LADM Valuation Information Model Compliant Prototype for Visualisation and Dissemination of 3D Valuation Units and Groups

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LADM Valuation Information Model Compliant Prototype for Visualisation and Dissemination of 3D Valuation Units and Groups

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Key words: Property valuation, ISO 19152 Land Administration Domain Model (LADM), Valuation Information Model, 3D visualization, Dissemination.

SUMMARY

The interest in using 3D data in property valuation has been increasing during the last decade. The usage of 3D data models in valuation can be basically grouped in two main categories: (a) supporting mathematical models with variables produced through 3D analyses (e.g. view) in order to better estimate the values of properties and (b) consuming 3D data models to visualise valuation units in 3D and disseminate values of properties associated with the visualised units (legal or physical space). The current paper focuses on the latter category in particular.

The main purpose of this paper is to develop a prototype system utilising the proposed Valuation Information Model extension of ISO 19152 Land Administration Domain Model (LADM_VM) compliant dataset in order to create web-based, thematic valuation maps for 3D valuation units (e.g. condominium) and groups (e.g. multi-occupied building). In the first part of the paper, it is attempted to justify why an extension to the core LADM is required to represent valuation information. It is noted that LADM_VM enables to record 3D spaces of valuation units, and input and output data of 3D analyses. Therefore, LADM_VM can be used as basis for developing 3D visualisation and dissemination prototype. In the second part of the paper, special attention will be given to the 3D visualisation and dissemination of spatial, thematic and temporal characteristics of valuation information and a prototype is developed using the open datasets of the Netherlands.

It is expected that the outputs of this paper will contribute to the development of local or national prototype systems for sharing valuation information effectively and efficiently. Therefore, it may be considered that the outputs of the paper not supports in increasing the communication level with public, but also supports politicians and planners in decision-making processes and helping them to understand the property market better. With the proposed system (prototype) the trust in the valuation is expected to further increase due to the high level of transparency.

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1. INTRODUCTION

The usage of 3D data in property valuation processes is increasing in the recent years. It is observed that the studies in the literature mostly focus on supporting the valuation processes by deriving variables from 3D data models (e.g. 3D cadastre, BIM) in order to improve the valuation results (Tomić et al., 2012; Isikdag et al., 2014; Kara et al., 2020; El Yamani et al., 2021). These researches are important as the characteristics of apartments derived from 3D models can be used in the calibration of Artificial Intelligence (AI) valuation models and improve the performance of the models, because mass valuation practice is now on the edge of implementing AI models. Consuming 3D data models to disseminate property values is another topic in this research area. It can be observed in the literature that visualization prototypes developed for a different purpose (e.g. 3D cadastre) is generally utilised to disseminate property values. In such approach, property value is included as a simple attribute attached to the 3D visualised unit (e.g. basic cadastral unit). This approach works well when a visualised unit and a valuation unit represent the same object (and share the same conceptualisation). However, it is not case all time. For example, the basic registration unit in cadastral systems (e.g. a cadastral parcel) can be different from the basic valuation unit (e.g. building) in several countries.

The land registry and cadastre are the main data sources for property valuation processes as they record rights, restrictions, responsibilities (RRRs) and their associated basic administrative unit with associated spatial units; and the property rights to be valued is the fundamental and indispensable information for these processes. As indicated above, cadastral systems may not meet the needs of valuation processes in some cases. Considering this problem, Land Administration Domain Model (LADM) based valuation information extension was developed for the specification of valuation information maintained by public authorities. The proposed model was firstly introduced in Çağdaş et al. (2016) and it has been reviewed, revised and improved addressing the comments received from the several workshops, including 7th, 8th and 9th FIG LADM Workshops. The latest version of LADM_VM is designed to facilitate all stages of administrative property valuation, namely identification of valuation units, assessment of units through single or mass appraisal procedures, recording transaction prices, representing of sales statistics, and dealing with appeals (Çağdaş et al., 2016; Kara et al., 2018, 2020, 2021a). It is worth noting that the systematic review of ISO 19152 LADM has been started under ISO TC/211. One of the new parts, which is based on LADM_VM definitions, will be about property valuation (Part 4 – Valuation Information). A country profile developed using LADM_VM can be consumed as basis for a 3D visualisation and dissemination prototype for valuation information.

The purposes of this paper are to show why a new model (i.e. LADM Valuation Information Model – LADM_VM) other than the ISO 19152 Land Administration Domain Model (LADM) is required to represent valuation information, and to develop a prototype system utilising a LADM_VM compliant dataset to create web-based, thematic valuation maps for 3D valuation units (e.g. condominium) and groups (e.g. multi-occupied building).

The remainder of this paper is organised as follows: Section 2 presents UML instance level diagrams using the Netherlands country profile of LADM_VM (Kara et al., 2019) in order to show why an extension (i.e. LADM_VM) to the core LADM is required to represent valuation information. In Section 3, special attention will be given to the 3D visualisation and dissemination of spatial, thematic and temporal characteristics of valuation information. The requirements, opportunities and challenges for web-based, 3D visualization and dissemination of valuation information are investigated in Kara et al. (2021b), where a classification for the aggregation of valuation units into valuation unit groups is proposed. More specifically, the dissemination of statistics on sales prices / values requires aggregation of valuation units into valuation units group. In other words, the distinct levels for valuation unit groups are needed in order to share valuation related statistics effectively. In this paper, the proposed classification is further refined with new categories (i.e.. building floors), and individual characteristics (attributes) are specified for the each category (e.g. average values in different years, average building age in neighbourhood, and so on), considering the property function (use) types. Based on the proposed classification of valuation units group, a prototype is developed using the open datasets of the Netherlands. When developing the prototype, the answers of the following questions will be sought: (a) How can apartments (condominium units) in a multi-storey building be visualised in 3D without having any plans (e.g. architectural plan, survey plan, as-built plan)? (b) Is it possible and meaningful to visualise them with some assumptions (e.g. 3 m ceiling height) and inferences (e.g. number of apartments per floor, floor number and direction of an apartment)? (c) Which inferences can be made using the open dataset of the Netherlands? Section 4 presents the conclusions and further research topics.

2. LADM VALUATION INFORMATION – WHY SUCH A MODEL IS REQUIRED?

ISO 19152:2012 LADM has an external class, ExtValuation, for the specification of valuation information. However, it does not provide enough information to represent all cases related to valuation information systems as it only includes value, value type and value date attributes. The LADM_VM proposed for a complete representation of valuation information information, including valuation unit types (e.g. condominium, building and parcel), transaction prices, valuation unit groups, valuation procedures and statistics on sales and valuation data.

In this section, the Netherlands country profile of LADM_VM (Kara et al., 2019) is used to test LADM_VM in order to find out to what extend it enables representing the property valuation information. UML instance level diagrams are drawn to delineate the capabilities of LADM_VM and the country profile.

In the Netherlands, cadastral registration units can be different from valuation units in some cases. In fact, the relationship between valuation units (WOZ-objects) and cadastral units (parcels and cadastral apartment rights) is simple. There are several valuation units on one cadastral parcel for units that are rented out, for instance houses that are rented out by a social housing association or business units within a multi-company building. Figure 1 presents this relationship between a cadastral unit and (four) valuation units. It should be noted that if adjacent buildings or parcels of land are owned and used by the same person, then these parcels and buildings together form a single WOZ-object. On the other hand, multiple adjacent cadastral parcels that are owned by the same owner constitute one object that is one valuation unit. This results in a m:n relation between valuation units and cadastral units. The fact that there can be more than one valuation units within one cadastral units is typical for the property tax system in the Netherlands (where both the owner and the user are taxpayers). The case where more than one cadastral parcel is bought by the same owner and combined to one complex is more general.

It is worth noting here that a new registration named 'coherent registration of objects' (SOR) is under preparation. It is intended to make the registration as much as possible based on data in existing registrations, but also to extend the data with a 3D component. In this registration the complex relation between buildings, units within buildings, floors etc. will be made explicit. At Geonovum they have done a 'high-5 session' [1] to experiment with existing data to come to a 3D representation including 3D representation of units within a building.

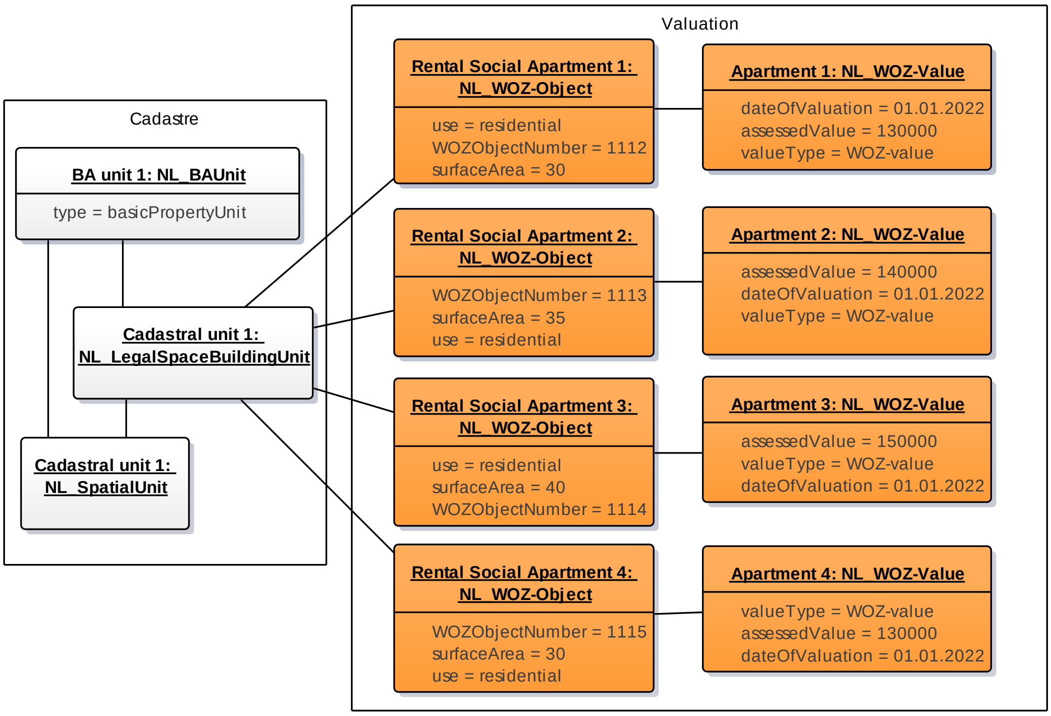

Figure 1. The relationship between cadastral unit and valuation units in the Netherlands

[1] https://docs.geostandaarden.nl/disgeo/dll3a/

LADM_VM can also be used to record sales/valuations statistics related to a valuation units group (e.g. neighbourhood, municipality, district and country). Figure 2 shows the diagram produced using the Netherlands profile of LADM_VM, representing the sales statistics retrieved from data that is available as open data provided by the private firm Calcasa Wox (https://www.calcasa.co.uk/wox-online). The diagram shows basePriceIndex and dateOfBasePriceIndex attributes to record the value and date for specification of the base index (e.g. Base Index Value = 100 at 1995 January), and priceIndex and dateOfPriceIndex attributes to record the calculated price index at a given date (e.g. Index Value = 426 at 2021 July)

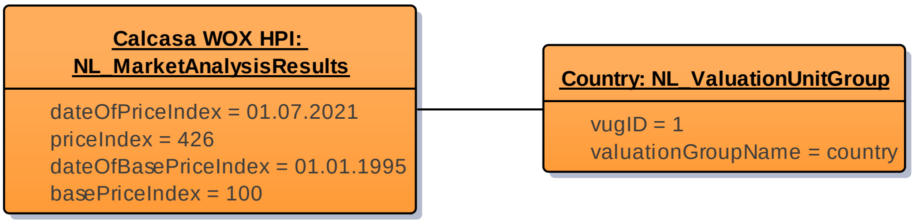

Figure 2. Sales statistics in the Netherlands

It is noted that LADM_VM is also required to record internal and external characteristics of valuation units (including 3D ones produced through spatial analyses, e.g. view), transaction prices, single and mass valuation procedures.

3. A PROTOTYPE FOR VISUALISATION AND DISSEMINATION OF 3D VALUATION UNITS AND GROUPS

This section firstly proposes an approach for a multi-level visualisation prototype in order to disseminate property valuation information effectively. An initial implementation of the proposed approach is provided using the open datasets of Netherlands in the Section 3.2.

3.1 A multi-level visualisation prototype proposal for property valuation information

In the Netherlands, the WOZ-values of residential properties are publicly available on the Web for all sorts of private use in the context of a fair and transparent government since 2016. The assessed values together with valuation dates and some characteristics (e.g. construction year, property function/type, floor size) of residential properties (single units) are publicly disseminated through footprints of apartment buildings (see WOZ-waardeloket[2]). However, visualization of 3D single (valuation) units may be required in order to disseminate valuation information more effectively and efficiently. Furthermore, it is important to share statistical analyses of sales prices / values with general public and professionals in order to support property market. The Central Agency for Statistics (CBS) regularly publishes statistical analyses on house price changes (e.g. Price index of existing own homes, Price index purchase prices). The shared statistical analyses is just textual information, not associated with spatial (legal) component(s) of valuation information. Publishing statistical analyses

[2] https://www.wozwaardeloket.nl/

associated with 3D visualised valuation units and groups may increase the transparency, reliability and communication level between users.

Kara et al. (2021) propose a classification for the aggregation of valuation units into valuation units groups in order to share valuation information effectively. The proposed classification is refined with the building floor level in this study, also because floor level will become part of the new registration SOR in the Netherlands, see Figure 3. This proposed classification may be considered in the provision of a solid framework for effective sharing of valuation/sales data.

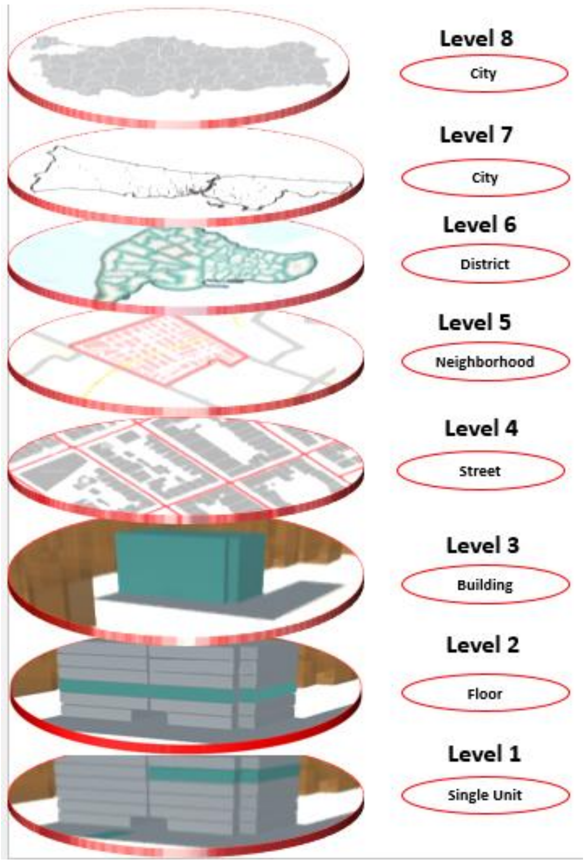

Figure 3. Aggregation of valuation units into valuation units groups

The identified levels in Figure 3 may vary in different countries because of administrative classifications. Therefore, each country may add new levels to the proposed structure. For example, two extra levels (i.e. province and region) are added to the proposed classification for the Netherlands.

Table 1 presents the identified levels and their certain attributes determined for value dissemination prototype in the Netherlands.

Table 1. Levels and their attributes determined for value dissemination prototype in the Netherlands

Levels	Attributes
Level 1 – Single unit (condominium, apartment, residence unit)	WOZ-value, date, floor area, use type, energy label, …
Level 2 – Building floor	Average WOZ-value, date, average WOZ-value per square meter, average floor area, …
Level 3 – Building (multi-occupied building)	Average WOZ-value, average WOZ-value per square meter, total unit number, average floor area, energy label, …
Level 4 – Street	Average WOZ-value, date, average building age, use types, …
Level 5 – Neighbourhood	Average WOZ-value, date, average building age, use types, index value, index date …
Level 6 – District	Average WOZ-value, date, average building age, use types, index value, index date …
Level 7 – Municipality	Average WOZ-value, date, average building age, use types, index value, index date, …
Level 8 – Province	Average WOZ-value, date, index value, index date, …
Level 9 – Region	Average WOZ-value, date, index value, index date, …
Level 10 – Country	Average WOZ-value, date, index value, index date, …

3.2 A prototype for visualization and dissemination of valuation information in the Netherlands

For the prototype developed in this study, 4 adjoined multi-occupied buildings were chosen (Figure 1), located in Papendrecht, which is a town in the province of South Holland. In the municipality of Papendrecht (15.000 valuation units) valuation is done by a shared service center, Drechtsteden.

Figure 4. The photo of the buildings chosen for the 3D visualization prototype (source: Google)

The Netherlands has a standardized and well-established addressing system that is kept and presented in a national data set called the addresses and Buildings key register (BAG). The information is collected by municipalities and integrated into a form of national base register by the Cadastre, Land Registry, and Mapping Agency (Kadaster). BAG provides 2D geometries and some basic attributes such as identification, year of construction, purpose of use, total number of building units and status of the buildings. However, the height, the number of floors, and number of condominium units per floor are not included in the register. BAG provides information on residence units as well, such as area, status, purpose of use, address information (house number, house letter, postal code, public space, residence area) and building information (construction year, building status, building ID). The units are geometrically represented as points (in 2D)

For 3D visualization of residence units (apartment/condominium) footprints of condominium units, total floor number and height of each floor in a building are required. The total number of floors have been determined by the photos of the building. Each building has 11 floors (including ground floor) as can be seen in Figure 4. The total residence unit number of each building is given in the total residence unit number attribute of BAG buildings as 20, and also can be seen in Figure 5. Therefore, it is interpreted as, the ground floor is allocated for common use and each of the 10 floor has 2 units. Also, the difference between total residence units on a floor and the footprint area of the building (which was measured using BAG data) is considered as the common place area on each floor above the ground floor. It is assumed that the locations of points that represent the residence units in BAG are consistent with the reality.

Figure 5. BAG data of the buildings and residence units

With these inferences and assumptions, the footprints of residence units and common places for one floor are estimated and drawn in 2D space (Figure 6) to be extruded for 3D visualization afterwards.

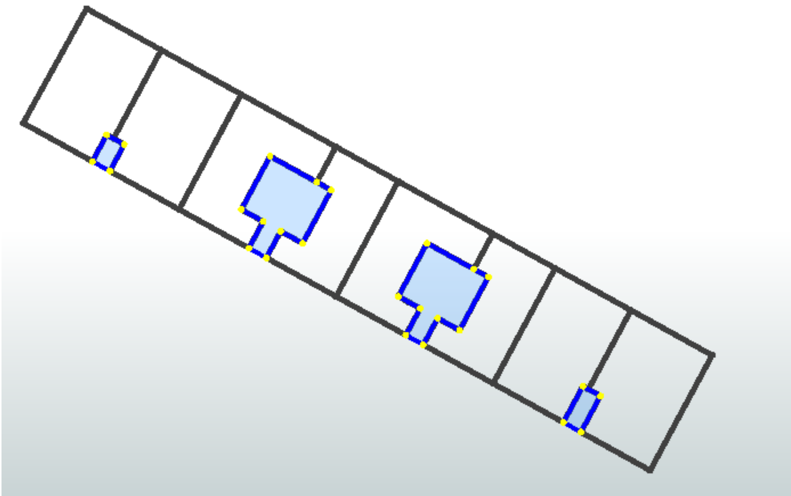

Figure 6. Estimated footprints of residence units and common places

The heights of the buildings have been obtained from 3D BAG [3]dataset, which is another open data platform aiming to present BAG buildings in 3D in different levels of detail (LoD), using the national height data AHN. In LoD 1.2, the heights of the buildings are 31 m. Therefore, it is assumed that each floor has 2.82 m of height and residence units are extruded with 2.82 m in each floor, accordingly.

Figure 7 shows the specified classification levels for the aggregation of valuation units into valuation units groups. It is noted that only two levels (i.e. condominium and building) are implemented in this study.

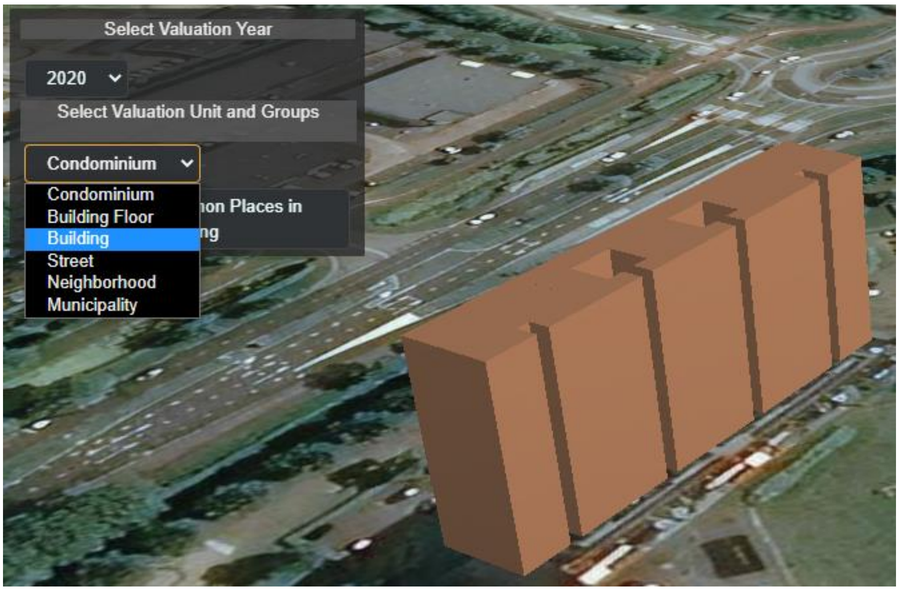

Figure 7. Specified classification for the visualization of valuation information

[3] https://3dbag.nl/

The values (WOZ-value) of each residence unit (WOZ-objects) between 2014 and 2020 have been obtained from the WOZ register. Figure 8 shows how the selected building looks like in the current WOZ register.

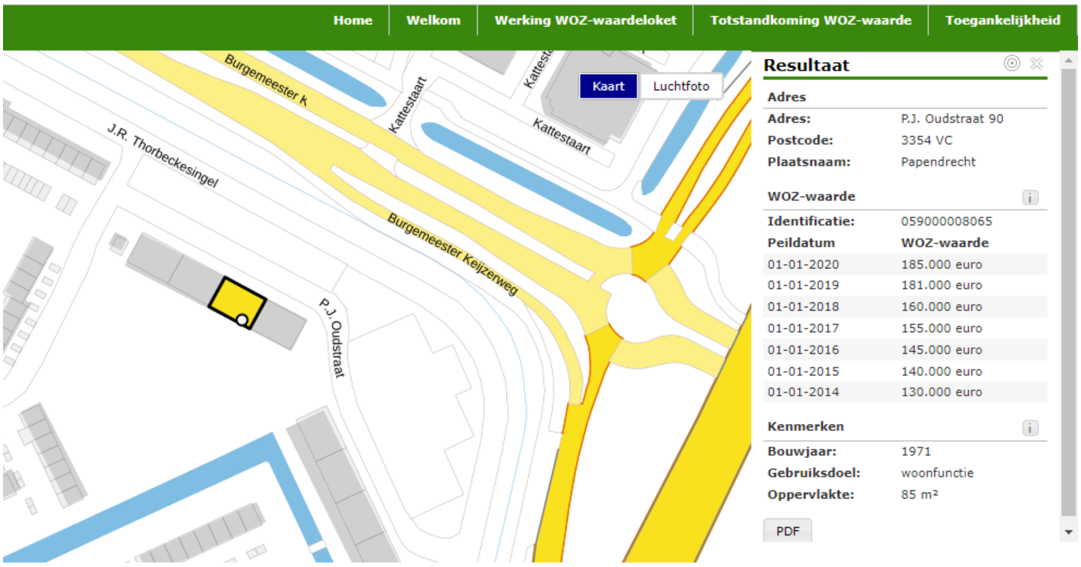

Figure 8. WOZ register view of the selected building

The WOZ-objects and residence units are associated with each other by the address attributes. The prototype presented in this study allows users to query the values for each condominium unit in a selected year (Figure 9).

Figure 9. Attributes of a residence unit and its value in 2017

Finally, the building footprint obtained from BAG is extruded by 31.1 m. The average residence unit values and values per square meter for each building in each year is calculated using the existing residence unit values (Figure 10).

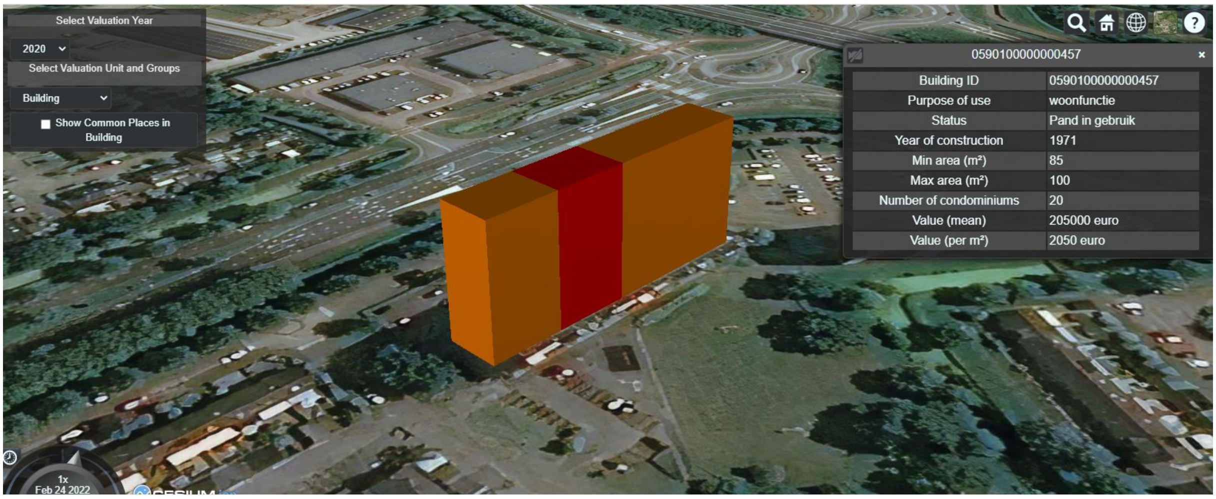

Figure 10. Attributes of building and its mean value in 2020

4. CONCLUSION

This paper presents an initial prototype system to disseminate valuation information through 3D single valuation units (e.g. condominium) and valuation unit groups (e.g. multi-family dwellings) for the Netherlands. The prototype is based on a proposed classification for the aggregation of valuation units into valuation units groups, and is developed using open datasets and some assumptions.

Creating 3D models for single-family dwellings is relatively easy compared to multi-family dwellings (multi-occupied building). However, it is important also to make these 3D models for multi-family dwellings because especially for these dwelling the 3D location gives extra information. A 3D model for multi- family dwellings requires dividing the space in separate dwellings and this is a very difficult task without floor plans or BIM models which may be used as basis to visualise 3D property units in the future. These BIM are not available for instance buildings built in the 1970's. Therefore, some assumptions are made to visualize multi-family dwellings in 3D, some of them sustainable some of them not.

It is noted that only two levels of the proposed multi-level visualisation approach are implemented (i.e. condominiums and multi-family dwellings) in this paper due to time limit. The developed prototype will be extended to the municipality level and will be supported with various thematic and temporal maps in the future. Moreover, developing a suitable tileset creation methodology to make this application available throughout the country is also planned as a future work activity also in the context of developing a new registration in the Netherlands (SOR).

The followings is determined as further research (a) is privacy an issue to disseminate valuation information associated with 3D visualised valuation units (e.g. apartment), more than visualizing the value on a 2D map? (b) how can the possible value of airspace or underground areas be included in such a prototype?

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BIOGRAPHICAL NOTES

Abdullah Kara holds BSc in Geomatics Engineering from Istanbul Technical University and MSc degree in Geomatics Programme of Yıldız Technical University (YTU). He worked as an engineer in the Development of Geographical Data Standards for Turkey National GIS Infrastructure. He received a PhD from YTU in 2021. During his PhD, he visited GIS Technology Section, Department OTB, Delft University of Technology as a guest researcher in 2018. Currently, he is a postdoctoral researcher at Delft University of Technology.

Peter van Oosterom obtained an MSc in Technical Computer Science in 1985 from Delft University of Technology, the Netherlands. In 1990 he received a PhD from Leiden University. He is professor at the Delft University of Technology, and head of the ‘GIS Technology’ Section, Department OTB, Faculty of Architecture and the Built Environment, Delft University of Technology, the Netherlands. He is the current chair of the FIG Working Group on ‘3D Cadastres’.

Ruud M. Kathmann has studied geodetic engineering at the Delft University of Technology and graduated in 1985. He is a member of the management team of the Dutch Council for Real Estate Assessment. From this position Ruud is closely involved to the development of the System of Base Registers. In The Netherlands Ruud is considered to be one of the leading specialists on the areas of geo-information, mass-appraisal and e-government. Ruud is also a observing member of The European Group of Valuers' Associations (TEGoVA).

Azer Ilgar had her Ph.D. in land information management from Yıldız Technical University in 2021. She has been working in Hacettepe University, Department of Geomatics Engineering in Ankara, Turkey. Her research interests include land administration, cadastre, and geographical information modeling.

Christiaan Lemmen is full Professor Land Information Modeling at the Faculty of GeoInformation Science and Earth Observation of the University of Twente in the Netherlands. His other main job is as Senior Geodetic Advisor at Kadaster International, the international branch of the Netherlands Cadastre, Land Registry and Mapping Agency. He is director of the OICRF, the International Office of Cadastre and Land Records, one of the permanent institutions of the International Federation of Surveyors (FIG).

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