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Preparing Cadastral Map Databases for Mosul District

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Abstract

Investigates the development and implementation of digital cadastral map databases for Mosul District, Iraq, addressing the transition from traditional paper-based systems to modern geospatial technologies. The research explores the integration of Geographic Information Systems (GIS), remote sensing, and Global Positioning System (GPS) technologies to enhance cadastral mapping processes.

Encompass data collection from diverse sources, including high-resolution satellite imagery, aerial photography, and existing cadastral maps. A comprehensive analysis of data types—vector, raster, Triangulated Irregular Network (TIN), and tabular—is conducted to establish an optimal database structure. The study delineates the technical capabilities of GIS in data processing, spatial analysis, and model preparation, emphasizing the importance of data accuracy and consistency.

A systematic approach to data entry, including map scanning, georeferencing, and digitization, is presented. The research outlines the creation of a multi-layered geographic database, incorporating both spatial and descriptive data. Protocols for database updating using satellite imagery and field surveys are developed, ensuring the currency and reliability of cadastral information.

The results demonstrate significant improvements in data management, spatial analysis capabilities, and information accessibility compared to traditional methods. The study concludes that digital cadastral databases offer enhanced decision-making support for land administration and urban planning in Mosul District.

Contributes to the body of knowledge on modernizing cadastral systems in developing regions, providing insights into technological integration, data standardization, and the challenges associated with transitioning to digital cadastral management systems. The findings have implications for policy makers and land administrators seeking to implement similar systems in comparable urban contexts.

Keywords *Cadastral mapping, Geographic Information Systems, Remote sensing, Database management, Spatial analysis, Mosul District.*

1. INTRODUCTION

The goal of establishing a geographic database is to implement advanced technology, means, and standard criteria that will lead to the efficient and effective use of both geographic information systems data and services. Therefore, when institutions and organizations establish a comprehensive geographic information system, users of this data from different departments can devote themselves fully and increase the time required to perform the required analytical tasks on spatial data while reducing the time and effort to search, collect, and integrate the data required to carry out those tasks.

Geographic information systems techniques have demonstrated other dimensions to the concept of spatial databases with spatial and query linkage of information, which in turn have become one of the primary sources of geographic data in building databases, mapping, and preparing models in the study of cadastral map updating. These techniques have relied on digital technology and continuously updatable maps to provide a clear picture of the changes that occur over time, as well as the contribution of various software in preparing the optimal model for updating cadastral maps. Therefore, this chapter has been studied according to the following important main axes:

The nature of geographic data for the study area.

1. The modern technical database structure for geospatial and descriptive data.
2. The main purpose of preparing spatial databases.
3. Digital map outputs for cadastral maps.

2. THE NATURE OF GEOGRAPHIC DATA FOR THE STUDY AREA

Cadastral maps are one of the maps that reflect the geographical distribution of land uses. Modern digital techniques in the field of maps and satellite images are important means in building and updating cadastral map databases, which concern the study of a specific topic in a specific period. This is due to the complete ability of these techniques to process paper maps and convert them into digital form that can be read by their coordinates. From this perspective, a set of these modern digital technologies has become a necessary tool used by planners to control data variables at a specific time and place. The inefficiency of paper maps due to their inability to determine the logical relationships between spatial map elements does not show its effect on any other logically related element. Moreover, the difference in the drawing scales of these maps is considered an obstacle in analysis and comparison work. Finally, the time in which spatial and descriptive data were taken is considered another obstacle. Therefore, updating thematic map data is considered a very costly and time-consuming process. Hence, the lack of an engineering planning approach to overcome these obstacles is the research problem that was relied upon in setting the foundations of the thesis and drawing its objectives in finding and adopting engineering planning methods that have efficiency and accuracy through relying on digital techniques. (Jassim, 19:2015)

This approach is summarized by adopting satellite image techniques with a discriminatory accuracy of less than one-meter, digital processing programs, geographic information systems programs, as well as the global positioning system navigation survey technology. The paper cadastral map of the study area is the main geo-spatial and temporal determinant of the study.

2.1 Data Sources for the Study Area

The most important sources of data collection, whether geographic or statistical, are:

1. Remote sensing, which includes: a. Satellite Images b. Aerial Photography c. Digital Elevation Models (DEM) d. Digital video photos e. Differential Global Positioning System (D.G.P.S)
2. Thematic maps: A set of maps that serve a specific topic such as topographic maps, vegetation cover maps, and land use maps.

2.2 Types of Data

The geographic database can be defined as several files linked together through the network distribution of information stored in GIS. This database contains logical data as well as data derived from satellite images.

The geographic database is defined as (a huge amount of coordinated and organized data stored in computer memory in a specific logical system and in a symbolic form that has special keys that allow searching for and retrieving the required data for use, developing it, and then returning it to its specified place in memory). (Abdel-Samad, 94:1988)

The degree of success in using any geographic database depends on the degree of linkage between spatial data and descriptive data. In general, GIS deals with the following main data:

1. **Vector data**

The linear model is one of the most common digital representation models for geographic data. Due to its simplicity and efficiency in employing it in various fields of geographic information systems, this type of information relies on the basis of simple analytical geometry as it uses the idea of orthogonal coordinate network as a main element in the model and representing any natural or human geographical phenomenon within this type with one of the following three elements:

a. **Points** are represented by a pair of coordinates (X, Y) and are used to represent the earth's surface whose dimensions can be ignored, such as the location of a well or a weather station.
b. **Line data** is represented by a series of coordinate pairs and is used to represent surface phenomena of the earth whose thickness can be neglected compared to its length, such as roads, rivers, and political borders.
c. **Polygons** are represented by a closed series of coordinate pairs and are used to represent surface phenomena of the earth that have specific dimensions, such as representing the dimensions of a lake, land use, or a specific land cover.

2. **Raster data**

These are systems that rely on representing data in the form of small square-shaped cells or areas called (pixels), which are often entered into the computer through scanner devices and include these data in maps and aerial photographs or ready-made digital files such as satellite visuals and have degrees of light intensity ranging between (0-255). One of its disadvantages is the constant resolution, which means the deterioration of image quality if it is enlarged to different scales, especially if the resolution is not high, in addition to its acquisition of a large space in computer memory. The location of the cell is determined by the row and column, as each cell is defined by a coordinate number in the row and takes a number in the column. According to this method, the set of points that make up the satellite image, which are in the millions, are stored inside the computer. (Jassim, 22:2015)

3. **TIN data**

Features are represented by a network of triangles connected to each other by nodes at unequal distances, which is an important method for representing surfaces in three dimensions.

4. **Tabular data**

Tables are usually used to express descriptive data (attributes) of geographic features. Tables may contain other non-geographic information but linked to geographic features present in the map document, such as names of house owners, customer addresses, salaries, and others. This data can be linked with geographic data, thus obtaining new and useful information in many applications. The table consists of a series of rows and columns, and each row represents a geographic feature such as land parcel boundaries, electricity pole, and others, and each column or field describes a specific attribute of that feature such as length, depth, cost, etc. (Al-Dwekat, 173:2000)

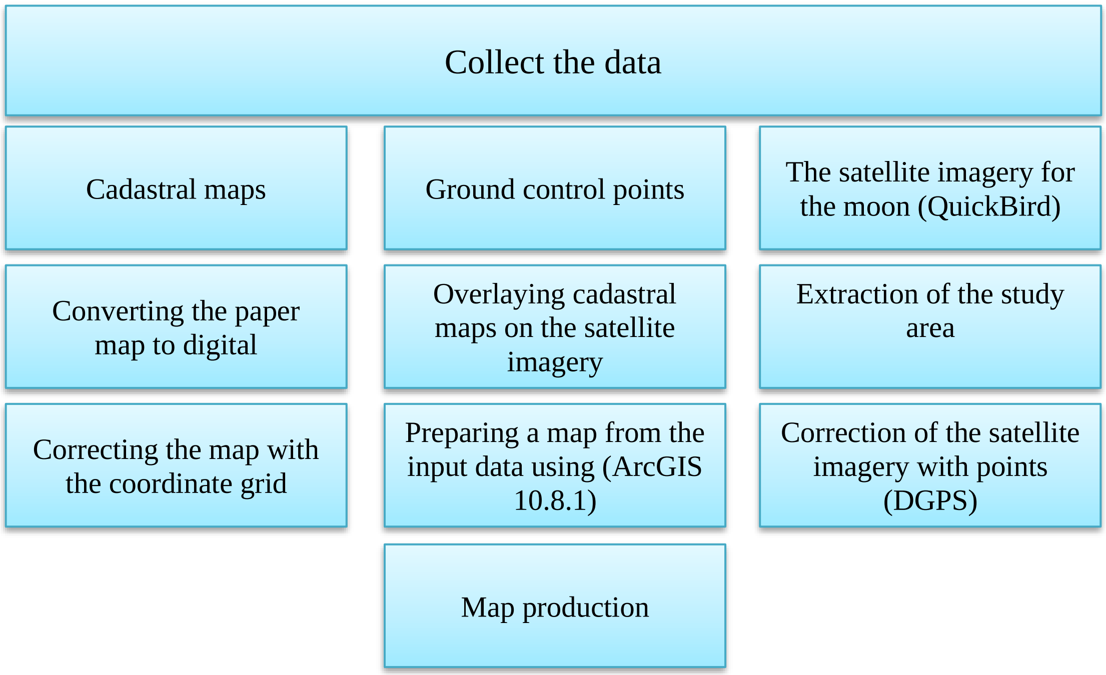

Table 1. Methodology of Work

3. THE NATURE OF GEOGRAPHIC DATA FOR THE STUDY AREA

The Solid Database Structure for Geospatial and Descriptive Data:
A database is an integrated or unified set of data on a specific topic. A geographic database is a set of geographic or spatial data about a specific spatial spot and a specific topic. The geographic database is considered one of the most important components of the geographic information system based on two factors:
First, the cost of creating and maintaining the geographic database.
Second, the impact of the nature of the geographic database on what can be applied in terms of analysis, modeling, and decision-making. (Dawood, 118:2014)
The corrected raster spatial data does not give any benefit in meeting the inquiry or spatial analysis using geographic information systems unless that raster data is converted into vector data (point, line, and area) for all features of the corrected raster map image using construction programs in the geographic information system, including (ArcGIS 10.8.1). This process is carried out by tracking thematic point features, thematic line features, and thematic area features and drawing them using approved cartographic methods. Consequently, during the drawing processes, descriptive databases will be prepared for each feature, thus converting the corrected raster data image into positional vector data based on its digital description and any data to be linked to the vectors. (Juha, 182:2016) All of this is done with complete reliance on the year of preparing the paper cadastral map as the basis for drawing what exists in the reality of the map area.
As for the process of updating both spatial and descriptive data, this depends on the availability of satellite visuals of the study area for the update year that achieves 80% of the study's validity, as well as the availability of the field survey mechanism that achieves 20% of the study's validity. (Jassim, 24:2011) In case this mechanism is not available, one

of the positioning methods is used using modern ground survey devices, which is the D.G.P.S global positioning technique, which is considered one of the methods of determining vector data starting from the point to the line that consists of two points and the area that consists of more than three points. Therefore, the updated spatial data coordinates are taken by satellite receivers and then converted to the map that was prepared from the corrected raster data image for the year of production of the paper thematic map and using one of the icons in geographic information systems programs. Then all descriptive data is filled according to the purpose of the thematic map and the drawing scale for the updated data, and thus we obtain spatial and descriptive databases for the current situation. (Juha et al., 183:2011) D.G.P.S positioning devices can also be used, which give accuracy in the work that is with the updated feature in the field and thus will save time and accuracy in converting the updated data to the computer.

3.1 Technical Capabilities Provided by the Geographic Database

GIS is considered the best technology entering the field of processing, analysis, and model preparation, as these systems have several software through which analysis, linking, matching, representation, and model preparation operations can be implemented for various phenomena and monitoring developments on them, especially spatial correction studies for maps, as it is known that cadastral maps are not spatially matched and not geographically referenced. Thus, this software can redraw and have the ability to delete, modify, and add (update) in addition to displaying the geographical phenomenon on GIS in a moving style, which traditional methods are unable to do (Xiuwa et al. 1999:56)

It is worth mentioning that the most important thing that distinguishes geographic information systems (GIS) programs is their analytical ability of information and data in addition to their participation with other systems in directly linking information to its locations on survey, geographic, or planning maps with the simplicity of modification and updating and converting data to spatial images in the form of maps. These are concerned with processing and determining several planning criteria, analyzing them with a set of graphical equations contained in the program with the possibility of linking with other systems programs such as engineering drawing programs, spreadsheets, databases, and image processing programs. Thus, we can summarize some of the technical capabilities provided by the geographic database through: (Al-Fallahi and Al-Alwani, 593:2016)

1. Preparing integrated geographic databases with base maps that can be updated and linked to an information network in all bodies and ministries concerned with development projects, in order to prevent duplication of efforts in entering information and ease of obtaining it.
2. The ability to perform topological correction, which gives accuracy in calculating adjacency areas and correctness of entry.
3. Preparing rural and urban land ownership plans for cadastral maps linked to administrative boundaries digitally to measure distances, lengths, areas, and determine locations for entered shapes point - line - and area (with all accuracy with the possibility of limiting these values).
4. The ability to store and display entered data separately in the form of layers for the possibility of modification, updating, and addition.

5. Searching and querying spatial and descriptive data can determine any type of information through asking spatial questions, which is spatial query or logical query.
6. Future prediction of urban, economic, and social variables by studying and tracking influencing variables and putting them in the form of planning models for temporal changes based on satellite images.
7. Analysis of dynamic phenomena of land uses, desertification, or degradation of agricultural lands according to the study of the impact of a number of variables, as well as the possibility of predicting the size and spatial direction of these phenomena.
8. Data updating: These programs provide an opportunity to update them, so if a change or update of the data occurs to prepare the map, this task could be carried out and at the same time, the previous data can be preserved and then cartographic comparison can be made to show the amount of change.
9. Storing and displaying entered data separately in the form of layers for the possibility of modification, updating, and addition.
10. Building a digital system for plots, sections, and administrative units with which all information and data can be retrieved for them and each region.
11. Building a digital system for land uses with which a relationship can be made between land uses and advanced spatial analyses can be performed.

The ability to prepare a model that analyzes data from more than one element and more than one layer at the same time.

3.2 Stages of Preparing Databases for the Study Area

3.2.1 Data and Information Collection Stage:

This is the initial stage in the preparation of the map and is linked to the type of map to be prepared. The preparation of climate maps and agricultural maps requires obtaining data and statistical tables, as well as base maps for the study area. In contrast, the preparation of cadastral and topographic maps, for example, necessitates surveying operations, either through traditional ground surveying methods or photogrammetry, or by using remote sensing capabilities via satellites. In this study, data collection was based on:

1. Pre-prepared maps from relevant authorities.
2. Remote sensing (satellite imagery).
3. Reports and studies.
4. Field surveys and on-site recording.

First - Pre-prepared Maps from Relevant Authorities:

1. Cadastral Maps:

Cadastral maps at scales of 1:10000 and 1:5000 was imported into the ArcGIS 10.8.1 software to delineate the study area boundaries, build an information database, and create an informational layer representing the area boundaries. Cadastral maps rely on natural or artificial landmarks with known features in the region, such as rivers, roads, wells, springs, and villages, among others. These maps are a crucial source of information and data. The database is a vital structure for Geographic Information Systems (GIS), representing essential processes for the success and continuity of work (Gong, P., Wang, L., Zhong, et al., 2015:193-206, Dronova).

Digital mapping is the process through which data acquisition, integration, and management are achieved in possible images. The primary use of this technology is to create maps that provide accurate impressions of a specific area, documenting fields and points of interest. The concept involves using digital maps to enhance accuracy, which has been recently amplified and linked with Differential Global Positioning System (DGPS) technology. Data represent samples pertaining to precise phenomena without originating their processes, so that data are stored, collected, and analyzed to serve the community. GIS relies on natural phenomena or spatial elements in nature and other attractions. Various landmarks are a key element in GIS, thus adding importance to the data when they are accurate and close to reality, and vice versa when the data are outdated and not updated, making it challenging to interpret categories with the help of data. The types of spatial data that can support this process are as follows:

- **Data Description Basis:** As per the legal meaning of land type, it is the natural, formative, or exploitative description of the land, such as agricultural land.
- **Road Data:** Public highways, subsidiary tourist highways, local road names, and others.
- **Churches and Other Places of Worship:** Documenting basic information regarding location, name, and all other relevant information.
- **Water Sources:** Documenting water resources like rivers and their tributaries, intersections near marshes, lakes, reservoirs, rainwater, tides, wells, springs, canals, streams, and other water sources.
- **Other Data:** For example, when discussing mountain ranges, data can include the length, width, height, slope, and nature of exploitation.

2. Topographic Maps:

The study area is covered by a topographic map at a scale of 1:50000, through which an informational layer for basic landmarks was created, identifying prominent site coordinates in the area. Additionally, some terrestrial features such as the water network and its channels were identified, as well as human phenomena such as settlements, transportation routes, irrigation channels, and land use patterns (see Figure 27).

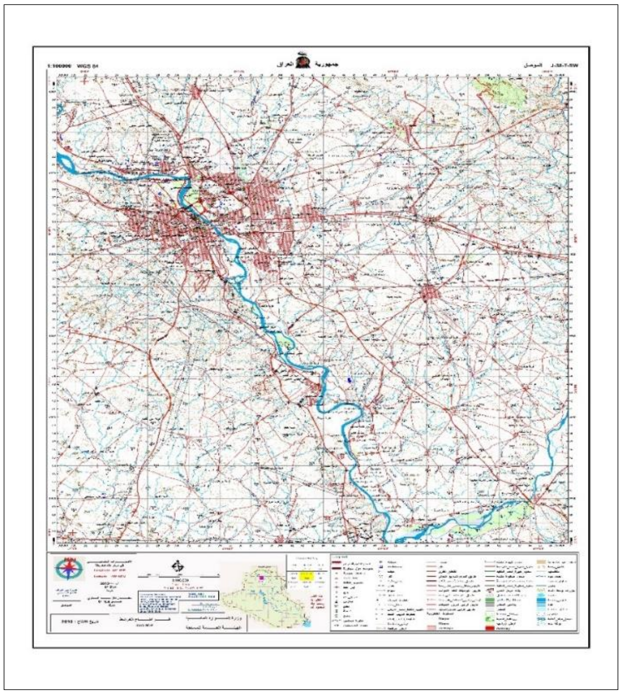

Figure 26 Sample of Topographic Maps at a Scale of 1:100000 for the Study Area (Ministry of Water Resources, 2015)

3. Administrative Maps

Administrative maps prepared by the General Directorate of Surveying at scales of 1:1000000 and 1:500000 were imported into the ArcGIS 10.8.1 software to delineate the study area boundaries and align them with the administrative boundaries of the cadastral maps.

Second - Satellite Imagery:

The study area was covered by a single satellite image from the QuickBird satellite for the year 2023, with a resolution of 30 cm × 30 cm in color. This image was imported into the ArcGIS 10.8.1 software to utilize it in mapping prominent features such as road networks and irrigation and drainage networks.

Third - Reports and Previous Studies:

Some studies may include information about the locations of landmarks, often provided as descriptive data. By attaching these data to the subject, the available descriptive data can be expanded and displayed in an independent topic.

Fourth - Field Survey:

To achieve high accuracy in interpreting the information obtained from the previous sources, thorough examination and verification are necessary. This is only possible through comprehensive field studies and surveys of the study area to compare the collected information with the actual conditions. Since satellite images are not geographically referenced, they need to be validated through field surveys. This was done through repeated field visits to the study area from October 1, 2023, to February 29, 2024. The site study is an important step in producing and updating maps. During the first visit to the study area, field surveys were conducted for each category of land use in the study site to determine ground control points for correcting the satellite image using GPS. Another visit was conducted after updating to review some features that might not be clear in the satellite image and to verify some names of features with the help of local administrations in the study area.

3.2.2 Data Input and Storage

The data input and storage phase are the first step in building a GIS and represents a crucial stage in the database after collecting information from various sources such as topographic maps, district maps, satellite images, and field studies for the study site. The data were verified to ensure scientific results when applied to the map. In the data input process, devices and software aids are used with a computer within one of the GIS systems (Al-Azzawi, 2000:359).

The principle of entering information into computer memory is based on the fundamental rule of converting information obtained from various sources from paper form (Hard Copy Analog) to digital form (Digital Form), so that the computer can read it and facilitate handling through several programs (Al-Saleh, 2004:105).

The study reviewed the key practical steps followed in data input, storage, processing, and output, along with the main devices and tools used in the study. GIS requires a number of high-performance devices to carry out its tasks efficiently. These electronic devices are fundamental elements in Geographic Information Systems (GIS) (Al-Azzawi, 2000:359). It is not possible to conduct various data processing operations without them. The key devices can be summarized as follows:

1. **Computer:** This is a crucial element in managing and operating GIS. The main specifications include:
    - A laptop (MSI SWORD 15 A12UE).
    - CPU: Core i7.
    - Operating System: Windows 11.
    - Hard Drive: 500 GB.
    - RAM: 32 GB.
2. **Color Printer:** PLOTTER-EPSON.
3. **Scanner:** COLORTRAC SMART LF SC 42.
4. **Software Used in the Study:**
    - ArcGIS 10.8.1: One of the most important scientific programs for managing GIS, produced by the global company Esri.
    - ERDAS IMAGINE 2015.
    - Global Mapper 25.
    - Microsoft Office 2022: This suite was used in the study for converting maps from ArcGIS 10.8.1 to JPG format for printing, providing ease of work and flexibility in printing methods.

4. REQUIREMENTS FOR PREPARING SPATIAL DATABASES

The orientation is summarized in the engineering computing work using physical devices and specialized software for digital technologies.

4.1 Stages of Work in Preparing Cadastral Maps

First: Converting ordinary paper maps into digital counterparts in the computer memory using a scanner and converting them into a raster system containing numerous pixels. These pixels only represent the notional values of light reflection from the features depicted in these maps. Therefore, these pixels do not carry true digital coordinate values. It is necessary to perform geometric correction and link these maps to their real-world locations using georeferencing. The paper maps are converted to digital format using a scanning device known as a transverse scanner for map conversion (Figure 28) (Juha et al., 2011:185).

Figure 27 The Digital Scanner

Second: Correcting the paper maps using the ArcGIS 10.8.1 system through the coordinate grid present on the map (Figure 29). This allows for drawing, taking measurements, analysis, and matching them with the satellite image.

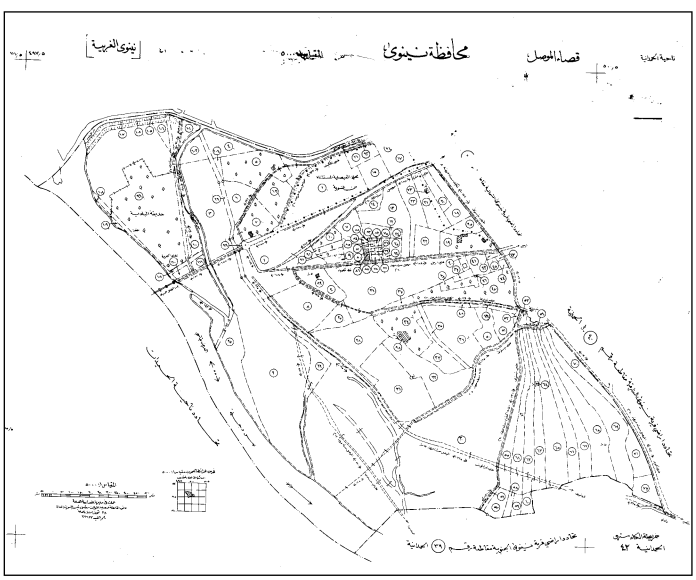

Figure 28 Georeferencing Maps (Ministry of Water Resources, 1954)

Third: Digitization of the map using the (ArcGIS 10.8.1) system by redrawing the map's content according to the type of feature, whether point, line, or area. The drawing process is organized in layers, allowing for the display of each layer individually or the display of multiple layers simultaneously. Figure (30).

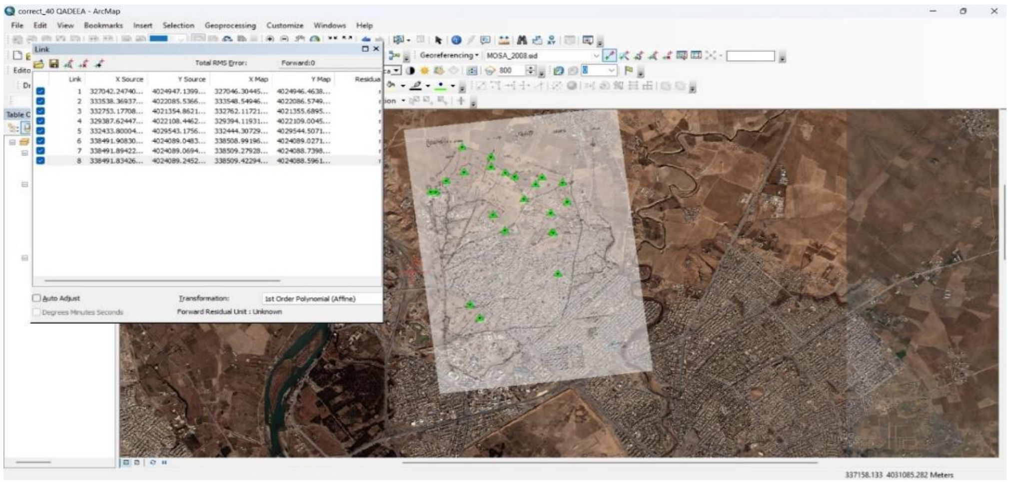

Figure 29 Digitization of Maps (software, (ArcGIS 10.8.1))

4.2 Stages of Preparing Satellite Images:

First: A satellite image from the American QuickBird satellite, captured on February 28, 2023, was used due to its high spatial resolution. Additionally, this image was used for matching and spatial correction using DGPS points. Figure (31).

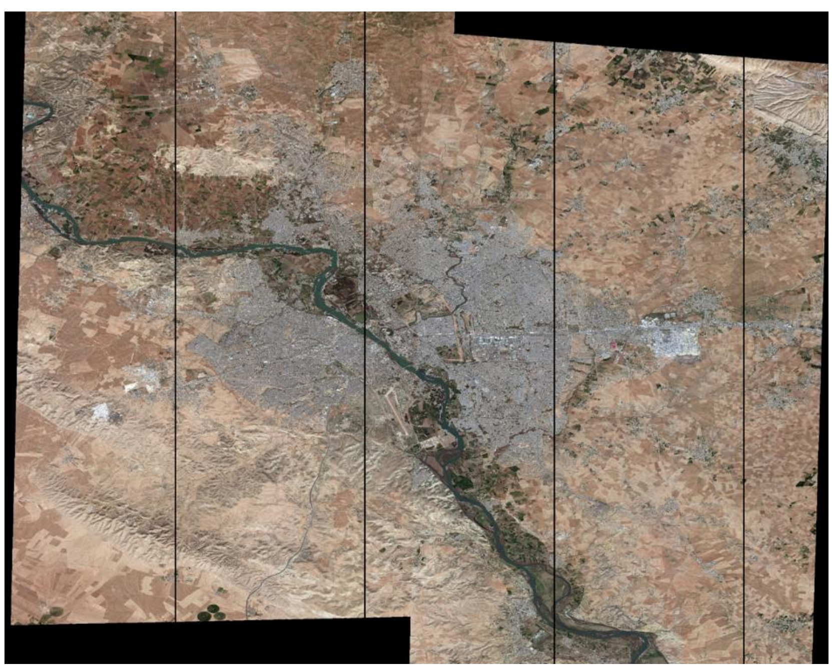

Figure 30 Preparation of Satellite Images (software, (ArcGIS 10.8.1))

Second: Geometric correction of the satellite images was performed using the ArcGIS 10.8.1 system and ground control points (D.G.P.S). The correction of the satellite images was based on the topographic map by taking thirty clearly defined points on both the map and the image, ensuring they have the same projection. Figure (32).

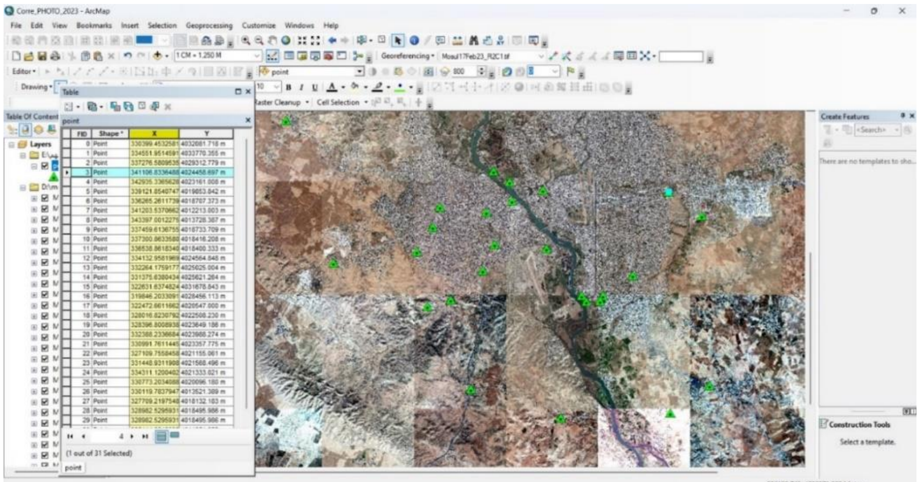

Figure 31 Geometric Correction of Images (software, (ArcGIS 10.8.1))

4.2.1 Workflow Steps

After scanning the map and performing geographic correction, as well as conducting enhancement and geometric correction of the satellite images and matching them, we proceed to input the data according to the following steps:

First: Select the transformation rank for the map along with the type of projection grid, reference surface, ellipsoid, and the longitudinal zone in which the study area is located. It is important to note that this stage heavily relies on the geometric basis of the inputs (reference surface and ellipsoid type) that will be used. Additionally, the final map's scale has a decisive role, particularly after implementing geometric correction based on a corrected satellite image, which is corrected according to the WGS84 reference surface and ellipsoid. Here, the longitudinal zone for the study area in Mosul District, which is longitudinal zone 38 north of the equator, was entered. The mechanism of this step is demonstrated using ArcCatalog, where files for the drawn map data of the three types (point, line, and area) are created, and the same geographic reference system as the satellite image (WGS_1984_UTM_Zone_38N) is selected. Figure (33).

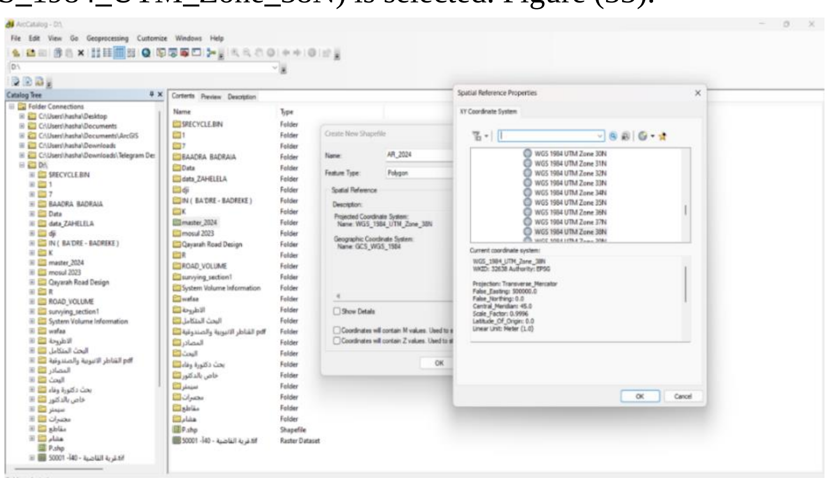

Figure 32 Selection of the Appropriate Geometric Model (software, (ArcGIS 10.8.1))

Second: Draw the data in its three forms: point, line, and area (and input the accompanying data separately, including number, name, classification, etc. as shown in Figure 34). After creating these layers, the Editor tool in the program is activated, and the type of layer to be drawn is selected, such as the layer for paved main roads. Then, all the main roads are drawn according to their location in the satellite image. Once the paved roads are completed, the unpaved roads are drawn in their respective layer. Subsequently, the drainage channels and residential units are drawn, and so forth, with the other features being drawn in their respective layers.

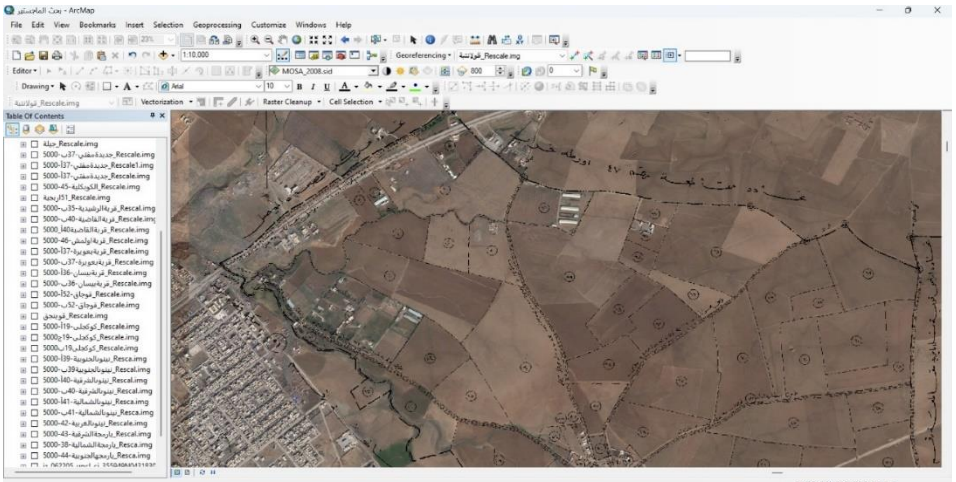

Figure 33 Data Entry (Numbering) (software, (ArcGIS 10.8.1))

Third: Compare all the data drawn from the map with the satellite image to identify discrepancies between the planned and actual features and extract the results, as shown in Figure (35). After opening the ArcGIS 10.8.1 software, add the satellite image through "Add Data" and also add the cadastral map that was scanned with high precision and saved in TIF format. Then, in Windows, go to "SEARCH" and type "RESCALE." This will open the RESCALE window. In the first window, enter the RASTER, and in the second window, specify the file path for the corrected file. Next, correct the X and Y coordinates by dividing the actual distance by the distance measured by the program. The linear scale is considered the known actual distance, and the measured distance is obtained using the TOOLS - MEASURE tool within the program. Use the Calculator for the mathematical division: actual horizontal distance / distance within the program. Enter the same result for X and Y. Additionally, rescaling can be performed using the Python language as illustrated.

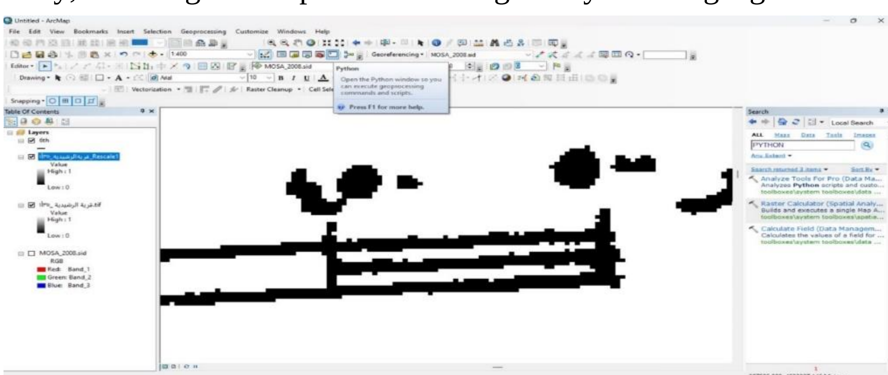

Figure 34 Scale Verification Using the Measure Tool (software, (ArcGIS 10.8.1))

This is a Python script sample for the Rescale tool.

```
##====================================
##Rescale
##Usage: Usage: Rescale_management in_raster out_raster x_scale y_scale

import arcpy

arcpy.env.workspace = r"C:/Workspace"

##Rescale a TIFF image by a factor of 4 in both directions
arcpy.Rescale_management("image.tif", "rescale.tif", "4", "4")
```

Figure 35 Python Script Sample for the Rescale Tool (software, (ArcGIS 10.8.1))

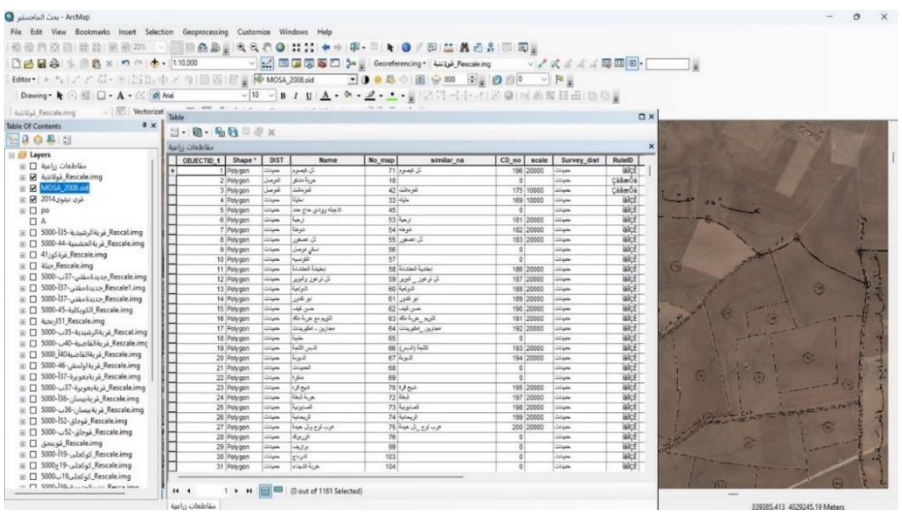

Figure 36 Drawing Data Results (software, (ArcGIS 10.8.1))

Fourth: Establishing a Geographic Database Using ArcCatalog

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A geographic database is established using ArcCatalog to accommodate all the data used in this study. This allows for linking any feature drawn to its specific database within the Attribute Table associated with the layer. For instance, in the roads layer, specific tables can be added for the road's name, type, and the number of lanes for each road drawn. Similarly, for other layers, any relevant information can be added to their respective Attribute Tables. This is done for the purpose of analysis and obtaining information to derive results, as shown in Figure (36).

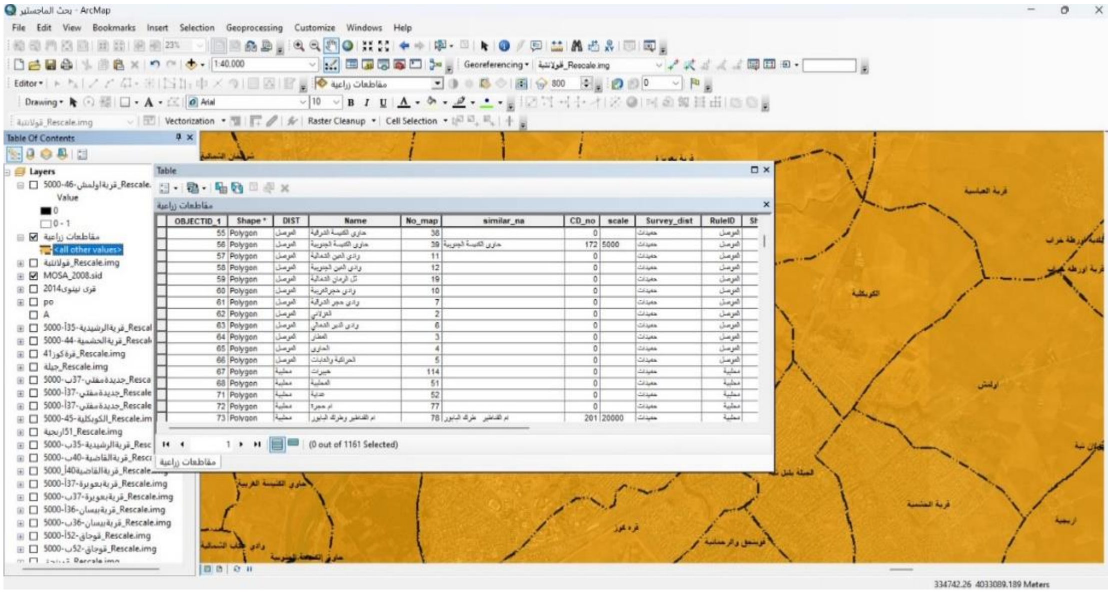

Figure 37 Establishing a Geographic Database (software, (ArcGIS 10.8.1))

Fifth: Presenting the Data in Its Final Form

The data is presented in its final form from the geographic database for validation and results extraction, as shown in Figure (37).

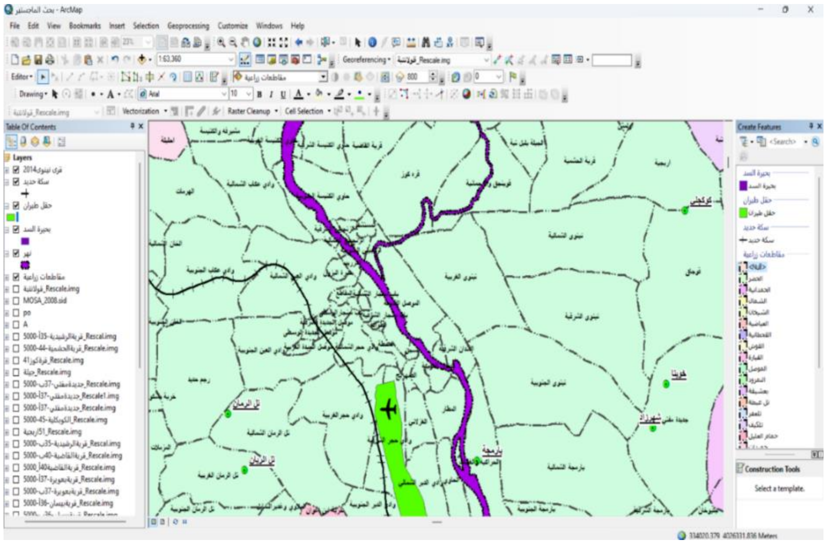

Figure 38 Presenting the Data in Its Final Form (software, (ArcGIS 10.8.1))

4.3 Displaying Digital Cadastral Maps

Below, we present digital maps created using the geographic information database after providing it with the necessary information. As previously mentioned, in this study, the cadastral map of the districts is the most important source of data, as all symbols and classifications were included in the accompanying data. The most important of these are the indexes for the cadastral maps.

Below, we present the index for these maps produced according to this data:

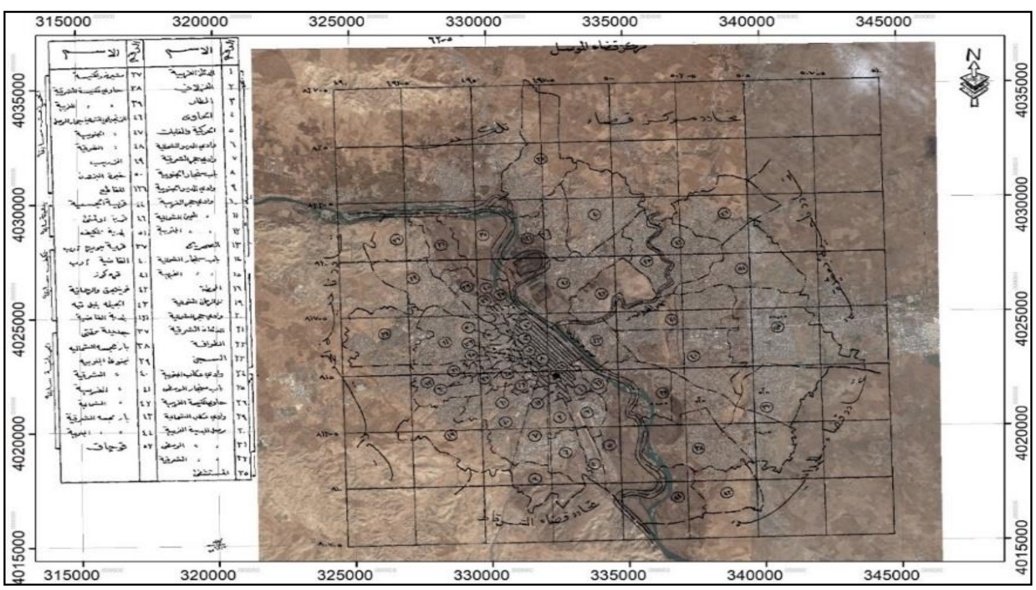

Figure 39 Index of Land Rights Registration, Mosul District Center (software, (ArcGIS 10.8.1))

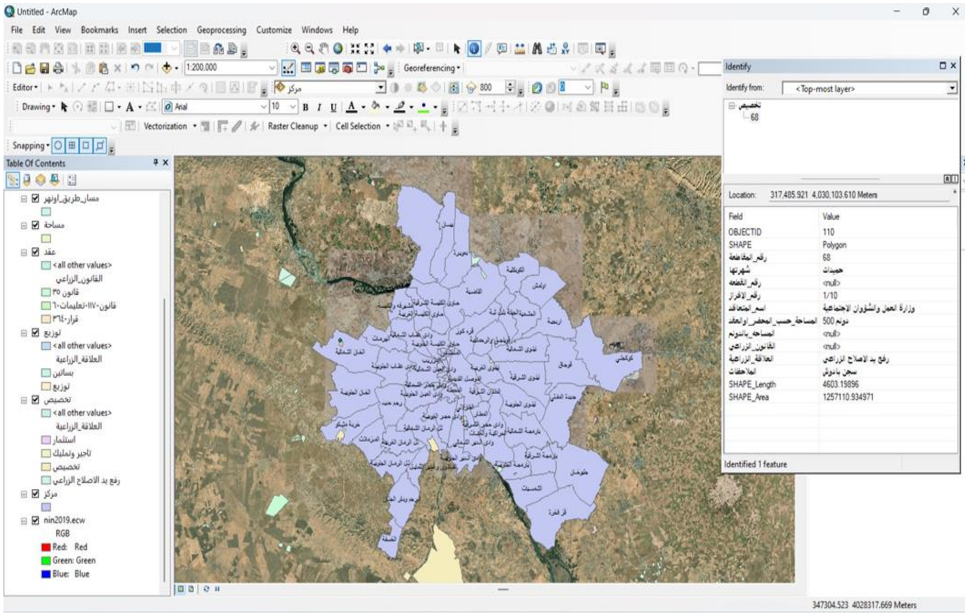

Figure 40 Digital Maps Created Using the Geographic Information Database (software, (ArcGIS 10.8.1))

Conclusions

1. **Mismatch in Systems:** Cadastral maps (Clarke 1880) don't align with satellite maps (WGS 1984) due to differences in scale and Earth's shape.
2. **Projection Differences:** Cadastral maps use orthogonal projection; satellite maps use central projection before correction.
3. **Distortions:** Edges and coordinates have distortions; aligning maps requires unifying scales and coordinate systems.
4. **Satellite Imagery:** High-resolution satellite images and DJI drones facilitate paper map corrections.
5. **Digital Capabilities:** Software technologies support building spatial databases and correcting paper maps.
6. **Modern Conversion:** Old paper maps converted to digital maps with WGS 1984 coordinates.
7. **Ground Control Points:** Established using DGPS and DJI drones for accurate surveys and data updates.
8. **Generalized Updating:** Study methods can update any cadastral map in Iraq, linking to a specific database.
9. **Land Use Monitoring:** Satellite data and technical communication can update land use changes and publish information online.
10. **Mobile Applications:** Apps like Alpine Quest can identify locations on cadastral maps.

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Outputs from the (ArcGIS 10.8.1) software.