

Designing Future Land Administration Systems: A Practical Approach

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Key words: land administration system, LADM, standard, cadastre, land use, land value

SUMMARY

Today's land administration systems include numerous functions and services for managing land information. However, due to historical developments of different authorities, these functions and services are usually operated in a heterogeneous environment. One of the possible means to address this situation is the implementation of standards. Standardization is an established approach for organizations to coordinate and organize their resources and processes to ensure product and service quality and to raise work efficiency. One of the most dominant standards in land administration domain is the LADM. Initially released in 2012 as a generic conceptual model, LADM is revised and in its second edition covers all functions of land administration. However, the sixth part of the second edition, which is expected to include implementation aspects, is currently yet to be developed. Most of the previous research papers have dealt with design and capabilities of LADM through development of country profiles. This has resulted in two approaches or methodologies for development and adoption of LADM. In this paper, the authors provide third proposal which is mainly focused on tasks to implement LADM into existing LAS. The proposed methodology consists of three phases which include steps which could lead to potential implementation of LADM. The proposed methodology is described in context of Croatian land administration system on a conceptual level. Furthermore, the paper discusses potential challenges in modeling different sets of land administration data and importance of optimizing use cases through standardized data organization.

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1. INTRODUCTION

Today's land administration systems (LASs) include numerous services and functions for managing land information. Generally speaking, there are four main functions of land administration, namely, land tenure, land use, land value and land development. (Enemark 2006). These diversified services and functions have their own view and interpretation of their importance, use, and application; they also have unique vocabularies and are quite autonomous, employing different procedures which are usually defined by regulations affecting their domain (Kalantari et al, 2006, Kalogianni et al. 2020). This heterogeneous environment is caused mainly by historical developments of jurisdiction areas, and is present in most of the LASs around the world (FIG 2022; UNECE 2021).

The transition of these heterogeneous functions into an integrated LAS could be achieved through the development and implementation of international standards. Standardization is an established approach for organizations to coordinate and organize their resources and processes to ensure product and service quality and to raise work efficiency. The objects of standardization usually include network technologies, operating systems, database systems, applications and processes (Ahlemann et al. 2023). In domain of geospatial data, for few decades, the Open Geospatial Consortium (OGC) has developed data technology standards and has grown into the worldwide leading organization for the geospatial IT domain. On the other hand, a more formal standardization organization is International Organization for Standardization (ISO), in which, one of the most dominant standards have been published to describe LASs, namely ISO 19152 the Land Administration Domain Model (LADM). This standard represents a generic conceptual model for describing relationships between people and land (van Oosterom and Lemmen 2015).

The first edition of LADM included eight country profiles and since the initial publication, the development of country profiles has significantly increased. So far more than 40 country profiles have been developed, making LADM a highly relevant international standard (Kalogianni et al. 2021). However, standardization is complex and challenging process (Simonis 2019). The second edition of LADM is currently under final stages of development and covers all of the LA functions (Kara et al. 2024). This will enable upgrades of existing country profiles with new functions or encourage those who have never tackled with standardization of LASs to experience the possibilities of LADM in its full extent.

There are two known approaches for incorporating LADM into LAS. First being presented by Kalantari et al. (2015), which describes roadmap for LADM adoption and second being a generic methodology for developing a LADM country profile proposed by Kalogianni et al. (2021). The objective of this paper is to propose a third, more practical approach for designing future LADM based LASs on a case study of Croatian LAS.

The proposed methodology is somewhat based on previous experiences and findings, but utilizes some steps in different order to enhance practicality and operational aspects of implementing standard into existing LAS. The goal of this paper's findings is not to present a

complete solution for implementing LADM, but to discuss operational steps, workflows, and possible outcomes, as well as to identify potential challenges.

The paper is organized as follows: the second section describes previously-developed approaches and practical approach proposed in this paper. The next sections deal with phases of proposed methodology by utilizing experiences from Croatian LAS. Finally, possible outcomes, challenges and future work are discussed.

2. METHODOLOGY

Standard characteristics include all the features of the standard that make it superior to current practice. This results in a higher chance that it will be adopted. These characteristics usually refer to technological superiority, relative advantage, observability, comprehensibility and customizability (Van De Kaa 2023). The said characteristics can be found in LADM as well. Firstly, technological superiority is evident, since there is no internationally recognized standard for development of LASs. Relative advantage usually refers to benefits of implementing standard, e.g. higher reputation of organization or accreditation. Observability refers to extent to which the standard is known by the organization, e.g. better understanding of the benefits leads to higher adoption rate. In most cases, the LADM research included experts from academia, industry and public sector (Kalogianni et al. 2021). Furthermore, the comprehensibility, refers to extent to which the standard is understood by the organization. In some cases, the standard may be found to be too complex and difficult to understand. In case of LADM, this is validated by cooperation between academia, industry and public sector as well. Lastly, customizability is one of the core attributes of LADM, as it is not prescriptive, but descriptive standard. This means that LADM can be adapted to cover specific components of targeted jurisdictions (Kalogianni et al. 2021; Lisjak et al. 2021; van Oosterom and Lemmen 2015; Vučić, Markovinović, and Mičević 2013). Given the fact that all of the said characteristics can be linked to LADM, the question which remains is how to successfully implement it into existing LAS.

There are two known general approaches concerning LADM implementation. First one is a roadmap, consisting of six stages leading to adoption of LADM. This roadmap (Figure 1) was proposed by Kalantari et al. (2015) and tested on two use cases. This holistic view reveals more non-technical considerations such as organizational motivation, arrangements or capacity building. The authors have tested roadmap on a well-established LAS in Australia and suggest that it might be difficult to justify the introduction of LADM into the existing system. On the other hand, in case of newly-established LAS, they suggest that LADM could provide new opportunities as well as challenges. Some of the identified challenges include technical aspects such as data conversion of textual documents and organizational aspects such as negative impact on the performance of existing staff. Furthermore, the authors argue that in cases of well-established LAS, the first three stages of the roadmap could be skipped.

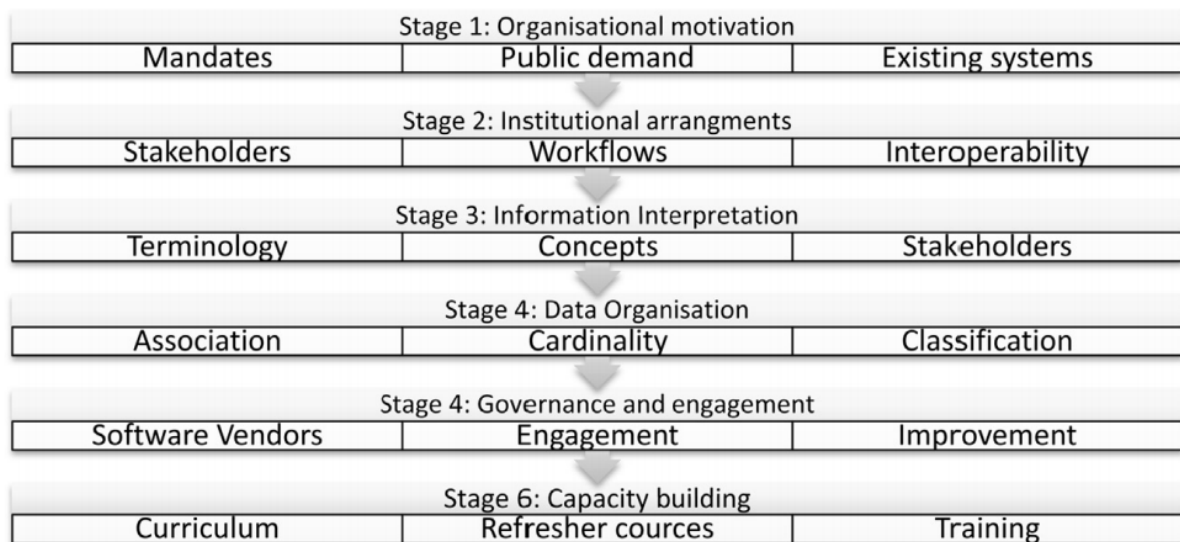


Figure 1. A roadmap to adopt LADM in a land administration organisation (Kalantari et al. 2015).

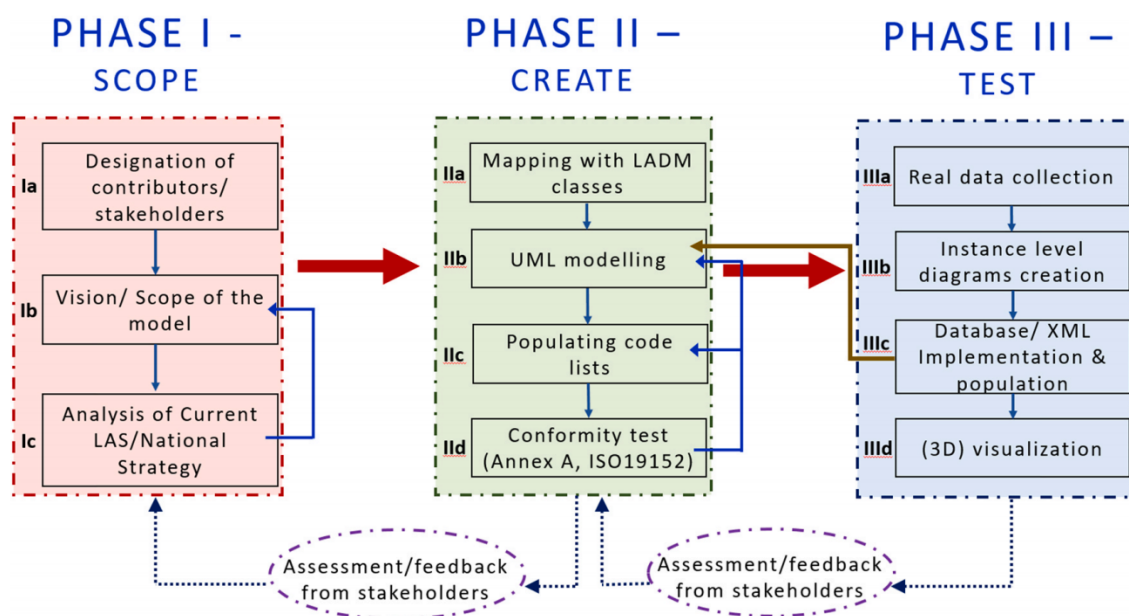


Figure 2. Phases of the LADM-based country profile development (Kalogianni et al. 2021).

The reverse engineering is defined as process of analyzing a subject system to identify the system's components and their interrelationships and to create representations of the system in another form or at a higher level of abstraction (Chikofsky and Cross 1990). Additionally, the focus of this methodology is to focus on operational aspects which usually include practical steps and real-world use cases. The proposed methodology is shown in Figure 3 below.

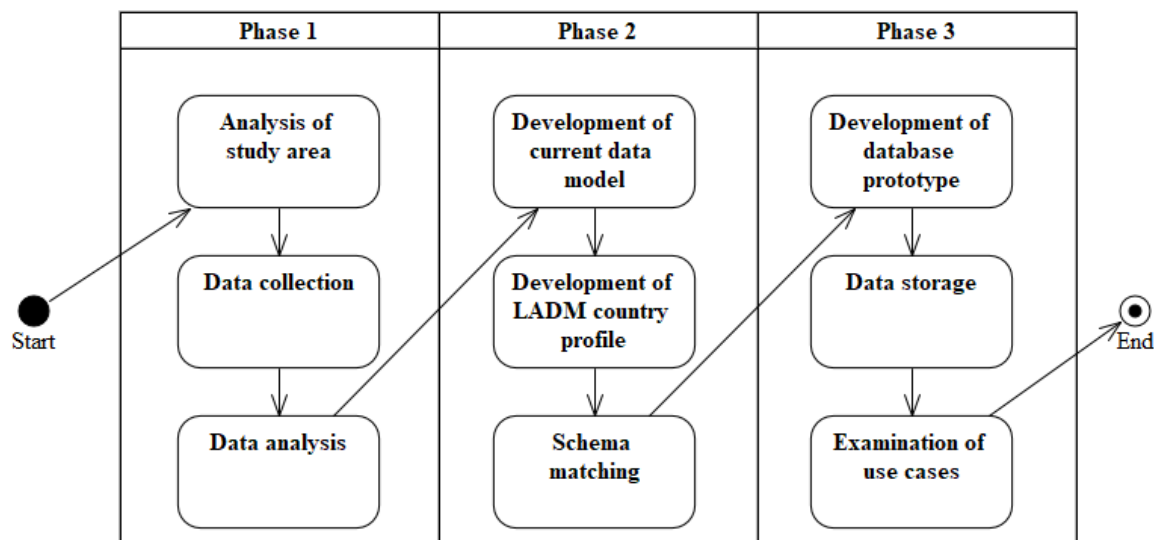


Figure 3. Methodology for implementing LADM.

The proposed methodology consists of three phases; first phase refers to determination of study area or jurisdiction data collection and analysis. Second phase refers to modelling, similar to methodology from Figure 2, but includes additional modeling of existing LAS. This may be crucial in adoption as it could be used to showcase issues of existing model and why is LADM based one actual improvement. Furthermore, schema matching should be used to establish relations between existing and standardized model. The third phase refers to realization and implementation. In this phase the developed country profile model should be translated to database. Furthermore, the collected data should be adjusted to requirements of standardized database and ready for examination of use cases. The development of use cases, or improvement of existing ones may be the most important evidence for the need to implement LADM into existing LAS. Further sections will describe each phase of the proposed methodology on a case study of Croatian LAS.

3. PHASE I: Study area, data collection and analysis

Croatia is organized as a two-tier system of local self-government existing alongside a parallel cadastral division. At the administrative level, the country is divided into 20 counties plus City of Zagreb. Under these counties there are 128 cities and 428 municipalities, which together form the basic units of local self-government (LSG). In parallel with the administrative structure, Croatia is fully covered by a network of approximately 3300 cadastral municipalities. For the purposes of this case study, this paper explores data in regard to land tenure, land use and land value. Land tenure function is in domain of cadastre and land book, or simply cadastral system.

Croatian cadastral system is mainly managed by State Geodetic Administration (SGA) and local cadastral offices. Data is stored, maintained and disseminated via Joint Information System (JIS). Land use function is imposed by spatial planning, which is on state level in domain of Ministry of Physical Planning, Construction and State Assets. Their responsibilities include state-level regulations and provision of Physical Planning Information System (ISPU) in which some parts of spatial planning data are disseminated to users as well as functions to submit land development requests (e.g. building permit, location permit, etc.). Additionally, it is regulated by law that each LSG is required to develop spatial plans for its area and disseminate spatial planning information publicly via designated website. Spatial planning data consists of spatial plan map and textual part of spatial plan, which detailly describes zoning regulations. Land value function is in domain of Ministry of Physical Planning, Construction and State Assets as well. This data is collected and stored via Real Estate Market Information System, which is only accessible with authorization. However, some of the land value data is disseminated via ISPU as approximate value blocks.

It should be noted that same regulations apply to each cadastral municipality equally, as well as spatial plans and value blocks as they must be made in compliance with state laws. This means that the proposed methodology does not need to be examined at a country-level, but on the level of the LSG unit which can be later scaled to cover entire country. We propose this approach as it may potentially lead to pilot development.

For purposes of developing LADM profile according to proposed methodology following data sets are required: cadastral system data, spatial plans (map and textual part) and land value (land value blocks). One of the possible obstacles, when modeling area of one LSG unit is that the boundaries of cadastral municipalities do not always align with the borders of administrative units. This can potentially create challenges for spatial planning, property registration and coordination between administrative and land administration authorities.

The identified authorities, registers and data sources are presented in Figure 4 below. Notably, this is only part of the Croatian LAS stakeholders required for the purposes of justifying the proposed methodology.

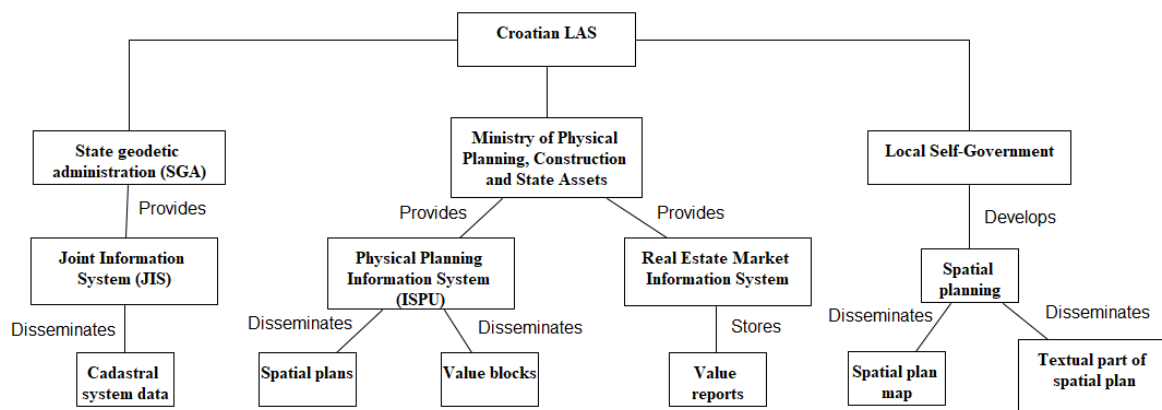


Figure 4. Overview of identified stakeholders, services and data.

Croatian LAS represents a heterogeneous system in which each set of LA data is governed by different authority. As per scenario modeling defined by UNECE (2021), Croatian LAS can be identified with three scenarios, namely conventional, as-a-service and platform LAS. Data is captured and updated in a controlled way, services and processes are regulated in detail and

functions, operations, services and data are managed by public authorities. In case of some LAS data, private sector is involved in technical system development and maintenance through public-private partnership. Example of this partnership is JIS. Apart from being data dissemination service, JIS represents a form of platform LAS as well, since it includes functions for other professionals such as lawyers, banks, notaries and surveyors. The identified data sets are presented in Table 1 below.

Table 1. Identified data sets, formats and sources.

Data	Format	Source
Cadastral system data	GML	JIS (URL 1)
Spatial planning data	PDF	Local-Self Government website (URL 2)
Land value data	Shapefile	ISPU (URL 3)

For purposes of professional use, cadastral system data can be exported in GML format, however, via JIS it is not possible to retrieve data for entire municipalities. Such request must be directly submitted to SGA. The data includes every piece of information stored in cadastral system disaggregated into multiple GMLs. This includes points, boundaries, buildings, owners, registered land uses, etc.

Spatial planning data is usually available via official websites of LSG units. Additionally, spatial plans are available via ISPU, but can only be retrieved from official LSG websites. This may be one of the most challenging data sets, as both graphical and textual parts are provided in PDF format. This may require requesting data in digital format from designated authority which can sometimes be quite time consuming. In this paper the authors provide example of spatial planning data from Stari Grad on the island of Hvar, Croatia.

Land value data is represented by land value blocks. As per information provided in ISPU, the data is available in shapefile format, but cannot be retrieved directly from ISPU. In that format it is only available to land appraisers, real-estate agents and LSG officials and must be requested from the Ministry of Physical Planning, Construction and State Assets.

4. PHASE II: Modelling and matching

First edition of Croatian LADM country profile was developed by Vučić, Markovinović, and Mičević (2013). Since initial development, several adjustments have been made and attempts to expand the country's profile with elements of second LADM edition. Tomić et al. (2021) have modeled Valuation Information Model and Spatial Planning Information packages in context of Croatian LAS to test the applicability of LADM for purpose of effective mass valuation. Lisjak et al. (2021) have extended country profile with agricultural land management for purposes of managing state-owned agricultural land. Križanović and Roić (2023) have modeled some of the most common data dissemination processes in Croatian LAS and matched process elements with existing LADM classes, but also identified which classes are missing from current version of LADM.

Mađer, Matijević, and Roić (2015) have explored possibilities of linking cadastre with other relevant registers, such as registers of non-natural and natural persons. Their findings have resulted in identification of major redundancies within the registers in Croatian LAS. Overall, the research regarding implementation of LADM in Croatian LAS is extensive and indeed

proves the need for LADM adoption. However, now that the LADM II is becoming official and parts are being published (or in final form), it may be time for new development of Croatian's LADM country profile.

Since cadastral system data was modeled previously on case of Croatian LAS in Mađer, Matijević, and Roić (2015), this section will describe modeling of land use and land value data. The part of methodology concerning development of LADM country profile is also already known to LA experts, therefore it can be only stated that the model should be developed in accordance with LADM II models and adjusted to targeted jurisdiction.

Value blocks can be divided into three themes, namely, blocks for land value, apartments and buildings and lease prices (Figure 5.) Additionally, the land value blocks provide information for different time periods, and as can be observed in Figure 5, there are land value blocks for years 2020 to 2025 available for the area of Stari Grad, Hvar.

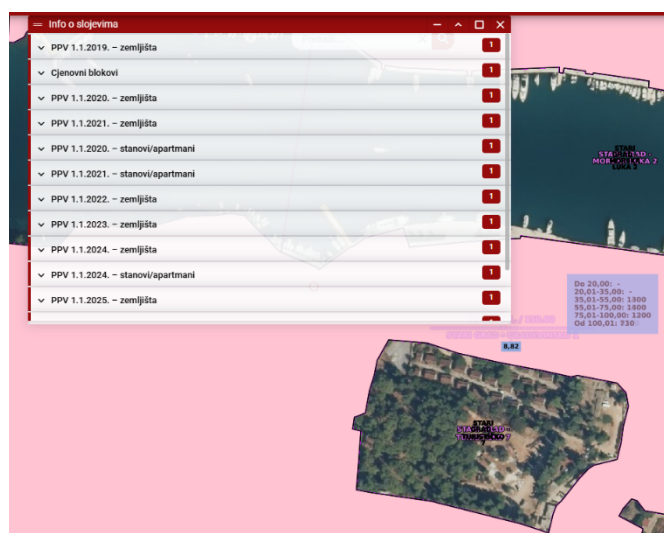


Figure 5. Part of land value blocks for Stari Grad, Hvar.

Value blocks for land have 29 attributes, blocks for apartments/buildings have 12 attributes, while blocks for lease are described with 5 attributes. Attributes for land value blocks are shown in Figure 6 and include combination of spatial planning attributes and attributes required by valuation system. These include name of the value block, administrative area, type of land, land category, current land use, planned land use, approximate values per square meter.

▼ PPV 1.1.2024. – zemljišta	
Naziv cjenovnog bloka	STARI GRAD - GRAĐEVINSKO 1
Pretežita namjena	(GP) MJEŠOVITA NAMJENA
Koeficijent iskoristivosti (Prostorni plan)	
Administrativno područje	
Datum utvrđivanja PPV zemljišta	20240101
Vrsta zemljišta	Građevinsko zemljište (GZ)
Kategorija zemljišta	1.
Koeficijent iskoristivosti (uzor čestica)	0
Namjena zemljišta	S
Približne vrijednosti zemljišta (EUR/m2)	159

Figure 6. Part of land value blocks attributes.

As can be observed from the Figure 6, some of the attributes remain empty, and those are related to address register (e.g. administrative area) and spatial planning (e.g. coefficient for floor area ratio - FAR). It can be stated that this is one of the evidences for need of integrated LAS, as it would avoid empty attributes of land value blocks. But in regard of modeling land value data, this shouldn't be an issue as these attributes can be easily determined and matched with models from LADM. The real challenge could be in modeling spatial planning data.

Spatial planning data is indeed complex. The data includes zone plans, planned infrastructure plans, water bodies, areas of protection and textual descriptions of zone rules and other regulations. Figure 7 and Table 3 represent parts of spatial plan and textual descriptions of construction zone for Stari Grad, Hvar.

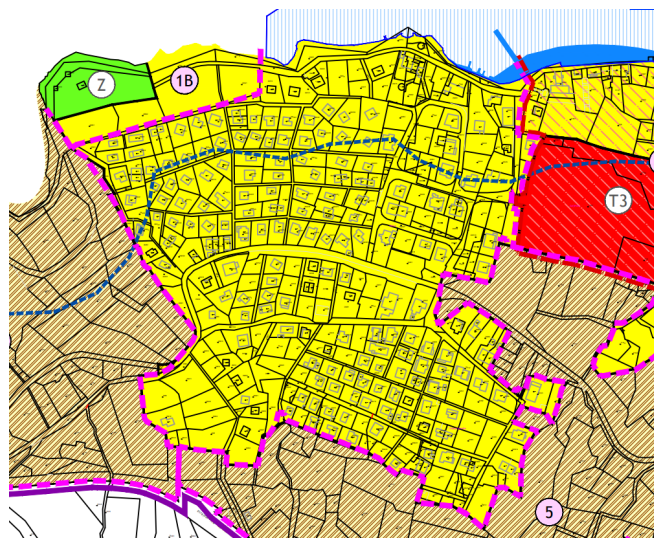


Figure 7. Part of spatial plan for Stari Grad, Hvar.

One of the first issues which arise from inspecting spatial planning data is the fact the colours are used to distinguish different planning zones and codes for their sub-zones. This means that as per this example, yellow colour is for residential zone, which further divides into sub-zones with different rules (e.g. 1B sub-zone in Figure 7), meaning that there are general rules for each planning zone and additional rules for sub-zones. Furthermore, textual part of spatial plans describes zone rules in detail providing their basic attributes. These attributes are additionally constrained by other spatial units, such as cadastral parcels. Some of the rules and constraints for residential zone of Stari Grad, Hvar are presented in Table 2 below:

Table 2. Part of planning rules for residential zones.

Attribute	Condition	Value / Limit
Total utilization of building parcel (FAR)	For single-family buildings	1.0
Total utilization of building parcel (FAR)	For parcels > 800 m ²	Max 800 m ²
Site coverage ratio	Detached buildings	≤ 0.3
Site coverage ratio	Semi-detached buildings	≤ 0.35
Building parcel size	Detached buildings	500 m ² – 2000 m ²
Building parcel size	Semi-detached buildings	400 m ² – 1000 m ²

From Table 2, it can be observed that cadastral parcel area defines the type of building which can be built, as well as total utilization of cadastral (building) parcel. Given the complexity of

spatial planning data, which includes spatial units (zones and sub-zones), their attributes (general rules and sub-zone-specific rules) and special constraints (factors from other functions), we propose a workflow shown in Figure 8 below.

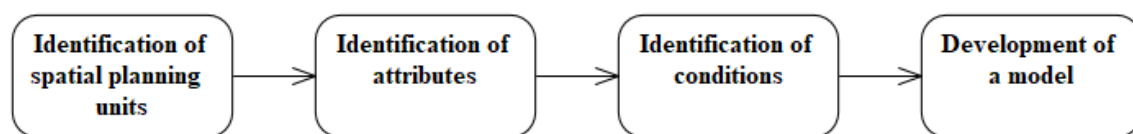


Figure 8. Modeling of spatial planning data.

This is different from modeling cadastral system and land value data because of imposed conditions which are truly diverse and depend on many factors contained within spatial planning domain as well as other domains such as cadastral system data (e.g. area of cadastral parcels). Lastly, another issue might arise with spatial planning data in case of Croatian LAS, which is related to availability of spatial planning data in electronic format. In cases when data is only available via PDF format, it could require complete digitization of spatial planning data prior to any further analysis or modeling.

5. PHASE III: Realization and examination of use cases

Third phase of the proposed methodology may be the most important one into adopting LADM for existing LASs. Usability and performance of the country profile can only be evaluated by its implementation. Kalogianni et al. (2021) propose two approaches, namely database implementation and data exchange format between systems. This part should really depend on technical capabilities of experts conducting the methodology or the most convenient available technology. In Croatian LAS majority of LA data is stored in databases, therefore; development of a prototype database is would be logical step after the modeling. The standardized database would be used to store real data in a standardized format. Additionally, the relations between different data sets would be established. This enables the examination and development of use cases. Use cases pose a very helpful tool to justify the adoption of standards such as LADM as it offers means of improving data organization by means of interoperability and integrity.

Generally, the LAS use cases can be split between those conducted by professionals and citizens. This paper will demonstrate how to improve two use cases in Croatian LAS with potential LADM data integration. The use cases are demonstrated on a conceptual level without too many details regarding steps and procedures.

For the purposes of use cases, the point of view is from a citizen user requiring LA related information for parcel of interest. Both of the presented process use cases are carried out without any professional knowledge or help, only by utilizing existing services and data sources. The first use case (Figure 9) describes activities of a LAS User, who is utilizing LA services to obtain spatial planning information for certain cadastral parcel of interest. As was identified in Phase I, cadastral system data is provided by SGA via cadastral system data service, the JIS. Spatial planning data is provided by LSG via official website. Activities include accessing data services, locating cadastral parcel of interest, identification of planning zone, examination of zone regulations and then finally summary of collected data. The second use case (Figure 10) describes activities of a LAS User who is interested in finding approximate values for cadastral

parcels in area of interest. The activities again include accessing data services, locating cadastral parcel of interest, identification of value blocks, examination of value block attributes and then finally summary of collected data.

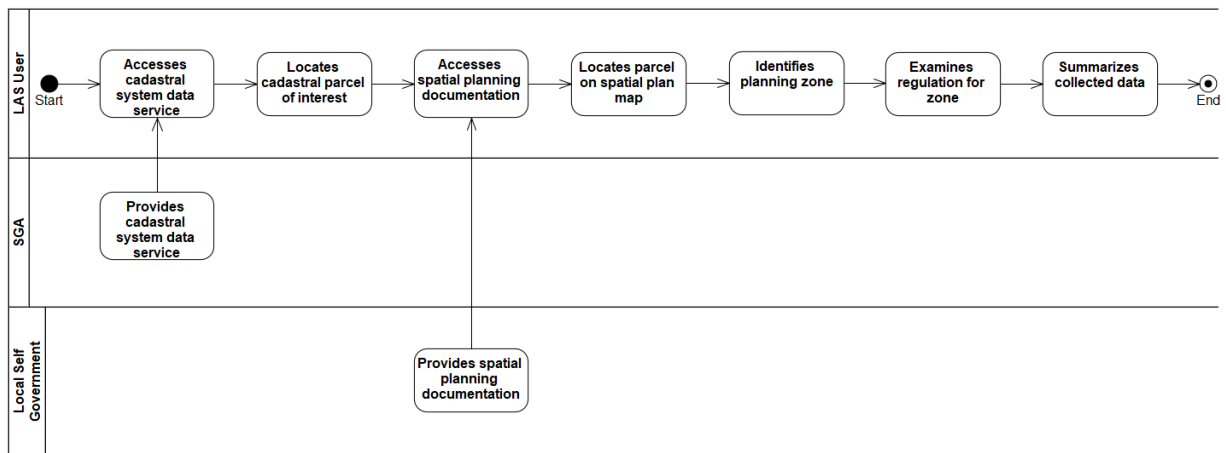


Figure 9. Use Case 1: Retrieval of spatial planning data.

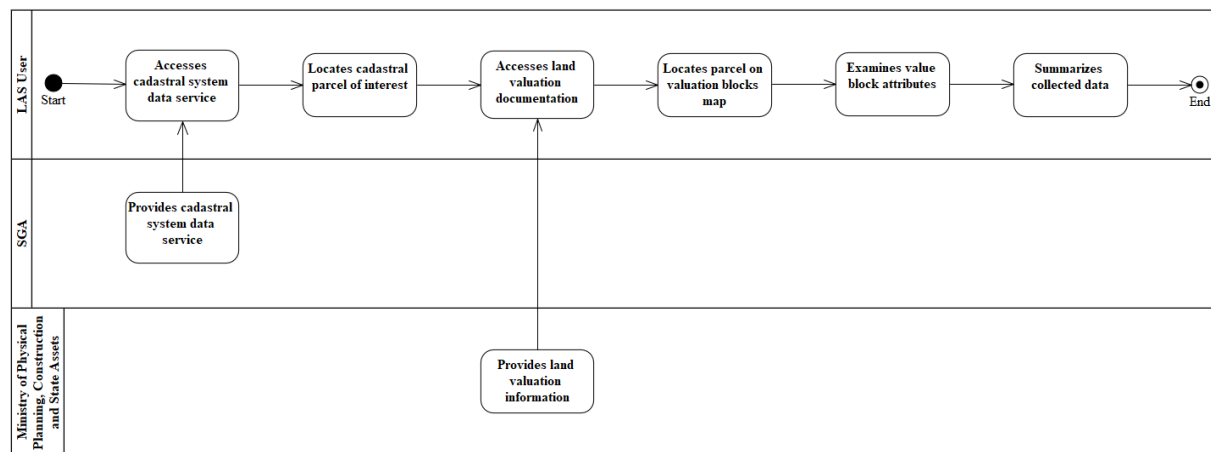


Figure 10. Use Case 2: retrieval of land valuation data.

Figures 9 and 10 depict simplified use cases of LAS User retrieving data from different LA functions, namely land use and land value. These are one of the most common use cases for LA data dissemination in Croatian LAS.

As it can be observed, the majority of activities is conducted on the User's side of the process. For non-professional users this may be very difficult and potentially lead to discourage into using LA services and data. Of course, professional users can do these processes quickly as they possess domain knowledge and know-how with LA data. In order to improve the overall service quality and enable optimized use of LA data for all kind of users, integration, optimization and automation are necessary.

Figure 11 presents a conceptual use case, which utilizes both previously described processes, but the environment is set in interoperable, standardized LAS. The authorities provide services to central service which is accessed by User. In this scenario, the activities related to determining parcel-related data are conducted automatically by the central service. This

minimizes the interpretational errors and requires no prior knowledge by the user except the knowledge of existing service and means to identify area of interest. As can be observed from Figure 11, the majority of activities now fall under the services, leading to fully automated execution of data dissemination processes.

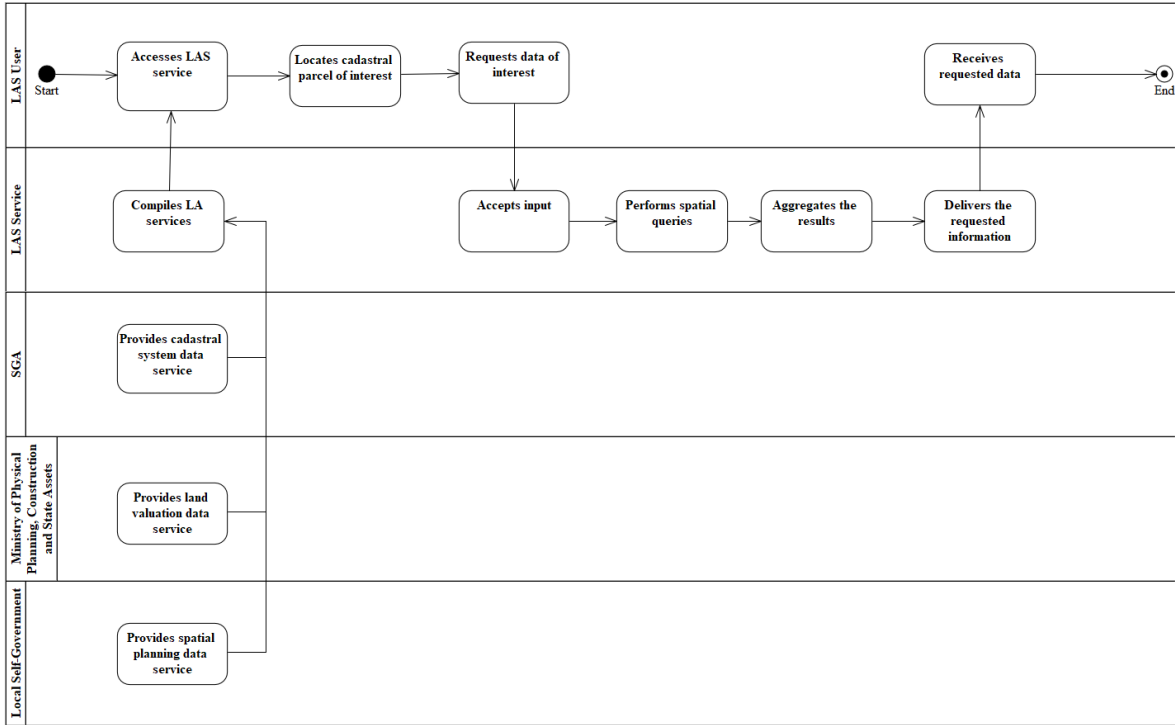


Figure 11. Improved state of the examined use cases.

6. DISCUSSION AND FUTURE WORK RECOMMENDATIONS

Implementing LADM into existing LASs is most likely going to be a complex task for all LA stakeholders. Complex data organization, procedures, regulations and autonomy of institutions may be more challenging obstacle to LADM adoption than developments of country profiles and new data models. This paper presents and analyzes practical approach to implementing LADM into existing LAS. The paper examines different parts of Croatian LAS through three phases of the proposed methodology.

It is evident that spatial planning data may be the most challenging to model and implement in an interoperable standardized environment. Furthermore, the approach to develop implementation models for LSG administrative unit may be endangered by fact that in some cases cadastral municipalities do not align with area of just one LSG unit. Additionally, from the examined use-cases, it is also very clear that processes can be improved and optimized for benefits of both professional and non-professional users. While majority of research papers dealt with developments of models rather than implementation aspects, this area is yet to be explored. Recently, it was announced that Part 6 of LADM, which deals with Implementation aspects, is to be developed in partnership with OGC (Kara et al. 2024; Unger et al. 2023). This may encourage more experts from private sector to get involved in LADM development since

OGC is known to have good expertise into developing practical standards for geospatial domain. The presented methodology may be observed as a mean to “sell” the standard to the authorities. This might be possible with identification of differences and similarities between existing and proposed LADM model. Moreover, the development of highly relevant use cases could be optimal solution to further boost the need for adoption of new technology presented by LADM and improve overall LAS services. Some other recommendations should be considered as well. Best practices for spatial data on web offer good starting points in developing modern LASs (URL 4) and should be utilized when developing new implementation models. Implementation of other standards shouldn’t be neglected as well, especially because LADM could be linked with or benefit from other domain-relevant standards. Future work should begin with collection of LA data from authorities and modeling. Finally, it can be expected that a detailed analysis of the existing state of LAS will additionally reveal the need for the implementation of LADM.

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