LAND USE CHANGES AND RUNOFF PRODUCTION IN MEDITERRANEAN EPHEMERAL STREAMS: THE CARRAIXET AND POYO BASINS (1956-1998)

Mª José López García, Ana Mª Camarasa Belmonte and Joan F. Mateu Bellés
Departamento de Geografía. University of Valencia

Ephemeral streams are characteristic of the hydrological systems of Mediterranean environments. They are typically formed by small, steep basins with ephemeral flows, connecting the coastal and near-coastal mountain ranges with the coastal planes. Their hydrogeomorphological dynamics lead to a great variety of floodable spaces (alluvial fans, piedmonts, flat river beds, flood plains). Although many of these spaces have traditionally been occupied by human settlement and productive activities, recent unprecedented economic development and urbanisation have caused major transformations in land use which have affected both the headwaters of the basins and the flood plains. Amongst the most notable changes are the reduction in the forested area (mostly due to forest fires), the abandonment of traditional rain-fed agriculture (vine, olives, carob trees,...), the introduction of new irrigated areas (citrus orchards) and the increase in impermeable surface area (urban expansion, the phenomenon of second homes, industrial polygons, communications networks).

The introduction and extension of irrigated agriculture together with urbanisation have increased the demand for water and, at the same time, affect the production of runoff. Determining and quantifying the hydrological consequences of land use changes is not easy given the diversity and complexity of the changes, the lack of long time series hydrological records, the rarity of experimental catchments with real data, and the variability of the hydrological systems which makes the extrapolation and generalisation of existing studies especially difficult. Since the dynamics of change are variable both in space and time, some effects may counteract each other when considered at a catchment scale, whilst the effects of land use change may alter over long time scales as the nature of the transformations alters.

This paper attempts to determine the influence of recent land use changes on runoff production in Mediterranean ephemeral streams. Two semiarid catchments (Carraixet and Poyo) were chosen for analysis, located respectively to the north and south of the city of

Valencia. These are two small catchments that have been subject to high human pressure over recent years. The evolution in both space and time of the production of runoff has been analysed in relation to the changes in land use during the period 1956-98 based on land use maps for the years 1956, 1991 and 1998.

Since the aim was to characterise the hydrological response of the different sectors of the basins against identical rainfall conditions, in this study the generation of runoff has been calculated based solely on the basin characteristics, ignoring the precipitation. Thus, the accumulated amount of rainfall needed to generate surface flows was estimated as a function of the *potential capacity of the basin to produce runoff*. In terms of the hydrological balance, the runoff coefficient (P_0) reflects the threshold at which, under the hypothesis of sufficient gross rainfall distributed evenly over the whole surface area, a *Hortonian* flow is produced once losses due to evapotranspiration, interception and infiltration have been satisfied.

The runoff threshold (P_0) was estimated by the US Soil Conservation Service method (1972) modified by Témez (1978) which combines values of slope, vegetation, land use and hydrological soil type. The method was adapted by Camarasa *et al*. (2006) who proposed estimating the hydrological soil type from the hydrogeomorphological characteristics of the catchment, and in this way using information on the lithology, geomorphology and soil type.

Both the analysis of the land use changes and the calculation of the runoff coefficient were carried out using the IDRISI 32 (v.release2) and Arc-View (v3.2) geographic information systems. Raster files were used with a 20 m x 20 m grid cell. The GIS allowed the generation of dynamic maps representing the evolution of land use and runoff production, showing the stable zones and those regions where the runoff either increased or decreased. The maps of land use change were crossed with the runoff changes to determine the most extensive changes and those with greatest influence on the genesis of runoff.

The results showed very high spatial and temporal variability in runoff production although values calculated for whole catchments were relatively stable as they tended to even out changes occurring in different sectors and trends that changed over time.

In the Poyo basin the runoff production for the period 1956-98 appeared to be practically stable, with values around 56 mm, when the whole basin was considered at each of the three dates. However, the dynamic maps obtained showed different trends depending on the sector of the basin and the time period analysed. Some 58% of the basin remained unchanged, over 29% of the area the production of runoff decreased and over the remaining 13% it increased. By sector, in the headwaters of the basin, between 1956 and 1991 the observed trend was a decrease in the production of runoff due to the reforestation in the 1970's but this was followed in the period 1991-98, by an inversion of the trend with an increase in the production of runoff due to the degradation of the forest mass due to fires. Over the whole period (1956-98) these variations cancelled each other out giving an apparently stable picture.

In the Carraixet basin an overall tendency for the runoff production to increase was seen as the runoff threshold dropped from 68.4 mm in 1956 to 63.6 mm in 1998. This increase was due, on the one hand, to the degradation of the wooded areas in the headlands of the basin and, on the other hand, to the increase in the urban land area mostly occurring in the lower part of the catchment. With respect to spatial changes, only 39% of the basin remained stable over the period, with a decrease in runoff seen over 32% of the basin and an increase in the remaining 29%.

In general, the land use changes that most significantly affect the production of runoff were: the increase in area occupied by citrus orchards and shrubland which caused a decrease in the production of runoff, the increase in urban areas that led to increasing runoff, and the degradation of forest into shrubland that also produced an increase in runoff production.

In both catchments the greatest increase in runoff production, with values over 30 mm, corresponded to the changes of land use (from rain-fed agriculture, woodland or shrubland) to urban. Even though in neither catchment were the increases in urban area the biggest changes in terms of area, they were the most significant in terms of runoff (above 30 mm) in both cases. In comparison, the changes to citrus orchards or shrubland, which produced decreases in the runoff, only amounted to changes of between 0 and 30 mm.

This study demonstrates that the spatial variability of the changes in land use produce changes in runoff (either increases or decreases) that can be compensated over the catchment as a whole but can lead to significant differences according to sectors. For this reason it is important that dynamic maps are available that register and update the changes in land use and their consequences in the production of runoff, distinguishing between the sectors where runoff is generated (headwaters) and the sectors where flood risk predominates (alluvial planes). GIS provide an excellent tool since they allow changes to be updated and their implications for the production of runoff to be calculated.