USING ARCMAP TO CREATE A CADASTRAL DATABASE. CASE STUDY

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ABSTRACT

GIS – The Geographic Information Systems can be used today in many areas of activity due to their multiple functions. Cadastre is a fundamental area of today's society which uses various computer programs with geographic functions.
With the help of these programs it is possible to create cadastral databases united in a system of cartographic projection having the possibility to query the databases, to make calculations with layers, to make amendments when changes are made on the various functions of the real estate. GIS programs offer a wide variety of information representation using maps. Thus, it is possible to create thematic maps with multiple layers, as well as relationships within the database between the use of the land and the owner.

KEYWORDS: *cadastral database, lot, ArcMap, GIS, perimeter, ortophoto*

1. INTRODUCTION

Between 2015 and 2023, the National Program of Cadastre and Land Registry (NPCLR) will operate under a self-financing scheme, this being possible thanks to the funds made available by the European Union as of 1 January 2018. In a press release by the National Agency for Cadastre and Land Registry the following are specified:

"The Emergency Ordinance, which stipulates that the financing of the current and capital expenditures of the National Agency and the subordinated institutions is fully ensured from its own revenues, was approved at the Government meeting that took place on December 6th. Thus, ANCPI (Cadastre and Real Estate Publicity Office) will pay from own incomes both salaries and works under the National Program of Cadastre and Land Registry 2015-2023 (PNCCF) and will no longer receive funds from the state budget, except for the co-financing of projects financed by European funds." [8]

PNCCF was approved by Government Decision no. 294/2015 and provides for the free registration of all the real estate on the territory of the country in the integrated cadastre and land registry system. Over the past two years ANCPI (Cadastre and Real Estate Publicity Office) has improved the legislation and simplified its internal procedures repeatedly to accelerate the Program, given the need to prioritize agricultural land so that

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farmers can continue to benefit from subsidies. In 2016, the Law on Cadastre and Real Estate Advertising no. 7/1996 was amended by Ordinance no. 35/2016, which created the legal framework necessary for the ANCPI to fund the systematic registration works initiated by the administrative-territorial units (ATUs) at the level of the cadastral sector outside the city and, exceptionally, in the urban area, irrespective of the quality of the owner of the right, respectively the owner, holder of a real right over the real estate or possessor.

Thus, at present, "the agricultural lands are registered with priority in the cadastre within the PNCCF", as stated in the mentioned document. According to the law, in 2016 each city hall that signed a financing agreement with the Cadastre and Real Estate Publicity Office in its county received 135,000 lei to carry out the systematic registration works. This year, the amount has increased by 150,000 lei. In addition, "starting 2017, budgets are multiannual, which means that municipalities do not lose money unless they complete their work by the end of the year", as mentioned by ANCPI.

"The result was the expected one - the PNCCF registered in almost two years seven times more real estate than in the period 2005-2015, that is, in 2016 and 2017, NPCLR issued free of charge to citizens over 515,000 of land registries, according to www.ancpi.ro. The program is funded from ANCPI's own incomes - over 4 billion lei, but also from external funds obtained through the Regional Operational Program amounting to 312.89 million euro (265.96 million Euros come from the European Regional Development Fund, while 46.93 million Euros is the co-financing from the state budget). "Another source of funding may be the local budget of the city halls" argued the institution. [8]

2. LEGAL FRAMEWORK

According to Government Decision no. 294/2015, with the subsequent amendments and completions, the territorial administrative units (ATUs), in which the general cadastre was made with European funds, were selected by a committee made up of specialists from several ministries - Regional Development, Agriculture, and Transport.

According to the Cadastre Agency, selected localities must meet at least one of the priority criteria, according to the 2014-2020 Regional Operational Program:

- Administrative-territorial units that are subject to the development of the infrastructure projects stipulated in the Master Plan of Transport of Romania, approved by the Government Decision no. 666/2016;

- Administrative-territorial units that implement or are included in the infrastructure development projects under other programs, according to the law;

- Administrative-territorial units in which areas with particular social vulnerabilities are identified for informal access to property. The criterion will include areas with Roma communities as well as disadvantaged areas.

In this list it can also be found villages where procedures for the systematic registration of buildings have already been initiated and meet the priority criteria of the law. "In this situation, only the cadastral sectors in which the systematic registration works have not started will be auctioned", the Agency specifies.

In the following period, ANCPI employees will identify the territorial administrative units (ATUs) on this list, where the cadastral works of the PNCCF are already underway. "Most likely, the first 200 villages will be auctioned by mid-January 2018. In the summer of 2018, ANCPI will initiate procedures for the next 200 villages and the remaining ATUs will be auctioned in December 2018 ", ANCPI reported.

The general cadastre is an information system of all land and real estate, regardless of their destination and owner. The general cadastre has as a primary source the topo - cadastral data, obtained through topographic measurements on the land and their representation on cadastral plans.

Furthermore, the general cadastre provides the following information:

- Provides data on the state and evolution of the land fund;
- Prepares preliminary studies on territorial planning, environmental protection and other activities, to be carried out on large areas of land;
- Identification of financial resources and provision of necessary data on the updating of cadastral maps and plans.

The general cadastre is evolving towards a spatially referenced information system, being the core of land information systems and urban information systems, providing geo-referencing elements, indispensable tools for urban planning and the modern management of economic activities. [1] [5]

The Law of Cadastre and Real Estate Advertising (Law no. 7/1996) contains the following definition:

> "The general cadastre is a unitary and binding system of systematically recording and inventory of real estate across the country, from a quantitative, qualitative and legal point of view, irrespective of their destination and owner, through which are identified, registered and represented on maps and cadastral plans." [5]

The database used in the general cadastre

According to Wikipedia - the largest on-line encyclopedia, a database, sometimes called a "data bank", is a way of storing information and data on an external medium (a storage device), with the possibility of further expansion and rapid retrieval. [6]

The databases were first created in the secret services and the army. In March 1989, physicist Tim Berners-Lee made a proposal to develop an electronic system that would allow access to information from any part of the globe, and a year later the project began to take shape. [2]

A database (DB) is a collection of data or information. There are databases on real estate in the cadastre. From these databases, data about specific objects or phenomena can be extracted. Information retrieval is done according to certain criteria, special forms and reports can be created with extracted data, etc. These databases can be relational or on objects. [4]

The main elements of a relational database are lists or tables. Within the table there are lines and columns (fields) of cells. All the elements of a line form a logical record or article. The element at the intersection of a column with a line or record is called a cell.

Each piece of information is inserted into a cell; all the cells of a column form a field. The name of the field is given by the name of the column.

Designing the cadastral database:

- Establish the data to be included in the database, their organization, the types of tables and the fields;
- Establish types of operations for data entry and types of forms to be filled in with data;
- Establish types of possible queries and reports printed or displayed.
- Organize tables so as to avoid repeating data in different tables and data redundancy. Some redundant data are required but only for control. Certain common fields may be common in multiple tables, thus joining the tables is allowed.

Creating the cadastral database

The cadastral database is carried out with the help of information technology within cadastral information systems. The cadastral entities are the parcel, the construction and the owner. These entities have different attributes; some of the attributes serve to identify entities. The attributes for identifying cadastral entities are called identification keys. An identifier attribute is an attribute that is characterized by the uniqueness of its value for each achievement of the cadastral entity that it characterizes in the entity-association diagrams. [4]

Establishing the layers of a cadastral database

The main feature of the cadastral database is that the cadastral entities are represented by thematic layers and the attributes of the cadastral entities are organized in relationships (shown in the table) and are recorded in data files in the form of relational lists containing the attributes of the represented cadastral entities.

The following principles shall be taken into account for the starts:

- Each cover (category of topographic details) is to be represented on a single layer;
- On a layer, the cadastral entities are to be represented by a single type of geometric entity;
- Each layer shall produce only one topology type;
- For each layer, a table of attributes and a relation of the cadastral entity that represents the registered coverage shall be created in the cadastral database.
- A variant with starts and coverings determined by the structural analysis of the analyzed computer system is presented in a table. Access to the cadastral data recorded in the database is based on data dictionaries, called system catalogs.
- From the point of view of logical organization, the cadastral information system consists of a base, exploited by one or a few specialized cadastral applications on different sub-areas of interest or on different levels of decision. [2]

3. THE ELEMENTS USED IN CADASTRE

- The lot

The lot represents the reference element, the territory of a locality being considered as the sum of all the lots existing in the locality, irrespective of their size. The lot is considered to be any subdivision of the territory with a specified use (separate by use) and belonging to an owner. Several adjacent lots, belonging to one owner and having a common address, form the body of the property, the respective land being the main object of the cadastral registration (separated according to the property criterion or the ownership criterion). For organization, structure and location reasons, several steps and categories of lot grouping can be considered, in addition to the body of the property.

Thus, several property bodies in the sector delineated by traffic arteries form a quart. One or more blocks compiled on the basis of geographic, administrative, economic or urban criteria, is an area or territorial reference unit (TRU). One or more territorial reference units, geographically, historically or traditionally, form a neighborhood. The city can be considered as the sum of all neighborhoods. In the cadastral database, geospatial or G data can be retained in a shp or parcel layer while the thematic or T data in a SDE-managed table or other SGBD. [4]

The fields of the table result from the classification of lots in classes and subclasses (by destination, by use).

- The building

The building is a high construction on / under the surface of the land with the main purpose of protecting and sheltering people, property, installations, machinery, etc. in principle, any building is located on a plot (the territory of the building) within a single property body. A construction is constituted by at least one body, which is a unitary component regarding its structure, height regime, construction date.

Also, a construction includes at least one identifiable subdivision by owner, functionality, etc. a subdivision can be extended to several building bodies belonging to the same building. In turn, the subdivision is composed of at least one room (chamber).

In the cadastral database, the G-type spatial data which define the position on the terrestrial surface of the building can be retained in a shp file or building layer while the thematic or the type T data in a SDE-managed table or with another SGBD. The fields of the table result from the classification of buildings and apartments in classes and subclasses (by destination, use, building material, according to the legislation in force)

- The network

The network is built from a transport carrier - the road artery - on which the means of transport, the means of intervention, between different connection points, called nodes - these can be intersections of road arteries, garages, etc. In the cadastral databases the network is represented by the position of their nodes and by the route of the transport support (arcs) which connect the nodes between them. Routes may be of the type - corridor - but considered to be linear.

- The circulation artery

The traffic artery (street network) is an important element through the transport infrastructure function. Also, streets represent land-bound elements and a general route for urban networks. In thematic databases systems, the traffic arteries - the streets - represent by postal address the main element of localization of the other entities that make up the urban environment.

Given the multiple functions of the traffic arteries, the following attributes must also be transferred to the database - the occupied field of the transport function, the transport direction, the spatial reference.

- The owner or holder

The owner or holder is the natural or legal person who owns or uses a real estate (parcel, building, network, network portion) based on legal deeds. Taking into account the requirements for registrations and reports, it is necessary to create a table or a list of owners in which the person - physical or legal - appears only once with the defining data (name, personal numeric code, home address, etc.) and with the elements necessary to identify the material goods belonging to them (the cadastral lot), in the table of lots/parcels and the table of buildings, or which are leased for a certain period of time and under a certain legal basis.

- The relationships between entities

Among the various entities existing in the database there are interdependence relationships. A building is always on a lot, on a land - property - or a subdivision of a building in which there are several apartments and it can be owned by several persons (as tenancy), or a land or a building subdivision, owned by one or more owners, may be rented or granted to natural or legal persons.

- The position database

The database consists of two components consisting of two interrelated components. Thus, a spatial or geospatial database, i.e. position data or G type data, consisting of multiple data layers and a thematic or T-type database, consisting of several related tables including the attributes that characterize the various entities included in the cadastral information system.

Within the created database we used thematic layers with their attributes.

These starts are organized so that different graphic information could be stored on separate layers.

The main layers can be:

- Plot - polygon type;
- Buildings - polygon type;
- Streets - line type;
- Cadastral number - point type;

After determining the attributes required for each layer, the parameters specific to each attribute and the types of values to be stored are determined. The data dictionary will contain all information related to tables or lists, namely field names, field type (integer,

decimal, text, etc.), field default value, value range limits, and relationship between list and list items. [4]

Defining the value of each attribute consists of three steps:

- Encoding - how the attributes will be stored in the form of numbers, letters, or otherwise;
- Allocating the memory for storage;
- Creating a dictionary with attribute names and a description of attribute values.

4. CREATING THE DATABASE WITH ARCMAP 10.1

ArcMap users can create and manipulate datasets to include a variety of information. For example, the maps produced in ArcMap generally include features like north arrows, scale bars, titles, legends, neat lines, etc. The software package includes a set of these features as well as the ability to upload many other reference styles to apply to any mapping function. (Figure 1)

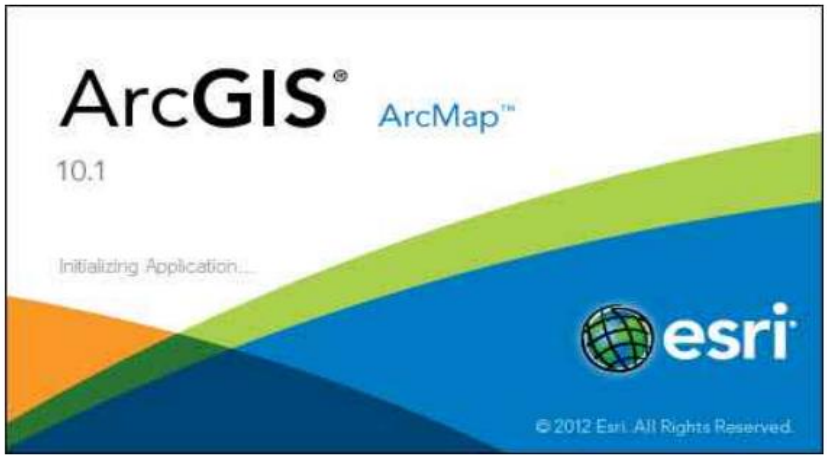


Figure 1. Interface of the program ArcMap10.1
(http://www.ce.memphis.edu/1101/GIS/arcmap_intro/ArcMap_insert_scale.html)

To exemplify, we cut off a perimeter in Bucharest from the Orthophoto of the City Hall of Bucharest. [9] The Orthophoto was downloaded from http://www.ocpib.ro/

The area for which the cadastral database was created is located in Sector 1 of the capital. Sector 1 is geographically located in the north of the capital. This area is delimited in the North by the Road Bucharest - Ploiesti, in the West by the Kiseleff Road (E60). The Kiseleff Road continues with the Polygraphic Avenue. In the southern part the area is bounded by Turda Street which intersects with Ion Mihalache Boulevard and Calea Griviţei Road (DN 7). The connection between the Kiseleff Road and the Griviţa Avenue is via the Exhibition Avenue and the Clăbucet Street. (Figure 2)

In order to establish and implement the necessary database for the creation of a GIS in cadastre, we took the following steps:

- Designing the database
- Collecting and validating data, populating the database
- Tracking the changes in the territory and their operation in the database by continuous and periodical updating
- Extracting reports from the database
- Acquiring data - data acquisition is the data conversion process, more precisely conversion from the existing form into a form that can be used by a GIS
- Thematic data sources - attributes - can be analogous (notes, statistical data) or digital (databases, computer systems, files). Data may be registered into the Territorial Information System but must be controlled and verified before registration. [2]

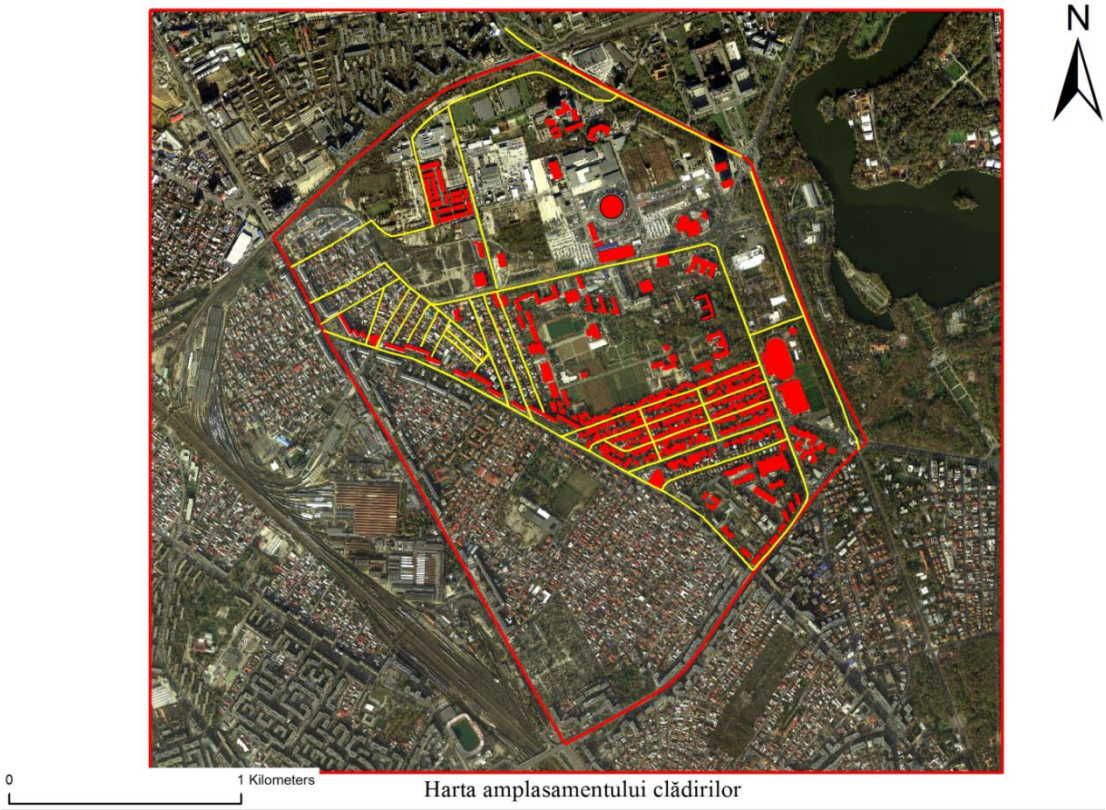


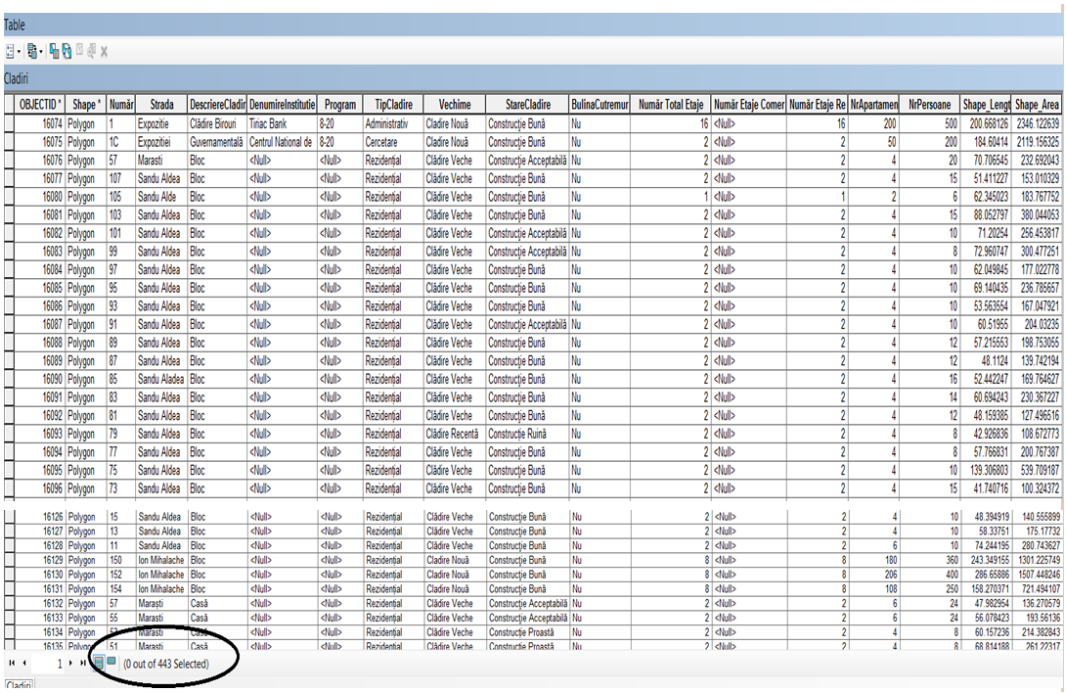
Figure 2. Map of the building site and the streets in the studied perimeter

There are 443 buildings identified in the study area. Figure 3 shows the table created in ArcMap 10.1 with the attributes of each construction. It can be seen that each building has a set of attributes.

The database created can be used by interrogation for the purpose of identifying certain building characteristics or identifying the number of people living in a particular building or street.

Also, the perimeter of the studied area overlaps the Open Street Map. Open Street Map is a free license provided by http://opendatacommons.org/licenses/odbl/ and is a

collaborative project designed to create an editable free map of the world. There have been restrictions on the use or availability of map information in various parts of the world due to the emergence of cheap portable satellite navigation devices. [7]



Table

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OBJECTID *	Shape *	Număr	Strada	DescriereCladir	DenumireInstitutie	Program	TipCladire	Vechime	StareCladire	BulinaCutremur	Număr Total Etaje	Număr Etaje Comer	Număr Etaje Re	NrApartamen	NrPersoane	Shape_Lengt	Shape_Area
16074	Polygon	1	Expozitie	Clădire Birouri	Tinac Bank	8-20	Administrativ	Cladire Nouă	Construcție Bună	Nu	16	<Null>	16	200	500	200.668126	2346.122639
16075	Polygon	1C	Expozitiei	Guvernamentală	Centrul National de	8-20	Cercetare	Cladire Nouă	Construcție Bună	Nu	2	<Null>	2	50	200	184.60414	2119.156325
16076	Polygon	57	Marasti	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Acceptabilă	Nu	2	<Null>	2	4	20	70.706545	232.692043
16077	Polygon	107	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	15	51.411227	153.010329
16080	Polygon	105	Sandu Alde	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	1	<Null>	1	2	6	62.345023	183.767752
16081	Polygon	103	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	15	88.052797	380.044053
16082	Polygon	101	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Acceptabilă	Nu	2	<Null>	2	4	10	71.20254	256.453817
16083	Polygon	99	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Acceptabilă	Nu	2	<Null>	2	4	8	72.960747	300.477251
16084	Polygon	97	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	10	62.049845	177.022778
16085	Polygon	95	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	10	69.140435	236.785657
16086	Polygon	93	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	10	53.563654	167.047921
16087	Polygon	91	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Acceptabilă	Nu	2	<Null>	2	4	10	60.51955	204.03235
16088	Polygon	89	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	12	57.215553	198.753055
16089	Polygon	87	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	12	48.1124	139.742194
16090	Polygon	85	Sandu Aladea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	16	52.442247	169.764627
16091	Polygon	83	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	14	60.694243	230.367227
16092	Polygon	81	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	12	48.159365	127.496516
16093	Polygon	79	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Recentă	Construcție Ruină	Nu	2	<Null>	2	4	8	42.926836	108.672773
16094	Polygon	77	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	8	57.766831	200.767387
16095	Polygon	75	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	10	139.306803	539.709187
16096	Polygon	73	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	15	41.740716	100.324372
16126	Polygon	15	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	10	48.394919	140.555899
16127	Polygon	13	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	4	10	58.33751	175.17732
16128	Polygon	11	Sandu Aldea	Bloc	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Bună	Nu	2	<Null>	2	6	10	74.244195	280.743627
16129	Polygon	150	Ion Mihalache	Bloc	<Null>	<Null>	Rezidențial	Cladire Nouă	Construcție Bună	Nu	8	<Null>	8	180	360	243.349155	1301.225749
16130	Polygon	152	Ion Mihalache	Bloc	<Null>	<Null>	Rezidențial	Cladire Nouă	Construcție Bună	Nu	8	<Null>	8	206	400	286.65886	1507.448246
16131	Polygon	154	Ion Mihalache	Bloc	<Null>	<Null>	Rezidențial	Cladire Nouă	Construcție Bună	Nu	8	<Null>	8	108	250	158.270371	721.494107
16132	Polygon	57	Marasti	Casă	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Acceptabilă	Nu	2	<Null>	2	6	24	47.982954	136.270579
16133	Polygon	55	Marasti	Casă	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Acceptabilă	Nu	2	<Null>	2	6	24	56.078423	193.56136
16134	Polygon	53	Marasti	Casă	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Proastă	Nu	2	<Null>	2	4	8	60.157236	214.382843
16135	Polygon	51	Marasti	Casă	<Null>	<Null>	Rezidențial	Clădire Veche	Construcție Proastă	Nu	2	<Null>	2	4	8	68.814188	261.22317

1 (0 out of 443 Selected)

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Figure 3. Database of the studied perimeter

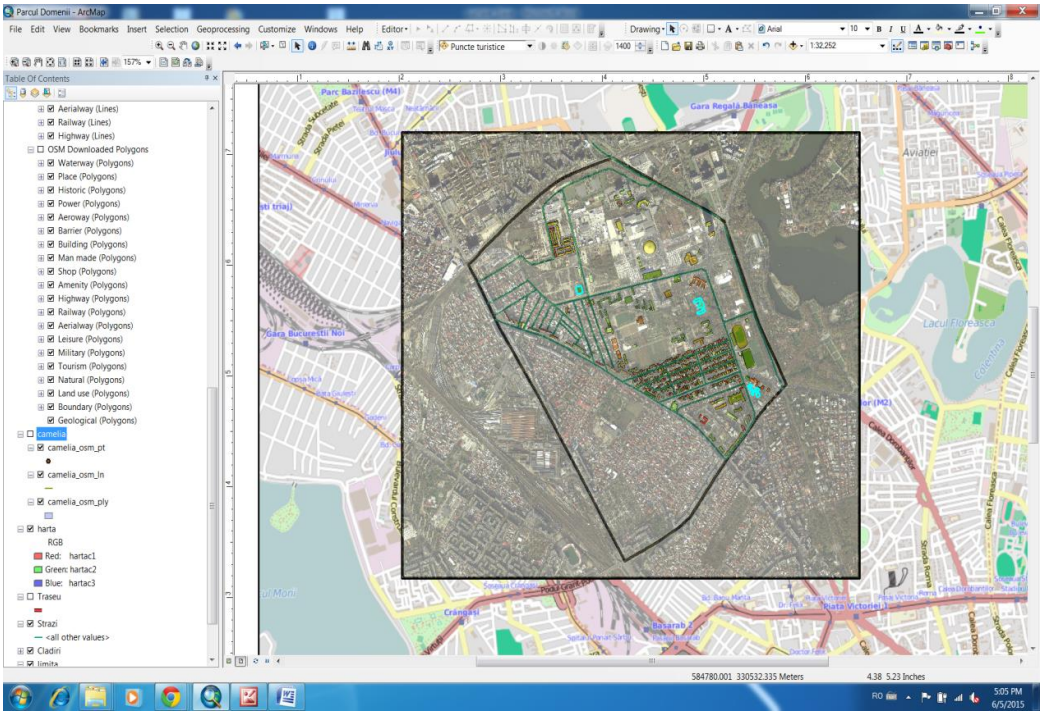

Figure 4. The map of study area which overlaps the Open Street Map

5. CONCLUSIONS

A GIS can combine map types and display them in realistic, three-dimensional images that present information more effectively and to a wider audience than traditional two-dimensional maps. Traditional maps are abstractions of the real world, a sum of important elements sketched on a sheet of paper with symbols representing physical objects. People who use maps must interpret these symbols. Topographic maps show the shape of a lot/field with the aid of level curves. The real shape of the field can only be seen with the eye of the mind. Graphical presentation techniques of GIS make the relationships between map elements visible, increasing the ability to extract and analyze information. Various maps and satellite information sources can be combined in ways that simulate the interactions of the complex natural system. Through a feature known as visualization, a GIS can be used to produce images - not just maps but representations, animations, sounds and other cartographic products. These images allow specialists to see the objects of their work in ways they could not be seen before. Images are often helpful in representing the technical concepts of GIS study objects for non-technical persons.

Advantages of using a GIS:

- The data is better organized
- It eliminates redundancy in data storage
- Enhancements feature
- Analyses, statistics and easier searches
- Users are more productive

Disadvantages:

- Complexity
- Difficulties in staff training

It should be noted that a GIS cannot run in a network of scenarios the syntagm *what if?* But other applications developed to use GIS databases can run such scenarios. The Geographic Information Systems (GIS) technology can be used in scientific investigations, resource management, and development planning; Therefore, GIS application domains are countless.

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