Biophysical- and socioeconomic aspects of land degradation in the Guadalentin (SE-Spain): towards understanding and effective soil conservation

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ABSTRACT
Desertification and land degradation have been widely studied in the Guadalentin basin (SE Spain) through various national and international research projects. Most important identified degradation types are due to soil erosion, soil surface crusting, aridity, soil organic matter decline and salinisation. On the one hand, political and socioeconomic drivers have caused important land use and management changes, which have formed an important driver for further land degradation. On the other hand, soil conservation practices were initiated by the government and by individual land users, although there is very limited knowledge on their effectiveness. The objective of this work is to provide an overview of previous studies that addressed land degradation in the Guadalentin and to present an integrated synthesis of the main biophysical- and socioeconomic factors identified in these studies as being responsible for land degradation, with a focus on feasible soil conservation strategies. In overall, there has been strong emphasis on the study of biophysical characteristics related to climate, vegetation, soil, flooding, hydrology, and partially on the socioeconomic and political drivers of land degradation. The latter especially focussed on the effects of agricultural subsidies on land use changes and land degradation. Most studies have concentrated on the headwaters of the Guadalentin and on areas with (semi-) natural vegetation. Important examples of issues that remain under-researched are: 1) costs of land degradation (on-site and off-site), 2) effects of different conservation strategies on the short- and long-term, on-site and off-site, 3) the effect of large-scale land conversion by land levelling and urban expansion, and 4) the future implications of land managers' decisions on land degradation.

Keywords: Guadalentin; soil erosion; land use change; soil conservation.

INTRODUCTION

During the last two decades, the Guadalentin basin in south-eastern Spain has been the study area for many national- and international studies dealing with land degradation and desertification. One of the reasons for such a broad interest in the Guadalentin basin is that land degradation is generally considered severe in large parts of the basin. The main types of degradation are due to soil erosion, soil surface crusting, aridity, soil organic matter decline and salinisation. Numerous publications have been produced based on works done to address land degradation in the Guadalentin. However, until now there is no concise and integrated up-to date overview of what has been done and what is still missing regarding the study of the biophysical- and socioeconomic aspects of land degradation and soil conservation. This is in fact crucial to assist policy makers in making decisions that would effectively navigate land management in the area to a sustainable way. Here, we aim to provide such an overview by listing and discussing the main studies performed in this area (see Figure 1), and by providing an integrated synthesis of the main biophysical and socioeconomic factors identified in these studies as being responsible for land degradation, with a focus on feasible soil conservation strategies.

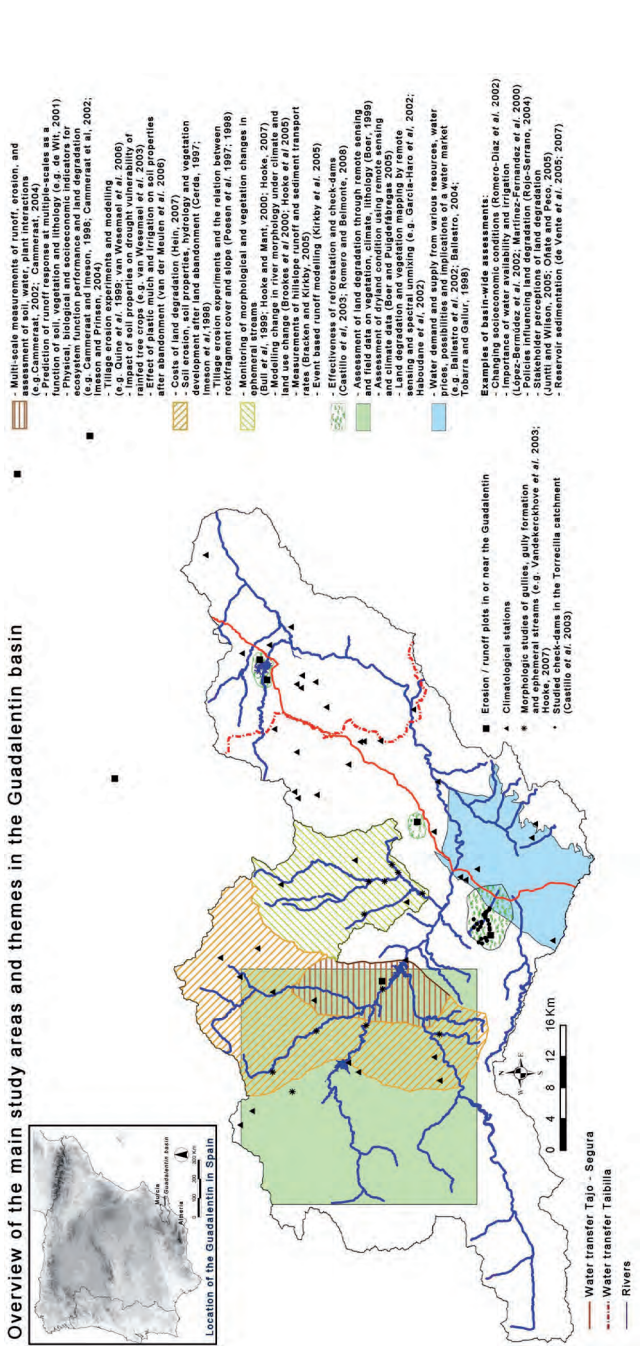

Figure 1. Overview of studies performed in the Guadalentin basin during the last 25 years.

Figure 2. Examples of land use changes induced by socioeconomic incentives (A: heavy machinery for land levelling; B: levelled and irrigated lettuce plantation; C: Mouldboard ploughing of an abandoned field).

BIOPHYSICAL ASPECTS

Most biophysical research is performed at the pedon to hillslope scale. At these scales, the spatial pattern of soil surface characteristics like stoniness, vegetation cover, crusting, organic matter content and water repellency appears determining for runoff generation and soil erosion and affects hydrologic connectivity and sediment transport (Cammeraat and Imeson, 1998; Boix-Fayos *et al*., 2006). Increased erosion and runoff rates are observed during first years after land abandonment, until vegetation recovers and rock-fragment cover increases (Cerda, 1997; Govers *et al*., 2006). At the hillslope scale erosion rates on shrubland (<0.1 t $ha^{-1}yr^{-1}$) and arable land (~1 t $ha^{-1}yr^{-1}$) are generally low, while causing accumulation of sediments behind terraces in valley bottoms that are only removed during high intensity rainfall events. At the catchment scale, sedimentation rates in reservoirs are higher (2-5 t $ha^{-1}yr^{-1}$), which suggests that gully- and bank erosion are responsible for over 50% of total sediment yield (Poesen *et al*., 2003; de Vente *et al*., 2008). Precipitation thresholds for runoff generation are defined at different spatial scales. At the catchment level runoff and sediment export depend on extreme events and are highly conditioned by lithology, topography, and land use (Bull *et al*., 1999; Cammeraat, 2002; Bracken and Kirkby, 2005). Finally, vegetation cover in channels has a significant influence on the impact of floods by protecting channel bars and river banks from erosion (Brookes *et al*., 2000).

SOCIOECONOMIC ASPECTS

Triggered by various political and socioeconomic drivers, important land use and management changes have taken place over the last centuries, which have formed a driver for land degradation. Examples of such changes are large-scale land abandonment, a shift from dryland cereals production to almond plantations (Rojo Serrano, 2003), large-scale land levelling for irrigated horticulture (see Figure2). The fact that in the year 1995 only 37% of the land use was the same as in 1957 illustrates the extent of land use change (Cammeraat & Imeson, 1999). One of the main political drivers is formed by a range of agricultural subsidies towards land use types and management strategies that intend to increase the economic situation of agriculture and promote a lower intensity of agriculture in marginal areas (Juntti and Wilson 2005). Yet, a decrease in almond crop yield was noticed from 0.8 t ha^{-1} in the 1960's to 0.4 t ha^{-1} in the 1990's, which may be due to expansion of almond plantations into more marginal areas (van Wesemael *et al*., 2003).

Figure 3. Examples of common conservation measures in the Guadalentin (A: vegetated terraces with almond trees in a cereal field; B: check-dam; C: terraced reforestation).

SOIL CONSERVATION STRATEGIES AND EFFECTIVENESS

The most important soil conservation strategies applied by the government in the Guadalentin consist of reforestations and the construction of check-dams. However, there are many other, more hidden, conservation strategies applied by land users such as earthen-terraces, stone barriers, water harvesting and winter cover crops that are potentially very effective. Nevertheless, very few studies addressed the effectiveness of soil conservation strategies. Studies that were performed indicate that check-dams and reforestations do often not reach expectations. Check-dams rapidly get silted-up and induce erosion downstream (e.g.Castillo *et al*., 2003; Romero Díaz *et al*., 2007). Reforestations are often not successful due to harsh environmental conditions and destructive machinery, so that even after 30 years erosion rates are higher than on surrounding shrubland (e.g.Romero Díaz and

Belmonte Serrato, 2008). Presently, the effectiveness of locally applied conservation strategies is being assessed in the DESIRE project (www.desire-project.eu).

CONCLUSIONS

In overall, there has been a strong emphasis on the study of biophysical characteristics at the pedon to hillslope scale related to vegetation, soil, flooding, hydrology, climate, and on the socioeconomic and political drivers of land degradation. Most studies have concentrated on the headwaters of the Guadalentin and on areas with (semi-) natural vegetation. Several critical issues remain under-researched including but not limited to: 1) impact of land degradation on ecosystem goods and services (on-site and off-site) and a cost-benefit analysis of soil conservation, 2) effects of different conservation strategies on the short- and long-term, on-site and off-site, 3) the effect of large-scale land conversion by land levelling and urban expansion, and 4) the future implications of land managers' decisions on land degradation at a regional scale.

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