ICT Tools to enhance the utility of a Spatial Decision Support System – Methodological essays

Eduarda Marques da Costa[1], Nuno Marques da Costa[2] Patrícia Abrantes[3] and Ana Louro[4]

[1] Associate Professor (CEG-UL), eduarda.costa@campus.ul.pt; [2]Assistant Professor (CEG-UL), nunocosta@campus.ul.pt; [3] PhD Researcher patricia.abrantes@campus.ul.pt; [4] Research fellow (CEG-UL), analouro@campus.ul.pt

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ABSTRACT

The need for "well decide" in urban planning has been enhanced with the development of technologies and methods of data analysis, along with a considerable increase of the information available not only for the decision-makers but for all community. However, the disjointed of information impedes a more informed and qualified decision making.

The SPOTIA Project [1], whose main objective is to analyse the coherence between Portuguese territorial policies, but also to analyse the impacts that mega-projects have on territory. As an example we present the EFMA (Multipurpose Alqueva Project) case study. We intend to develop some tools that may be relevant to a more efficient planning system, through a greater availability of information in a user-friendly system. In this sense, we consider the development of relevant tools to support, in different manners, Spatial Decision Support System (SDSS), namely consultative platforms, WEBGIS and geographic modelling tools.

This paper consists of three parts after this brief introduction: the first part is related with the use of GIS in territorial planning, culminating with a reflection about the SDSS; the next part will focus on the different tools developed in the SPOTIA project in the context of a potential SDSS for the case of Portuguese planning system, detailed in three distinct tools: consultative platforms, WEBGIS and geographic modelling. The third and final part is the preliminary conclusions.

1 THE ROLE OF GEOGRAPHIC INFORMATION SYSTEM AS AN ICT TOOL IN URBAN PLANNING

Gar-On Yeh citing Douglass and Friedmann (1998) wrote that “In the West, the urban planning paradigm has moved away from the technological approach of the 1960`s and 1970`s to a more participatory approach and greater role of civil society”, changing from a model-based urban planning generated by computer to a planning process based on consultations and negotiations between various stakeholders. In this sense, the geographic information system (GIS) started to integrate the urban planning process as a tool that that would develop the new urban planning paradigm, where is required a greater volume of information and analysis that facilitates stakeholder information, discussion and decision making, allowing the existence of computerized systems that could store, retrieve, visualise, analyse and model spatial information (Yeh, 2008). Considering Manabe and Teraki (1999) in Kohsaka (2001), the main purpose of local government to use GIS in urban planning is to

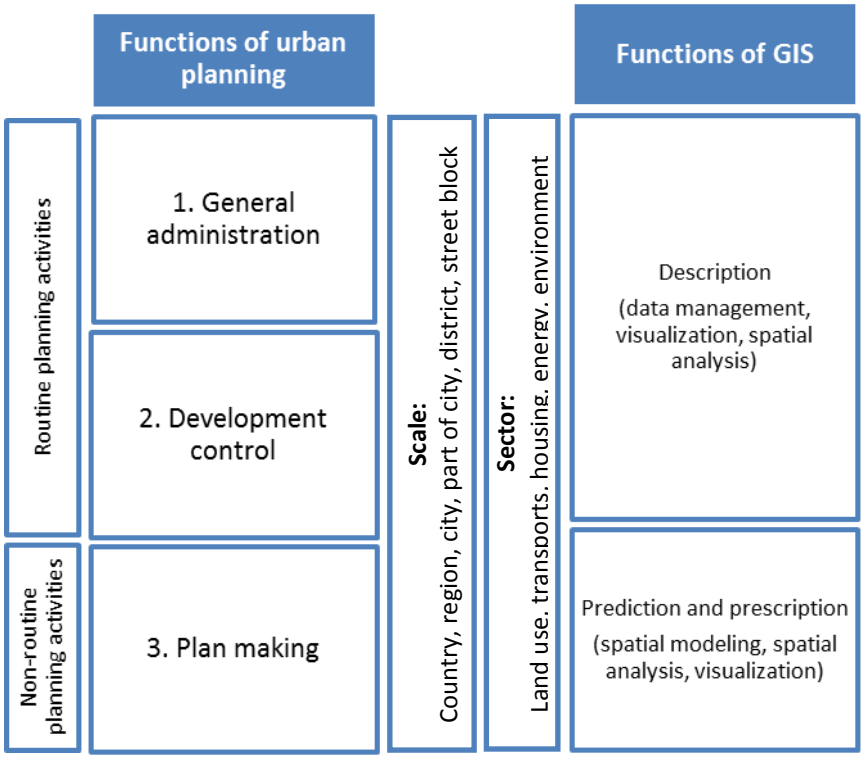
[1] SPOTIA Project: Sustainable spatial policy orientations and territorial impact assessment – contribution to portuguese context (PTDC/CS-GEO/105452/2008). Coordenation: Professor Eduarda Marques da Costa, Centre of Geographical Studies, University of Lisboa

store and update urban plan information, planning, inquiry and inspection of urban plan information, mapping and offer of urban plan information to other departments. In this context, there are a vast number of fields that, for some reason, uses GIS in planning, for example:

a. Property – Urban development, control land use;
b. Facility Management – Pipe location and underground cable, utility planning coordination, telecommunication network service, Energy consumption planning, Building site selection;
c. Environmental Management – Waste management, Disaster management, Analysis of environmentally sensitive areas, Study the suitable of crops, forest management, agricultural land, water resources, wetlands
d. Road network - Vehicle navigation, Home and road location, Site assessment, Ambulance service, Transport planning;
e. Design and Engineering – Development strategy, Population growth and migration, Availability of land for development, Highway route location, Utilities development;
f. Land Information System – Cadastral administration, Tax, Land use zoning, Use of space information such as water, air and soil, Reclamation of land. (Selamat et al., 2012)

There are some evident benefits to use GIS in urban planning and management (Royal Town Planning Institute, 1992), where is included a better, faster and actualized production of maps, more retrieving capacity, more informed forms to create scenarios and predictions, a more friendly-use for stakeholders and community, among others. Having the urban planning different functions and stages, the uses of GIS are also diverse, adapted to the needs of each task and depending of some scopes, as the territorial scale or the sector in focus. According to (Yeh, 2008) (Fig. 1), there are three main functions of urban planning - “General administration”, “Development control” and “Plan making” – related with different types of activities (more or less regular) and, consequently, with different functions of GIS – “Description”, “Prediction” and “Prescription”.

Figure 1. Urban planning functions and the use of GIS. Adapted of Yeh (2008).



The two first functions of urban planning, "General administration" and "Development control", are mostly related with routine planning activities, appealing the GIS function of "Description" using the functions of data management, visualisation and spatial analysis. This GIS function of "Description" includes tasks as:

- Management of land use records;
- Thematic mapping;
- Planning application processing;
- Building control application processing;
- Land use management;
- Land availability and development monitoring industrial, commercial and retail floor space;
- Recreational and countryside facility planning;
- Environmental impact assessment;
- Land use-transport strategic planning; public facilities and shops catchment area and accessibility analysis;
- Social area and deprivation analysis.

The third urban planning function - "Plan making", is especially related with non-routine planning activities, using the GIS function of "Prediction" and "Prescription" for spatial modelling, spatial analysis and visualisation (Yeh, 2008).

Analysing with more detail the several planning phases (**Figure 2**), since the "Determination of objectives" until the "Plan evaluation, monitoring and feedback", GIS functions have not the same use and even relevance. In different phases, GIS tools have an important role to produce a stronger diagnosis; to create different scenarios according multiple criteria, recurring to modelling and projection; or to evaluate the results of policies.

Figure 2. Urban planning functions and the use of GIS. Adapted of Yeh (2008).

Planning Phases	Technologies and their relevance in Planning
1. Objectives	
2. Data collection	**GIS – Other databases & models** Save time in collection of information, sources of spatial information and it`s changes
3. Data analysis	**GIS – Other databases & models** Store, manipulate and analyse physical, social and economic data Mapping function to analyse the actual situation Identify conflict areas through the overlay of data
4. Modelling and Projection	**GIS – Other databases & models** Projection of future (ex. population, economic growth) Estimate the impact of possible trends (ex. future demand of land resources) Model different scenarios and formulate different planning options
5. Development of Planning Options	**GIS – Other databases & models** The spatial optimization models with GIS – maximize or minimize some functions Simulation of different scenarios, integration of cellular automata, location-allocation models find optimal locations of public facilities, multi-criteria decision analysis could consider multiple criteria in deriving different planning options
6. Selection of Planning Options	**GIS – Other databases & models** Majorly a political process, where planners could provide technical inputs to reinforce the decision-making
7. Plan Implementation	**GIS – Other databases & models** Evaluate and minimize environmental impact, for programming and monitoring land development, automate the planning office, enable more consistent decision making in development control
8. Plan Evaluation, Monitoring and Feedback	**GIS – Remote Sensing – Other databases & models** Monitor and evaluate changes and dynamics as in land use and if that dynamic correspond to the planned It could help to develop adjustments to the plan

Yet in this context, it`s possible to identify some benefits and constrains in the use of GIS in urban planning. As benefits, especially in public organizations and for urban planning, we can list:

- The increase of productivity – more produced information in less time; more public information, efficiency on mapping producing and actualization, development of monitoring systems, increasing of data sharing both for technicians and users;
- The cost reduction, not only in employee`s time saving but in other costs, as space;
- Improving in technic support, due to the different kind of information, decision support, expert assistance, among others;
- The organizational enhancement, through new forms of integration that promote an increased efficiency related with the realization of advanced analysis, faster and cheaper mapping (Budié, 1994; Kohsaka, 2001)

In the other hand, as constrains, we highlight that:

- There is an evident increasing of working volume to create and maintain an actualized GIS, otherwise the information lose its relevance for urban planning;
- The huge cost of data and, consequently, the data updating, independent of its type;
- The need of high specialized workers to create and maintain the GIS and the time and money costs to promote training for users, as planners and decision-makers;
- It only could be useful if used in an integrated perspective by the several decision-makers and other users. So, it`s relevant to pay attention to the needs of users and, at the same time, consider the available resources. Being an information technology, it`s relevant that the planning organizations stay committed to the project;
- The existence or lack of data is a fundamental aspect. The availability, the cost and the characteristics of data are central to create and maintain an actualized SDSS. The use of outdated information compromises the relevance of the tool as well as the analysis;
- The gap between the existence technologies and the way of how to make urban planning, according to the used tools or technical skills of planners remains evident, even in more developed countries (Kohsaka, 2001; Yeh, 2008).

Nowadays, the planners, the politicians and the stakeholders aren`t the only players in the urban planning, having the society, the NGO, the public and private institutions, among others, a role too. In this sense, “public participation is increasingly important in the planning system” (Yeh, 2008), having all the players the right and the duty to be involved in policy making. With resource to the new technologies, as Internet, and having more and more access to specific information related with territorial planning (using, for example, WebGis platforms), common individuals could participate “in plan discussion, local community information collection, and decision making support” (Yeh, 2008).

Despite all, GIS *per se* it is just a tool, allowing mapping various types of information and visualise all data at the same time, adding the capabilities that the tool has to model and project different scenarios, with some criteria defined by each user, and according to the available data. Also related with urban planning, there are other tools beyond GIS, as Remote Sensing, Expert Systems or Decision Support Systems, which reinforce the decision-making process, supporting spatial decisions (Sugumaran and DeGroote, 2011). In this context, we will focus briefly the Spatial Decision Support Systems as reference of the SPOTIA project's main objective.

The development of Decision Support Systems (DSS) and, specifically, the Spatial Decision Support Systems (SDSS), begins in the late 1960`s and early 1970`s as an answer to the limitations of the management information systems, as the lack of capacity for analytical modelling and the difficult interaction between the decision makers and the solution

processes (Budié, 1994), since it conjugate data management, analysis and modeling, accessed by an user interface (Sugumaran and DeGroote, 2011).

For Sugumaran and Degroote (2011), an SDSS have to have a set of characteristics as:

- Spatial data management and analysis;
- Iterative problem solving;
- Report generation;
- Scenarios evaluation;
- Visualization through maps, graphs, tables and reports;
- Semi or ill-structured problem solving;
- Easy to use and existence of interactive user interfaces;

It is in the context of demand for tools that could support the Portuguese planning system in its different phases and its own SDSS, with the main goal to become it in a more coherent planning system, that are in course the following methodological experiences in SPOTIA Project:

- Consultation Platforms for diagnosis, planning and evaluation phases;
- WEBGIS as dynamic and user-friendly monitoring system, and;
- Geographical modelling as a tool to reinforce the decision-making process.

2. EXPERIENCES IN SPOTIA PROJECT – APPLIED METHODOLOGIES AND PRELIMINAR RESULTS

As a final objective of this investigation project, it is intended to develop a Spatial Decision Support System to help the decision-making for Portuguese planning context. In this part, firstly, it will be focus a brief presentation of SPOTIA Project and specifically one of the case-studies – Alqueva multi-purpose project - Alqueva Dam (EFMA Project). After this introduction, it will be focus some tested tools that could reinforce, through different perspectives, the SPOTIA SDSS.

2.1 Brief presentation of SPOTIA Project and the EFMA Case-Study

The SPOTIA Project – "Sustainable spatial policy orientations and territorial impact assessment – contribution to Portuguese context" - is focus on the development of methods for assessing the coherence and relevance of territorial policies issued by Land Management Instruments (plans and programs). Related with the main purpose, stand out as work objectives:

(a) Assessment of internal coherence and relevance of Portuguese programs and plans;

(b) Assessment of the coherence and relevance among PNPOT – National Program of Policy Planning - and NSDS - National Sustainable Development Strategies - (top-down orientation policies) and other programs and plans (like the regional Operational Programmes and regional spatial plans;

(c) Identification, collection and analysis of the most relevant indicators for the policy areas policies of the EU, national and regional, as well as for the case studies analyzed, with the ultimate goal of;

(d) Construct a Spatial Decision Support System (SDSS) that is able to produce results that support decision-making respecting to territorial problems.

Alqueva multi-purpose project is one of three SPOTIA case studies that appeared to minimize structural problems, in this specific case of a peripheral Portuguese region – Alentejo that is now changing its economic, social and environmental conditions. This reading is relevant due to the need of evaluate if mega-projects brought important results for

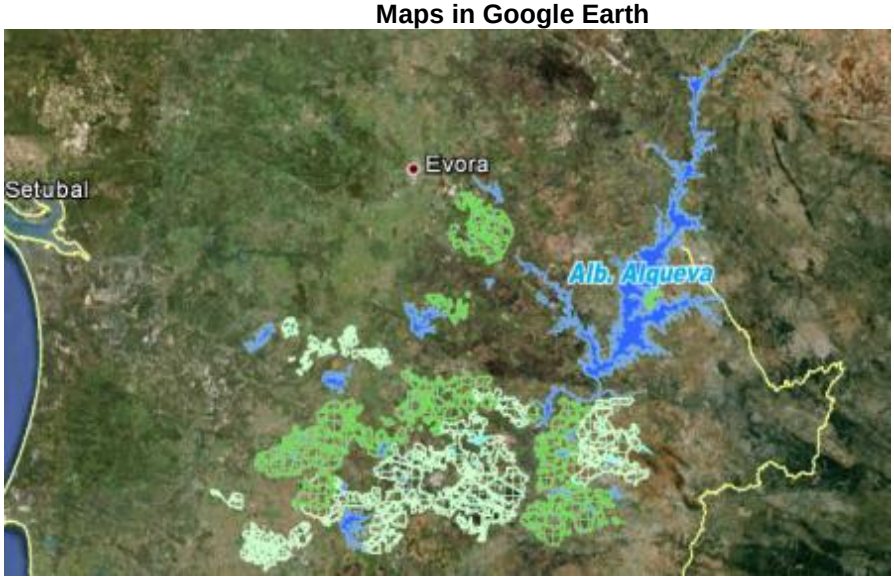
the territory, people and economy, if they are able to generate a better cohesive performance and if the expected impacts in spatial development and regional convergence have been attended.

Figure 1– Alqueva Dam
Source: Portal do Alentejo

Figure 2 – EFMA municipalities
Source: Own production

The EFMA Project, centered on the Alqueva dam and built in the Guadiana River, is a structuring project for regional development in southern Portugal. It aims to contribute to the economic and social valorisation of Alentejo, one of the poorest regions of Portugal. EFMA Project has direct influence over 21 municipalities, in a range of 10.000 Km^2. According to EDIA - Enterprise Development and Infrastructure Alqueva, S.A., this mega-project could be the key for a boosting of economic and social development by increasing the Gross Domestic Product through the creation of new investment and the development of new economic activities; the integration and complementarity of projects and activities; the creation and employment qualification; branded Alqueva reference-quality products and services and Alqueva area as a reference for innovation and technology. This project has a strong sustainable connotation as it pretended to support the social, institutional and business in the region; to maintain and enhance the character, culture and regional identity; to promote Alqueva as a paradigm of environmental quality; and to generate criteria for competitiveness and profitability of investments.

Figure 3 – EFMA Area (Legend: Blue - reservoirs generated by dams, Dark green - New areas of existing irrigation, Light Green - New irrigation areas in project). Source: EDIA, SA – Interactive Maps in Google Earth



The several activities developed in SPOTIA Project pretended to focus in the several planning phases – Diagnosis, Planning and policy implementation and Evaluation - combining various territorial instruments at regional and national scales, meanwhile, other activities pretended to reinforce the studies about the previously cited case-studies.

Table 1. Territorial planning process and respective tools for support of decision-making

Phases and functions	Tasks	SPOTIA Project activities
1 Diagnosis		
- Identification of the context/ start reality - Identification of the problems and it`s causes - Identification of the several instruments of the national planning system	- Identify the main demographic, economic, environmental and socio-cultural changes; - Identify the main problems and SWOT*presented by all territorial instruments - Identify the main territorial changes - Create different scenarios to reinforce the policy options	1.1 WEBGIS - Main themes: Agriculture, energy, Economy, Housing, Mobility, Population, Scholar network, Health network, Tourism; 1.2 WEBGIS - Land use dynamic (CLC 1990, 2000, 2006); 1.3 Consultation platform of the problems and SWOT identified in the main national and regional planning instruments; 1.4. Consultation platform of the main reports of the national planning instruments 1.5. Geographical modelling to create scenarios
2 Planning and Policy Implementation		
2.1 External coherence - Identification of the expected actions/changes in the several instruments that comprises the general structure of territorial planning - Identification of the results of the last planning cycle and/or the best experiences to determinate the problems and solutions	- Consult the expected goals for a particular instrument in the context of the national planning system (both territorial and sectoral approach), considering the objectives, the actions and the agents	2.1.1 Consultation platform of the objectives, measures, actions, indicators of the planning instruments organized by domains and/or agents and/or instruments; 2.1.2 Network analyses based on the agents that should respond to the planned objectives;
2.2 Internal coherence - Analyse the coherence among the diagnosis and the expected plan/programme	- Develop an internal analysis between diagnosis and plan goals, plan and indicators, diagnosis and indicators	2.2.1 Exercises of internal coherence to answer to the main planning concepts: sustainability, territorial cohesion, regional competitiveness, etc.
3 Evaluation		
- Confront the expected goals with the executed programmes - Identification of the new reality	- Resume of the executed or non-executed project and/or objectives and understand what and where are the main difficulties - Monitoring and evaluation - Actualization of the initial indicators	3.1 Analysis of the approved projects of NSRF 2007-2013 (quantitative analysis and WEBGIS) 3.2. Geographical modelling for monitoring and evaluation

Source: Own elaboration. Consult of Marques da Costa (2011). *SWOT – Strengths, Weaknesses, Opportunities and Threats.

2.2 Experimented tools in SPOTIA Project

The next experiences were realised in the context of SPOTIA Project methodology and pretended to understand what kind of tools could be useful for the decision-making process and, at the same time, could be part of a Spatial Decision Support System. These different exercises depend not only of the available tools and data but are strongly related with the decision-making phase or phases that we pretend to develop – support for diagnosis, construction of objectives and actions framework, evaluation of policy`s implementation, etc..

2.2.1 *Supporting a more coherent planning system: consultation Platforms for diagnosis, planning and evaluation phases*

In order to interconnect the several instruments of territorial management and / or sectorial instruments at various scales (essentially at national and regional), it is relevant to create a tool that can bring together some of the most relevant information resulting from them: managing to link them, thus seeking a higher efficiency of all planning system performance. The efficiency of the entire planning system would be due to a bigger and better knowledge of "what to do", particularly aspects such as "who should act", "what funding systems are available", "which instruments should respond to a particular aim", "which problems and diagnoses were identified" by the various instruments at various scales and across sectors. Despite this is not a GIS tool, it remains relevant to support it, deciding and making know what dynamics and, consequently, what indicators to monitor or to evaluate the policies through the confrontation between the initial context and the new context of reality after the execution of policies, suggested by the policies instruments.

In this sense, SPOTIA Project pretended to develop four consultation platforms that could be used in different planning phases, as we identified previously in Table 1:

1. Consultation platform of the problems and SWOT identified in the main national and regional planning instruments;
2. Consultation platform of the main planning instruments at European, national and regional scales;
3. Consultation platform relating the objectives, measures, actions, indicators of the planning instruments with the concepts of "sustainability", "regional competitiveness", "territorial cohesion", "polycentricity", "territorial governance" and "territorial impact";
4. Consultation platform of the approved projects of NSRF 2007-2013.

For these settings, we used Microsoft Access 2010, transforming simple tables in a query application easily accessible for any user. Previously to the creation of these applications, there were created a coding system of Themes and Domains and all items in all tables were codified (**Table 2**). This coding system becomes the basis of consults, related with other criteria filters such as "instruments" or "scale", having applications this preview (**Figure 4**) – the first component with the criteria variables and the second component present the searched results.

Table 2. Themes of the SPOTIA coding system

SPOTIA Themes	
Economy and business	Land uses
Research, Technological Development and Innovation	Climate change and carbon emissions
Information Society and ICT	Energy
Employment and labour market	Water, sanitation and solid waste
Tourism	Risks
Demography and aging	Environment
Social inclusion / exclusion	System Development and urban areas
Education, lifelong training and qualification	Development of rural areas
Health	Equipment and social infrastructure
Culture and heritage	Transport, Mobility and accessibility
Housing	Public Administration
Agriculture, forestry, industry and fisheries	Land Management

Source: Own elaboration

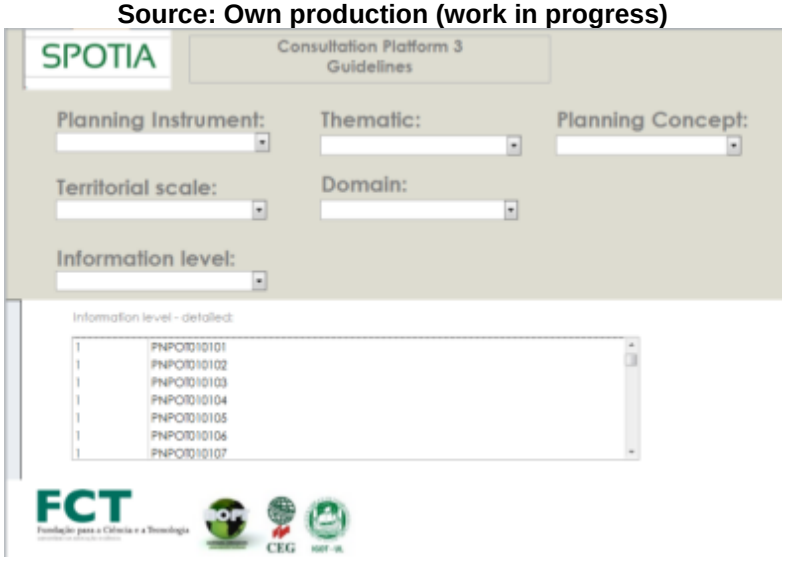
Consultation Platform 1. The first consultation platform is related with the diagnosis elaborated in the context of the main territorial instruments of the national planning system. In these diagnosis is usually to have a SWOT analysis, as in the Portuguese regional spatial plans, or a set of problems, as in PNPOT. This platform allows a search by "instrument", by "item`s category" (problem, strength, weakness, opportunity, threat), by "coding system"

created by the Project SPOTIA and also by the main “planning concepts”. However, it is noted that, according to the territorial scale and the instrument`s type (guidance vs. programmatic; land management vs. sectoral), the diagnostic would have different but complementary perspectives, for an integrated national planning system. This platform could be useful for different agents in different moments:
- To support the internal coherence of instruments, that is, according to the diagnosis previously identified, are objectives and evaluation indicators meaningless?
- To support the external coherence of the various instruments, as the guidelines of the central instruments should be implemented for all other instruments.

Consultation Platform 2. This second consultation platform pretend do aggregate the major national and regional planning instruments, both territorial and sectoral, in a single application. Into this package we highlight, as instruments of territorial basis, the National Policy Planning (PNPOT), the National Strategy for Sustainable Development (NSSD), the various Regional Plans, the various thematic and regional Operational Programmes; and as sectoral instruments arise between others, the National Strategy for Energy or the National Employment Plan, among others. Also included are some European guiding documents, especially white papers and green papers related with the themes developed by SPOTIA Project.

Consultation Platform 3. The third consultation platform is related with the main goal of Project SPOTIA, which focuses on the analysis of the coherence of the main instruments in analysis and the main European planning concepts - “sustainability”, “regional competitiveness”, “territorial cohesion”, “polycentricity”, “territorial governance” and “territorial impact”. In this platform, it will be possible to consult different levels of information, in other words, it pretend to demonstrate what general and specific objectives, actions or indicators at national or regional territorial scale, could answer to the planning assumptions declared by the European Commission. In this platform too, after these first filters – the “planning concept”, the “territorial scale” and the “level of information”, it`s possible to filter by the SPOTIA “coding system” too (see Figure 4).

Figure 4 – Consultation Platform 3 – Instrument`s Guidelines
Source: Own production (work in progress)



Consultation Platform 4. This last platform pretends to focus the approved projects of the NSRF 2007-2013, with filters as the “Operational Programme” (among five regional PO and three sectoral PO), “policy area”, “type of operation”, “beneficiary”, “region and municipality”, “approved eligible investment” and “approved community fund”. This consultation platform

becomes relevant when related to another package of filters linked to the main planning concepts - “sustainability”, “regional competitiveness”, “territorial cohesion”, “polycentricity”, “territorial governance” and “territorial impact”. The data source for this platform is the available database of the approved projects for all Portugal by NSRF 2007-2013. This platform is helpful to understand the potential new dynamics in several thematics after the concretization of the projects, to exchange information among all agents, and allows the evaluation of the programmes, confronting the initial objectives with the executed actions, being a relevant source for policy`s evaluation.

This kind of tool, as all tools, has positive and negative aspects. As **positive aspects,** it`s possible to highlight:

- The ease to query relevant information in the context of territorial policies to support the various phases of planning, from diagnosis to evaluation;
- The greater disclosure of the various agents, allows a greater transfer of knowledge of the national planning guidelines among various instruments;
- The greater availability of knowledge strengthens the action of all agents, including municipalities, communities, schools, companies, among others, and consequently, strengthens the governance;

However, strongly related to the inherent characteristics of the sources of information, in SPOTIA Project, it is verified some **limitations** too:

- There is not easy to actualize these platforms, requiring an active participation of the various actors of planning regarding the centralization of information when changed or updated to the responsible technicians for the maintenance of the platform, being necessary to transform the raw information provided by the agents in the proper format for the operation of the platform;
- The great diversity of the organization of the instruments, even considering the instruments of the same type (eg. the various regional plans of spatial planning), make difficult the task of construct this type of platforms;

The operationalizing of this platform and being the agents available to participate in an integrated form, some **potentialities** are found:

- The main potential of this tool is the effort for a more coherent system of national planning, through the knowledge of the main national guidelines of the main policies.

2.2.2 Knowing better for better decisions: WEBGIS as dynamic and user-friendly monitoring system

The WEBGIS refers to a GIS tool that uses the Internet as the main mean to access analysis, processing and dissemination of geographical information (Peng, 1999; Peng e Beimborn, 1998; Plewe, 1997 in Dias, 2010). The easy access and an interactive interface makes it as a great tool for exchanging information, spatial processing and public participation all through the Internet. The main potentiality of the WEBGIS is the not need of installed programs in the local computers, allowing a higher access to the general community, and at the same time, is not required a complex GIS software knowledge to visualise the spatial information by the users. However, some limitations are identified, as the lack of access to the Internet for all community`s members, especially for individuals with low-income and/or low-education levels (Peng, 2001 in Dias, 2010).

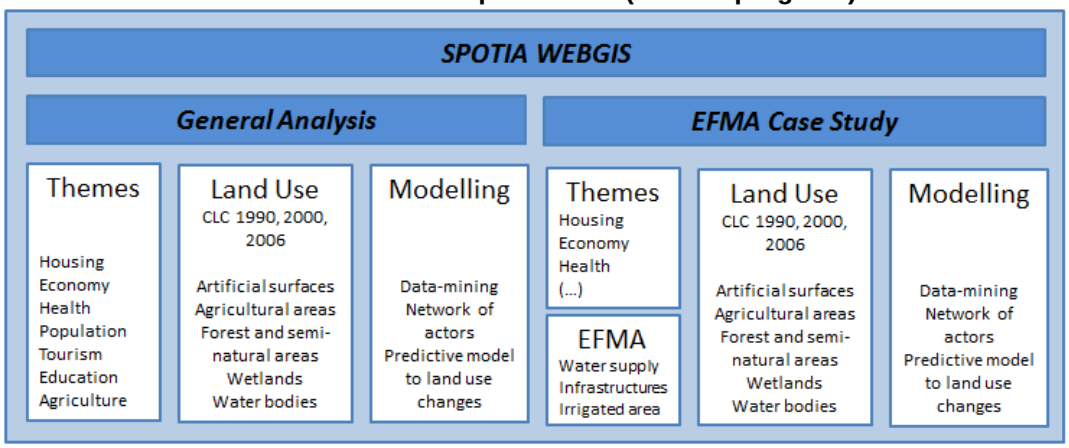
At the same time, there are continuous discussions about the utility of indicators in planning, especially for diagnosis or evaluation phases, indicators that will be the basis of web mapping. For example, Hoernig and Seasons (2004) synthetize the main strengths of its use – the simplification of a complex reality, the possibility of describe and track some dynamics, the identification of trends and patters, the comparison of the different units, the support for predictive mechanisms and the reinforce of decision-making are some of them. In this

context, the indicators types could have distinct perspectives too (Hoernin and Seasons in Marques da Costa, E. (2011)):

- Conventional – with a single-sector approach, as “Economy”, “Social well-being” or “Environment”;
- Integrative – a multi-sectoral approach, as “Sustainability”, “Healthy cities” or “Quality of Life”;
- Performance – with a performance, production or financial approaches of the department or programme.

In SPOTIA Project, the dissemination of information not only for the decision-makers but for the community in general is one of the main goals. Recurring to ArcGis Online and ArcGis Explorer as tools, the developed SPOTIA WEBGIS (**Figure 5**) presents two axes of information: the first – General analysis – is based on the total of parishes, municipalities and regions of mainland Portugal, and the second – EFMA Case Study - is focus only on the 21 municipalities that composed the EFMA case study (previously referred in part 2.1).

Figure 5 – Consultation Platform 3 – Instrument`s Guidelines
Source: Own production (work in progress)



In both, there are three common axes: cartography of the main indicators by theme, cartography of land use and its evolution, and geographical modelling. In the EFMA case study perspective, there is an extra axe, related with the location of the constructed infrastructures in the context of this mega-project and the resulted water bodies. To understand the main changes with spatial impact arising from the EFMA Project in the respective area of influence in Alentejo Region, two perspectives were specified now, leading to the main themes and the land use dynamic.

EFMA Case study - Main themes. The first aspect in analysis have the aim of mapping the main trends in accordance with the various themes that are related with the case-study dynamics – “Agriculture”, “Energy”, “Economy”, “Housing”, “Mobility”, “Population”, “Scholar network and Education”, “Health network and Health”, “Tourism”; searching for the main indicators at the lowest spatial scale and the most updated as possible. This WEBGIS present a conventional approach for data analysis. In **Figure 6** it`s possible to see the desktop of the Thematic WEBGIS for EFMA Area. In this tool, selecting one thematic, we could find several indicators to consult. After selecting one specific indicator, it`s possible to visualise the mapping of the most recent results for all territorial units, and clicking in one of them, it`s possible to find a specific table with the results for several years. For example, in the “Scholar network and Education” thematic, it`s possible to find 10 indicators, as the “Dropout rate”, “Illiteracy rate”, “Number of students”, “Number of schools per square kilometer” or “Proportion of primary schools with fewer than 21 students”. This last indicator is represented in **Figure 6**.

EFMA Case study - Land use dynamic. This second perspective for EFMA area is related to the land use dynamics. The main source of information used to map the land use dynamics was the Corine Land Cover (CLC) for 1990, 2000 and 2006. Unfortunately, this source don`t have more actualized data. The CLC data is composed for 3 levels of information: the first level have 5 main categories of land use – "1. Artificial surfaces","2. Agricultural areas","3. Forest and semi-natural areas", "4. Wetlands", and "5. Water bodies"; the second level covers 15 classes of physical and physiognomic entities, and the third and last level have 44 categories. For example, in **Figure 7** it`s possible to visualise the WEBGIS Desktop, considering all land use categories of CLC level 1 for EFMA Area in 2006.

Figure 6 – Thematic WEBGIS for EFMA area. Case of Scholar Network and Education
Source: Own production. SPOTIA Project

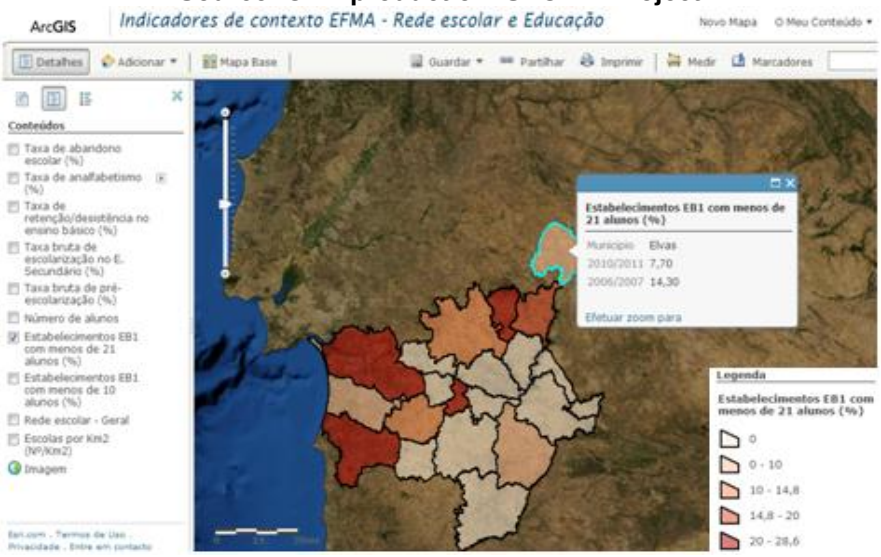
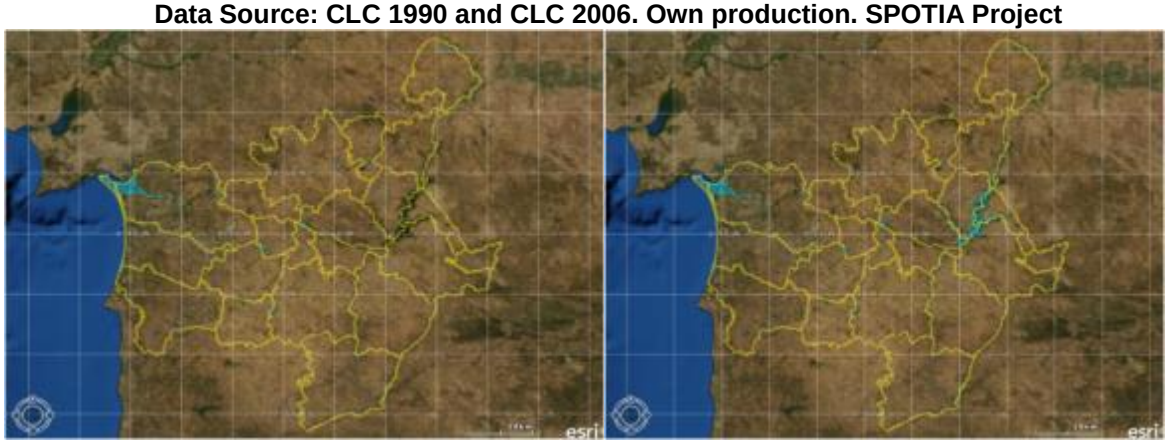


Figure 7 – Land Use WEBGIS for EFMA area
Data Source: CLC 2006. Own production. SPOTIA Project

Benefiting from the very good interdependency of data by the various classifications of land use, and the possibility to transport it to the WEBGIS, we can select only one class of any CLC level. In the case of EFMA Project is important to understand what changes occurred in the water bodies of the region after the construction of EFMA infrastructures, which includes the Alqueva dam, Pedrogão dam, Alqueva hydroelectric central, the Global System for Irrigation Pumping Station, among others. The "5. Water bodies" category at CLC level 1

includes two CLC level 2 categories and five CLC level 3 categories: “5.1. Continental waters”, with “5.1.1. Water courses” and “5.1.2. Water bodies”, and “5.2. Marine waters”, including “5.2.1. Coastal lagoons”, “5.2.2. Estuaries”, and “5.2.3. Sea and ocean”. The **Figure 8** is a good example of this analysis, where is possible to see the evolution of the “water bodies” area between 1990 and 2006, especially in the area where several infrastructures were constructed.

Figure 8 – Land Use WEBGIS for EFMA area. Case of “Water bodies” CLC category
Data Source: CLC 1990 and CLC 2006. Own production. SPOTIA Project



Concluding about the WEBGIS tools, it`s possible to highlight some notes on its use. As **positive aspects** we consider:

- WEBGIS is a user-friendly tool for general people, free and available for who have Internet;
- allows decision-making processes more transparent, due to the dissemination of the information;
- the possibility to map several indicators in the same WEBGIS, adding a summary table with the evolution of the same indicator or even other indicators for each territorial unit reinforce the understanding about the territorial dynamics;
- the capacity to create combinations of overlapped layers by the users in the same WEBGIS (for example, using the CLC 2006 data, we can overlap the layers “1. Artificial surfaces” and “2. Agricultural areas”; or overlap the same layer in different years, as 1990 and 2006, allowing the visual analysis of the evolution of land use of one category; or at last, overlap one specific indicator at municipality scale and one network, for example, the “Proportion of primary schools with fewer than 21 students” and the scholar network of all schools).

It`s possible to identify some **negative aspects** too:

- there is some difficulties to conciliate all available spatial scale for all data, since the parishes until regional scale, still having nowadays some lack of data for some territorial units;
- the obsolescence of the data undertakes a reliable analysis for decision support (for example, the gap between the land use source CLC 2006 and the actuality);
- this tool needs qualified human resources to create and actualise all system to maintain it operational for all users;

This tool reveals a great utility for several phases of planning – diagnosis, monitoring and evaluation, for example, to understand the main trends of the context indicators or the evolution of the land use, but if the data is not updated as regularly as necessary, both by the WEBGIS manager and by the main statistical sources, as Eurostat or the National Institute of Statistics, the tool becomes useless in the course of time.

2.2.3 Geographical modelling as a tool to reinforce the decision-making process

The geographical modelling is linked to the function of predict and prescript in spatial planning, allowing the elaboration of scenarios. These techniques could support the monitoring and evaluation functions, allowing to create several answers depending on the various scenarios prepared in accordance with the initial reality and policy options to take, but also to change the direction of policy options in advance, adapting it to the dynamics observed by the monitoring system.

One last activity in SPOTIA Project recurring to ICT tools is focused on Modelling exercises. In this sense, there are some working groups developing different studies, using several methods. Among the methods, we highlight: Graph Theory and Complex Networks; Neural networks (e.g. SOM); combining neural networks with Multicriteria Analysis; Cellular automata (combining neural networks and or Multicriteria Analysis, i.e. Weighted linear combination (WLC) to adjust the transition rules).
Being a work in progress, some of the activities that are now under development are focused on:

1. Build, analyse and visualise the network of actors (stakeholders) concerning spatial planning, for all scales of Spatial planning instruments (IGT) and for each individually. The metrics arising from the Graph Theory and Complex Networks, can allow identifying which agents are more accessible, more central, which are the bridging ones, the cluster of agents, as well as the degree of connectivity of the network and its resilience.
2. Data-mining, namely to explore the variables of the different domains (social, economic, demographic, biophysical, legal, etc.) and to develop explorative (what if scenarios?) and predictive scenarios
3. Building a predictive model to land use/cover changes

It is intended that this information integrate the developed WEBGIS proposed by SPOTIA Project, being one more element to reinforce the Spatial Decision Support System, fostering the dissemination of information and decision support.

3 FINAL REMARKS

The task of construct an SDSS is strongly related with the search for a more cohesive national planning system. To develop that perspective, it`s relevant to improve the general system through the availability of information in a more user-friendly way, considering the existent technology and data, being the ICT tools a strong ally to optimize this system.

Having the objectives of SPOTIA Project as premises, and according to the managed data and policy`s instruments (objectives, actions, indicators, projects, etc.), several tools were tested to consolidate possible components of a SDSS, recurring to several tools and methods, as some softwares as Access to database management or ArcGis for mapping and modelling. It is also intended that these tools support different phases of planning - from diagnosis, to policy definition, monitoring and evaluation.

As it was referred, all experimented tools present positive and negative aspects. However, the gains of have this kind of tools and consultive platforms are largely higher than the loose of do not have any available information to support the decision-making, having the tools the function of promote an ease access to policy`s for decision-makers, academics and general community, integrating several national and regional policies. All tools have the same threat: if there is not a regular actualization, as we talk about the indicators, maps or policies, the tools become obsolete.

Concluding, there is no doubt that only an integrated spatial planning system relating the multiple territorial and sectoral policies could make develop a more cohesive national planning system, thereby enhancing the values proposed by the European Commission of promote more sustainable, more competitive but also more social, economic and territorially cohesive regions.

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