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Towards a 3D Real Estate Valuation Model Using BIM and GIS

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Abstract. Real estate values are needed and used in many finance, engineering, and construction operations. It is significant to assess property values in a standard-based, objective manner. Utilizing Geographic Information Systems (GIS) and Building Information Modelling (BIM) technologies, real-estate values can be assessed with three-dimensional (3D) geospatial and built environment analysis. In this study, criteria that affect real estate value are grouped as environmental, physical, legal, and socio-economic factors. Then, the Industry Foundation Classes (IFC)-based 3D property valuation model is designed. By proposing new property sets and properties, features and their attributes are mapped with entities and data types in the IFC schema to demonstrate the likely use of IFC data for property valuation. Conducting BIM&GIS analysis for both external and internal criteria, property values can be assessed by using the created holistic model. It is thus aimed to develop a valuation framework that can be used as a reference in several value-based applications such as property taxation, urban renewal, and land share calculation.

Keywords: BIM, IFC, GIS, Real Estate Valuation, Property Valuation, 3D Valuation.

1 Introduction

Land administration that consists of land tenure, land use, land value, and land development relates people to land [1]. Land administration systems (LAS) provide semantic and spatial information for the effective management of activities relating to land administration. The rights, restrictions, and responsibilities (RRR) with respect to people, policies, and places are recorded and stored through these systems [2]. Although the complexities of buildings and built environment increased, a vast majority of LAS relies on the registration approach that considers two-dimensional (2D) spatial data and relevant legal information [3]. In land-related activities, 2D-based systems might have some drawbacks for realistic delineation of the RRR [4]. To overcome these drawbacks that stem from the use of only 2D spatial data, previous efforts focused on developing and exploiting national and international standards that primarily concentrate on three-dimensional (3D) data from conceptualization and data modelling points of view [5–

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7]. The Valuation Information Model (VIM), as a newly developed extension of the Land Administration Domain Model (LADM) [8], is an important example [9]. The increasing availability of the 3D building and city models that are produced by using Building Information Modelling (BIM) and Geographic Information Systems (GIS) technologies triggered those efforts [10].

Property valuation, as a significant component of the land administration, needs to be carried out by taking a wide range of information pertaining to real-estate properties into account. This information comprises various aspects such as physical qualities, locational and environmental attributes [11]. In order to obtain the required information in the valuation of the properties in a reliable manner, there is a growing interest in the literature to use 3D models where the rich semantic and geometric information is stored [12–14]. For example, El Yamani et al. [15] proposed to use the integration of BIM and GIS for 3D property valuation by identifying effective factors. The authors classified those factors depending on they can be obtained BIM or GIS models. Celik Simsek and Uzun [16] suggested exploiting Building Information Models (BIMs) for obtaining the factors such as openness of the views that are used to determine values of the properties in Turkey. Zhang and El-Gohary [17] put forward an approach that extends Industry Foundation Classes (IFC) schema such that it comprises required entities for assessing values of buildings. Scholars proposed new entities (e.g., IfcParkingElement), and property sets (e.g., RecycledMaterial) for existing entities in that study.

This chapter first identifies the valuation indicators that can be obtained from BIM and/or GIS. Then, it presents the features and possible attributes for 3D real-estate valuation, based on international standards. Finally, it maps these features and their attributes with entities and data types in the IFC schema by proposing new property sets and properties to demonstrate the likely use of IFC data for property valuation.

2 Background for 3D Data Modelling

In this section, information with respect to the current state of BIM and GIS, their open standards, and integration between them is given.

2.1 Building Information Modelling

BIM can be defined as a set of processes that contain the production, communication, and analysis of BIMs that store all essential data in a machine-readable format for a facility's whole life cycle including design, maintenance, and demolition [18]. Figure 1 shows the life cycle of BIM.

The maturity levels of BIM differ depending on used tools, standards, and formats. For example, whereas the initial maturity level benefits from papers as tool and lines or arcs as format, the advanced maturity level exploits integrated web services as tool and interoperable data as format [19]. BIM provides important benefits in different stages of the life cycle of the facilities. For instance, it contributes to increasing the performance and quality of the building and improving the collaboration before the construction phase. In terms of design, BIM enables more accurate visualization, automatic

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correction of low-level mismatches, and effective collaboration of various disciplines. It facilitates the determination and omission of errors in design and synchronization between design and implementation in the construction phase. BIM also helps the management of facilities by providing information integration after construction [18]. Ordinarily, the adoption of BIM in different sectors, especially in the AEC industry, increased due to the abovementioned advantages [20]. For example, BIM models are significant for the digitalization of building permit issuing [21].

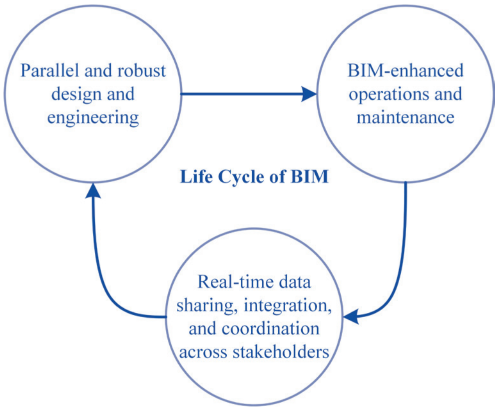

Fig. 1. The life cycle of BIM (adapted from Gerbert et al. [22]).

Interoperability is, as a result of efficient standardization, highly significant for BIM because of a large number of software vendors. Differences in modelling concepts of BIM authoring tools create the need for standardization in data exchange. In this connection, Industry Foundation Classes (IFC) [23], as an open and international standard, provides a standardized data schema by logically defining the semantics, attributes, relationships, objects, concepts, processes, and people involved within the complete life cycle of buildings and infrastructures [24]. Alongside the IFC, BIM Collaboration Format (BCF), Model View Definitions (MVDs), and Information Delivery Manual (IDM) [25] are other standards developed by buildingSMART to ensure information flow in respect to data and workflow. The development of the IFC is an ongoing activity. IFC4 ADD2 TC1 is the current official version. Objects and their relations conceptually form the structure of the IFC. Numerous entities in the IFC schema meet the specific needs of different domains such as architectural and electrical.

2.2 Geographic Information Systems

GIS are decision-support systems that allow users to model, store, analyze, and visualize the georeferenced spatial features with their semantics (i.e., attributes) and their relationships with other spatial features in order to better manage the built environment. Due to the growing complexities of objects in the built environment, the need for 3D GIS emerged many years ago. In this sense, 3D city models are exploited in a broad range of application areas, including energy simulation, indoor navigation, taxation,

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and emergency response [26]. 3D models of cities or buildings require specific needs in terms of various topics such as database management, modelling approach, and visualization. That is why data standards are of strong importance for 3D GIS so as to enable interoperability between stakeholders who produce and use 3D models. Regarding this, several data standards are developed, for example, Infrastructure for Spatial Information in Europe (INSPIRE) [27], 3D Tiles [28], and CityGML. The CityGML [29], which has two versions currently, is the most widely-used standard in 3D city modelling. It provides the spatial data structure that permits to model and to represent the features as 3D in a wide range of themes in the built environment such as buildings, tunnels, and bridges. CityGML uses the concept of Level of Detail (LoD) to manage the complexities of the objects that are modelled. While the second version of the standard uses five LoDs, namely from LoD0 to LoD4, the third version will have four LoDs and it will permit to be modelled the objects independently from LoD [30].

2.3 Integration of BIM and GIS

The integration between BIM and GIS has attracted noteworthy interest in recent years since they complement each other in terms of the modelling of building and built environment [31]. This is because whereas BIM provides rich information for buildings, GIS enables the spatial data for the whole built environment. However, the precise integration has not been achieved yet because of a set of reasons such as modelling differences in the adapted standards of two domains and georeferencing approaches [32]. Nevertheless, it is aware that the integration of BIM and GIS is of powerful significance for many application areas such as 3D cadastre, asset management, and urban environment analysis. For this reason, there do exist numerous studies in the literature that focus on this integration [10]. For example, a CityGML ADE that enables to convert IFC to CityGML by storing a certain subset of information is proposed [33]. Moreover, a standard, namely LandInfra/InfraGML [34], is developed to facilitate the integration of data that come from BIM and GIS. It is also highlighted in a report that the integration of IFC, CityGML, and LandInfra is very vital to better management of the built environment [35]. Figure 2 illustrates the overlap between BIM and GIS domains.

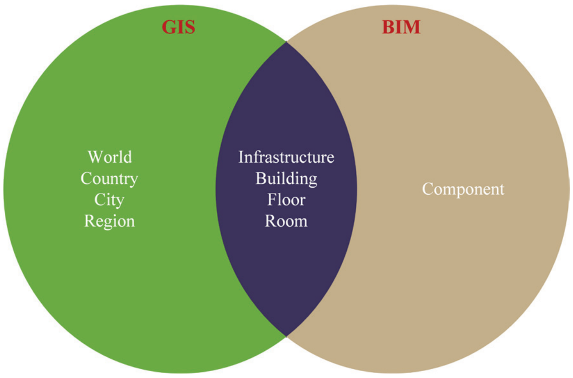

Fig. 2. The intersection between BIM and GIS domains (adapted from Liu et al. [10]).

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3 Real-Estate Valuation

Real estate valuation is the process of estimating the unit value under current market conditions by examining affecting factors in a holistic manner, considering the environmental, physical, legal, and socio-economic characteristics of the properties [36, 37]. Real estate valuation has great importance for both the state and citizens since it is needed in many applications such as buying and selling, taxation, expropriation, zoning applications, capital market activities. There are various valuation methods like Sales Comparison Approach, Income Capitalization Approach, Replacement Cost Approach, known as classical methods. Those methods are used widely for the valuation of single real estate. However, mass valuation methods like Nominal Valuation, Hedonic Pricing, Multiple Regression Analysis, Artificial Neural Networks are being used more and more for the valuation of a large number of properties. The Nominal Valuation Method provides calculated parametric scores of weighted criteria which affect real estate values [37]. This method does not require the market value and provides a distribution of land values as parametric quantities. Furthermore, it is also possible easily to convert nominal coefficients into market prices [38]. The Nominal Valuation Method can be used in both single and mass valuation processes.

Deciding the criteria which affect the real estate's value is one of the preliminary works of the valuation process. It is very hard to limit the valuation criteria since there are numerous affecting factors for real estate, and their importance can vary by person. In order to provide objective and proper real estate valuation, affecting criteria should be determined and analyzed in detail. Valuation criteria are generally classified into two groups as external and internal factors. While external factors are related to locational, environmental attributes, internal factors are related to physical attributes of the property. Properties should be analyzed and assessed in three-dimension using 3D data resources like Digital Surface Model (DSM), Digital Terrain Models (DTM), building footprints, and BIM [9, 15, 39–41].

3.1 Valuation Factors

The factors which affect real estate value are classified into four general groups after analyzing related studies in the literature [36, 42–46] (Figure 3).

Environmental Factors. External valuation factors of real estate are related to the environment it belongs. Location is one of the most important criteria determining the land value of a property. We defined environmental factors which affect the property value as proximity, terrain, view, traffic density, noise, air quality, sunlight, indoor daylight, geological structure, and municipality infrastructure services.

Proximity to important localities significantly increases the value of the property. There are many distance calculation methods like Network-based Distance, Euclidean Distance, Cost Distance to analyze and assess the proximity criteria. On the other hand, travel mode also affects the proximity since one can go on foot, drive or use public transportation.

View and topography are some other major factors affecting real estate value. Forest, lake, and sea views add attraction to the property and increase its value. The slope of

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the region where the real estate is located is also an important factor for valuation. Properties located on flat terrain are more preferred and more valuable than sloping land. Moreover, real estate with south-facing slope is preferred since they benefit more from sunlight.

Fig. 3. Classification of real estate valuation criteria.

Aspect, building floor, outdoor obstacles (buildings, trees, etc.) are some factors that affect the indoor daylight of the buildings. Indoor daylight can be simulated and assessed for condominiums using BIM.

Traffic density is another criterion that affects the real estate value. Properties located in a region where near roads with heavy traffic congestion are less preferred. Traffic jam also causes noise and poor air quality in the region. Those factors can be analyzed with 3D geospatial analyses for each condominium unit.

Geological structure and municipality infrastructure services are other environmental factors that affect the value. Ground structures like rock, stone, gravel, sand, clay, alluvium have different soil features. Buildings located in regions with solid ground structures are more preferred since their earthquake-resistant characteristics. Moreover, the availability of municipal infrastructure services such as water and sewage, electricity, telecommunication, and gas has a significant impact on real estate values.

Physical Factors. Physical criteria which affect real estate value can be grouped as land properties and building properties. Parcel area, parcel geometry (shape and number

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of vertices), parcel location (corner or middle), and parcel frontage are structural properties of the land parcels. Land type (barren land, bottomland, wetland), land yield class (good, moderate, weak, or unproductive), land use status (dryland or irrigated agriculture), and land productivity value are land properties that affect the value for agricultural land. On the other hand, building area, number of floors, construction type (steel carcass, reinforced concrete carcass, masonry, adobe, wood, stone-walled building), construction date, quality type (first class, second class, etc.), number of rooms, number of bathrooms, number of bedrooms, number of balconies, heating, cooling system, energy efficiency level, and utilities (elevator, garden, pool, parking lot, fitness center) are building structural properties which affect the value of buildings. Physical factors of buildings can be analyzed and assessed by using BIM in 3D for each condominium.
Legal Factors. Legal factors have great importance on real estate value because it is related to RRR of the properties. Building use type (residential, office, or retail), easement (usufruct, right of habitation, right of construction, right of source, or right of way), mortgage, rental annotation, building coverage ratio, floor area ratio, maximum building height, building construction order (adjoining, separate, or block), yard distances, and the maximum number of floors are legal factors that affect real estate value.
Socio-Economic Factors. Socio-economic factors represent development level indicators that reveal living quality in the region. Socio-cultural development level, population density, building density, regional education level, regional income level, crime rates, depreciation recovery period, tax value, and annual net income are socio-economic factors that affect real estate value.

3.2 International Standards for Real Estate Valuation

Inconsistent assessment is a debated issue of property valuation due to subjective approaches. Resultant values may differ slightly from each other and cause economic losses in value-based applications. To overcome those problems and to develop technical standards for promoting high qualifications in the real estate valuation activities, international valuation standards organizations have been established. International Valuation Standards Council (IVSC), International Association of Assessing Officers (IAAO), Royal Institution of Chartered Surveyors (RICS), The European Group of Valuers' Associations (TEGoVA), are umbrella institutions that set standards to promote consistency and professionalism for the valuation business.

Apart from those organizations, an International Organization for Standardization (ISO) standard LADM has a conceptual framework for property valuation and taxation. The second edition of the LADM which has been proposed to ISO by the International Federation of Surveyors (FIG), will include a revised data model, more semantics, explicit four-dimensional (4D) profiles, and integrated with data encodings like BIM/IFC, Geography Markup Language (GML), CityGML, LandXML, LandInfra, IndoorGML, RDF/linked data, GeoJSON [47]. The extended model will also cover the valuation package, on the top of Land Administration Fundamentals [48].

Valuation Information Model (LADM_VM) is designed as one of the packages of the LADM Edition II [49–51]. It is a conceptual model that defines the semantics of the valuation processes. LADM_VM can be used to construct information systems for real

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estate valuation and can be associated with other public registries. It includes the classes VM_Valuation, VM_ValuationUnit, VM_SpatialUnit, VM_ValuationUnitGroup, VM_CondominiumUnit, VM_Building, VM_MassAppraisal, VM_SaleStatistics, and VM_ValuationSource. LADM_VM is designed to cover all phases of real estate valuation like property identification, single or mass valuation, registration of transaction prices and sale statistics by considering standards and directives of the aforementioned institutions [9, 51].

3.3 Property Valuation Using GIS and BIM

GIS and BIM are two important data creation and manipulation sources in city and building scales. Using GIS and BIM in property valuation activities provides easy data manipulation, advanced automation, and robust spatial analysis capabilities. It also has great potential to increase assessment accuracy since it establishes a scientific and objective approach [52]. GIS analysis can be utilized to assess environmental factors like proximity, terrain, network, traffic density, sunlight exposure. On the other hand, physical factors like indoor daylight, energy efficiency, indoor sound level, air quality, and view can be analyzed by using BIM. GIS and BIM enable to conduct of holistic 3D property valuation by taking into consideration both internal and external criteria. While measuring the valuation factors in the assessment phase, valuation methods like Sales Comparison, Replacement Cost, Nominal Valuation, Hedonic Pricing can be used. It is also possible to use mass valuation methods for assessment of the properties on a street or in a neighbourhood after having the criteria results by conducting the analysis.

4 IFC-Based 3D Property Valuation Demonstration

There are numerous factors that affect the valuation of the property. Obtaining the nominal values of all factors from one data source seems quite difficult since these factors are related to both buildings and the built environment. For this reason, the integration of GIS and BIM may be very useful for 3D property valuation. This chapter focuses on how to model the affecting factors using the IFC schema with the aim of benefitting from their attribute values in property valuation. The features and their attributes related to property valuation are identified by using the proposed conceptual models in the literature, for example, LADM_VM. In the IFC schema, several entities can be used to model legal rights with their physical counterparts. Mostly used entities for this purpose are IfcZone and IfcSpace. A similar approach is also utilized in different studies in the literature. In the context of the property valuation, specific ownership types such as condominiums can be modelled with their physical counterparts by means of entities in the IFC schema to extract nominal values of attributes.

The IFC permits to be added any number of properties sets and their properties to different entities as required for meeting the specific needs of various applications, for example, property valuation. New property sets and their properties are thus determined. After, the property types and data types based on the current official IFC version

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are identified. Table 1 shows the property sets, property names, property types, and data types that can be used to link conceptual valuation models to the IFC schema. As can be seen from Table 1, different logical spaces should be modelled for property valuation. For instance, calculating the values of condominium units is very important since these values might affect the land share in the cadastral registration. That is why Pset_PV_CondominiumUnit and its properties (i.e., factors) that enable obtaining the nominal values for property valuation are added to the IfcSpace entity. IfcZone entity is composed of multiple IfcSpace entity instances. So, Pset_PV_ValuationUnit is added to the IfcZone entity since valuation units might contain several annexes that are represented by using IfcSpace. It is important to pay attention to select the proper data type for properties. IFC schema has many data types that are proposed to correctly store values of properties.

Table 1. Property sets, property names, property types, and data types for IFC-based 3D property valuation.

Property Set Name	Property Name	Property Type	Data Type
Pset_PV_Owner	name	IfcPropertySingleValue	IfcLable
	surname	IfcPropertySingleValue	IfcLable
	fatherName	IfcPropertySingleValue	IfcLable
	pID	IfcPropertySingleValue	IfcIdentifier
	nationality	IfcPropertyEnumeratedValue	IfcLable
	ownerType	IfcPropertyEnumeratedValue	IfcLable
Pset_PV_RRR	share	IfcPropertySingleValue	IfcReal
	registrationDate	IfcPropertySingleValue	IfcDateTime
	ID	IfcPropertySingleValue	IfcIdentifier
	easement	IfcPropertyEnumeratedValue	IfcLable
	mortgage	IfcPropertySingleValue	IfcBoolean
	rentalAnnotation	IfcPropertySingleValue	IfcBoolean
Pset_PV_RegistrationUnit	ID	IfcPropertySingleValue	IfcIdentifier
	type	IfcPropertyEnumeratedValue	IfcLable
Pset_PV_Parcel	propertyNumber	IfcPropertySingleValue	IfcInteger
	parcelNumber	IfcPropertySingleValue	IfcInteger

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	area	IfcPropertySingleValue	IfcAreaMeasure
	ID	IfcPropertySingleValue	IfcIdentifier
	parcelUseType	IfcPropertyEnumeratedValue	IfcLable
	parcelGeometry	IfcPropertySingleValue	IfcBoolean
	parcelFrontage	IfcPropertySingleValue	IfcReal
	parcelLocation	IfcPropertyEnumeratedValue	IfcLable
Pset_PV_Building	buildingID	IfcPropertySingleValue	IfcInteger
	ID	IfcPropertySingleValue	IfcIdentifier
	builtDate	IfcPropertySingleValue	IfcDateTime
	name	IfcPropertySingleValue	IfcLable
	footprint	IfcPropertySingleValue	IfcReal
	noOfFloors	IfcPropertySingleValue	IfcInteger
	constructionType	IfcPropertyEnumeratedValue	IfcLable
	qualityType	IfcPropertyEnumeratedValue	IfcLable
	constructionDate	IfcPropertySingleValue	IfcDateTime
	heatingCooling	IfcPropertySingleValue	IfcBoolean
Pset_PV_CondominiumUnit	floorNumber	IfcPropertySingleValue	IfcInteger
	area	IfcPropertySingleValue	IfcAreaMeasure
	volume	IfcPropertySingleValue	IfcVolumeMeasure
	useType	IfcPropertyEnumeratedValue	IfcLable
	condominiumNumber	IfcPropertySingleValue	IfcInteger
	landShare	IfcPropertySingleValue	IfcLable
	noOfRooms	IfcPropertySingleValue	IfcInteger
	balcony	IfcPropertySingleValue	IfcBoolean
	energyEfficiency	IfcPropertyEnumeratedValue	IfcLable

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	indoorSound-Level	IfcPropertyEnumeratedValue	IfcLable
	indoorDaylight	IfcPropertySingleValue	IfcRatioMeasure
	ID	IfcPropertySingleValue	IfcIdentifier
	condominiumID	IfcPropertySingleValue	IfcInteger
Pset_PV_CommonFacility	type	IfcPropertyEnumeratedValue	IfcLable
	tngisID	IfcPropertySingleValue	IfcIdentifier
Pset_PV_Annex	type	IfcPropertyEnumeratedValue	IfcLable
	sID	IfcPropertySingleValue	IfcIdentifier
Pset_PV_Valuation	ID	IfcPropertySingleValue	IfcIdentifier
	date	IfcPropertySingleValue	IfcDateTime
	method	IfcPropertyEnumeratedValue	IfcLable
	value	IfcPropertySingleValue	IfcReal
Pset_PV_ValuationUnit	ID	IfcPropertySingleValue	IfcIdentifier
	type	IfcPropertyEnumeratedValue	IfcLable
Pset_PV_ValuationUnitGroup	ID	IfcPropertySingleValue	IfcIdentifier
	type	IfcPropertyEnumeratedValue	IfcLable
Pset_PV_MassValuation	date	IfcPropertySingleValue	IfcDateTime
	algorithm	IfcPropertyEnumeratedValue	IfcLable
	value	IfcPropertySingleValue	IfcReal

For example, IfcBoolean can be used to store the value that shows whether the condominium unit has a balcony or not. IfcInteger can be used to store property values that should always be an integer, for example, floor number where the condominium unit locates. Besides, IfcIdentifier can be used for storing the values that are not needed to be understood by people, for example, object identifications (IDs). A floor of the simple building is used to show the demonstration of the proposed approach that enables to obtain values related to property valuation from the IFC data model. After creating the model in the BIM authoring tool, the spaces and zones are defined. Besides, new property sets in Table 1 are added to the model, and properties of spaces and zones are populated. Lastly, the IFC data of the floor is exported by using the IFC export

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extension that allows users to export user-defined property sets in the BIM authoring tool. Figure 4 illustrates a condominium unit example with its property values for Pset_PV_CondominiumUnit that is modelled by using the IFC schema and visualized in the BIM viewer. Figure 5 shows a valuation unit example with its properties pertaining to Pset_PV_ValuationUnit and Pset_PV_Valuation that represents a condominium unit that has an annex.

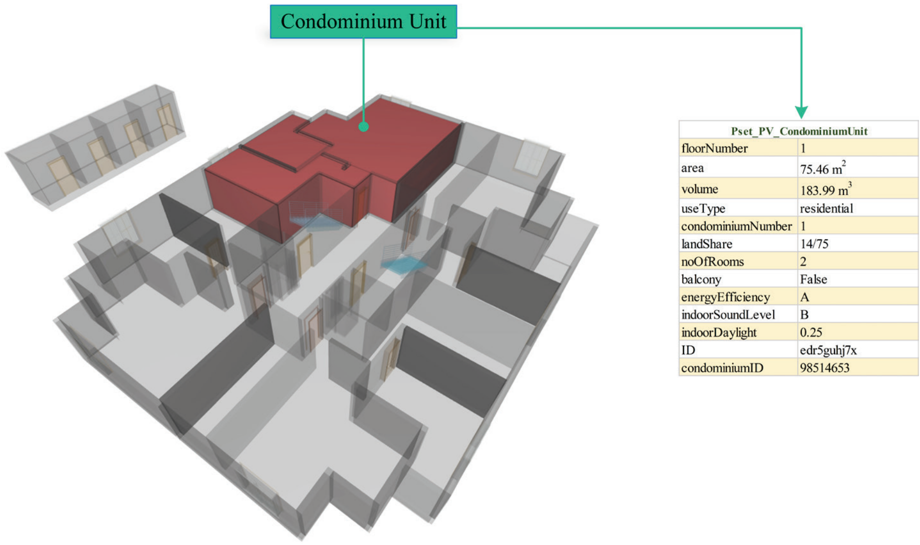

Fig. 4. IFC-based model of a condominium unit in the sense of 3D property valuation.

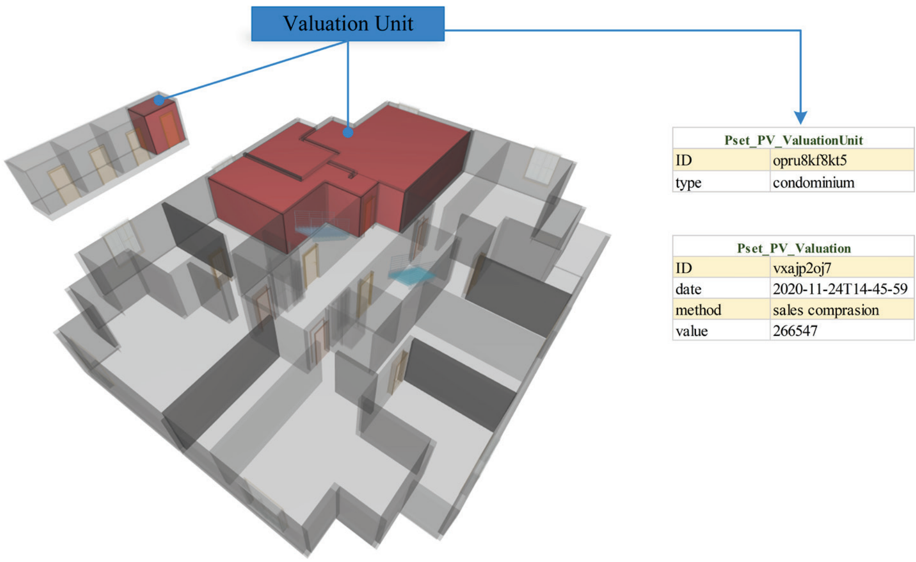

Fig. 5. IFC-based model of valuation unit in the sense of 3D property valuation.

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5 Discussion and Conclusion

The applications such as property valuation that have an important effect on people, land, and administrations are needed to be conducted in a precise way. This can be achieved by giving more consideration to objective information rather than subjective evaluation. Property valuation is one of the major use cases of the intersection of GIS and BIM applications. There is a data need for both external (environmental) and internal (physical) factors which affect the property value. In order to propose a holistic model that can be used for all valuation purposes, it is categorized the valuation factors into four classes according to the criteria type. While classifying the valuation factors, various works are reviewed from the literature. Celik Simsek and Uzun [16] analyzed criteria like floor, heating system, utilization of the sunlight, utilization of the daylight, orientation, openness of views, building annex, facades facing the street for valuation of condominiums. Zhang and El-Gohary [17] considered valuation factors like energy conservation, daylight and views improvement, material conservation, indoor air quality improvement, acoustic comfort, fire safety, cost-saving accessibility for IFC-based building value analysis. Bünyan Ünel and Yalpir [45] classified the criteria which affect the land value as legal, physical, locational, and neighborhood features. Bovkir and Aydinoglu [43] categorized the residential property valuation criteria into eight groups: parcel characteristics, legal factors, transportation, socio-cultural factors, public services, improvement characteristics, locational factors, and utilization. Some of the studies analyze few criteria for BIM-based property valuation, yet other studies consider valuation criteria for only land parcels or residential properties.

In this study, criteria that affect the real estate values are examined in detail and classified into four general groups for all property types. Environmental, physical, legal, and socio-economic factors are explained in the chapter and a detailed table is given in the appendix section as supplementary material. Given that the production of digital models of built environment besides building and infrastructure increased, the information that is required for property valuation is now more accessible. This is possible thanks to the international standards that enable data exchange and interoperability within a workflow. In terms of conceptualization, international standards such as LADM provide a common basis that can be adapted in various jurisdictions and countries. On the other hand, linking these standards with data standards that allow to elaborately model both built environment and buildings are highly important for effective property valuation. This is because both GIS and BIM domains enable to model and store spatial objects with their attributes in a comprehensive way. LADM offers a conceptual data model which deals with physical, legal, geometric, and semantic features of properties for functional land management [8, 53]. With the revised LADM (Edition II), valuation and taxation external class will be an additional package (LADM_VM) of multi-part standard. LADM_VM defines the semantics of real estate valuation processes and links valuation registries with other public registries [49–51]. In the OGC White Paper on Land Administration [47], further integration of geo-information standards like BIM-IFC is encouraged for establishing a link between construction works and land administration. In this chapter, the LADM-compatible 3D property valuation model is designed in IFC-schema which contains property sets, property names,

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property types, and data types. In the IFC schema, Pset_PV_CondominiumUnit and Pset_PV_ValuationUnit correspond to VM_CondominiumUnit, and VM_ValuationUnit, respectively. Considering the factors that affect the values of the property, the use of 3D models can augment the quality of the property valuation process in terms of automation and accuracy. This chapter accordingly shows the possible use of the IFC schema for obtaining the nominal values regarding different factors. It is important to highlight that effective transition to 3D LAS can be put into practice by operating a system that comprises constituent parts of land administration, for example, 3D registration of ownership and 3D property valuation. In this connection, the database management approaches that permit to storage, manipulation, and visualization of 3D models from BIM and GIS domains are of great significance. It is also significant to note that Information Delivery Specifications (IdSs) and MVDs should be considered as way of obtaining required semantic information for valuation since IFC data might have some inconsistencies in practice [54].

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Supplementary Material

Supplementary material for this chapter can be accessed at https://doi.org/10.6084/m9.figshare.14600268.v2

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