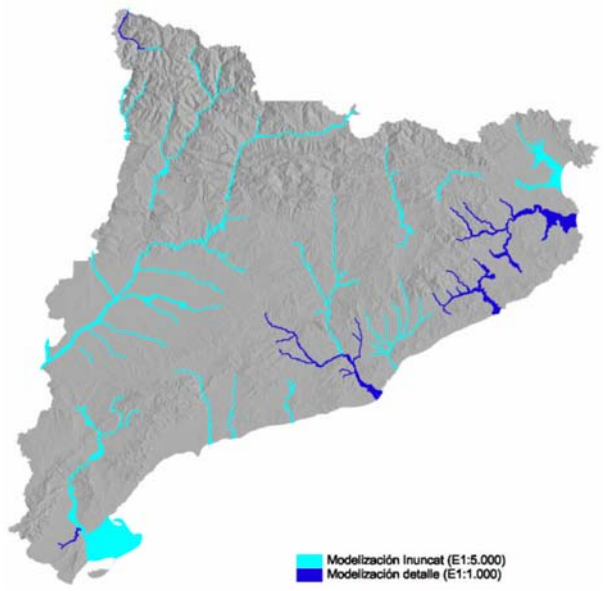

Figure 4 - Delimitation of the flooding zones according to hydraulic criteria.

Other phenomena that can cause slight floods inland are referred to:

- Abrupt changes of the sea level in meteorological conditions and geometrics of coastline very specific that can produce a decimeter wave of amplitude (*seixes*).
- The sequence of high rainfall intensities and aggradations of the sea level that can in addition cause the difficulty in the water-drainage of the main fluvial streams.
- A quantitative valuation of the incidence of possible tsunami in the Catalan coasts. The configuration of some Catalan deltaic and coastal zones with intense anthropic activity recommends evaluating in future revisions to evaluate and assess the incidence of tsunamis of moderate heights.

VULNERABILITY ANALYSIS

The vulnerability analysis determines the degree of losses and damages. There are diverse factors that allow us to assess the damage and losses caused by a flood, among them are the maximum draught, the speed, the duration of the event, the sediment load, etc. Starting off the data of the obtained hazard analyses of the previous phase, the draught-like main factor in the vulnerability analysis has been used.

The direct damages have been evaluated in function of a damage-draught curve. This curve represents the relation between the column water and the costs of the damages for each type of land

use, expressed by area unit, fact that has implied to know the economic value of the element. The different land use classes are housing, industrial and commercial uses, camping sites and agricultural zones. For each use a topology curve of damage-piercing of the specific depth water has been applied. In the case of housing the curves of "Economic Guidance Memorandum (EGM) 01-03" of the USACE have been used; for industrial zones, commercial and camping sites, the generic draught-damage relationships elaborated by FEMA (Federal Emergency Management Agency) have been used. For agricultural zones, the estimation of damages has been made from statistics of prime agrarian yields and insurance bases.

The process of assessment of the hazard per unit (of 5 m spacing) is done combining different draughts for different periods.

The final valuation of losses has been made from the curves of damages and the established monetary valuations according to the use classes. The balance at municipal level has consisted of the sum of the results for each one of the municipalities. Estimation of the population who can be in floodable zone is considered for greater than 1 m of draught. The quantification of the length overall of routes affected by draughts greater than 0.3 m, critical value for the safe circulation of vehicles, has been made at municipal level.

RISK ANALYSIS

The analysis of the flood risk has taken into account the existing elements in the territory and of the municipality. For the characterization of the elements the classification established in the Basic Directive of Floods has been applied. The directive establishes the risk level for each element based on the recurrence period or probability of occurrence and the level of damages.

The flooding risk at municipal level has been assigned from the value of different factors between which they emphasize the classification of the level of risk of the elements of the territory, the calculations made for the evaluation of the vulnerability (monetary losses, people located in flooding areas, length overall of lifelines of communication possibly affected) and parameters relative to the hazard of the river basins.

From the conjunction of the values of the variables previously assessed at municipal level. Finally, the municipalities have been classified based on risk-class (fig. 5).

CONCLUSIONS

This study has allowed making a first quantification of the flood risk of the Catalan municipalities. From this study the actions of self-protection and adequate procedures have been stablished.

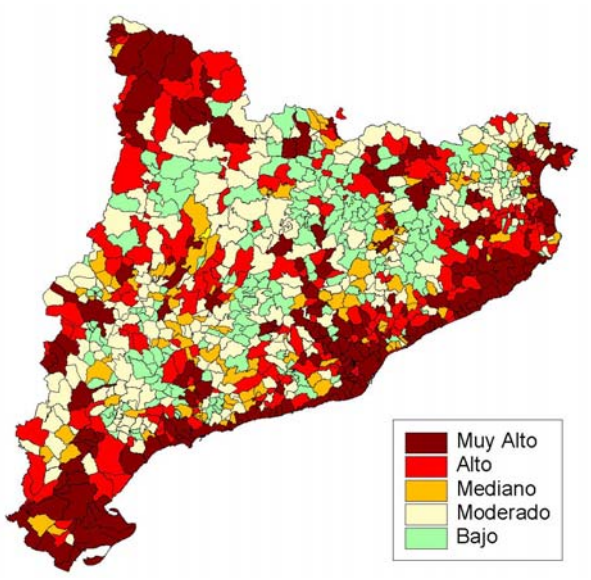

Figure 5 – Flood risk analysis zonation at municipality level.

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REFERENCES

ACA, 2002. Delimitació de zones inundables per a la redacció de l'Inuncat, conques Internes de Catalunya.

ACA and CONFEDERACIÓ HIDROGRÀFICA DE L'EBRE, 2002. Delimitació de zones inundables per a la redacció de l'Inuncat, conques Intercomunitàries.

DEFRA, 2003. Flood Risks to people. R&D Technical Report FD 2317/TR. ISBN 1844321355. 114 pp.

EMERGENCY MANAGEMENT AUSTRALIA, 2002. Disaster Loss Assessment.

FEMA, 2003. Multi-hazard Loss Estimation Methodology. Flood Model. HAZUS MH. 22 pp.

LATORRE, X., 1998. Història de l'Aigua. Ed l'Abecedari.

MELBOURNE WATER, 2003. Guideliness for Development in flood-prone areas.

PENNING-ROWSEL, E., FORDHAM, M., 1994. Floods Across Europe Hazard Assessment, Modelling and Management. ISBN 1898253013. Middlesex University Press, Middlesex, 214 pp.

USACE, 2000. EGM 01-03, Generic Depth-Damage Relationships.

WHITE, G.F., 1945. Human Adjustements to Floods. A Geographical Approach to the Flood Problem in the United Satates. Doctoral Dissertation and Research paper no. 29. Departament of Geography, University of Chicago.