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Note

Analysis of soil capability versus land use change by using CORINE land cover and MicroLEIS

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A b s t r a c t. Land use and land cover changes in agricultural lands between 1956 and 2007 in Seville province (SW Spain) were analyzed in this research. The agricultural land use change was compared to land capability with the aim to analyze dysfunctions related to agricultural capacity of the area. Furthermore, factors affecting agroecological land use in the province were examined in the light of their implications for agroforestry sustainability. There are significant differences in the extent and rate of agricultural land use change at regional level. Present circumstances in the province are favourable for a reversal of agroforestry uses, nevertheless urbanization process is the major pressure in the agricultural regions in the province.

K e y w o r d s: decision support tools, land use change, land evaluation, soil capability, MicroLEIS

INTRODUCTION

Sustainable land management is crucial for the prevention of land degradation, the reclamation of degraded land for its productive use, the reaping of benefits of crucial ecosystem services, and the protection of biodiversity (Pino *et al*., 2010). To this respect, the role of soils is essential to evaluate the optimal land use for each particular area based on its own capability and vulnerability (FAO 1976; 1978).

On the other hand, land use change, influenced by processes like urbanization, industrialization, and intensive agriculture often result in rapid landscape changes, losses of ecological capacity, diversity, and scenic beauty, as well as damage to historically valuable cultural landscape (Bastian *et al*., 2006). Corine Land Cover 2000 (CLC2000) contributes to the knowledge of land cover (LC) and its changes in 24 European countries. Land cover reflects the biophysical state of the real landscape (including the effects of human activity on the biophysical unit). For this reason LC data are increasingly used for derivation of different landscape attributes such as its changes, diversity, forecasting, *etc*. and for modelling of land different properties (Feranec *et al*., 2010).

Sustainable management of natural resources requires an exhaustive knowledge of the physical environmental components with particular focus on the relations between these elements and the different plant communities. In this way, emerging technology in data and knowledge engineering provides excellent possibilities in land evaluation analysis. Such analysis involves the development and linkage of integrated databases, biophysical models, computer programs, and optimization and spatialization tools, which constitute the innovative decision support systems (DSS). DSSs are computerized technology that can be used to support complex decision-making and problem-solving (Shim *et al*., 2002).

In the present research, we formulated a methodology to quantify and explain the land use change (LUC) *vs*. land capability which can be used in similar cases elsewhere. The approach is tested in Seville province, considering the LC maps of 1956 and 2007 (1:25 000, minimum map unit 0.5 ha; Moreira, 2007) made by Andalusian Network of Environmental Information (REDIAM) belonging to Regional Government of Andalusia. The agricultural capability of the soil was determined using the MicroLEIS system and data from the soil data base of SEISnet-IRNAS.

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Taking this into account, the aim of this paper is:
– to evaluate quantitatively and objectively the agricultural land use change between 1956 and 2007,
– to compare agricultural land use change with the land capability prediction in order to analyze dysfunctions related to agroforestry capacity of the territory.

METHODS

Sevilla province is located in the Mediterranean region of Andalusia, SW Spain. The approximate geographic coordinates of Sevilla Province are 36º51' to 38º 12' N and 5º04' to 6º30' W. Its slopes range from <2 to 30%, and the elevation ranges from 2 to 740 m above sea level. The total province area is 1 425 726 ha.The climate is semi-arid, with mild rainy winters, and hot dry summers of high solar radiation and a high rate of evaporation. This seasonal contrast is exacerbated by the erratic and unpredictable rainfall distribution from year to year, and crops can suffer from moisture deficits even during years receiving the mean precipitation.

Seven benchmark sites were selected from the soil data base of SEISnet-IRNAS (Evenor-Tech, 2009). A general description of each site is summarized in Table 1. Typical soils were selected because they occupy large proportions of the corresponding natural region (Fig. 1). For each bench-mark site, a representative meteorological station was selected, based on monthly mean climate variables for the long period 1961-1990.

The agroecological decision support system MicroLEIS (De la Rosa *et al*., 2004; 2009) is used to design the most sustainable land use and management. This DSS is based on the multifunctional evaluation of soil quality, using input data collected in standard soil surveys, and with particular reference to the peculiarities of the Mediterranean region. At present it is applied and tested in other countries such as Iran (Shahbazi *et al*., 2008).

In the present study, we used two models included in MicroLEIS DSS: Terraza and Cervatana. While Terraza gives an empirical prediction of the bioclimatic deficiency of a site, Cervatana model forecasts the general land use capability or suitability for a broad series of possible agricultural uses. The models were applied for the selected seven benchmark soils. At present, a Spin-off from the CSIC (named Evenor-Tech; www.evenor-tech.com) is being launched in basis to the MicroLEIS technology.

The LC nomenclature of Andalusia comprises three class levels characterized by quoted attributes. The present study was focused in the first level (artificial surface, wetlands and water bodies, agricultural areas, and forest and natural areas) which indicates the major categories of LC on the planet. To evaluate the coincidence between the LC of 1956 and 2007, we built contingency tables for each natural region. Table 2 shows an example for Aljarafe natural region. These tables throw data for understanding the main pressure for biodiversity and natural resources sustainability. In this sense, the land cover flow (LCF) in agricultural areas was analyzed in order to stand up the principal processes related to the agroforestry capacity of the territory.

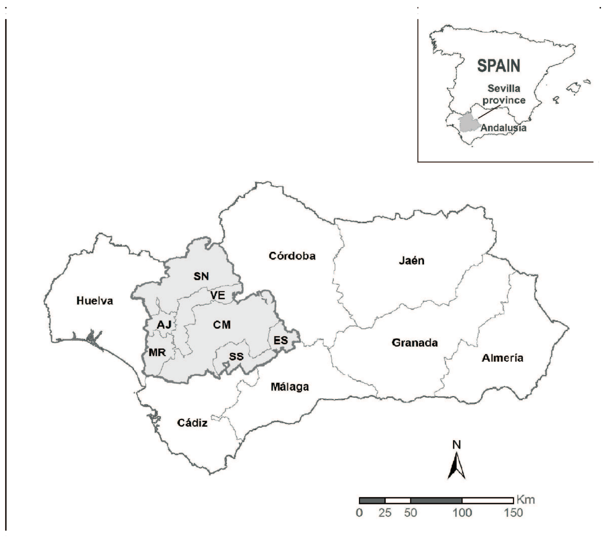

Fig. 1. Natural regions of the Mediterranean Province of Sevilla, SW Spain.

Table 1. General description of the selected seven benchmark sites in the Mediterranean Province of Sevilla

Natural region	Typical soil profile[a]	USDA-98 Soil classification	Average slope (%)	Elevation (m)	Approx. extension 10^3 ha
Aljarafe	SE0201	Typic Rhodoxeralf	2 - 8	100	59.2
Campiña	SE0302	Typic Chromoxerert	8 - 16	60	558.8
Estepa	SE0101	Entic Haploxeroll	16 - 30	480	59.1
Marismas	SE0103	Salorthidic Fluvaquent	<= 2	2	99.8
Sierra Norte	SE0401	Palexerult	8 - 16	740	375.8
Sierra Sur	SE0701	Vertic Xerorthent	16 - 30	250	115.3
Vega	SE0501	Typic Xerofluvent	<= 2	10	157.6

[a]From the SEISnet-IRNAS (Evenor-Tech, 2009).

T a b l e 2. Contingency table: LC[1] change in Aljarafe natural region (Sevilla, Spain) for the period 1956-2007

		Land use (2007)		1	2	3	4	Area (1956)
Land use (1956)	1	Artificial surface	Area (ha)	561.00	0.00	21.00	1.00	583.00
			%	96.23	0.00	3.60	0.17	100.00
	2	Wetlands and water bodies	Area (ha)	6.00	715.00	60.00	125.00	906.00
			%	0.66	78.92	6.62	13.80	100.00
	3	Agricultural areas	Area (ha)	5488.00	121.00	43302.00	610.00	48521.00
			%	11.31	0.25	87.18	1.26	100.00
	4	Forest and natural areas	Area (ha)	338.00	117.00	3875.00	4868.00	9198.00
			%	3.67	1.27	42.13	52.92	100.00
		Area (2007)	Area (ha)	6393.00	953.00	46258.00	5604.00	59208.00
			%	10.80	1.61	78.13	9.46	100.00

[1]LC – land cover was used following Moreira (2007).

T a b l e 3. Comparison between bioclimatic deficiency-land capability results from Terraza and Cervatana models[1] and agricultural actual land use and land cover flow during 1956-2007

Natural region	Bioclimatic deficiency (GPL, day)[2]	Land capability class[3] (Benchmark site)	Agricultural land (2007) 10^3 ha (% natural region)	LCF[4] (1956-2007) 10^3 ha (MLU)[6]	LCF[5] (1956-2007) 10^3 ha (MLU)[6]
Aljarafe	210	S2rb	46.3 (78.1)	4.0 4)	6.2 (1)
Campiña	250	S2tl	494.2 (92.0)	45.0 4)	17.3 (1)
Estepa	210	S3t	51.0 (86.2)	0.7 4)	2.6 (1)
Marismas	210	S2lb	57.3 (57.3)	33.3 2)	1.9 (4)
Sierra Norte	270	Ntl	46.3 (12.3)	4.9 (4)	6.2 (4)
Sierra Sur	250	Nlr	72.9 (63.3)	6.4 (4)	4.7 (4)
Vega	210	S1	102.5 (65.2)	14.1 (4)	19.1 (1)

[1]Development, inputs and validity of these models are described in De la Rosa *et al*. (2004). [2]GPL – length of growing period. [3]Land capability classes: S1 – excellent, S2 – good, S3 – moderate, N – not suitable. Limitation factors: t – topography: slope type and slope gradient; l – soil: useful depth, texture, stoniness/rockiness, drainage, and salinity; r – erosion risk: soil erodibility, slope, vegetation cover, and rainfall erosivity; b – bioclimatic deficiency (GPL). [4]LCF – land cover flow from other uses to agricultural areas. [5]LCF – land cover flow from agricultural areas to other uses. [6]MLU – main land use affected: 1 – artificial surface, 2 – wetlands and water bodies, 4 – forest and natural areas.

RESULTS

The results of applying Terraza (bioclimatic deficiency) model and Cervatana (land capability) model in the selected seven benchmark sites are shown in Table 3. Additionally this table indicates the agricultural actual land areas and LCF resulting from the respective contingency tables of each region.

Five application sites (Aljarafe, Campiña, Estepa, Marismas and Vega) are classified as arable or best agricultural lands, and another two (Sierra Norte and Sierra Sur) as marginal or unsuitable lands. The Vega site (Typic Xerofluvent soil) shows the highest capability for most agricultural crops. In this region 11 610 ha were converted from forested and natural areas to agriculture during the last half century. Similar transformation took place in Campiña, Marismas and Aljarafe site where a 47 582 ha of forested and natural areas and 33 661 ha of wetlands and water bodies were converted to agricultural areas. This was high linked with urban development in thee zone (Aljarafe, Campiña, Estepa, Marismas and Vega), where 31 370 ha were transformed from agriculture to urban, industrial or transport uses.

In contrast, the Sierra Norte site (SE06: Palexerult soil) and the Sierra Sur site (SE07: Vertic Xerorthent soil) show the most-unfavourable conditions. The length of the growing period, the slope, and the soil depth are the major limitation factors in this agroecological zoning classification of Sevilla sites. There was a low land cover flow (LCF) in both areas during the period 1956-2007. It should be highlighted the high percentage of agricultural use in Sierra Sur despite these land capability results. In this way, changes in land use from natural habitat to intensively tilled agricultural cultivation are one of the primary reasons for soil degradation.

Assessment of soil properties upon conversion of natural forests for agricultural purposes and reforestation is important to detect early changes in soil quality. Thus, the conversion of forest into cropland is known to deteriorate soil physical properties and subsequently soils become more susceptible to erosion since macro-aggregates are disturbed (Celik, 2005). Loss of organic matter is expected to have soil aggregates easily broken down, and consequently the finer particles are transported by erosion. On the other hand, Merino *et al.* (2004) shows that soil also plays a major role in reducing to the atmospheric concentrations of other greenhouse gases, such as CH_4 and N_2O. The fluxes of these gases are influenced by soil variables that influence microbial activity, such as pH and concentrations of NO_3^-, NH_4^+ and O_2, which, in turn, are controlled by a combination of soil properties (soil moisture, texture, structure) and soil management practices. Intensive soil management has therefore led to a considerable increase in the exchange of N_2O and CH_4 between soils and the atmosphere (IPCC, 1995). In summary, a positive correlation between current land use and potential land capability would be necessary.

CONCLUSIONS

1. Comparing land use with soil type information in decision-making is at the heart for sustainable use and management of agricultural land.

2. This agroecological approach can be especially useful when formulating soil-specific agricultural practices to reverse environmental degradation, based on spatial variability of soils and related resources.

3. Any type of agricultural management system will have a negative environmental impact when applied on land with very low suitability for agricultural uses.

4. In the Mediterranean region, for example, marginal agricultural land under any type of farming system is the ideal scenario for soil erosion.

5. Finally, high capability land should be preserved in order to attend to a sustainability development.

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