

GEOMORPHOLOGY, FLOODS AND ANTHROPIC MODIFICATIONS TO FLOOD AREAS: THE RIU GIRONA, A CASE STUDY (ALICANTE, OCTOBER 2007)

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Floods are complex phenomena produced by the interaction of different natural and man-made factors. Natural factors include exceptionally heavy rainfall, the physical characteristics of river basins, flood area topography and channel characteristics. Exceptionally heavy rainfall tends to cause flash floods along the Mediterranean coast as a result of its intensity and volume and peak flows exceed the capacity of the channels. The Mediterranean coast is made up of small river basins drained by ephemeral streams. The headwaters are situated on prelitoral reliefs close to the sea, while the lower basins are located at the foot of the mountain ranges. The high slopes of the upper reaches disappear progressively as they decrease towards the coastal plains. These areas, formed by alluvial fans deposited by ephemeral streams, flood very suddenly.

In addition to these physical conditions which favour flooding, human activities have substantially modified natural conditions, in particular from the 1960s onwards. These factors include changes in traditional agriculture and, above all, major urban development which has led to indiscriminate occupation of flood areas. This has modified the natural geometry of the flood plains both in concave areas (flow convergence) and in convex areas (flow divergence). At the same time, in order to protect urban areas, engineering works have been carried out on the channels and in many cases this has actually increased the damage caused by flooding.

This paper presents a study of the floods which occurred in October 2007 in the Riu Girona basin (in the Marina Baixa, province of Alicante). The analysis was undertaken using a Geographical Information System (ArcMap v.9.1) in which the flooded area mapped by GPS was included. A geomorphological analysis of the flooded area was made using cartographical information and data was obtained from field studies. Special emphasis was placed on distinguishing natural fluvial dynamics from recent anthropic changes.

The Riu Girona (also known as the Rio Bolata or Barranc del Verger) rises in the mountains of the External Prebetic and flows into the sea near Dénia. The river flows 32

km from west to east and forms a small basin of 117.7 km². On 12th October 2007, flooding in the lower basin affected the towns of Beniarbeig, El Verger and Els Poblets. A bridge collapsed in Beniarbeig and an old woman died in El Verger. A house also fell down in El Verger and water levels rose as high as 3 m in some houses.

On 11th and 12th October, between 400 and 800 mm of rain fell on the upper basin of the Riu Girona, mostly between 6am and 6pm on the second day. The rainfall gradually increased from the coast towards inland areas. The heaviest rain (700-800 mm) fell on the mountains and valleys inland (Gallinera, Alt Serpis, Beniarrés), while between 300 and 400 mm of rain fell on the lower basin (La Carrasca, Alcalalí and Isbert). With an estimated average rainfall of 524 mm, approximately 62 hm³ of water fell on the basin, which is a considerable amount of water for such a small river to carry. The rainfall was particularly heavy at the weather stations in Isbert, Alt Serpis, Gallinera, Font d'En Carròs and Alcalalí, where intensity exceeded 150 mm/h but was lower towards the coast and the south. The time sequence of the storm indicates that the heaviest rainfall occurred between 10am and 12pm, especially in the middle and upper basins. The progression of the storm suggests that fairly unstable storm cells entered the southeast from the Mediterranean and released rain on the lower basin. When they reached the mountainous area where the headwaters are situated, the topographical characteristics of the area forced them to rise and more rain was released on this area, this time with greater intensity. As a result, the flood was fed by the headwater streams and moved towards the coastal plain. In contrast, only a limited volume of water was registered in the ravines of the lower section, in particular those of the Serra de Segària mountain range.

The waters from the upper basin then reached the coastal plain. There, Riu Girona has formed three prograding alluvial fans which make up a wide apron between Orba and the sea longitudinally, and between El Verger and Denia latitudinally.

In the middle basin, the flood waters mainly occupied the point bars, whereas in the lower basin the alluvial fans belonging to the Pleistocene and the Holocene were the worst affected areas. The convex topography of these landforms means that the water is dispersed over a wide area and floods occur for various different reasons:

- a) The occupation of lateral bars and point bars. These forms, used for agriculture and other economic activities, become flooded very easily at times of heavy rainfall because they themselves were created by fluvial dynamics.
- b) Alluvial fan apexes. These usually coincide with breaking points in the river banks, increasing the risk of flooding due to the channel's lack of capacity.
- c) Roads built perpendicular to flooded streams act as a barrier, modifying the flooded area.
- d) Channelization. Engineering works undertaken to alter the channel can have negative effects as a result of the flow being re-routed or the river dynamics being affected.
- e) The urban development of the flood area, which causes overflowing or alters the flow direction.
- f) Natural and artificial depressions. From a dynamic perspective, these are concavities in which flood waters gather. There is a severe risk of the water flow stagnating.

- g) Paleochannels. The channel avulsion processes form paleochannels which become flow concentration areas. These are some of the highest flood risk areas along the Mediterranean coastal plains.
- h) Vegetation. The large amount of vegetation which grows in the channels obstructs bridges and can cause occasional flooding as it acts as a flow barrier.

In conclusion, this article aims to demonstrate that, although floods are difficult to forecast, knowledge of flood areas is fundamentally important in order to determine flood hazard areas. It is perfectly possible to predict flood areas from large-scale geomorphological studies and the analysis of man-made changes. Such studies must be included as a part of planning instruments. Whilst authorities are unwilling to invest in this subject and make a commitment to rational town and country planning through the application of existing laws and other laws which have yet to be passed, we will continue to witness similar floods. Society will continue to demand safety guarantees which are impossible to deliver when the land has been so brutally and irreversibly occupied.

