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# Development of Cadastral Information System Using Geographical Information System (GIS): A Case of Tepi Town, South Western Region, Ethiopia

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**Abstract** The efficient and effective administration of land and its associated resources depends upon the availability of good land information. Many countries are computerising their cadastral records and creating large, national databases. Land-related data are now being integrated, analysed, and distributed in ways that until recently were not possible. In the study area, the existing land management system is carried out in analog format; fully conventional way. Therefore, the purpose of this study is to conduct cadastral information system in GIS environment for the betterment of land management system in the Town. To do this, a detailed GIS-based approach was used to build a geodatabase of spatial and non-spatial data of the study area. The spatial data were added using coordinate geometry (COGO) in GIS environment. The non-spatial data was encoded using key board entry method in Arc Map environment. Then, Graphics were linked with non-spatial attributes data base. Similarly, spatial and non-spatial queries were performed in GIS environment. Some of the operation was, query at owner name, land acquisition type and population density As a result, GIS –based digital cadastral map of Tepi town was produced. The paper revealed that, the system will provide reliable and easy system for collecting information, analysis, retrieval, and monitoring trends pertaining to any particular plot of land which is invaluable for efficient land management in the study area.

***Keywords:*** *Cadastral Information System, GIS- based, spatial and non-spatial data, land*

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## 1. Introduction

Most human activities and developmental efforts are based on land. Therefore, a systematic record of land and rights in land are vital for public administration, planning, land development and private transactions in land. However, the ever-growing world population and increasing pressure on both natural and manmade resources renders critical the need for land information as a basis for managing and exploiting the land resources in a sustainable manner. This has brought about a transition from communal or customary law based land tenure systems to statutory law based systems such as freehold.

According to [1] suggested that, without adequate up-to-date land information it becomes difficult to implement planning, development and exploitation projects of such resources sustainably for the betterment of communities. Land is undoubtedly one of the most valuable resources of any nation and land information management forms an integral part of urban development. Likewise, the increasing growth in rural population and the massive migration of people to the cities (especially in the developing countries) have put increasing pressure on rural and urban lands [2]. Therefore, a systematic record and rational use of the land should be of prime importance to planners and policy makers.

According to the International Federation of Surveyors [3] defined cadastre as: "a parcel based and up-to-date information system containing a record of interests in land (e.g. rights, restrictions, and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of interests and ownership or control of those interests and often the value of the parcel and its improvements".

More succinctly, a cadastral system consists of collection, recording and storage of all information related to individual land parcels. Cadastral surveying is that which establish and record the location, boundaries of features thereon and ownership of land and property. This is one of the data sources in Geographic Information System.

According to [4] explained that, GIS is a system for capturing, storing, manipulating, analyzing and presenting geographically referenced data. It is a multidisciplinary concept because it cuts across virtually every profession. They, however, stressed further that basically a GIS consists of a set of tools that professionals in various

disciplines use to improve the way they work. GIS allow many different types of data to be geographically viewed, organized and analyzed. This information can be used to computerize Cadastral register.

# 2. Methodology of the Study

## 2.1. Materials Used

In this study, different materials such as hardware's and software's were used to achieve the objectives of the study as indicated Table 1.

**Table 1. List of materials**

| Hardware | | | |
|---|---|---|---|
| No | Name | company | Purpose/for |
| 1 | GPS | Trimble | collecting parcel data |
| Software | | | |
| 2 | Trimble business center (2.1.0 ) | Trimble | Downloading the collected data |
| | AutoCAD (version 2007) | Autodesk | Plotting and exporting data into GIS environment |
| | ArcGIS (version 10.5) | ESRI | building geo-database and make analysis |

## 2.2. Methods

### 2.2.1. Source of Data

This section focused on the methods and data's required to analyze and evaluate the existing and present approaches of land management system using GIS software to come up with the right solutions for the improvement of poor delivery service. The main data sources for this study were both primary and secondary data source. The primary data was gathered through questionnaire's, interviews and field survey on the other hand secondary data was obtained from written documents such as tepi town research papers, books, booklets and other publications as tabulated in Table 2.

**Table 2. List of data sources**

| No. | Item | Data | Source | Purpose/for |
|---|---|---|---|---|
| 1 | Primary | spatial data | Ground survey | Plotting the parcel data |
| | | Road data | Ground survey | Showing the types of road |
| 2 | Secondary data | Attribute data | Field booking | Describing for each parcel data |
| | | Boundary data | Tepi town municipality | Delineating the study area |

### 2.2.2. Data Preparation

After gathering all the necessary data, the first requirement was preparing the data for further analysis. Therefore, the study used the above mentioned tabulated data to achieve the objectives using GIS techniques. The spatial data was gathered using Trimble GPS including parcel and road data of the study area. Then, the collected data was downloaded using Trimble business center application in the form of excel csv extension file format. Moreover, the downloaded data was imported into Auto CAD environment for the purpose of plotting the parcels of the study area. The plotted data were converted into Arc GIS environment using arc tool box/conversion/to geodatabase tools to link the spatial and non- spatial data. Shapefiles were created (parcel, road and boundary) in Arc catalogue packages to form spatial database. A table automatically created by the ArcGIS software for the formation of attribute database, the table was edited by deleting unwanted fields and creating new ones where the attribute information were entered thus forming the attribute database.

The attribute data are information about the plot owner, such as names, address, sex, occupation, date of acquisition, plot ID etc. obtained from oral services and social surveys in door to door conducted through interviews on the tenants.

The two databases were linked together by identifier number to form a land information system of the study area. Queries were generated to test the efficiency and effectiveness of the system.

Finally, GIS based digital cadastral map of the study area was prepared as shown the model of the methodology in Figure 1.

# 3. Data Analysis, Results and Discussions

## 3.1. Data Analysis and Results

The study on the development of cadastral information system at Tepi town was carried out by performing spatial and non-spatial queries in GIS environment. In this study the factors necessary for cadastral information system were reviewed and incorporated with ground survey, an interview with tenants and municipality.

According to [5] stated that, queries were generated for retrieval and displaying of parcel information. By the help of this system, different analysis was performed by generating queries from the database table with the use of selection tool in Arc Map environment.

### 3.1.1. Spatial Query Analysis

According to [6] Stated that, spatial queries are always performed based on spatial data. According to his explanation, spatial data (see Appendix A) play a vital role for the building of geodatabase as well as for spatial queries to get answers quickly that are otherwise very difficult or take a lot of time to figure out.

In this study, Identify Tool is used to identify the parcel information and its description. This was done Select the tool from the 'Tools' toolbar/Identify and click on that parcel which attribute user wants to view. Automatically a dialog box will be open in the center of the screen with all attached attributes and changing its color, so that it appears different from the rest.

Figure 2 below it shows that plot number 130 is highlighted and all attached properties are displayed.

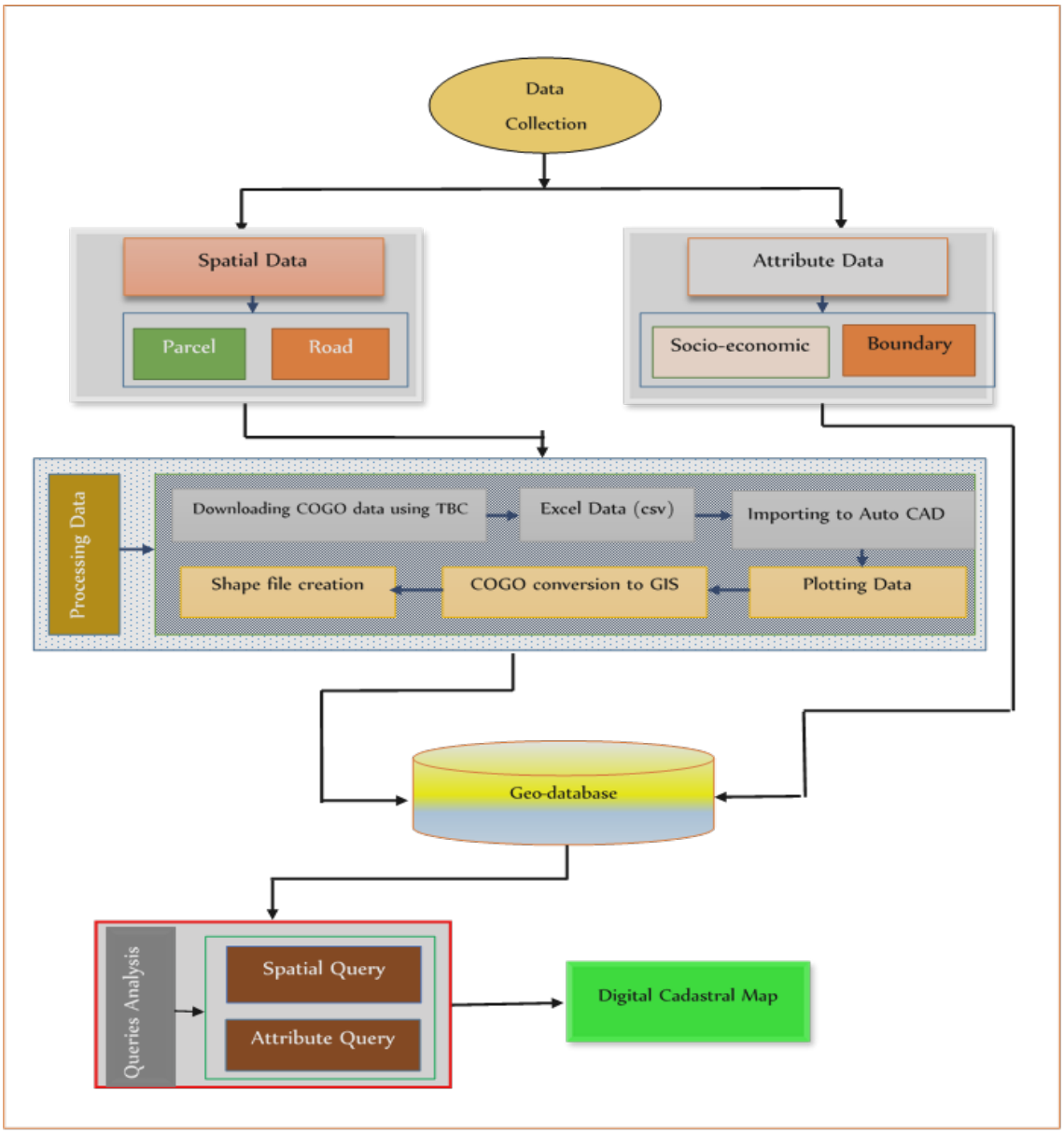


**Figure 1.** Technological schemes of cadastral map of Tepi Town

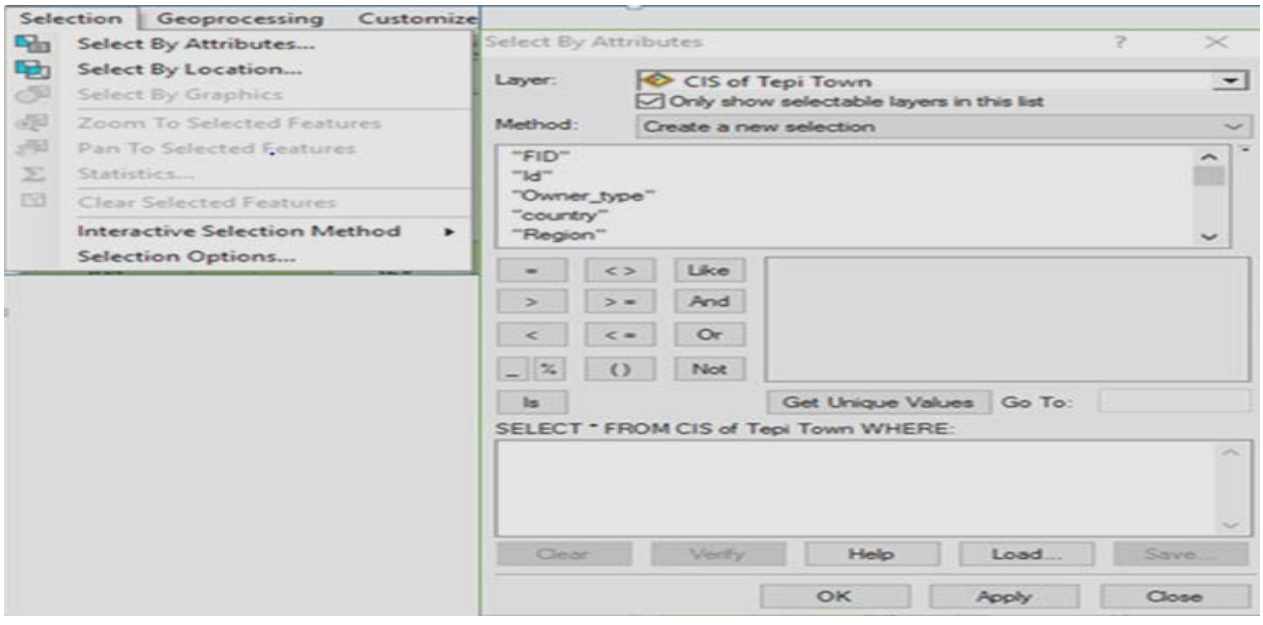


**Figure 2.** Shows the Parcel data and its information of part of Tepi Town

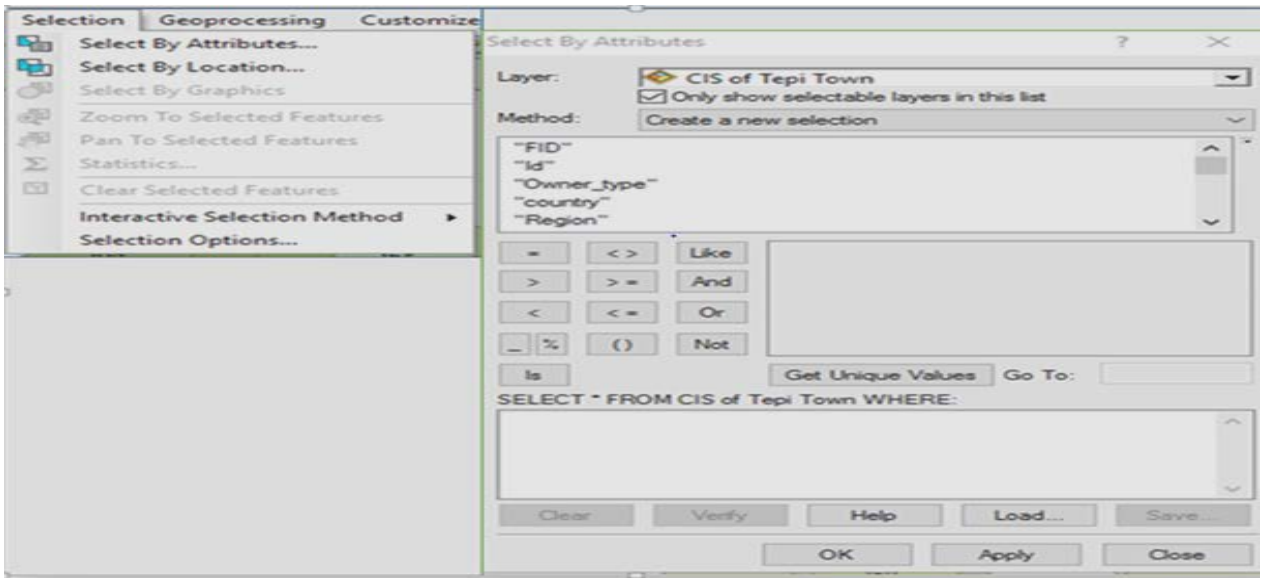


**Figure 3.** Shows Select by Attributes dialog box in ArcMap

### 3.1.2. Attribute Query

Attribute queries ask for information from the tables associated with parcels in Arc Map environment. It can be numeric values, text strings, Boolean values (i.e., true or false), or dates.

This kind of query is similar to a query made to any database; however, when using a GIS, the answers (i.e., the features related to the records selected by the process) are highlighted on the map as well as in the table.

The Select by Attributes dialog box in ArcMap helps to generated different queries by presenting the values and SQL operators available in the database as indicated in the Figure 3.

#### 3.1.2.1. Attribute Table Creation

The table for the parcel was automatically created when the parcel file was imported into the Arc Map environment. Consequently table creation here involved editing the table for the parcel so created. Editing involved deleting unwanted columns automatically created by the Arc Map package and creating columns of interest. The column of interest are those attribute information that were obtained through interviewing such as owner address, owner name, occupation, plot number, parcel address, land use type, date of acquisition, type of acquisition, etc.

#### 3.1.2.2. Populating Density Query

According to this study, however, the population size and the area of land of the study area is 1415 and 0.212058 square km respectively. Therefore the density of population in the study area was computed using the formula Population Density = Number of People/Land Area. Accordingly, around 6673 people per square kilometer is living in the town. Figure 4 below illustrates population query from family size table where the population size is greater than or equal to five.

**Table 3. Shows the attribute table of a parcel of part of the study area**

Table

CIS of Tepi Town

| Lot_No | Owner_Name | Adress | Occupation | Work_place | Lnd_acq_ty | Lnu_use_ty | Area_m | Fam_size |
|---|---|---|---|---|---|---|---|---|
| 147 | Ali Kassa | Tepi | Civil_servant | sheko | Municipal | Residential | 235.42999 | 6 |
| 53 | Ali Musa | Tepi | Serve in Mosque | Tepi | Free_hold | Residential | 304.64001 | 4 |
| 62 | Amane Abache | Tepi | Preist | Meti | Purchase | | 323.68701 | 0 |
| 83 | Anduallem | Tepi | Civil_Servant | Tepi | Purchase | Residential | 267.112 | 1 |
| 45 | Aschalew | Tepi | Merchant | Tepi | Purchase | Residential | 460.96301 | 2 |
| 58 | Atinaw Agegnehu | Tepi | Civil_servant | Tepi | Municipal | Residential | 326.56699 | 4 |
| 49 | Ayalu Asefa | Tepi | Farmer | | Purchase | Residential | 742.08301 | 2 |
| 70 | Degu | Tepi | Merchant | Tepi | Purchase | Mixed | 382.306 | 4 |
| 179 | Degu Ligidi | Tepi | Civil_servant | Tepi | Municipal_service | Residential | 310.73101 | 3 |
| 142 | Dejen Mulatu | Tepi | Civil_servant | Tepi | Purchase | Residential | 315.686 | 4 |
| 60 | Derbew Kebede | Tepi | Civil_servant | Tepi | Purchase | | 275.01199 | 4 |
| 176 | Diriba Olijira | Tepi | Teacher | Tepi | Purchase | Residential | 353.461 | 4 |
| 44 | Etagegn Molla | Tepi | Merchant | Tepi | Free_hold | Mixed | 449.797 | 3 |
| 96 | G/Egziabhere | Tepi | Merchant | | Municipal | Mixed | 384.16 | 3 |
| 144 | Garibo Gebito | Masha | Civil_servant | Masha | Municipal | Residential | 253.13499 | 4 |
| 97 | Getachew Tesfaye | Tepi | Civil_Servant | Tepi | Municipal | Residential | 386.052 | 4 |
| 173 | Getahun Ali | Tepi | Merchant | Tepi | Purchase | Residential | 353.104 | 4 |
| 92 | Hagos Asefa | Mizan | Civil_Servant | Mizan | Purchase | Residential | 278.86301 | 7 |
| 72 | Haile | Tepi | Farmer | Tepi | Purchase | Mixed | 304.211 | 5 |
| 171 | Kassahun Yibro | Tepi | Farmer | Tepi | Purchase | Residential | 277.327 | 5 |
| 59 | kedir Seid | Tepi | Merchant | Tepi | Purchase | | 291.08099 | 6 |
| 47 | Menglstu Abebe | Tepi | Merchant | Tepi | Purchase | Residential | 287.22198 | 6 |
| 54 | Misikir Alnegash | Tepi | Merchant | Tepi | Purchase | | 252.714 | 3 |

(30 out of 577 Selected)

CIS of Tepi Town

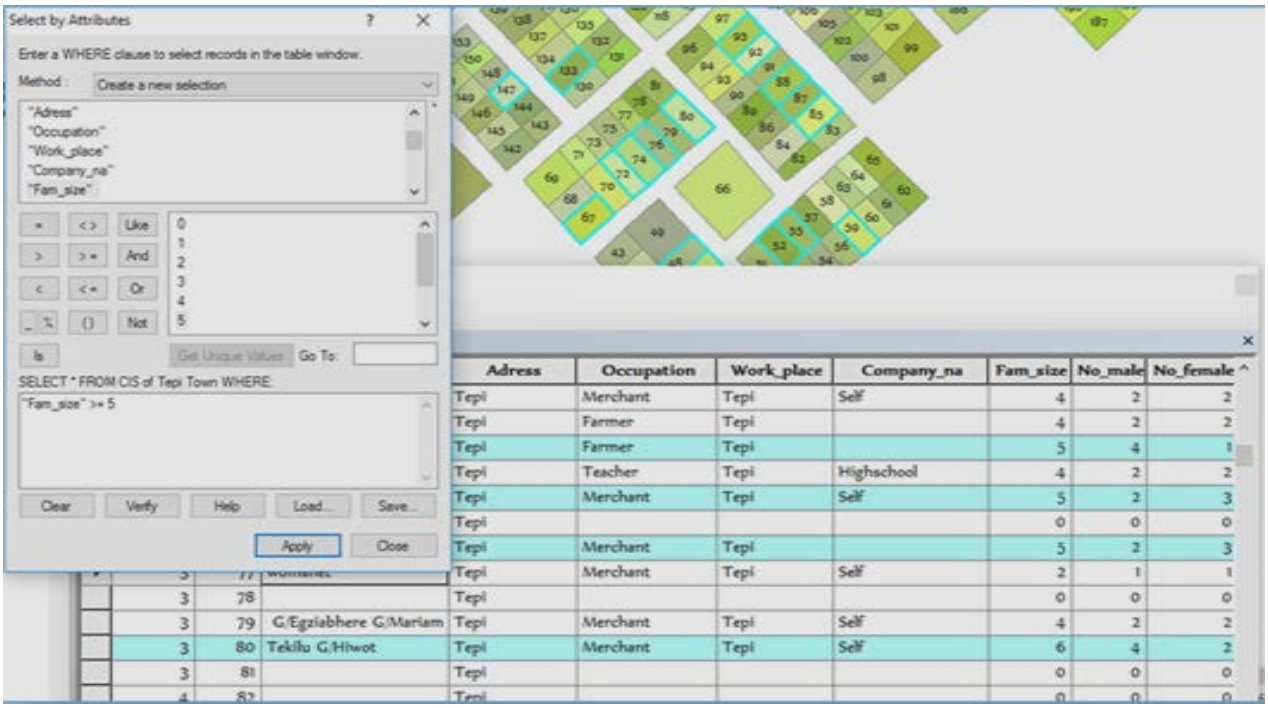


**Figure 4.** Query result having family size above five (shaded in blue colour)

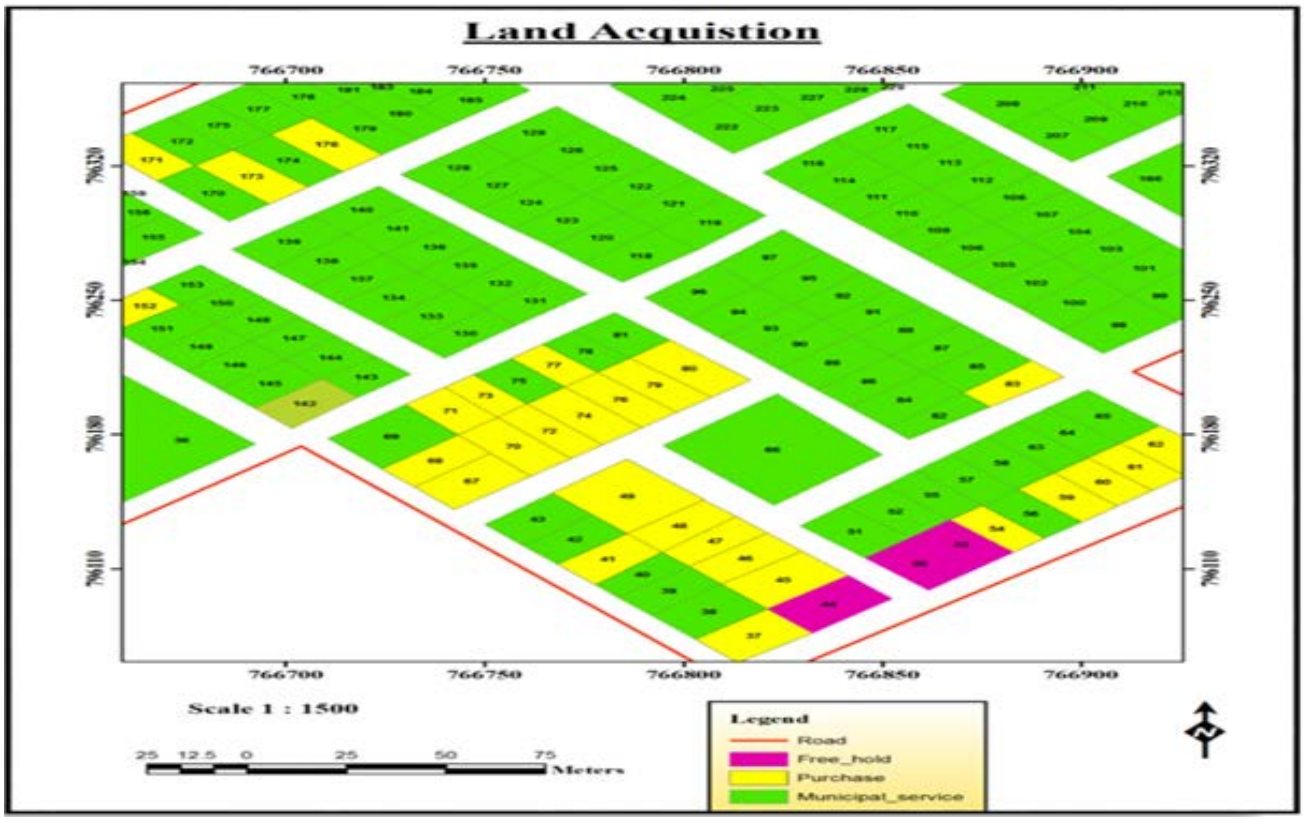


**Figure 5**. Query at land acquisition type

### 3.1.2.3. Query Based on Land Acquisition Type

In the study area, the Land was given by free hold, Municipal service, and purchase from tenants. Around 75% of the parcel was given by municipal service and the remaining 15% and 10% was given by purchasing and free hold respectively. Figure 5 shows the land acquisition type of the study area retrieved by using select by attribute query language.

### 3.1.2.4. Query Based on Owner Name

Figure 6 shaded by yellow color below Shows the owner's property and its detail information description including the coordinates of the owners' property. Using the selection tool/select by attribute/owner name/=/get unique value/Tadesse Getye /apply/ok was retrieved in GIS environment.

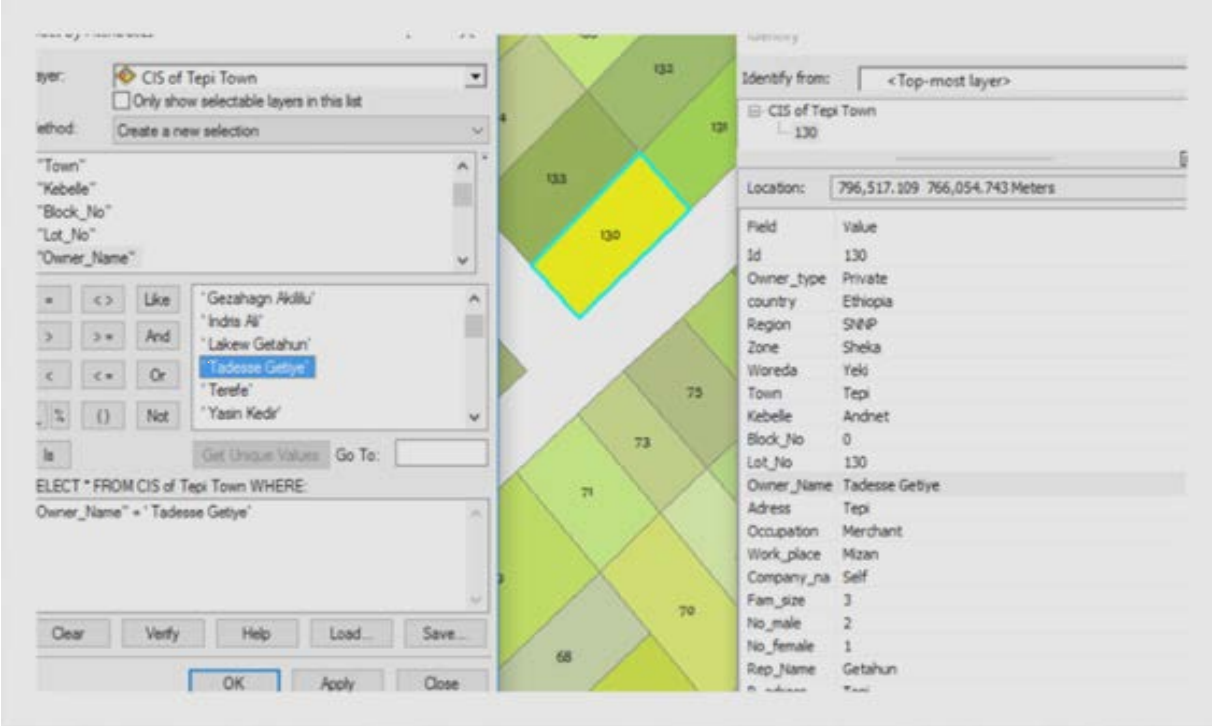


**Figure 6**. Query at Owner Name of the Study Area

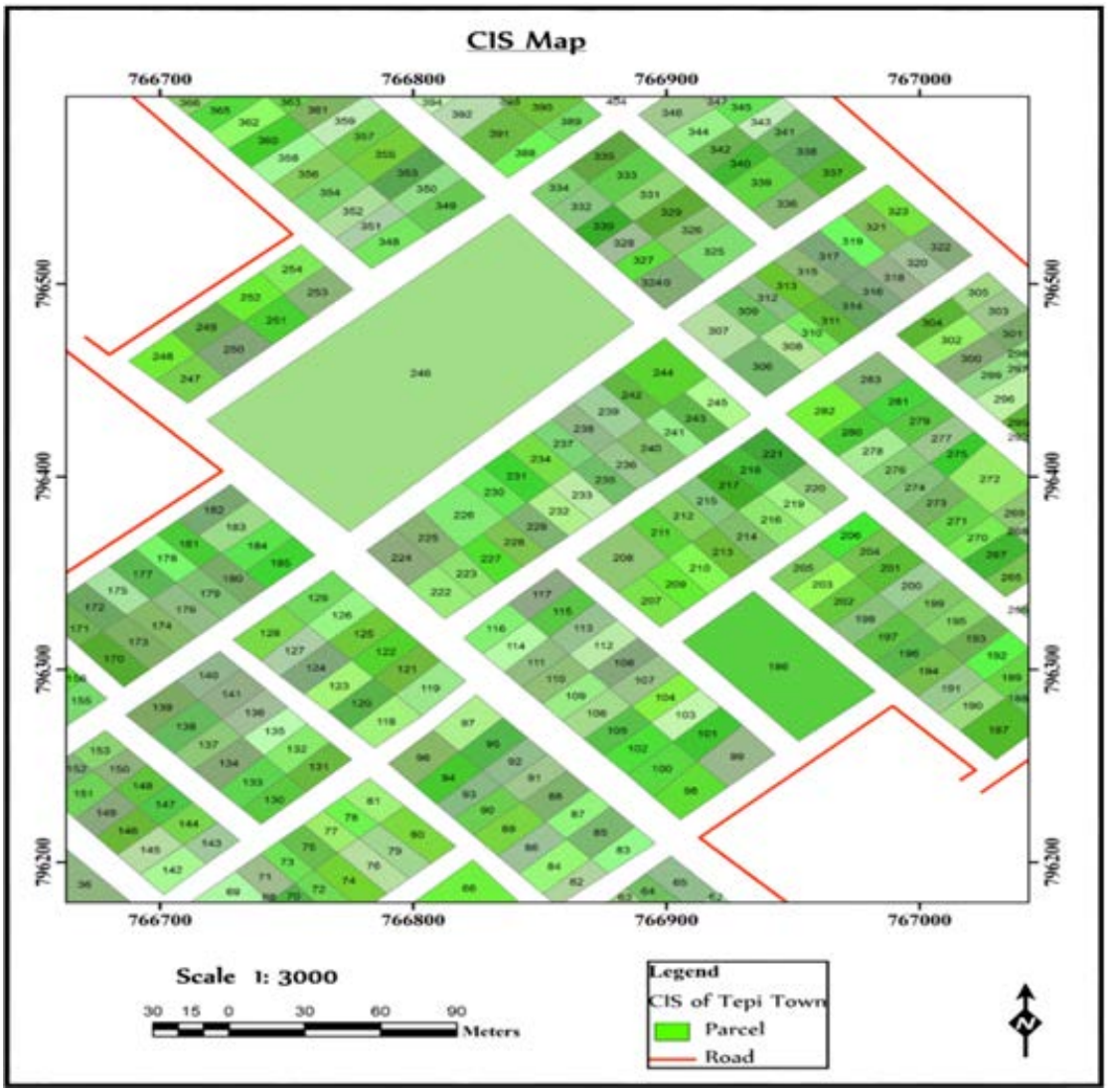


**Figure 7**. Digital Cadastral Map of Tepi Town

#### 3.1.3. Digital Cadastral Maps

A parcel based Cadastral Information System for the study area was created including all parcels in their appropriate geometric representation. Each parcel polygon should be attributed with a unique parcel identifier and bound by blocks. It also shows the road networks and the boundary the study area as illustrated in Figure 7.

### 3.2. Discussions

The study has demonstrated that, cadastral information system is capable of producing an accurate computer-aided cadastral map. It has also demonstrated that CIS can cope with large volume of spatial and non-spatial data. Prompt and accurate decision taking on land matters which are some of the vital ingredients necessary for any economic development of any organization was fully enhanced. Implementation of an automated cadastral information system will go a long way in helping the relevant authorities charged with the responsibility of handling land records more efficiently. This CIS has also given the authority an opportunity to make some typical analysis in the assessment of land use, as well as building code violations; the sale transaction of a particular parcel or for the whole block; and the assessment of property for issues of planning permission. Finally it can also serve as an interactive means of land information for immediate and ready extraction of plot-wise details through the multi-query facility that was provided in the database which allow any individual user to gather information regarding land holding.

## 4. Conclusions

Land is a major resource for economic activity in third world countries. Good land governance is a pre-requisite to sustainable development which ensures proper resource utilization and a land heritage for future generations. The following conclusions were made based on the findings:

A digital cadastre can aid in achieving this goal through improving the efficiency and effectiveness of the cadastre and the execution of land management system to propagate the switching from analogue system of storing, assessing and retrieving cadastral data.

The study concludes that, however, spatial and non-spatial queries were successfully conducted for the accomplishment of the study. Spatial data queries were performed by applying identify tools whereas the non-spatial data queries were executed by using the select by attribute of the database.

The study revealed that, 212058 square meters or around 21.2 ha (21%) area of total town coverage was discovered in the study. Therefore, different land use land cover types were incorporated to develop the cadastral information system. Residential 17.2 ha, mixed (residential and commercial) 1.8 ha, recreational and green areas 1.0ha and the rest 1.2 ha was used for different activities like religious and for different governmental and non-governmental activities.

The result also confirmed that, GIS is a powerful tool for collecting, storing, retrieving transforming and displaying spatial data from the real world without loss the data. The system is so versatile in applicability where information on cadastral plots can easily be stored and retrieved by querying any plot of interest.

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