DIGITAL CARTOGRAPHY AND GIS, DECISION TOOLS FOR SUSTANAIBLE DEVELOPMENT IN THE PROVINCE OF CUENCA (CENTRAL SPAIN)

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ABSTRACT

The Spanish High Council for Scientific Research and an association for rural development are promoting the implementation of the Local Agenda 21 which aims at reaching sustainable development in La Mancha Alta Conquense. A GIS has been produced to implement Local Agenda 21 which includes environmental and socio-economic cartographic variables. Socio-economic variables from statistical sources were considered also on a municipal level. Sustainability indicators were obtained to provide a territorial diagnosis. The GIS produced is a valuable tool both to help spatial decision making on different management levels and to guide the Local Action Plan. Cartography is used as the tool to communicate this information to the local population in a double sense: showing the current situation of their territory and the proposals for territorial planning.

INTRODUCTION

The Local Agenda 21 is a local action plan set in the United Nations Conference on Environment and Development which took place in Río de Janeiro, in June 1992. It is based on the concept of integrating environmental, political and economic policies within a sustainability perspective and on the principle of shared responsibility. It calls for an active participation on behalf of the local population as well as having decision making processes which require a consensus among groups involved with environmental, economic and social matters. It is a non-compelling instrument for management, which seeks sustainable development based on an equilibrium between nature preservation and socioeconomic development. This is what experts refer to as detaching economic growth from an intensive use of natural resources.

This is a demonstrative project that will be used as a model to be applied in the rest of the province. It is supported and funded by local, provincial, regional and state administrations, according to the principles of consensus and shared responsibility. The idea of carrying out this project took place in the framework of the teaching and training courses regularly directed by the High Council for Scientific Research and attended by local leaders and territory managers. Two institutions have formed a strategic alliance: first, the Institute of Economics and Geography (IEG), that belongs to the Spanish High Council for Scientific Research, specialized in territorial studies and the use of Geographical Information Technologies (Remote Sensing & GIS) for regional diagnosis applications, and second, the Association for the Integral Development of the Municipalities of La Mancha Alta Conquense, a group of municipalities in a rural region within an operative program for economic and rural development (PRODER-2) promoted by the Spanish Ministry of Agriculture, with similar aims to those in the LEADER + of the European Union.

The Local Agenda 21 is firstly expected to widen the knowledge on the state of the territory. Secondly, it ought to improve the municipal management as a result of applying the recommendations derived form the diagnosis and thirdly, it should make headway towards implanting a more sustainable model for the future in the study area. Likewise, a coordinated implantation of the Local Action Plan is expected to increase the quality of life of the inhabitants in the municipalities within the study area.

STUDY AREA

La Mancha Alta Conquense, which is a 1,775 Km^2 rural territory located to the west of the province of Cuenca, in the Autonomous Community of Castilla-La Mancha, Spain (Figure 1), and comprises 28 municipalities. Its main distinguishing marks are: depopulation, an economy based on agriculture and cattle, the loss of functionality of forested areas, incipient rural tourism and the existence of Special Protection Areas (Bird Directive 79/409/EEC). The current development model in this territory is encouraging several environmental impacts: the draining of protected water bodies, water contamination due to either excess of agriculture fertilizers or direct dumping of waste, a reduction of landscape quality as a consequence of the uncontrolled dumping of solid waste, soil erosion and an increase of forest fire risk owing to biomass accumulation.

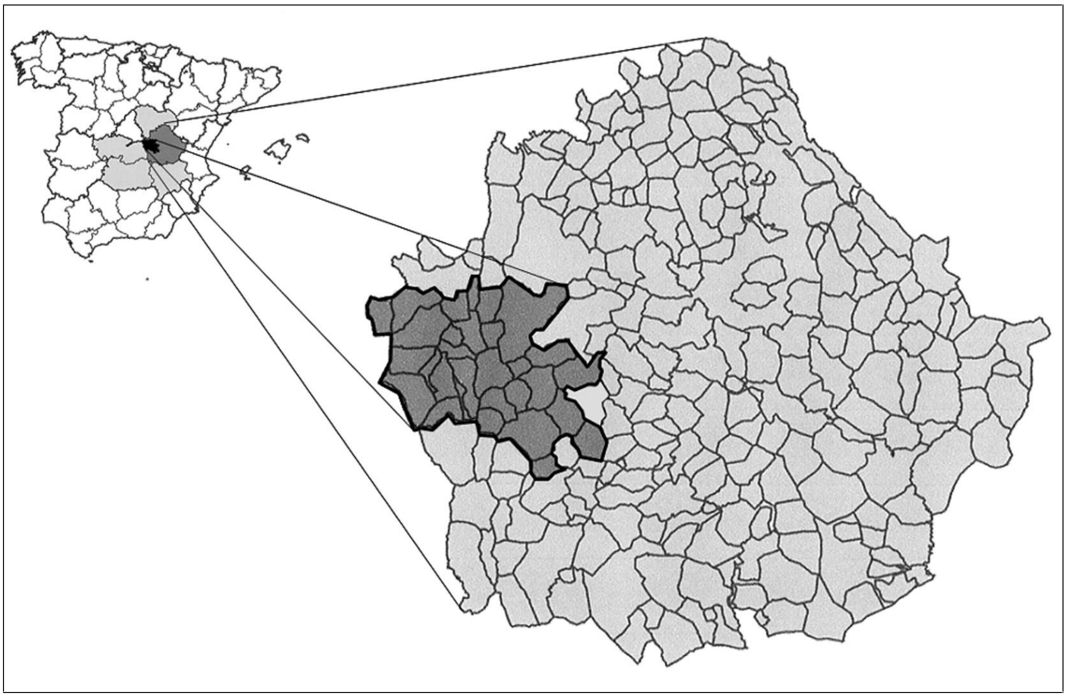

Figure 1: Study Area

Despite these downsides and risks, La Mancha Alta Conquense has strengths that must be exploited in order to foster sustained socioeconomic development and social cohesion, which are the aims of Programme 21 as well as the regional planning and sustainable development policies.

ORGANIZATION OF THE LOCAL AGENDA 21 PROJECT. METHODOLOGY AND PHASES.

The general outline of the project is based on a process whereby the local population participates in a *bottom-up* flow, as recommended by United Nations Programme 21 and the 1994 Aalborg Charter. From a methodological point of view, the project is divided into three work phases.

The first phase is focused on the project preparation and organization. A series of agreements were required to formalise collaborations among the institutions involved. In addition, agreements were also established with the agencies that produce the geographical information which was to be used during the environmental auditing phase. A schedule was planned which includes both the project tasks and people responsible for each task.

The second phase is focused on carrying out an environmental audit in the study area. This tool is an unbiased method of territorial analysis which provides a methodological framework for various tasks: inventorying strategic natural resources, assessing its state of preservation, and getting to know the main aspects of the local population, their socioeconomical activities and the environmental vectors. The information gathered and organised through the environmental auditing serves as an input to obtain the territorial diagnosis, which has a double approach. First, a qualitative diagnosis was carried out based on opinion polls from the local population. As well as interviewing local leaders and territory managers, part of the local population was also consulted, and the polls were stratified according several criteria: gender, age, economic activity group and municipal residence. Second, a quantitative diagnosis was carried out based on a series of sustainability indicators obtained from the statistical and cartographic data. Thus, an integrated diagnosis (subjective and objective), allows for a SWOT matrix that will spot the main weaknesses, threats, strengths and opportunities in the territory and will establish a sustainable development strategy through the Local Action Plan.

The third phase defines a Local Action Plan using local population participation. Three strategic guidelines have been set, as well as seven action programmes. Programme participants made of experts and specialists from administrations and representatives from environmental, economical and social organizations in the study area. Their task is to propose an agreed list of specific projects or actions, in order of priority, which optimises the strengths and opportunities the territory holds, minimises de weaknesses and neutralises the risks. Thanks to this strategy, the plan is expected to be introduced together with its 147 actions, which will draw closer towards obtaining a model for sustainable development.

THE ROLE OF GEOGRAPHIC INFORMATION TECHNOLOGIES IN SUSTAINABLE DEVELOPEMENT

Rural regions in the European Union are undergoing a process of change that seeks to revitalise their economic, social and cultural life attempting to balance nature preservation as a means of maintaining the natural resources for the coming generations. This is a commitment for the future, promoted since 1992 by the EU and the United Nations as a result of the Summit of Rio de Janeiro, which emphasises on the role of local leaders as being responsible of driving this process of change. The programmes for local leaders' education and training are essential for creating favourable conditions to produce the strategic activities included in Local Action Plans, aimed at promoting sustainable development in their regions.

The role of the scientific and academic institutions in promoting this process of change is essential. They make contributions in several fields such as training local leaders, applying geomatic technologies (GIS, remote sensing and automatic cartography) to create instruments for sustainable administration (specifically Local Agenda 21), transmitting geographical information using web mapping technologies to aid decision making process, or training end users.

Geographic Information Systems

One of the main targets of the project is to build a geographic information system, understood as an added product to the AL21 and as a spatial decision making system to aid local authorities and social and economic workers in the study area.

The regional GIS seeks to fulfil three tasks: to define the present situation in the territory; to monitor its environmental conditions and to assess the impact of environmental policies. The GIS describes geographical space in a double way: directly, by means of its attributes, or processing the data coming from satellite imagery and digital elevation models (DEM), and indirectly, from the elements or fields described by their attributes and their relationships. The software chosen to process the data was a general purpose CAD (Microstation) and a relational GIS (Microstation GIS Environment, MGE), given its simplicity and flexibility (Newell and Theriault, 1989). However, for the future installation of the GIS on the inter-municipal net ARC-GIS will probably be used, due to its easy handling. GEOMEDIA (Intergraph) is used for format exchange.

Part of the information included in this GIS was supplied by state administrations. The most relevant are as follows:

- *Geographical Service of the Spanish Army:* topographic cartography, 1:50,000 scale, * dgn format.
- *National Meteorological Institute:* climatic database
- *Ministry of Agriculture:* present land use map, including crops, in digital format and digital panchromatic orthophotos (1m spatial resolution).

- *Ministry of Environment:* forestry maps and a list of Sites of Community Importance (SCI), which the regional governments have proposed to become part of the Natura 2000 Network, and Special Protection Areas (SPA).
- *Spanish Geological and Mining Institute*: underground aquifer perimeters and the wells and drilling database (water quality and use data, well depth, etc.).

Another part of the geographic information was produced during the project. For instance, the soil map was produced by means of photo interpretation from stereo-pairs, office and fieldwork. Soil formation and development are subject to topographic and pedologic factors (organic matter or underlying rock). The cartographic units outlined show soil associations with two taxonomic units. There are five groups of soils and twelve defined units classified according to the *World Reference Base for Soil Resource* based on the FAO classification.

Finally, some cartographic variables were obtained using models which are based on several spatial analyses techniques. A Digital Elevation Model (DEM) was built on a triangular structure where the Delauney triangles were determined from Thiessen polygons (Peucker et al., 1978). The elevations were interpolated from z coordinates from significant topographical landmarks: measured points, survey points, 20m equidistant contour lines and other flat landmarks, such as water bodies. The resulting model infers the gradient break points. For practical reasons, the model was converted to a raster format with a 20 x 20 m cell size. The DEM was verified using non-aligned random stratified sampling (Chuvieco et al., 1991). With the help of more detailed topographical maps (1:25,000), a check was performed on 1,776 points, situated on the four corners of 444 quadrants selected on a 1 km^2 grid. The confusion matrix (Aronoff, 1989), shows 97,8% global reliability, and 8,25 m errors on average. In order to characterise the terrain, gradient and aspect, hypsometric maps were derived from the DEM. The hypsometric map has colour tables that range from green, for the lowlands, to Sienna tones for the highlands. In order to enhance terrain descriptiveness, a relief shading effect was added using the following parameters: sun elevation angle = 35º; sun azimuth = 315º and sun intensity = 100. The raster DEM (in .grd format) calculates the maximum gradient percentage by examining the altitude differences between each centre pixel or cell and its north-south and east-west neighbours (Intergraph, 1994; Skydmore, 1989). Yellow and light ochre tones are assigned to flatter areas (‹7%) or hilly terrain (7 to 15%), whereas dark and mid-brown tones represent higher gradients (›15%). The aspect of each terrain feature is set in azimuth degrees (north based). It is cartographically represented using cold tints (greens and blues) for north facing slopes and warm tints for south facing slopes.

Also available in this project is the land use capacity model. This is a raster model which integrates, according to FAO (1976) guidelines, four limiting factors which have an influence on the general capacity of the land: the topographical factor, the soil factor, the climatic factor and the erosion risk. In order to assess each factor, several biophysical restrictions are considered. The topographical factor measures the gradient and the soil factor takes into account the useful depth, texture, stoniness, rockiness, drainage and salinity. The climatic factor examines the risk of frosts and the aridity index. Finally, the erosion risk factor considers, again, the gradient, vegetation density, soil erodibility and rain erodibility (R factor in the universal soil loss equation, USLE). In sum, the model assesses the information supplied by a total of 12 variables. The data was integrated using MicroLEIS (de la Rosa et al., 1992) expert system and was then spatialised using standard GIS utilities. This model has been compared with the land use map with the objective of setting sustainable planning strategies (Figure 2) which could guide the Local Action Plan.

On the other hand, in order to propose sustainability strategies in accordance to the landscape features (Figure 3), the project has developed a raster cartographic model that integrates, using GIS utilities, several variables related to the visual quality and the landscape fragility. The model is based on the past experience of the research team (Martínez Vega et al., 2003) and literature references. The visual quality of the landscape is analysed by integrating its intrinsic and extrinsic visual quality. The former is defined by the quality of the land cover, which takes into account aesthetic and ecological criteria, and the visual quality of the terrain (flatness/ruggedness). The latter is influenced by the visual exposure of a series of (positive or negative) elements that add or subtract quality from the landscape. Landscape visual fragility was calculated considering two components. First, the intrinsic visual fragility, determined by the environmental features of the territory which increase or decrease its visual absorption capacity, such as vegetation height and the terrain (slope and aspect). Second, the extrinsic visual fragility refers to the greater or lesser likelihood of a given territory to be seen, which depends on its visual accessibility.

Some of the variables mentioned are in a raster format with a 20m spatial resolution (altitude, gradient, aspect, land capability, landscape visual quality and fragility) whereas others are in vector format using a minimum cartographic unit of 1 ha. (land use, forest ownership, protected areas, geology, soils, underground water, livestock trails).
Finally, it is worth mentioning that the GIS has plenty of socioeconomic variables for the municipalities that form the study area. The data was obtained from statistical sources (census, cadastre), opinion polls and query results from the

relational database itself, after combining several variables using spatial operations analysis. Fieldwork and GPS were used for inventorying outstanding landmarks in the cultural heritage within the study area, whose attributes were recorded on to the database.

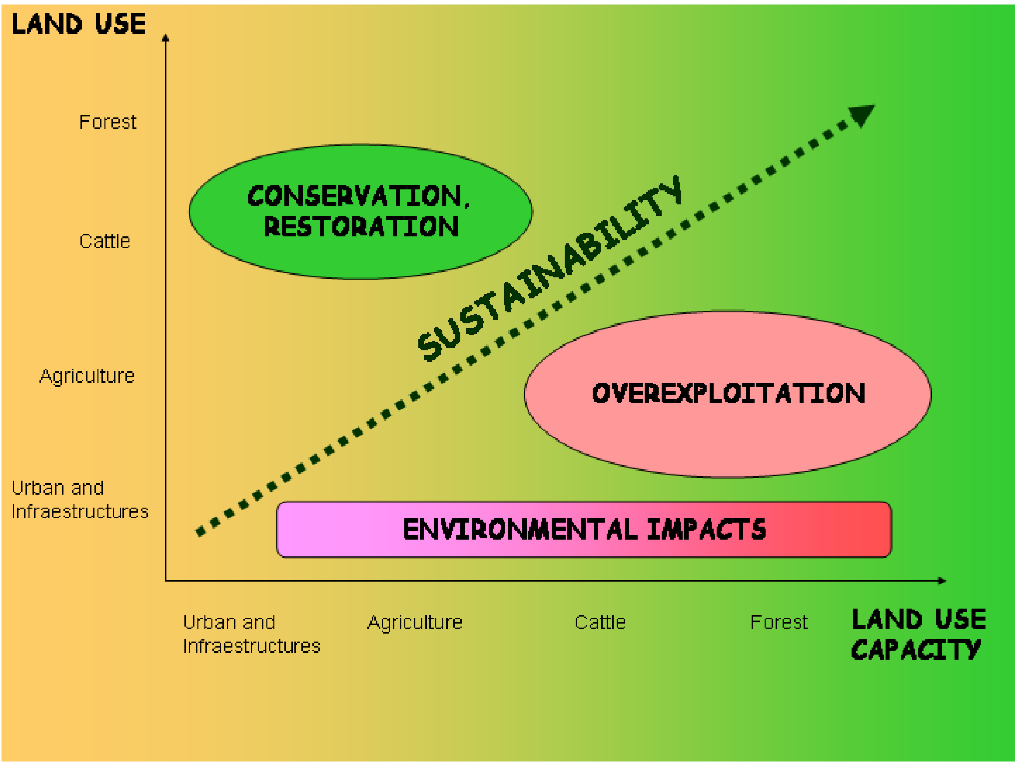

Figure 2: Planning strategies according to land use adjustment to land use capacity

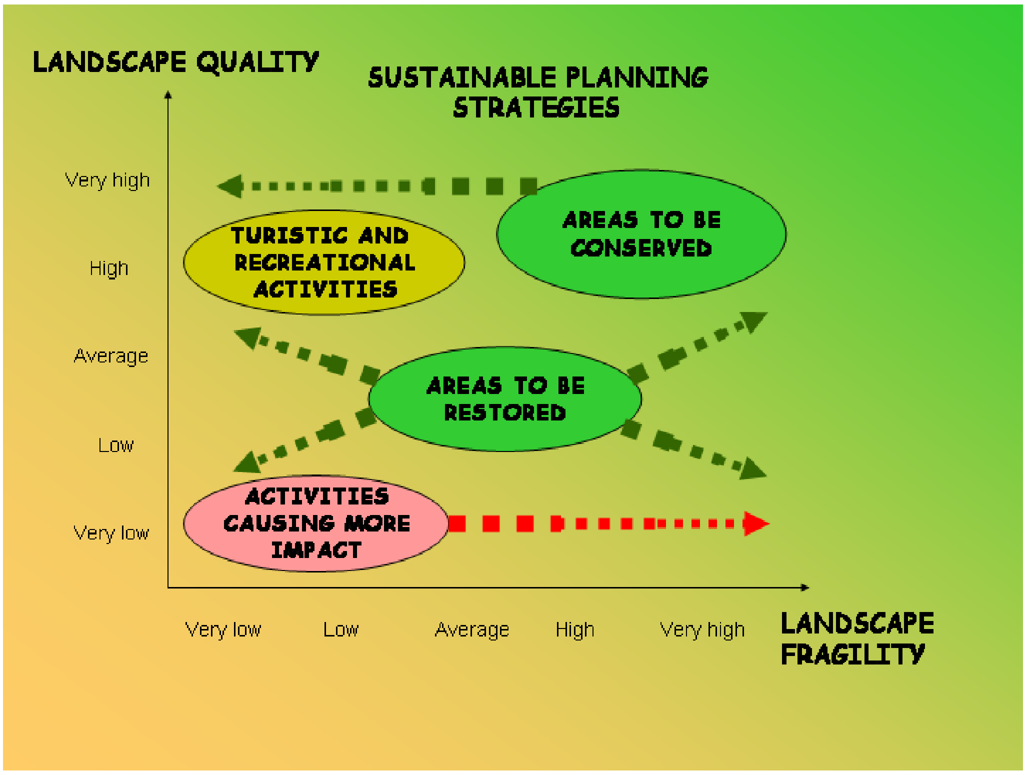

Figure 3: Planning strategies according to landscape value

Remote sensing

Satellite imagery plays a relevant role as a source of updated high quality geographic information, thanks to repetitiveness of its passes. In regional planning, in general, and in sustainable development projects, in particular, land use is regarded as a strategic input variable for the obtention of multiple models (Buchanan, 1975; EC, 1993). For this project, updating the land use cover was considered a priority, since the data provided by the Ministry of Agriculture was outdated and the information from the CORINE-Land Cover project does not have sufficient spatial detail.

Thus, the project decided to acquire scene 200/032, dated August 5th 2002 and registered by the Enhanced Thematic Mapper (ETM) sensor on board LANDSAT 7 satellite. The image covers the whole of La Mancha Alta Conquense. It was geometrically corrected using evenly distributed control points that were obtained from 1:50,000 topographic maps. The resulting colour is obtained assigning bands from the near infrared (NIR), middle infrared (MIR) and red (R) to the primary colours, that is, red, green and blue, respectively. The red band was substituted by the panchromatic (PAN) band in terms of HSI in order to visually improve the colour composition. Prior to this, the pixel size of the multispectral bands was resampled to 15 meters to even the spatial resolution with that of the PAN.

The land use map was produced by means of computer aided visual analysis. Thus, polygons representing land uses were digitalised on the screen over the LANDSAT image using photo interpretation techniques and with the aid of panchromatic orthophotos and fieldwork notes from the reconnaissance and verification phase. A reliability test was applied using the same 1,776 points from the DEM verification phase. The results from the confusion matrix show a 94,9% global reliability. The coupled analysis among the 23 classes that were discriminated show a higher confusion among closely related thematic categories. For instance, the reliability between the pine forest class and the reforested pine forests class is 81,2%.

Digital cartography and the Internet map server

Despite the digital medium of the maps produced, a paper collection of thematic maps was edited. Each thematic layer was stacked under basic planimetric entity layers (road networks, towns, administrative boundaries and hydrographical networks), an elevation layer (contour lines and altitude landmarks) and place-names from the 1:50,000 scale base map. The idea was to get the local population more involved in the contents of the map and to favour a certain geographic culture. In addition, this cartography is meant to act as a means of communication when it comes to showing the local population the regional planning proposals (Núñez de las Cuevas and López-Vizoso, 1989).

Once the GIS is completed, it will be linked on to a map server based in the Environment Office of the Local Association which is encouraged by the Local Agenda 21. The aim is to allow end users (experts from regional administrations, managers and politicians) to consult the geographic information in the study area in a multi-purpose scenario and to convert the GIS into a system that helps spatial decision making. Additionally, the geographical data in the server is meant to be accessible on the Internet for tasks such as documenting reports. *Webmapping* or a similar technology will be required to implement a selective system of data access according to its nature. For instance, the information on the location of archaeological sites cannot be of general access.

Geographic information technologies and sustainability indicators

Many organisations on international (OECD, 1993; EEA, 2000), national (Ramírez, 2002) and autonomous (FEMP-CLM, 2005) levels have recently published lists of sustainability indicators. These indicators measure, normally in an objective and quantitative fashion, several aspects related to sustainability: the *state* of the environment or some of its components, the *pressure* it is put under and its *response*, *via* adaptation or defence mechanisms that either the ecosystems themselves have or, are favoured by pressure compensation policies and actions that are designed by regional planners. In a sustainability chart, the environmental indicators are completed by other social and economic indicators that measure the degree of human development.

Given the wide nature of the indicators listed, the sources and calculation methods are quite diverse. In this field, geographic information technologies strongly support the study of sustainability. GIS are noted for their ability to integrate diverse information from different sources. In addition, its high spatial analysis capacity produces new data derived from adequate queries. In turn, satellite imagery provides large amounts of data thanks to its repetitiveness.

Temporal analysis, with a yearly and/or seasonal approach, provides strategic information in terms of knowing the trends of changes and, therefore, allows us to understand environment responses to certain pressures.

A list of sustainability indicators on a municipal level was done for this project. Its aim is to provide a basis for the environmental diagnosis on the territory, as quantitative and objective as possible. Table 1 includes a list of some sustainability indicators that were calculated using several GIS queries.

THEME	CODE	INDICATOR DESCRIPTION	TYPE*	SOURCE
WASTE	WAS01	Presence of uncontrolled dump yards and rubbish heaps	P	GIS
URBAN PLANNING	UP01	Percentage of urban area/municipal area	S	GIS
	UP02	Percentage of industrial area/ municipal area	S	GIS
	UP03	% of Highly Protected non-urban area / municipal area	S	GIS
BIODIVERSITY	BIO01	Fragmentation index	S	GIS
	BIO02	% of Protected Nature Reserves / municipal area	S	GIS
	BIO03	% habitat area of Directive EEC 92 /43 in relation to the municipal area	S	GIS
	BIO04	Agricultural intensification index	P	GIS
	BIO05	Road density (Km/Km²)	P	GIS
	BIO06	Protected Nature Reserves that are under a Natural Resources Plan	R	GIS
WOODLAND	WOO01	Forested area	S	GIS
	WOO02	Forested area burned	P	GIS
	WOO03	Reforested area	R	GIS
	WOO04	Protected forested area	R	GIS
LANDSCAPE	LAND01	% of municipality area with high or very high landscape quality	S	GIS
	LAND02	% of municipality area with high or very high landscape fragility	S	GIS

* S: Status; P: Pressure; R: Response

Table 1: A list of some of the indicators obtained with the help of a GIS

In turn, sustainability indicators are a starting point for iconographic comprehensive matrices (Franchini and Dal Cin., 2000; Franchini et al., 2004). The distribution of the values of each indicator were analysed throughout the municipalities that form the study area. According a the critical value of each indicator, which is taken as a reference threshold, and the standard deviation (S), each municipality is classified into different groups which may be closer (the green cells in the matrix) or further away (red cells) from sustainability (Table 2). This criterion is not applied on dichotomic variables (for example, the indicator WAS01).

Among other uses, these sustainability indicators as well as the iconographic comprehensive matrices have been the basis for the quantitative diagnosis of the study area and they justify the actions selected for the Local Action Plan.

NEW CHALLENGES IN SUSTAINABILITY

As mentioned, GIS contain a large volume of both physical and socioeconomic georeferenced information. However, this information can be further exploited to develop new models. Social and economic responsibles (farmers, cattle breeders, industry managers, office executives) as well as territory managers may benefit from these models as they will guide them in decision making processes, always under a sustainable development perspective.

In view of the need or convenience of developing new models, the possibility of subscribing a new agreement is being studied. In the immediate future, the territory is faced with new challenges. Among others, we have mentioned those that have a priority for the local population: projects of new irrigated lands, reforestation of specific areas, producing an Environmental Resources Plan for protected areas, defining potential habitats to reintroduce native floral and faunal species, detecting areas which require supplies of equipment and infrastructures, identifying suitable locations for waste tips, simulating future scenarios by means of cellular automata, introducing diverse conditions of change (Lavalle et al., 2002).

GEOCODE	MUNICIPALITIES	WAS01	BIO02	BIO03	BIO05	UP03	WOO01	WOO03	LAND01	LAND02
16002	Acebrón (El)	NO	51,34	1,53	0,21	0	0,00	0,34	11,03	90,21
16010	Alcázar del Rey	NO	3,10	8,92	0,18	0	1,41	3,82	11,07	94,40
16016	Almendros	YES	47,07	24,80	0,30	0	16,92	1,58	26,81	74,02
16018	Almonacid del Marquesado	YES	0,00	16,15	0,21	0	5,65	5,71	22,90	81,86
16032	Belinchón	NO	0,10	28,71	0,16	0	5,65	4,53	22,90	69,52
16086	Fuente de Pedro Naharro	YES	46,45	2,41	0,10	0	0,00	0,00	31,74	72,26
16087	Fuentelespino de Haro	NO	0,00	24,05	0,24	0	21,08	0,73	29,81	69,88
16101	Hito (El)	NO	9,22	10,43	0,13	0	2,69	2,45	6,11	89,41
16106	Horcajo de Santiago	YES	72,35	0,92	0,17	0	1,48	0,10	8,53	76,05
16108	Huelves	YES	4,15	19,22	0,42	0	1,06	14,79	26,95	80,94
16129	Montalbanejo	YES	0,00	4,15	0,16	0	1,57	3,99	6,65	92,80
16130	Montalbo	YES	7,26	3,88	0,29	0,91	0,05	0,05	2,17	94,90
16148	Palomares del Campo	NO	0,00	7,36	0,34	0	1,50	0,72	11,11	92,76
16151	Paredes	YES	47,05	39,49	0,20	0	30,25	3,29	35,58	69,09
16167	Pozorrubio	YES	37,53	12,25	0,09	0	10,35	3,63	17,64	79,63
16172	Puebla de Almenara	YES	0,00	16,91	0,22	0	9,75	0,00	19,90	83,07
16181	Rozalén del Monte	NO	0,00	14,38	0,18	0	9,34	2,78	15,60	87,96
16186	Saelices	NO	0,00	32,02	0,43	0,27	25,79	4,98	34,43	70,77
16203	Tarancón	NO	0,12	7,67	0,23	0,45	0,44	5,90	10,35	82,44
16212	Torrubia del Campo	NO	83,91	6,52	0,17	0	2,06	0,51	9,61	91,24
16217	Tribaldos	NO	0,00	1,87	0,18	0	0,00	0,00	4,50	94,78
16218	Uclés	YES	11,83	28,11	0,08	0	5,39	10,91	26,97	80,69
16253	Villar de Cañas	YES	0,00	9,10	0,27	0	0,31	3,13	10,69	88,07
16264	Villarejo de Fuentes	YES	0,00	23,80	0,27	0	18,61	0,59	31,90	71,05
16270	Villarrubio	NO	30,06	2,71	0,43	0	0,16	0,00	1,17	98,76
16277	Zafra de Záncara	NO	0,00	16,91	0,27	0	7,56	0,45	22,24	87,26
16279	Zarza de Tajo	NO	28,54	30,93	0,37	0	2,04	16,63	49,16	72,00
16901	Campos del Paraíso	YES	4,25	14,16	0,32	0	2,39	6,56	19,67	87,42

Table 2: Fragment of an iconographic comprehensive matrix

* See indicator code in Table 1

Additionally, in order to reach conditions that may guarantee success, it is indispensable that the end users are committed to participating in teaching programmes and technological training. This will improve their qualification to handle and extract the maximum out of the GIS. The project is expected to contribute to the modernization of the municipal administration. The training should be organized on several levels: seminars and workshops for users of terminal nodes and advanced courses for the system administrator.

CONCLUSIONES

In the past decades, international organizations have taken on the challenge of sustainable development. To do so, municipalities must get involved in a direct way, since they are in the administrative level closest to the citizens.

Although there a still a long road ahead, many local entities have started to take several initiatives. The municipalities of La Mancha Alta Conquense have got themselves organised and united, in order to promote a Local Agenda 21 in their territory. However, rural municipalities do not always have sufficient human and economic resources to set out on this adventure on their own. Tutoring from upper level administration and technical advice from other institutions are necessary.

Methodologically speaking, physical and socioeconomic information is difficult to integrate due to the different spatial resolutions. While many natural variables are georeferenced, in either raster o vector format, on a highly detailed minimum spatial unit (20 x 20 m cell or 1 ha polygons), socioeconomic variables from statistical sources remain attached to much larger spatial units (municipality).

Despite the difficulties, geographic information technologies (GIS and remote sensing) are a recognised tool to help organize and systematise territorial information, to make spatial decisions and finally, to propose sustainability strategies. Cartography continues to be an extraordinary and irreplaceable means of communication. The actions chosen in order to reach sustainability are better understood when the impact is illustrated on a map.

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BIOGRAPHY OF THE AUTHORS

Javier Martinez-Vega received his PhD in Geography from the Complutense University (1989), and joined the Institute of Economics and Geography (CSIC) in 1990. Since then he has participated in research concerning the applications of Geographic Information Technologies (GIS and remote sensing), to the study of problems with territorial and environmental components. He collaborates in European research projects and he is principal investigator in national and regional research projects, some of which are coordinated with the Department of Geography of the University of Alcalá. He is a member of the Higher Geographic Council. He was head of the Department of Geography of the Institute of Economics and Geography (CSIC) from October 2002 to February 2004. From February 1989 to September 2000 he was Visiting Lecturer in the University of Alcalá, giving doctorate courses and classes in Geography and Environmental Science. He is presently carrying out his teaching activities, co-directing different masters degrees in rural development with international cooperation organisations and participating in a masters degree in Geographic Technologies and Regional Planning in other universities.

Pilar Martin-Isabel received her PhD in Geography from the University of Alcalá (1998) and she is a lecturer in Regional Geographic Analysis in the Geography Department of the University of Alcalá (1997-2001 and 2004-2005). She is presently carrying out her research as principal investigator for the Institute of Economics and Geography (CSIC), where she began working in January, 2000. Her research line began in the Department of Geography of the University of Alcalá, with which she still maintains strong ties. Her activity is focused on the use of new tools for spatial information (remote sensing and GIS) applied to the study of environmental problems, especially forest fires in Mediterranean areas. In this area she has shown interest in the development of methodologies that may be operative for fire prevention, detection and damage assessment.

Raúl Romero-Calcerrada received his degree in Geography and his PhD in Cartography, Geography and Remote Sensing Systems from the University of Alcalá (2001). He has worked as pre-doctoral and post-doctoral researcher in the Spanish Research Council, and he has been in short research stay in various Universities and Research Centres within the European Union. In broad terms, his areas of scientific interest are centred on territory planning in rural areas and on Natural Protected Areas, from a Sustained Development perspective. He is especially interested in the study of changes in territory as a means to understand the interactions between socio-economic transformations and environmental alterations (such as Forest Fires), and to establish more efficient formulas of regional planning and rural development. Also, he is working in to join the economic and environment decision making in regional planning. Also, he is working in Payments for Environmental Services. For this analysis, quantitative and qualitative research methods are used, based on Geographic Information Systems, remote sensing, spatial statistics, spatial landscape indexes, etc