Analysing the factors affecting gully development and their relationships with land-use changes in the east Alentejo (Portugal)

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ABSTRACT

The land abandonment and land-use changes as a consequence of the implementation of the European Union Common Agricultural Policy (C.A.P.), in the SE of Portugal, have been generating, differences in the equilibrium of the geomorphic processes.

The head waters catchments of some of the Guadiana River tributaries show in the study area several degrees of gully initiation and development both on the hillsides and valley bottom infill. This gully generation process is closely related with the changes in the soil and cover properties occurring when agricultural practises have been replaced by intensive grazing areas or by abandoned land.

High resolution panchromatic and Landsat images, dating from the last 40 years have been analysed in combination with field observations and the analysis of the data from soil erosion plots series in the Estação Experimental de Vale Formoso, in order to establish and parameterise the sequence of changes in soil surface properties and vegetation cover and distribution.

The results show the connection between the different degrees of gully development and their morphological characteristics with the land cover properties at different times and after different sequences of land-use changes.

Key words – land abandonment, land-use changes, soil erosion, Inner Alentejo

INTRODUCTION

In European Mediterranean countries, land abandonment has been on the rise, due to the Common Agricultural Policy, with the implementation of measures such as the set-aside, the agro-environmental protection, or the early retirement of farmers. In 2000 statistics showed that around 8 to 15% of farm land had been abandoned in the countries in the South of Europe, but the tendency is for a substantial increase, fundamentally, in the areas of marginal soils. This tendency is also observed in Portugal, particularly in the South (Alentejo).

In this way, when you intend to evaluate the environmental consequences of abandoning farming activities in a territory, it is fundamental to pay due attention to important elements such as, previous sequences of soil use, and, after abandonment, equate their effects in terms of soil erosion processes, landscape evolution and biodiversity (MacDonald et al, 2000).

Diverse authors, (Martinez-Fernandez et al., 1995; Lopez-Bermudez et al., 1996; Puigdefabregas et al., 1996) refer that abandoned lands, by converting spontaneously to

grazing areas, do not suffer a lessening of pressure upon abandonment, but in many cases it intensifies, due to overgrazing.
It is important to measure, that in many cases it was precisely the soil degradation (reduction in thickness, weak organic matter composition, destruction of aggregates, amongst others) with the consequential loss in fertility, which led to abandonment.
Land abandonment has been focussed specially as a problem with consequences over the soil erosion and sedimentation processes, and usually giving a negative character to the process. Several authors have demonstrated, in contrast, that erosion is effective in the five year following the abandonment and an important decrease in soil erosion rates occurs with the progressive vegetation cover recovery and the improvement of soil properties.

STUDY AREA AND METHODOLOGY

The study area in this paper is located (figure 1) in the north of the Mértola municipality (Inner Lower Alentejo, SE of Portugal). The area under continental Mediterranean climatic conditions is affected by heavy rainfall events (more than 100 mm day^{-1}) as well as long drought periods (years of 1980/81 with 236 mm, and 2005/06 with 117mm of annual rainfall). The annual rainfall average is about 561mm, but is possible to occurred very wet years like 1989/90 with 1041 mm. The landscape, draining to the Guadiana River is dominated by a rolling topography but with an important relief rate to the local base level (100-200 m) Soils, are mainly shallow litosols developed over schists and natural vegetation is very degraded, reduced to matorral in the steepest areas besides the main valleys. Disperse trees (*Quercus suber* and *rotundifolia*) appear as part of a mix productive system named Montado

The area has been affected by deep and important land use changes mainly driven (i) between 1930 until 1974 by the wheat campaign of the *Estado Novo* regime, (ii) after April 1974 revolution with the implementation of the “Reforma Agrária” that introduces changes in cultures and farm dimensions and (iii) after the 1986 adhesion to the European Union and to the Common Agriculture Policies that become in changes in crops and animal production (i.e. sheep, wheat, sunflower, and in last years to cattle).

Soil erosion studies has been developed in the area since 1960, when a series of erosion measuring plots (Wischemeier experimental design) where established in a governmental property named “Estação Experimental de Vale Formoso”, in order to know how the different crops rotations and practices are affecting soil loss, and improve soil conservation practises.

In the area between this experimental station and the Guadiana River a series of 13 small catchments (0.4 to 8 ha) has been selected as representative of the different land use situation at present time. Each catchment was visited several times in the year in order to describe soil erosion evidences in relation with the different crops situation and to appreciate the effects of rainstorm events.

All the catchments have been also identified in a sequence of 16 available Landsat images dating from 1976 to 2005. Using both, vegetation indexes calculation (NDVI) and visual interpretation from the images, land use at each gully catchment was determined in one of the following categories: Bare soil, Cultivated and Pasture/matorral.

In order to know the amount of the soil loss rates under different situations the data series of three of the experimental station plots have been analysed. These cover the wheat/stubble/bare conditions, as well as abandonment tending to matorral cover.

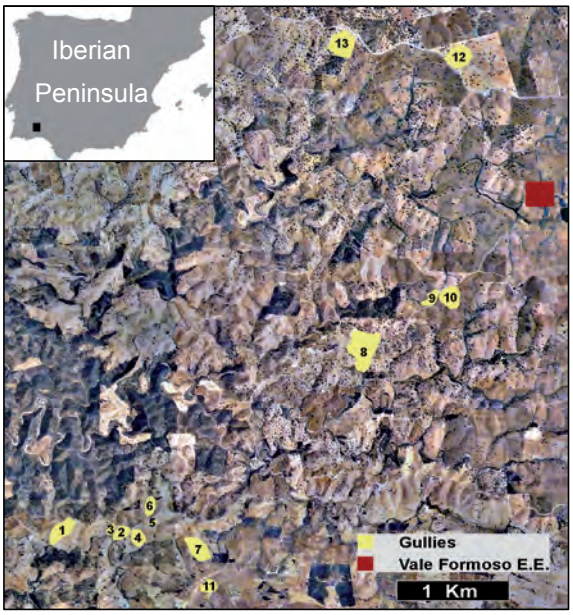

Figure 1. Location map of the studied area, the gully catchments and the Estação Experimental de Vale Formoso (Mértola, Portugal).

MAIN RESULTS

During decades, in the Alentejo region of Portugal, have been used for agriculture soils that per their physical and chemical properties are not suitable. These marginal areas must be used for extensive grazing, but reality was different. Those, in the Inner Alentejo (Mértola municipality), where there is a domain of impermeable metamorphic rocks (mainly schists) with poorly developed soils and very low organic matter content, today degradation and desertification processes are very advanced (Roxo *et al*,1993), as well as the degradation of natural resources (Roxo, 1994; Casimiro 2001).

Field observations and analysis of sequences of satellite images allow checking that land abandonment is an state that occur in a vast area. Nevertheless, as a recent phenomenon, different degrees of evolution of the systems after the abandonment can be found. Mainly as a consequence of the European agricultural policies implementation, land use changes are very dynamic in this area including abandonment but also the reversion of this situation back to crops or livestock.

In an area where soils can be in considered 'artificial', as rock weathering and sediment accumulation at the valley bottoms are favoured by the agriculture, specially, but also by livestock. Under these to kind of land use the amount of sediments delivered to the rivers is important, as not all removed material from hillslopes is accumulated in the tributary valleys, because no soil conservation practices are applied.

Abandonment seems apparently responsible for a great amount of soil loss; gullies are developed and begin to remove all sediments accumulated at the valley bottoms, after exhausting available material on the hillslopes. This is true on the hillslopes during the first years before the development of an effective vegetation cover or before the soil surface armouring by the increase of the rock fragments cover and the development of biological crusts. Following, erosion rates increase at the valley bottoms infill, by gulling. With the time (2-5 years on the hillslopes, if the process is not interrupted, and several decades for the valley bottom areas) the erosion process decrease (figure 2).

Figure 2 – Gully formation (number 1 in figure 1)

Soil removal from the hillslopes becomes almost nothing as can be seen on the vegetated Vale Formoso plots; although infiltration is still relatively low as water storage capacity in the soils is still low. After abandonment processes, implies a progressive increase in the biological and pedological diversity; and a progressive improvement of the quality of the water exported by the tributary systems, together, in the long term, with and improvement of the water storage capacities in the systems.

This land use sequence analysed here suggest that together with the implementation of soil conservation practices during the crops and livestock activities, may be useful to apply also some soil conservation measures immediately after the end of the agricultural activities, tending to preserve the more fertile valley bottoms soils.

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