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A Reformative Framework for Processes from Building Permit Issuing to Property Ownership in Turkey

Dogus Guler, Tahsin Yomralioglu*

Department of Geomatics Engineering, Istanbul Technical University, Istanbul, Turkey

(gulerdo, tahsin)@itu.edu.tr

**Corresponding author*

Abstract

A smart built environment has become necessary for ensuring social well-being due to uncontrolled population growth and unrestrainable urban sprawl. In this connection, effective land administration is a significant element to actualize sustainable development. Yet existing building permit procedures fail to satisfy the need for current construction demands because of the insufficient transparency and inefficient procedures. Two dimensional (2D) based systems also remain incapable to unambiguously delineate the property ownership related to complex buildings. Keeping up-to-date the three dimensional (3D) urban models is another key for smart cities but this issue has become difficult owing to the rapid changes in the cities. In this sense, this paper first examines thoroughly the current situation in Turkey in terms of the building permit procedures, land administration, and 3D city modeling. Then, the paper detailedly proposes a reformative framework. The framework consists of the use of digital building models for both building permit processes and 3D registration of property ownership, as well as updating the 3D city model databases. The proposed framework is evaluated in terms of its applicability with a discussion of the prospective directions.

Keywords

Building Permit, Digitalization, Property Ownership, 3D Land Administration, 3D City Model, Turkey

1. Introduction

In these days, the sustainable development of the smart cities has become crucial due to climate change and excessive urbanization that substantially force the governments to practice complex strategies. These strategies that contain the improvement of the infrastructure facilities, city services, and environmental quality aim to secure the wealth, habitability, and healthiness for citizens (Macke et al., 2019). The management and efficient use of spatial information is a notable issue because smart cities have become more widespread (Ma and Ren, 2017). In this sense, the interplay between Geographic Information Systems (GIS) and Building Information Modeling (BIM) can facilitate both integration of spatial data at different levels and effective, standardized urban planning for securing the sustainable built environment (Marzouk and Othman, 2020). Thus, BIM and GIS domains have pivotal roles to actualize the smart city concept thanks to efficient procedures that result from development in information and communication technologies (ICTs) as well as social sciences (Wang et al., 2019).

The smart built environment is closely associated with effective management of the land, natural and water resources. The perspective for this management has deeply changed due to the numerous environmental, social, political, and technological factors over the last fifteen years. In this context, the processes with respect to registration and dissemination of data related to value, ownership, and usage of land and its relevant resources are universally expressed with land administration (de Vries et al., 2015; Kalogianni et al., 2020; Williamson et al., 2010). In this regard, Sustainable Development Agenda 2030 suggests securing the tenure and registration of proprietary rights, since these issues are vital to achieve sustainable development on the global and urban scale (United Nations, 2015). So, the land administration that benefits from current ICTs is quite important to ensure the continuity of planned urbanization and better settlement, as well as high production quality within the context of sustainable development goals (Aydinoglu and Bovkir, 2017; Bennett et al., 2019; Orozco and Steudler, 2017).

In sum, digital technologies and techniques can contribute to raising productivity, expanding access, allowing for the utilization of big data, and making public services available more easily. They also have huge potential to decrease production costs and harmful emissions, improve resource efficacy, and facilitate zero-carbon energy systems (Sachs et al., 2019). Hence, it can be emphasized that the use of digital technologies and techniques is significant in the sense of enabling a smart built environment and effective land management, as well as e-government services (CDBB, 2015; Lindgren et al., 2019; Wagner and de Vries, 2019). The building permit procedures, three dimensional (3D) property ownership, and 3D city modeling, which are highly important issues for achieving the sustainable, smart cities (Eirinaki et al., 2018; Oldfield et al., 2018). In this context, this paper focuses on these issues as an integrated process in Turkey.

1.1 Problem Description

There is an increasing demand for the construction of new housing in urban areas of several countries because of the rapid population growth (OECD/European Commission, 2020). Accordingly, as every new building should have a construction permit, regulatory bodies and policymakers seek efficient improvements and extensions related to requirements for getting the building permit in order to succeed in making smart built infrastructures a reality. Numerous regulatory bodies generally take part in both obtaining building permit and approval of completed construction; therefore, building permit issuing might be a complicated work, especially in large cities. The procedure often includes controlling the building design and inspection of the construction in compliance with current law, regulations, and zoning plans. However, the building permit processes have some drawbacks such as the lack of transparency, heavy paper workload, and slow review procedures (Malsane et al., 2015; Shahi et al., 2019; Tan et al., 2010). In this regard, the digitalization and automation of building permit procedures are attractive research topics to overcome the shortcomings in building permit processes. This aspect includes exploiting spatial data models and standards that are internationally accepted, for example, CityGML (OGC, 2012) and Industry Foundation Classes (IFC) (ISO, 2013) (e.g. Macit İlal

and Günaydın, 2017; Noardo et al., 2019; Olsson et al., 2018; Solihin and Eastman, 2015). In this sense, the building permit procedures in Turkey vis-à-vis other countries (e.g. Singapore) are not at a sufficient level. For this reason, there is a need for constructive efforts to make building permit procedures more effortless and efficient.

In addition, there is a growing interest in creating the 3D digital city models around the world. These composed city models help to administrators for urban management from various aspects such as energy demand estimation, facility management, emergency response, and taxation and valuation (Biljecki et al., 2015; Jackson and Simpson, 2020). In this connection, the buildings are commonly represented as 3D within the context of digital city models during the last decades, particularly in metropolises (Ohori et al., 2018a). Architecture, Engineering, and Construction (AEC) companies are intensely interested in 3D digital modeling of buildings by the use of BIM techniques that take the place of traditional Computer-Aided Design (CAD). For example, BIM adoption in the United Kingdom (UK) was 13% in 2011, it raised to 73% in 2020 (NBC, 2020). Although the BIM-based models were created for presentation purposes only before, these models nowadays are used for not only different analyses related to buildings but also integration with urban or national geospatial databases that contain 3D representations. Thus, the digital transformation of smart built environment benefits from 3D urban models through created digital city models. Such 3D models are generated by using different techniques in the various platforms depending on the expert opinion and intended use of the model (Eriksson et al., 2020; Song et al., 2017). However, the production of 3D city models is an uphill task in the complex living areas at the present time. In addition, keeping up-to-date of created 3D geospatial databases has become difficult day by day because of the numerous alterations that occurred in the cities (Biljecki et al., 2017). For this reason, the workflows that can pay dividends for both generating and updating the 3D urban models have become significant. In this direction, there is a need for an efficient framework in Turkey in order to entirely achieve national spatial data infrastructure (SDI) that contains 3D city models.

Another important and timely issue is the land administration systems (LASs) that make a significant contribution to the acquiring of the essential datasets, enabling the digitalization of economies, and actualization the smart sustainable cities (Krigsholm et al., 2018; Rajabifard, 2014). However, the 2D systems that use the 2D parcel as a key unit for property registration generally underlie the greater part of the existing LASs across the globe. Although LASs utilize the processes that enable the digital representation of 2D parcels and are typically practiced by using 2D paper-based records, they have the ability to depict the underground and aboveground interests related to the land surface, which are by nature 3D. Yet there is a need for restructuring of LASs in terms of the use of 3D property units so as to be able to tackle occasions associated with society such as social injustice, urbanization, and the digital transformation. In this way, both the security of land tenure and taxation, market, and planning with respect to land will improve in the context of the spatial development (Kalogianni et al., 2020; Kitsakis et al., 2019; Paulsson, 2013; Shojaei et al., 2016). A great number of scholars touched on the significance of this issue (Döner et al., 2011; Olfat et al., 2019; Rajabifard et al., 2018; Stoter et al., 2013). In this regard, the 3D digital representation and registration of property ownership that is a subject of LASs are, therefore, necessary due to the insufficiency of 2D delineations in the multilayered and complex buildings of today. The transformation to 3D can be achieved by using current modeling techniques, e.g. BIM (for example Larsson et al., 2020; Oldfield et al., 2017). In this context, the 3D digital transformation of property registration in Turkey is not at the expected level currently even though there are some valuable efforts in the literature (e.g. Land Administration Domain Model (LADM) (ISO, 2012) (Alkan and Polat, 2017) and CityGML (Cagdas, 2013)). Besides, there is no study related to the delineation of property ownership using BIM, or more specifically IFC, in Turkey. Because of this, there is a need for efficient perspectives and procedures that will facilitate the 3D delineation and registration of property ownership in Turkey.

1.2 Objective

In light of the above-mentioned problems and information, the objective of the study is to provide a tripartite framework for Turkey that includes the processes all together: building permit procedures, updating of 3D city models, and 3D registration of property ownership. The present study also aims to reveal the current situation in Turkey with respect to building permit procedures, 3D city modeling, and land administration by comprehensively examining performed projects and existing legislative efforts. It is purposed to provide a basis for future works and planning on the digitalization of building permit procedures, updating the 3D city models, and 3D registration of property ownership in Turkey. Another aim of this paper is to contribute to becoming widespread of the use of digital building models formatted as international data standards (e.g. CityGML and IFC) for both building permit processes and 3D registration of legal rights, as well as keeping up-to-date the digital city models in Turkey. To the best of the author's knowledge, this is the first study that proposes the use of digital building models for both building permit processes and 3D registration of property ownership, as well as updating the 3D city models in Turkey.

The remainder of the paper is organized as follows. The second section examines the current situation in Turkey in the context of building permit, land administration, and 3D city modeling. In the third section, the reformative framework proposal is presented in detail, and then the fourth section discusses the framework. Lastly, the fifth section concludes the paper with suggestions for future work.

2. Examination of the current situation in Turkey

There are lots of important laws and regulations with respect to property registration and building permit issuing in Turkey. Yet these procedures can be enhanced by utilizing more practicable and effective ways. In this regard, the *Doing Business* statistics that are prepared and shared by the World Bank can be used as a relative indicator for the current examination of Turkey in terms of property registration and building permit procedures. *Doing Business* presents a comparison between one

hundred ninety economies across the globe for seventeen years by providing quantitative indicators regarding the protection of property rights and business regulations. Twelve business regulations are covered in the statistics; for example, getting credit, protecting minority investors, and paying taxes (World Bank, 2020). Figure 1 shows the rankings of Turkey in the sense of ease of doing business, dealing with construction permits, and registering property over the last five years.

It can be seen from the figure that Turkey has the best ranking related to registering property in all years. This result is reasonable due to the long experience of the country with regards to land registry and cadastre. In addition, Turkey made progress for the ranking of ease of doing business every year except 2017. The figure also shows that the ranking associated with building permits improved in all years but in 2017. As illustrated in Figure 1, dealing with construction permits is the most underdeveloped among the other topics. The statistics report that Turkey can have more efficient procedures regarding building permits and property registration. In this direction, the current situations of these issues and 3D city modeling in Turkey are examined thoroughly in the next sub-sections.

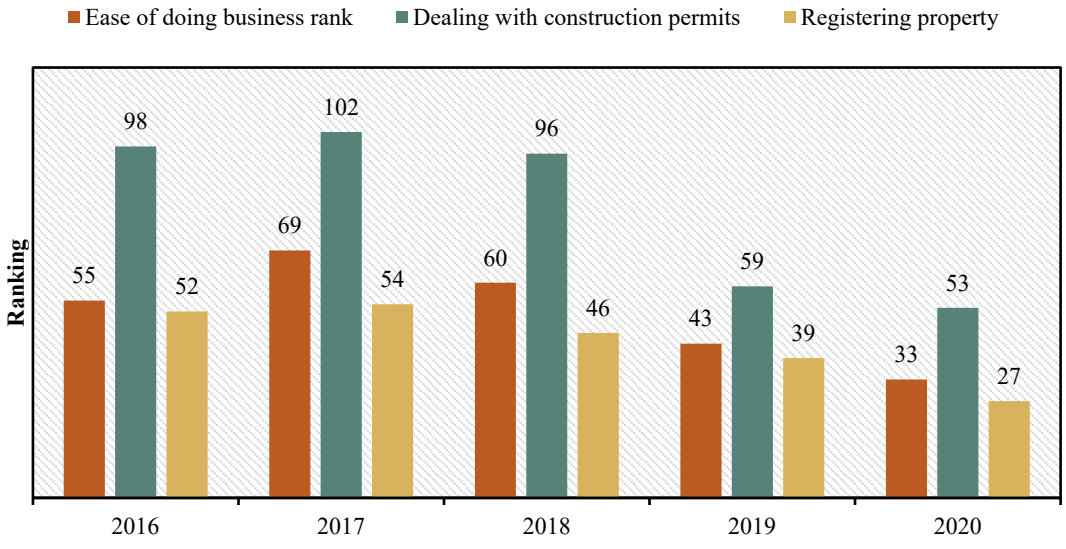

Figure 1. The rankings of Turkey related to doing business, building permit, and property registration in the *Doing Business* statistics (World Bank, 2020).

2.1 Building Permit Context

Every new building located on land parcel should meet the conditions indicated in the related laws and regulations. In regard to this situation, in Turkey, Article 21 of Zoning Law *(Imar Kanunu)* requires to get building permit *(yapi ruhsati)* from municipalities or governorates before starting construction (Official Gazette, 1985). There is no need to take building permit for repairs and modifications in the existing buildings if the changes do not affect the bearing elements of buildings that are indicated in building regulations. The conditions for getting a building permit are explained in Article 22 of Zoning Law. According to this Article, the petition should be submitted to municipalities or governorates with title deed, architecture project, static project, electric and installation projects, and sketch. The conditions that should be fulfilled by building projects are expanded in Planned Areas Zoning Regulation *(Planli Alanlar Imar Yonetmeligi)* along with Zoning Law (Official Gazette, 2017).

Moreover, there are time limitations specified for building permit procedures. Accordingly, the institution that processes the application should give the building permit in thirty days from the application date if there is no incompleteness or mistake in the application documents. Otherwise, the institution should inform the applicant about deficiencies or failures of the application in fifteen days at most. Then, the institution should give a building permit to the applicant within fifteen days from the new application that remedied the deficiencies.

The applications that are made according to the relevant laws and regulations are examined by component units of institutions in terms of architecture, electric, landscape, and mechanic in order to decide whether the building permit can be given or not. If the construction project satisfies the conditions that are stated in the laws and regulations, the building permit is prepared. Thus, the construction can be legally started after delivering the building permit to the applicant. Every building project is inspected by an independent building inspection authority during its construction because of Law on Construction Inspection *(Yapi Denetimi Hakkinda Kanun)* in order to confirm that the

construction is built according to the approved building permit (Official Gazette, 2001a). The building inspection authorities are responsible for giving information to the relevant administrations if they detect any nonconformity with regards to construction.

After completing the construction, the occupancy permits *(yapi kullanma izin belgesi)* should be obtained as indicated in Article 30 of Zoning Law. The building is inspected whether it is built according to the approved building permit or not, within the context of the occupancy permit application. The application should be brought to a conclusion within thirty days; otherwise, it is assumed that the permission is given to use the building. As stated in Article 31 of Zoning Law, the buildings that do not have an occupancy permit cannot utilize public services such as electricity, water, and sewage. The construction project is finalized by getting the occupancy permit. Figure 2 shows the building permit procedures in Turkey.

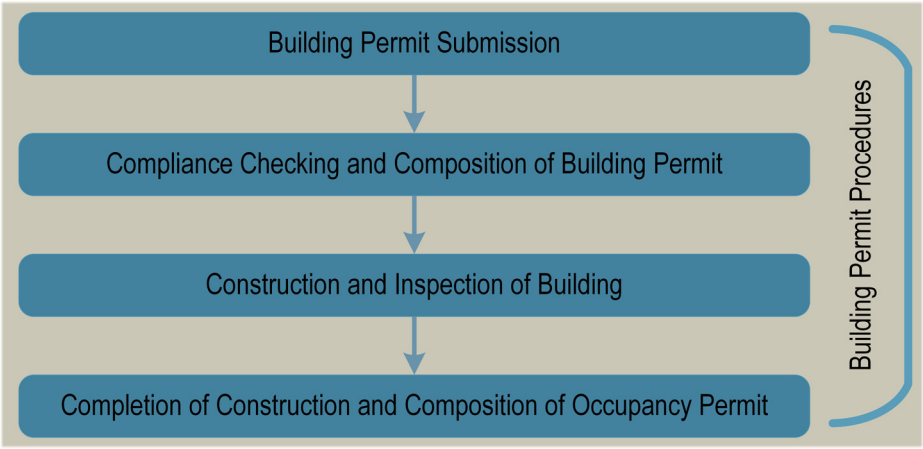

Figure 2. Building permit procedures in Turkey.

The construction sector has great importance in Turkey in terms of the economy of the country. A great number of new buildings are being built to meet the needs of the increasing population in big cities because of the migration that occurs from rural areas to metropolises (OECD/European Commission, 2020). Besides that, the new buildings are constructed by pulling down the existing structures that are vulnerable to earthquakes and natural disasters within the scope of urban renewal. Figure 3 illustrates the total number of building permit and occupancy permit created in the last eleven

years in Turkey (TurkStat, 2020). This figure is formed by using statistical data that is shared by the Turkish Statistical Institute (TurkStat). Figure 3 shows that the total number of building permits is always larger than forty thousand. In addition to this, it was reached the number of one hundred forty thousand in 2010 and 2014. More than one hundred sixty thousand building permits were composed in 2017 and hence it reached the highest number in the last eleven years. Yet there is a decrease in 2018 and 2019. Also, more than eighty thousand occupancy permits were composed in all years except 2008. In 2018, more than one hundred twenty thousand occupancy permits were composed which is the highest total number in eleven years. It can be understood from the figure that the building permit processes take an important place among public services that are frequently practiced. In Turkey, there is no detailed instruction about how to carry out the submission and examination phases in the laws and regulations related to building permit. For this reason, the submissions of the building permit are generally accepted as printed papers and compact disks (CD). Furthermore, the examination of the submissions is realized manually in general.

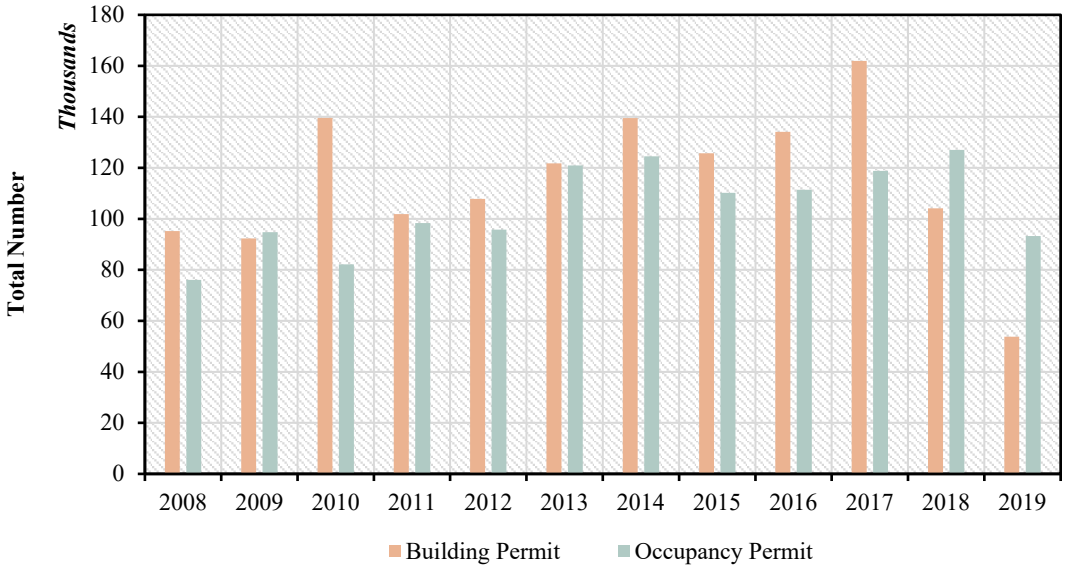

Figure 3. The total number of building permit and occupancy permit created in Turkey between 2008 and 2019 (TurkStat, 2020).

The building permit procedures in the European countries show similarities with the procedures that are realized in Turkey. However, some process steps such as consulting with neighbors do not exist in the building permit procedures of Turkey based on the evaluations that are done regarding the current situation. The essential process steps of building permit issuing in European countries can be specified as follows (Meijer et al., 2002; Meijer and Visscher, 2017; Noardo et al., 2019);

- Preliminary consultation,
- Building permit application,
- Consultation with neighbors and citizens who live close to the project site,
- Examination of application and compliance checking,
- The decision of planning,
- Start of construction,
- Construction inspection in the project site,
- Completing the construction and notifying the related administrations,
- Final examination,
- Giving the building permit and completing the process.

The European countries give importance to the improvement of the building permit processes. In connection with this, one of the most important developments is the action plan that is announced by the European Union (EU) in 2002, which suggests the use of electronic systems to improve the effectiveness of public services. This action plan underlines that the EU countries should start to use online services as soon as possible. It is aimed to become prevalent and enhance the e-government systems by publishing the new action plan in 2005 (European Commission, 2006, 2002). Currently, the last e-government action plan published by the EU contains the years between 2016 and 2020 (European Commission, 2016a). In this sense, the EU published an evaluation report in 2016 on the countries made progress in the transition to e-government (European Commission, 2016b). Turkey is

invited to participate in the project in 2001 as a candidate country. Thus, several actions are done to reach the goals of the project by preparing emergency action plans relating to e-transformation in Turkey.

According to the report published in 2007 that evaluates the current building permit procedures of countries, the average score of the EU and candidate countries is 51%, while Turkey is near down with Bulgaria by having 12% (Capgemini, 2007). This result gives an insight on the functionality of the building permit procedures in Turkey based on the mentioned year. Besides, Turkey is on the forty-fourth rank in the *International Digital Economy and Society Index* that is prepared by evaluating forty-five countries, namely the EU28 Member States and seventeen other countries, in terms of connectivity, digital skills, citizen use of the internet, business technology integration, and digital public services (European Commission, 2018). Moreover, the United Nations (UN) has been publishing the rankings of the *e-government development index* and *e-participation index* since 2003 in order to evaluate one hundred ninety-three UN member countries in terms of e-government (United Nations, 2018). Figure 4 illustrates the rankings of Turkey in these indexes between 2008 and 2018.

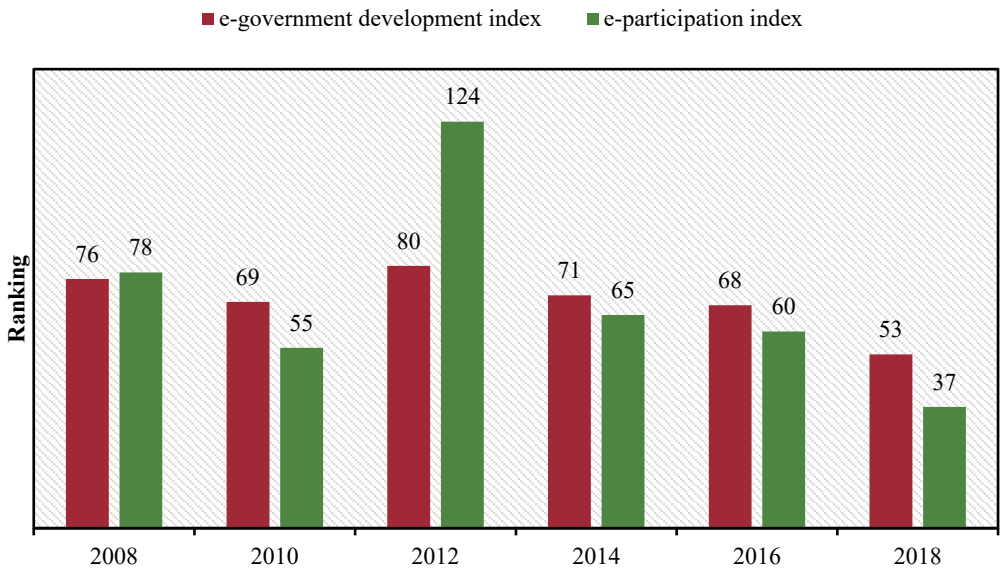

Figure 4. The development and participation rankings of Turkey related to e-government between 2008 and 2018 (United Nations, 2018).

It can be seen from the figure that while Turkey is on the seventy-sixth rank in the *e-government development index* in 2008, it rose to fifty-third rank in this index in 2018. Likewise, Turkey is respectively on the seventy-eight and thirty-seventh ranks in the *e-participation index* in 2008 and 2018. The ranking of Turkey rose in this index. The statistics in Figure 4 show that Turkey made significant headway in the sense of performing public services by exploiting electronic systems. Additionally, Figure 4 demonstrates that the Turkish government placed emphasis on the development of e-government services, citizens also adapted to the use of new electronic public services. Regarding this, Turkey has an action plan entitled "National e-Government Strategy and Action Plan" that is prepared by the Ministry of Transport and Infrastructure (MTI) related to e-government services (MTI, 2016). This plan includes the years between 2016 and 2019.

The EU officially recommends the use of digital building models and electronic submission systems in order to digitalize and improve the building permit procedures (European Union, 2014). The digitalization of building permit procedures is not at the desired level in European countries as of today; therefore, the research on this topic continues (for example Noardo et al., 2019; Olsson et al., 2018). Likewise, there are visions that aim to increase the functionality of the building permit procedures in Turkey. For example, it is planned to facilitate the building permit procedures in the "2018-2022 Strategic Plan" prepared by the Ministry of Environment and Urbanization (MEU) (MEU, 2017). In addition, it is underlined that there is a need for BIM-based building permit procedures in the "2020-2023 National Smart Cities Strategy and Action Plan" by MEU (MEU, 2019). Furthermore, the necessity of digital transformation and related targets are specified in the "11th Development Plan" in Turkey (Presidency of Strategy and Budget, 2019). With the mentioned publications and information, the alterative framework for building permit procedures becomes even more important in Turkey.

2.2 Land Administration Context

Turkey has significant experience in terms of land registration and cadastre. Before the establishment of the Republic of Turkey, the government owned nearly all of the lands and their related ownership rights in the period of the Ottoman Empire. Only some people who were successful in wartime or carried out important duties could have the land right of use. The first organization related to land registration was founded in 1847. This organization carried out operations associated with the registration of lands until the proclamation of the Turkish Republic. The Ottoman Land Code (1858) *(Kanunname-i Arazi)* was the most important legal regulation that includes legal provisions with respect to land registration in that period of time (Aytekin, 2009). According to this legal code, it was practiced a combined land registration system that contains deed and title. However, the property boundaries of lands were registered without using any plan or map. It occurred important developments with regard to land registration and cadastre after the proclamation of the Turkish Republic (Aydinoglu and Bovkir, 2017; Sahin et al., 2017). First, Turkish Civil Law No. 743 was promulgated in 1926 to express how to practice a land registry system that encapsulates the cadastral maps. This law defines the rights, responsibilities, and restrictions (RRRs) relating to real properties. The latest version of Turkish Civil Law No. 4721 was published in 2001 (Official Gazette, 2001b). Besides this law, the main laws that are prepared to conduct land registration activities in Turkey can be sorted as follows;

- Land Registration Law No. 2644,
- Cadastre Law No. 3402,
- Law on Renewal of Deeds and Cadastre Maps No. 2859,
- Zoning Law No. 3194,
- Expropriation Law No. 2942,
- Forestry Law No. 6831,
- Law on Amending in the Cadastre Law No. 5304.

The fourth book in Turkish Civil Law is related to the law of property. While the first section of this book describes the ownership, the second section defines the immovable ownership. According to Article 704 of Turkish Civil Law, the subjects of the immovable ownership are land, unqualified and permanent rights that are registered to separate page in the land register, and independent sections that are recorded to property ownership register. Table 1 itemizes the essential RRRs that are being used in land registration in Turkey.

Table 1. The essential RRRs in Turkey.

Rights			
Name	*In Turkish*	*Name*	*In Turkish*
Property Right	Mülkiyet Hakkı	Right of Usufruct	İntifa Hakkı
Joint Property Right	Paylı Mülkiyet Hakkı	Right of Residence	Oturma Hakkı
Co-Property Right	Elbirliği Mülkiyeti	Right of Superficies	Üst Hakkı
Property Ownership	Kat Mülkiyeti	Right of Passage	Geçit Hakkı
Right of Easement	İrtifak Hakkı	Right of Spring	Kaynak Hakkı
Responsibilities			
Name	*In Turkish*	*Name*	*In Turkish*
Right of Encumbrance	Taşınmaz Yükü	Possession	Zilyetlik
Restrictions			
Name	*In Turkish*	*Name*	*In Turkish*
Annotation	Şerh	Right to Purchase	Geri Alım Hakkı
Right of Pre-Emption	Önalım Hakkı	Lien	Rehin
Mortgage	İpotek	Zoning Status	İmar Durumu

It can be seen from the table that quite a few rights relating to properties are considered and registered in the Turkish land registry system. Several of these rights represent 3D descriptions but they are in writing registered to the book of land registry in the current situation. Also, several responsibilities that indicate the liabilities such as taxation, repair and maintenance are defined in Turkish Civil Law. In addition, many restrictions related to properties are used for the cadastral works

in Turkey. In Turkey, the establishment of the property ownership for different parts of the buildings that are constructed is realized according to provisions of the Property Ownership Law No. 634 (Official Gazette, 1965). Article 10 underlines the use of the architecture design that is electronically prepared for the land registry and approved by the related institution. The same article indicates that the registration notice is transmitted to the institution preparing the occupancy permit in the land use type change process, and that the institution sends the occupancy permit and its supplementary documents to the directorate of the land registry electronically. Currently, both the registration of real properties and cadastral works are fundamentally arranged according to Land Registration Law and Cadastre Law in Turkey. The General Directorate of Land Registry and Cadastre (GDLRC) *(Tapu ve Kadastro Genel Mudurlugu or TKGM)* is the responsible organization in regard to these practices. This organization was established in 1924 with containing only the land registry works and then the cadastre unit was attached to this organization in 1925. The current structure and objectives of GDLRC were defined with Law No. 2997 in 1936 (GDLRC, 2020). Figure 5 shows the current organization schema of the land registry and cadastre in Turkey.

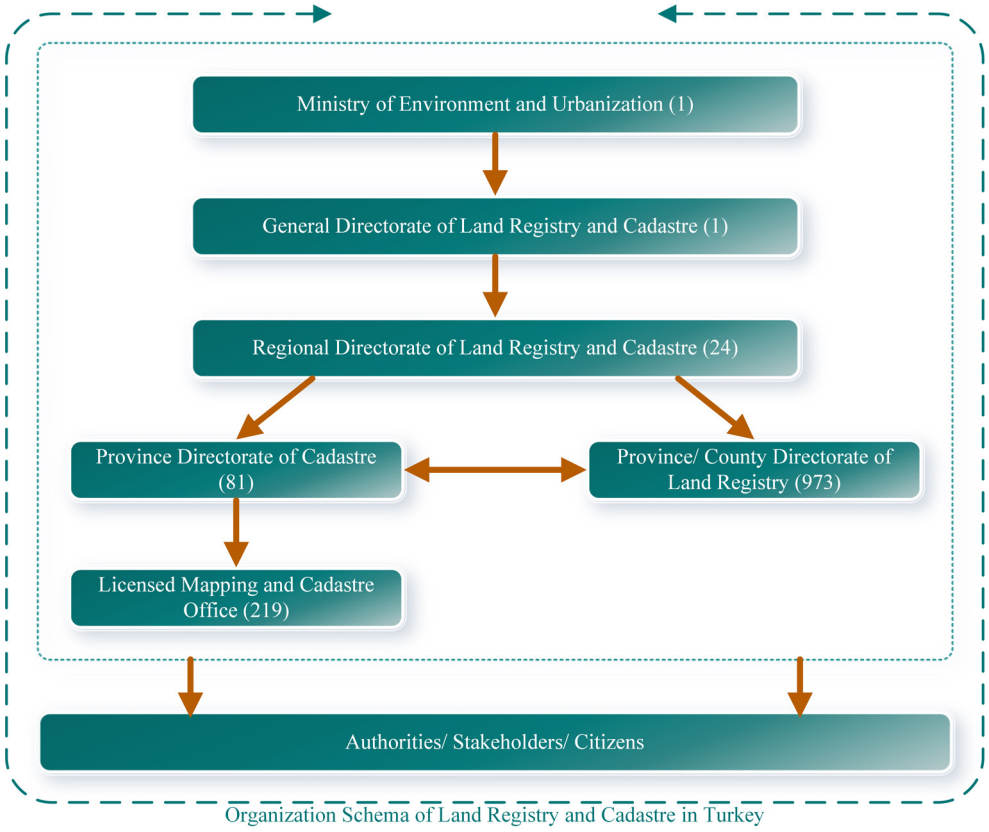

Figure 5. The current organization schema of the land registry and cadastre in Turkey (GDLRC, 2020).

GDLRC was connected to several ministries before such as the Ministry of Finance, Ministry of Justice, and Ministry of Public Works. In 2011, it was finally connected to MEU as can be seen from Figure 5. GDLRC has twenty-four regional directorates with an important role in field service. There are also several province directorates of cadastre (81) and province/county directorates of land registry (973) (GDLRC, 2020).

The cadastral works that include land registry and cadastre maps were performed to achieve completed cadastral database throughout Turkey from the 1920s to the beginning of the 2010s. In this regard, Licensed Mapping and Cadastre Offices (LMCO) *(Lisansli Harita Kadastro Muhendislik Burolari or LIHKAB)* were introduced to the cadastral organization with Law No. 5368 in 2005 in order to make the cadastral works accelerated and productive all around the country (Official Gazette, 2005). The job definitions of these offices were defined with Regulation on Licensed Surveying

Engineers and Offices *(Lisansli Harita Kadastro Muhendisleri ve Burolari Hakkinda Yonetmelik)* (Official Gazette, 2013). According to this regulation, LMCO is responsible for conducting the technical cadastre works that are assigned to LMCO by cadastre directorates. While LMCO is responsible for carrying out and controlling the works that are not subject to registration, cadastre directorates are in charge of controlling the works that are subject to registration. So, LMCO is only responsible for conducting these works. The works that are not subject to registration are application service, showing the parcel in the field, and giving the layout example. The works that are subject to the registration are the use type conversion of the parcel, constitution and cancellation of easement right, consolidation of the parcel, and correction of the independent section by virtue of Property Ownership Law No. 634. In addition to LMCO, the private sector contributed to the technical part of the cadastral works; thus, the completed part of cadastre in Turkey reached 99.4% in 2014 (Yomralioglu and Cete, 2017). Yet the aim of the creation of the completed cadastral database is not completely realized because some cadastre maps do not have coordinate systems owing to the use of graphical methods such as plane table and chain survey. Also, a considerable part of the cadastre maps has different coordinate systems, namely European Datum (ED) and International Terrestrial Reference Frame (ITRF). Figure 6 illustrates the percentages of the coordinate system types of cadastre maps in Turkey.

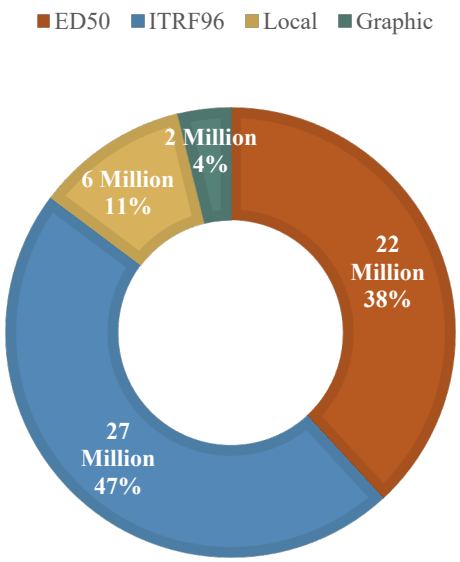

Figure 6. The current coordinate system type distribution of cadastre maps in Turkey (GDLRC, 2020).

As can be seen from the figure, while cadastre maps mainly have ITRF96 coordinate system (47%), and ED50 coordinate system (38%) secondly. Local coordinate system (11%) and graphic method (4%) are ranked after these systems respectively. The drawbacks that stem from coordinate system incompatibility might interrupt the cadastral works. For this reason, a lot of projects were put into practice by administrations such as GDLRC in Turkey in order to increase the functionality of the land registry system. The first project is the Mapping-Cadastre Reform Project *(Harita-Kadastro Reform Projesi or HAKAR)* that aims to update national maps and transfer these maps into digital formats. In Turkey, while the General Command of Mapping (GCM) *(Harita Genel Komutanligi or HGK)* performs the production of digital maps, GDLRC and local authorities produce large scale maps that are larger than 1:5000. In this direction, the project is conducted by GCM in company with GDLRC. After this project, the Land Registry and Cadastre Information System (LRCIS) *(Tapu ve Kadastro Bilgi Sistemi or TAKBIS)* project is started with an aim to transform the paper-based cadastre into a digital cadastre throughout the country. That is to say, the system enables all operations related

to land registration to be carried out online and digitally. The project is started in 2001 and planned as three stages. These stages are analysis, design, and experiment.

After the first stage of the project is completed, the second stage is started by implementing the system in several directorates of GDLRC. There were some difficulties in the practice of the project in terms of the digitalization of cadastre maps due to the inadequate data quality and coordinate system unconformity. The third stage is composed of the finalization of the development of the system and extension of the developed system to all GDLRC units. With the implementation of this stage, other organizations would reach to cadastral data digitally (Cete and Yomralioglu, 2013). After this project, the Spatial Real Estate System (SRES) *(Mekansal Gayrimenkul Sistemi or MEGSIS)* is started to facilitate the sharing and management of spatial data in 2011 because the LRCIS project did not completely reach the estimated outputs. SRES based on an open-source software has different aims in terms of the digital cadastre. These aims are: 1) matching the CAD data that are stored in the local computer of cadastre directorates with title deed information by collecting the data in a central system, 2) sharing the obtained data with the stakeholder institution, organization, and municipalities that need these data via international data standards, 3) presenting the data to citizens through e-government platform. Three main works are conducted as part of the project. These works are the web-based software, map services that have international standards such as Web Map Service (WMS) and Web Feature Service (WFS), and e-government services. As of today, the ratio of the integration between title parcels and cadastre parcels is 99.87% within this project, SRES. Besides LRCIS and SRES, there are other important projects and efforts.

One of the prospective initiatives is the emergency action plan related to the electronic transformation of government services. This plan is called e-Transformation Turkey (Kurfalı et al., 2017). Many projects connected to the digitalization of the land registration applications are put into practice thanks to the e-government transformation in Turkey. For example, the Land Registry Archive System (LRAS) *(Tapu Arsiv Bilgi Sistemi or TARBIS)* was started in 2005. The aim of the system is

to facilitate reaching the documents in the Istanbul Regional Directorate of Land Registry and Cadastre that are not subject to ownership. With the realization of the project, the users who work on the original documents can easily reach the information digitally within the scope of Title Deed Archive Automation (TDAA). The reporting functions of the users also enhanced because of the accomplishment of the project. The project was finalized in 2009.

In 2008, the Land Registry and Cadastre Modernization Project (LRCMP) *(Tapu ve Kadastro Modernizasyon Projesi or TKMP)* is started as a five-year project with the agreement between the World Bank and GDLRC. The purposes of the project are to update the current land registry data for creating national SDI by considering the Cadastre Law and to transfer them into a computer environment. In the meantime, there are problems related to the repeated production of spatial data in Turkey owing to the miscommunication between different government agencies. To solve this problem, Map Data Bank (MDB) *(Harita Bilgi Bankasi or HBB)* project is conducted by GDLRC for creating large-scale SDI at the country level. The aim of the project is to create a spatial information system through the internet that enables the input, update, and presentation of metadata belonging to maps created by relevant institutions and organizations. The duplicate production of spatial data is prohibited after putting the web site into service. Also, the users can get information anytime about the date, location, and type of map that is produced by any organization. Those concerned can obtain information without having to go to GDLRC with saving time and money.

One of the important initiatives related to the cadastral database is the Turkey National GIS (TNGIS) *(Turkiye Ulusal Cografi Bilgi Sistemi or TUCBS)* project carried out by GDLRC according to the action plan published in the official gazette. The project aims to form national SDI suited for both technological developments at the national level and Infrastructure for Spatial Information in the European Community (INSPIRE) directives. As an e-government project, the web portal is created to present spatial data that are managed by public institutions and organizations. The conceptual schemas are generated in the manner of meeting the needs of all user institutions. Besides, the geographic data

interchange standards are identified in part of the project. The Land Registry/Cadastre Theme *(Tapu/Kadastro Temasi)* is prepared within the scope of TNGIS in order to enable the efficient use of the land registry and cadastral data among various organizations. The project was finalized in 2012.

In 2016, the Land Registry and Cadastre Modernization Supplement Financing (LRCMSF) *(Tapu ve Kadastro Modernizasyon Projesi Ek Finansmani or TKMP EF)* entered into force with the agreement between the World Bank and the Undersecretariat of Treasury. This five-year project aims the renewal and update of the cadastre maps for the purpose of,

- supporting digital cadastre and title deeds,
- enabling the reaching of the digital land registry information by public and private institutions,
- enhancing the customer relations of directorates of land registry and cadastre,
- improving the human resources in GDLRC,
- developing the policies and adequacies,

so as to bring the best international applications to real property valuation in Turkey. Another purpose is to increase the quality and efficiency of the land registry and cadastre services.

Furthermore, there are important targets related to land administration in the "11th Development Plan". They can be sorted as follows;

- The production of the multidimensional cadastre will be completed,
- Digital, up-to-date, and reliable cadastral data will be presented electronically to form a basis for investments that are made by public and private institutions,
- The modernization of the cadastre will be completed by using a single coordinate system throughout Turkey.

In order to overcome the problems that result from the 2D representation of property rights in multifaceted buildings, the concept of 3D cadastre is investigated by different countries around the

world. In this connection, the 3D Urban Models and Cadastre project (3DUMC) *(3 Boyutlu Sehir Modelleri ve Kadastro Projesi)* was started by GDLRC in 2018 to make possible the 3D delineation of property rights and to facilitate the creation of 3D digital city models. The tenders are initiated by GDLRC to accomplish the project. The Golbasi county in Ankara is selected as a pilot study area within the context of the project. Both the buildings in this area and the related property rights are modeled as 3D for the prototype. The created model is presented to the users via the web site[1]. In addition, the Department of Land Valuation (DLV) *(Tasinmaz Degerleme Dairesi Baskanligi)* attached to GDLRC was established in 2019. The missions of the department include determining the values of real estate, establishing and managing the value information center, and producing and updating the valuation maps. DLV is responsible for needs analysis associated with land valuation and mass appraisal, and following international developments and good practices. Conducting studies with regards to standards on the mass appraisal of real property is also among the duties of the department.

2.3 3D City Modeling Context

3D city models are closely related to national SDI and hence they are very significant to put the smart city concept into practice. In 2012, the General Directorate of GIS (GDGIS) *(CBS Genel Mudurlugu or CBSGM)* was established in Turkey. The responsibility for the formation of the national SDI was given to this institution. In 2015, the Directive on Establishment and Management of National GIS *(Ulusal Cografi Bilgi Sisteminin Kurulmasi ve Yonetilmesi Hakkinda Yonetmelik)* was published in the official gazette (Official Gazette, 2015). This progress is important because the national SDI gained a legal basis. The aims and contexts of the directive can be sorted as follows;

- Establishment and management of national GIS,

[1] http://3dtest.tkgm.gov.tr:44444/

- Making the geographic data definitions within the scope of the geographic data themes and the production of these data by responsible institutions in compliance with these definitions,
- Sharing the geographic data, geographic datasets, geographic data services, and metadata of them,
- Realizing the coordination between the institutions for works and transactions related to geographic data.

After the completion of the first stage, the TNGIS Standardization project was completed by the GDGIS and the Scientific and Technological Research Council of Turkey (STRCT) *(Turkiye Bilimsel ve Teknolojik Arastirma Kurumu or TUBITAK)* as the second stage in 2018. The aim of the project is to efficaciously put the semantic interoperability of the geographic data into practice for fulfilling the information needs of the institutions, organizations, and citizens. In this direction, the geographic data themes are formed and standardized with the active participation of the academicians, managers and practitioners of the institutions, and private sector representatives. Additionally, composing a national geographic data strategy and action plan is aimed. This plan includes the enablement of efficient, participatory, and sustainable governance; management of the standardized geographic data and services through innovative processes; increasing the human resources and communication capacity; conducting the monitoring, assessment, and reporting activities. There is also an integration project that purposes to decrease the bureaucracy between public institutions and organizations, to facilitate the processes related to the transfer of geographic data service and metadata into the national geographic data portal, and to practically show the works that are carried out by GDGIS.

It is highlighted in the "2018-2022 Strategic Plan" prepared by MEU that the SDI of the e-government *(e-devlet)* will be established and operated. In addition, the target with regard to completion of the TNGIS project appears in the "11th Development Plan". Regarding these plans, the

updated conceptual schemas of the geographic data themes are recently published by GDGIS. The Building Theme *(Bina Temasi)* is highly significant for generating the 3D city models. Building Theme is prepared as ready to comply with national studies that aim the buildings to be defined by international standards enabling the 3D geometric representations. It is noted that the buildings can be defined with different geometric levels of detail without changing the semantic structure of the conceptual model. Furthermore, it is pointed out that storing the 3D building models produced by using CityGML and IndoorGML is of great importance for various city management applications such as urban infrastructure and energy efficiency. It is also mentioned that creating a Building Information Repository (BIR) *(Yapi Bilgi Havuzu)* that stores the IFC models of the new buildings is highly significant for the digital transformation of different sectors, for example, construction (GDGIS, 2020a).

The e-Plan project was completed by MEU in 2019 (GDGIS, 2020b). The project context consists of the production, representation, enablement of the publicity, serving, and archiving the spatial plans. These plans are prepared in conformity with GIS structure in an electronic environment by institutions and organizations that have the authority to make and approve the plans within the scope of standards determined by the ministry. By using the created system, producing, announcing, and sharing the spatial plans are realized in a holistic manner. The project enables to create an infrastructure that can be integrated with TNGIS and to prepare the potential land-use datasets that are necessary for TNGIS. The PlanGML standard that allows the creation of data structure of spatial plan and symbology files in the direction of determined standards is also developed.

Recently, important progress occurred with publishing the Presidential Decree on GIS *(CBS Hakkinda Cumhurbaskanligi Kararnamesi)* at the end of 2019 (Official Gazette, 2019). The purpose of the decree is 1) to enable the coordination between public institutions and organizations, 2) to form the objectives and strategies, 3) to determine the procedures, principles, and standards related to production, update, management, usage, access, security, sharing, and distribution of the geographic

data within the geographic data themes. The Turkey GIS Board (TGISB) *(Turkiye Cografi Bilgi Sistemi Kurulu)* and the Turkey GIS Executive Board (TGISEB) *(Turkiye Cografi Bilgi Sistemi Yurutme Kurulu)* are established pursuant to Article 8 and Article 9 of this decree. The preparation of the national geographic data responsibility matrix and the national geographic data sharing matrix are among the missions of the executive board. Soon afterwards the "2020-2023 National Smart Cities Strategy and Action Plan" *(Ulusal Akilli Sehirler Stratejisi ve Eylem Plani)* is published in the official gazette (MEU, 2019). The plan is of great significance in the sense of transition to smart cities in Turkey. The Act of 15.13 is related to increasing the maturity of GIS as a smart city component. As mentioned in sub-section 2.2, the 3DUMC project is the most recent and concrete step in the context of the generation of 3D city model databases in Turkey. Figure 7 illustrates the timeline of the efforts in Turkey related to building permit procedures, land administration, and 3D city modeling as part of the SDI.

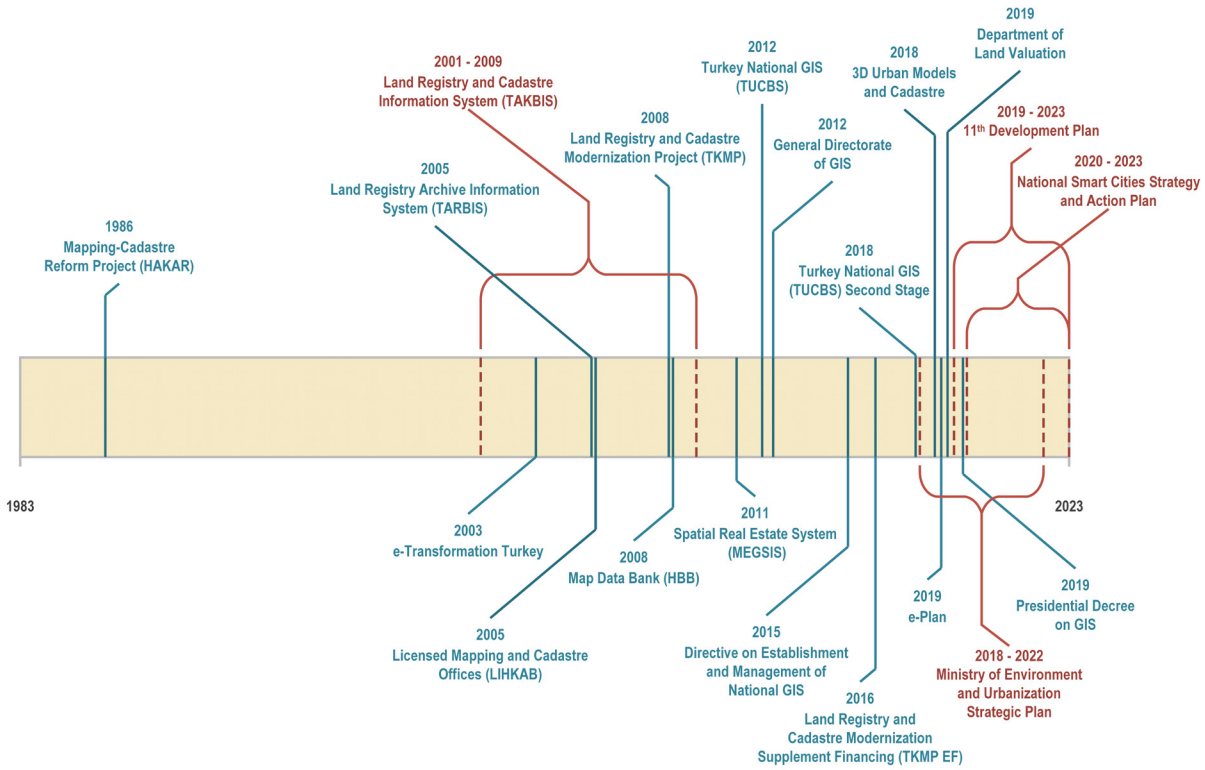

Figure 7. The timeline of the efforts related to the building permit processes, land registry and cadastre, national SDI, and 3D city modeling in Turkey.

3. Reformative Framework Proposal

3.1 Description of the Framework

Every country seeks effective solutions to make living spaces more sustainable. In this sense, urban areas mostly face with excessive population growth because of the migration from rural areas (OECD/European Commission, 2020). For this reason, a great number of buildings are being constructed to meet the need of the housing right (Prout Quicke and Green, 2017). The cities can also have buildings vulnerable to natural disasters. Therefore, these buildings are pulled down, and then sturdy buildings are constructed in line with building laws and regulations (Cheng and Chang, 2018). The building permit issuing process should be practiced within this period so that the building designs and constructed buildings can be controlled. This is why the compliance checking is of great importance to ensure the safety and quality of the buildings (S. Li et al., 2016).

Every contractor should apply to an authorized local agency to start the construction. The architects benefit from the land registry data and zoning plans to design the new buildings in a comprehensive manner. Thus, the building designs that are fit to the current planning and policies can be achieved. The construction is carried out after getting a building permit (Shahi et al., 2019). The building inspection can be practiced while the construction continues; hence, the deficiencies related to the construction can be noticed and corrected faster. The final inspection is done after the completion of the construction. In this connection, the occupancy permit can be obtained depending on the examinations with respect to the constructed building. These examinations control whether the building is constructed in line with the building design that is approved in the building permit process, or not. With obtaining the occupancy permit, the building permit procedures are finalized. These procedures do not have many differences for different countries but the outline of the procedures remains similar (Noardo et al., 2019).

The building permit procedures are chalked out thus far. In the following text, the reformative framework that can enhance the building permit procedures, 3D registration of property ownership, and updating the 3D city models is given in general terms. Subsequently, this framework is scrutinized in the context of Turkey. Figure 8 shows the reformative framework in general.

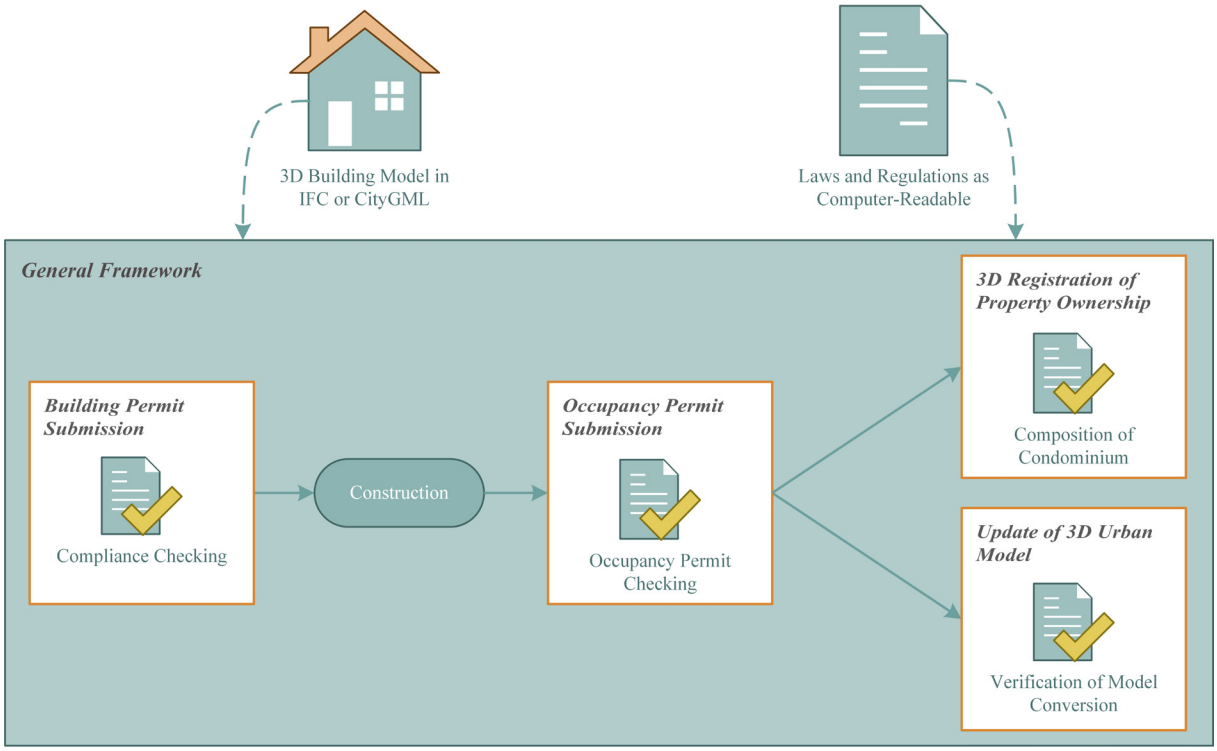

Figure 8. The general framework for improved building permit procedures that are associated with 3D registration of condominium rights and update of 3D city models.

This framework begins with the electronic building permit submission by means of digital building models (Preidel and Borrmann, 2018). Nowadays, the building permit applications are being done through paper-based drawings commonly, even though the buildings are digitally designed as 3D (Lee et al., 2016). The other important part of the framework is the compliance checking, which is carried out by using the digital building models, digital zoning plans, and digital cadastral data. In this way, the overall control can be performed by taking the built environment into account in an effective manner (Olsson et al., 2018). The use of digital building models in compliance checking is at the investigation phase these days. This approach draws attention recently because of the common usage

of digital data models and data standards such as IFC and CityGML. In this direction, there is a need for computer-readable rules and regulations so as to digitalize the building permit processes (Dimyadi et al., 2016).

The 2D representations can remain incapable of making efficient and practical decisions with respect to the occasions and problems that occur in the complex cities these days. For example, operating the urban infrastructure facilities in a powerful way is needed for 3D city models (Ohori et al., 2018b). On the other hand, the concept of 3D cadastre, i.e. 3D land administration, becomes more and more important since it not only enables detailed delineation of the buildings but also provides information about who is responsible for different parts of the buildings in a realistic manner (Kalogianni et al., 2020; Van Oosterom, 2013). In this sense, the framework suggests that the generated building models are used to keep up-to-date the 3D urban models at the national and regional level as well as 3D registration of the property ownership realistically. The as-built building models formatted in such as IFC can be converted to an efficient data format for 3D city models, for example, CityGML. Thus, an important advantage can be exploited in updating the 3D urban models.

The 3D registration of property ownership is processed after getting the occupancy permit in the general framework as can be seen from Figure 8. The constitution of the condominium can be realized after the construction of the building. This is generally not assessed as an integrated process with building permit procedures. However, the whole cycle might be incomplete unless the property rights are registered, because the construction starts with a demand for a parcel and obtainment of the current cadastral information of that parcel. The general framework is fairly related to efficient land management and land administration at both urban and rural levels. These notions aim to create more livable and safe spaces for citizens (Dale and McLaughlin, 2000, 1988). Therefore, the implementation of the integrated workflows for building permit procedures, 3D city models update, and land administration can be more beneficial and effective.

Currently, the building permit procedures are carried out by using 2D data in Turkey. Also, the compliance checking process is conducted manually by authorized personnel. Although there are laws and regulations about the building permit processes, it is not detailedly clarified how to carry out building permit procedures. Similar to other countries across the world, these situations may cause disadvantages in terms of different components of the building permit processes such as transparency and finalization time (Martins and Monteiro, 2013). Besides, the ownership rights are registered as 2D in the land registry system in Turkey even though several rights are defined as 3D in the laws. Even so, the registration processes are mainly carried out in the electronic environment because of the various projects (e.g. LRCIS). Yet 3D land administration is not completely accomplished in Turkey notwithstanding some notable efforts (e.g. Alkan et al., 2020).

Another important issue is the creation of national SDI in Turkey. The country is making progress by developing effective visions and actualizing various projects, but there is a need for strong enhancement with regards to composing of 3D geospatial databases at both national and urban scale. In light of this information, the constructive framework can enhance the building permit procedures in parallel with developments related to digital data models and formats. The framework could also help to create 3D digital city models by reusing digital building models on the way to form a national SDI. Additionally, the reformative framework offers the opportunity to enable the 3D registration of property ownership due to the use of as-built models. Figure 9 shows the reformative framework aiming to improve building permit procedures, the update of 3D urban models, and the registration of property ownership by using digital data models in Turkey.

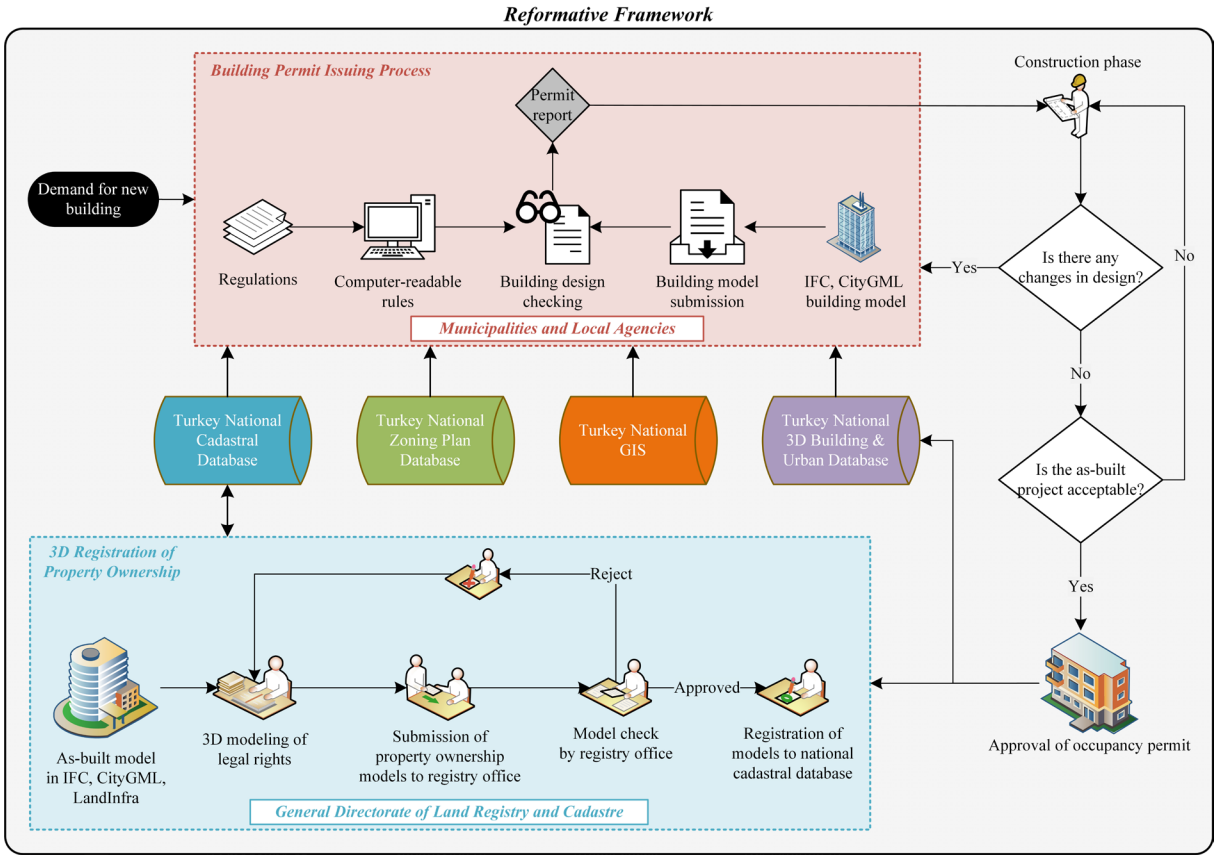

Figure 9. The reformative framework relating to building permit procedures, generating the 3D urban models, and registration of property ownership in Turkey.

The building permit procedures generally start with new building demand in the land parcel. This demand can be related to the renewal of the existing buildings or the construction of a new building. The building permit should be obtained from authorized agencies in both situations. The cadastral and built environment data are necessary to design new buildings realistically and conveniently. Architects benefit from underground and aboveground data during the design stage. Several restrictions about the surroundings of the buildings are able to be considered by using these data (Olsson et al., 2019). That's why both 3D cadastral data and 3D urban models are of vital importance. For example, the spatial and ownership information related to infrastructure facilities can be obtained from the national cadastral database to be used in building design. Besides, architectural design is closely related to the built environment. The spatial data provide an advantage for

multifaceted building design. Thus, the Turkey national 3D urban database and Turkey national cadastral database can be used in building design and compliance checking as well.

Furthermore, construction projects should be prepared in accordance with confirmed zoning plans (Chognard et al., 2018). Based on this, reaching the zoning plans electronically will be more useful because buildings can be evaluated in the design phase detailedly. The e-Plan project carried out in Turkey can contribute to the implementation of this notion by managing the works related to zoning plans electronically. As can be seen in Figure 9, the building permit issuing process is handled electronically by benefiting from digital building models. This is important because most of the buildings are being designed by using digital data models, for example, BIM. Although the building permit procedures are being carried out with paper drawings or PDF files (Solihin and Eastman, 2015), the use of BIM is increasing in Turkey and the rest of the world day by day (BIMgenius, 2020; European Commission, 2019; NBC, 2020; World Economic Forum, 2016). The architects create much more 3D digital building models thanks to the common usage of data formats and standards. This is encouraging for enhancement and digitalization of building permit processes in Turkey. The reformative framework aims to conduct automatic compliance checking by exploiting digital building models and computer-readable rules. Many countries conduct projects to automate the compliance checking (Eastman et al., 2009), but the works related to the automation of building design checking in Turkey is very limited. Nevertheless, the use of digital building models for building permit is mentioned in the "2020-2023 National Smart Cities Strategy and Action Plan" for the first time. This positive action raises the importance of the reformative framework proposal for Turkey.

The building permit is prepared based on the created permit report. If the building design satisfies the conditions that are indicated in the relevant laws and regulations, the building permit is constituted. The construction can start after getting the building permit. The construction phase is important in Turkey because the buildings should be built according to the earthquake regulation. The country experienced a large number of earthquake disasters in the past and still experiences these days

(DEMP, 2020, 2018); therefore, earthquake regulation is prepared and published in order to strengthen the buildings and to ensure the required safety. Every building is audited by authorized building control firms during construction. Another important thing is that the design of the buildings might change in the construction phase. In that case, the new design of the building should be approved by the agencies that carried out the building permit procedures. By using digital building models, this process can be arranged more easily and accurately. At the same time, the as-built model of the building can be acquired. The as-built model of the building should be approved after completion of the construction to create the occupancy permit in Turkey. There is no strict guideline in the occupancy permit or building permit on how to control the as-built model of the building and relevant documents. For this reason, the evaluation of the occupancy permit can be conducted by using 2D data in general. However, more realistic assessments can be practiced if the current as-built model of the building is used (Zhang and El-Gohary, 2017).

After getting the occupancy permit, citizens can dwell in the new building and utilize various public services such as electricity and natural gas. Getting the occupancy permit finalizes the building permit procedures as such in several other countries (Noardo et al., 2019). Besides, the use type change of land parcel should be processed into the cadastral database in order to ensure effective land administration (UN-GGIM, 2019). Currently, there is no obligation for stating the use type conversion of the parcel in Turkey. This might cause damage to the country financially because the taxation cannot be implemented realistically. In this connection, the condominium can be created for independent sections of the buildings pursuant to Property Ownership Law No. 634 in Turkey. There is a need for detailed building models to actualize RRRs with respect to property ownership since 2D representations fail to satisfy the requirements of the complex buildings (Oldfield et al., 2017). The 2D representations are used for the land registry in Turkey. The RRRs are registered to the cadastral database in writing even though there are initiatives regarding the 3D representation of property ownership. The reformative framework can contribute to these initiatives by providing as-built models

of the buildings. Nowadays, various countries seek to use digital building models for registration of legal rights related to real properties and their physical counterparts (Rajabifard et al., 2019). In this regard, the use of as-built building models that are obtained after building permit procedures can provide an advantage for panning out of projects in Turkey. These digital building models can be formatted as IFC or CityGML, which are state of the art open data formats for modeling of urban areas and buildings (Deng et al., 2016).

As illustrated in Figure 9, the registration process starts with 3D modeling of the legal rights by using digital building models. This modeling should be performed by using the as-built model of the building pursuant to Property Ownership Law. In this way, realistic and accurate registration can be obtained (Atazadeh et al., 2019). The registration of property ownership is realized by supplying the building designs to the land registry offices via CD in the current situation. After modeling the legal rights, the submission is checked by land registry offices to confirm whether the verisimilar representations with respect to the property ownership are accomplished, or not. The modeling can be reproduced if there are defects or mistakes. With the approval of the 3D model, the registration of property ownership can be performed, which enables the up-to-dateness of the cadastral database.

Another essential part of the framework is the reuse of the as-built models for updating the 3D geospatial database. 3D city models are very significant to put into practice the sustainable built environment, since they provide a strong data basis for actions to be taken in association with urban areas (Biljecki et al., 2016). 3D digital models of urban areas become even more critical because cities are complex and multilayered than ever before. In addition, more holistic building permit procedures taking the built environment into account can be performed if 3D city models are used. Currently, most cities in Turkey do not have 3D digital city models completely even though several projects are carried out (e.g. 3DUMC). Creating the 3D digital models of the cities is a time-consuming process and it requires modeling works a lot. For this reason, the ensuring of the timeliness of the 3D geospatial database is of great significance (Ohori et al., 2018a). By using the as-built models of the buildings,

this process can be run efficiently. There is a strong potential to use digital building models approved for occupancy permit in Turkey. As mentioned before, a considerable amount of building designs is created digitally as 3D. It is important to benefit from these building designs for updating 3D city models. This results in a contribution to the objectives related to the generation of the 3D urban models in Turkey.

3.2 Evaluation of the Framework

The reformative framework aims to digitalize the building permit procedures in order to enable an efficient and holistic approach. In this sense, the architects should be able to reach the necessary information, including cadastral data and zoning plans, to design the new buildings comprehensively. For this reason, digital databases can be used to provide this information to architects electronically. Thus, it does not only improve the processes related to data exchange between municipalities and architecture offices but also facilitates the creation of realistic, digital building designs. In this connection, web-based e-government applications can be used to serve the required data to relevant stakeholders (Mouloud et al., 2019). The electronic building permit submission will contribute to the enhancement of the functionality of the current processes. The conversion of the relevant regulations into a computer-readable format is an important step to automate and digitalize the building permit procedures. This conversion can be realized by using markup language methods and natural language processing methods (Nawari, 2018). The key issue here is that there is a need for 3D digital building models with sufficient semantic information and level of detail. BIM can easily satisfy this need as it enables the detailed 3D representation of buildings physically and semantically (Teicholz et al., 2018).

The practicality of the automated code checking process has increased with the widespread usage of BIM in the AEC industry. In this sense, the IFC standard offers a powerful solution to virtually conduct the compliance checking, since it holds the types, relationships, and attributes between objects in the digital building model (Zhang and El-Gohary, 2016). The buildings in the 3D digital

environment are designed, realized, and operated through the universal data structure provided by IFC. The semantically enriched depiction, including architectural and structural components, and utility elements, of the buildings is enabled with several hundred entities that are arranged in a hierarchical structure within IFC. Also, the IFC standard can be extended with new data elements by using a built-in mechanism that contains property sets and user-defined types as two extension parts (ISO, 2013). A set of new attributes can be assigned to any IFC standard by means of property sets. User-defined types enable the enrichment of the IFC standard semantically through defining enumeration that does not exist in the IFC schema. For instance, a property set can be used to store the legal attributes of an apartment unit, while the land surveyor can be defined as the *Role* attribute of *IfcActorRole* with the help of a user-defined type (Rajabifard et al., 2018). Regarding this, there are several efforts that focus on IFC-based 3D property registration (for example Atazadeh et al., 2017; Larsson et al., 2020; Sun et al., 2019).

Considering the features of the IFC standard, unsurprisingly, there are significant case studies and efforts in the literature regarding IFC-based compliance checking for building permit procedures (e.g. Jiang et al., 2019; Lee et al., 2016; Trebbi et al., 2020). Generating the BIR that stores the IFC models of the new buildings is an important potential for BIM-based building permit processes in Turkey. The aims of generating BIR and the reformative framework substantially overlap because both of them focus on using and storing the 3D digital building models. In addition, there is a strong potential to update 3D city models as part of the reformative framework, since enhancing the interoperability between international standards, namely IFC, CityGML, and LandInfra, is researched intensively (OGC & buildingSMART International, 2020).

Information related to the built environment might be needed in compliance checking. This need can be fulfilled easily with GIS-based data. Regarding this, an integrated framework that includes the joint use of BIM and GIS based models for building permit processes is introduced recently in the literature (Shahi et al., 2019). In this direction, CityGML, an international standard handled by Open

Geospatial Consortium (OGC), is one well-known standard for modeling, storing, and exchanging the 3D city models (OGC, 2012). The geometric model and the thematic model form the basis of the information model of the CityGML standard. Both the geometrical and topological characteristics of 3D city objects are provided by the geometric model in a consistent and homogenous manner. The geometric model is assigned to lots of thematic urban objects such as buildings, bridges, and land uses through the thematic model. In addition, CityGML standard has Application Domain Extension (ADE) mechanism that allows for extending feature types, attributes, and relations in the existing schema. By this way, it can satisfy the requirements for a specific 3D geographic information application purpose (Gröger and Plümer, 2012).

The current version 2.0 of the CityGML standard is fully revised recently into version 3.0 so as to meet the increasing need for better interoperability with relevant standards such as IFC, IndoorGML, LandInfra/InfraGML, and LADM. The new space concept is introduced in the CityGML 3.0 to enable the clear semantic distinction of spatial features. So, CityGML has the capability of easy communication with other standards such as IFC and LADM (Kutzner et al., 2020). The new Construction module is added to the CityGML standard. The Building[2] module is also revised in CityGML 3.0 to simplify the linking with relevant standards that are closely related to the buildings. A new feature type *AbstractConstructiveElement* and corresponding subclasses *BuildingConstructiveElement*, *BridgeConstructiveElement,* and *TunnelConstructiveElement* are introduced in the new version. The constructive element classes in IFC standard such as *IfcWall*, *IfcRoof*, and *IfcBeam* can be readily mapped onto CityGML. This means that a more direct mapping of IFC onto CityGML is facilitated. Because of the adopting attributes from the INSPIRE Building data theme, the revised Building module allows for specifying various elevation levels and measured heights, which are subject to compliance checking. Additionally, several events and their dates with respect to building permit processes can be expressed in CityGML 3.0, such as the date of building

[2] See Figure 1 in Supplementary Material

permit issuing, the start and the end of the renovation. In order to make possible the depiction of the building units and storeys, a new class *AbstractBuildingSubdivison* and two specializations *BuildingUnit* and *Storey* are introduced in the new Building module. In this way, the apartment rights can be modeled within the CityGML standard (Kutzner et al., 2020).

There are several studies focusing on the integrated building permit procedures that contain the use of digital models based on BIM and GIS (e.g. Olsson et al., 2018). With the improvements in CityGML standard, the possibility of the use of the standard in building permit procedures is increased enormously. The Building Theme in TNGIS is useful as it allows 3D modeling by using international standards such as CityGML and IndoorGML. In light of the recent developments, there is a strong potential to put the reformative framework into practice in Turkey effectively that exploits 3D digital models formatted with CityGML.

Additionally, there is an OGC standard named LandInfra (Land and Infrastructure) that is recently developed with the aim of connecting GIS and BIM domains. The encoding of the standard is prepared by InfraGML (OGC, 2017), which is a multipart OGC standard. As an open conceptual data model that is published in eight parts, LandInfra standard focuses on the representation of the land and infrastructure features, and their management. The parts of the standard are LandInfra Core (Part 0), Land Features (Part 1), Facilities and Projects (Part 2), Alignments (Part 3), Roads (Part 4), Railways (Part 5), Survey (Part 6), and Land Division (Part 7). Also, LandInfra has ten requirement classes, which are implemented in InfraGML, in harmony with these parts, for example, *Facility* and *LandDivison* (OGC, 2016). LandInfra is based on the integration of concepts from various domains, namely CAD, BIM, and GIS. In this connection, the standard has some overlaps with CityGML and IFC in terms of the thematic classes and modeling tools.

Open standards are very important to integrate the geospatial information and the information with regards to the built environment. A significant milestone is reached with the development of

LandInfra and InfraGML. LandInfra standard aims to provide extensive semantic data for the representation of features with respect to both land and infrastructure facilities through integrating GIS and BIM (Kumar et al., 2019a). Accordingly, the standard can offer a remarkable solution to actualize integrated building permit procedures that consider buildings and built environment as well. For instance, LandInfra can be used in the reformative framework for compliance checking with regards to the underground utility network and land surfaces, since it allows for the depiction of the underground infrastructure and surrounding of the building.

To record of legal interests, including ownership and RRRs, with respect to above and below of the land, LADM standard offers a detailed conceptual scheme. For this reason, LandInfra is developed by exploiting LADM. Based on this, the standard has two core requirement class, namely *LandDivison* and *Condominium*, to handle with cadastral information. *LandDivison* class contains two entities, namely *AdministrativeDivisions* and *InterestsInLand,* to define the land as public or private, respectively. There exist two subclasses, i.e. *Easement* and *PropertyUnit*, of *InterestsInLand*[3] that is documented by a *Statement*. *PropertyUnit* that corresponds to the *LA_BAUnit* of LADM standard involves multipartite ownership rights and has two subclasses, namely *LandPropertyUnit* and *CondominiumUnit*. *Condominium*[4] class based on CityGML Immovable Property Taxation ADE, which is developed for Turkey (Cagdas, 2013), intends to describe the property ownership with regard to the main part, accessory part, and joint facility in multipart buildings. The concurrent ownership with respect to the private and common parts of immovable property is defined by the *CondominiumUnit*. The exclusive legal rights are described through *BuildingPart* that is a subdivision of *CondominiumBuilding* and is associated with *CondominiumUnit* via two relationships, namely *mainPart* and *accessoryPart*. The *IfcSpatialZone* entity of IFC is used as a base for *BuildingPart*. The boundaries of the legal object, i.e. *SpatialUnit*, are modeled partially or entirely through

[3] See Figure 2 in Supplementary Material
[4] See Figure 3 in Supplementary Material

BoundingElement. There are two options, namely *BEFace* and *BESolid*, to depict 3D spaces for legal rights. In light of this information, the LandInfra standard offers a significant option for 3D registration of property ownership within the context of the reformative framework. Nevertheless, there does exist some issues related to the standard such as lack of example usage, validation dataset, supporting LOD, detailed semantics, and software package (Kumar et al., 2019b).

Besides, there is an ISO standard called LADM that is developed with the aim of ensuring efficient and effective land administration by providing both an extensible basis and involvement of various parties. The core of the standard is based on Model Driven Architecture (MDA) and an ontology. LADM provides a conceptual schema that allows for depicting spatial and semantic information with respect to RRRs affecting above and below of the land or water, in order to make up the shortage of formal and common language in the land administration domain (ISO, 2012). The conceptual schema of LADM comprises three main packages and one subpackage, namely Party, Administrative, Spatial Unit, Surveying and Representation. 3D legal rights related to buildings and utility network is modeled through *LA_LegalSpaceBuildingUnit* and *LA_LegalSpaceUtilityNetwork*, which are subclasses of *LA_SpatialUnit* (Lemmen et al., 2015). LADM standard enables complete modeling of multipartite legal rights, including unit, car park, and storage, by *LA_BAUnit*; however, physical counterparts of those legal rights can only be depicted partially in the standard. Therefore, in LADM, the legal object and its physical element can be modeled by defining a limited external connection. Yet it might be challenging to link legal and physical objects due to the difficulties in the transformation of geometric information and in the harmonization of semantic information (Rajabifard et al., 2018). 3D description of the legal boundaries is realized by *LA_BoundryFace* and by its relations with the *LA_Point* and *LA_SpatialSource*. Nevertheless, the ability to distinguish semantic attributes with regards to multiple types of legal boundaries is not available in the *LA_BoundryFace* entity. So, the current version of the LADM standard does not provide the semantic distinction between the surface of a wall boundary and the surface of a ceiling boundary (Aien et al., 2013). For this reason,

there are several studies to integrate LADM and physical information models such as CityGML and IFC (for example L. Li et al., 2016). The 3D legal interests and their physical counterparts can be modeled realistically by this way. As mentioned before, the new version of the CityGML standard is developed by considering interoperability with LADM. In this sense, it is clear that there is an important potential to exploit LADM for 3D registration of condominium rights within the context of the reformative framework. In addition, the LADM standard can be used for building permit procedures in the near future as the new version of the standard will include spatial planning (Indrajit et al., 2020).

Many stakeholders take part in the reformative framework for building permit issuing processes. Contractors and architects need basic information and data to start the process for construction. In this part, municipalities and local agencies provide necessary data to them. For example, zoning plans are very important to design the building. GDLRC provides cadastral information associated with land parcel or existing building. LMCO involves processes to provide several data, for example, boundary sketch. The reformative framework aims that various databases such as cadastral and zoning plan can be accessed through e-government applications. MEU and GDGIS play an important role in providing data. Municipalities and local agencies realize compliance checking. Also, the central system is a substantial option for submission and tracking. After obtaining the building permit, building inspector firms involve in the procedures. Municipalities and local agencies take part in processes for approving the occupancy permit. Digital building data plays a significant role in the whole of the reformative framework. After getting the occupancy permit, GDGIS takes part in the processes for updating the 3D city model.

The next part of the reformative framework is 3D registration of property ownership subject to land administration. Currently, various stakeholders do exist associated with land administration in Turkey. MEU is the top organization, considering that land administration has four key attributes, namely land tenure, land value, land use, and land development (Dale and McLaughlin, 2000; Enemark

et al., 2005; Williamson et al., 2010). GLRC, including land registry and cadastre directorates, and LMCO, is the fundamental stakeholder that carries out processes with respect to land administration. Considering the conducted projects, it is clear that the aim of the reformative framework coincides with the vision of GLRC in the sense of 3D registration of property ownership. That is to say, the use of 3D as-built models in the registration of condominium rights offers a significant advantage to succeed in prospective objectives. It can be said that the real property valuation domain that serves as an important counterpart of land administration encompasses various interest groups. In this regard, DLV is a significant stakeholder in Turkey even though it is established a short time ago. The availability of up-to-date 3D city models and 3D property ownership data will be substantially beneficial for the land valuation practices in Turkey (see for example Kara et al., 2020). Moreover, the General Directorate of Spatial Planning (GDSP) *(Mekansal Planlama Genel Mudurlugu)* that deals with land use planning and land development parts of land administration can benefit from the reformative framework to put into practice integrated building permit procedures that consider building and built environment at the same time. As mentioned before, municipalities that commonly conduct permit processes can exploit the proposed framework in the sense of both land use planning and land development, in order to ensure effective land administration. Citizens, as an essential stakeholder in land administration, can also access and utilize the detailed and useful information in 3D about their ownerships via e-government application by means of the reformative framework. Considering that all mentioned stakeholders 1) aim to digitalize and facilitate the building permit procedures, 2) enable the 3D registration of condominium rights, 3) keep the 3D city models up-to-date, the reformative framework is expected to gain wide acceptance positively.

4. Discussion

The reformative framework considers the building permit procedures as an integrated process that involves the use of spatial databases related to various topics such as the built environment and zoning plan. The enablement of efficient building permit procedures has become even more important since

the construction sector has a significant role in the economy of the country (Tekin and Atabay, 2019). In this connection, forward-looking strategies have digital production of spatial data and cadastre maps across the country in Turkey. These objectives appear in several strategies such as the "11th Development Plan". Yet not much effort has been put into enhancing the building permit procedures in Turkey. On the other hand, there are several countries searching for ways to improve building permit procedures by using spatial data standards (Chognard et al., 2018).

Nonetheless, there is promising progress about the smart cities and relevant issues in Turkey with the publication of the "2020-2023 National Smart Cities Strategy and Action Plan". This plan mentions the use of digital building models for building permit procedures and facility management as well. Hence, improving perspectives about the digitalization of building permit procedures have become crucial in accomplishing the objectives with respect to enablement of both 3D city models and 3D property registration. The creation of 3D urban models is a comprehensive project as it needs qualified manpower for modeling large areas (Ohori et al., 2018a). 3D cadastre requires too much surveying works and modeling works as well. Considering that the country has a completely 2D cadastral database, the transition to 3D registration of legal rights requires vast workforces (Rajabifard et al., 2019; Van Oosterom, 2018). Therefore, the viewpoint on how to efficiently model the physical parts of the legal rights by benefiting from 2D drawings is of vital importance to succeed. In this context, there is a need for a detailed assessment to actualize the reformative framework in Turkey. First, the feasibility research about the digitalization of building permit procedures can be conducted to reveal the current situation of different sectors such as AEC, urban planning, and land administration. In addition, it is important to present whether public agencies have sufficient resources for using the digital building models in terms of the infrastructure and human-resource because digitalization of building permit procedures requires authorized personnel, who have vast knowledge of handling with 3D data standards and models, e.g. IFC.

The serviceable e-government applications are needed for building permit submissions and manipulation of the digital data models in the sense of infrastructure. Second, the guidelines that explain how to carry out the building permit processes by using digital building models can be beneficial for local agencies and municipalities from a managerial aspect. By this way, the complaints that might arise during the practice will be prevented and the discrepancies in the applications will be eliminated. In this regard, the practicalities of the guidelines are quite important in terms of efficient operation of the building permit processes. In this connection, the transformation of related laws and regulations into computer-readable format is another important issue for the automation and digitalization of building permit processes (Nawari, 2018). This is currently at the research phase but more efforts will be helpful to easily adapt the processes for automation later on. Third, the multifaceted approach could be more helpful to put the proposed framework into practice since it contains the utilization of various data sources belonging to different notions, namely cadastre, planning, and data infrastructure. In this sense, the interoperability between different agencies should be ensured in terms of spatial data. That is to say, open data formats and standards such as IFC and CityGML have important potential to enable data exchange between users properly (Kang, 2018).

One of the objectives of the reformative framework is to enable the use of as-built models of the constructed buildings for registration of property ownership. In this regard, the issues on how to create, model, and store the 3D legal rights are needed to be elucidated in the guidelines or regulations (Larsson et al., 2020). By doing so, it can contribute to the productive use of as-built models as well as getting the legal infrastructure. As of today, the property ownership related to the buildings is modeled as 3D by using architectural drawings and land registration data within the context of the project carried out in Turkey. In this sense, the reuse of the as-built models of the buildings can facilitate keeping the 3D national cadastral database up-to-date. It is important to decide which level of detail is used to model property ownership. The current efforts in other countries can be reviewed as a pathfinder (Van Oosterom, 2018). Another important issue is to increase the number of staff who

can handle CAD, BIM, and GIS in land registry offices. At present, to the authors' knowledge, the number of civil servants who have experience in the 3D spatial data handling is limited in Turkey. This ratio can be enhanced with training and projects.

The reformative framework also aims to support the creation and the update of the 3D national geospatial database by benefiting from as-built models. The contents of this database change due to the new constructions. Because of this, keeping the 3D digital city models up-to-date becomes difficult. This problem can be solved by reusing the as-built models that are obtained after getting the occupancy permit. Additionally, it can significantly contribute to enriching the content of the TNGIS in a multidimensional sense. In this connection, the e-government services in Turkey related to the property registration, SDI, and building permit can be improved with the developments conducted related to the reformative framework. Furthermore, it will be beneficial if the guidelines are specified with regards to the model conversions between different data standards, for example, IFC and CityGML (Noardo et al., 2020).

5. Conclusion

This paper presents a reformative framework that aims to improve the building permit procedures, 3D registration of property ownership, and update of the 3D city models in Turkey. The study provides current and fundamental information about relevant issues by conducting a thorough examination. The detailed description and evaluation of the reformative framework can be used in forward-looking plannings and policies. The present work puts forward a significant viewpoint that focuses on the efficient use of the 3D digital building models. Accordingly, this paper contributes to the body of knowledge by considering the building permit procedures, 3D registration of property ownership, and update of 3D urban models as an integrated concept.

Further studies can concentrate on the practicality of the various standards such as LandInfra and CityGML 3.0 within the proposed framework. For instance, CityJSON is recently introduced to

enhance the encoding of the CityGML data models (Ledoux et al., 2019). More recently, the OGC has announced that the evaluation phase is started for CityJSON to be accepted as an official standard. Besides, the next version of the LADM standard can be analyzed for the reformative framework in terms of digital planning (Lemmen et al., 2019).

The present study has a limitation in terms of the application even though it provides a substantial perspective and elaboration for improvement and digitalization of building permit procedures, enablement of 3D registration of condominium rights, and update of 3D city models in Turkey. For this reason, future work is expected to include 3D modeling of property ownership in Turkey by using digital models formatted with BIM techniques, especially IFC, as well as web-based representation of the created models. Moreover, the automatic compliance checking process in Turkey can be researched by using digital data models and computer-readable building regulations.

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