3D City Models as a 3D Cadastral Layer: The Case of the TKGM Model

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SUMMARY

Optimal land administration systems; It aims to record data in a comprehensive, sustainable and accessible way, although it includes individual/public rights and restrictions in 3 dimensions (3D) as well as in 2 dimensions (2D) of the land. The systems developed within the scope of the objectives will provide a basis for planning activities in a broad sense and will enable public institutions and organizations to use the land effectively and to provide services. Modern land administration systems; In addition to the 2nd Dimension of the land, it is expected to record and secure the individual/public rights and restrictions in the 3rd Dimension in a continuous, accessible, and comprehensive manner to provide a basis for planning activities in a broad sense and to support the taxation activities of the public.

On the other hand, with the new system designed, in addition to the own data of the institutions, interoperability will be ensured with the data produced or recorded by other institutions. This situation enables the creation of a Model that includes 3D data and geospatial data from different sources created by institutions, with the effect of developing technology.

In this study; The General Directorate of Land Registry and Cadastre (TKGM) carried out the interoperability of the data in the Amasya district combining them under a single roof and creating a model, together with all the above-mentioned data sets, depending on the new requirements based on developing technologies. Within the scope of the TKGM Model, 3D photogrammetric models, 3D modelled indoor data from physical architectural projects and other attributes of land administration were used.

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1. INTRODUCTION

This century is the age of technology in which the economic and social potential of data is tried to be revealed. The fact that land registry and cadastre transactions can be carried out completely electronically, independently of the physical archive, will increase the accuracy and speed of the transactions and will lead to great progress in the implementation of real estate policies and increase the efficiency of the real estate market. However, keeping up with the developments made possible by the developing and developing technology will be possible by keeping an accurate and integrated data structure in a consistent data model.

The expansion in the content and scope of the cadastre has resulted in the traditional 2D cadastre falling short of registering, representing, and managing large datasets of land ownership, use, and value (UN and FIG, 1996; UN and FIG, 1999). This situation has brought a new terminology such as 3D cadastre, which includes intensive technology, to the agenda (Döner et al., 2009).

However, it is known that many studies have been carried out in the international arena to reveal the basic principles of the modern cadastre understanding of the future. The most striking of these studies is the "Cadastre 2014 Vision" report published by FIG in 1998 (Kaufmann et al., 1998). Report; It has become a phenomenon in its field with its vision of where the cadastre should be in the next 20 years. In the report, the cadastral vision of the future is summarized under six main headings as follows:

- All legal status of the land will be shown, including public rights and restrictions.
- The distinction between maps and records will disappear.
- Cadastral mapping will be replaced by cadastral modelling.
- Traditional cadastre will be replaced by the basic data model.
- Cadastre will be privatized to a great extent, and the public and private sectors will work in close cooperation.
- Cadastre will have cost recovery (Yomralıoğlu, 2011).

From these expressions, the modern cadastre of the future; Enables the effective registration of the rights, restrictions, and responsibilities in the vertical, as well as the horizontal dimension of the land, providing more effective property rights assurance, involving intensive technology in the collection, processing, storage and presentation of cadastral data to users, using private sector opportunities more effectively, and It, is understood that it is envisaged to evolve into a self-financing structure. Of course, the implementation of these principles on a global scale is very difficult due to the different cultures, ownership understandings, and technical, legal, institutional, and technological infrastructures of the countries. However, the vision put forward for the modern cadastre of the future makes these six basic principles extremely valuable for countries.

For attribute data of 3D building models produced from photogrammetric data; World coordinate values of the reference point that will enable it to be moved to 3D real-world coordinates, city, district, neighborhood, and building roof area information, and the total number of independent sections, architectural project approval date and several elevators, independent section floor information, independent section number, and independent section facade information Studies have been carried out to create a unique format for the institution in the CityGML structure, which has specific issues.

Based on all these developments, the "3D City Models and the Integration of Cadastre Bases Pilot Project" in Amasya to improve and update the cadastral data of our country and strengthen its technological infrastructure, by the General Directorate of Land Registry and Cadastre (TKGM) recently. has been implemented.

2. METHODOLOGY

Scope of work; In the project, which was carried out in Amasya to support the implementation of an effective land management approach, the production of the 3D cadastral data set and the design of the working model were focused on, and it was aimed to achieve the following objectives.

- Determination of all the building stock on the land,
- Production of 3D building models and independent section models,
- 3D Plot-Structure-Independent Section-Spatial Address Registration System (MAKS) integration,
- Identification of all public restrictions on the land,
- 3D Parcel - Public Rights, Restrictions and Responsibilities (RRR) integration,
- Determination of real estate values by collective valuation method,
- Designing a database for the joint management of all integrated data,

- Determining the principles for the presentation of data and keeping the system alive.

2.1. Creation of 3D City Models and Sustainability of The Project

The expectations of human beings from the places they live in are changing day by day. Today, it is accepted as one of the most important duties of the state to provide a livable environment, brand cities vision, cities with high quality of life and sustainable environment and transfer them to future generations in the best way. To fulfill these duties, the administrations are obliged to monitor, record, interpret and make new plans for all kinds of data and developments with information system applications in the complex city life (Figure 1).

Figure 1. Sample 3D City Model.

Almost all information systems applications will need precise location information and a highly accurate map base. Because it is of great benefit to interpret the data by associating it with the location after the analysis. In the past, our records, which were kept only in the horizontal dimension, have started to be recorded in 3D, which is the ideal of the 3D earth, and the studies that will enable these data to be displayed in 3D have been focused on (Figure 2).

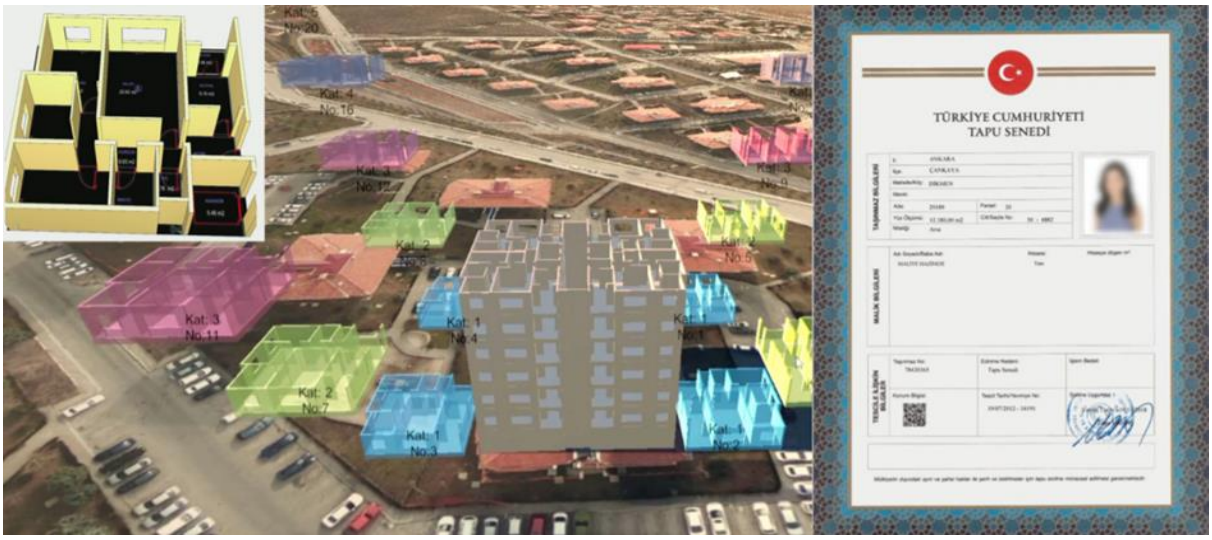

Figure 2. Sample 3D Building.

Firstly, it started three-dimensional property studies, which are also the basic needs of smart cities. In this context, work started in 2019 to produce three-dimensional city models and create a three-dimensional cadastral base. Within the scope of the studies, after the architectural projects are scanned, they are vectorized and turned into a three-dimensional model that includes room and area information.

At the same time, by comparing the architectural models with the actual building models obtained using oblique aerial images, those that meet the accuracy criteria are coordinated in the ITRF Datum. However, it is of great importance that the project is updated within the normal cadastre and registration works without bringing additional burden (Figure 3).

Figure 3. 3D Photogrammetric Buildings.

The photogrammetric building dataset includes data obtained from image acquisitions performed by TKGM. In the production of building models, roof drawings made in stereo and digital terrain models belonging to the same region were used. (Figure 3).

Architectural building datasets; architectural projects produced as CAD consist of projects that are kept in paper form after obtaining the necessary approvals. Projects kept in this paper environment are first scanned and digitized and brought back to the 2D CAD environment, then 3D models are produced by 3D modelling.

The models produced in the real coordinates of the world are saved in GML format and included in the architectural project for the interior models of the building; The entire building, the information about the floor and all the information about the independent section contain as attributes (Figure 4.)

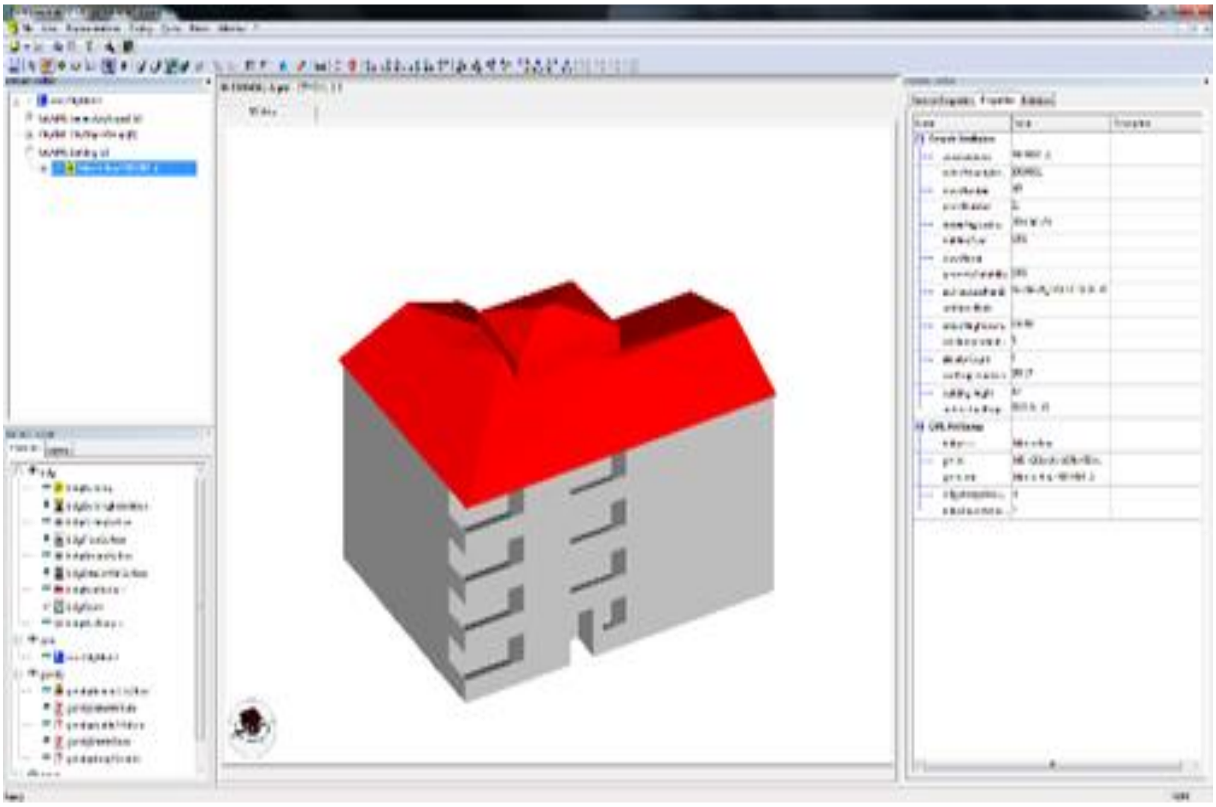

Figure 4. 3D Architectural Building.

2.2. Use of 3D City Models for Real Estate Valuation Studies

In project scope; will cover the determination of the values of the independent sections by the collective valuation method. As a result of the gains to be obtained from the Amasya Project, it is aimed to determine the values of the immovables with the collective valuation method, manage them, work on the collective valuation standards, to follow the international developments and good practices.

In this context, the following tasks were fulfilled in the Amasya Project to establish standards regarding the variables to be used for the independent sections in the collective valuation studies and to determine the methods for the integration of the data.

2.2.1. Data in TKGM Records

To ensure that data definitions and types are made by the relevant legislation for the determination of the data to be used as a variable in the valuation studies from the data included in the Architectural projects with the Land Registry and Cadastre Information System (TAKBİS) and the CityGML created within the 3D City Models and Cadastre Project.

2.2.2. Non-Location Data that is not in TKGM archives

These are data that are not found in TKGM archives. Identifying dependent (value/price) and independent (attribute information and other factors affecting value) data, obtaining data from relevant institutions/organizations and the field, providing a structure to be used in valuation studies, collecting data for use in collective valuation studies and entering them into the system and following up.

2.2.3. Location Data

To provide and follow up on the data that should be used in collective valuation studies, from the POI (point of interest) list, which will enable spatial analyzes such as proximity/distance in collective valuation studies.

2.2.4. Valuation

To make the necessary preparations for the determination of the methods and requirements for the standardization of all variables in a way that will allow them to be used in statistical analysis and modelling studies, to manage and follow up.

2.3. Case Study of Amasya District

To determine the common hysteria of the cadastral update, real estate valuation, and 3D City models production projects carried out by TKGM, a pilot application was carried out in 26 neighborhoods located in the Merkez district of Amasya Province (Figure 5).

A work plan has been prepared for the implementation of the project in the aforementioned area. In this direction, an application has been initiated to reveal the parcel, structure, independent section, address, public restrictions, and value relationship in the immovables within the project area.

Within the scope of the application, for the integration of land registry and cadastral data; Data entry and verification processes of 12,552 parcels in 26 neighborhoods in the project area were carried out. In this context, data entry and approval processes of 12,552 parcels have been completed. All public restrictions based on spatial representation in the central district of Amasya have been collected and for the public restrictions on the right to property by public institutions and organizations; Integration of the data obtained from public institutions at the parcel-structure and independent section level has been completed. Likewise, zoning amnesty data and Spatial Address Registration System (MAKS) data were obtained and the integration was completed. Likewise, building registration information in the land registry and zoning plans were obtained from Amasya Municipality, and data integration was completed.

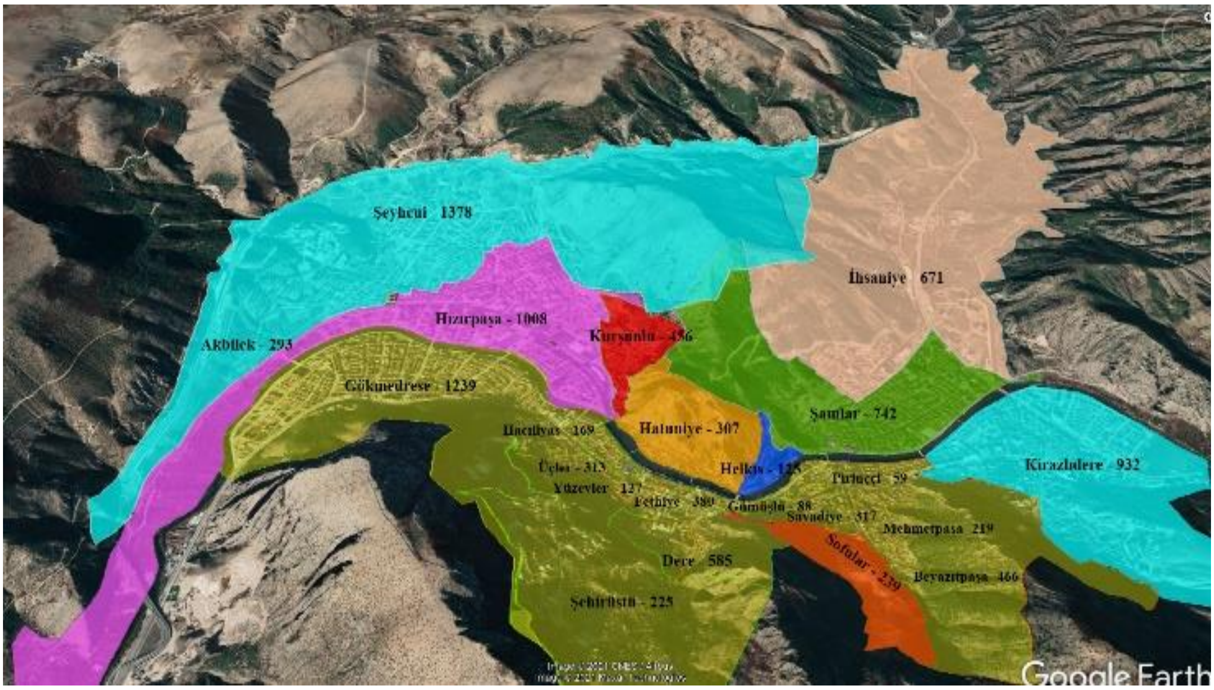

Figure 5. Working Area.

In the first stage, 3D photogrammetric data production processes were carried out regarding the structures on the parcels. An orthophoto and elevation model of the city center of Amasya has been created, and its integration with the neighborhood-based Amasya cadastral data, orthophoto, and elevation model services have been provided. Architectural projects in the land registry inventory were modelled and rendered in 3D. In this framework, 20,237 photogrammetric models, 3,854 architectural building models, and 45,191 independent section models were produced. In this context, it has been determined that there are 18,577 buildings in the city center, 13% of which are public buildings and 87% are subject to private property. In the light of attributes such as registered, unregistered, subject to condominium ownership, subject to construction servitude, and benefiting from zoning peace, a total of 12 titles were classified under 3 main titles among those that are subject to private property.

- Registered Buildings
  - Registered / Condominium,
  - Registered / Defined building in attribute type,
  - Unregistered / Condominium and Settlement,
  - Unregistered / Floor Easement and Settlement,
- Unregistered Buildings
  - Unregistered / Floor Easement and Settlement,
  - Unregistered / Defined building in attribute type and Settlement,
  - Unregistered / Defined building in attribute type and Inhabited,
  - Unregistered / Settlement,
  - Contrary to unlicensed construction,
  - Unregistered / Zoning Amnesty,
- Public Buildings
  - Public Building/Registered
  - Public Building/Unregistered,

With this building classification, the entire building stock has been removed throughout the province and will facilitate all kinds of actions in terms of monitoring/management of buildings in city methods in city administrations (Figure 6).

Finally, a platform was designed for the integrated 3D presentation of the data obtained as a result of all these studies. A platform has been designed in an open-source manner.

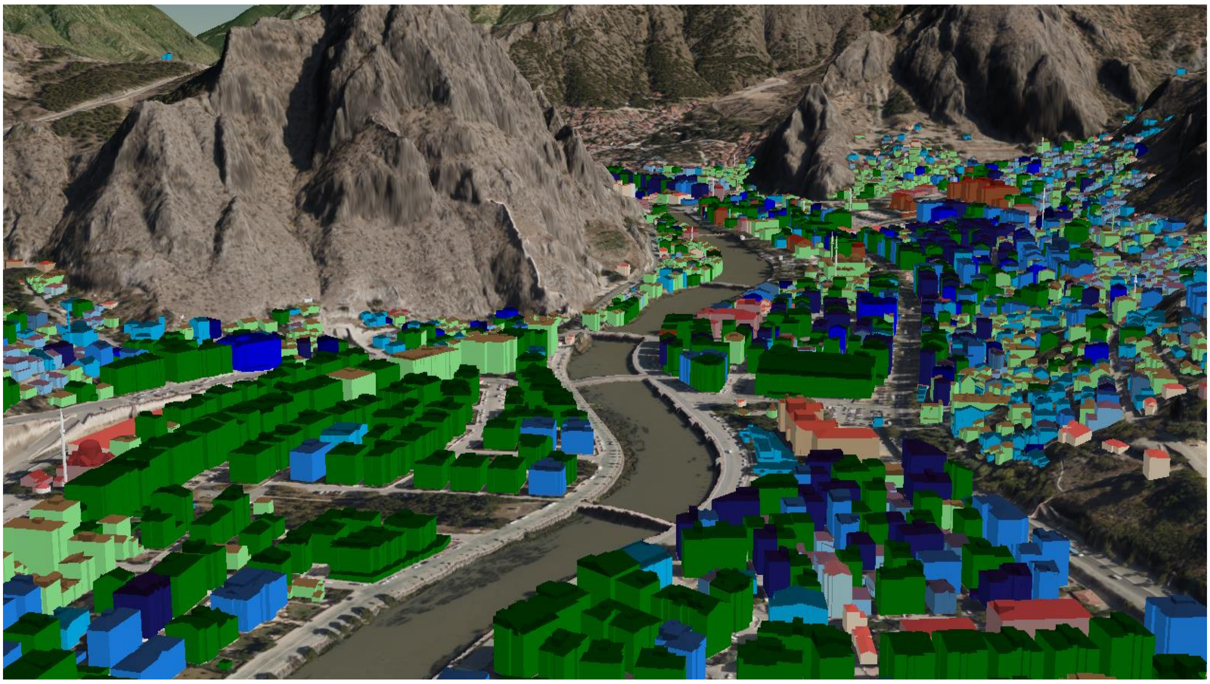

Figure 6. Building Classification.

TKGM has created a unique TKGM-CityGML model using the CityGML structure. It has been designed by the TKGM-CityGML data structure, on the institution's own 3D database, to be interactive with the internal and external services of the institution. The application interface has been developed as open-source code based on HTML5, CSS3, Javascript, WebGL, and ReactJS technologies. Within the scope of this application, 2D map uses have been prepared over the LEAFLET JS API. The 3D rendering and sphere application were developed over the CESIUM JS API. The presentation of 3D tiles (b3dm) and 3D data in I3S format has also been prepared in a way that works on Cesium JS within the scope of this application. Indoor mapping/architectural gml floor plans viewing and querying processes to be used within the scope of the application have also been developed over a WEBGL-based web submodule.

Different analyzes of buildings can be made on this platform. E.g; According to the value of the parcel where the immovable is located and the values of the building and the independent section, whether it has a Building Registration Permit, whether it benefits from the Reconstruction Peace, the distance to important points in the city, its relations with the cadastral parcels (Figure 7).

Figure 7. Open Source Platform.

Also, within this scope, a property information form was created for the users, which includes information about the independent section, real estate values, public restrictions, and address, as well as the attribute data of the immovables (Table 1).

Parcel Attribute	
Property ID	69339954
City	Amasya
District	Merkez
Neighborhood	Şeyhcui
Block Number	101
Parcel Number	83
Area	650 m²
Quality Type	Kargir Sekiz Katlı Apartman ve Arsası
Ground Type	Condominium
Independent Partition Information	
Block	-
Floor	2
Independent Partition	5

Facade	South - East
Gross Area	142 m²
Clear Area	132 m²
Public Restrictions Information	
It is located in a natural protected area.	
Property Value	
Independent Partition Value	346.000.00 ₺ (October/2021)
Address Data	
Building ID	172123
Independent Partition ID	2
Neighborhood	İsmet Paşa
Street	Galip Erdem
Building No	18
Apartment ID	5

Table 1. Property information form.

3. CONCLUSION

In this study, the integration and presentation of 3D data obtained from the modeling of architectural projects with 2D data such as land registry-cadastre data, address, zoning, and public restrictions, with photogrammetric methods, has been tested and presented as a good example of land administration by completing it.

To determine the joint demands of cadastral update, real estate valuation, and 3D city models production projects and to determine the works that can be done together, a pilot application was carried out in our province of Amasya and within the scope of the pilot project; Field and office studies were carried out on the compatibility and interoperability of cadastral data, title deed data, photogrammetric and architectural models and MAKS data, which will be formed as a result of the ongoing update works in the Central district of Amasya province. Within the scope of the project, the workability of stakeholder institutions and spatial data on the common denominator cadastre was tested, and new perspectives were brought to the work of other institutions. As project output; It is thought that cadastral studies in Turkey will evolve into a new path, and it is known that it is a pioneer in the international arena as a project of this size and is followed with interest in the international literature.

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BIOGRAPHICAL NOTES

Ismail DURSUN; Born in Ilgın, Konya in 1985. Geomatics Engineer. Received a BS Degree in Geomatics Engineering from Istanbul Technical University and MSc Degree in Geomatics Engineering from Erciyes University. Continues Ph.D. studies in Geomatics Engineering at Necmettin Erbakan University. Worked as an engineer for 4 years in the Ministry of Environment and Urbanization. Working as Senior Specialist in General Directorate of Land Registry and Cadastre. Married with 2 children. Speaks English.

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