A COMPARISON OF TURKEY-MALAYSIA LADM COUNTRY PROFILE FOR 3D CADASTRE PURPOSES

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ABSTRACT

This paper summarises the comparison of Turkish and Malaysian cadastral registration systems based on the Land Administration Domain Model (LADM, ISO 2012) associated with 2D and 3D cadastral situations. Literature review shows that many countries propose their profile based on the LADM, such as The Netherlands, Australia/ Queensland, China, Greece and others. Turkey and Malaysia are some of the potential candidates for the LADM based country profile, as described in this paper. The study presents a detailed overview of the Turkish and Malaysian cadastral system, and LADM-based country profiles developed by the two countries are compared thanks to the common ontology offered by LADM.

1. INTRODUCTION

Cadastral maps should provide complete information regarding record rights, restrictions and responsibilities (RRR) on the cadastral parcel (Kaufmann and Steudler, 1998; Stoter and Oosterom, 2007). However, although cadastral objects are three and four dimensions in most of the countries, they create cadastral maps that still mainly rely on 2D-based cadastral systems for current Land Administration Systems (LASs) (Ho et al., 2015; Atazadeh et al., 2016; Kalogianni et al., 2017; Rajabifard et al., 2018). Thus, RRR on the land cannot be adequately represented. The research and development in 3D cadastres hence have gained momentum over the last years. A very detailed and advanced analysis of studies in 3D cadastres in a wide range of countries worldwide can be found in the International Federation of Surveyors (FIG) 3D cadastres best practices book (Oosterom, 2018).

The most efficient standardised model in the land administration system (LAS) field is the Land Administration Domain Model (LADM). It was an ISO standard in 2012; ISO19152:2012 (ISO, 2012), which aims to establish a common ontology for RRR affecting land administration and its geometric components. Thus, it will enable communication between related parties within a country or between different countries (Atazadeh et al., 2017; Sürmeneli and Alkan, 2018; Sürmeneli and Alkan, 2020). Although LADMs current version provides an international framework for LAS, it is limited to support 3D cadastre lack of geometry or topology and time profiles (Kalogianni et al., 2020). Having a well created and maintained 3D cadastre will benefit many other applications such as urban planning and land and property management (Rajabifard et al., 2018). Legal and physical standards have been developed for these applications (LADM, CityGML, IFC/BIM, LandInfra etc.). While these standards can be used alone for each application, they can also be used to integrate each other (Sun et al., 2019).

Thanks to the advanced technology in geographic information science, 3D cadastre developments have matured with storage, analysis and visualisation of 3D objects (Kitsakis et al., 2016;

Dimopoulou et al., 2018; Su et al., 2019; Kalogianni et al., 2020). Within the scope of these developments, most countries have improved their cadastral systems according to the 2014 (Stuedler, 2014) and 2034 (ICSM, 2015) visions. While the first 3D cadastral registration has been made in the Netherlands (Stoter et al., 2017), a prototype for a 3D cadastre has been developed in Shenzhen, China, to support urban planning and management (Guo et al., 2013; Ying et al., 2015). Also, many academic studies have been carried out in Queensland and Victoria states of Australia, and physical models for 3D cadastre have been developed (Aien, 2013; Aien et al., 2015; Rajabifard et al., 2018), whereas research on the environmental impact of 3D public law restrictions in Greece is described (Kitsakis and Dimopoulou, 2020). The transformation of 2D analogue cadastral boundary plans into 3D digital information and visualisation in Stockholm, Sweden, is described in academic study (Larsson et al., 2020). The main motivation of the study is to show that the similar and different aspects of the cadastral systems of the countries are easily determined thanks to the LADM, which creates a common ontology. In the study, LADM-based cadastral models developed by Turkey and Malaysia were examined. Thus, it has become more understandable how the solutions developed for different registration systems are modelled.

The remainder of this paper describes the Turkish and Malaysia cadastral system and LADM in section 2. Section 3 discusses the comparisons, and finally the discussions and conclusion in section 4.

2. THE TURKISH - MALAYSIA CADASTRAL SYSTEM AND LADM

Turkish cadastre consists of two parts: land registry that represents the legal relationship between people and real properties, and the cadastral maps that, besides geometry data and annotations, contain the land-use. There is a title system, and it is under state guarantee in Turkey. The land registry records are officially formed by the title and the registry directorate and the maps by the cadastral branches. A 2D graphic representation of most rights, restrictions and responsibilities is possible. The

rights, restrictions and responsibilities regarding the 3D are recorded as textual. Land registration and surveying are managed by the General Directorate of Land Registry and Cadastre (GDLRC). Also, the cadastral system and cadastral data have been improved and developed several projects due to digitisation. Such projects are called in Turkish TUCBS, Turkey National Spatial Data Infrastructure and TAKBIS, Land Registry and Cadastre Information System (Sürmeneli et al., 2020). TAKBIS project aims to create the Turkish Land Registry and Cadastre Information System across the whole country. TUCBS is an e-government project aiming at establishing the infrastructure for Geographical Information System following the technological developments at the national level (Turkish National Geographic Information System-TUCBS) (Alkan et al., 2019).

Two different organisations manage the Malaysian cadastral system. The Department of Director General of Lands and Mines (DDGLM) and the Department of Survey and Mapping Malaysia (DSMM) are within the Ministry of Water, Land, and Natural Resources. One of the main aims of DSMM is serving cadastral survey information, which includes the dimension, size, and location of parcels. Thus, DSMM produces a Certified Plan (CP) within spatial components, including surveying and mapping cadastre parcels. On the other hand, the DDGLM, which deals with property ownership registration, is tasked with overseeing the legal aspects of land administration. The Land Registration System, which concerns the administrative (legal) data, is the responsibility of the Land Offices. The Land Office deals with ownership registration, namely, who owns the RRRs (Right, Responsible, Restriction). Each of these organisations has its different information management systems, namely the eTanah for the DDGLM and eKadaster in DSMM, which are two independent systems maintained in 2D. The Unique Parcel Identifier (UPI) was introduced to link the Land Office and DSMM, where every cadastral object has a unique identity number to differentiate from other cadastral objects. The Malaysian cadastral system deals with properties located on the surface level and above and below the surface level (Choon and Kam Seng, 2013; Zulkifli et al., 2015; WBG, 2017).

The land administration domain model is developed to contribute to Land Administration Systems (LAS). The land administration domain model has been established by ISO/TC211 with the aim of standardizing geographical information and geo-characteristics (Oosterom et al, 2006). The main objective of the LADM is to establish an ontology and facilitate the exchange of cadastral data with the shared land administration system (Oosterom et al, 2013). The main starting point of the LADM is to establish a common ontology for rights, restrictions and responsibilities affecting the land administration and its geometric components. Thus, it will enable communication between related parties within a country or between different countries (Oosterom et al., 2006; Lemmen et al., 2015). The LADM is developed in line with the Cadastre 2014 vision and complies with international ISO and OGC standards (Lemmen et al., 2009; Lemmen et al., 2011; Tjia and Coetzee, 2013). Besides, it has been conducted in the studies showing the compatibility of LADM with INSPIRE (Alkan and Polat, 2017). LADM has three main packages and one sub-package. These are LA_Party (Party package), LA_AdministrativePackage (Management package) and LA_SpatialUnitPackage (Spatial Unit package) and LA_SurveyingAndRepresentation (Figure 1).
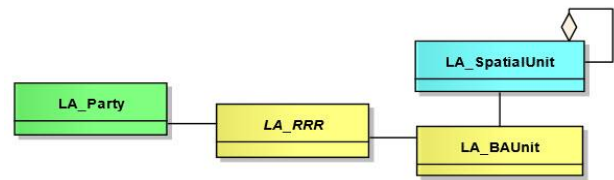

Figure 1. Basic packages of LADM (ISO19152).

3. COMPARISON OF TURKISH AND MALAYSIA CADASTRAL MODEL BASED ON LADM

3.1 Turkish Cadastral Profile based on LADM

The researchers developed the LADM-based 3D cadastral data model (Alkan and Polat, 2017; Sürmeneli and Alkan, 2018; Alkan et al., 2019; Alkan et al., 2020; Sürmeneli et al., 2020) was based on the analysis of the Turkish cadastral system. The model consists of 3 basic classes (TR_Party, TR_RRR and TR_RegistrationObject). The TR_ Right class is divided into two sub-classes as property rights and limited rights. The property right is the right of the owner or legal persons to make all kinds of operations, such as the use of property, purchase, sale, rent, etc. The limited real rights class is divided into two sub-classes as mortgage and easement. The restriction class is the part of the information that restricts the use of limited real rights in the title registration, where the restriction information is registered, and the information is determined. These restrictions are subdivided into representations, rights and liability, annotations and mortgages in the land register. In this class person's obligations are represented. These obligations include pausing the tax on the real estate, maintenance, repair, easement according to the type of real estate. There may be one or more types of obligations.The SpatialUnit class is the parent class where all cadastral objects are represented and associated with the other classes. The SpatialUnit class comprises parcel sub-classes, buildings and independent sections. The parcel class is obligatory for the cadastral system. The building class has a composition relation type with the parcel class. So every building must be on a parcel. The condominium is considered a spatial unit. A building can have non or more independent parts. According to the Property Law, the Annex is outside of a condominium. Also, it is referred to directly as allocated to that section. The Annex cannot be registered alone in the land register. Therefore, the type of 0..* (0-lots) relationship is selected between the condominium and Annex. Utility network, electricity, telephone, drinking water, sewerage, natural gas facilities are called technical infrastructure facilities. In the existing cadastral system in Turkey, utility networks are not registered to the land registry. The existence of a utility network is associated with the parcel or building. In addition, there may not be any utility network equipment under or above each parcel and building the existence facilities. The existing cadastral of a utility network is associated with the parcel or building. In addition, there may not be any utility network equipment under or above each parcel and building. Therefore, the UtilityNetwork class has a type of 0..* (0 and many) relationships with structure and parcel class. Since the land registry is not registered, data related to the utility network facility cannot be kept directly in the system. Also, it can be provided with the external class TR_ExternalUtilityNetwork.Finally, the survey and representation sub-package is the package in which the spatial objects and the geometric status are represented together with the rights, restrictions and responsibility processes. The package

represents geographic points, 2D and 3D borders, title and other resources. The attributes of the classes in the package have been created following the INSPIRE and LADM standards. Figure 2 shows the corresponding classes in Turkish conceptual model and the LADM data model.
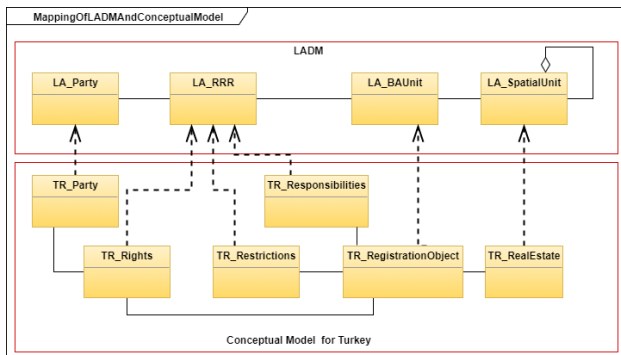

Figure 2. Turkish conceptual model based on the LADM schema (Alkan et al., 2020).

The LADM-based 3D cadastral data model developed by the researchers (Sürmeneli H.G. and Alkan M., 2020) was modeled in 4D by adding temporal attributes. The relationship of the developed model with international standards and LADM classes is shown in figure 3.
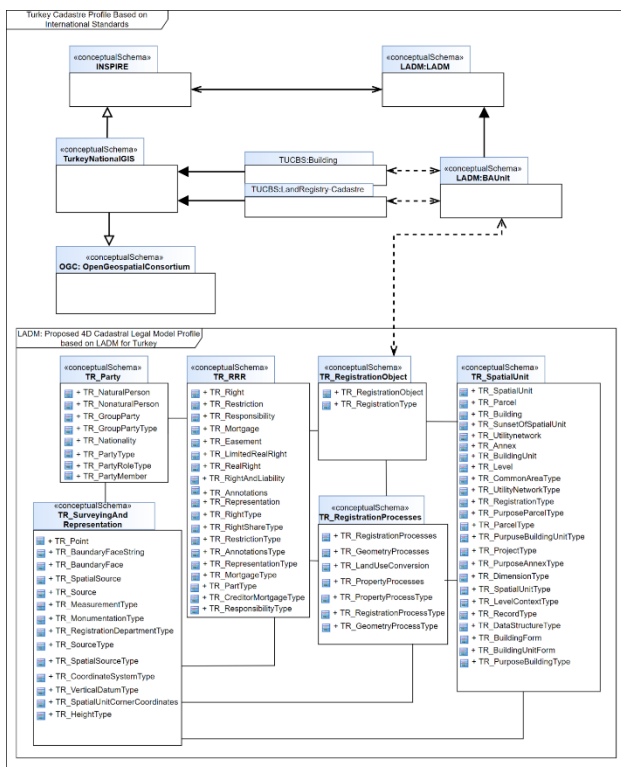

Figure 3. The proposed 4D cadastral legal model is associated with TUCBS sub-package themes based on international standards and LADM for Turkey (The hollow triangle arrow indicates the 'uses' status. A solid arrow indicates the 'dependent' status. The double arrow shows that they are in mutual relationship with each other. The dashed arrow relates the classes that correspond to each other)

3.2 Malaysian Cadastral Profile based on LADM

The development of the Malaysian LADM country profile is based on data sources from the District Land Offices and the Department Survey and Mapping Malaysia (DSMM). The Malaysian LADM country profile model was developed by Zulkifli et al., 2015 based on earlier studies (AbdulRahman et al. 2011; Tan and Looi, 2013; Zulkifli et al.,2013; Zulkifli et al., 2014). The Malaysian country profile is based on an inheritance from the LADM classes. the Malaysian LADM country profile contains the legal part and spatial part. The legal part has a party and administrative package (figure 4). The main class of the party package is MY_Party class with its specialization MY_GroupParty.There is an optional association class called MY_PartyMember. A party is a person or organization that plays a role in a rights transaction. The organization can be a company, a municipality or the state. A group party is any number of parties forming together a distinct entity. A party member is a party registered and identified as a constituent of a group party. The administrative package concerns the abstract class MY_RRR (MY_ Right, MY_Restriction and MY_Responsibility), MY_Mortgage, MY_BAUnit (Basic Administrative Unit) and MY_AdministrativeSource. A right is an action or activity that a system participant may perform or use an associated resource such as ownership, customary, easement and tenancy rights. A restriction is a formal or informal entitlement to refrain from doing something. Responsibility is a formal or informal obligation to do something such as maintaining a monument or a building. MY_Mortgage is a subclass of MY_Restriction. MY_Mortgage also is associated with the class MY_Right. A mortgage can be associated with (0..*) rights. A BAUnit is an administrative entity consisting of zero or more (parcels) against which one or more unique and homogeneous rights, responsibilities or restrictions are associated with the whole entity as included in the Land Administration System (Zulkifli et al., 2015).
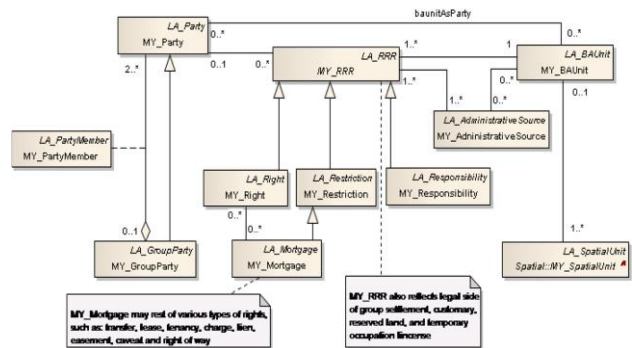

Figure 4. Overview of administrative (legal) part of the Malaysian LADM country profile (Zulkifli et al., 2015).

The spatial unit can be 2D or 3D. The lots are 2D, but subsurface lots exist with 3D volumetric descriptions without 3D topology. MY_GenericLot holds the attributes of a lot, and it has two specialisations, MY_Lot2D and MY_Lot3D, with their attributes and structure. MY_Lot2D is based on 2D topology concerning shared boundaries (MY_ BoundaryFaceString). In 3D, topology is not available for lots (MY_ Lot3D) and strata objects. In the model, one strata object type remains represented in 2D, that is MY_LandParcel (with buildings no more than four storeys). The other strata objects are proposed to be 3D and inherit from an abstract class MY_Shared3DInfo, with strata specialisations (and mutual aggregation relationships): MY_BuildingUnit, MY_ParcelUnit, MY_AccessoryUnit,

MY_CommonPropertyUnit and MY_LimitedCommonPropertyUnit. The LimitedCommonPropertys modelled as a part-of relationship to MY_CommonProperty(the aggregation class). MY_Level class is used to organise the various types of spatial units. There is a type attribute in the MY_Level class that describes the level type of the spatial unit, and such MY_Level is a collection of spatial units with a geometric or thematic coherence. MY_SpatialSource has an association with MY_SpatialUnit and MY_Point (figure 5).
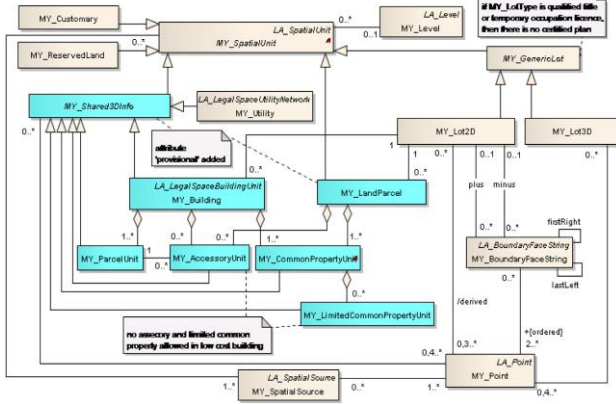

Figure 5. Overview of the spatial part of the Malaysian LADM country profile (Zulkifli et al., 2015).

3.3 Comparison of LADM Countries Model Between Turkey and Malaysia

Although there are differences in the cadastral systems of the two countries, they have many similarities in general. They carry out projects for the improvement of cadastral systems in both countries. In addition, academic and institutional studies are carried out for the transition to 3D cadastre. There are two essential differences in the cadastral system between the two countries. First, while it is possible to register the temporal information about real estate in the Turkish cadastral system, there is no temporal registration in Malaysia. However, the developed LADM model provides innovation for the Malaysian cadastral system. Secondly, it allows the registration of 3D real estate in Malaysia underground and above ground. However, the Turkish cadastral system gives this information in textual (mainly underground structures). Thanks to the common ontology provided by LADM, the differences and similarities in the cadastral systems between the two countries can be compared and understood more clearly. Table 1 shows the comparison of LADM classes and the country profiles based on LADM developed by the two countries. Generally developed packages are the same. Only some classes in the packages show differences. In particular, the classes defined as spatial units are different. Each class is explained in detail in section 3.1 and 3.2. These are: Party, Administrative, Spatial Unit and Surveying and Representations Packages respectively. The LA_Party Package describes the owners, right holders. LA_SpatialUnit Package described spatial units (e.g. parcel, building, apartment) and was mapped to the abstract class RealEstate. LA_RRR describes the rights, restrictions, and responsibilities over the property. The LA_BAUnit class represents a basic administrative unit, a set of rights, restrictions, and responsibilities of one or more real properties. Surveying and Representation classes are TR_Point, TR_SpatialSource, and TR_BoundaryFaceString.

LADM Classes	Turkey 3D Conceptual Model Classes	Malaysian 3D Conceptual Model Classes
Package Party		
LA_Party	TR_Party	MY_Party
LA_GroupParty	TR_GroupParty	MY_GroupParty
LA_PartyMember	TR_PartyMember	MY_PartyMember
Administrative Package		
LA_RRR	TR_RRR	MY_RRR
LA_Right	TR_Right	MY_Right
LA_Restriction	TR_Restriction	MY_Restriction
LA_Responsibility	TR_Responsibility	MY_Responsibility
LA_Right	TR_Easement	-
LA_BAUnit	TR_RegistrationObject	-
LA_Mortgage	TR_Mortgage	MY_Mortgage
LA_RRR	TR_Annotations	-
LA_RRR	TR_Representation	-
LA_RRR	TR_RightAndLiability	-
LA_AdministrativeSource	TR_AdministrativeSource	MY_AdministrativeSource
LA_RRR	TR_RegistrationProcesses	-
LA_RRR	TR_GeometryProcesses	-
LA_RRR	TR_LandUseConversion	-
LA_RRR	TR_PropertyProcesses	-
SpatialUnit Package		
LA_SpatialUnit	TR_SpatialUnit	MY_SpatialUnit
LA_SpatialUnit	TR_Parcel	MY_LandParcel
LA_Level	TR_Level	MY_Level
LA_SpatialUnit	TR_Building	-
LA_SpatialUnit	-	MY_Customary
LA_SpatialUnit	-	MY_ReservedLand
LA_SpatialUnitGroup	TR_SpatialUnitGroup	-

LA_LegalSpaceBuildingUnit	TR_BuildingUnit	MY_Building
LA_LegalSpaceBuildingUnit	TR_Annex	-
LA_LegalSpaceBuildingUnit	-	MY_ParcelUnit
LA_LegalSpaceBuildingUnit	-	MY_AccessoryUnit
LA_LegalSpaceBuildingUnit	TR_CommonArea	MY_CommonPropertyUnit
LA_LegalSpaceBuildingUnit	-	MY_LimitedCommonPropertyUnit
LA_LegalSpaceBuildingUnit	-	MY_Shared3DInfo
LA_LegalSpaceUtilityNetwork	TR_UtilityNetwork	MY_Utility
LA_BAUnit	TR_RegistrationObject	-
LA_RequiredRelationshipSpatialUnit	TR_RequiredRelationshipSpatialUnit	-
Surveying and Representation Sub_Package		
LA_Point	TR_Point	MY_Point
LA_SpatialSource	TR_SpatialSource	MY_SpatialSource
LA_BoundaryFaceString	TR_BoundaryFaceString	MY_BoundaryFaceString
LA_BoundaryFace	TR_BoundaryFace	-
LA_BoundaryFaceString	-	MY_Lot2D
LA_BoundaryFaceString	-	MY_Lot3D
LA_BoundaryFaceString	-	MY_GenericLot

Table 1. Comparison of LADM classes with the proposed 3D conceptual data model classes developed by Turkey and Malaysia

4. DISCUSSIONS AND CONCLUSION

In this study, the cadastral systems of Turkey and Malaysia were evaluated, and LADM-based cadastral data models were examined for the transition to 3D cadastre. Thanks to the LADM-based cadastral data models developed by Turkey and Malaysia, country profiles can be explained more clearly. As an international standard, LADM provides an opportunity to improve Malaysia's and Turkey's land management systems. There are many improvements and benefits that LADM can bring to both countries. Significantly, internal operations of land offices in Malaysia vary; as such, the way land administration data is recorded and used are different. It has resulted in database systems that are different in structure and schema. While it may not be practical or viable to make the databases consistent at the national level, LADM provides an opportunity for harmonising the data when there is a need to integrate the databases for national interests. Database systems of the land office can be mapped to LADM to provide a common ground for understanding how different data elements are described and used. For Turkey, the LADM is used to create 3D terminology and establish a common ontology. The objects registered in the cadastral system are defined, and the relations between the owners are represented. LADM standard facilitates the sharing of 3D digital land administration data with other jurisdictions since LADM provides a standardised approach for exchanging land administration data among all jurisdictions. Thus, it enabled the introduction of the Turkish cadastral system in national and international platforms during the transition to 3D cadastre with its legal aspects. One of the development purposes of LADM is to create a common ontology for different countries and cadastral systems. In this study, thanks to the common ontology presented by LADM, the cadastral systems of the two countries could be easily compared. Thus, the differences and similarities between the systems could be examined. Both countries improve their cadastral systems and develop models based on LADM for 3D cadastral studies, promoting their countries on international platforms. In addition, they will be able to set an example for other countries that plan to develop a cadastral model using LADM.

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