Land Administration Data to Support Development and Research

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Key words: Land Administration, Cyberinfrastructure, Cadastre, Open Data, Open Science

SUMMARY

The land administration infrastructure is of strategic importance for society and the economy. Due to historical developments, the land administration infrastructure contains many diverse and heterogeneous sources of registers information. The Development of Multipurpose Land Administration System (DEMLAS) project aims to discover what needs to be done to transform land administration from traditional to modern multipurpose systems that support all land development activities. A land administration cyberinfrastructure has been developed to support the research. The cyberinfrastructure - DEMLAS platform includes land administration data (cadastral maps etc.) and public open data, such as land satellite images, historical data, nature data, development data, meteorological data, soil data, etc. Some of this data is obtained from official sources and has the character of private data. Contained within are also links to commercial data, mainly satellite images and orthophotos, but also market related and voluntary data, for instance, OpenStreetMap. The integration of external land administration data is realized using principles of Open Linked Data.

The paper presents the development and functionalities of the platform DEMLAS. The open science principles were realized with the concept of user cases that were implemented as one component of the DEMLAS platform. The platform is offering a marketplace where data can be discovered and exchanged with the additional contribution of researchers who can publish their own data or applications based on the data, services and applications already provided.

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1. INTRODUCTION

Sustainable development is not attainable without sound land administration. The demand for sound land administration infrastructures also requires support from a well-developed spatial information infrastructure for sharing geo-referenced information. This includes the need to adequately address conceptual issues, as well as policy issues, such as data access, intellectual property, cost recovery, and design of an efficient institutional framework. A powerful link between appropriate land administration and sustainable development should also be seen as a result of the gradual evolution of land administration systems over time from a specific land tax and land market focus to a more managerial and multi-purpose role. This multi-purpose role should provide adequate spatial information infrastructures as a basis for sustainable decision making in all land-related matters. (Enemark, 2001).

Society and economy requires the collection, storage, sharing and analysis of large quantities of spatially and non-spatially referenced reliable data. Land Administration Infrastructure (LAI) data currently presents a hurdle to the commitment of user needs as the multitude of data models, formats, interfaces and reference systems in use results in incompatibilities. The planning and making of economically and environmentally sound decisions as a combination and the management of an official register data is needed. While many land related activities and policies appropriately receive a great deal of attention worldwide, there is much less attention given to either the land administration systems or infrastructures which facilitate the implementation of those policies and programs (Williamson, 2001).

The failure to recognize land administration systems as an infrastructure creates potential funding and maintenance issues. Consequently, a wider economic, social and environmental benefits of effective land administration are put at risk. The results of three empirical studies support the notion that land administration is a critical, public good infrastructure (Bennett, Tambuwala, Rajabifard, Wallace, & Williamson, 2013).

The primary purpose of the Land Administration System (LAS is to register legal or other (in)formal people to land relationships. In addition to its primary purpose, the LAS can, and should, serve as a basis for the formulation of sustainable land policies and land management. Unfortunately, traditional land administration systems are at present unable to meet additional requests, even in developed countries. The ongoing modernization and reform processes must be supported by scientific research. This paper focuses on public land registers data as an infrastructure that supports the development of society and economy and discusses the option to make the data available for research purposes to underpinning LAS reforms.

2. LAND ADMINISTRATION INFRASTRUCTURE

Almost all data and information relate to a location and form a geoinformation infrastructure (GII). Recently, more and more private companies and nongovernmental organizations are engaged in geoinformation everyday jobs and contribute to the development of geoinformation infrastructure. In addition to participating in international standardization committees (e.g. ISO), private companies form associations and establish common institutions (e.g. OGC) that jointly develop standards for a production, storage and dissemination geoinformations by means of services. Private companies are more effective in every respect than state institutions and also gradually take on the primacy of geoinformation production. They become a more important factor of geoinformation infrastructure than public institutions, which develop a national spatial data infrastructures (NSDI).

A part of the geoinformation infrastructure are a national spatial data infrastructure (Figure 1). They are being developed by the competent public authorities of a country as, until recently, the only producers of geoinformation. A large amount of existing geoinformation, managed by public authorities, is poorly (re)used, and efforts are being made to overcome this by the development of NSDI. National spatial data infrastructure has received great attention and there have been numerous achievements in many countries. Nevertheless, in numerous countries there are multiple simultaneously proposed standards, disagreement in basic issues such as coordinate reference systems and limited understanding in the value and use of metadata.

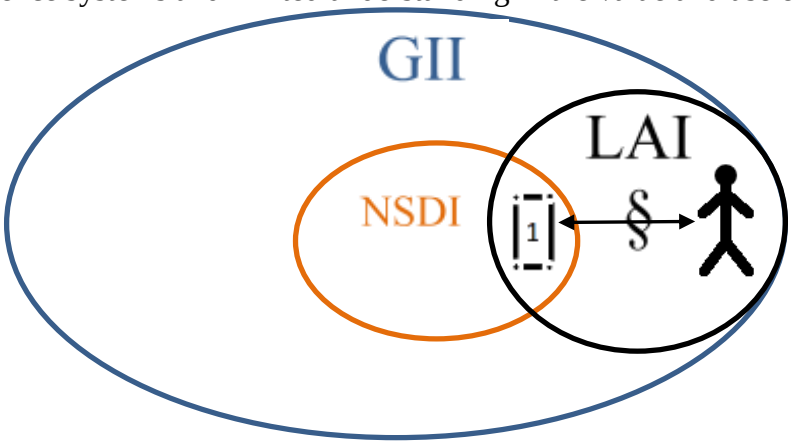


Figure 1. Land administration infrastructure as part of geoinformation infrastructure

Land information are the content of many official registers and an important part of the (geo)information infrastructure. Most land information is registered into cadastre and all other registers are in some way related to him. They can hardly be established without a cadastre and are frequently established by taking cadastral data and adding a set of data that is significant to the resource for which the register was established. Land information registered in the cadastre is the most comprehensive and the highest quality set of existing geoinformations in many countries. This is recognized by the development of NSDI endorsing cadastral as the fundamental data set of NSDI. The cadastral map is, therefore, a base layer of data necessary for effective land management within the geoinformation infrastructure (Roić, 2012).

Cadasters, one of the oldest and most long-standing official registers, are established primarily for the registration of private property rights. They were, originally, left out of public land as areas in special legal regimes managed by public authorities (public good, common good, etc.). For those areas, registers were set up unconnected from the (private land) cadastre (e.g. Public Land Cadastre, Railways Book, Forest Cadastre, etc.). The cadaster, and all other registers containing officially registered land and land tenure data, constitute a land administration infrastructure. The most important characteristics are that it contains information on people to land relationships, however this is not the case for other parts of the geoinformation infrastructure. Since phenomena are mostly caused by people, having the information is crucial to understand an environmental changes and development.

In addition to land information, which they register and maintain, public authorities are also responsible for the registration of many other data, thus, producing and maintaining statistical, financial, economic, traffic, legal and many other sets of information. Some of them are protected by copyright, and others are not. They all have huge potential to be used to make economic progress if they are available and used in multiple ways, i.e. in new ways, by adding new values through combining data and information from multiple registers. Linking public sector information to a location and linking it with other information can create a multitude of new location-based services. The precondition for further development is the clear and rapid availability of public sector information (Tanaka & Takagi, 2016).

In many public sector institutions, the culture tends to be somewhat conservative. This leads to conservative practices concerning data sharing, risk taking and the acceptance of innovative technology. Especially challenging is data sharing, where people to land relationships are registered due to personal data protection rules. This prevents access to data for scientific research in the field of land administration on factual data.

3. CYBERINFRASTRUCTURE

Data sharing and reuse yield great benefits for society and scientists and scholarships, including innovative research opportunities, justification of existing results, increased efficiency in the research, increased research potential by combining new data with reused data and effective knowledge exchange. The results of multilevel analysis on scientists' data reuse behaviors show that there is a significance between-discipline variances as well as within-discipline variances in the impacts of both individual and disciplinary factors on data reuse intentions (Kim & Yoon, 2017). An initial survey on scientific data repositories conducted on the web identified and described characteristics that shows heterogeneity in the approaches to data sharing and handling procedures across domains (Marcial & Hemminger, 2010).

Geospatial Cyber Infrastructure (GCI) refers to a cyberinfrastructure that utilizes geospatial principles and geospatial information to transform how research, development and education are conducted within and across science domains (such as the environmental and Earth sciences). Over time, the amount and availability of geographic information has grown exponentially, and a new dedicated GCI is needed to process and integrate geospatial information to, for example:(a) provide LBS for stakeholders, such as place-based policy

makers, (b) supply geospatial analysis and modeling as services and (c) support scientific and application problem solving across geographic regions (Yang, Raskin, Goodchild, & Gahegan, 2010).

Following experiences in developing cyberinfrastructures for scientific applications in other disciplines, there is an increase in explored requirements and recommendations on the publication of scientific geospatial data and on functionalities to be provided (Bernard, Mäs, Müller, Henzen, & Brauner, 2014). An urgent need to improve the infrastructure supporting the reuse of scholarly data initiated the endorsement of a concise and measurable set of principles that is referred to as the FAIR Data Principles. The FAIR Principles put specific emphasis on enhancing the ability of machines to automatically find and use the data, in addition to supporting its reuse by individuals (Wilkinson et al., 2016).

4. DEMLAS PLATFORM

Land administration reform by its very nature is long term and, as such, there is a need for permanent research and development activities. Consideration of the importance of land administration systems has recently increased. More and more research is being conducted, however, there is a constant lack of factual data and information of public registers. The exploitation of existing land information resources and services from various registers has shown that services do not exist and data, if available, are heterogeneous and not suitable for research.

To overcome the lack of research data, the land administration cyberinfrastructure is developed and realized within the DEMLAS project. The project priority goals were set as:

- develop temporary warehouse and link it to available official warehouses (registers),
- define the requirements of data producers and users,
- develop new products and services.

The work from involved researches in diverse sectors is required to achieve the planned goals in the project. With the exception of academics, the project incorporates land administration experts from the private and public sector. The researchers were subdivided into groups in which the primary interest was land administration, the land management, and the group whose focus was on land surveying.
Key directions of the research were in the fields of conceptual modeling, modeling of land administration processes and support for land governance monitoring.

Research is based on official registers data which were obtained from the institutions responsible for the upkeep of a specific register. User requirements to the land administration system are analyzed and documented by use cases. Typical use cases have been developed and tested in the final phase of the project as the cyberinfrastructure was available.

The needs for land tenure information are huge, and user's requests answers on questions including:

- Is the parcel of land registered and what is the area?
- Who owns it?
- How much is it worth?
- Is it permitted to cut the forest?
- Is there a building permit?
- Was it land use?
- What are the conditions for obtaining public land?
- Is the boundary in dispute?
- Which body of public authority is competent?
- Can I fish there?
- …

To be able to carry out research on land administration systems it is necessary to have factual and official data available. They are stored in official registers (Cadastre, Address register, etc.), usually incompatibly modeled and semantically difficult to compare. In addition to land administration data, for suitable research data from other parts of GII and are included in the platform. There are available online services (OSM, Google maps, Bing maps, etc.) that can serve as supporting sources for a land administration research (Figure 2). The project developed the cyberinfrastructure to enable an easier combination of heterogenous data sources. The infrastructure consists of data warehouse, metadata and user interface. In the warehouse, from previous research, available data and the data acquired within the project were stored. All data sets in the warehouse are described by metadata.

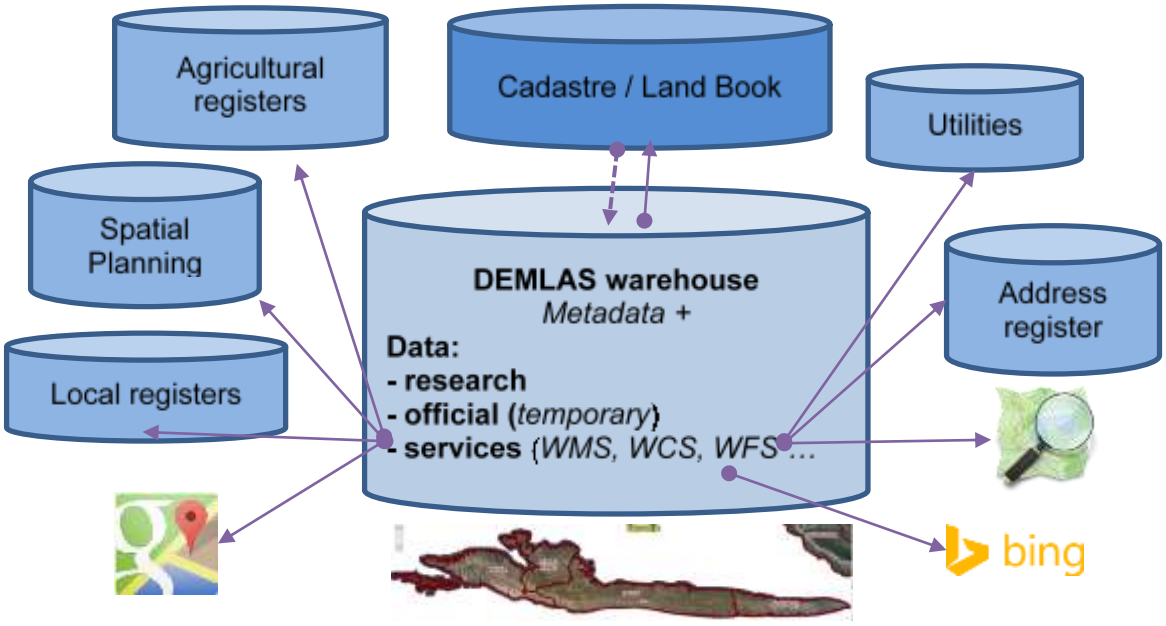


Figure 2. Warehouse and linked data sources

The development of the infrastructure is based on the principles of open science/data principles are what add additional value. DEMLAS cyberinfrastructure is fully developed using open

source free software, and the original source code is available for reuse. Open access primarily refers to online access to research data, allowing users to freely read and reuse content with the only obligation that the author is cited. Open access is key to free flow of information between researchers and society.

Land administration data is stored in registers using various formats. They are taken and stored temporarily in the warehouse. The warehouse is prepared for text, raster and vector data and data in several logical database models. The warehouse supports the storage of a textual cadastral data, raster sheets of the historical cadastral map, the electronic cadastral map, etc. The data is stored in the warehouse in the original form of the register. The research results of the original data are also stored in the repository and are available for future research, thus, allowing the reuse of scientific data and information.

Data is searchable and accessible to all users. The interface (Figure 3) allow users to search, create and manage metadata, preview, download and upload data. The access and use of data is free for all users while upload requires registration. Registration and compliance to special rules are mandatory for the use of personal data.

Figure 3. DEMLAS interface (Divjak, Roić, & Pivac, 2018)

Users can search for available land administration data that are described in a metadata catalogue. Given the importance of metadata in facilitating data and service discovery, research is conducted to facilitate ad hoc metadata generation, as well as formal metadata development processes. This research has addressed different metadata ontologies and the means for mapping metadata between metadata ontologies. This can support future integration into regional and global cyberinfrastructures.

Numerous types and formats of data are available, such as spatial sets of data, maps, measurements and accompanying spatial documents, pages, field notes, etc. It is possible to preview data by adding it to interface map or download and use it with your own software. In

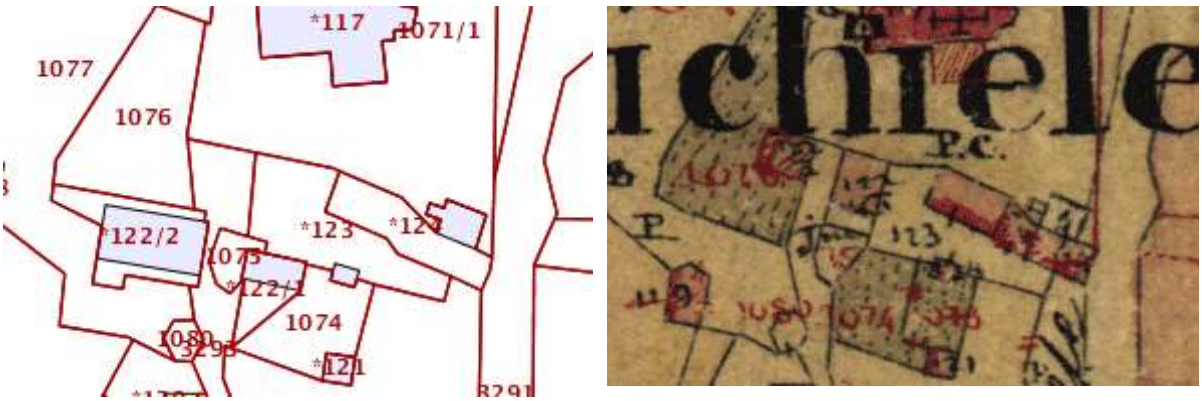
addition to the usual search modes, the interface allows the data search by the location where the user is located. This makes it possible to use cyberinfrastructure with mobile devices outside the office.

5. RESEARCH AND EDUCATION APPLICATIONS

Land administration systems and their technical components must be driven by the needs of the users. The usability of the infrastructure and the implemented data warehouse was tested on selected typical use cases:

- What information is registered on the parcel I am located on?
- Where is the nearest geodetic point?
- What is the planned use of the parcel on which I am located?

Research has shown that by combining data available in the warehouse these tasks can be completed more efficiently. In addition to official data, the infrastructure also includes historical data of the cadastre. This enables spatiotemporal research as well as practical research for students. Figure 4a shows the current state of the cadastral map obtained by vectorization of the paper map (Figure 4b). By comparing the registered parcel areas to areas calculated from electronic cadastral map, an unacceptable difference is obtained for parcel 123. From the picture 4b it is clearly visible that this is a mistake of the vectorization.



a) vectorized electronic b) source paper

Figure 4. Mistake of the cadastral map vectorization

The LAS's usability is limited if data coverage is not provided for the whole jurisdiction. Research has shown that although registered in several registers, maritime domains still lack necessary land tenure data. The application of the land administration system can be manifold and within the project, using the established data infrastructure, we analyzed applications in spatial planning and risk management activities. We have also investigated the classification of areas that should be prioritized for land consolidation. Outdated data are a chronic lack of registers. Data quality also can be investigated and solutions for monitoring the registers developed. Among others, an effective land administration system should provide land monitoring indicators so that appropriate land policy measures can be implemented.

The importance of the DEMLAS project was to create a platform on the cloud where land administration data is accessible for researchers. The platform offers the infrastructure needed for research on the integration of existing datasets related to lands and tenure. The platform allows data publication and data search which enables development of specific applications and services for the support of planning and policymaking. The project is addressed to researchers and students from the land administration sector. Researchers have the possibility to experiment on factual data, for the development of new applications and services.

In further developments, the usability of the infrastructure will be improved. That includes enhancements of interoperability, especially in terms of semantics, advance dealing with time and spatiotemporal information, assuring intellectual property rights for provided data and enable automatically collecting, storing and publishing indicators for land governance assessment.

6. CONCLUSION

There is a lot of restriction on access to the land administration registers data. Some of them are justified due to the protection of personal data, however, many other restrictions can be overcome. Research by factual registers data can make a significant contribution to this. The creation and use of land administration cyberinfrastructure supports research and fundamental training in the relevant aspects of land administration systems, as well as the promotion of increased appreciation for the science drivers. The land administration cyberinfrastructure approach is one strategy in facilitating the training and research in this area. Many of the difficulties described above are relevant to the establishment of cyberinfrastructure-based training and research on land administration systems. The multidisciplinary research team developed platform that is an important next step in the cyberinfrastructure paradigm. The initiation of research regarding the structure and use of cyberinfrastructure to address large-scale spatial data as scientific issue is one of the most significant advances of the project.

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BIOGRAPHICAL NOTES

Miodrag Roić graduated in Geodesy from the University of Zagreb, Faculty of Geodesy. In 1994, he received a PhD from the Technical University Vienna. Since 1996, he has been a professor at the University of Zagreb, Faculty of Geodesy. He was Dean of the Faculty 2011-2015. The topics that he specializes in are Cadastre, Land Administration Systems, Engineering Surveying and Geoinformatics. He is a corresponding member of the German Geodetic Commission (DGK) and many other national and international scientific and professional institutions.

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