LAND USE RECOMMENDATIONS. A TOOL FOR LAND USE PLANNING IN THE VALENCIAN REGION, SPAIN

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Abstract
Water erosion is the major soil degradation process in Mediterranean environments, including the Valencian Region, Spain. Many studies have applied methods, both qualitative and quantitative, to evaluate and predict erosion risk, being their main aim to provide useful information to land use planning. Most recently the incorporation of Geographical Information Systems (GIS) techniques has allowed the delimitation of Land Use Recommendations. This contribution shows a GIS based approach to integrate soil erosion information to derive Protection Land Use Recommendations in the Valencian Region at scale 1:300 000. The delimitation of Protection areas has been done using a vector GIS approach, for which the relation between actual and potential erosion risk, following an adapted version of the Universal Soil Loss Equation (USLE), has been a fundamental indicator. Basically the identification of such cartographic units has been established by analytical procedures of the database linked to the geometric elements. Results show that almost 23% of the region's territory would have to be protected in order to avoid erosion intensification and risk. Also such areas are located in open natural landscapes where most of the natural heritage can be identified.

Additional Keywords: land evaluation, database management, multicriteria analysis.

Introduction

Soil erosion remains a serious problem in many areas of the Valencian Region, and has been widely recognised as a critical environmental issue leading to desertification, an advanced stage of land degradation. During more than twenty years, both quantitative methods to predict soil erosion (coming mainly from the modification of the USLE model to the particular environmental conditions of the Valencian region) and qualitative approaches to estimate soil erosion have been developed and applied within the region. Although there is not yet an approach to satisfactorily evaluate soil erosion in the Mediterranean environments, the experience gained during several research projects shows that the approaches used allow to make adequate proposals of land use recommendations and land use plans. Policy makers, when assigning land use types, should pay attention to the recommendations derived from land evaluation studies as a support tool for decision making (Rubio *et al*., 1989; Recatalá *et al*., 2000). Thus, any land evaluation project should have to be oriented to the final proposal of eventual decision on land use to be applied in management policy (Añó *et al*., 1999).

In this way, the Valencian Region Land Use Recommendations map at scale 1:300.000 constitutes a useful tool for designing and implementing soil protection measures. The proposed Land Use Recommendations, elaborated from a pre-existing digital map of Land Capability, takes into account present erosion and potential risk. The assessment of soil erosion is based on the general principles and parameters defined by the USLE (Wischmeier and Smith, 1978) such as rainfall erosivity, soil erodibility, topography, vegetation cover and management practices, but in a modified form adapted to the region's conditions (Antolín *et al*., 1998). USLE, although limited, is by far the model most widely used for estimating and predicting soil erosion by water in the Valencian region because it's low data requirements and its ease of application. The conceptual development of this work has been achieved using GIS techniques for data treatment and analysis. Nowadays, GIS constitute tools of great importance in environmental and land management studies (Longley *et al.*, 1999), being almost essential whenever great amount of georeferenced information has to be treated.

Materials and Methods

The required data has been incorporated into a vector GIS structure (Burrough and McDonnell, 1998). The geometric elements, the polygonal features (or similar characteristic environmental units) have been considered in so far as non-variant. Thus, the analytical framework has been based in database management and modelling. For the extraction of land use recommendations a simple multicriteria analysis has been performed, which has been proved efficient in environmental studies and land management (e. g. Joerin, 1998; Cavallo and Norese, 2001). The approach is based on a step by step pairwise comparison of land capability, present erosion and potential erosion indicators. In this case pairwise comparison has consisted in a sequence of one on one judgement regarding the

significance of each indicator relative to the criteria established by an expert group (Mendoza and Macaoun, 1999). Finally, each indicator under a criterion is compared with every other indicator under its respective criterion to derive land use recommendations.

Accordingly agricultural land use recommendations are directly assigned from equivalent land capability classes. This is very high, high and moderate land capabilities are recommended as Intensive Agricultural, Moderate Intensive Agricultural and Restricted Agricultural, respectively. For the rest of Land Use Recommendations the database pairwise comparisons are as follows: Restricted Forestry would be assigned whenever rate of present erosion is less than 70 t $ha^{-1}yr^{-1}$ and potential risk is less than 200 t $ha^{-1}yr^{-1}$; afforestation is assigned when present erosion is higher than 70 t $ha^{-1}yr^{-1}$. Soils in lithic phase or very shallow soils without erosion problems would be considered as Natural Regeneration Land Use Recommendation. When natural vegetation is kept, Protection Land Use is recommended by the risk of degradation due to the high fragility of the ecosystem. A good indicator is the relation between present erosion and potential risk. Present erosion indicates the approximate soil loss according to the actual environmental conditions. Potential risk indicates the possible soil loss if some conditions change (potential erodibility, disappearance of the vegetal cover and abandonment of the conservation practices). In this land use recommendation present erosion is low or very low and potential risk is higher than 200 t $ha^{-1}yr^{-1}$. See Sánchez *et al.* (2000) for further details.

Results and Discussion

The proposed methodology gives seven Land Use Recommendations: Intensive Agricultural, Moderate Intensive Agricultural, Restricted Agricultural, Restricted Forestry, Afforestation, Natural Regeneration and Protection. Areas in which both present soil erosion and potential soil erosion are low or very low are have been recommended to intensive agriculture or moderate intensive agriculture depending on the land capability analysis. These areas account for about 16 % of the Valencian region (Table 1). Areas recommended for restricted agriculture, which represent about 22% of the region, usually show moderate present and potential soil erosion. Soil conservation practices are needed in these areas in order to maintain or even improve the productivity of soils. During the last decades, some of these areas have been abandoned from agriculture and consequently the erosion process has increased intensively. In other areas, land abandonment has evolved to forest ecosystems where vegetation has played an essential role protecting soil from erosion.

Table 1. Land Use Recommendations surfaces and percentages for Valencian Region (Sánchez et al., 2000)

Land Use Recommendation	Surfaces (hectares)	Percentages (%)
Intensive Agricultural	70,042	3
Moderate Intensive Agricultural	305,995	13.1
Restricted Agricultural	516,811	22.2
Restricted Forestry	316,680	13.6
Afforestation	409,499	17.6
Natural Regeneration	161,917	7
Protection	525,526	22.6
Non evaluated	20,814	0.9

When erosion is an important issue, the land use recommendations are afforestation, natural regeneration and protection. According to the multicriteria analysis carried out in the region, afforestation has been recommended to areas where both present and potential soil erosion are high or very high are high or very high and soil depth is not a limitation for vegetation. These areas represent near 18% of the region. Strategies focussed on tree planting to restore the vegetation are critical to control soil erosion and avoid great losses of soil resources in these areas. Natural regeneration that represents 7% of the region has been recommended to areas where both present and potential soil erosion are very high but having shallow soils in which an assisted afforestation to recover vegetation can not be managed. In these areas, land management implies the natural recuperation of vegetation. Protection has been recommended in areas where present soil erosion is low or very low whereas potential soil erosion is high or very high (Figure 1). In these areas the function of vegetation as a protection element for soil is crucial to maintain erosion in low levels. Any human activity that means the disturbance of vegetation such as uncontrolled fires, inadequate wood production, etc must be avoided in order to maintain the ecosystem equilibrium. Land management must be directed to protect the vegetation cover in these areas. Taking into account this land use has

been recommended in almost the 23% of the region, it must be highlighted that decision makers must concentrate land management efforts in such areas to maintain the soil resources and consequently ecosystems that in many cases hold a high biodiversity.

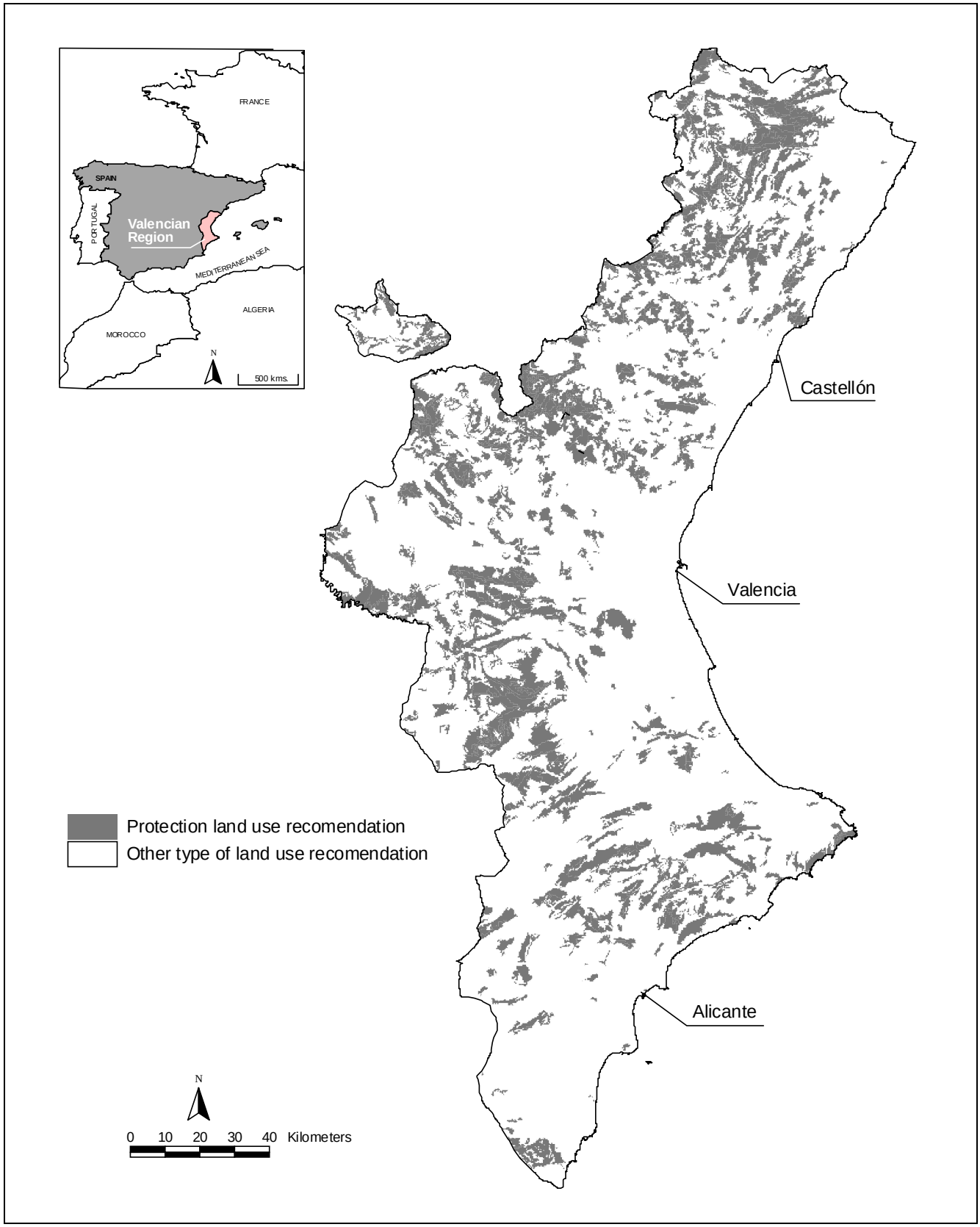

Figure 1. Distribution of Protection Land Use Recommendation in the Valencian region

Conclusions

Land planning and land management need to be organized according to the risk of degradation and to control soil erosion and preserve soil resource. According to this premise the Land Use Recommendations approach is a valuable tool for land use planning and management at regional level. Attention should be paid on the fact that the working scale (1:300000) makes appropriate for such planning scale. Therefore, for precise targeting of specific soil protection zones more detailed information should be needed.

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References

Antolín, C., Carbó, E. and Álvarez, D. (1998). Aplicación de la Ecuación Universal de Pérdida de Suelo en la Comunidad Valenciana. In "El Suelo como Recurso Natural en la Comunidad Valenciana", p136-165. COPUT, Generalitat Valenciana, Valencia.

Añó, C., Sánchez, J. and Antolín, C. (1999). The evolution of agricultural land evaluation in Spain. In "Ecosystems and Sustainable Development II. Advances in Ecological Sciences 2", p35-44. WIT Press, Southampton.

Burrough, P.A. and McDonnell, R.A. (1998). Principles of Geographical Information Systems. Oxford University Press, Oxford.

Cavallo, A. and Norese, M.F (2001). GIS and Multicriteria Analysis to evaluate and map erosion and landslide hazard. *Informatica* 12(1), 25-44.

Joerin F. (1998). Land Management with GIS and Multicriteria Analysis. In "MOPGP'98", *Proceeding of Third International Conference on Multi-Objectives Programming and Goal Programming*, Québec city.

Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. (Eds.) (1999). Geographical Information Systems. Volume 2. Management Issues and Applications. John Wiley & Sons, USA.

Mendoza, G.A. and Macoun, P. (1999). Guidelines for Applying Multi-Criteria Analysis to the Assessment of Criteria and Indicators. Center for International Forestry Research, Jakarta.

Recatalá L., Ive J.R., Baird I.A., Hamilton N. & Sánchez J. (2000). Land-use planning in the Valencian Mediterranean Region: Using LUPIS to generate issue relevant plans. *Journal of Environmental Management* 59, 169-184.

Rubio, J.L., Molina, M.J. and Sánchez, J. (1989). Land Use Recommendations for soil conservation planning in Mediterranean environments. *Soil Technology* 1, 207-216.

Sánchez, J., Añó, C., Carbó, E., Pascual, J.A., Antolín, C. and Colomer, J.C. (2000). Orientaciones de Uso Agrario de la Comunidad Valenciana. Escala 1:300.000. *Edafología* 7(3), 1-10.

Wischmeier, W.H. and Smith, D.D. (1978). Predicting rainfall erosion losses-a guide to conservation planning. USDA-ARS Agricultural Handbook 537, U.S. Government Printing Office, Washington D.C.