A Database Implementation of LADM Valuation Information Model in Turkish Case Study

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Key words: LADM Valuation Information Model, ISO 19152:2012 Land Administration Domain Model (LADM), Immovable Property Valuation

SUMMARY

A recently started joint activity under International Federation of Surveyors (FIG) Commission 9 (Valuation and the Management of Real Estate) and FIG Commission 7 (Cadastre and Land Management) has started development of an information model for the specification of valuation information maintained by public authorities especially for property taxation. In this initiative, ISO 19152:2012 Land Administration Domain Model (LADM) has been taken as the basis for the development of a Valuation Information Model. A first version of the LADM Valuation Information Model was created based on standards, literature survey and data gained from questionnaires replied by the national delegates of FIG Commission 9 and FIG Commission 7. The conceptual model was represented through class diagrams of the Unified Modeling Language (UML).

This paper describes the development of a prototype for the implementation of the conceptual model in terms of a Turkish case study. The main aim of this paper is to assess and improve the proposed conceptual LADM Valuation Information Model. In the development part, the classes, attributes, constraints, cardinalities and relations between classes of the conceptual model were converted to technical (physical) model, namely the Oracle Spatial 11g database schema has been generated from the conceptual model definitions. The conceptual schema definitions were implemented into the database, which next was loaded with sample datasets related to property valuation and taxation in Turkey. The sample data includes valuation units that are the subjects of recurrently levied property taxes in Turkey, such as unimproved urban parcel and parcel and improvements together as condominium property, valuation and taxation information of the valuation units in different years, and as well as geometries of valuation units. The technical model of LADM Valuation Information Model Turkish Country Profile has been tested in evaluation phase through SQL queries and visualization tools, respectively. In this phase, it is investigated that whether the both conceptual and technical models fulfill the needs of information management aspects of valuation activities for property taxation.

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1. INTRODUCTION

According to FIG (1995), cadastre is a parcel based, and up-to-date land information system containing record of interests in land and it usually includes geometric description of land parcels linked to other records such as interest in land, ownership of this interest and often the value of the land. Traditional cadastre can provide geographical and legal datasets concerning the legal objects required for property valuation and taxation. However, cadastral datasets used for identification and registration of legal information in relation to immovable properties, may not be sufficient for today's complex taxation and valuation practices. More specifically, they only provide two-dimensional geometry and legal information about property units, whereas valuation practices also require detailed physical, geographic, economic, and environmental characteristics related to components of the property units. Moreover, information produced through valuation activities and market indicators should be recorded for further market analysis, dispute resolution and quality control processes. These requirements reveal the need of the development valuation registries or databases which record input and output data used and produced in single or mass appraisal processes.

A recently established joint working group under International Federation of Surveyors (FIG) Commission 9 (Valuation and the Management of Real Estate) and FIG Commission 7 (Cadastre and Land Management) has started development of an information model for the specification of valuation information maintained by public authorities especially for property taxation. In this initiative, ISO 19152:2012 Land Administration Domain Model (LADM) has been taken as the basis for the development of a Valuation Information Model. A first version of the LADM Valuation Information Model was created based on literature survey, data gained from questionnaires replied by the national delegates of FIG Commission 9 and FIG Commission 7 and corresponding standards. The conceptual model was represented through class diagrams of the Unified Modeling Language (UML).

The conceptual structure of the proposed LADM Valuation Information Model was presented in previous studies (Kara et al, 2017 and Kara et al, 2018a). Further working steps are determined by the FIG joint working group as (1) creating country profiles and (2) development of prototypes for the assessment of country profiles and conceptual model itself.

A number of LADM based country profile have been implemented for prototyping. Hespanha proposed an approach for PostgreSQL/PostGIS implementation of LADM based Portugal Country Profile. The model described in Enterprise Architect (EA), and then the exported model parsed into Eclipse UML 2 class models and diagrams (Hespanha, 2012). Van Bennekom-Minnema (2008) developed a tool named Computer-Aided Software Engineering

(CASE) which is used translation from XMI files into SQL file with a set of DDL (Data Definition Language) commands. Zulkifli et al (2014) converted the conceptual model Unified Modelling Language (UML) class diagram of LADM based Malaysian Country Profiles to the technical model with using Enterprise Architect. However, it was stated that some manual fine-tuning was needed. In recent years, LADM based country profiles of three countries, namely Switzerland (Germann et al, 2015), Greece (Kalogianni et al, 2017), and Colombia (Jenni et al, 2017), were developed with INTERLIS conceptual schema language and translated to the database via INTERLIS tools. Moreover, Kara et al (2018) investigates the use of INTERLIS tools for the technical implementation of the Valuation Information Model and Turkish Country Profile.

Turkish LADM Valuation Information Model Country Profile was presented in Kara et al (2018b). In this paper, a prototype is developed for the Country Profile. The main aim of this paper is to investigate whether the conceptual models fulfill the needs of information management aspects of valuation activities for property taxation. Figure 1 depicts the followed methodology for the prototype implementation for the Turkish Country Profile.

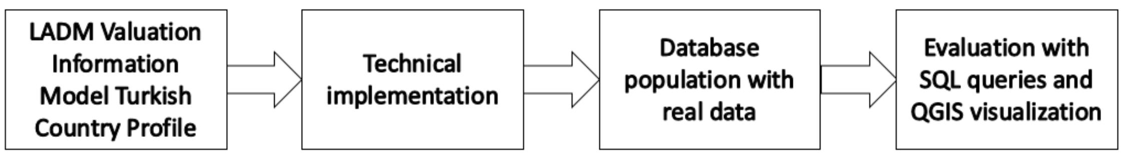

Figure 1. Methodology followed

The remaining part of the paper is organized as follows: Section 2 gives an overview of Turkey Country Profile for LADM Valuation Information Model. Section 3 describes the design decisions that have been taken during the conversion from conceptual model to technical model. This section also demonstrates the changes in the conceptual structure of LADM Valuation Information Model. Database population of the technical model with the some real valuation data is discussed in Section 4. Next section presents prototype development based on QGIS and evaluation of prototype with SQL queries. The last section suggests further research and concludes the present paper.

2. TURKISH LADM VALUATION INFORMATION MODEL COUNTRY PROFILE

Valuation activities conducted for recurrently levied immovable property taxes in Turkey are formed with the official statements issued by the Ministry of Finance. The official statements regarding Property Tax Law are published in every year and give information about how the tax values of properties are determined. The actual data used in valuation of improved and unimproved properties according to official statements regarding Property Tax Law. The tax values of improvements (buildings) determined by the cost of building per square meter, gross floor area, physical obsolescence, elevator and heating/air conditioning, while, tax values of parcels determined by parcel unit price per square meter and parcel area.

Some of this data has already been defined in the LADM Valuation Information Model. For example, building use type and gross floor area of building attributes were specified in the

VM_AbstractBuilding class and the parcel area attribute were specified in the LA_SpatialUnit class. Moreover, physical obsolescence and the cost of building per square meter attributes were specified in the VM_CostApproach class. But the model is still extended with new classes and attributes for fully representing country applications in Turkey. Therefore, the LADM Valuation Model is extended for the country profile with TR_Valuation, TR_ValuationUnitGroup, TR_Parcel, TR_AbstractBuilding, TR_CondominiumUnit and TR_ExtTaxation classes. The turquoise classes in Figure 2 presents the created classes in ORACLE 11g for the Turkish LADM Valuation Model Country Profile. It is noted that the yellow classes in the Figure 2 were not implemented in the database since (i) the data set used in this implementation have not provide such information (i.e. LA_Part, LA_BAUnit, and VM_SalesStatistics), (ii) abstract classes or (iii) parent classes (attributes are inherited to child classes).

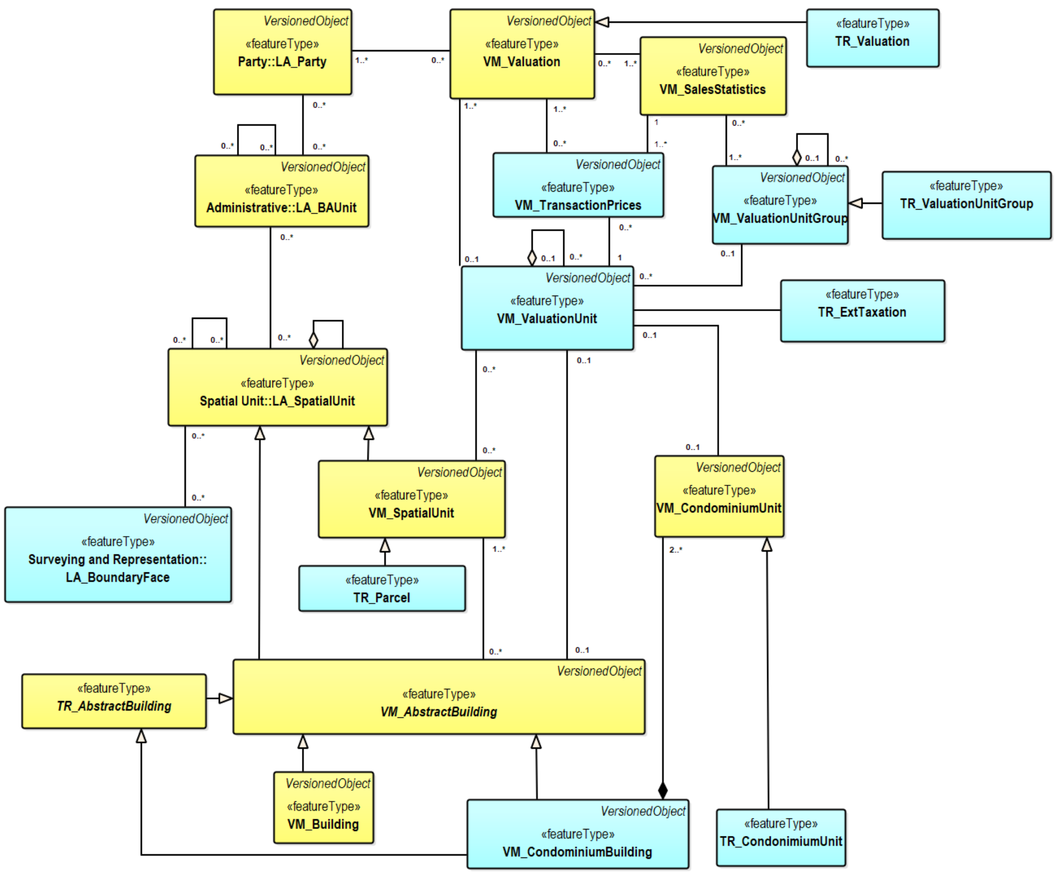

Figure 2. LADM Valuation Information Model and Turkish Country Profile

It is noted that Kara et al (2018b) provides more detailed information on valuation practices in Turkey. Next section gives detailed information about design decisions that design decisions that have been taken during the conversion from conceptual model to technical model.

3. FROM CONCEPTUAL TO TECHNICAL MODEL

There are various implementation strategy for the conversion of LADM based country profiles from conceptual model to database, as stated in the introduction section. The prominent tools for the automatic translation from conceptual model to technical are EA and INTERLIS. The both tool have superiority over each other. For example, while EA provides more user-friendly and more static environment, INTERLIS provides wide range of open source tools and more precise constraint conversion from conceptual to physical model. In this implementation, both of the tools were used for creating ORACLE SQL DLL, however, some manual improvements were needed for both of them. Therefore, both manual and automatic approaches were used when classes, code lists, attributes, relations, as well as, constraint of the Turkish LADM Valuation Information Model Country Profile were implemented in ORACLE 11g via SQL DLLs.

In the UML class diagrams, each class corresponds to a table in database. Moreover, code lists and many-to-many relation between classes are represented with a table in database. Each table should have an identifier (ID). According to LADM, identifiers consist of a namespace and a local ID. The IDs have to be unique for each object. Each table has a Primary Key (PK) that consist of one (e.g. ID) or more attributes (e.g. ID and beginLifeSpanVersion) (Oosterom, 1997). A Foreign Key (FK) is a key that used to link two tables together. It refers to PK attribute of another table. FK should not include beginLifeSpanVersion. One table can have more than one FK for referring more than one table.

In this implementation, each table has a unique ID and these IDs together with the beginLifeSpanVersion were specified as PK. Most of the tables. Each code list were implemented as separate tables. The code list tables has an ID (cID), name, description and code attributes. Moreover, they has beginLifeSpanVersion and endLifeSpanVersion for recording version history of code lists. Code list classes were linked to corresponding table with FKs. In LADM each table inherits VersionedObject class except for LA_Source, therefore, all the tables were directly implemented with the versioning support. This versioning support was provided by adding beginLifeSpanVersion and endLifeSpanVersion characteristics for each tables in the database. It is aimed that to create as few tables as possible in the database since the database performance purposes. Therefore, the yellow classes in the Figure 2 were not implemented in the database. Both spatial (R-tree index) and non-spatial (B-tree index) indexes were used for enabling efficient queries based on selected attributes. For example, TR_BoundaryFace class has both spatial and non-spatial index in this implementation. The B-tree index was mostly used for ID attributes of relevant database table. Figure 3 presents the core classes, attributes, PKs and FKs of Turkish LADM Valuation Information Model Country Profile. ORACLE Data Modeler tool was used for creating this figure. Since the limited space not all the classes, PKs, FKs, attributes and code list were displayed in the figure.

One of the main advantages of database implementation is to detect inconsistencies in conceptual model, duplicated data, and incorrectly defined relationships between classes.

Next subsection presents the changes of the LADM Valuation Information Model after the first database implementation.

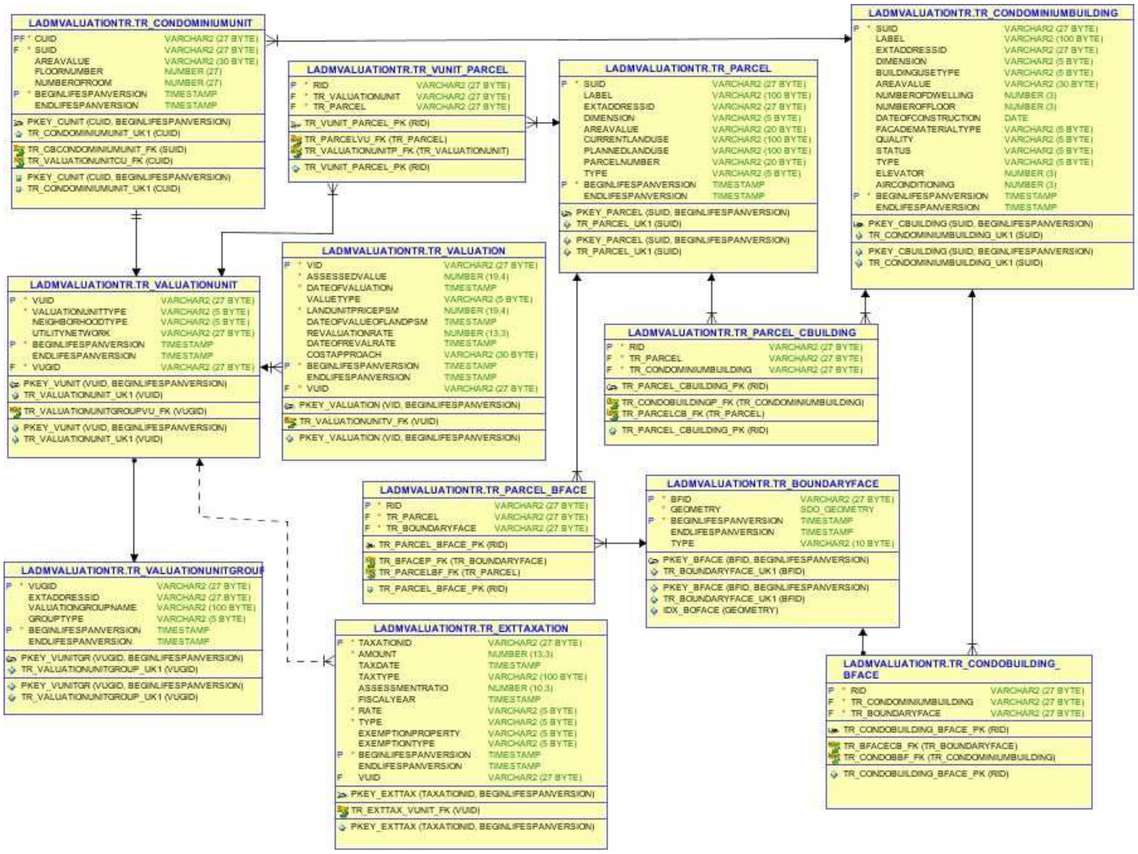

Figure 3. Core classes, attributes and relations of Turkish Country Profile in ORACLE 11g

3.1 Changes in the LADM Valuation Information Model

Some changes were made in LADM Valuation Information Model while and after the database implementation of Turkish LADM Valuation Model Country Profile. These changes can be grouped into three category, namely (i) changes in names of classes or attributes for the model simplification, correction purposes, (ii) changes in relations between classes for improving model structure, and (iii) duplicated attributes removed from the model. These changes can be listed as follow:

- VM_Parcel class was renamed as VM_SpatialUnit for the abstraction of the model.
- The name of ID attributes of each VM_ classes were abbreviated, for example, ValuationID was changed VID;
- Since it is a spatial unit, inheritance relation (parent-child) was specified between VM_SpatialUnit and LA_SpatialUnit;
- Inheritance relation was specified between VM_AbstractBuilding and LA_SpatialUnit;
- The inheritance relation between VM_SpatialUnit and VM_ValuationUnit classes was removed from the model since avoiding multiple inherence. These two classes were linked with association relation;

- Inheritance relation between the VM_AbstractBuilding and VM_ValuationUnit classes was removed from the model since avoiding multiple inherence. These two classes were linked with association relation;
- Inheritance relation between the VM_CondominiumUnit and VM_ValuationUnit classes was removed from the model. These two classes were linked with association relation;
- The address attribute in VM_ValuationUnit is removed from the model, since it has a relation with LA_SpatialUnit class that has an attribute named extAddressID;
- Area and volume attributes were removed from VM_AbstractBuilding class, since it now has generalization relation with LA_SpatialUnit;
- The association relation between LA_BAUnit and VM_ValuationUnit was removed from the conceptual model.

4. DATABASE POPULATION WITH REAL DATA

The created ORACLE 11g database schema was populated with data obtained from the General Directorate of Land Registry and Cadastre. This data sets were collected in the context of the modernization project supported by World Bank for performing the mass appraisal pilot applications and preparing guidelines for the local property tax system in selected municipalities. In this modernization project, Fatih District, İstanbul Province and Mamak District, Ankara Province were chosen as pilot application areas for mass valuation (Yildiz et al, 2015). Since there is not enough data to perform mass valuation, data about randomly selected valuation units, namely condominium units in Fatih, parcels in Mamak were collected. Figure 4 presents the selected study areas for the implementation of Turkish LADM Valuation Information Model Country Profile. All the selected valuation units in Fatih consists of improved properties, on the other hand, all the properties in Mamak are unimproved urban parcels in the selected study area. Table 1 presents the number of entries that has been loaded into the developed ORACLE database schema both in Fatih and Mamak.

Table 1. Number of entries in the Oracle database for these classes

	Fatih	Mamak	Total
TR_ValuationUnit	1351	49	1400
TR_Parcel	124	49	173
TR_CondominiumBuilding	125	0	125
TR_CondominiumUnit	1351	0	1351
TR_ValuationUnitGroup	43	1	44
TR_BoundaryFace	4122	49	4171

The geometries of valuation units were recorded at TR_BoundaryFace (i.e. polygon). While some of the geometries have attributes, some of them have not. For example, there are randomly selected 1351 condominium units in 125 different condominium buildings that consist of more than two condominium units in the Fatih study area. The green color in the left side of Figure 4 refers the geometries of condominium buildings with no attribute in Fatih, red color refers 125 condominium building. Similarly, green color in the right side of Figure 4 refers geometries of parcels with no attributes in the Mamak study area.

The tax values and tax amounts of the valuation units in the selected study areas were calculated from 2014 to 2018 and loaded to TR_Valuation and TR_ExtTaxation classes.

Table 2 and Table 3 show how to create the tables in ORACLE database and subsequently insert data in TR_Valuation and TR_BoundaryFace, respectively.

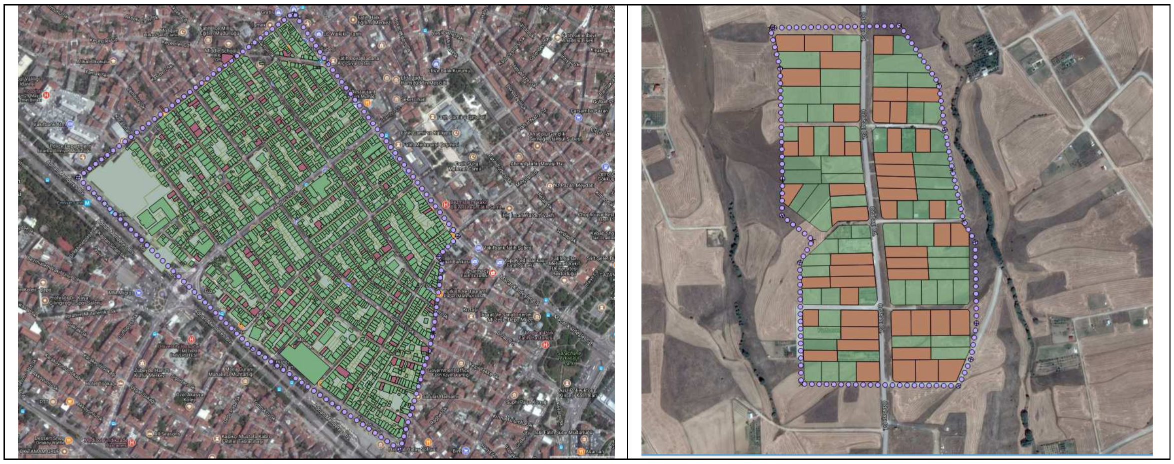

Figure 4 Study area (left: Fatih, İstanbul; right: Mamak, Ankara)

Table 2. Create table and insert data in TR_Valuation table using ORACLE

```
CREATE TABLE "LADMVALUATIONTR"."TR_VALUATION" (
"VID" VARCHAR2(27) PRIMARY KEY NOT NULL ,
"ASSESSEDVALUE" NUMBER(19,4) NOT NULL ,
"DATEOFVALUATION" TIMESTAMP NOT NULL,
"VALUETYPE" VARCHAR2(5) ,
"VUNITVALUEOFLANDPSM" NUMBER(19,4) ,
"DATEOFVALUEOFLANDPSM" TIMESTAMP ,
"REVALUATIONRATE" NUMBER(13,3) ,
"DATEOFREVALRATE" TIMESTAMP ,
"COSTAPPROACH" VARCHAR2(5) ,
"BEGINLIFESPANVERSION" TIMESTAMP NOT NULL ,
"ENDLIFESPANVERSION" TIMESTAMP
);
```

```
Insert into LADMVALUATIONTR."TR_VALUATION" (VID,VUID,ASSESSEDVALUE,
DATEOFVALUATION,VALUETYPE,LANDUNITPRICEPSM,DATEOFVALUEOFLANDPSM,
REVALUATIONRATE,DATEOFREVALRATE,COSTAPPROACH,BEGINLIFESPANVERSION)
values
('val5299','22603618',32815.5969942678,'01-JAN-2017','1',2354.55989204835,
'01-JAN-2014','0.0383','01-JAN-2017','cp_2017_903',CURRENT_TIMESTAMP);
```

Table 3. Create table and insert data in TR_BoundaryFace table using ORACLE

```
CREATE TABLE "LADMVALUATIONTR"."TR_BOUNDARYFACE" (
"BFID" VARCHAR2(27) PRIMARY KEY NOT NULL ,
"GEOMETRY" MDSYS.SDO_GEOMETRY ,
"BEGINLIFESPANVERSION" TIMESTAMP NOT NULL ,
"ENDLIFESPANVERSION" TIMESTAMP
);
```

```
Insert into LADMVALUATIONTR.TR_BOUNDARYFACE
(BFID,GEOMETRY,BEGINLIFESPANVERSION)
values
('24479176',
MDSYS.SDO_GEOMETRY
(
2003, 5254, NULL, MDSYS.SDO_ELEM_INFO_ARRAY(1, 1003, 1),
MDSYS.SDO_ORDINATE_ARRAY
(
413407.90756448416505009, 4542451.57615116517990828,
413413.47755162254907191, 4542451.73611651640385389,
413413.54753908480051905, 4542449.7261210847645998,
413407.95755187491886318, 4542449.5461559109389782,
413407.90756448416505009, 4542451.57615116517990828
)
),
CURRENT_TIMESTAMP);
```

5. PROTOTYPE DEVELOPMENT AND EVALUATION

After creating the database schema and populated it with sample data, the prototype was developed in QGIS 2.18. Using this prototype, queries were conducted via ORACLE SQL Developer Query Builder tool. The results of the queries were visualized using CREATE ORACLE SQL Developer and QGIS. It is noted that all the SQL query statements can be found in APPENDIX 1.

In the first query, tax values of condominium units in Akdeniz Street, Fatih, İstanbul were queried for last five years. Figure 5 visualizes the time series of tax values of 11 condominium units from 2014 to 2018 with the ORACLE SQL Developer. These condominium units may or may not in the same condominium buildings. According to this query, the condominium unit with the highest tax value on this street is 300.000 Turkish Liras.

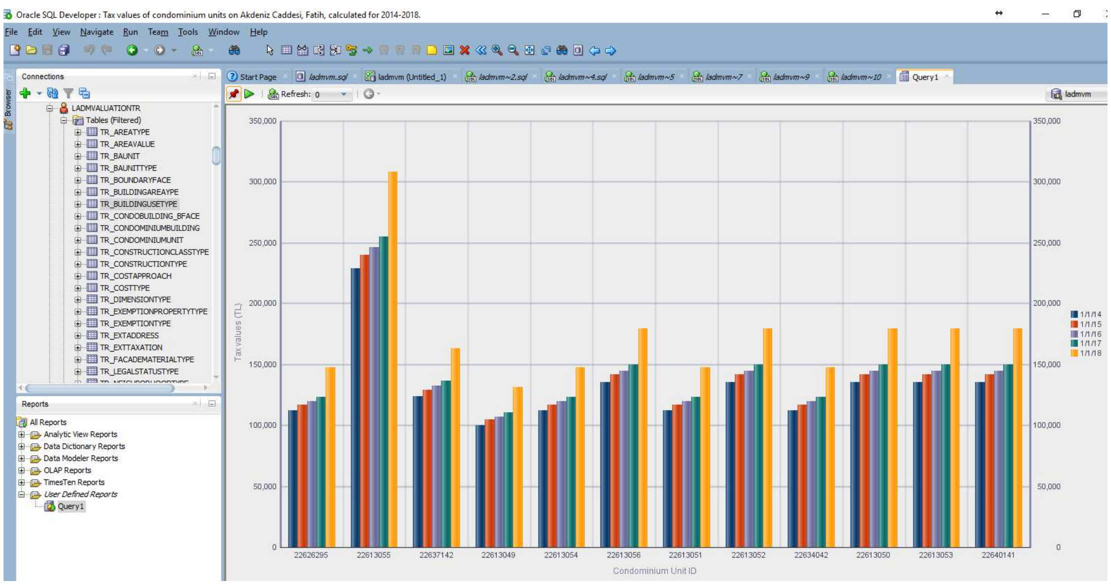

Figure 5.The time series of tax values of condominium units from 2014 to 2018 in Akdeniz Street

The condominium building which contains the condominium unit with the highest tax amount in the Fatih study area were queried in the second query. A view of the ORACLE database was created using CREATE VIEW statement of ORACLE and this view was used in the QGIS for visualization the condominium building.

Figure 6 below presents result of the second query. It is noted that the selected condominium building may have more than one condominium unit.

Figure 6. The condominium building which contains condominium units with the highest tax amount

The last query were made in Mamak study area. The main aim of the query is to specify the unimproved parcels with annual tax amount for 2017 is higher than 400 Turkish Liras. Figure 7 shows those parcels with their parcel numbers in QGIS. Similar to second query, a view of the ORACLE database was created and it was visualized in QGIS.

Figure 7. Unimproved parcels with annual tax amount for 2017 is higher than 400 Turkish Liras in Mamak Study Area

6. CONCLUSION

This paper describes the prototype development based on Turkish LADM Valuation Information Model Country Profile. The main aim of this paper is to investigate whether the conceptual valuation models fulfill the needs of information management aspects of valuation activities for property taxation. A prototype was developed for assessing the models. During the development of the technical model, some problems were specified and corrected. Some technical design and implementation decisions have been made during the conversion of the conceptual model to the database schema, for example, PK and FK management, versioning support, realization of generalization relation, and spatial and non-spatial indexes. The technical model evaluated with SQL queries and data visualization with geographical information system.

The overall assessment of the conceptual model based on the developed prototype is promising. Both the LADM Valuation Information Model and its Turkish Country Profile is feasible in terms of information management aspects of valuation activities especially for recurrently levied immovable property taxation. On the other hand, model should be tested with further valuation activities, for example, mass valuation conducted for property taxation purposes. 3D aspects of valuation activities can be investigated in the context of LADM Valuation Information Model. Moreover, some technical implementation issues will be searched, such as, modeling time in attribute level with ORACLE VARRAYS, NESTED tables for implementing composition and generalization (parent-child) relation in UML, defining more constraint both spatial and non-spatial, and implementation of multiple hierarchical code lists.

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APPENDIX 1

Query 1
```
SELECT
    ladmvaluationtr.tr_condominiumunit.cuid,
    ladmvaluationtr.tr_valuation.dateofvaluation,
    ladmvaluationtr.tr_valuation.assessedvalue
FROM
    ladmvaluationtr.tr_valuation,
    ladmvaluationtr.tr_valuationunit,
    ladmvaluationtr.tr_valuationunitgroup,
    ladmvaluationtr.tr_extaddress,
    ladmvaluationtr.tr_condominiumunit
WHERE
    ladmvaluationtr.tr_valuationunit.vuid = ladmvaluationtr.tr_valuation.vuid
    AND   ladmvaluationtr.tr_valuationunitgroup.vugid = ladmvaluationtr.tr_valuationunit.vugid
    AND   ladmvaluationtr.tr_extaddress.extaddressid = ladmvaluationtr.tr_valuationunitgroup.vugid
    AND   ladmvaluationtr.tr_valuationunit.vuid = ladmvaluationtr.tr_condominiumunit.cuid
    AND   ladmvaluationtr.tr_extaddress.streetname = 'Akdeniz Caddesi'
    AND   ladmvaluationtr.tr_valuation.dateofvaluation >= '01-JAN_2014'
GROUP BY
    ladmvaluationtr.tr_valuation.dateofvaluation,
    ladmvaluationtr.tr_condominiumunit.cuid,
        ladmvaluationtr.tr_valuation.assessedvalue
```

Query2
```
CREATE VIEW ladmvaluationtr.query2
 AS SELECT
 ladmvaluationtr.tr_boundaryface.bfid,
 ladmvaluationtr.tr_exttaxation.amount,
 ladmvaluationtr.tr_boundaryface.geometry
FROM
    ladmvaluationtr.tr_valuationunit,
    ladmvaluationtr.tr_condominiumunit,
    ladmvaluationtr.tr_exttaxation,
    ladmvaluationtr.tr_condominiumbuilding,
    ladmvaluationtr.tr_condobuilding_bface,
    ladmvaluationtr.tr_boundaryface
WHERE
    ladmvaluationtr.tr_valuationunit.vuid = ladmvaluationtr.tr_condominiumunit.cuid
    AND   ladmvaluationtr.tr_valuationunit.vuid = ladmvaluationtr.tr_exttaxation.vuid
    AND   ladmvaluationtr.tr_condominiumbuilding.suid = ladmvaluationtr.tr_condominiumunit.suid
    AND   ladmvaluationtr.tr_condominiumbuilding.suid =
ladmvaluationtr.tr_condobuilding_bface.tr_condominiumbuilding
    AND   ladmvaluationtr.tr_boundaryface.bfid = ladmvaluationtr.tr_condobuilding_bface.tr_boundaryface
AND   ladmvaluationtr.tr_exttaxation.amount = (
  SELECT
     MAX(ladmvaluationtr.tr_exttaxation.amount)
   FROM
     ladmvaluationtr.tr_exttaxation
  );
```

Query3
```
CREATE VIEW ladmvaluationtr.query3 AS SELECT
    ladmvaluationtr.tr_boundaryface.bfid,
    ladmvaluationtr.tr_taxtype.name,
    ladmvaluationtr.tr_parcel.parcelnumber,
    ladmvaluationtr.tr_exttaxation.amount,
    ladmvaluationtr.tr_boundaryface.geometry
FROM
    ladmvaluationtr.tr_exttaxation,
    ladmvaluationtr.tr_taxtype,
    ladmvaluationtr.tr_valuationunit,
    ladmvaluationtr.tr_parcel,
    ladmvaluationtr.tr_vunit_parcel,
    ladmvaluationtr.tr_boundaryface,
    ladmvaluationtr.tr_parcel_bface
WHERE
    ladmvaluationtr.tr_taxtype.cid = ladmvaluationtr.tr_exttaxation.type
    AND   ladmvaluationtr.tr_valuationunit.vuid = ladmvaluationtr.tr_exttaxation.vuid
    AND   ladmvaluationtr.tr_valuationunit.vuid = ladmvaluationtr.tr_vunit_parcel.tr_valuationunit
    AND   ladmvaluationtr.tr_parcel.suid = ladmvaluationtr.tr_vunit_parcel.tr_parcel
    AND   ladmvaluationtr.tr_parcel.suid = ladmvaluationtr.tr_parcel_bface.tr_parcel
    AND   ladmvaluationtr.tr_boundaryface.bfid = ladmvaluationtr.tr_parcel_bface.tr_boundaryface
    AND   ladmvaluationtr.tr_taxtype.name = 'landTax'
    AND   ladmvaluationtr.tr_exttaxation.taxdate = '01-JAN-2017'
    AND   ladmvaluationtr.tr_exttaxation.amount > 400
```

BIOGRAPHICAL NOTES

Abdullah Kara has his BSc in Geomatics Engineering from İstanbul Technical University and his 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 (TUCBS), supported by the Ministry of Environment and Urbanization. He has been working as a research assistant at YTU since 2013. Currently, he is visiting researcher at Delft University of Technology. His research field includes land administration, property valuation and geo-spatial data modelling.

Volkan Çağdaş has been working in Yildiz Technical University (YTU), Department of Geomatic Engineering, Istanbul / Turkey. He obtained his Ph.D. degree in 2007, and then studied as a post-doc researcher at Aalborg University for a year. In 2010, he became an assistant professor in YTU, and in 2014 he was awarded an associate professorship in cadastre and land administration. He has been teaching cadastre, immovable property law, land re-adjustment, immovable property valuation, and land information management systems at undergraduate and graduate levels. His research interest covers both the technical and the institutional aspects of cadastre and land administration.

Ümit Işıkdağ has his MSc in Civil Engineering and PhD (from the University of Salford) in Construction Information Technology with his work on integration of BIM with 3D GIS. His research interests include BIM / IFC, 3D GIS, Internet of Things, RESTful Architectures, BIM 2.0, and Spatial Web Services. He is lecturing in Mimar Sinan Fine Arts University Department of Informatics and actively involved in the organization of 3D GeoInfo and GeoAdvances Conferences, editorship of International Journal of 3D Information Modeling, and also serving as the Secretary of ISPRS WG II/2.

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. From 1985 until 1995 he worked at the TNO-FEL laboratory in The Hague. From 1995 until 2000 he was senior information manager at the Dutch Cadastre, where he was involved in the renewal of the Cadastral (Geographic) database. Since 2000, 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'.

Christiaan Lemmen is full Professor Land Information Modeling at the Faculty of Geo-Information 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). He is chairing the Working Group Fit-For-Purpose Land Administration of the Commission 7, Cadastre and Land Management of the International Federation of Surveyors (FIG). He is contributing editor of GIM International, the worldwide magazine on Geomatics. He is co-editor of the International Standard for the Land Administration Domain, ISO 19152 and the designer of the Social

Tenure Domain Model (in co-operation with UN HABITAT and FIG). He holds a PhD from Delft University of Technology, The Netherlands. Title of his thesis is 'A Domain Model for Land Administration'.

Erik Stubkjær is an emeritus professor for Cadastre and Land Lawat Aalborg University, Denmark. He originated the idea and performed the preparation of the ESF/COST-action G9 and served as its chairman. He is member of the Danish Association of Chartered Surveyors.

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