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SCHOOL OF ENGINEERING
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Final Report on
Determining Shortest Route
Using pgRouting, PostGIS, PostgreSQL and QGIS

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ABSTRACT

This project studies the application of pgRouting, an open-source extension for PostgreSQL, in determining the shortest route between Jadibuti, Kathmandu and Kathmandu University. Utilizing OpenStreetMap (OSM) data and the spatial capabilities of PostGIS, the project demonstrates a comprehensive workflow that includes data preparation, route calculation, and visualization. The process begins with importing OSM data using osm2po, and then identifying the nearest nodes to the origin and destination points. pgRouting's Dijkstra algorithm is employed to compute the shortest path, and the results are visualized using QGIS. The report discusses the integration of these tools and the methodology used in determining the shortest path. The findings highlight the effectiveness of pgRouting for route optimization and its potential applications in time management and transportation management. This project shows the real world application of PostgreSQL and QGIS.

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LIST OF ABBREVIATIONS

DB	Database
GIS	Geographic Information System
OSM	Open Street Mapping
SQL	Structured Query Language

1 Introduction

In the realm of geographic information systems (GIS) and spatial analysis, the ability to determine the shortest route between two points on a map is a fundamental and widely applicable task. This task, known as routing, has numerous practical applications in fields such as transportation planning, logistics, emergency response, and urban development(Chadha & Garg, 2019). One of the key tools that facilitate routing analysis is pgRouting, an open-source extension of the PostgreSQL database system. pgRouting enhances PostgreSQL with advanced routing functionalities, allowing users to perform complex routing calculations directly within the database environment. This integration is particularly powerful when combined with PostGIS, a spatial database extender for PostgreSQL, which provides the necessary spatial data management capabilities.

pgRouting offers a range of routing algorithms, including the well-known Dijkstra and A* (A-star) algorithms, which are designed to find the shortest path between two points on a graph. These algorithms take into account various factors such as edge weights (e.g., distance, travel time) and constraints (e.g., one-way streets, turn restrictions) to determine the optimal route(Pritee & R.D., 2017). The ability to handle such factors makes pgRouting suitable for a wide range of routing scenarios, from simple point-to-point routing to more complex multi-stop and time-dependent routing. This flexibility is further enhanced by the extensibility of pgRouting, which allows users to customize and extend its functionalities to suit their specific needs.

In addition to its routing capabilities, pgRouting also offers powerful network analysis tools that enable users to analyze and visualize spatial data in meaningful ways(Sankepally & Rajan, 2018). For example, pgRouting can be used to analyze the connectivity of road networks, identify critical paths or nodes in a network, and simulate the impact of changes to the network infrastructure. These capabilities make pgRouting a valuable tool for decision-making in various industries, including transportation, logistics, and urban planning.

This project aims to demonstrate the practical application of pgRouting in determining the shortest route between two points on a map. Using a real-world scenario of calculating the shortest route, the step-by-step process of preparing the data, performing the routing analysis, and visualizing the results is illustrated in this project. Through this project, the power and versatility of pgRouting as a tool for spatial analysis and routing is shown. Further exploration and utilization of this technology can be done in diverse applications.

2 OBJECTIVES

2.1 Primary Objectives

The primary objective of this project is to determine the shortest route between Kathmandu University and Jadibuti, Kathmandu using pgrouting.

2.2 Secondary Objectives

The secondary objectives are:

- To use OSM, QGIS, PostgreSQL, and PostGIS to solve real-world problems.
- To deepen the understanding of spatial database and their functionalities.
- To visualize spatial data and develop practical GIS skills.

3 METHODOLOGY

3.1 Study area

The study area encompasses the route between Jadibuti, Kathmandu and Kathmandu University, Kavrepalanchok located in Bagmati province of Nepal. The specific coordinates for the starting point (Jadibuti, Kathmandu) are 27.6727° N, 85.35125° E, and the ending point (Kathmandu University) is 27.6194° N, 85.53877° E.

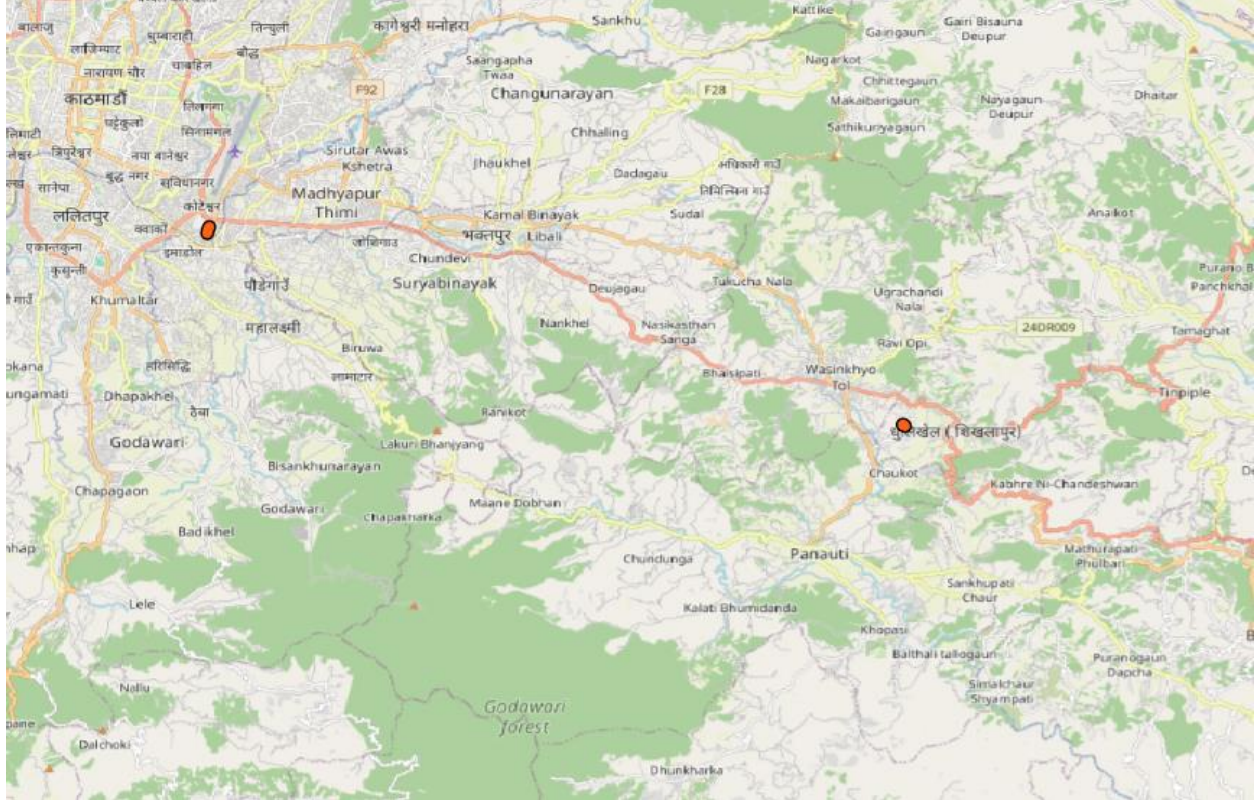


Figure 1: Study Area

3.2 Materials Used

3.2.1 Data used

OSM data for Nepal, which includes detailed information about the road network and other relevant geographic features was downloaded online.

3.2.2 Software used

The softwares used for this project are:

- PostgreSQL: A powerful relational database management system used for storing and managing spatial data.
- PostGIS: An extension of PostgreSQL that adds support for geographic objects, enabling spatial queries and analysis.
- pgRouting: An extension of PostGIS that provides routing and network analysis capabilities.

- QGIS: An open-source geographic information system used for data visualization, spatial analysis, and map creation.

3.3 Work Flow

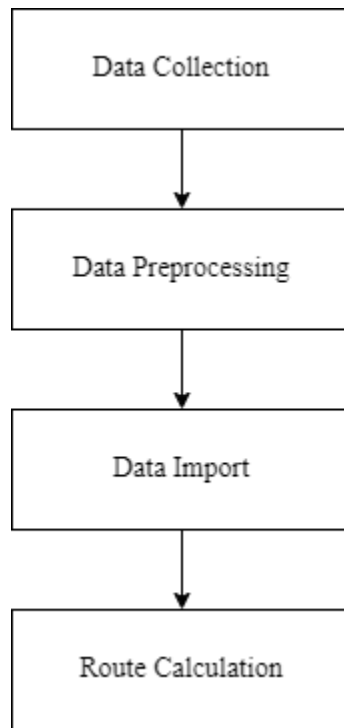


Figure 2: Project Workflow

The step-by-step explanation of each process is as follows:

3.3.1 Data Collection

OSM data for Nepal was downloaded through the link <https://download.geofabrik.de/asia.html> in .pbf format.

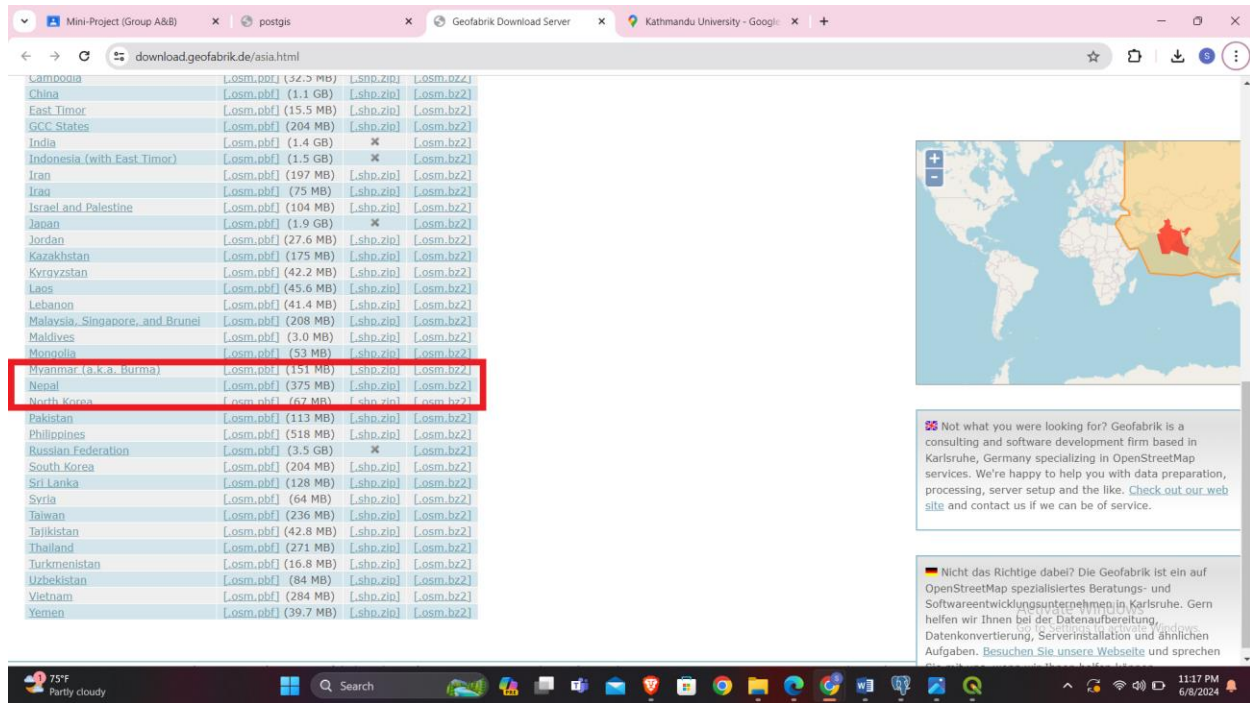


Figure 3: Downloading OSM data for Nepal

3.3.2 Data Preprocessing

The OSM data of Nepal was converted to usable form using command prompt and osm2po. osm2po is a powerful tool designed to convert OpenStreetMap (OSM) data into a format that can be used for routing and network analysis in PostgreSQL with PostGIS and pgRouting.

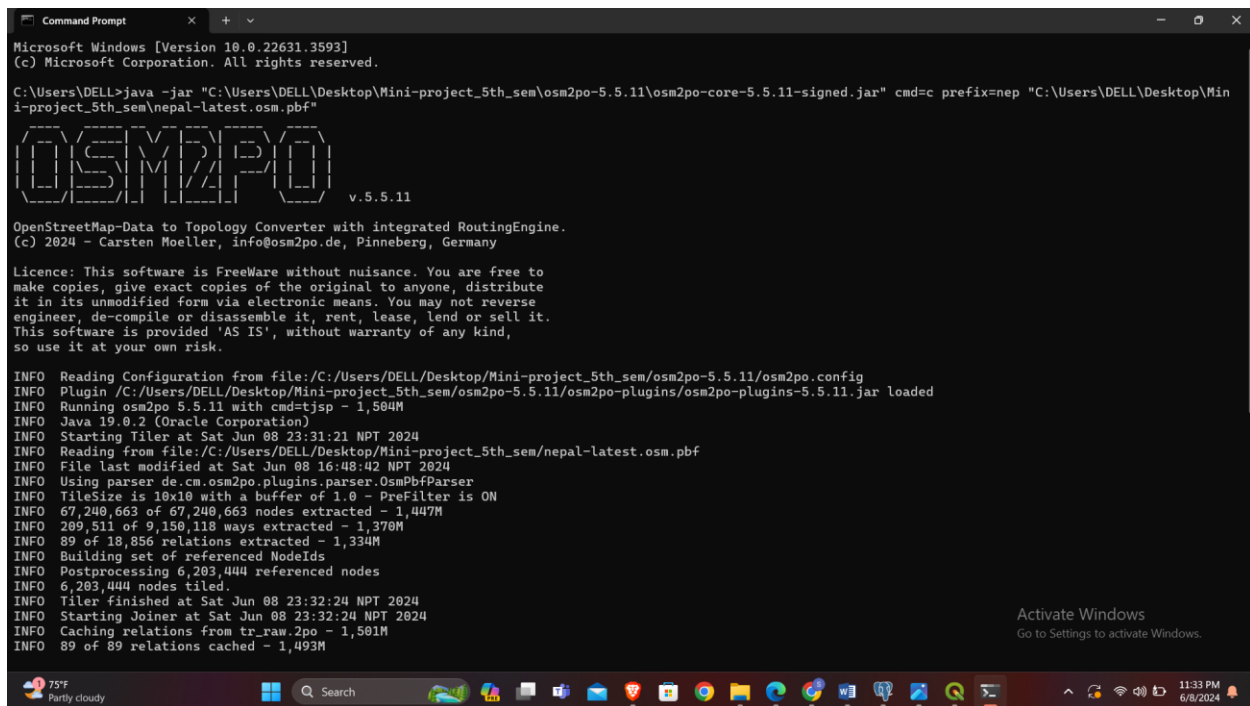


Figure 4: Preprocessing OSM data

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INFO Reading from file: C:/Users/DELL/Desktop/Mini-project_5th_sem/nepal-latest.osm.pbf
INFO File last modified at Sat Jun 08 16:48:42 NPT 2024
INFO Using parser de.cm.osm2po.plugins.parser.OsmPbfParser
INFO TileSize is 10x10 with a buffer of 1.0 - PreFilter is ON
INFO 67,240,663 of 67,240,663 nodes extracted - 1,447M
INFO 209,511 of 9,150,118 ways extracted - 1,370M
INFO 89 of 18,856 relations extracted - 1,334M
INFO Building set of referenced NodeIds
INFO Postprocessing 6,203,444 referenced nodes
INFO 6,203,444 nodes tiled.
INFO Tiler finished at Sat Jun 08 23:32:24 NPT 2024
INFO Starting Joiner at Sat Jun 08 23:32:24 NPT 2024
INFO Caching relations from tr_raw.2po - 1,501M
INFO 89 of 89 relations cached - 1,493M
INFO 6,203,444 of 6,203,444 nodes cached (N020E080) - 1,295M
INFO 404,309 of 404,309 nodes cached (N030E080) - 1,278M
INFO 209,511 of 209,511 ways read, 209,511 written
INFO Total 209,507 tiled, 4 shared
INFO 209,511 of 209,511 ways resolved.
INFO Joiner finished at Sat Jun 08 23:32:30 NPT 2024
INFO Starting Segmenter at Sat Jun 08 23:32:30 NPT 2024
INFO 571 of 371 WayNodes cached (SHARED) - 1,492M
INFO 6,187,354 of 6,462,090 WayNodes cached (N020E080) - 1,188M
INFO 209,317 ways analyzed, 397,162 segments created (N020E080) - 1,170M
INFO 330,743 vertices of 6,187,354 nodes written - 1,150M
INFO 15,517 of 15,717 WayNodes cached (N030E080) - 1,479M
INFO 190 ways analyzed, 241 segments created (N030E080) - 1,477M
INFO 231 vertices of 15,517 nodes written - 1,477M
INFO 4 ways analyzed, 4 segments created (SHARED) - 1,477M
INFO 8 vertices of 571 nodes written - 1,477M
INFO Segmenter finished at Sat Jun 08 23:32:37 NPT 2024
INFO Starting PostProcessor[0] at Sat Jun 08 23:32:37 NPT 2024
INFO de.cm.osm2po.plugins.postp.PgRoutingWriter
INFO Creating sql file nep\\nep_2po_4pgr.sql
INFO 397,407 Segments written.
INFO commandline template:
psql -U [username] -d [dbname] -q -f "C:\\Users\\DELL\\nep\\nep_2po_4pgr.sql"
INFO PostProcessor finished at Sat Jun 08 23:32:47 NPT 2024
INFO Config closed at 240608-23:32.47783
C:\\Users\\DELL>

```

Figure 5: Navigating converted data

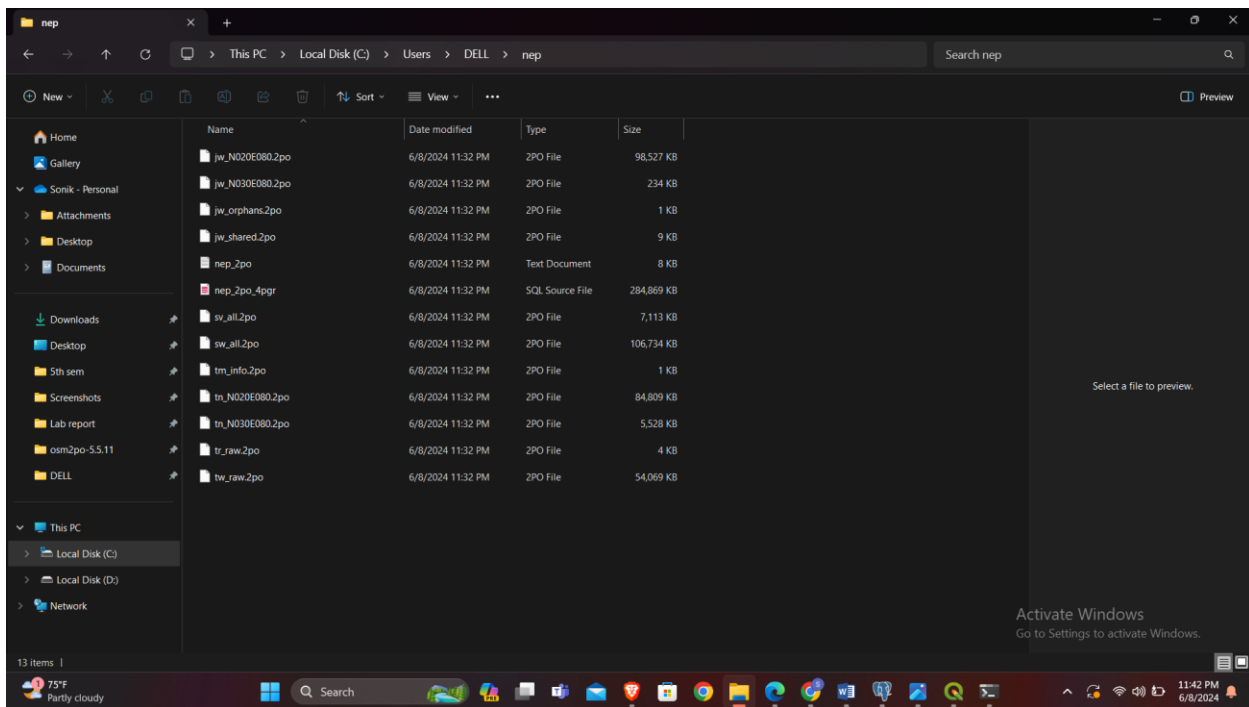


Figure 6: Opening converted data

3.3.3 Data Import

To import data from OSM to PostgreSQL, first of all a new database named “pgrouting” was created. Then two extensions “postgis” and “pgrouting” was created.

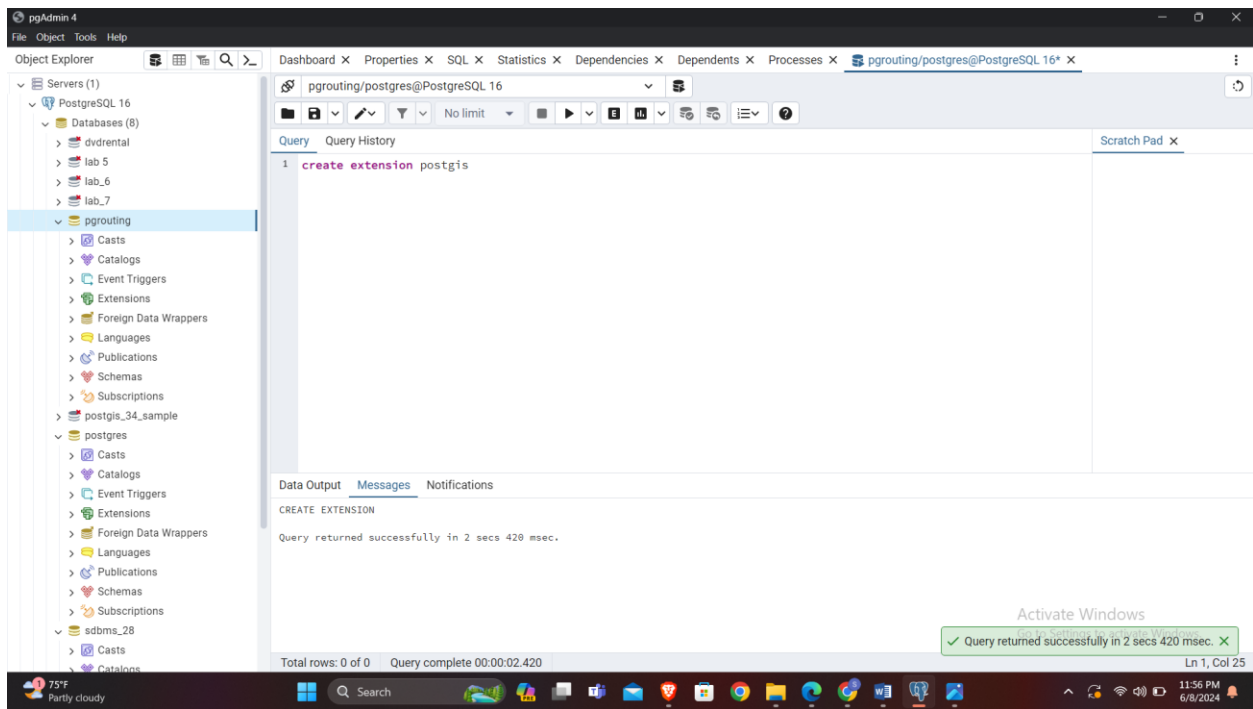


Figure 7: Creating extension "postgis"

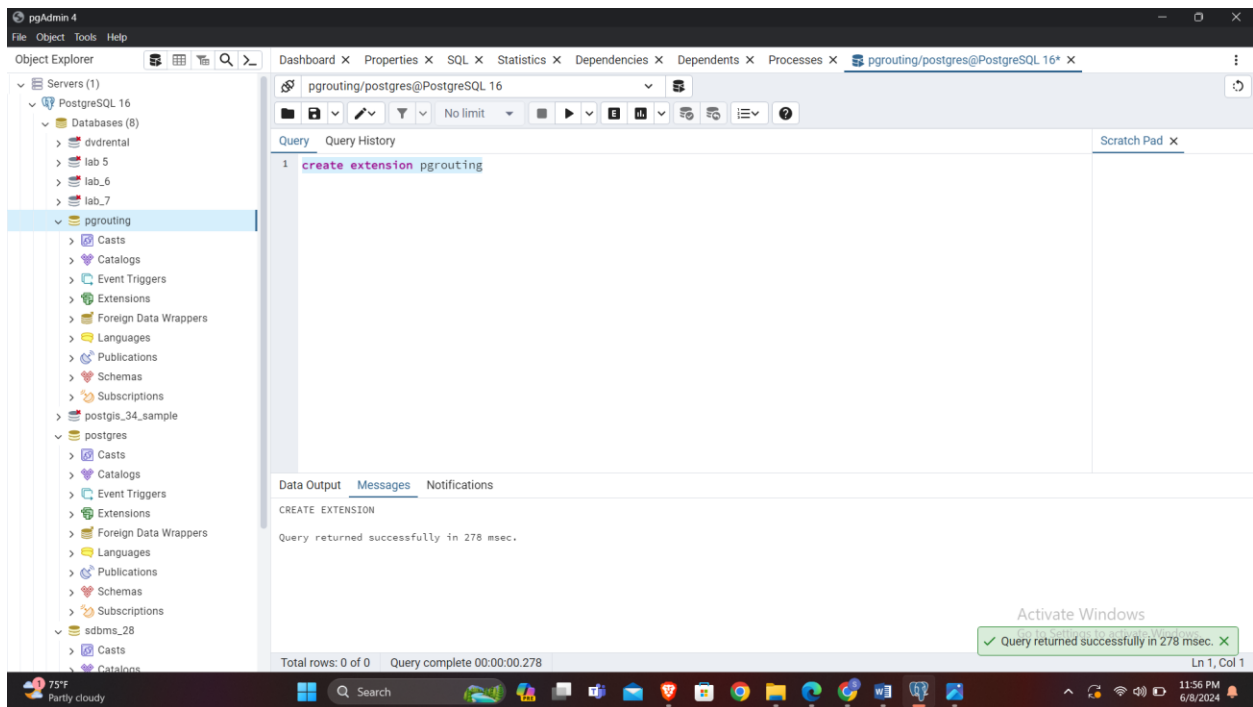


Figure 8: Creating extension "pgrouting"

Then, the SQL file of converted OSM data was run in pgadmin to create and insert data into table.

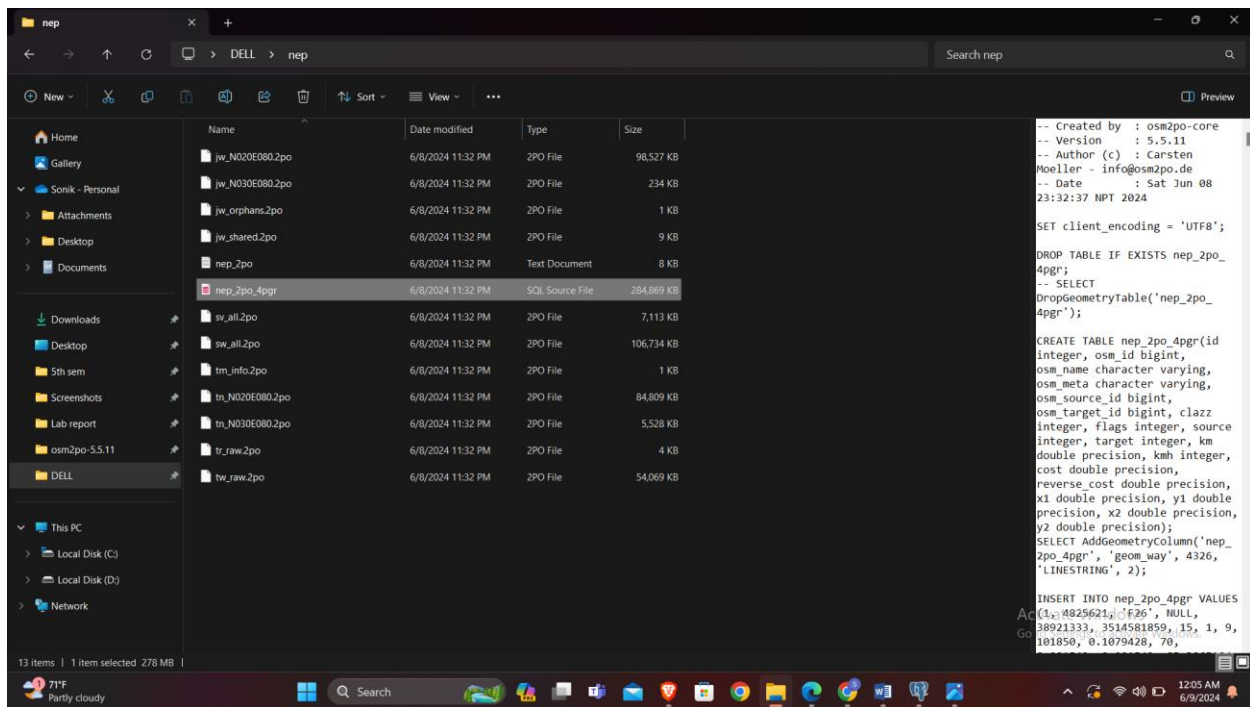


Figure 9: Navigating SQL file of OSM data

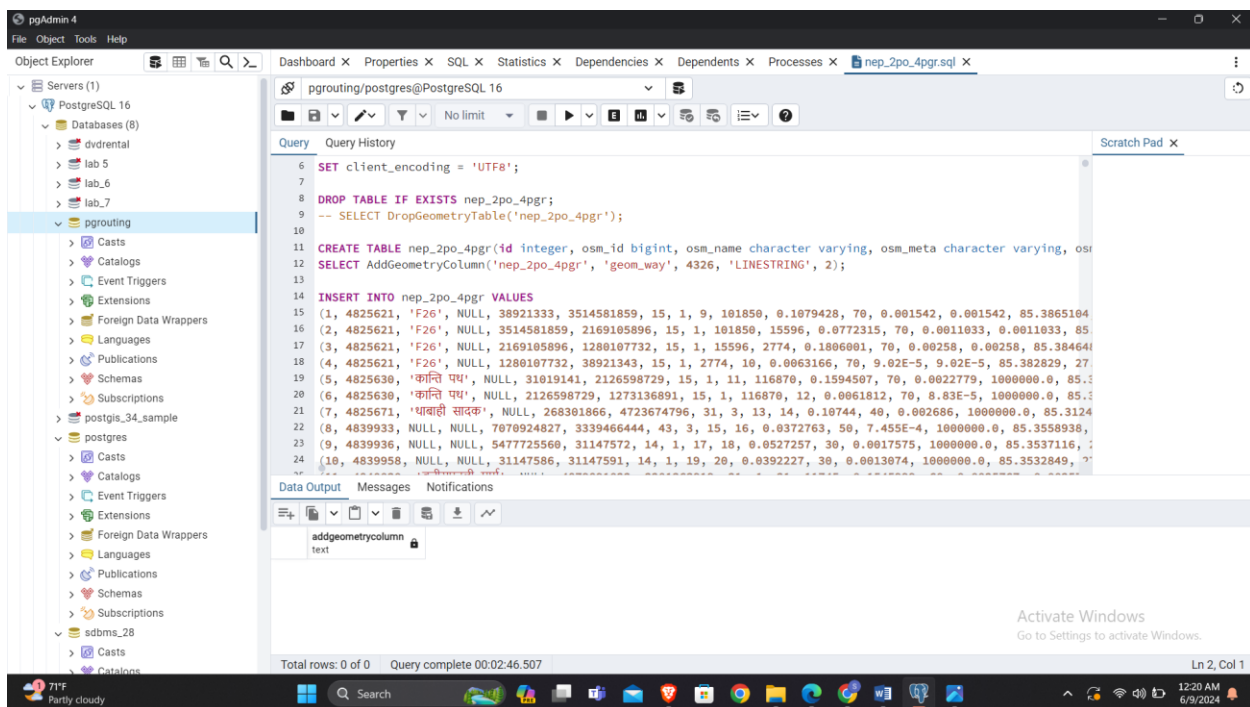


Figure 10: Creating a table and inserting data

Simple query was used to visualize the table:

id	osm_id	osm_name	osm_meta	osm_source_id	osm_target_id	class	flags	source	target	km
1	4825621	F26	[null]	38921333	3514581859	15	1	9	101850	
2	4825621	F26	[null]	3514581859	2169105896	15	1	101850	15596	
3	4825621	F26	[null]	2169105896	1280107732	15	1	15596	2774	
4	4825621	F26	[null]	1280107732	38921343	15	1	2774	10	
5	4825630	कान्ति पथ	[null]	31019141	2126598729	15	1	11	116870	
6	4825630	कान्ति पथ	[null]	2126598729	1273136891	15	1	116870	12	
7	4825671	धावली सादक	[null]	268301866	4723674796	31	3	13	14	
8	4839933	[null]	[null]	7070924827	3339466444	43	3	15	16	
9	4839936	[null]	[null]	5477725560	31147572	14	1	17	18	
10	4839958	[null]	[null]	31147586	31147591	14	1	19	20	
11	4840030	बत्तीसपुरी मार्ग	[null]	4879891022	2201363919	21	1	21	11745	
12	4840030	बत्तीसपुरी मार्ग	[null]	2201363919	1835392411	21	1	11745	8031	
13	4840030	बत्तीसपुरी मार्ग	[null]	1835392411	6089270919	21	1	8031	215464	
14	4840030	बत्तीसपुरी मार्ग	[null]	6089270919	5212357721	21	1	215464	7675	
15	4840030	बत्तीसपुरी मार्ग	[null]	5212357721	3547387340	21	1	7675	110678	
16	4840030	बत्तीसपुरी मार्ग	[null]	3547387340	1996642315	21	1	110678	326709	
17	4840030	बत्तीसपुरी मार्ग	[null]	1996642315	6089270926	21	1	215464	215466	
18	4840030	बत्तीसपुरी मार्ग	[null]	6089270926	1362317841	21	1	215466	215466	

Figure 11: Visualizing the table

The data was also visualized through a geometry viewer.

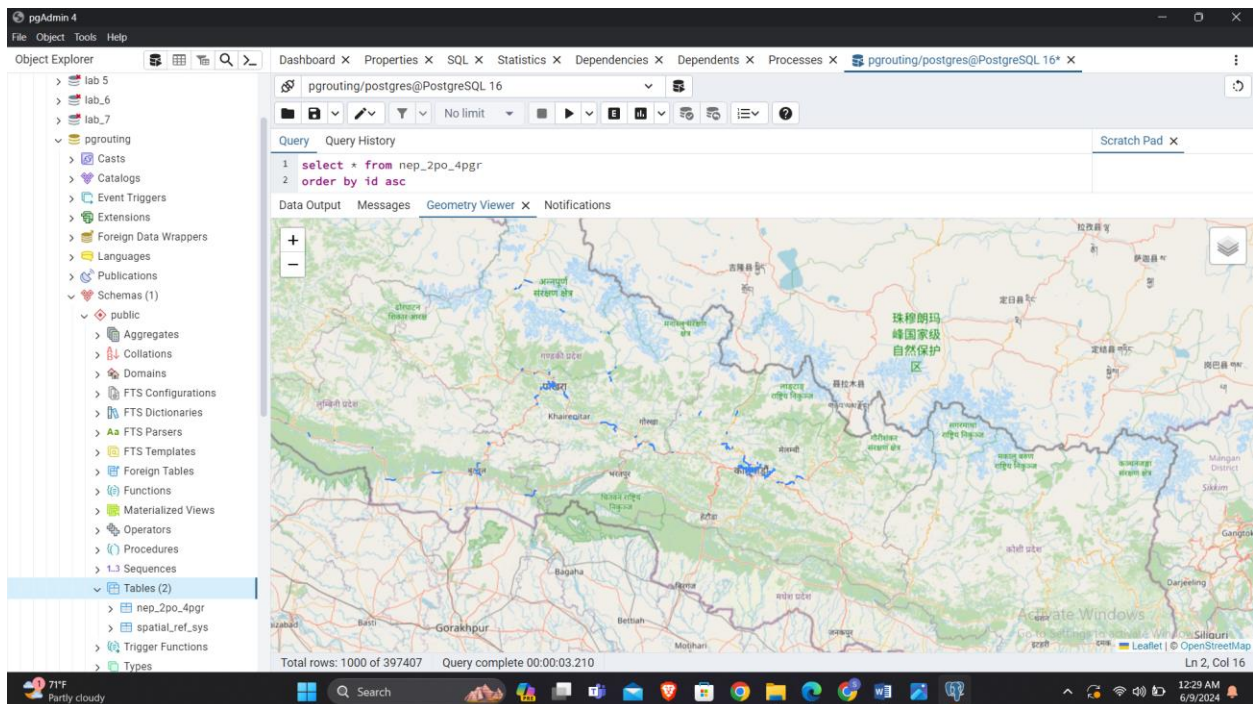


Figure 12: Visualizing data from geometry viewer

3.3.4 Route Calculation

For calculating the route the origin was selected as Jadibuti (27.6727° N, 85.35125° E) and the destination was selected as Kathmandu University (27.6194° N, 85.53877° E).

First of all, database was connected with PostgreSQL using a username and password. The OSM data of routes was loaded in QGIS. After that base map was added.

In QGIS DB manager, query was executed to determine the shortest route using pgrouting and three layers i.e. starting point, ending point and shortest route was added to QGIS.

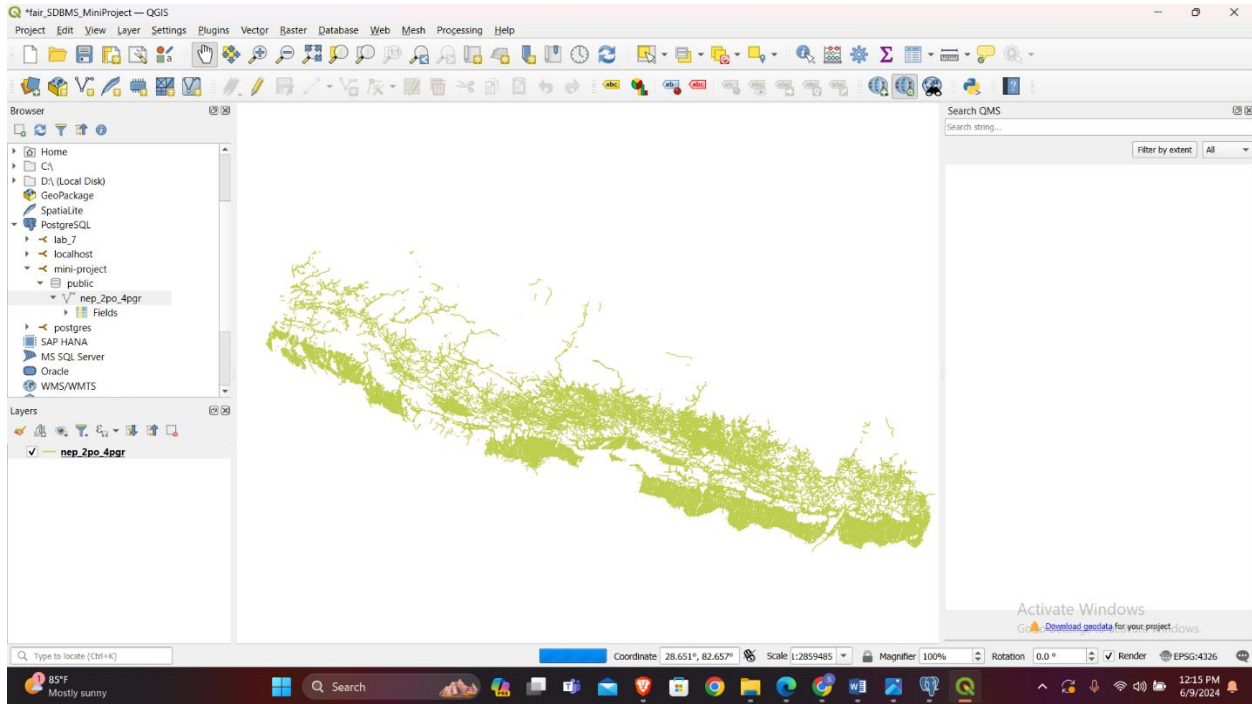


Figure 13: Adding OSM data of routes as layer

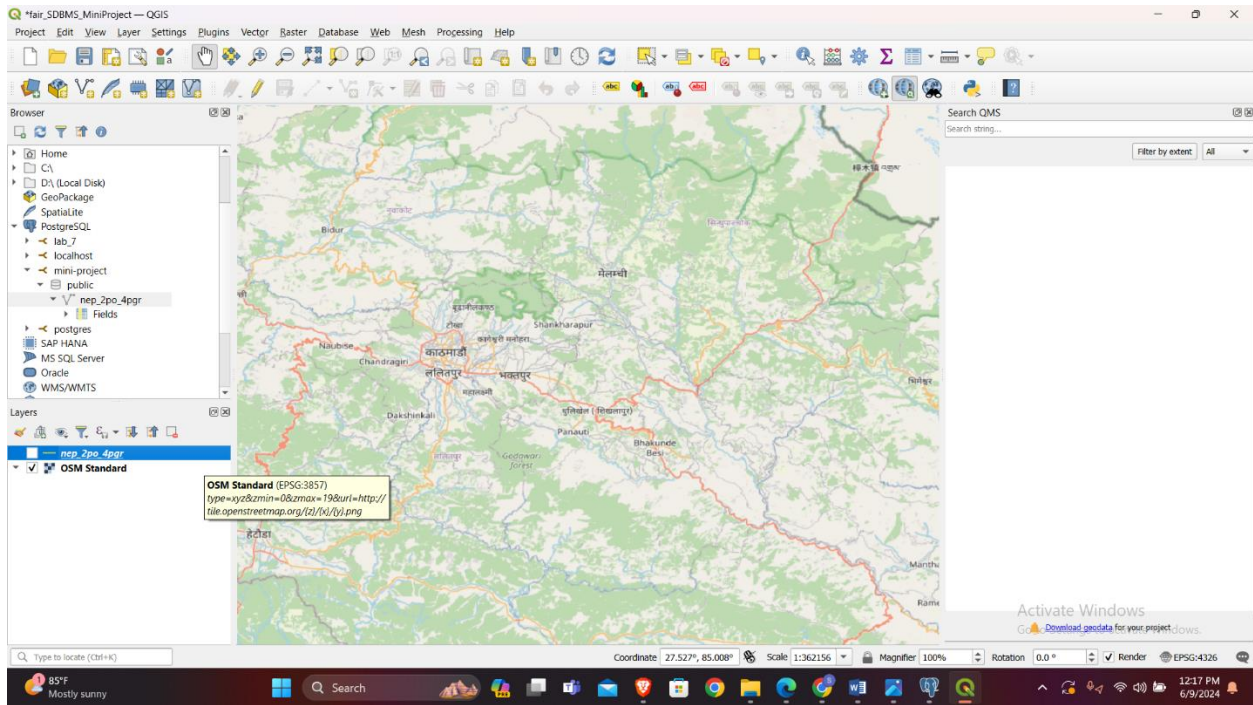


Figure 14: Adding basemap

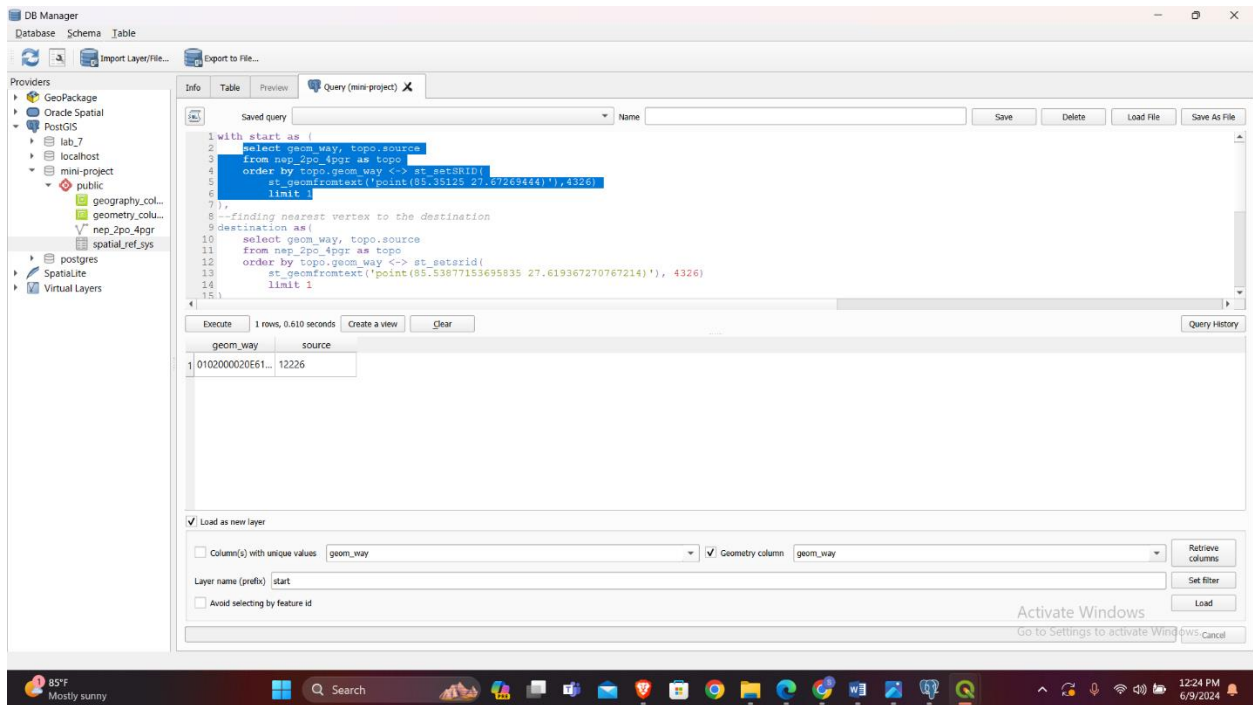


Figure 15: Executing query for start point

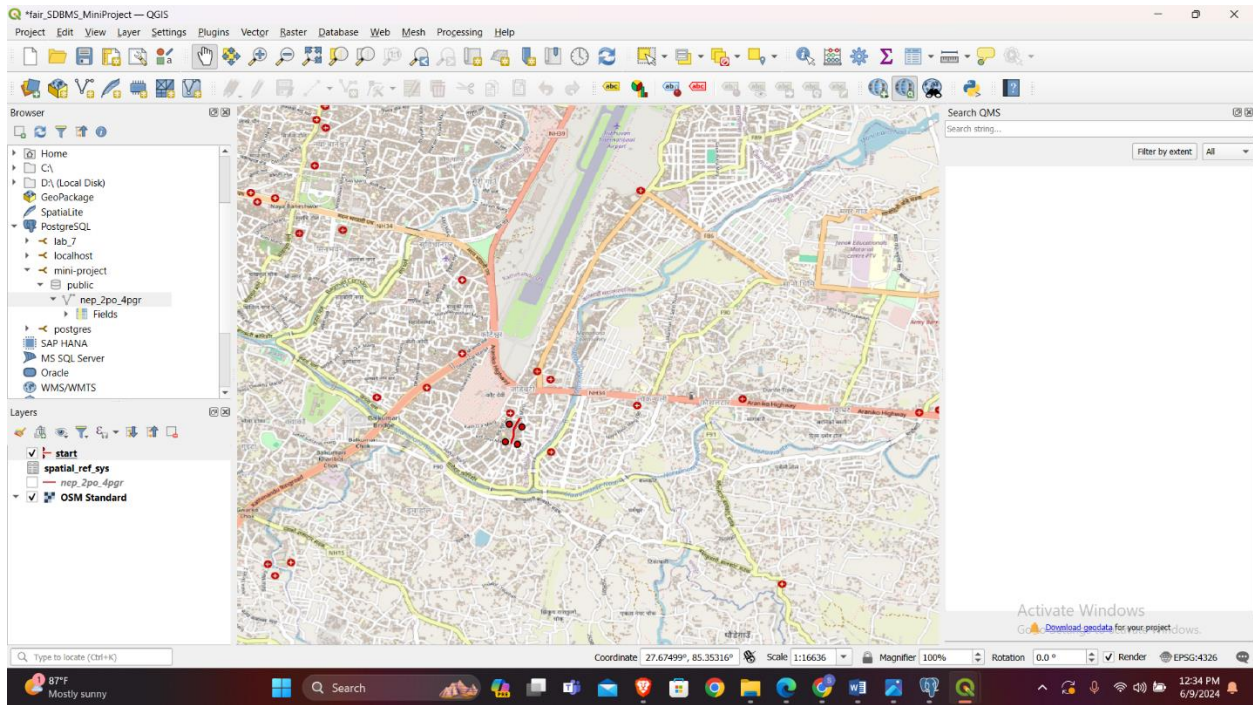


Figure 16: Loading layer with starting point

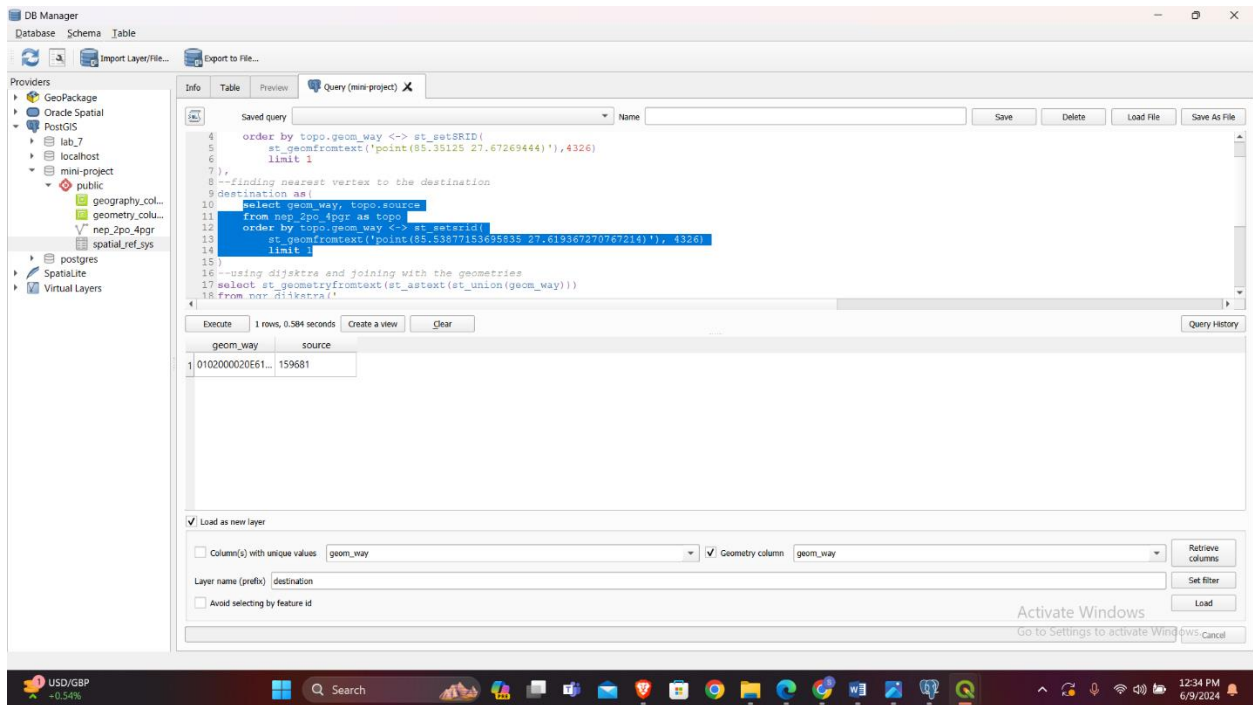


Figure 17: Executing query for destination point

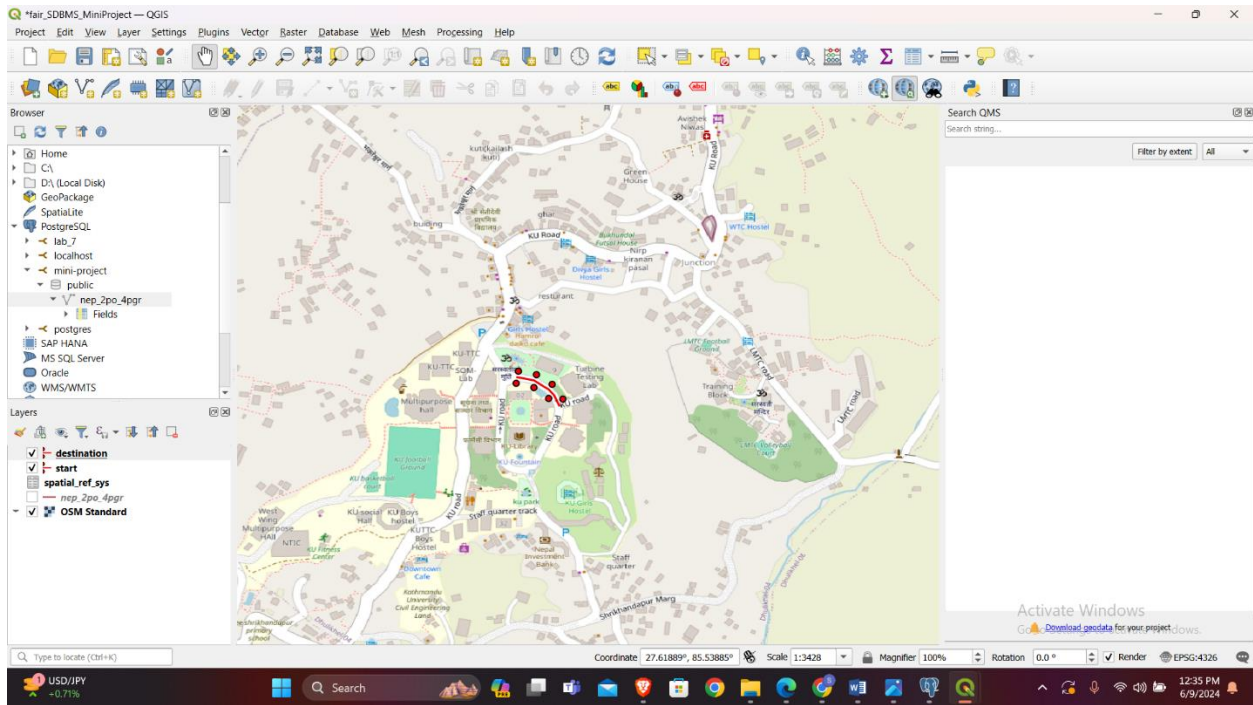


Figure 18: Loading layer with destination point

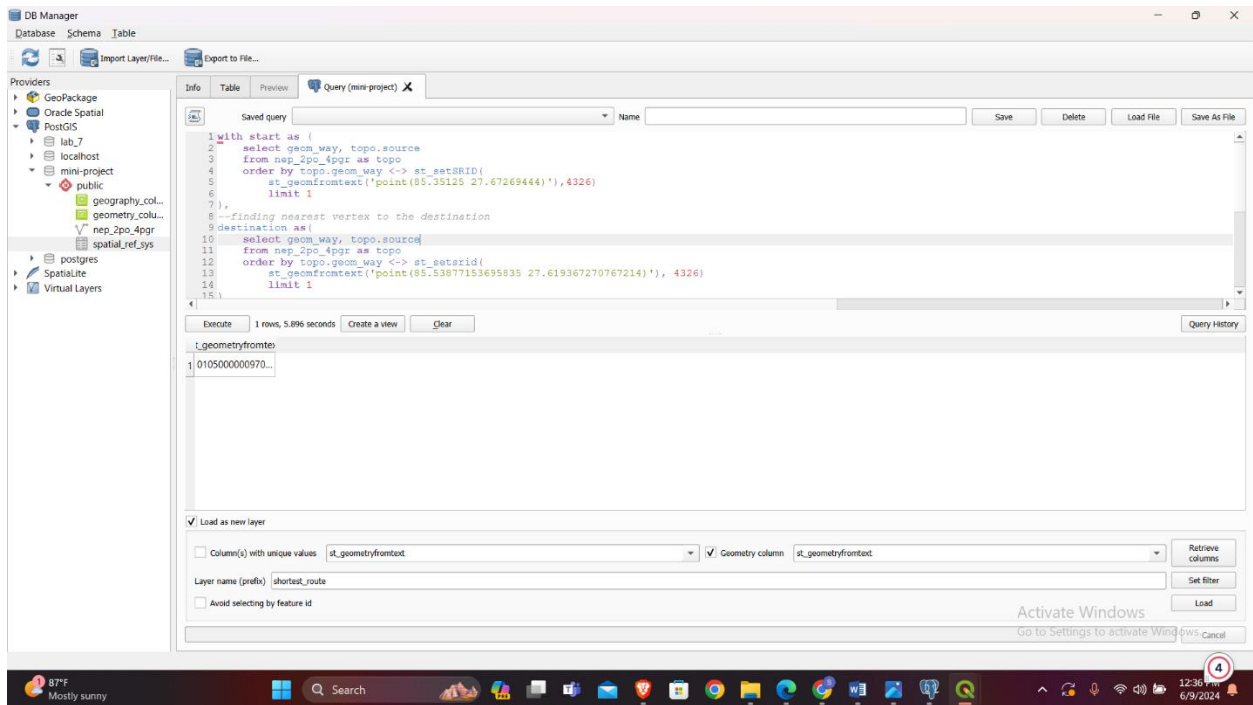


Figure 19: Executing query to find the shortest route

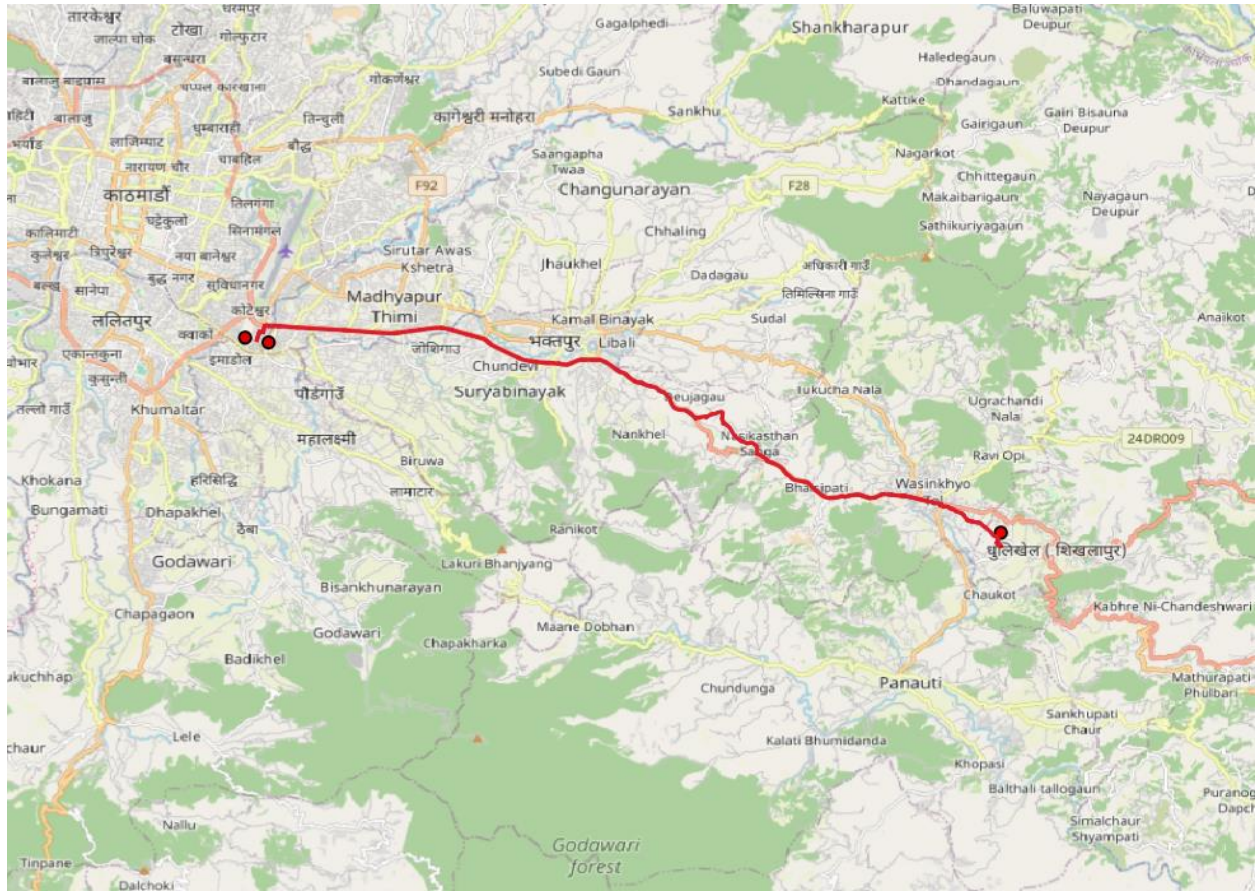


Figure 20: Shortest route visualization

4 RESULTS AND DISCUSSION

The shortest route between Jadibuti and Kathmandu University was determined using pgRouting. In the map below green dots represent Jadibuti, Kathmandu area and black dot represents Kathmandu University. The pink lines are the routes present in the area of map. The red line represents the shortest route between origin (Jadibuti) and destination (Kathmandu University).

The integration of OSM data with PostgreSQL, PostGIS, and pgRouting proved to be effective for routing purposes. The tools worked seamlessly together, enabling efficient route calculation. QGIS was used to visualize the calculated route.

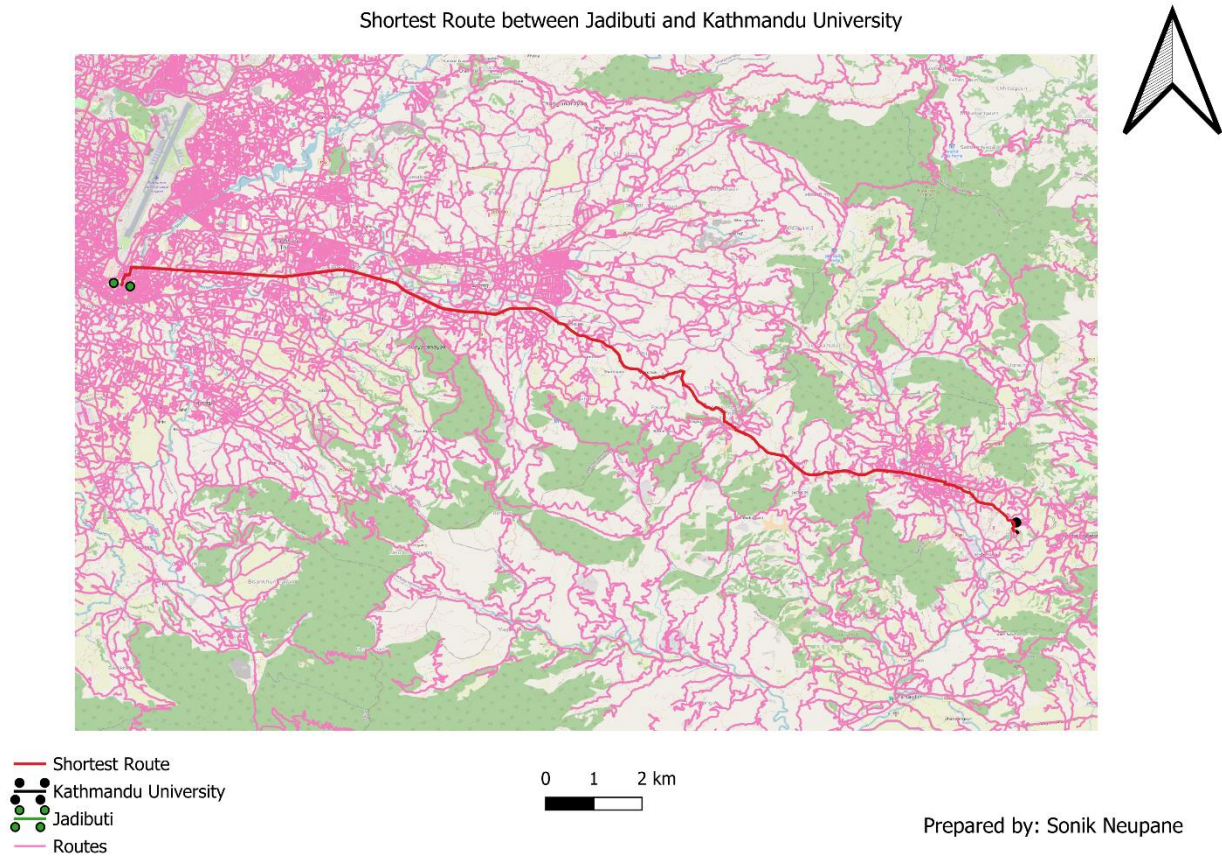


Figure 21: Shortest route between Jadibuti and Kathmandu University

5 CONCLUSION

In this project, the shortest route between Jadibuti, Kathmandu and Kathmandu University was successfully determined using OSM data, PostgreSQL, PostGIS, and pgRouting. The process involved data preparation with osm2po, spatial analysis using pgRouting, and visualization in QGIS. The integration of these tools allowed for accurate calculation of the route and clear visualization on the map. Despite some challenges, such as data quality issues and processing time, the methodology proved effective and demonstrated the robustness of open-source GIS tools.

6 REFERENCES

- Chadha, C., & Garg, S. (2019). Shortest Path Analysis on Geospatial Data Using PgRouting: Visualization of Shortest Path on Road Network. In *Lecture Notes in Networks and Systems* (Vol. 55, pp. 201–214). https://doi.org/10.1007/978-981-13-2324-9_20
- Pritee, K., & R.D., G. (2017). Identification of Optimum Shortest Path using Multipath Dijkstra's Algorithm Approach. *International Journal of Advanced Remote Sensing and GIS*, 6(1), 2442–2448. <https://doi.org/10.23953/cloud.ijarsg.321>
- Sankepally, R. R., & Rajan, K. S. (2018). IMPROVING PATH QUERY PERFORMANCE IN PGROUTING USING A MAP GENERALIZATION APPROACH. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-4/W8, 191–198. <https://doi.org/10.5194/isprs-archives-XLII-4-W8-191-2018>