Cadastral Data Management System in Turkey

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Key words: Data Management, Cadastre Automation, GIS/LIS, Data Modeling, Geodatabase

SUMMARY

Presently, information has become the most important economic and strategic resource. The data produced or acquired by automating the managerial and functional activities of the institutions having a multi-level hierarchical structure; and an organization spread throughout the country, by means of an Integrated Information System logic may be made visible, sharable, assessable, operable.

Cadastral and land registry systems are integrated and co-operated in Turkey. The geometric and ownership data were borned at the cadastral system and submited to land registry system for registration. The ownership and restrictions data on property is proccesed by land registry and the changes on geometry is carried out by cadastre.

Land Registry and Cadastral Integrated Information System, in Turkey has been under development since 2001 and is being implemented for one year.

The system is build on central architecture. Land registry data management is carried out by SQL/Server and cadastre data management is carried out by ArcSDE on SQL/Server Database Management System. Cadastral data management differs from land registry data management by its structure and contents.

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1. CADASTRAL DATA CONTENT AND DEFINITIONS

1.1 What is Cadastral Data?

Cadastral data are focused on immovible properties and have two main components:

- Geometry of properties
- Attributes of properties

Property geometric data composed of quarter or village boundaries, blocks, parcels, parcel segments, parcel corner points, ground control points, and buildings.

Property unit that should be registred can be a parcel, a construction (building) or a servitude. Parcel is the smallest unit of fixed property. Parcel unit must exist and be registred before all rigths and burdens can be registered. Construction belongs to the parcel on which it is built. Servitude is a usage right of property that is limited by servitude geometry. All these property unit should exist in the field and registred on the deed.

Attributes of properties are meta data which defines and give information about the geometry. Attribute data is not limited, but at least owners, rights, mortgages, annotations should be defined and registered with geometric data at the same time.

1.2 How Cadastral Data is Generated and Maintained?

Cadastral data are born in the field by surveying during the initial or primary cadastral activities. As a result of primary cadastral activities two main products are generated; cadastral maps and title deeds. After this, cadastral data live on the maps, by cadastral activities carried out by cadastral offices and title deed data live on the registrations by land registration activities carried out by land registration offices Figure 1.

Cadastral activities are composed of generating new geometric data, modifications on the geometry like subdivision or merging parcels, renovations, corrections on parcels, provision of plan layouts, preparation of application sketches, establishment and cancellation of servitude. Title deed activities are composed of changing of owners, rights and restrictions, sales,donations, exchange, lifelong ownership contracts, transfer of immovable property through inheritance, mortgage, establishment of individual apartment ownership, restrictions placed on immovable property, right of usage.

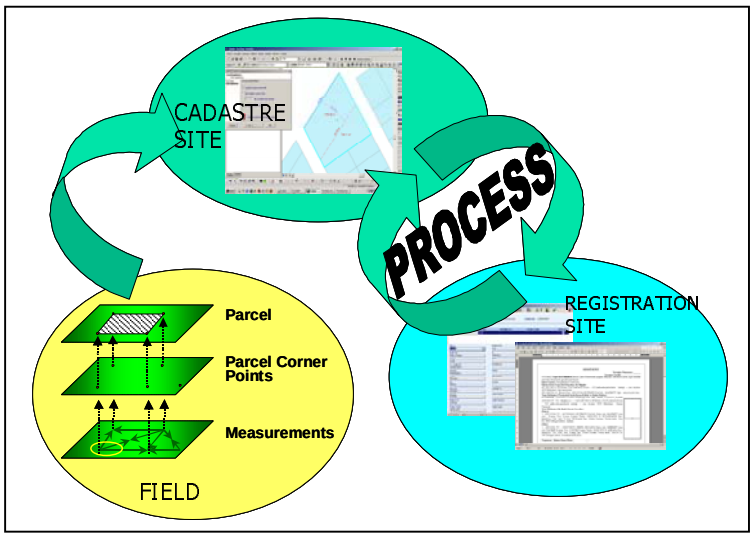

Figure 1: Cadastral System Cycle

Cadastral maps are produced by several methods in the cadastre activities. Transfer of these maps into computer environment depending on their production method and sensitivities are performed in several stages under technical and legal regulatory principles.
The most of the basic maps used in Cadastre procedures are in standard scales of 1/1000, 1/2000, 1/5000. Ocassionally, there are others which have been produced on non-standard scales, such as 1/10.000 or larger. In addition, technical data and other documents used to produce these maps are also produced by the Cadastre Offices.

2. STATISTICS OF TURKISH CADASTRAL DATA

The area of Turkey is 778.000.000 km^2. 26% of this area is forest and 12.3% is pasture area. The rest is the cadastral area which contains 480.000 km^2, in total. Residential area is about 5% (40.000 km2) and rural area is about 56% (440.000 km2). There are approximately 35.000.000 parcels and 600.000 registers in Turkey. Detailed values are provided below:

TYPE OF AREA	km^2	%
Forest	202,280.00	26.0
Pasture	96,000.00	12.3
Cadastral Arae (Rural)	440,000.00	56.6
Cadastral Area (Residential)	40,000.00	5.1
TOTAL	778,000.00	100.0

RESIDENTIAL AREA				RURAL AREA			
TOTAL	COMPLETED	NUMBER OF PARCEL	PRODUCED AREA (KM2)	TOTAL	COMPLETED	NUMBER OF PARCEL	PRODUCED AREA (KM2)
8,636	8,277	5,879,813	39,214,480	37,223	25,838	28,459,864	332,787,793

3. CADASTRAL DATA MANAGEMENT SYSTEM

3.1 Definition of Turkish Cadastral System

Turkish Cadastral System is an integrated system and called Turkish Land Registry and Cadastral Information System (TLRCIS).

The objectives of the System:

- Preparation and provision of a reliable and updated information system which reflects current situation, and which is required by decision–making bodies, and for all activities about and related to cadastral data and updating title deed records, transferring all information to database, keeping the data in computer medium in an updated form, and re-evaluating and putting into use these data, within the scope of Information Systems Technologies,
- More efficient, healthier, more expeditiously and reliable planning, administration and activation of services provided by General Directorate Land Registry and Cadastre, and enabling other organizations and institutions to use the data supplied in a better and broader manner.

The TLRCIS is a parcel-based Land Information System. It contains geometric cadastral information and proprietary information with respect to ownership. It covers all activities carried out in the General Directorate of Land Registery and Cadastre, in Regional Directorates (25), in Land Registery (1003) and Cadastral (325) Offices. The studies has began in early 2001. After the 3 months of analysis studies, 3 months of design work, and 16 months of software development work it has been implemented on actual distrubuted sites. Now, it has been used at the General Directorate, one Regional Directorate, 6 land registery and 2 cadastre offices. These sites are integrated into WAN environment. Detailed information with greater emphasis on cadastre is presented below:

3.1.1 Data Content

In the pilot area two main types of data are collected. Raster and vector data. Raster data is registered using ground control points. All map sheets and sketches are scanned and linked to the related parcels. Vector data are mainly converted from CAD data and others are collected from field measurements. Measurements data are not stored in the geodatabase. They are used for calculating the coordinate values and generating parcel data which are stored in the database.

Raster Data Set

- 68 pieces of digital map sheets at 1:250.000 scale (80MB), colored
- 16 pieces of digital map sheets at 1:25.000 scale (17MB), colored
- Ankara city map (10MB), colored
- 3000 pieces of Map Sheets (20MB), black&white5000 pieces of Measurement sketchs (30 MB), black&white

Vector data set

- 1:250.000 scale database of Turkey, mainly used for planning purposes
- Quarters (140)
- Blocks (6.000)
- Parcels (135.000)
- Registered Buildings (20.000)
- Ground Control Points (15.000)
- Owners (1.000.000)

3.1.2 System Architecture

The system is centrally designed. In the center there are 4 servers called SQL Server, Domain Controller Server, Backup Domain Server and Proxy Server. On the SQL Server, Windows 2000 and SQL/Server RDBMS software are running. Cadastral data is on the geodatabase and is managed by a special software package called ArcSDE which stores its data on SQL Server. Title Deed tables are on the SQL Server. All Cadastral data and Title Deed data are integrated by link tables. System architecture is shown in Figure 2.

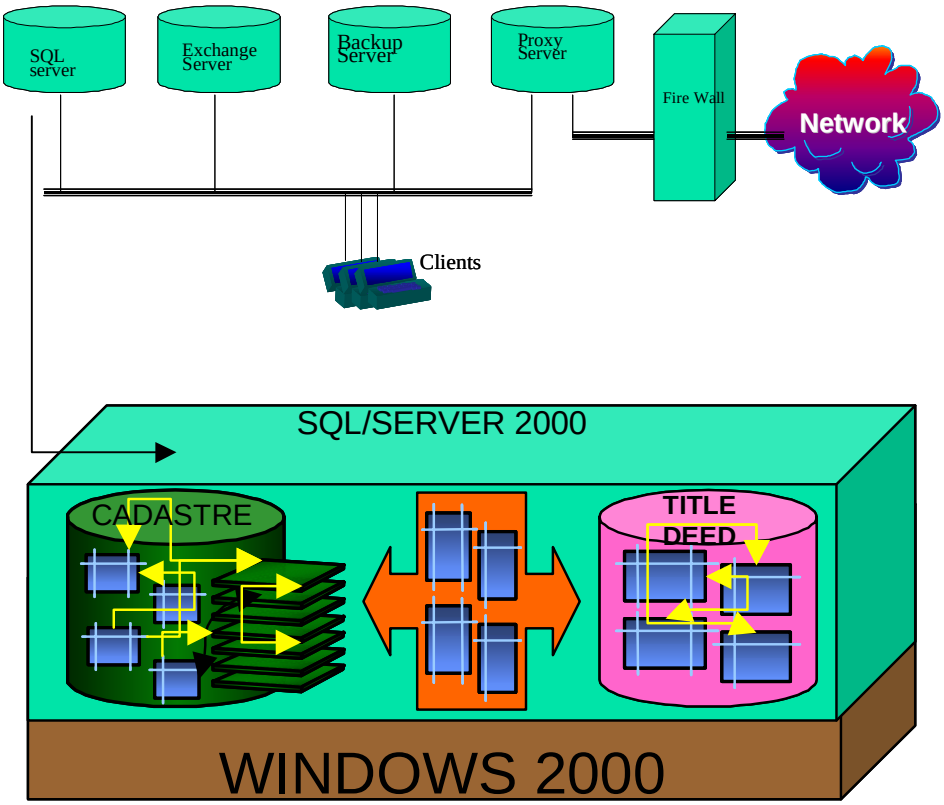

Figure 2: System Architecture of Turkish Land Registry and Cadastre System

3.2 System Modeling

It is necessary to define the data and functional model in order to represent a system. The data model is one part of the conceptual design process. The other part is typically is the functional model. The data model focuses on what data should be stored in the database while the functional model deals with how the data is processed. To put this in the context of the relational database, the data model is used to design the relational tables. The functional model is used to design the queries which will access and perform operations on those tables.

3.2.1 Data Model

A data model is a conceptual representation of the data structures that are required by a database. The data structures include the data objects, the associations between data objects, and the rules which govern operations on the objects. As the name implies, the data model focuses on what data is required and how it should be organized rather than what operations will be performed on the data. To use a common analogy, the data model is equivalent to an architect's building plans. It is necessary to define the spatial reference, database design and data content in order to identify a data model of system.

3.2.1.1 Spatial Reference

The spatial reference for a feature class describes its coordinate system (for example, geographic, UTM, and State Plane), its spatial domain, and its precision. The spatial domain is best described as the allowable coordinate range for x,y,z coordinates. In Turkish Cadastral system UTM projection system is used. Turkey has 7 zones composed of 3° meridians. 7 geodatabases with the same coordinate system has been designed for 7 different zones (Figure 3)

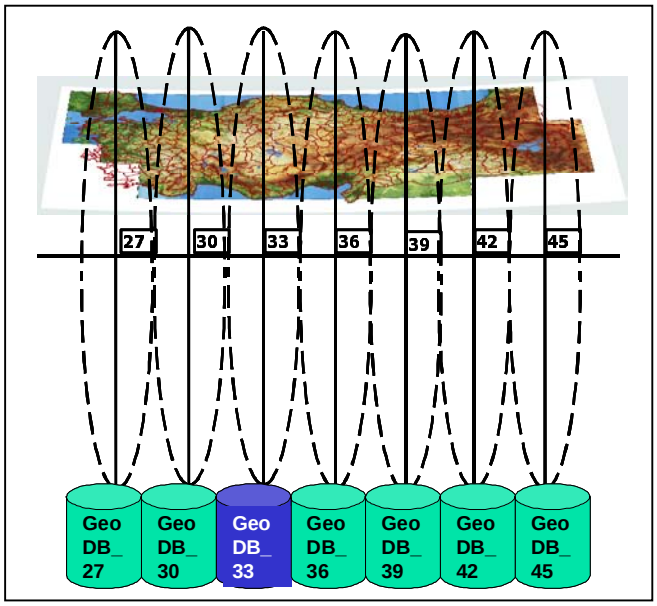

Figure 3: Spatial Reference of Turkish Cadastral System

3.2.1.2 Geodatabase Environment

Cadastral data model is desinged on ArcSDE geodatabase structure. The geodatabase is an open storage structure for storing and managing GIS related data (spatial geometry, tabular and imagery) in a database management system (DBMS).The geodatabase is based on the fundamental relation data model, in which each object and its attributes are stored as a row in a table. An object represents a feature or real world entity that the GIS is designed to emulate (e.g. parcel, a building, a street light, a river). A collection of a similar features (objects) such as parcels, buildings or or rivers stored in a DBMS table is called a feature class. Collections of related feature classes that share the same spatial reference can be organized into a larger structure called a feature data set.

A Geodatabase abstracs Geographic Information into five basic elements; Maps, Models, Data Models, Metadata and Geodatasets. These five basic elements and Software objects provide all neceserray components for building a GIS. The geodabase supports all the generic spatial data types in relational tables with rules that define relationships and behaviour (Figure 4).

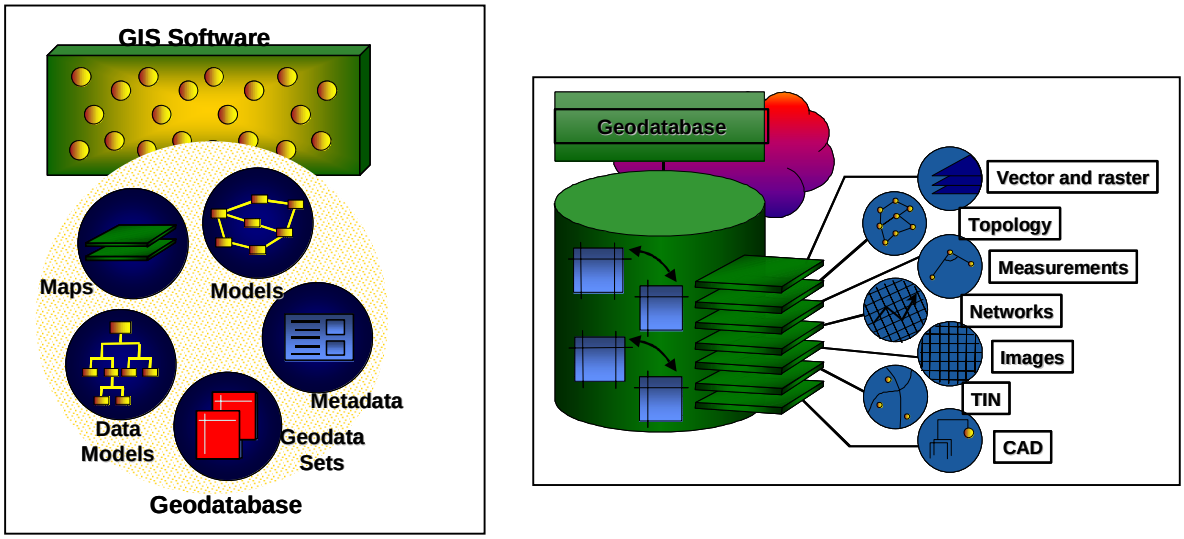

Figure 4: Geodatabase Environment

3.2.1.3 Data Catalogue

A"Feature and Attribute Codding Catalog" is prepared for the Cadastral System. It contains all map and map sheet features for large scale mapping, according to the map production regulation. Geodatabase is designed according to this catalog.

– Data Sets: There are 11 separate data sets (Land Surface, Vegetation, Miscellaneous Point Features, Rail Road, Communication, *Property*, Hydrograph, Highway,

Administrative Boundary, Project Area, Construction) in geodatabase. Four of them which are provided with bold letters are directly related to cadastre.

- Feature Classes: There are 135 feature classes in the geodabase, nine of them are cadastral features that are provided on Table 1.
- Attributes of features: There are a lot of attributes in catalog. The ones related with cadastral features are provided on Table 2.
- Domain Lists: There are a lot of domain list in the catalog and most of the cadastral features has domain list.

Data Sets	**Feature Classes**	**Geometry**
Administrative Boundary	Province	Polygon
	County	Polygon
Property	Village/Quarter boundary	Polygone
	Block	Polygone
	Parcel	Polygone
	Parcel Corner Point	Point
	Parcel Segment	Line
	Servitude	Polygon
	Ground Corner Points	Point
Project Area	Working Area	Polygon
Construction	Building	Polygon
	Numbering	Point

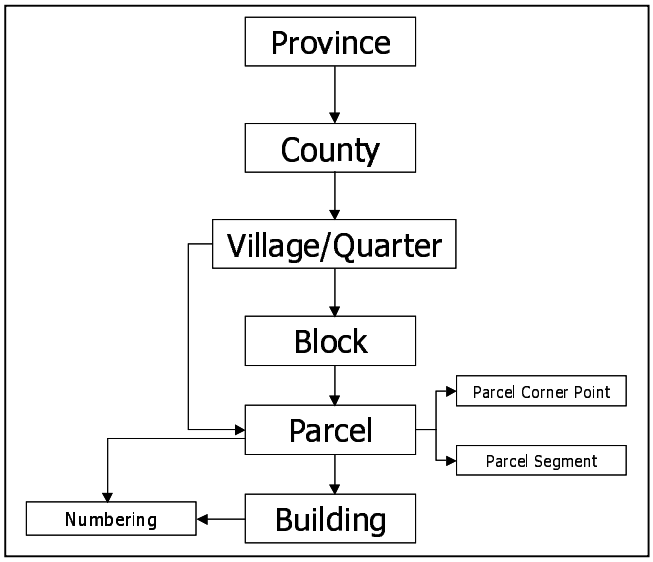

Table 1: Data sets, feature classes, and relationships among them

Besides these all definition, some rules and spatial relationships are also defined in geodatabase;

- Rules and relationships : There are some ownership rules like;
  - A parcel must be in a block or Village/quarter,
  - A block must be in a Village/Quarter,
  - A Village/Quarter must be in a County and a County must be in a Province.

The other important rule is the numbering system rules like;

- Find the last number of parcel in a block or Village/quarter, use it for new generated parcel
- during the renumbering of parcels in a block or village/quarter give the number 1 to the first parcel from northwest and increase it clockwise direction

In Geodatabase		In Registration	Domain list
Boundary of provincies, county, quarter	Name		
	Reference Code		
	Shape Area		
Block	Number		
	Shape Area		
ParcelPolygon	Block Number		
	Parcel Number/Name		
	Shape Area		
	Sheet Name		
		Owner	
		Share	
		Rights	
		Mortgage	
		Decleration	
		Parcel Type	X
		Registred Area	
Parcel Segment	Graphical lenght		
	Measurment lenght		
	Segment line type		X
Parcel Corner Point	Number		
	Production method		X
	Product by Organization		X
	Product date		
Building	Building Type		X
Groun Control Point	Number		
	Measurment type		X
	Coordinate X Value		
	Coordinate Y Value		
	Coordinate Z Value		

Table 2: Cadastral Data Catalogue Structure

3.2.2 Functional Model

The cadastral functional model is designed fully in compliance with the applicable regulations of daily procedures of the Cadastral Offices.

It is possible to classify all Cadastral activities in 3 main groups.

- Procedures depending on requests: Plan sketch, application sketch
- Control services: Most of the cadastral work is carried out by survey contractors. These works should be checked and approved by Cadastre Office. Some of these activities are Sub-division, union, Physical Land planning, leaving and saving parcel from road,
- expropriation process. The results of these procedures should be sent to land registry office for registration purposes.
- Other works which are carried out at cadastre offices like prime cadastre activities and cadastre renovation activities.

A versioning (short and long transaction) mechanism is used for each job in the Turkish Cadastral Functional Model.

It was a MUST to establish full automation in cadastral procces. After all the data are converted to the computer environment, updates are undertaken automatically by the process performed. At the end of each process historical data is generated and stored into the database.

3.3 Data Collection and Integration System

There are variety of data sources in the cadastral system. Most of them are graphical data (uncoordinated in UTM) in rural area and CAD data in residential area. All kinds of data are converted into geodatabase which is the same standards. Data collection and integration mechanism is presented in Figure 5.

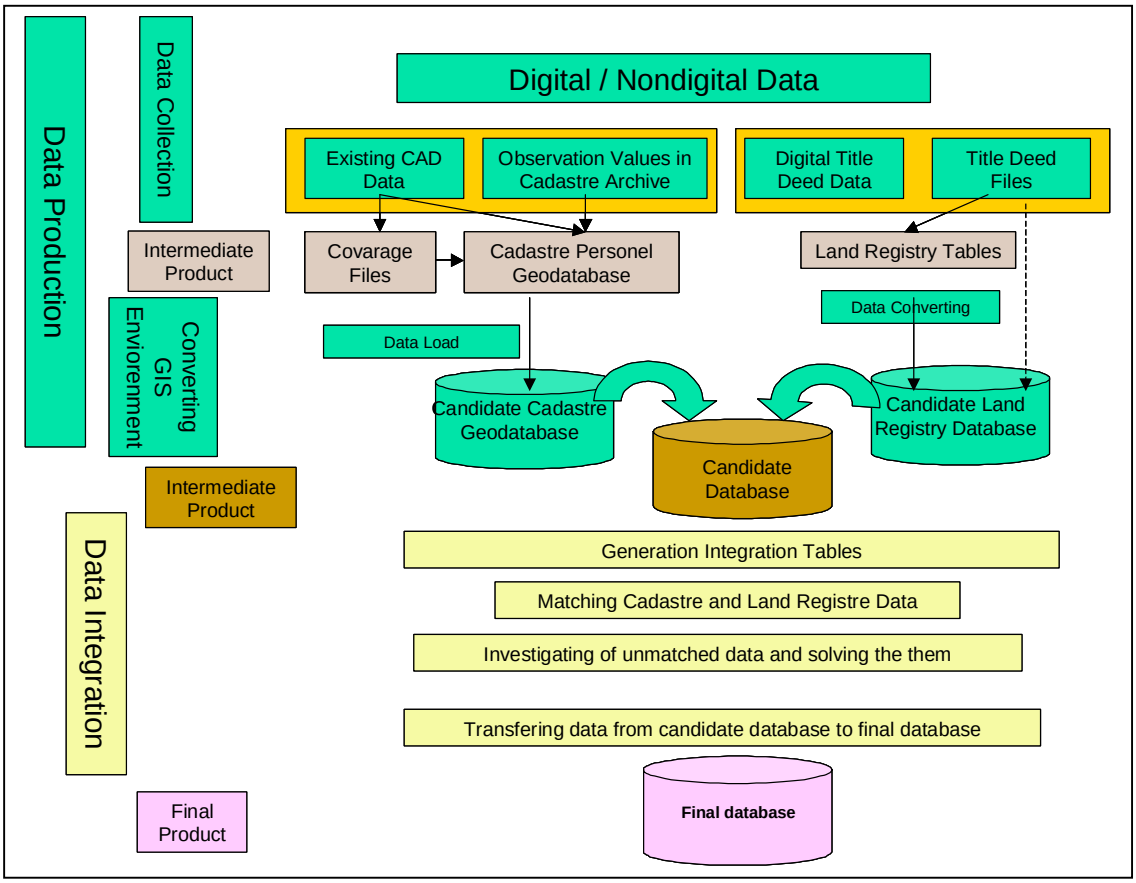

Figure 5: Data collection and integration mechanism in Turkish Cadastral System

3.4 Data Presentation via Internet

Cadastral data can be used by external users via internet. There are many external users of Cadastral data Figure 6.

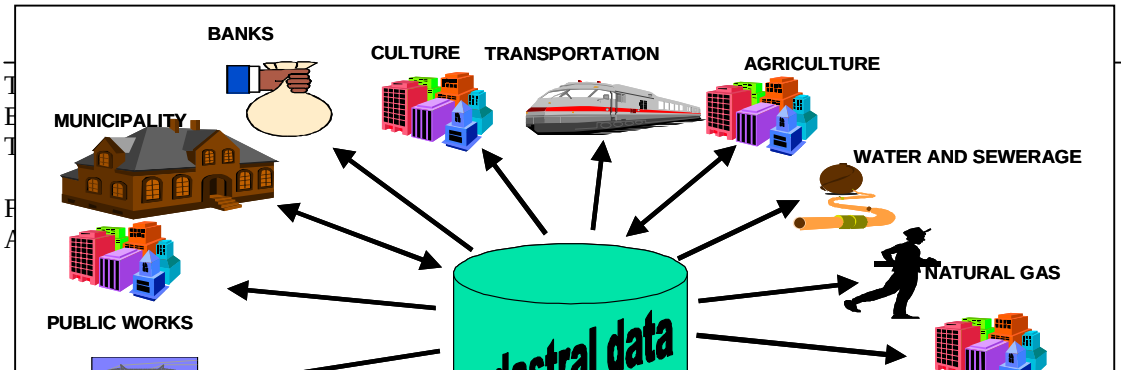

Figure 6: External Users of Cadastral Data

An external user should sign a protocol in order to have authorization for internet access of cadastral data. Specifications of data sharing are explained below:

- Standard zoom in, zoom out, pan, and information display functions are available
- Accessing and displaying data authority is limited to the owner.
- Query by attribute (by province name, district name, quarter name, block no and parcel no) is possible.
- Query by map sheet name in different scales (1:100.000, 1:50.000, 1:10.000, 1:5.000, 1:2.500, 1:1.000 and 1:500.
- Query by coordinate (box) extends
- Selection by map sheet index
- Exporting graphic and related non-graphic data in National Data Exchange Format
- Displaying Statistics of selected and exported data
- Calculating data purchase fee
- Loading converted data into the local machine.

4. CONCLUSIONS

Turkish Cadastral System is an integrated (Land Registry, Cadastre) information system. It is a vital project for the strategy and security of the country. It is a base system for many state users. It covers all activities carried out in the GDLRC, Regional Directorates (25), Land Registry (1003) and Cadastral (325) Offices.The project aims to generate the basic data of all kinds for the projects based on spatial (map) data in the standards of the Geographic Information System. Project objectives include:

- to provide accurate, valid and reliable land information required by land and land – related activities and decision markers

- to transform land registry and cadastral survey works and information into a multi – purpose land information system
- to plan, manage and activate the services of the organization in a better, quicker, more reliable and more effective manner
- to ensure that the data given to other institutions and organizations are used more broadly.

The system is based on variety of GIS standarts (OGC, FGDC / ISO, FGDC Metadata Content, ISO Metadata Content) and IT standarts (XML, Web Services /ArcXML), SOAP, HTTP, Open DBMS (Spatial types in Oracle, DB2, Informix,SQL/Server), Open Programming (C++, COM, JAVA, .NET), Open Platforms (Windows, Unix, Linux), Direct IS interfaces (SAS, SAP, Bentley, GPS, Image, Survey, Government Data formats, VPF, CAD, and more . . .)

It is possible to say that ”The basis of National Spatial Data Infrastructure for Cadastral System has been established in Turkey”. The main specifications of spatial data platform are provided below:

*Data safety***;** Data is stored in RDBMS environment and RDBMS backup facilities provides the safety. Data is managed centrally. Data access and usage rights are well defined centerally by authorized people. During the work proccess all data access and editing works are recorded by ArcSDE. At the end of a cadastral operation, a security report is generated for the manager in order to check what happened to the parcels which are related to the same job.
*Data Integrity***;** In the system, both geometric data integrity (topology) and the data matching integrity (spatial data and it’s tabular data) provided.
Data consistency; Cadastral data is stored in a continuous database. It is not possible to store a duplicate data due to defined rules. Most of the spatial and tabular data are matched. Unmatched data are reported to administration for fixing.
Data efficiency; Within the content of pilot area, the size of the cadastral data reached to 2 GB. ArcSDE check-out and check-in mechanism is very useful for the performance. During the distribution of the system to the whole of Turkey, it is estimated that the volume will reach 150-200 GB. Replication mechanism should be used in the future.*Data Sharing;* The most important characteristic of the system is the central management of data and sharing by many users. During the cadastral automation process, data sharing is provided for internal users by ArcSDE and for external users by ArcIMS, for accessing, querying and downloading.
Data Currency; The Cadastre Automation System is generating current data automatically. All the data which are generated after the system establishment is kept current. During the system establishment the old data have been transferred to the system. The improvement of the data is a big process and it will take long time. It will improve during the requested operations.

A general evaluation of the future of Turkish Cadastre System Project is presented below:

- Since all the data will be stored in the central database, data safety will be ensured, and regular backup of the data will be possible.It will be easier and faster to access and use

the data. Data in the archives will be transferred into computer environment, and necessary relations will be established. As a result, both procedures will be conducted faster.

- It will be possible to prevent damages to the original documents in the archives.It will be possible to standardize the activities throughout the organization by means of the application software developedThe external and internal exchangeability and sharability of the data produced will increase, because of standardization.“Asset investigation procedures” will be directly and immediately processed, because the data are stored centrally.Work loads and performances of a directorate staff will be monitored by both the director and by higher level management.By setting up required safety mechanisms, all citizens will be allowed to access updated data (related to their real estates, to understand title deed procedures and how to carry out them, and to learn the amount of taxes and fees, without personally going to Directorates)
- All applications will be based on “procedures”. (Operator, name of the procedure, time of the procedure, stage of the procedure etc. will be registred dynamically after the procedure has started.)
- Demands of courts, municipalities, and contractors will be met rapidly and accurately.It will produce Decision Support functions and reports for the Regional Directorates and the General Directorate by use of such centrally generated information.There are some weaknesses of the system and it should be completed.
- At the moment, cadastral data is living with its weakness of accuracy, currency and quality. In the future, data improvement proccess should be taken as an important project, which will be planned and solved in a specific time by the Cadastral Organization.
- Data quality should be classified and processed in accordance with its level of quality.
- Data should be enriched with other data, like value of parcel, tax value and land use in order to establish a multi purpose cadastral system.
- Cadastral organization should be reorganized in accordance with the system. Personnel quality should be increased by training.
- The body of current laws and regulations should be improved in accordance with the technological developments.

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ESRI, System Design Book

ESRI, ArcSDE Architecture Book

ESRI, Spatial Data Infrastructure Course Documents

ESRI, Modeling Our World Book

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War Academy	1976-1980	Military Education, Basic Land Surveying	
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Yıldız Technical University , Geodesy Photogrammetry Engineering-Cartography Branch,	1988-1990	Subject of M.Sc. Degree Thesis: Geographic Database Design	M.Sc. Degree
Yıldız Technical University , Geodesy Photogrammetry Engineering-Cartography Branch,	1994-1998	Subject of Ph. Degree Thesis: Production of 1/50.000 scale maps from 1/25.000 scale maps through Computer-Aided generalization	Ph. Degree,

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From 1990 to 1993, he worked as engineer for private surveying office.
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