Creating Spatial Database Infrastructure and Integrating Data among the Governorates of Riyadh Region

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ABSTRACT

The Kingdom of Saudi Arabia, which consists of 150 governorates and 13 regions, is among the first nations to gather descriptive and spatial data, create geographical databases that benefit society and policymakers. Creating a central database (SDI) for the governorates in the Riyadh region and integrating data between them, with its headquarters located in the capital city of Saudi Arabia, Riyadh is the largest city in the Kingdom of Saudi Arabia and the third most populous capital of the Arab world. Based on data from 2021, the population of Riyadh is approximately 10.5 million, and the capital of Saudi Arabia is regarded as one among the global cities with the quickest rate of growth. The area of the city has grown from 1,800 km^2 to 3,115 km^2 at this point. Each governorate operates independently, which makes it difficult to share information on local development and infrastructure projects amongst them. This causes projects to be duplicated within a single governorate, and costs money, time, and effort. In order to address these issues and provide a robust and current database, this research is carried out. Based on current and regularly updated data from the governorates, reports can be produced from them for every governorate, assisting the decision maker in making the right choice.

1. Introduction

The deficiency of the existing complex environment of different data formats, scales, storage, and accessibility with no specified user permissions increased the need of efficient and accurate digital maps (Ali, 2015).

Data is an essential component of geographic information systems, including descriptive data and spatial data. Metadata in geographic information systems contributes to describing the geographic characteristics of a geographical feature in terms of quantity and quality in nature according to its intended purpose. In addition, it contributes to describing the spatial data collected and analyzed by specialists and experts in this

field, then output it to the user in several different forms that serve the field for which it is used.

Sustainable development requires access to data, information, knowledge and understanding about the environment and natural resources. Often referred to as geographical or spatial data, the information is tied to a specific location. This one is an indispensable part of the available knowledge at modern science of Information and Communication Technology.

Therefore, one must consider available resources for collecting, managing, sharing and using geospatial data as a basis for sustainable development, hence the concept of Spatial Data Infrastructure (SDI) that puts an emphasis on partnership and coordination to deliver geographic information to decision-makers and public at large in an easy-to-use format. This kind of application is increasingly necessary, especially an inter-organizational environment which requires a high level of regional collaboration and in which all spatial data stakeholders (both users and producers) have to cooperate and utilize information and technologies in a cost-effective way (Ajmi et al., 2014).

2. Methodology and Sources of the Study

The gathering of data is a crucial stage in this research project. Land plots and plans for each governorate were gathered, and after examining every layer of the governorate and building a spatial database (SQL server), work was done to construct a layer for each of the two types of data. Governorates that do not operate in the project's environment (SDI) are linked to work on the database SDE, and it is noted that the project environment operates on the ESRI environment. The data will be updated and transferred via an ETL BY FME model into the central database (SDI).

Applications that are depended upon:
- ❖ ArcGIS Desktop and catalog (ESRI).
- ❖ SQL Server Database (SDE).
- ❖ Spatial database Infrastructure (SDI).
- ❖ FME Desktop and Server.
- ❖ QGIS.
- ❖ SQLITE Database.

3. Previous Studies

The Arab geographical library lacks comprehensive research on this topic, especially those related to the Kingdom of Saudi Arabia. There are a number of non-geographical scientific researches, including Ali (2015), Ajmi and et al. (2014), Alshehri (2011), Elghazali and Ibrahim (2023), Steiniger and Hunter (2012), Dragicevic (2004), The National Center for Spatial Informatics (NSDI) of the Ministry of Planning and Economic Development of the Arab Republic of Egypt, The National Geospatial Platform, Saudi Survey Authority, Geospatial portal Abu Dhabi, and European Union's geospatial platform.

Many conclusions from these studies highlight the significance of building Spatial Data Infrastructures data (SDI):

- Centralized storage, format standardization and access facilitation are essential prerequisites, to valorize spatial data in planning and establishing environmental programs and projects (Elghazali & Ibrahim, 2023).

- The development of Standardizing Spatial Data Infrastructures data (SDI) and its importance as a key resource in the development of the Nation. There is a lot of economic potential that is locked away in spatial data holdings and this potential is realized by making the data widely available through a SDI. Additionally, SDIs are contributing to sound decision-making, enhanced e-government applications, and location-based services (Ali, 2015).

4. The Study Area

Al-Aflaj, Al-Hareeq, Al-Kharj, Al-Diriyah, Al-Dalam, Al-Dawadmi, Riyadh, Al-Rayn, Al-Zulfi, Al-Salil, Al-Ghat, Al-Quwayiyah, Al-Majma'ah, Al-Muzahmiyah, Thadiq, Huraymila, Hotat Bani Tamim, Rumah, Shaqraa, Darma, Afif, Marat, Wadi Al-Dawasir are the governorates that make up the study area. The study looks at building a central database (SDI) that will act as the primary data source for the remaining regions and governorates. The SDI will be housed in the Riyadh Governorate and receive data from the other governorates (Figure 1).
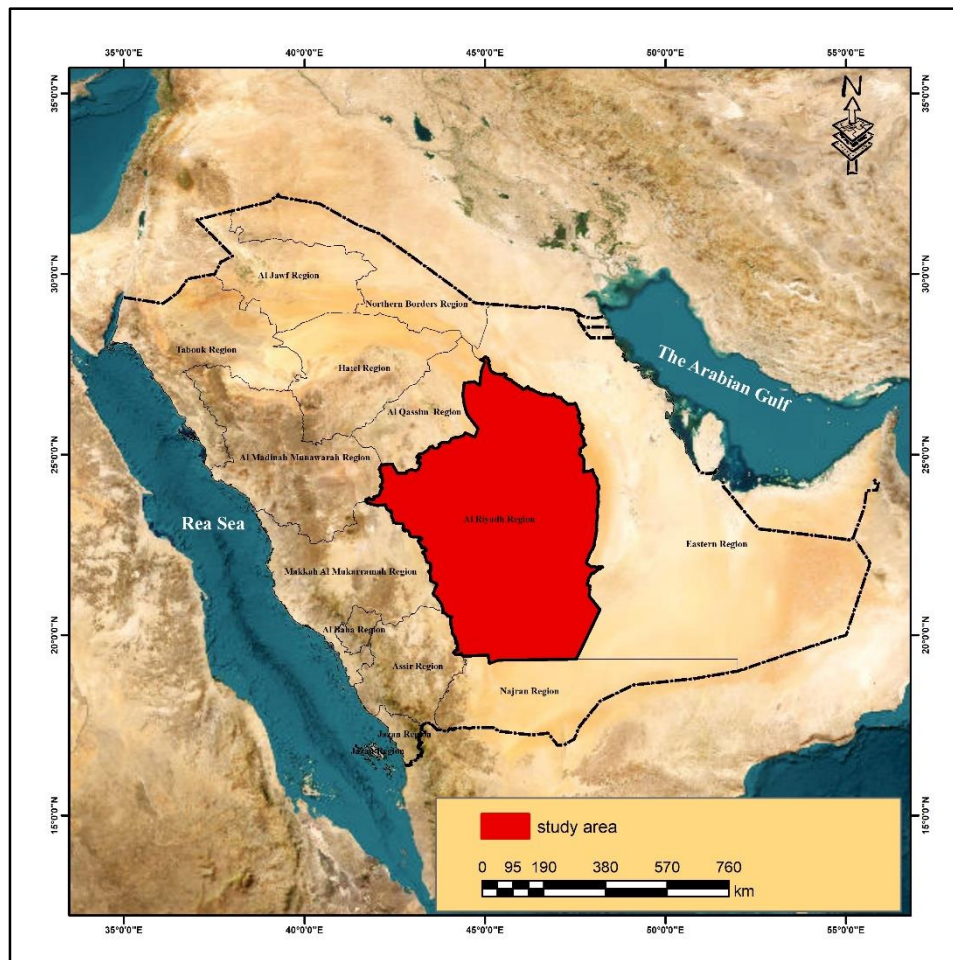
Figure 1. Location of the Study Area

5. Objective of the Study

Establishing a central database is the objective of the research in order to improve data quality and proper maintenance, increase officials' and decision-makers' confidence in the accuracy of geospatial data within the governorates' central database, prevent projects from repeating and make use of previous project data within the various governorates, and integrate data between the governorates of the Riyadh region. Additionally, the study aims to save time and money by reducing the amount of time and money spent on replicating projects due to a lack of information on previous projects, improve the accuracy of the geospatial data used in the projects, follow-up on all strategic plans, and realize the country's vision.

6. Inputs

Database analysis for the Riyadh region's governorates is among the most essential stages

of the project development process (SDI). Interviews with each governorate's database officer are being conducted in a variety of phases. The acquisition of databases from the governorate officer following the completion of the interviews constitutes the second phase. Data inventory, both spatial and non-spatial, is the third phase. Studying the reasoning in the databases that the governorates have provided and the current state of each tier is the fourth phase. A more thorough explanation of each step is provided below.

6.1. Interviews with every governorate's database officer:

To interview the database officer for each governorate, the SDI project team splits up into governorates. As of right now, the following questions are part of the established questionnaire:

- What type of database does the governorate contain?

- Is there spatial or non-spatial data available?

- What kind of database (ESRI OR Open Source)?
- What kind of geographical projection is used to create a spatial database?
- What are the attributes tables' number, layer count, and database size? How many updates are made to the database per day?

6.2. The process of collecting databases from the governorates designated representative:

All databases, both spatial and non-spatial, have been gathered up to this point. Official acknowledgement must be sent via letter or email with the databases attached. On how to get the additional layers and tables, negotiations take place between SDI project administrators and data officials in the governorates. In order for the project officials to have access to all layers and tables for every governorate, fresh data in the database was not provided to them prior to the start and operation of the SDI project.

Additionally, official emails or letters containing the new data must accompany each of these revisions as documentation.

6.3. A list of databases, both geographical and non-geographic:

At this stage, spatial data and non-spatial data are collected for each governorate of the Riyadh region, and in the research, land parcel layers and plans were obtained for each governorate within the study location.

6.4. To examine the state of all strata at the moment and the value of the governorate-provided databases:

This step involves analyzing the current state of the tables and strata that have been received from the governorates. Following this analysis, a unified structure, or schema, of tables and strata is created for all of the tables and strata that have been received from the governorates and it is then applied to the strata that have been obtained from the governorates (land plots and plans) (Figure 2).
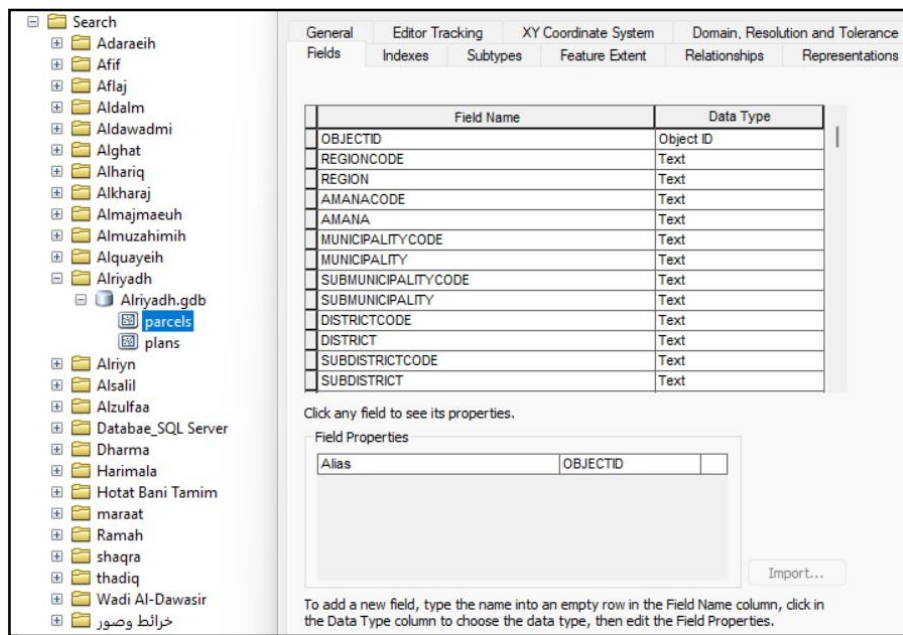

Figure 2. Study of the Current Situation after Collecting Data from the Governorates of the Riyadh Region (Parcels and Plans)

7. Handling and Examination:

7.1. Governorate databases are established in identical layers:

After collecting and studying the current status of the databases collected from the

governorates of the Riyadh region, then comes the creation of unified layers, for all layers received from the governorates, which are plots of land and plans and will be explained as follows:

7.1.1. After the present state of the databases is assessed, identical layers should be established for every governorate

After officially receiving the databases from the governorates, a study is conducted for all the received databases, and the SDI project team begins sorting and classifying the layers and tables and studying each structure of each layer and table present in the governorates' databases. After that, unified layers are created that serve the work of each, Classes and tables in the governorates. In this research, a unified land plots and plans layer was created for all governorates of the Riyadh region.

7.1.2. The database officer in every governorate is presented with standardized layers:

Once the single layers are created to support the work of the provinces, a copy of the layers is requested by each governorate. All phases of the SDI project are officially documented, and data managers in the provinces are only contacted via letter or email.

7.1.3. Taking in and addressing any governorate observations:

The project officials officially receive and examine any notes that are delivered to the governorates via letters or emails regarding the layers (SDI).

7.1.4. Once the necessary changes have been completed, approvals from each governorate will be requested:

After receiving notes from the governorate asking for modifications, such as adding fields to specific classes, those notes are sent to that governorate after its completion. The governor's office requests that the amendments be approved and this process is documented via email or letters to the project officials (SDI).

7.1.5. For final approval, send a final draft of the governorates' final layer structure, or schema:

This is one of the latest stages in the creation of the standard layers when the governorates receive the standard layers' structure from SDI project officials once all other phases have been completed formally via letter or mail. The final form of the unified database structure is the slope's or discourses central idea.

7.2. Creation of a cloud data center or data center with infrastructure:

7.2.1. Data center:

The physical location that contains the digital data of any organization or company is called a data center. It is a location that holds computers and related equipment as well as the computing infrastructure needed by information technology systems, including servers, data storage engines, and network equipment.

7.2.2. Data center service types include the following:

7.2.2.1. Local data centers:

These are completely owned data centers that are used by a corporation to hold vital information and important applications. The company also prepares the data centers, oversees daily operations, and buys and maintains equipment.

7.2.2.2. Data centers occupying a common storage:

These are huge data centers that offer space for rent for storage of workstations, servers, and other computer hardware. Co-location infrastructure is typically offered for security and support.

7.2.2.3. Cloud data centers:

It is the leasing of space and infrastructure, which cloud service providers keep completely secure and compliant with big data centers, this infrastructure may be accessible using several services that offer more adaptability in terms of use or cost.

A regional data center will be established in this search due to the security and privacy of the data in every governorate, including the following:

7.2.2.3.1. The creation of a Riyadh-based local governorate data center:

To protect the privacy of the data, a regional data center with computers and servers will be constructed, with its main office located in the Governorate of Riyadh.

7.2.2.3.2. The creation of a single local area network:

It is related to computing devices, that exchange information among themselves and share resources, and which use a system of rules

called communication protocols (IP) for the transmission of information via telecommunications (Figure 3).

Figure 3. Connecting Devices through the Network and Linking Them to the Data Center

7.2.2.3.3. The central database (SDI) was established as SQL Server Database Enterprise (SDE):

In two stages, establish SQL Server Database Enterprise (SDE) to serve as the SDI's central database:

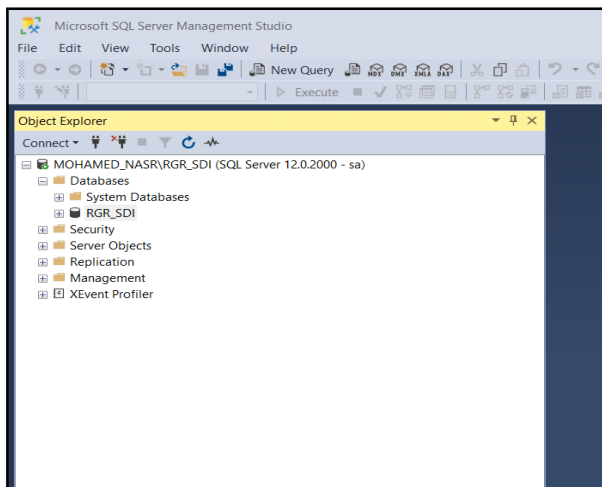- SQL Server Database Enterprise and the database name (RGR_SDI) (Figure 4).

Figure 4. The Name of the Central Database within SQL Server Database Enterprise

- Utilizing an Enterprise Geo-database to establish the various layers, SDE initiates the SQL Server Database Enterprise (Figure 5).
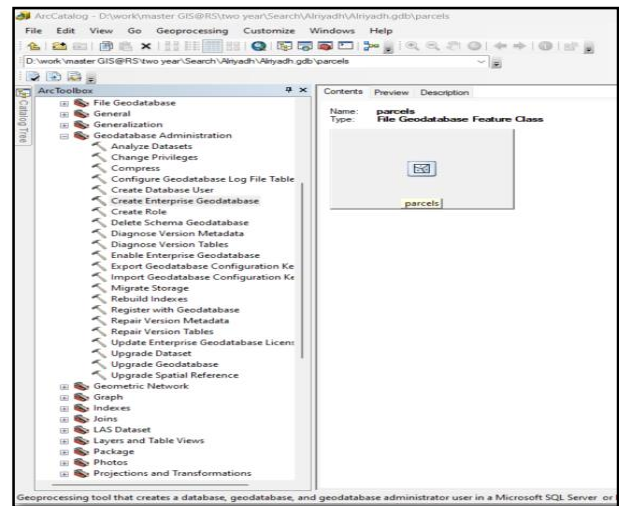
Figure 5. Activating SDE on the Central SQL Server Database Enterprise Database through Create Enterprise Geo Database

7.2.2.3.4. Creation of a dataset with final layers that complement each other:

The dataset was created under the name (Parcels_plans_RGRSDI) with the geographical location WGS84 (Figure 6).
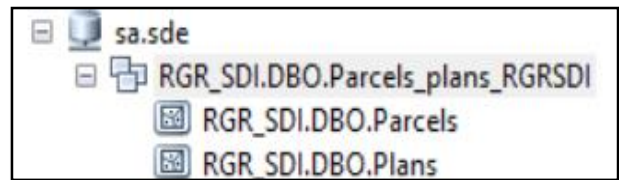

Figure 6. The Name of the Dataset and the Layers

7.2.2.3.5. Give each governorate a user name in the central database and grant it the ability to add, remove, and alter information:

Within the central database, a user name was established for every governorate, granting access to add, remove, and modify layers (Figures 7, 8).
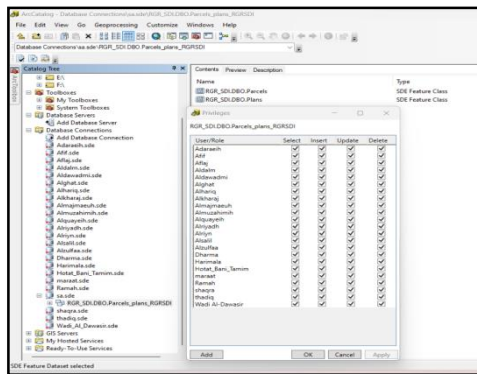
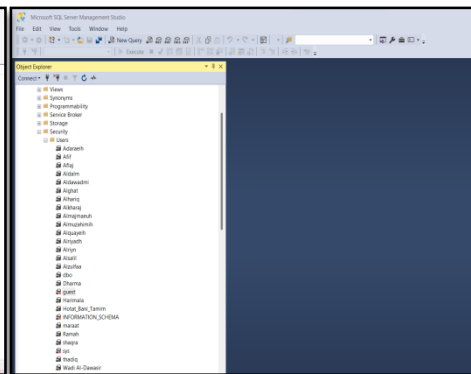**Figure 7.** Giving Additions, Changes, and Delete to Every Governorate in Riyadh

Figure 8: User Names of Each Governorate of Riyadh

7.2.2.3.6. Proceed with Registering the Chosen Objects without Allowing the Editors to be Moved Off-base:

There are two types of Register the selected objects:

• **Type I:** Register the selected objects with the

option to move editors to base; it's going from Default version to Base table directly.

• **Type II:** Register the selected objects without the option to move editors to the base, some tools should be used to move data from Default version to Base table, which is the type used in the search (SDI).
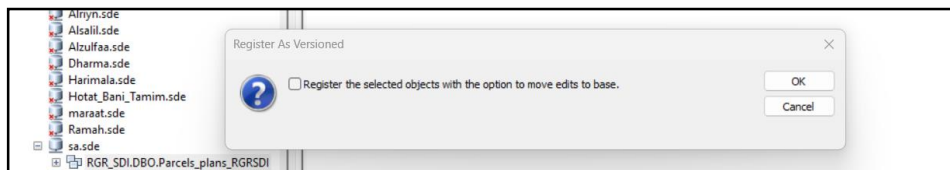

Figure 9. Register the Selected Objects without the Option to Move Edits to Base

7.2.2.3.7. Creation of a Protected Version of The Central Data Review Database for Every Governorate Before It Is Made Available to the Other Governorates:

There are three main version types in the
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central database: public, protected, and private. Each governorate in the Riyadh has a version designated as protected, and the default one was changed from public to protect (Figure 10).
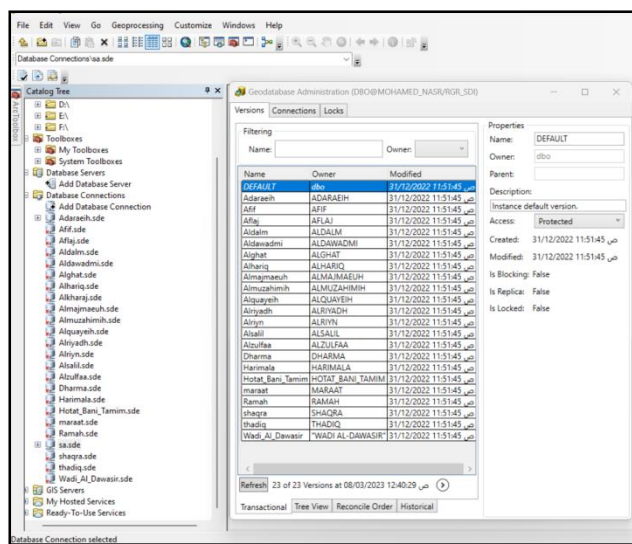

Figure 10. Creating a Version Protected for Every Governorate and Changing the Default Version from Public to Protected

7.2.2.3.8. For Datasets with Complementary Layers, Enable Editor Tracking:

The activation of the Enable Editor Tracking helps the dataset with the standard layers to determine the date and time when the modification will begin and the end of each database conservative (Figures 11, 12).
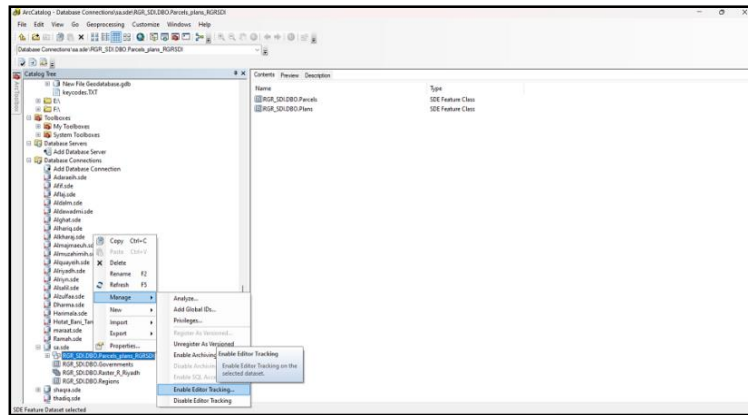

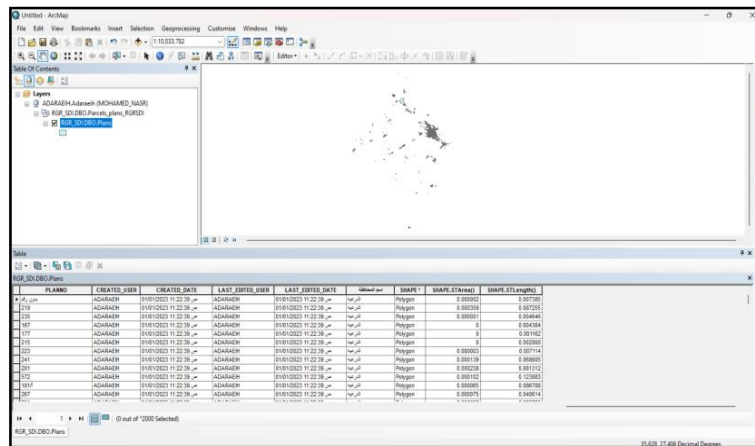**Figure 11.** Enable Editor Tracking on Datasets with Standard Layers

Figure 12. Creation of the Enable Editor Tracking Fields

7.2.2.3.9. Creation of a Mass Dataset in the Database for the Center of the Visual Display:

Mosaic Dataset was created within the central database (Raster_R_Riyadh) to display space-based viewers for the governorates of the Riyadh region, and to build a unified source of space-based mirrors from the central database (SDI) knowing that the source of viewers is Landsat 9 (Figure 13).
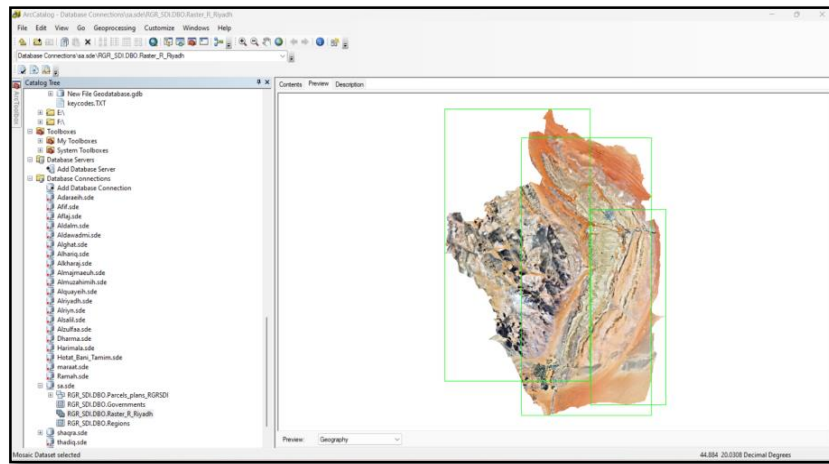
Figure 13. Creation of the Raster_R_Riyadh Dataset inside the Database

8. Conclusion and Discussion:

8.1. **Every governorate has enabled and is running the link to the central database (SDI):**

To activate the link via the SDI database, perform the following:

A. Go to the SDI project to ensure that the link is implemented correctly and that the data is correct. B. The SDI project managers start visiting the governorates, where they meet with the database officers and start the link process via the arc catalog (Figure 14).
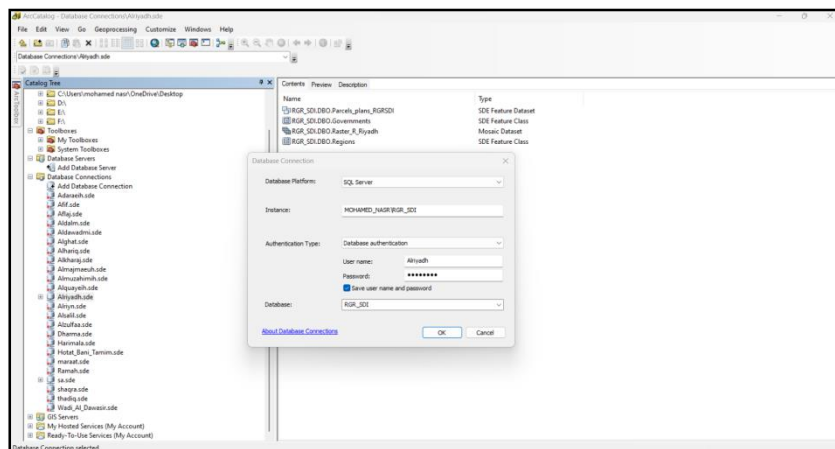

Figure 14. The Link from Riyadh Governorate to the Central Database (SDI)

C. Assign each governorate's database management responsibilities to the central database (SDI) and teach it to process data correctly:

Each governorate's database is turned over to the central database, which receives training to work on it and its version, following the establishment of a link to the SDI database and the accurate certification of the governorate data by two authorities. The SDI project has already benefited from an explanation and application of the various versions. Following the completion of the central database link for each governorate, this is the project's last stage (Figure 15).
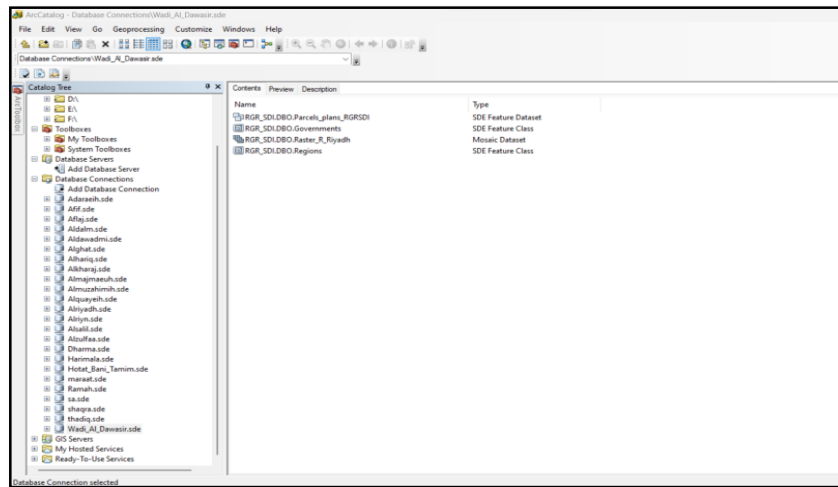
Figure 15. Completion of the Link between the Governorates of Riyadh

8.2. The Riyadh Region:

The governorates that do not have an ESRI workplace have the data integrated into them. The Al-Kurj governorate's use of QGIS as an open workplace was linked to the analysis of all governorates in Riyadh.

How to integrate Al-Kurj Governorate with other governorates:

A. The creation of the Model ETL BY FME Desk, which reads data from the governorate of Al-Kurj (SQLIT) database and writes it into the central database (SDI), was necessary for the ESI environmental reserves in order to transfer data to the central database (SDI). The Model serves as a data reader and applies the central database's structure, reading fields from the database. The central database is where the data (SQLIT) is entered and the mapping fields are completed (SDI) (Figure 16).
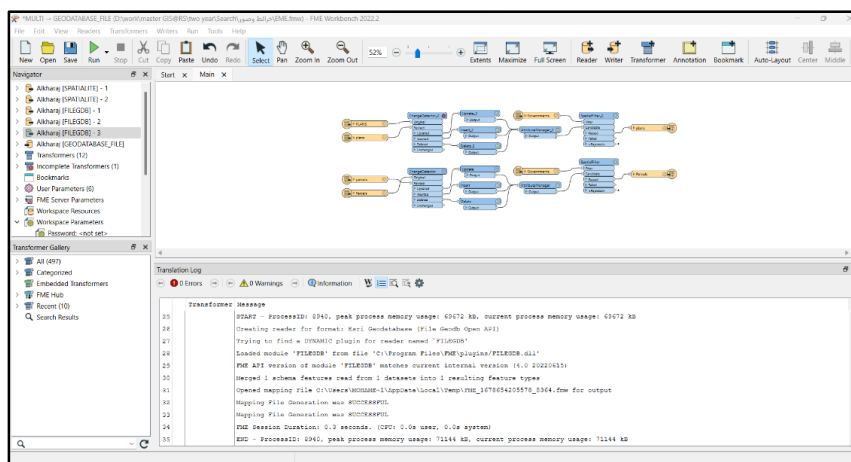

Figure 16. Model ETL BY FME Desk Creation for Al-Kurj Governorate

B. Decide on precise timing for data transmission that will be determined by the Governor and SDI project officials:

The governor and the SDI project officials will schedule a specific time for the transmission and updating of data within the central database. Following the data transfer, an email will be sent to the governorate confirming the transmission and updating of data via the FME Server within the automated central database (Figure 17).
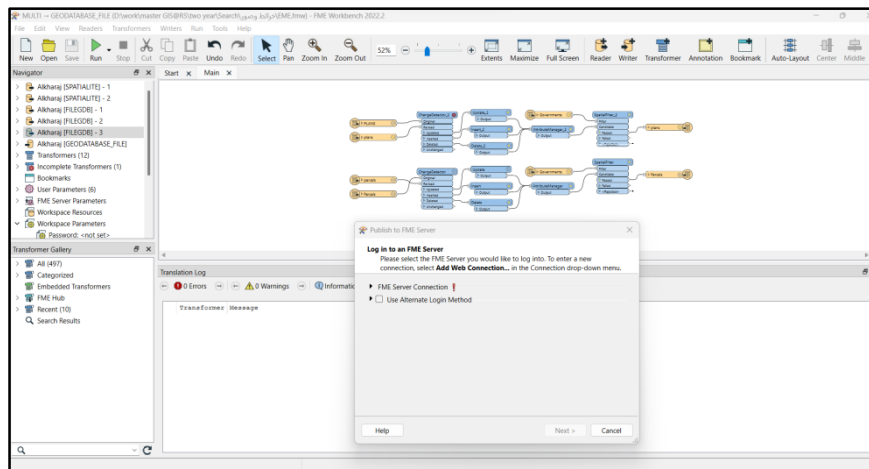
Figure 17. Run the Model Using the FME Server

C. Confirming that the information in the central database is current and correct after transmission (SDI):

Two SDI project officers verify the data once it has been changed and moved within the central database, and it is then updated suitably in accordance with the central database's structure.

The study suggests applying these results in the Kingdom of Saudi Arabia's regions, and the government approves the creation of a national center to oversee and profit from the data in all ministries and government organizations' general budgets and strategic plans, as well as a central database that will serve as the source and point of reference for geospatial data for the Kingdom of Saudi Arabia's regions.

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Geospatial portal Abu Dhabi.

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The National Geospatial Platform, Saudi Survey Authority.