3D Registration of Apartment Rights using BIM/IFC: Comparing the cases of the Netherlands, Saudi Arabia, and Turkey

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SUMMARY

The built environment has a vast and ever-growing number of complex and multi-layered buildings and other structures. The number of those is growing because of the increasing pressure on the limited space in cities. It is important to note that different professional sectors are involved in the realization of a new building. These sectors are mainly the Architecture, Engineering, Construction, and Owner Operator (AECOO), and land administration, which covers the cadastral registration, spatial or zoning plans, as well as property valuation. Noteworthy to mention at this point is, that today the subdivision plans regarding apartment rights in buildings are to be provided on the floor plans as submitted with the building/construction permit request. These plans show the apartment boundaries as two-dimensional (2D) representations, which are insufficient to clearly and completely describe the ownership rights in multi-storey buildings. What is more, the building parts obtained from 2D representations are also inadequate to estimate the valuation of these apartments in both taxation and selling/buying processes. Considering that digitalization and consequently digital data are becoming more and more the norm in the AECOO industry, including the building permit requests, there is an opportunity to exploit Building Information Model (BIM), specifically Industry Foundation Classes (IFC), in the registration of apartment rights in three-dimensional (3D) representations. To investigate the opportunity, this study will further analyze the cases of the Netherlands, Saudi Arabia, and Turkey by revealing the similarities and discrepancies with respect to the registration of apartment rights in terms of legislative basis and current practice and extrapolating the current 2D practices into fully 3D representations. In earlier work, ISO19152 LADM-based models for the 3D building legal spaces have been developed and are related to BIM/IFC. The main objective of the study is to highlight the possibility of providing an internationally standardized modeling specification for 3D registration of legal rights within buildings, based on the earlier detected information model overlaps. What is more, it is expected to increase the awareness in other sectors than land administration with regards to legal spaces in the buildings. Finally, this study endeavors to provide concrete guidelines for the other sectors, most specifically the Architects, regarding the type of information that BIM/IFC models should have, in order to facilitate the 3D registration of apartment rights.

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1. INTRODUCTION

The inevitable migration from rural areas to urban areas results in the need for new buildings with the urban sprawl. The built environment is currently highly dense because of the increased number of buildings and other infrastructure facilities (van Oosterom et al., 2020). Considering the areas in cities are limited, the trend for complex and high-rise buildings is also growing. On the other side, there is a growing interest in underground facilities development that is vital for many public services such as electricity, gas, network, and water (Ramlakhan et al., 2021). In this sense, the land administration that deals with the efficient management of on, above, and below of land and associated ownership rights is directly related to the need for new buildings and other infrastructure facilities (Yomralioglu and McLaughlin, 2017).

Land administration systems (LAS) aim to provide the basis for land management through the integration of spatial, legal, and administrative data. The management of the ownership rights is the subject of the three-dimensional (3D) cadastre that is interested in both measurement and registration of these rights including the vertical dimensions alongside the horizontal. In this scene, LAS that are generally based on the two-dimensional (2D) data need to be able to deal with the 3rd dimension for solving complex issues with respect to ownership. It can also be noted that the term '3D Land Administration' is gaining interest instead of '3D Cadastre' since it provides a meaning that covers the land registry and cadastral works as a whole (Kalogianni et al., 2020b). The reason for the 3D LAS is that 2D representations regarding ownership rights within complex apartments might be insufficient for complete delineations and registration of these rights (Atazadeh et al., 2017b). In this respect, the Land Administration Domain Model (LADM) ISO 19152:2012 is an international knowledge domain-specific standard capturing the semantics of the Land Administration Domain (ISO, 2012). It provides a common, standardized, global vocabulary, ontology, and semantics aiming to stimulate the development of software applications and accelerate the implementation of land administration systems that support sustainability objectives (Lemmen et al., 2015). Although the content of the various laws with respect to apartment rights might differ from the countries there are common issues that require the 3D modeling of rights, restrictions, and responsibilities (RRR) for the cadastral registration.

Architecture, Engineering, Construction, and Owner Operator (AECOO) is one of the most related industries to the registration of ownership rights within the apartments because the plans representing the locations of each unit of the apartment with the coordinates are regularly used to register the condominium rights. Within this industry, there is a growing interest in Building

Information Model (BIM) that allows for designing buildings digitally, detailedly, and collaboratively through an object-based modeling approach (NBS, 2020). Interoperability is significantly important for BIM-based works in common with the technologies that provide and exploit data exchange. To address the interoperability issues regarding BIM, there are a number of standards, with the Industry Foundation Classes (IFC) ISO 16739-1:2018, to be the most prominent as it provides highly detailed data modeling specifications for BIM models (ISO, 2018).

Therefore, this paper aims to reveal whether a basis for the modeling approach can be provided for the 3D depiction of condominium rights using BIM/IFC models of the apartments by comparing the cases from different countries namely the Netherlands, Saudi Arabia, and Turkey.

1.1 Related Work

Related work has been carried out in this domain, specifically for reusing BIM models for land administration purposes. Earlier studies intended the 3D delineation of property ownership in the buildings in the context of 3D cadastre by benefiting from modeling approaches within the 3D Geographic Information Systems (GIS) technologies (e.g., (Döner et al., 2011)). Following the publication of spatial data standards such as OGC CityGML (OGC, 2021) for 3D city modeling, researchers focused on how the RRRs can be modeled using these standards (i.e.,(Cagdas, 2013; Kalogianni et al., 2017)). The approach exploiting spatial data standards offers a noteworthy potential for the 3D depiction of ownership rights in the buildings because they provide the schemas containing the geometric specifications for 3D modeling of the physical objects. With the publication of the LADM as an ISO standard, scholars applied an approach that integrates LADM and CityGML to depict the apartment rights within the buildings and other infrastructure (as reported by (Góźdź et al., 2014)). Such an approach exploits the conceptual basis of the LADM for modeling RRRs and the physical/geometric models to link these RRRs to their physical counterparts.

Moreover, the utilization of BIM models in the 3D representation of RRRs in the buildings is researched in the different countries such as The Netherlands (Broekhuizen, 2021; Meulmeester, 2019), Sweden (Sun et al., 2021, 2019), Australia (Atazadeh et al., 2017a), Saudi Arabia (Alattas et al., 2021), and Turkey (Celik Simsek and Uzun, 2021; Guler and Yomralioglu, 2021a) because of the prominently increased adaptation of BIM in the different sectors, as around the world BIM is gaining rapid visibility within the industry and governments are starting to demand and even mandate BIM deliverables (Kalogianni et al., 2020a). Whereas some studies focus on the use of BIM models that are enriched with attributes regarding RRR for cadastral registration (such as (Atazadeh et al., 2017b)), some of them focus on the integration of LADM and IFC standards (such as (Atazadeh et al., 2018; Broekhuizen, 2021)), while the extension of IFC standards through adding a new entity is also proposed (Petronijević et al., 2021).

1.1 Motivation

The review of previous studies discloses that the consensus about the conceptual basis for 3D modeling of condominium rights by benefiting from the reuse of BIM/IFC models has not been researched and there are significant efforts emphasizing the usability of this approach. Therefore, the objective of this paper is to unveil how a modeling approach based on the use of BIM/IFC models for the 3D representation of both legal spaces and physical building elements, as well as the attached RRRs on the buildings can be developed. Following, this paper aims to create awareness in the land administration-related sectors (including AECOO and spatial planning) about 3D legal spaces and the attached RRRs on the buildings in order to increase the reuse of BIM/IFC models for 3D land administration and specifically the registration of condominium rights.

This paper is structured as follows: the next section provides the legal and organizational basis of the three countries in terms of the registration of the condominium rights. Moreover, Section 3 presents the already developed LADM-based country profiles and the research on the use of the BIM/IFC models in these countries. Subsequently, the comparison results in terms of legal and technical perspectives are presented in Section 4. Lastly, Section 5 provides the discussion in the context of the paper's motivation and concludes the paper.

2. LEGAL BASIS OF THE COUNTRIES

2.1 The Netherlands

The legal base of apartment rights in the Netherlands is described in the Dutch Civil Code, (Book 5, Real Property Rights, Title 5.9 Apartment Rights, Section 5.9.1 General Provisions). Article 5:106 (par. 4) describes what an apartment right precisely is, stating that an apartment right is a share in an asset that gives the exclusive right to use certain parts of the building as a separate private unit. Especially the (in English translated) "*...the exclusive right to use certain parts of the building, which parts are to be used, according to their functional arrangement, as a separate private unit....*" is important, as it states that, what can be seen as a separate private unit, is derived from its functional arrangement. However, the private unit does not necessarily have to be a residential apartment (condominium) in a building complex, it could also be an office, an entire house, a section of water (in a marina), or a piece of land without a building (Bartels and Velten, 2017). An apartment right itself can be therefore split into two or more apartment rights.

An apartment right is established with a notarial deed. This is a formal requirement, embedded in the law in Article 5:109. To split a building up into apartments, this notarial deed is called a *"splitsingsakte"* (spitting deed). A notarial deed to establish apartment rights consists of a written part in which, among other things, a written description of the parts of a building on which the apartment right is formed. This written part can refer to a drawing that is attached to

the deed, visualizing the ownership situation of a building when apartment rights are registered (Meulmeester, 2019).

The Netherlands' Cadastre, Land Registry and Mapping Agency, "het Kadaster", consists of both land registration and cadastre, providing legal certainty about every piece of land and water in the Netherlands. Formally the Dutch LAS is tasked to acquire, geometrically register, maintain and cartographically visualize public registries. The Dutch LAS has different RRRs which can be registered. First is the right of ownership (*eigendomsrecht*). This ownership includes in theory not only the land itself but also the space upwards and downwards from the parcel according to the principle of the rule of accession (*superficies solo cedit*). Next to complete ownership, there are forms of limited ownership rights. The right of superficies (*opstalrecht*) allows to own or place the immovable property in, on, or under the property of another party. The right of long lease (*erfpacht*) is a right to use the land, i.e. a municipality provides a long lease to a party, which owns the building on the land, in exchange for a one-time or re-occuring fee. The right of easement (*erfdienstbaarheid*) is a right of which the owner has the responsibility to allow access to his land to serve another party.

Finally, the apartment right (*appartementsrecht*) is a right to part of a split parcel used for multi-level apartments. Since 2D parcels do not define exclusive ownership of apartments, the ownership of a residence in an apartment building is required to have the boundaries of properties in a deed of division (*splitsingsakte*), part of this deed is a 2D drawing with a graphical representation of the boundaries (Stoter et al., 2013).

2.2 Saudi Arabia

Land administration is overseen by four different stakeholders (Ministry of Municipal and Rural Affairs, Ministry of Justice, Real Estate General Authority, and Ministry of Housing). There is a wide range of data that they are responsible for, including technical and legal data. During the process of registering ownership, each of the four stakeholders has a specific role. The Ministry of Municipal and Rural Affairs is in charge of city planning and defining land use in each district and parcel. It is also responsible for defining building codes and regulations for various buildings and infrastructure. Housing regulations are defined by the Ministry of Housing in Saudi Arabia to provide a well-structured market in the country. As a result, it has a wide range of activities to support its aims, including unit subdivision, owner's association, rent program, white land regulations, as well as the Building Technology Initiative. Land registration is the responsibility of the Real Estate General Authority, a government agency under the Ministry of Housing. It is responsible for implementing and enforcing all real estate market regulations. In addition, it is responsible for issuing all forms of property registration documents (https://rega.gov.sa). Last in line for property registration, the Ministry of Justice (https://www.moj.gov.sa) is responsible for delivering the deed registration documents to its users after obtaining the necessary data from the other relevant stakeholders (Alattas et al., 2020).

A new era in property registration in Saudi Arabia began when the Council of Ministers of Saudi Arabia approved the Real Estate Ownership and Subdivision Rules. Decision No. 40 from the Council of Ministers of Saudi Arabia was made on April 22, 2002, and It was approved by Royal Decree No. M / 5 on April 24, 2002. The procedure for issuance of the deed registration document differs according to the property type. The unit subdivision procedure begins with submitting a request to the Ministry of Housing through an architectural firm. Technical data will be checked by the architectural firm using information from the Ministry of Municipal and Rural Affairs (MMRCA). After that, the request will be sent to the Ministry of Housing, which will apply and verify all the necessary details. If all requests meet all requirements, the Ministry of Justice will be notified and instructed to issue a new deed registration document for each unit in the building (Alattas et al., 2021).

The subdivision regulation contains several articles that must be addressed throughout the subdivision procedure. After the initial construction of the building, specific conditions must be presented on the property in order to apply the subdivision processes. The following criteria have been established by the Ministry of Housing to secure full ownership of the property after the issuance of deed registration papers: each property must have a separate entrance, each property must have an electricity meter, common spaces and shared amenities must have a service meter, the property's building must have a common space from the roof to serve all properties, and each property must have a separate entrance. Furthermore, the Ministry of Housing has specified the categories of real estate that can be subdivided into multiple units and the units that can be gained due to subdivision procedures. Towers, malls, residential complexes, residential, commercial complexes, buildings (story buildings), and villas are all types of real estate properties that could be subdivided into many units. The second group includes units that may be acquired via subdivision processes and may have their own deed registration documents, such as a building, a connected building, a tower, a connected tower, an apartment, or a two-story apartment. Furthermore, the Ministry of Housing has employed the authorized numbering system by the National Address to issue a unit number to the property. Each building is assigned a unique number that comprises the building's number, the postal code, and an additional number (Alattas et al., 2021).

Different types of spaces have been identified by the subdivision regulation, including private spaces, exclusive common spaces, and common spaces. To be classified as a "private space," a space must belong to a specific unit and provide no common amenities. In addition, the private space cannot be utilized to access another unit or a common area, nor does it have any shared services. The exclusive common spaces have been described as those facilities and services that are exclusively available to a limited number of units. The facilities and services that are shared by all units, such as the shaft, roof, elevator, stairwell, setbacks, parking, and the building's outer facades, are considered common spaces (Alattas et al., 2021).

In addition, the subdivision regulation has outlined the procedures for determining the area of the unit and its boundaries. All parts of the building must be split by drawing the boundaries of all units, common spaces, exclusive common spaces, and private spaces, such that there are no regions that have not been calculated, i.e., a planar division (per floor). Setbacks and roof

areas must be evaluated and determined based on their function as a private or common space. On the borders of units, common and private spaces, the boundaries should be drawn from the center of the wall, no matter whether it is bounded by common spaces, units, or private spaces. Finally, the building's construction elements, such as the walls (which are placed on the property unit's boundary), columns, and slabs, have common ownership due to the subdivision procedures (Alattas et al., 2021).

2.3 Turkey

There are several laws and legislative documents regarding land administration and cadastral registration in Turkey. Turkish Civil Code No.4721 (Official Gazette, 2001) is the main law that describes real estate ownership. Article 704 of this law states that the subjects of real estate ownership are land, independent and permanent rights, and condominiums that are recorded in the condominium register. In addition to this article, it is provided in Article 718 of the same law that the ownership on land covers the air above it and below supply layers to the extent that is beneficial to use. The Civil Code also contains a number of articles that describe a wide range of rights such as superficies, usufruct, and right of way. There are also important legal references for cadastral registration such as Cadastre Law No.3402, Land Registry Law No.2644, and Zoning Law No.3194.

Condominium Law No.634 (Official Gazette, 1965) is the main legislative document that defines the RRRs with respect to condominiums. Article 1 of the Condominium Law states that independent ownership rights can be established by the owner or joint owners on the different units such as storey, apartment, office, store, cellar, and storage of a constructed building that are suitable to be used independently and separately. Clause 1 of Article 2 of the same law provides the definitions of the main real estate, main building, condominium, annex, condominium right, and condominium owner. It is also significant to note that the condominium rights can be established with the land shares of each condominium that are assigned depending on the values that are estimated based on location and size parameters.

According to the law, a condominium owner can have the right to use the condominium itself and spaces that are outside of the condominium as well. Annexes can be coal cellar, water tank, garage, electric meter box, or toilet. The Condominium law also states that condominium owners have jointly the right to use shared facilities and spaces that are outside of the condominiums in real estate and serve for protection and exploitation. Main walls, beams, columns, curtain walls, floors, ceilings, patios, stairs, elevators, and corridors are examples of shared facilities and spaces. The Condominium Law also provides that the management plan that shows the management style, aim and way of use are prepared and stored with the establishment documents of the condominium. Based on the Circular Letter 2021/4 published by the General Directorate of Land Registry and Cadastre (GDLRC) some of the common places within mass housing can be assigned to the use of the specific condominiums (GDLRC, 2021).

3. LADM-BASED COUNTRY PROFILES AND RELATED DEVELOPMENTS

3.1 The Netherlands

The first country profile of the Netherlands is included in Annex D of ISO 19152:2012 LADM (ISO, 2012). A first mapping was made between the model of Kadaster and the first version of the LADM. For the semantic transformation between the two data models the prefix "NL" is used to denote the Dutch country profile. This profile is an initial attempt to depict the land registry situation of the Netherlands within the concepts, associations, and terminology of LADM. It is noticed that this profile is quite simple, utilizing the core classes of LADM for the needs of Kadaster, and it is justified as the profile was developed at the same time that the LADM was voted as ISO, and hence, it was modeled simple yet consistent.

Following that, Soffers (2017) further developed the Dutch LADM-based country profile focusing only on the 'Survey and Representation' sub-package, named the Netherlands Survey and Representation Data Model (NLSRDM). Three classes have been created for the sub-package, NL_SpatialSource (with four subclasses), NL_Point, and NL_BoundaryFaceString; only the LA_BoundaryFace class was omitted and not mapped as a class at the profile, as at the time of the development there was no provision for 3D surveying and implementation. The NL_SpatialSource class and the superclass VersionedObject proved to be very useful for history management, which is crucial for the surveying part. The LADM considers points, boundaries, and parcels as stand-alone cadastral objects which are all related to each other. The benefit of the proposed LADM-based model is to store the specific information in relation to the object, taking into account the new Dutch storage system of cadastral survey data 'Terrestrische Registratie' (TR – Terrestrial Recordation), as described in Soffers (2017) and Soffers and Hagemans (2018).

What is more, Kara et al. (2019) have developed the ISO 19152 LADM Valuation Information Model for the Netherlands based on the proposed LADM Valuation Information Model for LADM Edition I (in 2020), before the revision of LADM revision and the decision for the development of a multipart standard.

Lastly, over the last five years Kadaster is redesigning the cadastral mapping and surveying information by starting a program for an improved cadastral map with higher and better geometric quality and at the same time building a new information system for cadastral survey information, inspired by the LADM (Hagemans et al., 2022). Within the 'Cadastral Map Next' program, a new data model is developed containing two maps (current (fitted) Cadastral Map and Reconstruction Map), which have connected points to describe the geometry and connect the measurement data to the map data. Furthermore, it is investigated how the BIM/IFC models can be used as a data source for the 3D registration of apartment rights in the country (Broekhuizen, 2021; Meulmeester, 2019).

3.2 Saudi Arabia

The development of the country profile of Saudi Arabia has passed through several phases, and it started with the development of the initial country profile. The initial country profile was created based on the interaction between all stockholders in order to represent Saudi Arabia's land administration system (Alattas et al., 2019). During the development process, the initial profile has reflected the core information of the existing land administration system, and it includes spatial and nonspatial classes.

The SA_SpatialUnit class has been added to the Spatial classes, and it has two subclasses, SA LandParcel and SA_BuildingUnit, to represent the parcel and building respectively. There are three subclasses of the SA_BuildingUnit: SA_InnerUnit, SA_AmenitiesUnit, and SA_SharedAreaUnit. The SA_InnerUnit class represents a unit such as an apartment, an office, a clinic, etc. The SA_AmenitiesUnit class identifies a service unit, such as a storage unit. Finally, the SA_SharedAreaUnit depicts all places where the owners share ownership, such as a corridor. All three classes are associated with SA_BoundaryFaceString to represent 2D boundary information since all inner units are represented in 2D according to the current land administration system in Saudi Arabia.

The SA_LandParcel, on the other hand, has just one subclass, SA_AmenitiesUnit. The party package, which consists of SA Party, SA_GroupParty, and SA_PartyMember, has been included in the Non-Spatial classes. A new attribute has been added to the SA_Party class to show the party's nationality. Additionally, the administration package comprises the SA_RRR class, which contains the SA_Right, SA_Responsibility, and SA_Restriction subclasses. SA_Mortgage is a subclass of SA_Restriction and has an association relationship with SA_Right (Alattas et al., 2019).

On the other hand, the initial country profile mainly included the fundamentals of Saudi Arabia's current land administration system. As a result, a different strategy has been used to gather all of the information required for the registration process from all stakeholders. The new method emphasizes the collection of multiple deed registration documents for various property types, including land parcels, buildings, and apartment units. For example, an analysis of deed registration documents belonging to the apartment unit has provided 35 attributes that have been utilized to identify essential information.

Every step of the procedure was performed for both the house and land parcel properties. The house property had 34 attributes, and the land parcel property had 16. The 16 attributes that appear in all three lists are classified as non-optional, including parcel number, district name, city, ownership border, etc. Moreover, the other attributes have been classified as optional attributes depending on the property registration's condition. A complete list of the new Saudi Arabia registration deed information is now being prepared. Afterward, all attributes were analyzed, resulting in three distinct categories of data: party information, spatial information, and administrative information. After that, each attribute was allocated to its corresponding class in the country profile. As a result, each attribute's data type has been established based on

the type of input information, and the values of each attribute's code list have been defined (Alattas et al., 2020).

The initial country profile has been updated to include all of the additional attributes. The Party and Administrative packages are the non-spatial classes. SA_Party class, SA_GroupParty, and SA_PartyMember are all part of the Party package. SA_Party contains three additional attributes: nationalID, nationality, and type. SA_Party does not have any optional attributes. The attributes of the SA_GroupParty and SA_PartyMember are inherited from the LA_PartyMember and LA_GroupParty (Alattas et al., 2020).

SA_BAUnit, SA_RRR, SA_AdministrativeSource, and SA_Mortgage are all classes of the administrative package. The SA_RRR class has subclasses called SA_Right, SA_Responsibility, and SA_Restriction. In addition to the attributes inherited from the LA_AdministativeSource, the SA_AdministativeSource has additional attributes. For example, the registration deed No. and registration deed date attributes are required, while the rest of the attributes are classified optional depending on the status of the property registration. Moreover, the SA_Mortgage class has more attributes, but only the shariah Board authorization number and the shariah Board authorization date are required attributes for the class. Furthermore, the SA_Mortgage is an abstract class with two subclasses, SA_MortgageSourceOne and SA_MortgageSourceTwo, representing distinct types of mortgages.

The spatial classes are composed of the SA_SpatialUnit abstract class, with four extra attributes: property Type, district No., district name, and city, all regarded as non-optional attributes. The SA_LandParcel and SA_BuildingUnit are both subclasses of the SA_SpatialUnit, and they also include extra attributes classified as non-optional attributes. The SA_LandParcel class contains five attributes: parcel No., area, ownership boundary, type, and reference. The SA_BuildingUnit class has four attributes: parcelNumber, reference, type, and numberOfFloors. The SA_BuildingUnit contains three subclasses: SA_InnerUnit, SA_AmenitiesUnit, and SA_SharedAreaUnit. The SA_InnerUnit class represents a unit, such as an apartment. The SA_AmenitiesUnit represents the services unit, such as the storage unit, and the SA_SharedAreaUnit represents all areas that are owned jointly by the owners, such as the corridor (Alattas et al., 2020).

In Saudi Arabia, building unit subdivision processes are based on a 2D representation of legal space ownership. The 3D depiction of legal space ownership, on the other hand, will provide a more detailed description of the spaces for better registration. As a result, the 3D depiction of legal space ownership has been proposed by applying the same laws and regulations as Saudi Arabia's existing building unit subdivision processes (Alattas et al., 2021). The 3D representation of legal space ownership was utilized to convert the 2D country profile into a 3D country profile that contains all of the new attributes that have been linked to the 3D model as detailed in (Alattas et al., 2021). The administrative package's SA_BAUnit, SA_Right, and SA_Party classes include new properties that correspond to the additional attributes suggested to establish the ownership of the spaces and construction components. The attribute 'type' on the class SA_Right takes values from the code list LA_RightType, which has three values:

private ownership, common ownership, and exclusive common ownership. There are four other attributes in the SA_Party class: name, nationalID, nationality, and IDType. The attribute 'Nationality' takes values from the code list SA_NationalityType, representing several nationalities such as Saudi Arabia and the Gulf countries. The SA_SpatialUnit is an abstract class with three more attributes from the ISO 19152:2012 UML: districtNo, districtName, and city. The SA_Level class is used to represent the three property description levels: level zero for parcels, level one for building units, and level two for construction components.

The SA_ConstructionElement class is abstract and has a generalization relationship with the SA_SpatialUnit class. Furthermore, it contains a constraint linked with the property representation level, representing level two of the SA_Level class. There are three subclasses of the SA_ConstructionElement: SA_Wall, SA_Column, and SA_Slab. Additionally, the SA_Building class has a generalization relationship with the SA_SpatialUnit, and it contains three extra attributes from the ISO UML: reference, type, and numberOfFloor. The reference attribute is set to GM_Point. The attribute 'type' takes values from the code list SA_BuildingType, representing various building forms such as residential, commercial, and industrial.

Furthermore, the SA_Building class is composed of the SA_ConstructionElement class. The SA_BuildingUnit class is abstract and represents the building's spaces; it contains three subclasses: SA_MainUnit, SA _AmenitiesUnit, SA_SharedAreaUnit, and two more attributes are added: floorNo and area. The SA_MainUnit class represents the most common type of space and has five attributes: type, propertyNo, percentageOfThePropertyAreaToTheParcelArea, propertyShareFromTheParcelArea (Sq.M), and ownershipBoundary. The attribute 'type' takes values from the code list SA_UnitType, representing various unit types such as office, apartment, shop, and clinic. The service spaces are represented by the SA_AmenitiesUnit class, which contains three attributes: type, AmenitiesUnitNumber, and AmenitiesUnitLevel.

The SA SharedAreaUnit class includes a single attribute called 'type,' which takes values from the code list SA ShareAreaType. The value of the attribute 'type' is SA ShareAreaType, which represents the type of service areas such as stairs, elevators, hallways, entry, and parking. Furthermore, the SA BuildingUnit class contains two '+/-' associations with the classes SA Wall, SA Column, and SA Slab to indicate the areas placed to the right and left of the building element to determine the correct kind of usage for the construction element. Finally, the SA LandParcel class is a generalization of the SA SpatialUnit class, and it contains five attributes: parcelNo, area, ownership boundary, type, and reference. In addition, the attribute 'type' is assigned a value from the code list SA landUseType, representing the land's use type, such as residential apartment complexes and government areas.

3.3 Turkey

With the publication of the LADM standard, the country profiles for the Turkish land administration system are also proposed similar to other countries. Alkan and Polat (2017) modified the conceptual model of LADM based on the needs of the current cadastral system in

Turkey. The new classes are proposed within the country profile. For example, TR_BuildingUnit, TR_SingleSpace, and TR_Premises are the classes created to store information regarding real estate. Next, Polat et al. (2020) proposed an LADM-based profile for managing easements by considering their temporal information in Turkey. Scholars added a new subclass namely Easement of TR_Right class with sufficient attributes with regards to easement such as type, duration, and recording date. Moreover, an LADM-based country profile for Turkey in the context of 3D cadastre purposes is also developed. This country profile encompasses all main classes of LADM Edition I. Another LADM-based country profile for Turkey is created based on the Valuation Information Model that is developed for real property valuation purposes and will be a part of the next edition of LADM (Kara et al., 2021). This country profile contains a number of classes related to condominium rights such as TR_VM_CondominiumUnit, TR_VM_Building, and TR_VM_Parcel. Researchers implemented the created conceptual model in a database by populating GML and GeoJSON data. Recently, Gürsoy Sürmeneli et al. (2022a) proposed a Turkish country profile that meets the needs of a four-dimensional (4D) cadastral system. As a complement study, the CityGML ADE is created for depicting the cadastral rights in 3D (Gürsoy Sürmeneli et al., 2022b).

In the context of the use of BIM models, the conceptual model matching the classes of LADM and entities of IFC for the 3D depiction of condominium rights is presented by Guler and Yomralioglu (2022). The model contains two parts. One of the aims of creating this model is to obtain the IFC model that contains entity properties that are enriched with the attributes of classes in LADM. This aim helps to use the obtained IFC model in representing the cadastral rights within the buildings in 3D. Another aim is to aid in the registration of condominium rights by means of extracting and reusing the entity properties of the IFC model. The developed model integrates the possible entities for the classes of the LADM. TR_Party that provides the attributes of different parties within land administration practices is linked with the IfcActor. TR_GroupParty that can be composed of a group of various parties can be matched with the IfcGroup entity. TR_BAUnit class is used to express the registration object can be linked with the IfcZone entity. TR_AdministrativeSource that stores the source information for TR_BAUnit can be matched with the IfcDocumentInformation entity through IfcRelAssociatesDocument. TR_Parcel that is utilized to store the required attributes for land parcels can be linked with the IfcSite entity. TR_Building can be matched with the IfcBuilding that stores the details of the buildings in the IFC schema. There is a composition relationship between TR_Building and TR_CondominiumUnit because the condominium rights can be established only if the building is constructed. There are the aggregation relationships between TR_CondominiumUnit and TR_MainUnit, TR_SharedFacility, and TR_Annex classes. These three classes enable the modeling of different types of physical legal spaces related to condominium rights and provide detailed attributes. As mentioned in Section 2.3, a condominium unit can have the right to use for an annex, a shared facility, and the main unit. While these classes can be modeled using the IfcSpace entity, IfcZone is used to store the TR_CondominiumUnit. This is because IfcZone enables the modelling of multiple IfcSpace instances. The developed model also contains the different building elements such as walls, stairs, doors, and columns that can be subject to condominium rights based on the legal background in the country. Accordingly, TR_BuildingElement that provides attributes to model

which condominium has the right to use is linked with the several IFC entities such as IfcWall, IfcSlab, IfcColumn, and IfcWindow. In addition, TR_Point, TR_BoundaryFaceString, and TR_BoundaryFace are linked with IfcCartesianPoint, IfcPolyline, and IfcConnectionSurfaceGeometry respectively.

4. COMPARISON OF LEGAL AND THE COUNTRIES

4.1 Legal Aspects

It can be noted that all three countries utilize the cadastral system that is based on 2D depiction. The Netherlands and Turkey have similar ownership descriptions in terms of the condominium rights. There is fundamentally private and common ownership regarding apartment rights in both countries. Saudi Arabia differs even a little from these countries because it has exclusive common ownership as well. In Turkey, Condominium Law provides that a common place in a mass housing can be assigned to the use of more than one condominium similar to exclusive common ownership in Saudi Arabia but there are two definitions in this law as a condominium (private ownership for a specific apartment unit) and common areas and there is no additional definition similar to the exclusive common ownership. Further, in the case of Saudi Arabia, there are different cases with respect to exclusive common ownership. For example, the exclusive common ownership is applied to the walls that are located between two condominiums. However, in the case of Turkey, such walls are considered as common ownership. In the context of defining boundaries with regard to their ownership type, the Netherlands and Turkey share a common approach since the nature of the boundaries is not defined legally. In Turkey, it is for example stated that the main walls of the buildings are used commonly. Similarly, in the Netherlands, there is no specific description of the modeling of the wall faces for condominium rights even though it is mandated that the drawings that show the boundaries regarding the private and common areas should be provided. In the case of Saudi Arabia, different private units have the right to use on different faces of the construction elements such as walls. In Turkey, the condominium plans that show the locations of each condominium in the building are prepared as 2D drawings. Saudi Arabia has a little bit different application since the approved condominium plans encompass all the floor plans and several section plans as well. The characteristic of the condominium rights differentiates slightly in Turkey from the other two countries because it is stated in the Condominium Law that the condominium right is a special right that is related to land share and the common places in the real estate. The land shares of each condominium are estimated based on their locations and sizes according to the law.

Regarding the responsible organization of apartment rights, the Netherlands and Turkey also do not differ because the registration of apartment rights is carried out by the land registry and cadastre agencies of the countries. However, different ministries such as the Ministry of Justice and the Ministry of Municipal & Rural Affairs are involved in property rights registration in Saudi Arabia. Noteworthy to mention that there is no specific development with respect to the use of BIM models for apartment rights in all countries even though there is a growing research interest in BIM-based cadastral registration as 3D. Nevertheless, in Turkey, it is stated in the

circular letter by the GDLRC that 3D digital building models will be submitted for registration of condominium rights.

4.2 Technical Aspects

This section provides a comparison of research from three countries related to the use of BIM models for the delineation of apartment rights. In the case of the Netherlands, it is identified the current requirements for the 3D depiction of apartment rights in the buildings. Based on these requirements, it is decided that the use of the IfcSpace entity can be sufficient for the current needs of cadastral registration of apartment rights in terms of legal background. Utilizing the IfcSpace for depicting the legal spaces within buildings is determined as adequate because there is no legal obligation to provide the nature of the structural elements such as walls, as mentioned in Section 3.1. It is however shown that the walls can be modeled such that they are enriched with the ownership information by means of adding the suitable properties to the entity instances. The structural elements such as walls, slabs, and columns are modeled in a way that contains the different ownership types namely private, common, and exclusive common in the case of Saudi Arabia because the ownership information regarding such elements is required on the legal basis, as mentioned in Section 3.1. In Turkey's case, different IFC entities such as IfcWall and IfcColumn are used to model condominium rights since the legal basis in the country provides that several structural elements within buildings can be subject to condominium rights. For example, IfcWall instances representing the main walls within the building are enriched with properties that provide the corresponding attributes in the proposed conceptual model. It can be observed the similar approach between Saudi Arabia and Turkey cases in terms of modeling the structural elements. It can also be noted that research for three countries enables to model of annexes, common areas, and main units as well. Yet there is a differentiation between the approaches of the Netherlands, and Saudi Arabia and Turkey. While IfcSpace is only used to model legal spaces in the case of the Netherlands by importing related information to the spatial database, the IfcZone entity is benefited in the cases of Saudi Arabia and Turkey in order to group legal spaces for annexes and common areas that the specific condominium has right to use. In Saudi Arabia’s case, the surfaces that can be subject to different ownership types are modeled using several attributes that can be attached to IFC instances of related construction elements, for example, slab. These attributes allow for defining the ownership information depending on the sides of the construction elements. In the case of Turkey, construction elements can be modeled based on the ownership type, namely common and private because the ownership information based on the surfaces of the construction elements is not defined in the laws. However, the surrounding faces of the legal spaces can be modeled in the proposed model through IfcConnectionSurfaceGeometry.

5. DISCUSSION AND CONCLUSION

The increasing trend for the usage of the BIM technique in the construction sector enables to exploit BIM models for different purposes such as registration of apartment rights in the buildings. The necessity to depict RRRs associated with the condominiums within the building is evident due to the insufficiency of the 2D representations. This can be also seen from the

research interests from three different countries that are compared in this paper. It is important to note there is a strong relationship between the building/construction permitting and registration of apartment rights (Guler and Yomralioglu, 2021b). This can be readily understood from the cases of Saudi Arabia and Turkey. In fact, the opportunity for exploiting BIM models in cadastral registration arises from the use of the BIM technique for designing buildings. Moreover, if the agencies that are responsible for issuing a building permit require BIM models for implementing the compliance checking in the context of digital building permitting rather than 2D plans more BIM models will be available (Noardo et al., 2022). The significant issue at this point is that BIM models that will be used for the registration of apartment rights should be in as-built form otherwise incorrect cadastral information would be registered to the cadastral database. For example, in Turkey, condominium units have the right to use in common places of the buildings based on their land shares. Considering the building designs might be altered during the construction phase, the land shares may be wrongfully calculated and this causes problems in the management of the condominiums. Also, there is a noteworthy potential for realistically estimating the land shares of the condominium units by benefiting from the BIM models that provide physical objects with semantics that can be beneficial for real estate valuation (Mete et al., 2022).

The paramount issue for the reuse of the BIM models is that these models should have adequate information for the 3D registration of apartment rights. The easiest way is to enrich the IFC data by adding property sets and properties regarding the RRRs associated with the condominiums. The content of these RRRs can be modeled based on the LADM standard as in the cases of the Netherlands and Turkey. At this point, it can be underlined that the national data specifications with respect to the BIM models in terms of the apartment rights are of great importance to ensure sufficient data source. For example, IFC models should not contain the missing spaces. Furthermore, these models should have spaces that correctly represent the legal counterparts of the condominium units. The guidelines that express how to model legal spaces and their attributes regarding RRRs can be enabled to different stakeholders such as architects. For example, there is a need for clear explanations about the georeferencing of the IFC models (Noardo et al., 2020). The underlying model that contains the modeling approach for registration of apartment rights could be beneficial in order to enable the common ontology for the 3D depiction of condominium rights. This model can include the classes representing the condominium unit, annex, and shared facility and building elements that can be subject to apartment rights.

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