# Creation of spatial plans package for the representation of RRRs caused by spatial plans within the LADM standard: A case study for Turkey

**Yilmaz OKAN and Alkan MEHMET, Turkey**

**Key words**: LADM, Land Administration, Spatial Planning, RRRs, Standardization

## SUMMARY

Land management is a versatile, complex discipline that needs a legal framework. Participation and interoperability are important components of successful land management. Land Administration Domain Model (LADM), one of the international standards in which the land's rights, restrictions, and responsibilities (RRR) are represented, does not yet cover all RRRs. In-country profiles created using the LADM standard, RRRs from land registration and title deed (or agreement) systems are generally used. However, spatial plans, valuation, taxation, legal regulations, and land development decisions create RRRs on the land. In order to realize the holistic, participatory, and sustainable land management approach, value, plan, registration, land development, etc., data in different formats and different institutions should be associated with each other in a land management system. In particular, spatial plans have an essential place in integrating physical city models and legal models with the help of 3D legal RRRs and many other RRRs. As the pressure of urbanization increases, the effective use of limited areas is possible with spatial plans. There may be different RRRs at different levels of immovable property (underground or above). In the real-life spaces, we are used to, and in the virtual worlds and metaverses that have recently entered our lives, the owners do not have unlimited rights in their grids. To create ideal cities in areas where people (or avatars) live together, there must be rules that everyone must follow. Therefore, spatial plans play a key role in providing this order. This study aims to obtain outputs to create a spatial planning package in LADM. Thus, the goal of representing each RRR affecting the land in a standard model is expected to be closer. The spatial planning system of Turkey was taken as a basis for creating the package. Legal documents, sample plans, international standards (INSPIRE LandUse Thema, Plan4All project, etc.), and studies in the literature were examined. By examining the legal documents, the hierarchy of the planning system, authorized institutions, the scope of the plans, and the relationship between them was determined. With the help of this relationship, the classes of the spatial planning package were created. Codelists were created from the information obtained by examining the sample plans and official documents. It has been concluded that the package created is sufficient to represent the spatial plans of Turkey and the RRRs they have created. It is thought that by defining the relationship of the package with the LADM core classes, the spatial plans that form the RRR on the land can be presented in a standard model.

# Creation of spatial plans package for the representation of RRRs caused by spatial plans within the LADM standard: A case study for Turkey

**Yilmaz OKAN and Alkan MEHMET, Turkey**

## 1. INTRODUCTION

According to United Nations (UN) data, 55% of people live in cities today, and this rate is thought to increase to 68% by 2050 (UN, 2018). The UN's urban population projection notes that rural-to-urban migration will also play a part in this increase in addition to natural population growth. The increasing population density causes significant problems in cities' planned construction, access to clean water, and waste management. According to the United Nations Agenda for Sustainable Development Goals for 2030, many countries will face challenges in meeting the needs of their growing urban populations, including housing, transportation, energy systems, and other infrastructure, as well as basic services such as employment and education and health care (UN, 2018). Increasing urbanization increases the demand for land in cities. Due to the need for effective use of small areas, the most efficient use of land has led to the formation of property structures that 2D cadastral maps have difficulty representing. The cadastre process determines the physical boundaries of the land while the registration process ownership of the land, and the legal rights, restrictions, and responsibilities (RRRs) affecting the registration are guaranteed. How the land uses and how will the type of future use be determined by spatial plans. Urbanization pressure restricts the arbitrary use of a scarce resource of land and diversifies land-use types into sub-plot objects. The task of linking the development of cities to certain projections and creating livable cities with future scenarios can be carried out with spatial plans. Spatial plans play a key role in coping with the pressures of urbanization and in many other issues such as food, environment, transportation safety, and management.

Land Administration Systems (LAS) effectively use information technologies to identify, record, and share land-related information following land policies (Aydinoglu & Bovkir, 2017). The ultimate benefit expected from the LAS is to record and store the boundaries of the land parts, their relationship with neighbouring lands, and the RRRs it hosts at certain time intervals. At this point, while the cadastral process determines the geometric shape and topology of the land, many transactions may constitute RRR on the land like title deeds, spatial plans, valuation, taxation, legal regulations, and land development. Components that create various RRRs on land, which are land administration functions for holistic and effective land administration, should be handled together in land management systems. Land administration may differ according to the management style of the countries, the human-land relationship, and the legal order. Therefore, countries adopt their management approach when creating their own LAS, and a standard approach does not occur. However, in cases without borders, such as international collaborations and environmental studies, they need to meet at a common point for data and procedure sharing. In land administration, this common point has been met by the LADM (Land Administration Domain Model) standard for nearly 15 years. 3D physical city

model standards such as CityGML; do not focus on modelling legal objects when visualizing 3D urban objects, including buildings, floor surfaces, streets, and vegetation. Cadastre data models, such as the LADM, manage and maintain 3D land and property ownership interests, including 3D property rights, restrictions, and responsibilities (Aien et al., 2015). Unlike physical model standards, the LADM sets legal RRR limits for registration objects. Through legal cadastral models, complex RRRs of objects from underground to a certain height can be presented as 3D digital maps. With achieving the integration of legal and physical models, physical and legal completeness at various levels of the land can be achieved, and the developments in the smart city and digital twin field can be assisted.

The standardized LADM model by the International Organization for Standardization (ISO) in 2012, provides a conceptual model of the RRRs affecting land (or water) and their geometric components. While fulfilling this purpose, RRRs such as mortgages, easements, and right of way, which are generally created by cadastre and registration processes, are represented in the model. Apart from these RRRs on the land registry, various contracts, municipal council decisions, real estate valuations, land development practices, and spatial plans lead to RRRs on the land (Indrajit et al., 2020). The model has a structure that allows external classes to be added to represent and standardize the RRRs produced by these land administration components in the model. In today's world, the work of registering the registration objects within the scope of the land administration in 3D, determining the RRR of the registration objects by taking into account the height and time directions, and the integration of the legal and physical model are inflamed. Hot topics triggered debates about whether or not the RRRs affecting the land are fully reflected within the scope of LADM. In this direction, the necessity of identifying and standardizing each RRR that makes a difference in the field has emerged (Paasch et al., 2015; Lemmen et al., 2019; Indrajit, et al., 2020). In addition, the detection of all RRRs that constitute the scope of legal models is essential for representing the real situation. Only in this way legal models and physical models can work in harmony (Atazadeh et al., 2017; Rajabifard et al., 2019; Alattas et al., 2021). In this context, the information from the registration and determination systems of the countries based on the LADM is insufficient. Spatial plans with many RRR in the third dimension constitute a good resource, especially for studies where the third dimension is essential. Associating the spatial plan information with the land parcel and presenting it in a standard model will ensure that the RRRs formed by the plans take their place in the land administration systems in a standard way. Thus, countries will be able to create and share plan data in a standard structure. In addition, the correlation of the spatial plan component, which creates a legal effect on the land, with the registration procedures will be an important step for creating an integrated land administration system.

The study aims to create a package of spatial plans suitable for the spatial planning system of Turkey within LADM to standardize the impact of spatial plans on the land. While creating the model, the spatial planning systems of many countries were examined, and the main lines of spatial planning were observed, so it is thought that the model can be adapted to various country profiles with minor changes. The second chapter of the study provided the standardization studies in land administration and the LADM standard. In the third part, explanations are given of the concept of spatial planning and the spatial planning system of Turkey. In the fourth

chapter, a package of spatial plans was created in the UML (Unified Modelling Language) structure using the planning system data examined in the third part. In the following section, the results obtained from the study are included.

## 2. STANDARDIZATION IN LAND ADMINISTRATION

Plenty of policies such as sustainable development, environmental protection, planned urbanization, agriculture, and property security targeted by countries are land-dependent policies (C. Lemmen, 2012). In order to work on these issues, governments need to have land policies. Governments need tools such as natural resource management, spatial planning, land tenure security, and taxation to implement their land policies. Land administration systems can be described in the broadest sense as a supporting tool to facilitate the implementation of land policies (UNECE, 2005). Country land administration systems differ according to the country's legal order, the land use pattern, and the human-land relationship. Some countries use register title deeds, while others register contracts systems. Some systems are based on the general boundaries approach, while others are based on the fixed boundaries approach, some LAS have a financial background, and others have a legal background (Bogaerts & Zevenbergen, 2001; UNECE, 2005). Although LASs structurally differ according to country policies, the recorded data is general information about the parties, RRRs of the land, and geographical and attribute information about the spatial object (Guo et al., 2011). The systems may differ according to some criteria, but in essence, LASs are created to protect property rights, provide tax revenue to the government, and facilitate the implementation of government policies.

The mission of creating and operating land administration of countries is not a mission that is limited only within the country in all cases. In the globalizing world, besides international and regional cooperation, issues that concern all countries, such as environmental problems, famine, and poverty, require countries to act together to overcome problems and maintain global balances. In order to ensure interoperability, systems prepared for different management understandings and functions must be ensured to speak the same language. The model presented as the Core Cadastre Domain Model (CCDM) in 2006, later renamed the Land Administration Domain Model and standardized by the International Organization for Standardisation, attracted the most attention from the efforts to create a common language in the field of land administration. LADM defines a reference model that encompasses key informational components of land administration. In defining the reference model, the LADM has two main objectives; the first is to provide a basic standard to the countries that will create their land administration systems and encourage them the other is to establish a common ontology to ensure the interoperability of parties in different countries. The terminology allows for a standard definition of practices and procedures in different jurisdictions. Countries create or modernize their land administration systems according to the LADM conceptual model. Although countries have different land administration mentality, thanks to the framework offered by LADM, they can present their land administration systems with common data models. The conceptual model developed by the countries that develop their land administration systems according to ISO 19152 LADM standards is tested concerning the conformity test in

ISO 19152:2012 Annex A (Kalogianni et al., 2019). If the test is successful, the country profile is considered to comply with LADM standards.

The LADM is an abstract model that focuses on land administration's legal and geographical aspects (Çağdaş et al., 2016) and covers land registration and cadastral operations. Data of administrative and spatial units related to these operations, RRRs on the land, and documents such as title deeds and measurements constitute the model's content. Although data such as an address, taxation, infrastructure networks, land use, and land cover are data covered by LAS, the standardization of this data is not covered by LADM (Lemmen et al., 2011). However, LADM offers the possibility to create external classes for this data. With this facility provided by the standard, the model can be expanded according to land administration (or other applications) requirements. The model uses the class structure, attribute data, and cross-class relationships provided by UML to represent land administration systems conceptually. LADM provides a conceptual model consisting of three main packages and one subpackage representing land administration components. The first of the main packages are the party package, in which all singular and plural actors related to the land are represented. The second package is the administrative package, which consists of the classes in which the RRRs on any land are defined and the Basic Administrative Unit (BAUnit) class. The basic administrative unit class is used to register the administrative units consisting of several spatial units belonging to the parties under the same RRR. The final main package is the spatial unit package used to represent the land parcel and other spatial components associated with the parcel. The package handled as a subpackage of the spatial unit package is the measurement and spatial representation package, which allows for numerous possible representations of spatial units in 2D, 3D, or mixed (Lemmen & Oosterom, 2010).

### 2.1 **LADM Administrative Package**

The ISO/TC211 standard LADM was published to describe basic information about land administration components and RRRs caused by land administration operations. One of the main objectives of the LADM is to document the RRRs of persons who have rights or interests in land or spaces (Indrajit et al., 2020). The relationship between spatial objects and the parties is established through the LADM administrative package. The administrative package includes three classes: basic administrative units (BAUnit), RRR information, and administrative documents (AdministrativeSource) (Atazadeh et al., 2021). The LA_RRR class provides three classes to be abstract, and these classes are LA_Right, LA_Restriction, and LA_Responsibility. These classes inherit their common features from the superclass (LA_RRR) and contain the types of rights, restrictions, or responsibilities in their attributes according to the class's features. LA_BAUnit is an administrative unit consisting of one or more spatial units (parcels) associated with RRRs in the LAS system (Zulkifli & Rahman, 2013). The BAUnit class must register administrative units consisting of several spatial units belonging to a party under the same RRR (ISO, 2012). Pool and flat (spatial units) with the same party and RRRs are examples of this situation. LA_AdministrativeSource is another class that is included in the administrative package. Documents related to land administration are represented in the source class. In

principle, all RRRs are based on an administrative document, while basic administrative units may not have an administrative document.

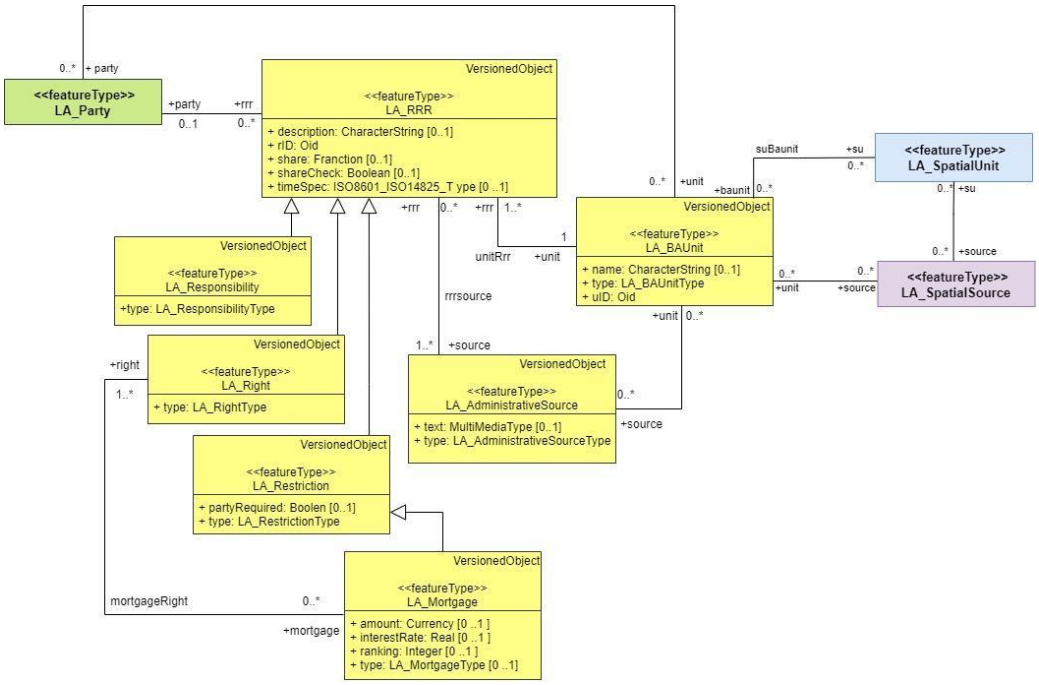


Figure 1 — LADM Administrative Package and its relationship with other packages

A modern LAS is needed to perform the four functions of land administration (land tenure, land development, land use planning, and land value) (Indrajit et al., 2021). For a modern and responsive LAS, the legal structure caused by all these four functions in the land must be considered.

## 2.2 **LADM Version 2.0 Studies**

Although the first version of LADM, which ISO standardized in 2012 with FIG initiatives, is quite functional, it is thought that the model still needs to be developed to improve land administration functions and expand its scope (Lemmen et al., 2021). It is a customary process to review and renew any standard over time. In 2018, ISO/TC 211 approved a revision of the model for both extension and improvement. It is planned that the version formed due to the revision in the light of requirements and ideas will include new packages and attachments. At the ISO 48th General Assembly, the ISO/TC 211 Geographical Information Commission decided to develop the 2nd version of the model as a multipart. The version was divided into six parts, and each section was scheduled to be completed at different times (Lemmen et al., 2021). The scope of the conceptual model will be expanded with piecemeal studies on valuation, spatial planning, utility networks, marine areas, and indoor space information. In addition, the new version will include encoding/technical models that will help physical and legal object integration. Establishing a coding standard between physical models and LADM

can make it easier for countries to create a 3D land administration system. ISO is developing the new version of LADM and in the broad collaboration between OGC, IHO, UN-GGIM, and FIG. With broad participation, a complete revision of the standard will be possible whenever possible.

## 3. SPATIAL PLANNING

According to the International Encyclopedia of Human Geography, spatial planning includes attempts to plan social, economic, and environmental change processes to achieve specific goals and prepare plans, maps, or diagrams that show where socio-spatial activities should be taken place. Spatial plans put forward a vision for the region by considering the region's current situation, and the vision is tried to be realized with various instruments, generally by the government. Plans for land parcels are implemented as a public power to bring the city to the intended vision (Indrajit et al., 2019). It can be said that spatial planning has emerged as a collective product of many sectoral policies. Policies: It can be diversified into many sub-titles such as education, health, and transportation. Spatial plans typically consist of written documents with cartographic representation and show hierarchical characteristics.

While spatial plans represent the current use type, land cover, and planned use of the land, they cause various rights, restrictions, and responsibilities in the spaces for the protection of land use and reach to the planned use. Although these RRR concepts are used as a privilege, prohibitions, and obligations in various sources for spatial plans (Paasch et al., 2013; Indrajit et al., 2021), the meanings corresponding to the concepts are almost the same. Therefore, there is no harm in using it as RRR.

### 3.1 Turkey Spatial Planning System

Planning processes in Turkey develop with a top-down approach. Also, spatial plans within the system are created in line with the objectives of non-spatial development plans and strategic documents published at regular intervals. In the Turkish plan legislation, the plans are considered in two categories as socio-economic and spatial plans. While socio-economic plans are considered development and regional plans, spatial plans deal with plans directly related to the space with cartographic representation.

Turkey's transition to the planned period began with the 1961 Constitution of the Republic of Turkey. This period, which started with development plans, gained maturity with adopting the Zoning Law No. 3194 in 1985. With the Spatial Plans Creation Regulation published after the zoning law, the plans gained a hierarchical structure, and the principles of creating spatial plans were determined. One of the basic principles of the Turkish planning system is the principle of gradual coordination of plans (Ersoy, 2000). The principle refers to the holistic handling of planning and reveals the hierarchical relationship between the plans. Gradual coordination of plans states that each lower-scale planning level should contain more details than the next upper-scale planning level. The plan should contain more information in the current scale than upper-scale plan, but it should also protect the main decision in the upper-scale plan. Only in

line with this principle can spatial planning be handled with a holistic approach and can be used to solve existing and future problems.

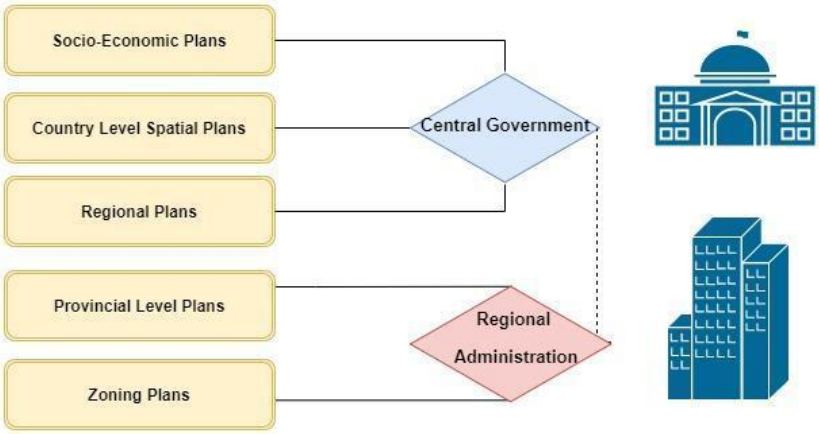


Figure 2 — Authorization sharing in the Turkish planning system

Property rights, spatial planning, and construction activities should be subject to legal rules to ensure social welfare and peace. While property rights are considered fundamental rights and freedoms, spatial planning activities determine how a person can use or not use one's property right to ensure social equality and order. The production and implementation processes of spatial plans must proceed following certain legal processes. The Turkish legal system has a hierarchy as required by the principle of the hierarchy of norms, and similar to the spatial planning hierarchy. The upper-level legal document directs the lower-level legal documents. The supreme legal source in the Turkish legal system is the constitution, and the constitution declares that the duty of planning is the state's responsibility. The Constitution explained the planning activity in general terms. The reduction of the planning activities from the general scope to the specific as spatial planning was realized with the zoning law. Since laws are below the constitution in the hierarchy of norms, they obey the constitutional rules. The zoning law was supported by various regulations at the point of creation and implementation of the plan, and the legal infrastructure of the Turkish planning system was established. Local and central governments have shared the authority to create spatial plans in the Turkish planning system. While the central government is responsible for creating national and regional plans, municipalities and governorships are responsible for the creation of local plans. However, the Ministry of Environmental Urbanization and Climate Change, which represents the central government, is authorized to create plans of all sizes when necessary. Figure 2 includes a relationship of authority in spatial planning. The local planning authority of the Central Administration is expressed with the dotted line representation.

Spatial plans use a variety of elements to present the planning decisions set for the planning zone. Elements come together to create spatial plans. Components that make up the plan; consist of cartographic plan representations and textual documents. The cartographic representations present the plan decisions on a layout through legends while the textual documents include the

research made about the plan region during the plan preparation process, the opinions of the institution, and the plan decisions that cannot be presented cartographically. Since the top-down approach is generally considered when creating spatial plans, the priority is to create upper-level plans covering larger areas. By directing upper-scale plans, detailed subscale plans are tried to be created. In spatial plans prepared with certain scales, the level of detail of the plan increases as the scale increases. Smaller-scale and more comprehensive plans guide the large-scale plan and determine how it is detailed. The Turkish spatial planning system consists of four plans located at the main level. According to the hierarchical relationship between them, these plans are classified as spatial strategy, environmental, land use-zoning, and implementation zoning plan. In Figure 3, spatial plans and the documents that guide them are presented hierarchically.

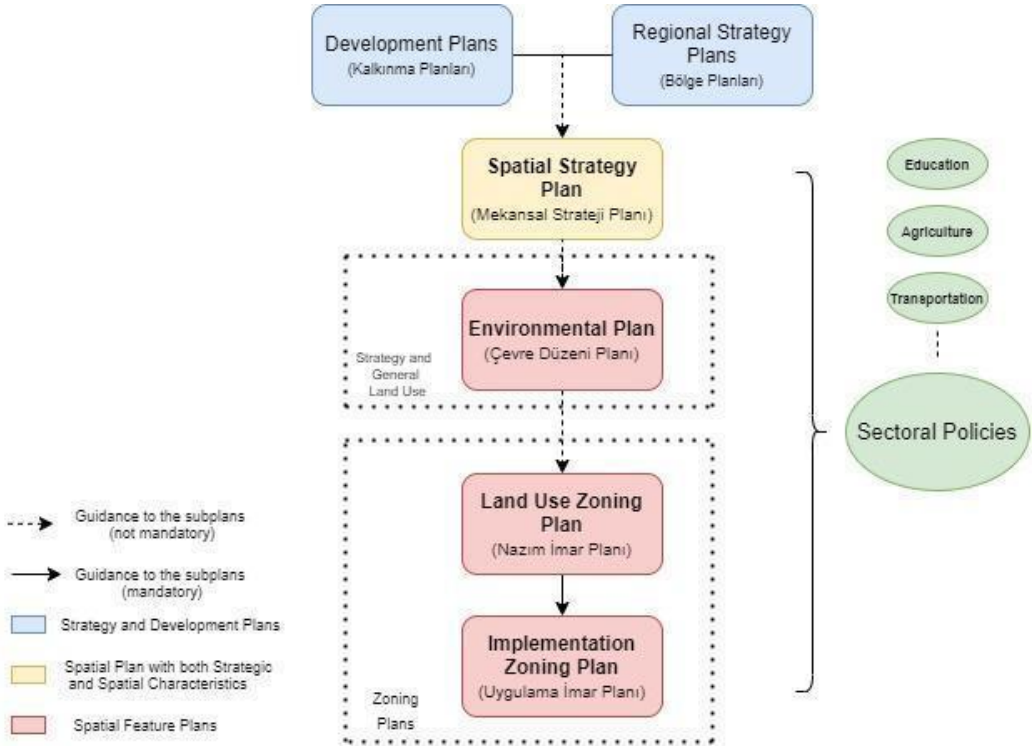


Figure 3 — The existing plans in the Turkish planning system and their hierarchical relationship

## 4. GENERATING A CONCEPTUAL MODEL FOR SPATIAL PLANNING

Today, the concept of data covers a comprehensive cluster. Users and technological devices are in the process of continuously generating and using data. It is impossible to transform data into information without managing the resulting large data stack. Data may occur in numeric values, graphs, shapes, metadata, etc. In order to store, query, and process this data, Database Management Systems (DBMS) harmonious for the data should be used. The data are categorized according to their properties under certain headings with specific labels in the

management system. In this way, the user has the opportunity to access and query the data. Databases consist of entities, attributes that specify properties about entities, process, constraints of data, and relationships between entities. The database designer uses the required dictionary and schematic rules to generate the database model, which is a high-level definition of the real world in a way that other users can perceive. The database design process consists of 3 stages: conceptual model, logical model, and physical model (Aydınoğlu, 2009).

The conceptual data model represents the overall structure of the data required to support business requirements, regardless of any software or data storage structure (Sherman, 2015). A conceptual model is a model structure used to represent entities whose attributes and relationships are represented in the database. Objects are presented in a standard structure because entities are represented independently of the software. Entity-relationship diagrams are used for graphical representation of the conceptual model (Polat, 2017). In conceptual models, some geometric objects generally represent entities and their attributes. UML schemas are widely used to create conceptual models independent of software and data storage structure. The ISO 19152 LADM standard also provides a conceptual model for countries to establish or modernize their LAS. Administrators can transform the conceptual model country profiles that they have created into databases or different end products.

LADM has a structure that allows the scope and functionality of the conceptual model to be expanded with the help of external classes. Within the study's scope, it aims to add the spatial planning structure of Turkey as an external package to the LADM main packages and to approach a holistic LAS structure by expanding the scope of the RRRs represented in the model. The structure offered by UML diagrams was used when creating the spatial plans package. Entities are represented as classes; properties of entities are represented as attributes of classes. UML relationship structures are used to reflect the relationship between entities. The classes of the spatial plans package created are named with the SPP_ prefix.

In order to create the spatial plans external package, firstly, the structure of the Turkish spatial planning system is introduced in chapter 3. Spatial planning system has been examined so that information about the framework of the system, such as the general lines of the planning process, the relationship between the plans, and the elements of the plan. Also, the subjective characteristics of each plan were obtained. As a next step, to represent the information about the planning system in UML diagrams, the data obtained as a result of the examination were classified. Besides, entities were created according to the classification. The relationship between entities is based on the relationship of plans between each other and with the plan area. In addition, the planning systems of various countries were examined in general terms, and standard planning features such as hierarchy and various scopes that were similar to most planning systems were determined. Standard features were considered in the creation of the package.

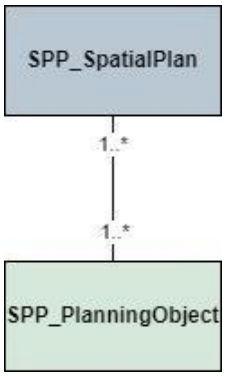


Figure 4 — The main structure of the spatial planning package

While creating the spatial plans package, the system is basically based on two classes. These are SPP_SpatialPlan and SPP_PlanningObject classes. Spatial planning basically intent to create a plan that effect a planning zone. When building the package, the focus was on this inherent purpose of spatial planning. Figure 4 presents the basic structure of the planning package. A structure was created in which the plans and the areas affected by the plans were represented. The SPP_SpatialPlan class is considered a superclass. Besides, the data that all spatial plans contain in common are represented in this class. All plans can have attributes of plan scale, plan purpose, and organizations with specific authority. The classes that inherited data from the SPP_SpatialPlan class were considered plans in the Turkish spatial planning system, and it was decided that only the attributes that such plans would have could be represented in these separate plan classes. In addition, the guiding effect of the spatial plans and the dependency relationship between them are represented by the UML composition and aggregation relationship structure. In order to reflect the revision and change processes, update relationship has been established within the SPP_SpatialPlan class itself. Spatial plans divide the planning area into specific subplansection entities and create planning decisions on those entities. Parts of land affected by plan decisions; can be classified as parcels, blocks consisting of parcels, and engineering structures in a linear structure. SPP_PlanningObject class is a class created to represent the properties of land parts with RRR created by plans. Subclasses and some attributes of the SPP_SpatialPlan and SPP_PlanningObject classes are included in Figure 5.

A piece of land can have only one plan from the same hierarchy in the Turkish spatial planning system. Even if the plan has been amended and revised over the years, two different plan decisions cannot be in force at the same time for the same area of use. Therefore, the relationship between the SPP_SpatialPlan and the SPP_PlanningObject class was established as "a planning object can have a zero or one plan, and the spatial plan can create a plan decision on one or more planning objects". A plan process number is given to each new and revised plan in the Turkish planning system. This ID number was used to establish the relationship between the planning zone and the plan. By including the relationship between the classes that can be planning objects and the structures in the model, it aims to present the plan decisions that will have to be followed by the structures on various plan objects.

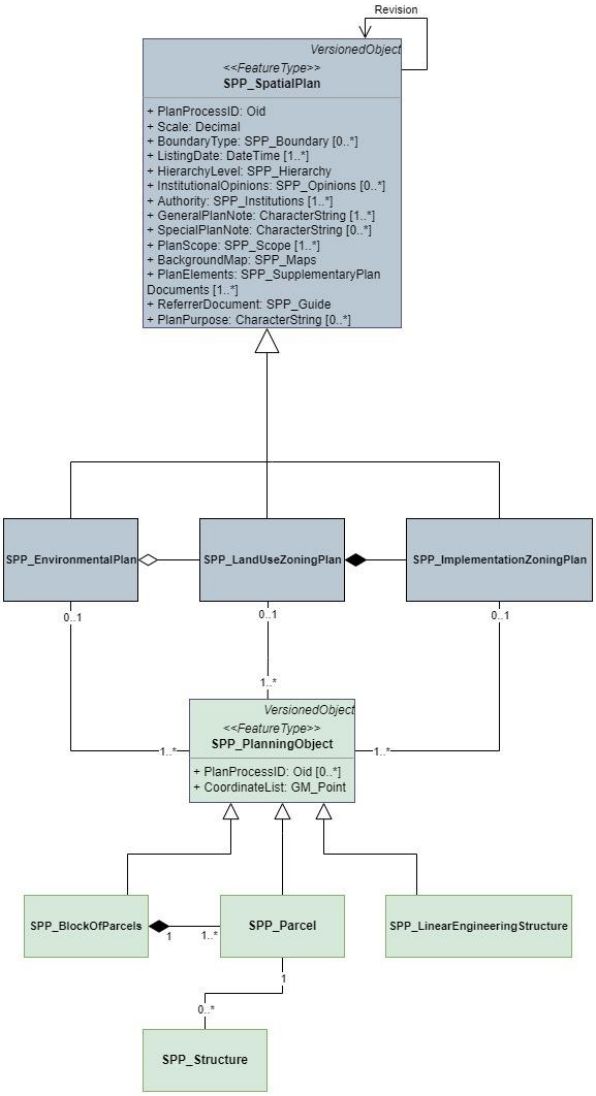


Figure 5 — External Turkey spatial plans package conceptual model

Figure 6 — Enumeration and codelist examples of Spatial Plans package

## 5. CONCLUSION

Spatial plans, besides the function of protecting natural balances and determining land use, also undertake the task of directing investments. Regardless of whether the investor is from the public or private sector, the investor wants to know the future and current population projections, land use, and possible RRRs of the region This information guides the investors' investment. Investor plans or invest investments according to information. The landowner or investor desire to estimate the fate of the land and avoids uncertainties. For investors, the knowledge of how they can use the land is as important as how many owners are entitled to the land. Keeping such information in separate systems can cause performance degradation and confusion. Therefore, the plan decisions should be integrated with land registration information in LAS. Instead of creating a new standard structure for integration, the use of the LADM standard structure, which provides a conceptual model structure to LASs, provides integrity and ease of the procedure. For the integration to be fully realized, the plan information must be detailed up to the representation on a parcel basis, such as land registration systems. Associating plan information with parcels in the plan area will allow this union as performed in the study. Knowing how the land parcel or building subject to an inquiry is handled in different hierarchical plans will prevent loss of rights and contribute to regular urbanization.

## 6. REFERENCES


Aien, A., Rajabifard, A., Kalantari, M., & Shojaei, D., 2015, Integrating legal and physical dimensions of urban environments, *ISPRS International Journal of Geo-Information*, *4*(3), 1442–1479. https://doi.org/10.3390/ijgi4031442

Alattas, A., Kalogianni, E., Alzahrani, T., Zlatanova, S., & van Oosterom, P., 2021, Mapping private, common, and exclusive common spaces in buildings from BIM/IFC to LADM. A case study from Saudi Arabia, *Land Use Policy*, *104*(February), 105355. https://doi.org/10.1016/j.landusepol.2021.105355

Atazadeh, B., Kalantari, M., Rajabifard, A., Ho, S., & Ngo, T., 2017, Building Information Modelling for High-rise Land Administration, *Transactions in GIS*, *21*(1), 91–113. https://doi.org/10.1111/tgis.12199

Atazadeh, B., Olfat, H., Rajabifard, A., Kalantari, M., Shojaei, D., & Marjani, A. M., 2021, Linking Land Administration Domain Model and BIM environment for 3D digital cadastre in multi-storey buildings, *Land Use Policy*, *104*(June 2020), 105367. https://doi.org/10.1016/j.landusepol.2021.105367

Aydinoglu, A. C., & Bovkir, R., 2017, Generic land registry and cadastre data model supporting interoperability based on international standards for Turkey, *Land Use Policy*, *68*(July), 59–71. https://doi.org/10.1016/j.landusepol.2017.07.029

Aydınoğlu, A. Ç., 2009, Türkiye İçin coğrafi veri değişim modelinin geliştirilmesi, *Karadeniz Technical University Institute of Science and Technology*.

Bogaerts, T., & Zevenbergen, J., 2001, Cadastral systems- Alternatives. *Computers, Environment and Urban Systems*, *25*(4–5), 325–337. https://doi.org/10.1016/S0198-9715(00)00051-X

Çağdaş, V., Kara, A., Van Oosterom, P., Lemmen, C., Isikdag, Kathmann, R., & Stubkjær, E., 2016, An initial design of ISO 19152:2012 LADM based valuation and taxation data model, *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *4*(2W1),

145–154. https://doi.org/10.5194/isprs-annals-IV-2-W1-145-2016
Ersoy, M., 2000, *İmar Mevzuatında Planlama Kademeleri Ve Üst Ölçek Planlama Sorunu*, Bölgesel Kalkınma ve Yönetişim Sempozyumu, http://www.melihersoy.com/wp-content/uploads/2012/04/TEPAV-Bildiri.pdf
Guo, R., Ying, S., Li, L., Luo, P., & van Oosterom, P., 2011, A Multi-jurisdiction Case Study of 3D Cadastre in Shenzhen, China as Experiment using the LADM, *Proceedings of 2nd International Workshop on 3D Cadastres, 2011, November*, 31–50.
Indrajit, A., Jaya, V. E., Loenen, B. van, Snaidman, A., Ploeger, H., van Oosterom P. J. M., 2019, Implementation of Spatial Planning Package for Construction of an LADM Country Profile: Reducing Asymmetric Access to Information of RRRs in Indonesia, *Proceedings of the 8th Land Administration Domain Model Workshop,* https://pure.tudelft.nl/portal/files/67728995/LADM2019_Paper_D3_F.pdf
Indrajit, Agung, Loenen, B. Van, Eresta, V., Ploeger, H., Lemmen, C., & Oosterom, P. Van., 2021, Implementation of the spatial plan information package for improving ease of doing business in Indonesian cities. *Land Use Policy*, *105*, 105338. https://doi.org/10.1016/j.landusepol.2021.105338
Indrajit, Agung, van Loenen, B., Ploeger, H., & van Oosterom, P., 2020, Developing a spatial planning information package in ISO 19152 land administration domain model, *Land Use Policy*, *98*(July 2019), 104111. https://doi.org/10.1016/j.landusepol.2019.104111
ISO., 2012, ISO 19152 International Standard Geographic information — Land Administration Domain Model (LADM), *International Organization for Standardization*, *2012*, 397.
Kalogianni, E., & Kalantari, M., Dimopoulou, E., Van Oosterom, P., 2019, LADM country profiles development: aspects to be reflected and considered, *8th International FIG Workshop on the Land Administration Domain Model*, *October 2019*, 287–302.
Lemmen, C., 2012, A Domain Model for Land Administration, In *TU Delft* (Vol. 78, Issue June).
Lemmen, C., Alattas, A. F., Indrajit, A., & Kalogianni, E., 2021, *The Foundation of Edition II of the Land Administration Domain Model, FIG e-Working Week 2021 Smart Surveyors for Land and Water Management - Challenges in a New Reality Virtually in the Netherlands, 21–25 June 2021*
Lemmen, C. H. J., van Oosterom, P. J. M., Uitermark, H. T., Zevenbergen, J. A., & Cooper, A. K., 2011, Interoperable Domain Models: the Iso Land Administration Domain Model Ladm and Its External Classes, *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XXXVIII-4/*, 31–40. https://doi.org/10.5194/isprsarchives-xxxviii-4-c21-31-2011
Lemmen, C., & Oosterom, P. V. A. N., 2010, *The Modelling of Spatial Units ( Parcels ) in the Land Administration Domain Model ( LADM ),* FIG Congress 2010 Facing the Challenges – Building the Capacity Sydney, Australia, 11-16 April 2010.
Lemmen, C., Van Oosterom, P., Kara, A., Kalogianni, E., Shnaidman, A., Indrajit, A., & Alattas, A., 2019, The scope of LADM revision is shaping-up, *8th International FIG Workshop on the Land Administration Domain Model*, *October*, 1–36.
Paasch, J. M., van Oosterom, P., Lemmen, C., & Paulsson, J., 2015, Further modelling of LADM's rights, restrictions and responsibilities (RRRs), *Land Use Policy*, *49*, 680–689. https://doi.org/10.1016/j.landusepol.2014.12.013
Paasch, J., van Oosterom, P., Paulsson, J., & Lemmen, C., 2013, *Specialization of the Land Administration Domain Model ( LADM ) - An Option for Expanding the Legal Profiles*, *May*, 6–10.
Polat, Z. A., 2017, *Arazi yönetiminin tapu ve kadastro İşlemlerine yönelik harici veri modeli tasarimi ve uygulaması*, Yıldız Technical University Institute of Science and Technology
Rajabifard, A., Atazadeh, B., Yip, K. M., Kalantari, M., Rahimipour Anaraki, M., Olfat, H., Badiee, F., Shojaei, D., Lim, C. K., & Mohd Zain, M. A., 2019, Design and Implementation of a 3D National Digital Cadastral Database based on Land Administration Domain Model: Lessons Learned from a 3D Cadaster Project in Malaysia, *8th International FIG Workshop on the Land Administration Domain Model*, *October*.
Sherman, R., 2015, Measuring Data Quality for Ongoing Improvement. *Business Intelligence Guidebook*, 173–195. https://doi.org/10.1016/b978-0-12-411461-6.00008-3

UN Department of Economic and Social Affairs, 2018, 68% of the world population projected to live in urban areas by 2050, says UN, URL:https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
UNECE., 2005, *Land Administration in the UNECE Region: Development trends and main principles*, https://unece.org/fileadmin/DAM/hlm/documents/Publications/landadmin.devt.trends.e.pdf
Zulkifli, N. A., & Rahman, A. A., 2013, Developing 2D and 3D Cadastral Registration System based on LADM : illustrated with Malaysian Cases, *Fig*, *September*, 447–464.

## BIOGRAPHICAL NOTES

**Okan Yılmaz** is currently an MSc student at Yıldız Technical University in the Department of Land Management and a research assistant at the same University's faculty of constructions**.** He graduated from the Karadeniz Technical University Geomatics Engineering Bachelor's program in 2019. He continues to work in the field of land management and GIS.

**Dr. Mehmet ALKAN** is a Professor in the Department of Geomatics Yıldız Technical University, Turkey. He finished Ph.D. in March 2005. His PhD thesis topic is "Design and Develop Cadastral Temporal GIS". He is research interests are Database, Geographical Information Systems, National Spatial Data Infrastructure, E-Municipality, E-government and Cadastral Systems. He is currently works at Land Management Division of the Department of Geomatics at Yıldız Technical University, Turkey.

## CONTACTS

Okan Yılmaz
Yıldız Technical University, Department of Surveying Engineering
Çifte Havuzlar, Davutpaşa Kampüsü, 34220 Esenler
İstanbul
TURKEY
Tel. +0 0212 383 5232
Email: okanymz@yildiz.edu.tr
Web site: https://avesis.yildiz.edu.tr/okanymz

Mehmet Alkan
Yıldız Technical University, Department of Surveying Engineering
Çifte Havuzlar, Davutpaşa Kampüsü, 34220 Esenler
İstanbul
TURKEY
Tel. +0 0212 383 5295
Email: alkan@yildiz.edu.tr
Web site: https://avesis.yildiz.edu.tr/alkan