Web-based Interoperability System: A Collaborative Method to Integrate Rural Buildings with Their Surroundings

Jin Su Jeong, Lorenzo García Moruno, Julio Hernández Blanco

(Ph.D. Student Jin Su Jeong, Universidad de Extremadura, Centro Universitario de Mérida, Dpto. Expresión Gráfica, C/ Santa Teresa de Jornet, 38, 06800 Mérida, Spain, jin@unex.es)

(Prof. Dr. Lorenzo García Moruno, Universidad de Extremadura, Centro Universitario de Mérida, Dpto. Expresión Gráfica, C/ Santa Teresa de Jornet, 38, 06800 Mérida, Spain, lgmoruno@unex.es)

(Prof. Dr. Julio Hernández Blanco, Universidad de Extremadura, Centro Universitario de Plasenica, Dpto. Expresión Gráfica, Avda. Virgen del Puerto, 2, 10600 Plasencia, Spain, juliohb@unex.es)

1 ABSTRACT

This research investigates the feasibility of web technology as a means of collaborative method to integrate rural buildings with their surroundings. The conceptual design of a GIS enabled web-based application this paper proposes supports public participations to the current business processes' limitations and increases the efficiency of these processes by means of web-based technologies. The prototype is dealing with a multi-criteria spatial decision-making borrowed from a geographical information system (GIS), a design criteria to predict and measure users' perceived impression as the tool of environmental assessment, and an interoperable knowledge map as sharing, documenting, and reusing practical information. The approach employs three-tier architecture in a server/client system programmed by active server pages (ASP), and consists of Map Server and MySQL relational database. ASP is a server-side script to create dynamic web pages that are able to retrieve and display database data and modify data records. The application developed ASP can be deployed on any web browsers, since it is server-side application. Map Server presents a quality output of GIS data including raster and vector graphics, labeling/annotation, multiple data layer support, and spatial analysis functionality between layers. MySQL is a multi-user structured query language (SQL) database management system (DBMS), which code and data will be held on a centrally located server where it could be accessed from any broadband-connected computer. Using the proposed prototype for integrating rural buildings with their landscapes, the ideas and theories discussed in this paper clarifies the contribution of the interface and helps to create a coherent and practical application that is transparent and collaborative.

2 INTRODUCTION

Some landscapes are still preserved to have a close relationship and harmonious balance with natural resources, farming, and human settlement carefully sited and oriented (Di Facio, 1989). However, the changes of the past few decades as agriculture and tourism have experienced an important transformation have proliferated in many other cases an abrupt and a discordant in the relation between man-made constructions and their landscapes (Montero et al., 2005). It is important that these new buildings should be designed and sited respecting their environmental emplacement (Tandy, 1979). For that reason, the professionals such as designers and developers should keep integration and functionality in mind and also consider traditional construction styles and materials and modern constructional needs to new buildings (Bell, 1995). Thus, human appreciation is another important criterion to preserve and improve the relationship of buildings and landscape (Brunson and Reiter, 1996) and collaborative process is an application to solve problems while making decision due to multiple stakeholders involve to the integration process (Renger et al., 2008).

Decision making is complex when multiple stakeholders involve doing spatial planning (Fountas et al., 2006). Due to the number of factors involved, decision-making cannot be the enterprise of a sole person. Instead, it must result from a collaborative process, whereby a range of stakeholders with different level of individual experiences as some authors have recently proposed (Lynam et al., 2007; Daniell, 2008; Renger et al., 2008) are able to share their knowledge on a compromise solution to yield conflicting views about desirable planning outcomes (Simão et al., 2009). During the last decade, efforts have been made to develop an integrative tool, capable of dealing with analytical and communicative side of spatial planning within a unique framework (Jankowski et al., 1997; Voss et al., 2004; Hernández et al., 2004a; 2004b). The definition of such a framework assumes critical importance because the internet appears to provide the primary mechanism for granting interested stakeholders the opportunity to participate in the planning process using asynchronous and distributed collaboration (Davison and Cotten, 2003; Voinov and Bousquet, 2010).

The use of web-based information system which has significant potential offers users to different channels, a part of information technology, for better decision-making and knowledge-sharing across geographical distributed teams (Thysen, 2000). The information management practices, however, are profoundly based on traditional ways of information collaboration and communication such as face-to-face meetings with the exchange of paper documents printed out from own computer. The need to increase the competence of these processes through exchanging massive information volumes at high speed and at relatively low cost has been long recognized by the industry (Deng et al., 2001).

This study describes an investigation into how web-based application can be a unique and cohesive framework to support the integration of rural buildings and their surroundings as to support decision-making, predict and measure users' perceived impact and document and share personal knowledge. In this paper, it consists of 6 parts. Part 3 describes the problem statement which provides the motivation why this research needs to be conducted. The review of the previous literatures gives more strength to probe this research in Part 4: we examine the process of rural buildings and their integration in landscapes and argue that it is a collaborative spatial decision support system to support siting selection and visual elements evaluation; then review web-based GIS applications, looking specifically into the interoperability of web technologies combined with other considerations and, finally, consider knowledge mapping in the whole decision making process, which represents knowledge map as the final resource to share and reuse among users. These elements are then woven together in Part 5, the proposed conceptual framework and system architecture. Finally, Part 6 summarizes this paper's objective and stances the suggestion of future researches.

3 PROBLEM STATEMENT

Current studies as Orr mentioned (2004) indicate that there are over 260 web-based collaboration systems (WBCS) available on the market. The appearance of these technologies gives new chances for users (experts and non-experts) to implement this to their own purposes. However, in the current industries, many practitioners are still hesitant using the web-based applications and even grant little recognition to their potentials. Practitioners' concerns are that WBCS do not enable them to achieve successful projects or may even waste more time (Laiserin, 2002).

A few research endeavors have only been carried out on diverse sides of GIS-enabled web collaboration systems to integrate rural buildings and their surroundings. These studies have rarely focused on the impact of decision supporting, users' perception, and knowledge mapping together. There is no research that provides empirical advice on how to implement these technologies to integrate rural buildings with their surroundings. Also, the usability of this system has rarely demonstrated empirically. Hence, it has a need to completely research the potential and understanding of these technologies for empirical studies of how users can use them for the specific use. This study may guide the development of an appropriate use to integrate rural buildings and their surroundings to evaluate decision supporting, users' perception and knowledge mapping.

4 REVIEW OF PREVIOUS RESEARCHES

4.1 Rural Buildings and Their Integration in Landscapes

In recent and contemporary rural architecture, several causes of the poor landscape impact are described as the following; first, they are not considered of the distinct characteristics of surroundings and have the uniform conception of little design consideration, second, they are mainly relied on standardized design solutions and prefabricated building components to fulfill functional requirements with limited design and construction costs, and third, they only have little consideration for the relations between buildings and their surroundings making the failure to involve expertise design professionals (Schmitt, 2003).

The main factors of general design criteria to improve the visual impact of rural buildings on the landscape have been referred by several researchers as the following sentence. There are characteristics to be considered correct sitting in relation to the natural contours of the landscape including couples of elements such as shape and form, materials, colors, textures, and subdivision of volumes. This process has a relationship with existing buildings and groupings of the space surroundings the building linking construction details and finishing elements (Di Facio, 1988; Schmitt, 2003). Additionally, a collaborative process is the right way to reconcile a large number of decision-makers with different backgrounds, interests, authorities and interpretations of some of their issues and to solve the problem of spatial planning satisfying all or most participants. For fair, rational and efficient decision making procedures, the well-tried interaction of decision-makers with geographical information systems (GISs) has to be integrated with a framework (Gordon et al., 1997).

Geographic information systems (GIS) have emerged over the last 20 years as an effective tool not only for analyzing spatial data but also for evaluating resource management alternatives (Hermann and Osinski, 1999; Kangas et al., 2000; Appleton et al., 2002; Seppelt and Voinov, 2002). In reality, in many cases data are simply stored and processed in a GIS centered on the patterns of land cover and land use, and of social, economic, and demographic characteristics. Planners and decision makers need to know not only the current state of affairs but also require some idea of future conditions. Ideally they would like to be able to see the possible consequences of the plans and policies they may have under consideration (Blaschke, 2006).

In the case of the integration of rural buildings and their surroundings in landscape management, two methods are to select the proper location for new rural buildings based on GIS (Gómez Orea, 1994; Hernández et al., 2001; 2004a; 2004b) and to stance the visual element evaluation of man-made constructions and other landscape components on photographic management (Cañas et al., 1996; García et al., 2003; 2006; 2010), which are depicted in Fig. 1.

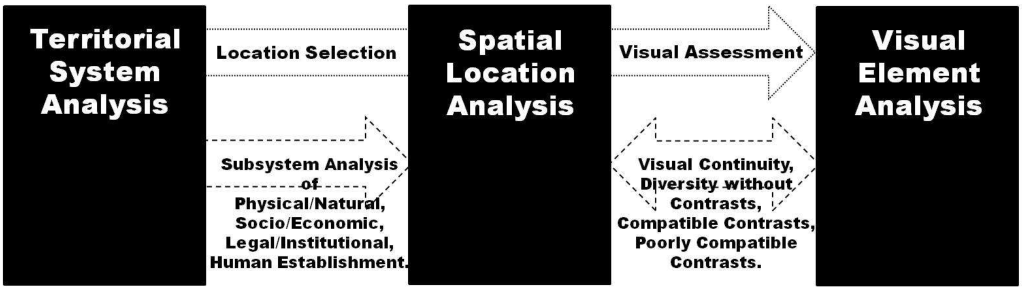

Fig. 1: The integration process of rural buildings and their surroundings.

4.2 Collaborative Web-based GIS Applications

Web application is an application that is accessed over a network such as the internet or an intranet (Shklar and Rosen, 2009). Web applications are popular because of the ubiquity of web browsers and the convenience of using a web browser as a client, sometimes called a thin client (Peng and Tsou, 2003). A key reason for their popularity is the ability to update and maintain web applications without distributing and installing software on potentially thousands of client computers and is the inherent support for cross-platform compatibility (Fowler and Stanwick, 2004).

The number of web-based applications that use techniques derived from geographic information system (GIS) have seen an enormous increase (Haklay et al., 2008). Through a web interface, GIS equipped tools can provide a wide range of planning activities. At the same time, they are able to assist the coordination between the planning authorities and public. In the planning processes, these tools, hence, can be a simple map to front-ending complex spatial analysis ranging from day-to-day to future planning which make more effective processes. To give users' expected results of real time GIS analysis, the proper tool requirements are important with the choice of mapping, database, and development technologies and standards. This further presents an assessment involving different technologies and thier value in order to achieve in a range of circumstances (Grunwald et al., 2003).

Web-based GIS is a GIS distributed across a computer network to integrate, disseminate, and communicate geographic information on the world wide web (WWW) (Peng and Tsou, 2003). Also it provides end-users a cost-saving solution to access up-to-date spatial datasets and information comparing to other GIS systems (Horanont et al., 2002; Painho et al., 2001). Hence, an important part of every web-based GIS application is its mapping or visualization technology, which makes it possible to show data in the form of maps. Visualization of data as maps has become increasingly popular, with hundreds of websites presenting geographic data. The popularity of web-based mapping applications arises in large part through the wide dissemination of software that makes it easy for users and developers to publish map data. Improvements in usability through improved user interfaces also account for the increased popularity of visualization techniques (Aoidh et al., 2008). In similar vein, the growing interest in visualization and analysis of social networks has led to the development of several methods of structural analysis in order to analyze individual and group behavior. This visualization is not limited to the display of raw data in maps but is increasingly widely applied in the representation of large spatial databases (Bishop and Lange, 2005).

4.3 Knowledge Mapping

In today's information centric world, people deal with a great amount of information every day. Many different kinds of information systems are interpreting data and transforming it into some kind of information (Dave and Koskela, 2009). As discussed by many researchers, knowledge management (KM) cannot be implement using technology alone even though technology has an important role to play (Anumba et al., 2003; Davenport and Prusak, 1998; Ruikar et al., 2007). They have mentioned that information and communication technologies (ICTs) have been implemented to support KM. Thus, KM oriented non-information technology is quite effective within organizations. Some knowledge management technologies use pretty expensive information technology (IT) infrastructure. These technologies, however, are difficult to implement and also highlight on explicit knowledge (Al-Ghassani, 2002). The negative impact of these tools is causing information overload because of unorganized and ad-hoc information exchange on KM capabilities of organizations.

One of the most important resources in any organization is knowledge (Ofek and Sarvary, 2001; Smith, 2001). The success or even the survival of any organization depends on how effectively it manages the knowledge present internally and externally (Switzer, 2008). Organizational knowledge is recognized as a key resource and a variety of perspectives suggest that the ability to marshal and deploy knowledge dispersed across the organization is an important source of organizational advantage (Teece, 1998; Tsai and Ghoshal, 1998). Significant efforts have been made by industries to develop and implement systems to manage capturing, storing and retrieval of explicit project related information. Traditional organizations are beginning to comprehend that knowledge and its inter-organizational management, as well as individual and organizational capability building, is becoming crucial factors for gaining and sustaining competitive advantages (Preiss et al., 1996). However, not enough attention has been paid towards managing tacit knowledge (Lin et al., 2006; Newell et al., 2006).

What is knowledge map? It can be defined as a knowledge "yellow pages" or a cleverly constructed database that point to knowledge but does not contain it (Davenport and Prusak, 1998). Generally, knowledge map points out people, documents and databases which make possible a single person to find a proper knowledge source. A person needs to investigate what kind of knowledge work will be used as different solutions for different types for an organization prior to implement any kind of KM (Ruikar et al., 2007).

In the knowledge management context, collaboration work is the most difficult to address, which is very iterative and improvisational and also is mostly done by workers who are experts in their roles and who may have a certain degree of experience or education behind them (Anumba et al., 2003; Davenport, 2005). Hence, organizations need to put workers in more knowledge available to them to improve this type of knowledge work. The static nature of most knowledge maps, however, is an obstacle of disseminate knowledge just-in-time (Mertins et al., 2001). A method of web-based technologies can enhance a static knowledge map as using easy additions and modification to the map. Many tools and techniques of KM within organizations have been discussed over the years. Among these ICT, they have prompted workers and organizations to utilize platforms for collaborative knowledge sharing (Hearn et al., 2002; Newell et al., 2006). In more recent, the knowledge mapping concept has evolved to expert locator and/or the searching capability via a set of biographies for an expert in a particular knowledge domain (Davenport and Prusak, 1998).

5 CONCEPTUAL DESIGN

5.1 Proposed conceptual framework

The conceptual framework of the interoperable web-based GIS application to integrate rural buildings and their surroundings consists of a general overview area, a visual evaluation and assessment area using multi-criteria spatial decision supporting system and building envelopes design criteria, and a knowledge map area in the consistent approach of a single user interface via the internet. The purpose of the general overview area provides some introductory information, case description, user manual, and registration form to fully access the system, and facilitates access to other resources but with limited functions. The overall functions are illustrated in Fig. 2 as the conceptual framework of the proposed system.

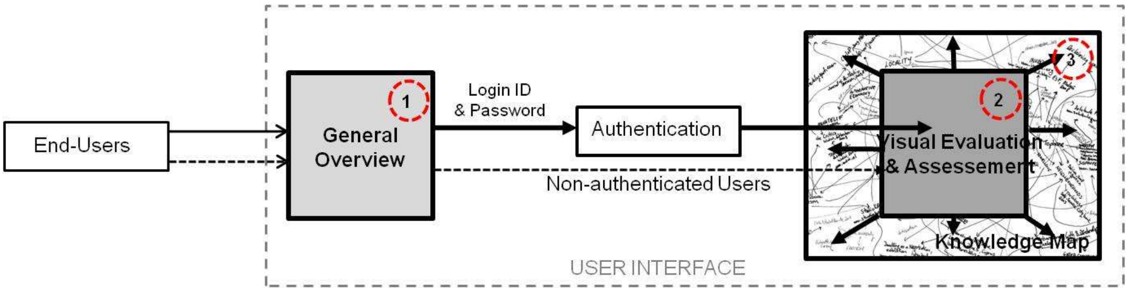

Fig. 2: The conceptual framework of the interoperable web-based GIS prototype.

The visual evaluation and assessment area consists of two major parts: location and building components analysis. For the location selection, multi-criteria spatial decision support systems assist the processes of complicated spatial issues by presenting an application. Through the framework generating alternative solutions, users can search and find out their preferences to make a decision. In the selected location, users can use building design criteria such as form, size, height, material, and color from the defaulted viewpoints. Thus, each step has own function to document their knowledge through comment transcript. However, this study is limited to use only color option of building envelopes and other options are already set to use.

A single person might not be possible to have the entire view and in-depth knowledge of visual integration and its individual implication. Thus, participating in the visual integration process is a learning experience, and should be considered from the point of view of a learning theory (Hamilton et al., 2001). These processes enhance users to make sense of their own experiences and tacit knowledge. Therefore, all parts of application using comment transcripts absorb personal tacit knowledge and represent a knowledge map as the final resource of this application for sharing and reusing these among users.

5.2 System architecture

The architecture of a prototype, an interoperable web-based GIS system, was constructed as a multi-criteria decision support system, an environmental assessment to measure users' perception, and a knowledge documentation medium. This system is a channel to collaborate and communicate to integrate rural buildings and their surroundings for users the specific and practical purposes by using web-based GIS technologies.

The conceptual framework as shown in Fig. 3 describes the relationships among the five major system components, the user's web browser, the web server, the application server, the map server, and the database server. Arrows and numbers explain the starting and ending points of an information processing procedure. The web browser with users' inputs starts the interaction between the web and users. The web server receives users' requests, specified parameters of a query, and then the application server programmed by active server pages (ASP) gets these parameters and parses them as a structured query language (SQL) query to the database server, MySQL. The database management system (DBMS) then returns its results to the ASP program, which processes the result and output. In the case of map files, Map Server can render these files including the information of spatial objects, classification method, symbology and labeling method. The client JavaScript program gets parameters of the data which a user has requested before. By now, the whole information processing procedure numbered 1 to 10 in Fig. 3 finishes and users can repeat the same procedure according to their preferences. The following paragraph present some of factors and reasoning that were considered as the prototype was designed.

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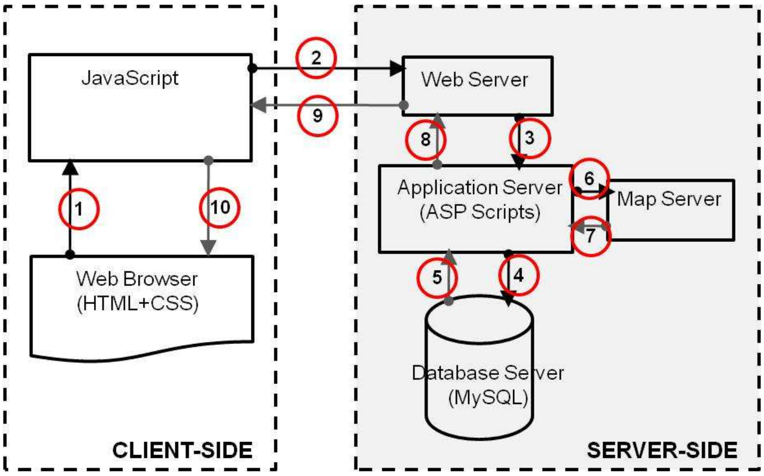

Fig. 3: The integration process of rural buildings and their surroundings.

The general structure of this prototype application is a client/server system. The client/server model defines the communication between clients and servers (Umar, 1997). A web browser such as Microsoft Internet Explorer or Mozilla Firefox is common browser products, clients, on common system platforms such as Windows and Linux but service providers, servers, have more diversified types. A basic server is web server software, which is providing for efficient process and memory management for responding to hypertext transfer protocol (HTTP) requests. Including this basic HTTP response, the web server could delegate the generation of a dynamic response to some other programs and serve-side technologies. JavaScript is necessary for dynamic programs and has an essential role with accessible forms of web application programming interfaces (APIs) to bridge client and server side communication. ASP is a server-side script to create dynamic web pages that are able to retrieve and display database data and modify data records. ASP is performed an embedded text script rather than a complied program. This method of processing request is frequently used in today's web application. Besides web server, application servers and database servers need to deploy and delegate the prototype application. Application server provides for common programming and/or scripting languages, which provide adequate documentation and communication between the web server and the database server. To design an interoperable web-based GIS application, map server needs to be a part of the application server. Map server presents outputs such as raster and vector graphics, multiple data layer support, spatial analysis between layers, annotation/labeling, and etc. MySQL is a multi-user SQL DBMS, which is a database server to enforce data integrity, security and reliability and to provide adequate documentation. Also, code and data can be held on a centrally located server where it could be accessed from any broadband-connected computer.

6 CONCLUSION

The ideas and theories discussed in this paper are an introduction to issue and facilitate the conceptual framework of an interoperable web-based GIS application to integrate of rural buildings with their surroundings. The prototype of this application is dealing with three types; individually, first, a multi-criteria spatial decision support system typically borrowed from a geographical information system (GIS) which is an information system used to input, store, retrieve, manipulate, analyze and output geographically referenced data, second, a design criteria to predict and measure users' impression as the tool of environmental assessment and third, an interoperable knowledge mapping as being capable of tackling different facets of design and planning processes to provide a better way.

The future studies will be conducted in order to implement and test the suitability of web-based interface. Also, it will determine whether this system improves stakeholders' learning in the whole process. The research also will identify appropriate directions for the use of knowledge management system in the industry. A software usability engineering approach (Nielsen, 1994) will be considered during prototype application testing for evaluating both computational capability and a graphical user interface (GUI). After establishing a web application prototype, a set of survey and interview will provide numerical data about participants' performance using this system as the part of the future research. The research results will clarify the benefits to stakeholders of using web interface, the impact of users' perception and the knowledge mapping into business processes.

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8 REFERENCES

AL-GHASSANI, A.M.: Literature review on KM tools. Technical Report, Department of Civil and Building Engineering, Loughborough University, UK, 2002.

ANUMBA, C.J., RUIKAR, D., AZIZ, Z., CARRILLO, P.M., BOUCHLAGHEM, N.: Towards a web of construction knowledge and services. In: 4th ASCE International Joint Symposium on IT in Civil Engineering, Nashville, 2003.

AOIDH, E., BERTOLOTTO, M., WILSON, D.C.: Understand geospatial interests visualizing map interaction behavior. In: Geo Visualization of Dynamics, Movement and Change 7 (3), pp. 275-286. 2008.

APPLETON, K., LOVETT, A., SUNNENBERG, G., DOCKERTY, T.: Rural landscape visualisation from GIS databases: a comparison of approaches, options and problems. In: Computers, Environment and Urban System 26, pp. 141–162. 2002.

BELL, S.: Elements of visual design in the landscape. E&FN Spon, London, 1995.

BISHOP, I.D., LANGE, E.: Visualization in landscape and environmental planning: technology and aplications. 1st ed. Taylor and Francis, New York, 2005.

BLASCHKE, T.: The role of the spatial dimension within the framework of sustainable landscapes and natural capital. In: Journal of Landscape and Urban Planning 75, pp. 198-226. 2006.

BRUNSON, M., REITER, D.: Effects of ecological information on judgments about scenic impacts of timber harvest. In: J Environ Manage 46, pp. 31-41. 1996.

CAÑAS, I., AYUGA, F., ORTIZ, J.: Visual impact assessment for farm building projects. In: Proceedings of the International Conference Agricultural Engineering, pp. 1007-1014. Madrid, 1996.

DANIELL, K.: Co-engineering participatory modeling processes for water planning and management. Ph.D. Australian National University and Institut des Sciences et Industries du Vivant et de l'Environnement, 2008.

DAVE, B., KOSKELA, L.: Collaborative knowledge management – A construction case study. In: Automation in Construction 18, pp. 894-902. 2009.

DAVENPORT, T.H., PRUSAK, L.: Working knowledge: How organizations manage what they know. Harvard Business School Press, Boston, 1998.

DAVENPORT, T.H.: Thinking for a living. How to get better performance and result from knowledge workers. Harvard Business School Press, Boston, 2005.

DAVISON, E., COTTEN, S.R.: Connection discrepancies: unmasking further layers of the digital divide. In: First Monday 8 (3). 2003.

DENG, Z., LI, H., TAM, C., SHEN, Q., LOVE, P.: An application of internet-based project management system. In: Automation in Construction 10, pp. 239-246. 2001.

DI FACIO, J.: La progettazione dell'edilizia rurale nei suoi rapporti con il paesaggio. In: Rivista di Ingegneria Agraria 10, pp. 379-385. 1988.

DI FACIO, J.: Designing agricultural buildings in relation to the landscape. In: Proc Intnl Congress Agric Eng, pp. 1191-1198. Balkema, Holland, 1989.

FOUNTAS, S., WULFSOHN, D., BLACKMORE, B.S., JACOBSEN, H.L., PEDERSON, S.M.: A model of decision-making and information flows for information-intensive agriculture. In: Agricultural Systems 87, pp. 192–210. 2006.

FOWLER, S., STANWICK, V.: Web application design handbook: best practices for web-based software (Interactive Technologies). 1st ed. Morgan Kaufmann, San Francisco, 2004.

GARCÍA, L., HERNÁNDEZ, J., AYUGA, F.: Analysis of the exterior color of agroindustrial buildings: a computer aided approach to landscape integrations. In: Journal of Environmental Management 69(1), pp. 94-103. 2003.

GARCÍA, L., HERNÁNDEZ, J., AYUGA, F.: Analysis of the materials and exterior texture of agro-industrial buildings: a photo-analytical approach to landscape integration. In: Journal of Landscape and Urban Planning 74(2), pp. 110-124. 2006.

GARCÍA, L., MONTERO, M., HERNÁNDEZ, J., LÓPEZ, S.: Analysis of lines and forms in buildings to rural landscape integration. In: Spanish Journal of Agricultural Research 8(3), pp. 833-847. 2010.

GÓMEZ OREA, D.: Ordenación del Territorio. Una aproximación desde el Medio Físico. Editorial Agrícola Española. Instituto Tecnológico Geominero de España, Madrid, 1994.

GORDON, T., KARACAPILIDIS, N., VOSS, H., ZAUKE, A.: Computer-mediated cooperative spatial planning, In: Timmermans, H. (Ed.), Decision Support Systems in Urban Planning. E & FN SPON, pp. 299-309. 1997.

GRUNWALD, S., REDDY, K.R., MATHIYALAGAN, V., BLOOM, S.A.: Florida's wetland WebGIS. In: Proceedings of the ESRI User Conference, San Diego, CA, 2003.

HAKLAY, M., SINGLETON, A., PARKER, C.: Web mapping 2.0: the neogeography of the GeoWeb. In: Geography Compass 2(6), pp. 2011- 2039. 2008.

HAMILTON, A., TRODD, N., ZHANG, X., FERNANDO, T., WATSON, K.: Learning through visual systems to enhance the urban planning process. In: Environment and Planning B: Planning and Design 28 (6), pp. 833–845. 2001.

HEARN, P., BRADIER, A., JUBERT, A.: Building communities: organisational KM within the european commission's information society technologies programme. In: ITcon, Special Issue ICT for KM in Construction 7, pp. 63–68. 2002.

HERMANN, S., OSINSKI, E.: Planning sustainable land use in rural areas at different spatial levels using GIS and modelling tools. In: Landscape and Urban Planning 46, pp. 93–101. 1999.

HERNÁNDEZ, J., GARCÍA, L., AYUGA, F., GARCÍA, J.: Las construcciones agroforestales y su integración en el paisaje: estudio de localización mediante Sistemas de Información Geográfica. In: Ingeniería Civil 122, pp. 127-136. 2001.

HERNÁNDEZ, J., GARCÍA, L., AGUGA, F.: Assessment of the visual impact made on the landscape by new buildings: a methodology for site selection. In: Landscape Urban Plan 68(1), pp. 15-28. 2004a.

HERNÁNDEZ, J., GARCÍA, L., AGUGA, F.: 2004b. Integration methodologies for visual impact assessment of rural buildings by geographic information systems. In: Biosyst Eng 88(2), pp. 59-86. 2004b.
HORANONT, T., TRIPATHI, N., RAGHAVANA, V., SANTITAMNONT, P.: A comparative assessment of internet GIS server systems. In: Map Asia, Bangkok, Thailand, 2002.
JANKOWSKI, P., NYERGES, T., SMITH, A., MOORE, T.J., HORVATH, E.: Spatial group choice: a SDSS tool for collaborative spatial decision-making. In: International Journal of Geographical Information Systems 11 (6), pp. 577–602. 1997.
KANGAS, J., STORE, R., LESKINEN, P., MEHTÄTALO, L.: Improving the quality of landscape ecological forest planning by utilizing advanced decision-support tools. In: Forest Ecology and Management 132, pp. 157–171. 2000.
LAISERIN, J.: Hey buddy, can you spare some change. Laiserin Letter. 2002.
LIN, Y., WANG, L., TSENG, H.P.: Enhancing knowledge exchange through web map-based knowledge management system in construction: lessons learned in Taiwan, In: Automation in Construction 15, pp. 693–705. 2006.
LYNAM, T., DE JONG, W., SHELL, D., KUSUMANTO, T., EVANS, K.: A review of tools for incorporating community knowledge, preferences, and values into decision making in natural resources management. In: Ecology and Society 12. 2007.
MERTINS, K., HEISIG, P., VORBECK, J.: Knowledge management. Best practice in europe. 2nd ed. Springer, Berlin, 2001.
MONTERO, M.J., LÓPEZ-CASARES, S., GARCÍA-MORUNO, L., HERNÁNDEX-BLANCE, J.: Visual impact on wetlands: Consequence of buildings sprawls in rural areas of the west of Spain. In: MODSIM Intnl Cong on Modelling and Simulation, pp. 170-176. Zerger, A., Argent, R. M. (Eds.), Modelling and Simulation Society of Australia and New Zealand, 2005.
NEWELL, S., BRESNEN, M., EDELMAN, L., SCARBROUGH, H., SWAN, J.: Sharing knowledge across projects: limits to ICT-led project review practices, In: Management Learning 37, pp. 67–185. 2006.
NIELSEN, J.: Usability Engineering. Academic Press Inc., Boston, MA, 1994.
OFEK, E., SARVARY, M.: Leveraging the customer base: creating competitive advantage through knowledge management. In: Management Science 47 (11), pp. 1441–1456. 2001.
ORR, J.: Extranet news: The list. Cyon Research. 2004.
PAINHO, M., PEIXOTO, M., CABRAL, P., SENA, R.: WebGIS as a teaching tool. In: Proceedings of the ESRI UC 2001, San Diego, CA, USA, 2001.
PENG, Z.R., TSOU, M.H.: Internet GIS. John Whiley & Sons, Hoboken, New Jersey, 2003.
PREISS, K., GOLDMAN, S.L. NAGEL, R.N.: Cooperate to Compete: Building agile business relationships. Wiley, New York, NY, 1996.
RENGER, M., KOLSHOTEN, G., DEVREEDe, G.: Challenges in collaborative model - a literature review and research agentda. In: International Journal of Simulation and Process Modelling 4, pp. 248-263. 2008.
RUIKAR, K., ANUMBA, C.J., EGBU, C.: Integrated use of technologies and techniques for construction knowledge management. In: Knowledge Management Research & Practice 5, pp. 297–311. 2007.
SCHMITT, H.: Landschaftbezogenes Bauen in Baden-Wüttemberg. In: Landtechnik 2, pp. 88-89. 2003.
SEPPELT, R., VOINOV, A.: Optimization methodology for land use patterns using spatially explicit landscape models. In: Ecological Modelling 151, pp. 125–142. 2002.
SHKLAR, L., ROSEN, R.: Web application: principles, protocols and practices. 2nd ed. Wiley, Glasgow, UK. 2009.
SIMÃO, A., DENSHAM, P.J., HAKLAY, M.: Web-based GIS for collaboration planning and public participation: An application to the strategic planning of wind farm sites. In: Journal of Environmental Management 90, pp. 2027-2040. 2009.
SMITH, E.A.: The role of tacit and explicit knowledge in the workplace. In: Journal of Knowledge Management 5, pp. 311–321. 2001.
SWITZER, C.: Time for change: empowering organisations to succeed in the knowledge economy. In: Journal of Knowledge Management 12 (2), pp. 18–28. 2008.
TANDY, C.: Industria y paisaje. Ed Leonard Hill Books, Madrid, 1979.
TEECE, D.: Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets. In: California Management Review 40, pp. 55–79. 1998.
THYSEN, I.: Agriculture in the information society. In: Journal of Agricultural Engineering Research 76, pp. 297-303. 2000.
TSAI, W., GHOSHAL, S.: Social capital and value creation: the role of intrafirm networks. In: Academy of Management Journal 41, pp. 464–476. 1998.
UMAR, A.: Object-oriented client/server Internet environments. Prentice Hall Press Upper Saddle River, NJ, 1997.
VOINOV, A., BOUSQUET, F.: Modeling with stakeholders. In: Journal of Environmental Modeling & Science 25 (11), pp. 1268-1281. 2010.
VOSS, A., DENISOVICH, I., GATALSKY, P., GAVOUCHIDIS, K., KLOTZ, A., ROEDER, S., VOSS, H.: Evolution of a participatory GIS. In: Computers, In: Environment and Urban Systems 28 (6), pp. 635–6. 2004.