DOES VEGETATION COVER SUPPOSE GULLY EROSION STABILIZATION?

Martínez-Casasnovas, J.A.*, García-Hernández, D., Ramos, M.C.

University of Lleida, Department of Environment and Soil Science, Rovira Roure 191, 25198 Lleida, Spain.
*j.martinez@macs.udl.cat

1. Introduction

Vegetation cover is one of the factors affecting sidewall stability. Apparently, the presence of vegetation cover on gully sidewalls contributes to their stabilization. However, observations in gullies of some study areas, as the Penedès – Anoia region (NE Spain), evidence that the presence of vegetation is not sufficient to avoid gully retreat.

Gully erosion research has been traditionally addressed to determine retreat and sediment production rates (Poesen et al., 2003). Few research works have been addressed to analyze the influence of vegetation cover in gully erosion or sediment production within gullies, concluding that vegetation cover is important to reduce gully erosion and for sidewall stabilization (Rey, 2001). The present research is addressed to study the evolution of vegetation cover on gully sidewalls and its influence on sediment production due to gully erosion and on gully walls' stabilization. A sample gully system of the Penedès – Anoia (NE Spain) was selected as study area (Fig. 1). In this region, gully erosion is a problem which affects 23 - 32% of the land. It is part of the Penedès Tertiary Depression, where calcilutites (marls) and, occasionally, sandstones and conglomerates outcrop.

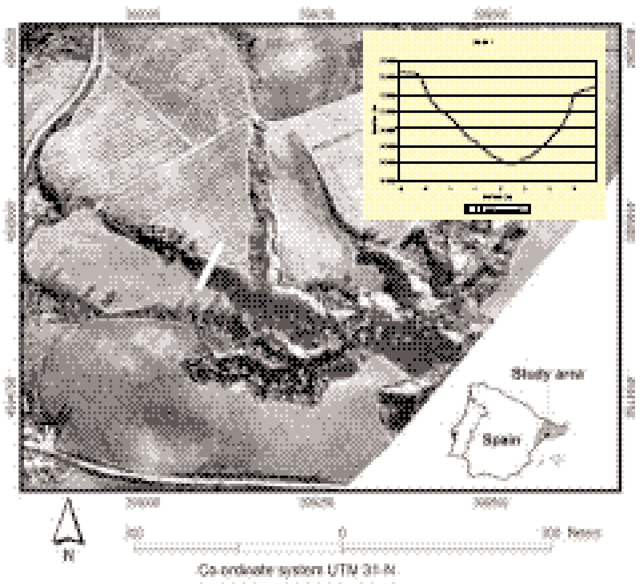

Fig. 1. Location of the study area. The white line indicates the cross-section in the upper-right part of the figure.

2. Methods and material

The analysis of the vegetation cover changes within the sample gully system of the Penedès – Anoia region was based on the use of multi-temporal and detailed aerial photographs: 1975 (1:7,000), 1995 (1:5,000) and 2002 (1:5,000). Those photographs were rectified to produce 1:1,000 orthophotos and digital elevation models (DEM) of 1 m resolution. From that material, vegetation cover was characterized for the respective years. Field work was carried out as ground truth to classify 2002 vegetation cover and to get photo-interpretation guidance to train the interpretation of the 1975 and 1995 vegetation cover maps.

The vegetation cover maps of 1975, 1995 and 2002 at 1:1000 scale were overlaid to produce change maps for each period. The geographic information system software ArcGIS 8.1 was used for that purpose. The vegetation cover change results were compared to catchment land use changes and gully erosion (sediment production rate) in both periods (1975-1995 and 1995-2002).

3. Results

The analysis of Table 1 reveals that in the period 1975-1995 there is an important diminution of the scrubland cover of 20.8% and an increase of coniferous forest of 21.5%. In addition, a reduction of the non-vegetated gully walls is observed (-4%). In the period 1995-2002 the same trend was observed: the scrubland decreased by 4.3%, the coniferous forest increased by 5.8% and the non-vegetated walls decreased by 1.6%.

These changes could be indicating stabilization of gully walls and a decrease of sediment production rates in the study area. In this respect, the second period (although shorter) could have a more favourable rate of vegetation cover increase. The vegetation cover class of greatest interests from the point of view of gully wall stabilization, the coniferous forest, increased by 14.7% from 1975 to 2002, with a rate of 0.15 ha per year (1.7%). The major growth occurred in areas previously covered by forested scrubland.

Regarding the relation of vegetation cover changes with respect topographic factors, mainly aspect, the results show that coniferous forest has mainly growth in north and east oriented walls, while non-vegetated areas are mainly south oriented. In these last walls, an opposite effect has been observed. On one hand, a certain increase of vegetation cover in non-vegetated walls in the period 1975-2002 was

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observed due to the growth of herbaceous and scrubland vegetation. However, the main vegetation cover decrease occurred on south oriented walls due to higher gully retreat rates of those walls.

Table 1. Vegetation cover changes in the sample gully area (Years 1975, 1995 and 2002).

Vegetation cover class	Percentage with respect total gullied area		
	1975	1995	2002
Coniferous forest	14.7	36.2	42.0
Scrubland	53.7	33.0	28.7
Forested scrubland	4.6	6.1	7.1
Herbaceous cover	0	0	0.8
Non-vegetated gully walls	27,0	23.0	21.4
No described	0	1,7	0

Table 2. Vegetation cover changes in the catchment of the sample gully system (Years 1975, 1995 and 2002).

Vegetation cover class	Percentage with respect total catchment area		
	1975	1995	2002
Traditional vineyard	24.5	16.1	12.3
Mechanized vineyard	0	18.9	18.9
Winter cereals	31.2	0	3.9
Urban area	0.2	2.7	2.7
Infrastructures	1.8	2.9	2.9
Scrubland	14.2	8.9	8.9
Unproductive	2.2	6.3	5.9
Forest	4.6	23.3	23.7
Orchards	1.6	2.6	2.6
Buffer between gully and fields	2.4	1.8	2.1
Gully area	17.3	16.5	16.2

The analysis of land use changes in the catchment of the gully systems indicates main changes in the vineyard and cereal classes (Table 2). In 1975 traditional vineyard and cereals occupied 90% of the total agricultural land, while in 1995 the first class decreased by 18.9% to favour the implantation of mechanized vineyards. Winter cereals were reduced from 31.2% in 1975 to 0% in 1995 and then to 3.9% in 2002. This is due to the higher profitability of mechanized vineyards in front of traditional cultivation. These land use changes produced a significant increase of overland flow from the fields to the gully walls, as consequence of the field restructuring carried out in the period 1975-1995 (including land levelling). This fact influenced higher moisture contents on gully walls and, as consequence, better conditions for vegetation development.

The subtraction of multi-temporal DEMs allowed to analyze the relationship between vegetation cover development and gully erosion. The most significant is the increase of vegetation cover in sedimentation areas within the gully (mainly gully bottom and walls' lower section): 62.7% of vegetation cover increase occurred in sediment deposition areas and in particular the development from scrubland to coniferous forest.

In the period 1975-1995 gully sidewall failures were observed, mainly located in the vicinity of the gully-wall border, where tension crack development is the main process promoting wall collapse. However, in the period 1995-2002, some wall failures also occurred near the gully bottom, indicating active undercutting by water and debris flow due to the important and high intensity rainfalls in this period (Martínez-Casasnovas et al., 2004).

4. Discussion and conclusions

The results suggest that gully sidewall processes in the study area, similar to other landslide activities do not depend on wall vegetation cover but are determined by two types of interrelated factors. The first type of factors express the progressive preparation of gully-wall materials, acting against the shearing resistance of the soil, e.g. tension crack development in the vicinity of the wall's border area by saturation of the materials and by changes in wetting-drying conditions. In those cases, wall slope and height also influence gully-wall stability. The other type of factors express a local short-duration drop in slope stability, such as large and high intensity rainfalls, that generate important runoff and provoke undercutting by concentrated runoff. In those cases, sidewall failures are not so dependent on slope angle, bank height or vegetation cover, but merely on material cohesion and runoff flow intensity (Martínez-Casasnovas et al., 2004).

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