SISLA – Web application and spatial database to foster natural resource management at Mato Grosso do Sul State, Brazil

SISLA – Aplicação Web e base de dados espaciais para promover a gestão de recursos naturais no estado do Mato Grosso do Sul, Brasil

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Abstract: Crucial demands for sustainable land management and environmental governance have trigged solutions based on remote spatial databases and web-based systems. Those solutions provide valuable public services for the citizens and businesses. This paper described SISLA (Interactive System to Support Environmental Licensing), tailored to Mato Grosso do Sul State, Brazil. The modules available at SISLA and described in this article are: metadata, supplementary spatial layers, license process workflow, and spatial analysis report. This study also has found that private companies have been the largest group to use SISLA as described by a brief survey.

Keywords: spatial database, environmental licensing, web system application.

Resumo: Demandas importantes para o gerenciamento sustentável de terras e governança

Introduction

The use of database systems to represent spatial information has steadily increased in the last years, mainly due the proliferation of spatial information through the Internet. According to Yeung & Hall (2007), the popularization of spatial information has been driven by the increasing availability of spatial data from government and commercial sources, distributed via several mechanisms in the Internet, such as spatial data gateway and digital geolibraries. Another

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ambiental tem suas soluções implementadas por meio de bases de dados espaciais remotas e sistemas Web, os quais fornecem serviços públicos para cidadãos e empreendimentos. Este artigo descreve o ambiente SISLA (Sistema interativo de suporte ao licenciamento ambiental) projetado para o estado do Mato Grosso do Sul, Brasil. Os módulos disponíveis no SISLA e descritos neste trabalho são: metadados, camadas espaciais suplementares, workflow do processo de licença ambiental e finalmente um relatório de análise espacial. Adicionalmente, este estudo demonstrou que empresas privadas constituem o maior grupo utilizando o ambiente SISLA, como descrito por um breve questionário**.**

Palavras-chave: base de dados espacial, licenciamento ambiental, sistema Web.

reason highlighted by the authors is the growing awareness of the importance of spatial information by sectors of modern society, like policy makers in the public sector, which consider the spatial information as an important requirement of good governance, and commercial organizations, which offer a sort of paid services based on the spatial information.

To provide storage and search capability with respect to spatial information, and to ultimately make it available to a diverse audience, a spatial database structure is needed. A spatial database as defined by Gütting (1994) is a database system that offers spatial data types in its data model and query language, providing at minimum spatial indexing and efficient algorithms for spatial join. A contemporary typical spatial database system offers not only simple management, display, and analysis of geographical information, but also capabilities for manipulating new data types and models, structures for spatial indexing, and sophisticated algorithms for efficient data processing (YEUNG & HALL, 2007). A Geographic Information System (GIS) represents the principal technology motivating interest in Spatial Database Management Systems (SDMS), and it provides a rich set of analysis functions allowing a user to effect powerful transformation on geographical data (SHEKHAR & CHAWLA, 2003).

Considered in the context of environment management, spatial database systems have been used mainly to organize existing information and support GIS for different applications. The role of GIS in governance is huge; spatial databases and GIS tools, for example, have been regarded by governmental agencies and other public-sector entities to be an important source of spatial information for supporting decision makers and to provide a public-service function. One major driving force of spatial databases is the popularization of web-based tools like Web Mapping and Web-GIS. Web Mapping may be defined as the process of designing, implementing, generating, and delivering maps to the Internet, while Web-GIS emphasizes processing specific geodata and exploratory analysis (FU & SUN, 2010).

Responding to insistent demands for sustainable land management and environmental governance, an increasing number of Brazilian state agencies and local governments have been pursuing solutions based on using remote spatial databases and web-based systems to provide public service for both individual citizens and businesses. One example is the State of Mato Grosso do Sul, where the process of environmental license application requires entrepreneurs to provide an actual geo-referenced vector map. This mandatory map contains information about property registration, vegetation cover, land-use, land-cover, flooding zones, etc. However, there still exist many situations involving a great deal of paper work and lacking an integrated geo-referenced structure.

To address such issues, the government of Mato Grosso do Sul decided to initiate project GeoMS (Geo-referenced Information System as a support for decision-making – Case Study of Mato Grosso do Sul State), to be carried out by the Brazilian Agricultural Research Corporation (Embrapa). The principal expected project outcomes were: development and validation of a web-platform to perform the monitoring of all environmental licensing processes, spatial databases, consolidated maps, and end-users and technical teams trained to use the proposed system.

This paper describes the first GeoMS project outcome, SISLA, that stands for Interactive system to support environmental licensing (SPERANZA et al., 2011a; SPERANZA et al., 2011b; SILVA et al., 2011) and is available at http://sisla.imasul.ms.gov.br. SISLA was additionally conceptualized as having capabilities for collecting, organizing, integrating, and managing geo-referenced information related to environmental licensing process from state and local government offices. The goal of this web-based program is to enable state environmental specialists and technicians to follow the entire process starting from spatial analysis of a property's immediate surroundings all the way up to final evaluation of license grant or permit.

Material and Methods

The study area encompasses the state of Mato Grosso do Sul, located at about 17º to 24º S, 51º to 58º W in a central-western region of Brazil, and with a total area of 357,125 km^2. A tropical climate is predominant in almost all of the state's area. Its wet and warm season stretches from October to March and its dry and cold season from April to September. Annual average rainfall varies from 1,250 to 1,500 mm in this area. There are two prevailing types of vegetation in this area, Cerrado and Pantanal, and both deciduous and semi-deciduous forests (CÁCERES, 2008; IBGE 1992).

It was a team decision to use open-source software in developing this project, to both lower cost and provide a customized solution. For this reason, SISLA's database management system was implemented using PostgreSQL. An open-source tool, GeoNetwork, was also employed to store and retrieve SISLA metadata. This software provided complete integration not only with the data layer but also with the user web interface (SPERANZA et al., 2012). Overall, SISLA functionalities were developed to be fully Web-based using open and widely-known source tools and programming languages, e.g., PHP and Java. Another essential tool used in SISLA development was I3Geo software that makes possible the generation of interactive maps and spatial analysis.

SISLA was also incorporated into the IMASUL (Environment Institute of Mato Grosso do Sul) System of records and strategic information to environment (SIRIEMA). SIRIEMA, a contracted third-party system, managed textual information related to processing the flow of environmental licenses. While SISLA deals with spatial data, the local system is in charge of storing textual information about license applicants and their properties.

A classification of end-users of SISLA was desired to achieve better understanding of these segments and to subsidize further improvements in the system, so an online survey was designed to collect answers from such users.

Results and Discussion

Three main modules were developed for the SISLA environment: metadata, spatial layers supporting license process information, and user management. These modules are described in the following sections.

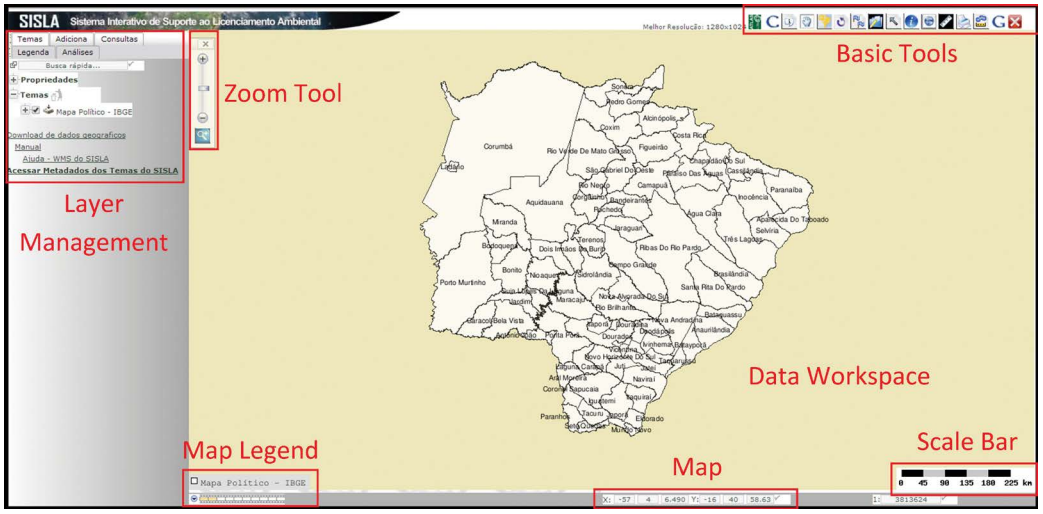
Metadada module

Using guidelines established by the federal government, it was decided that SISLA should adopt the Brazilian Geospatial Metadata profile (MGB profile), elaborated by the National Committee of Cartography (Concar). This decision ensured alignment of SISLA with Spatial Data National Infrastructure (INDE) policies. INDE's purpose is to catalog, integrate, and conciliate actual geospatial data from diverse governmental Brazilian agencies that produce and maintain spatial data; in that way, the data can be successfully identified and accessed by its metadata (MINISTÉRIO DO PLANEJAMENTO, ORÇAMENTO E GESTÃO, 2013). The adoption of an MGB profile for SISLA, also developed by EMBRAPA, guarantees that SISLA would become interoperable, e.g., the system would be able to exchange data with different web services and avoid issues such as redundancy of information.

Spatial layers supporting license process information module

Key features in the SISLA spatial database include capabilities for storing, searching, and querying vector and raster data. Using PostgretSQL that provides spatial extension of Postgis, it supports both spatial and non-spatial data models (e.g., polygons, tables) and complex spatial operations (e.g. overlap, close to). Raster files are managed by the operational system and referenced by specific scripts or database management system procedures. The initial interface of SISLA is shown in Figure 1, and Figure 2 shows two reference spatial layers: ecological corridors (green areas) and conservation units (brown areas).

Figure 1. SISLA initial interface and main tools.



User module

The characterization of SISLA users is available through the Users Module that requests information about all potential users interested in obtaining a SISLA account. This survey module asks users for their professional and academic background and their intended use of SISLA. For security and practical reasons this module separated users into two profiles: public and specialized.

Figure 2. SISLA and two reference spatial layers: wildlife corridors and conservation units.

SISLA – Capabilities

The interface functions offered by SISLA are: i. Functions that use a Web Mapping interface, e.g. interactive maps, ii. Functions that use a common web interface for entrance, storage, and search, and iii. Functions that allow integration with governmental systems, e.g., web services. The basic set of Web mapping features was primarily developed in SISLA using framework i3Geo as customized in Brazil by the Ministry of Environment (MMA). Some of the i3Geo features are freely open to users in general; there are, however, a few features that require authentication for access.

Spatial analysis and vicinity reports are important features of SISLA (VENDRUSCULO et al., 2008; VENDRUSCULO et al., 2009a; VENDRUSCULO et al., 2009b) because they allow a user planning to apply for an environmental license

to spatially identify property in accordance with public requirements (Figure 3). The user must therefore upload, as input, a file in shapefile format designating the area officially defined to be the affected property. The system then proceeds to a spatial analysis of that specific area related to slope extraction, proximity, or intersection with protected areas. The final report generated by SISLA is the starting point for producing licensing paperwork in Mato Grosso do Sul State (Figure 4).

Figure 3. SISLA screen displaying user's property shapefile downloaded into SISLA environment.

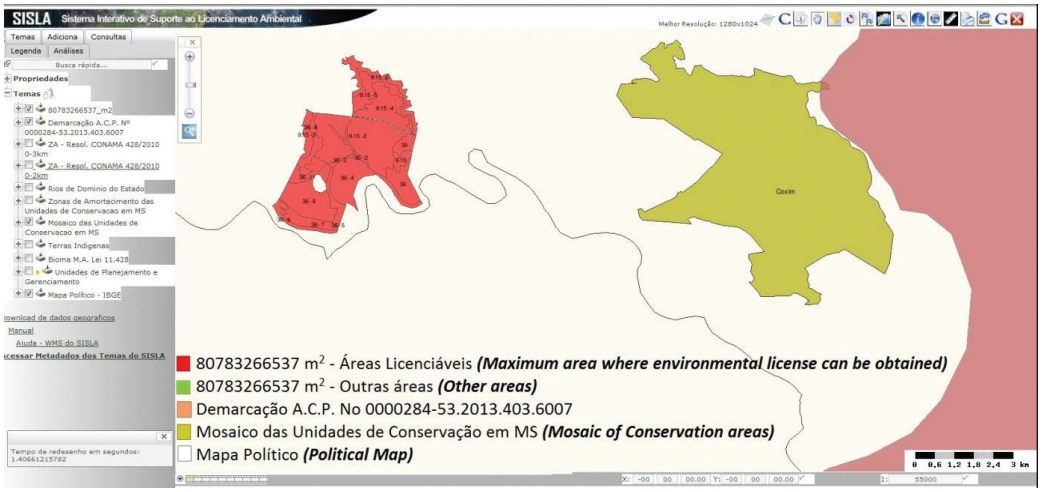
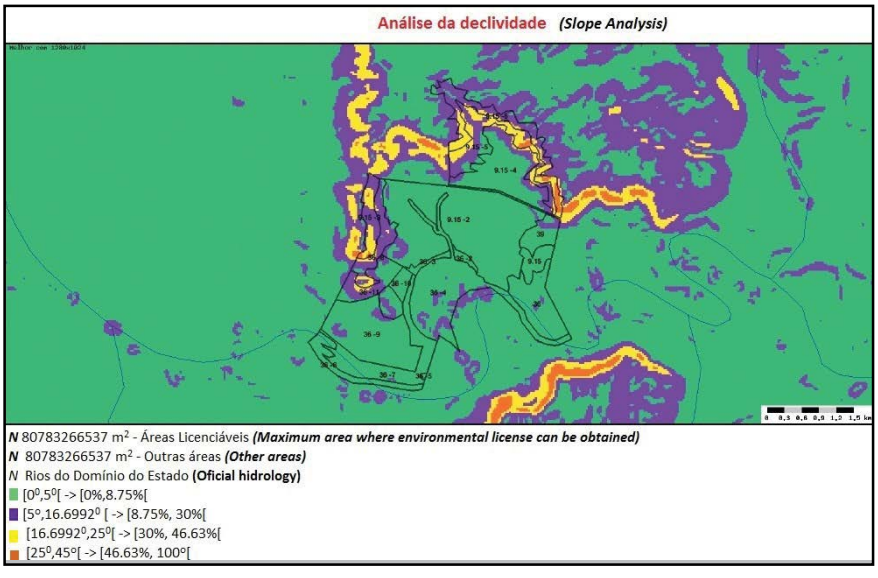


Figure 4. Section of final report with slope classes throughout property area.



The second key capability of SISLA is storage and management of the environmental license process, allowing experts to register any kind of information related to this activity. This extra module is employed when the local or state agency does not have a specialized system for storing their information. If this system is already set up, SISLA captures the input information through web services. Thus, with the local system in charge of collecting the initial textual information required for licensing, the spatial data will also be sent and recovered by Web-Services (SPERANZA et al., 2010c).

The third capability of SISLA is technical analysis of license processes, allowing public technicians to visualize all attached maps underlying the process. This function makes it easier to analyze spatial agreement between a reference area and that owned by the applicant, avoiding, for example, a situation in which the applicant uploads a larger area than the official area or specifies a license area outside of his or her development. Satellite imagery and raster maps available at SISLA are also provided as supplementary sources of information for this investigation (SPERANZA et al., 2010b). Furthermore, SISLA also implements an additional function based on fuzzy logic, legal guidelines, and data from applicants to guide the technician through the licensing process.

Finally, a spatial search function was provided to allow decision makers to obtain consolidated information about ongoing environmental processes, starting from the general on to the specific search. This function makes it possible, for example, to visualize type of licenses by county or whether license requests apply to establishment in indigenous areas (SPERANZA et al., 2010a).

Analysis of actual SISLA users

The results obtained by the SISLA Users module prior to November 2012 have shown that "private companies" were the largest segment requesting access to web-application SISLA (53.4%), followed by employees of IMASUL, as indicated in Table 1. These results suggest that SISLA has been mainly used by the private sector as an external source of information during the licensing process. Furthermore, SISLA works as an internal support and reference resource during licensing procedures. Although group 5 might be considered to be an insignificant percentage of SISLA users (2.71%), this analysis has shown that there has been little interest shown in this system by out-of-state users.

Table 1. Main group of users and number of accesses*.

	Users group types**	# of Accesses	(%)
1	Private companies **	21,946	53.39
2	Environment Institute of Mato Grosso do Sul (IMASUL)	9,894	24.07
3	Self-employed and freelancers	4,533	11.03
4	Education organizations***	1,399	3.40
5	Other State and Federal Public Institutions****	1,113	2.71
6	Municipal Administration or Local government	1,097	2.67
7	Brazilian Agricultural Research Corporation (Embrapa)	723	1.76
8	Banks	397	0.97
	Total	**41,102**	**100.00**

*Results consolidated until November of 2012.

**Private Companies (companies of large, medium and small business (Limited Liability Company/ Corporations, small business, farms, account offices and consultant companies, etc.).

***Educational organizations (university, colleges, public and private schools).

****Other State and Federal Institutions (state secretaries, ministries, army, firefighters, local government, etc.).

Table 2 shows that users have used SISLA mainly for environmental licensing activities that match its original purpose. However, SISLA is also a source of spatial information and an object of interest for academic groups (20.2 %). Nonetheless, a correlation of users and purpose is not implied by Tables 1 and 2.

Table 2. Classification of users according their purpose of using SISLA.

Main Purposes	# of Users	(%)
Environmental Licensing*	1,056	40.44
Download data and general inquiries	682	26.12
Academic	527	20.18
Environmental projects	176	6.75
Experiencing SISLA	74	2.83
Other	96	3.68
Total	**2,611**	**100.00**

* Environmental licensing encompasses activities of environmental processes including status of the process.

Since its initial release in 2007, SISLA has been intensively tested and incrementally improved in terms of user requirements until its final registration at the National Institute of Intellectual property (INPI) at 2012. Although, SISLA is currently used only in Mato Grosso do Sul State, it could be used in other states with virtually effortless customization of interfaces and processes.

Conclusions and further research

In modern society, growing consciousness of importance and impact of spatial information in both government and private sectors has motivated development of specific systems for dealing with such information. This paper describes SISLA, a web platform for monitoring of the environmental licensing process at

Mato Grosso do Sul State. SISLA was implemented using open-source tools and programming languages through a Web interface.

The system presented in this paper is a breakthrough with respect to organization and automation of environmental-licensing steps such as application, revision, and grant. SISLA provides to both Mato Grosso do Sul state and local agencies the opportunity to improve government performance through providing, for example, spatially-referenced data, a fundamental resource for land planning, to a diverse audience; it also optimizes the way that license processing has been performed in past years.

User's purposes analysis has suggested that spatial information related to the Mato Grosso do Sul has been widely used in academic and private sectors through the SISLA system. A qualitative outcome might be an increase of license project quality because users are required to use a unified spatial database. Consequently, the licensing process cycle may take less time, mainly due to a decrease in number of project resubmissions.

For further research, we believe that SISLA may continue its evolution to increasingly meet user needs by dynamic simulation of complex phenomena, multi-dimensional visualization, and public interaction. All those characteristics are envisioned in Virtual Geographic Environments – VGE's – with the availability of 3D data models and cutting-edge visual methodologies that might improve the ways in which human reasoning solves spatial problems.

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