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Effectiveness and geomorphological impacts of check dams for soil erosion control in a semiarid Mediterranean catchment: El Cárcavo (Murcia, Spain) ☆

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Abstract

The construction of transverse structures (check dams) is a widely used method in Spanish Mediterranean areas to stabilise gullies and ephemeral streams, to reduce channel incision and to prevent sediment deposition downstream. The effectiveness of check dams and their effects on the morphology of ephemeral channels (ramblas) were investigated in a semiarid, highly degraded catchment. In the study area, 36 dams were surveyed, of which 29 were filled up with sediments, 2 had been destroyed and only 5 had still not completely filled with sediments. The streams above the dams held sediments, which resulted in a decrease in the longitudinal gradient. Field observations of changes in the cross-sectional shape of the stream channel, the composition of channel bed material, and bankfull stage measurements indicated that the dams cause erosion downstream. The amount of sediments stored by the dams was found to be higher than the amount of eroded material in the downstream reaches of the dam.

Keywords: Check dams; Ephemeral streams; Fluvial erosion; Sedimentation; Land degradation

1. Introduction

Forest Hydrological Restoration Projects are frequently applied by the Spanish Forest Administration to reduce soil erosion and to combat desertification. These projects consist of the reforestation of degraded hillslopes, and the construction of check dams in ephemeral channels (ramblas), usually constructed in low order catchments in the upper part of the drainage network. The small dams (in general less than 5 m high) are supposed to stabilise the channels and reduce erosion. However, their actual impact is not well known. Most research on the impact of dams has focused on the influence of large dams and reservoirs, but less attention has been paid to the effects and efficiency of small check dams.

As far as we know, there is little information on the effectiveness of check dams in controlling gullying and soil erosion. Marston and Dolan (1999) concluded that engineering structures to control sediment export in an arid watershed in Wyoming (U.S.A) were not always effective or even necessary. In a study on the effectiveness of loose rock check dams for gully control in northern Ethiopia, Nyssen et al. (2004) found that 39% of the dams surveyed had been destroyed during the first 2 years. Their collapse was

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strongly associated with the runoff energy, expressed as the product of drainage area (A) by the slope gradient (S).

The upstream geomorphological effects of dams differ from the downstream effects. Channel aggradation gradually takes place upstream, because of the increase in base level (e.g. García Ruiz and Puigdefabregas, 1984). As a consequence the dams are rapidly filled up with sediment, especially in semiarid environments, where sediment yield is high (Poesen and Hooke, 1997).

Downstream effects seem to be more complex. Changes in discharge and sediment load can cause an alteration of the cross-sectional shape, channel form, slope gradient and grain size of the bed material (Brandt, 2000). Erosion can increase because of an increase in the erosion capacity of the "clear" water, after deposition of sediment behind the dam.

The study of how fluvial processes are affected by dam construction in ephemeral channels is complicated by the absence of fluvial processes most of the time. The morphological regime of ephemeral channels is unsteady, because the responses to irregular, torrential rainfalls are rapid and cause extreme morphological dynamics in the ephemeral channels: channels that are dry for several months may suddenly carry high discharges and sediment load (Conesa Garcia, 1995). For this type of environment, large floods that transform channels and produce large sediment movements have return periods of 2–6 years (Conesa Garcia, 1995). These high magnitude, low frequency floods appear to govern channel development (Knighton and Nanson, 1997).

The variability of torrential rainfalls both in space and time, coupled with the effect of transmission losses in the channels makes it difficult to obtain good data about the discharge and sediment load of ephemeral channels. As processes are difficult to measure, this study has concentrated on changes in channel morphology.

The objectives of this paper were to evaluate the effectiveness of check dams for gully control as implemented in the study area, to identify morphological effects of check dams in ephemeral streams based on field observations, and to analyse the impacts on erosion–deposition dynamics caused by the establishment of the check dams.

2. Study area

The study was carried out in the Cárcavo catchment (38°13′ N; 1°31′ W) in the NW of the province of Murcia. This area was subject to a Forest Hydrological Restoration Project that started in 1969 and its revision began in 1977. During these projects about 36 check dams were constructed in the catchment (Fig. 1), and in 1988 a large dam was built at the outlet of the main channel for flood control purposes.

The Cárcavo catchment has an area of about 2732 ha. It mainly consists of limestone, marls and quaternary deposits. Gypsum is present locally. The relief is formed of limestone and dolomite ridges with occasional outcrops of Keuper marls in the northwest. The lower parts of the terrain consist of extended pediment surfaces that have been developed in the Miocene marls and Quaternary deposits. Ephemeral

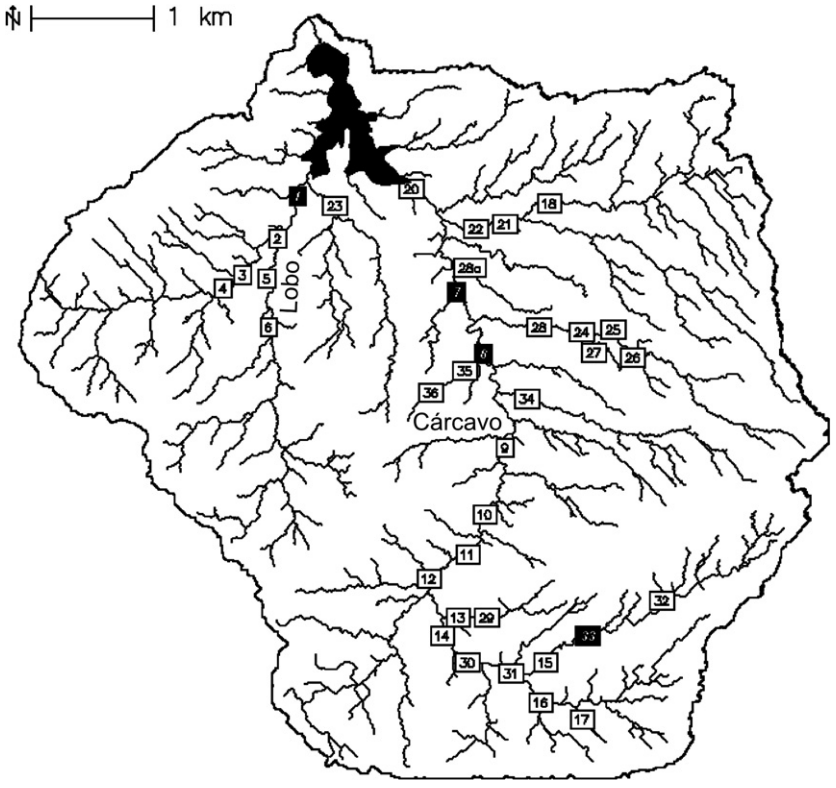

Fig. 1. Location and drainage network of the Cárcavo catchment, and the position of the check dams. The check dams studied in detail are indicated in black.