Automating the Spatial Analysis of Healthcare Facility Distribution using OpenStreetMap Data: Design and Development of a QGIS Plugin (HealthOSM)

1. Introduction

Among GIS platforms, QGIS (Quantum Geographic Information System) has grown into one of the leading open-source, cross-platform desktop GIS applications in use today, supported by a large global community of developers and users (Graser et al., 2025). A defining strength of QGIS is its plugin architecture (Graser et al., 2025). QGIS plugins typically automate repetitive geoprocessing sequences, expose specialised analytical functionality through simple graphical interfaces, and lower the technical barrier for non-expert users to perform sophisticated spatial analysis (Duarte & Teodoro, 2021).

OSM is built largely by volunteers, releasing its map data under an open-content licence (Haklay & Weber, 2008; OpenStreetMap Wiki, n.d.). Because OSM data can be freely queried, extracted, and reused, it has become a foundational resource for humanitarian response, infrastructure planning, and public health mapping, particularly in regions where authoritative government datasets are incomplete or inaccessible.

Healthcare facility location data is one such domain where open OSM-derived data has proven especially valuable. The Global Healthsites Mapping Project (healthsites.io) is building an open data commons of health facility data by leaning on the methods and infrastructure of OpenStreetMap, with the explicit goal of supporting epidemic preparedness, immunisation programmes, disaster response, and health-capacity planning (healthsites.io, n.d.). South et al. (2021) similarly demonstrate that open, reproducible health-facility location data from sources such as healthsites.io and OpenStreetMap can materially support evidence-based health planning and emergency response.

It is on this note – the availability of free OSM-derived healthcare data, the extensibility of QGIS through plugins, and the demonstrated public health value of spatial healthcare-access analysis – that the present work automates a previously manual QGIS/OSM healthcare mapping workflow into a single, reusable plugin.

2. Statement of the Problem

A learning resource — a QGIS and OSM tutorial titled "Unlocking Geospatial Insights with Open Source Tools" (Ezekiel, O., 2024) — was selected as an abstract for the SOTM Nigeria 2024 conference but was later moved to one of the workshop sections of the conference, teaching OSM users how to extract OpenStreetMap healthcare facility data and analyse its spatial distribution within a given administrative area using QGIS. The tutorial's demonstrated workflow, applied to Ondo State, Nigeria, involves importing health-site and administrative-boundary data, converting polygon health features to centroid points, merging point layers, selecting and clipping data to the area of interest, counting facilities within each sub-administrative boundary, and finally applying graduated (choropleth) symbology to visualise facility density.

While effective for instructional purposes, this workflow is entirely manual: it requires a trainee to correctly execute upward of eight discrete steps across several different QGIS toolboxes (Geometry Tools, Data Management Tools, Research Tools, and Analysis Tools) in a fixed sequence, using region-specific inputs and menu selections. Replicating the same analysis for a new region — a different state, country, or humanitarian response area — requires repeating every step from scratch, which is time-consuming, and demands a working familiarity with multiple QGIS toolboxes that not all intended users possess. Hence, the need to automate this replicable analytical task so that it can be executed consistently and rapidly for any region, without requiring the user to manually operate each individual geoprocessing tool.

3. Justification

Automating the manual workflow described above is justified on several grounds:

i. it eliminates repetitive, multi-step manual operations, reducing the time required to move from raw OSM data to a finished healthcare-distribution map.

ii. it standardises the analytical methodology, ensuring that the same sequence of geoprocessing operations is applied consistently regardless of who runs the tool or which region is analysed, reducing the risk of human error inherent in manual, multi-tool workflows.

iii. automation directly supports the reproducibility and rapid-response goals emphasised in the open-data health-facility literature (South et al., 2021), where the value of open data is only realised when it can be efficiently queried, processed, and turned into actionable spatial insight.

4. Aim and Objectives

The aim of this project is to design and develop a QGIS plugin, HealthOSM, that automates the end-to-end extraction, processing, and visualisation of OpenStreetMap healthcare facility distribution within any user-defined sub-administrative boundary.

The specific objectives are to:

i. Define the specific steps in the entire workflow.
ii. Design a simple and suitable user interface to match the needs of the plugin.
iii. Prepare the detailed code script for each step in the workflow.
iv. Test and troubleshoot the plugin tool.

5. Methodology and Tools Used

The methodology automated by HealthOSM is derived from the manual workflow in the base tutorial. The plugin uses QGIS Desktop (version 4), a direct Overpass API connection via QGIS's built-in network request handling (no third-party plugin dependency), and QGIS's native Processing algorithms for clipping, point-in-polygon counting, and kernel density estimation.

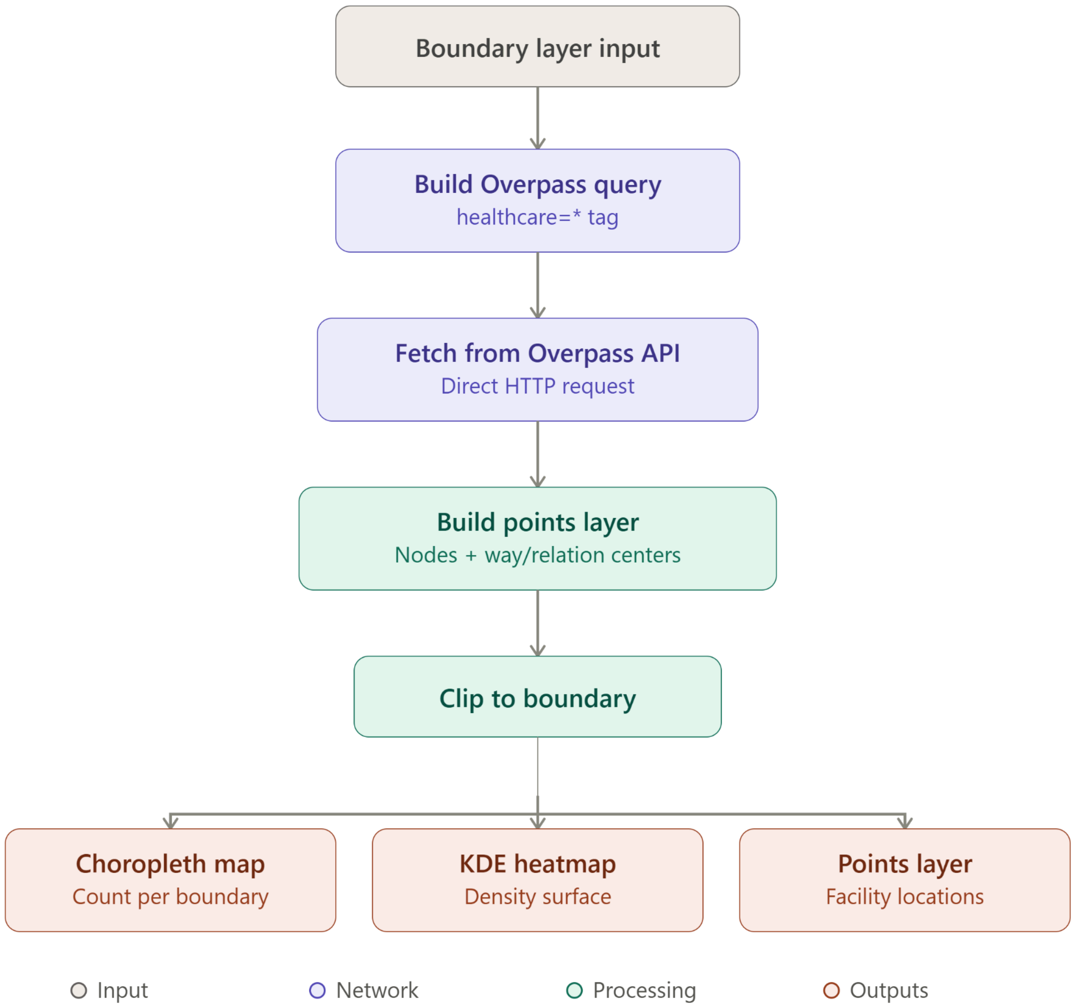


Fig. 5.1: Flowchart

5.1 Data Acquisition

Rather than manually visiting healthsites.io, the HOT Export Tool, or the OpenStreetMap website, or specifying OSM tags by hand, the plugin requires only one input: an administrative boundary layer defining the area of interest. From this extent, the plugin automatically builds an Overpass query for every feature tagged healthcare=* — the general-purpose OSM healthcare classification covering clinics, hospitals, pharmacies, doctors, dentists, and related facility types — and sends it directly to the Overpass API.

5.2 Unified Point Layer Construction

The query requests each matched node, way, and relation's centre coordinate directly from Overpass, so every feature — regardless of whether it was originally mapped as a point or an area — is returned as a single representative coordinate. This replaces the tutorial's separate centroid-conversion and layer-merging steps with one pass: the plugin builds one unified point layer directly from the query response.

5.3 Spatial Extraction to the Area of Interest

The unified point layer is clipped to the user-supplied administrative boundary using QGIS's Clip algorithm, restricting the dataset to features within the Area of Interest.

5.4 Density Computation

The Count Points in Polygon algorithm tallies the number of health facilities within each sub-administrative polygon (for example, each Local Government Area or district boundary), producing an attribute field recording the facility count per polygon.

5.5 Cartographic Styling — Choropleth

The boundary layer, now carrying a facility-count field, is styled with a graduated (choropleth) renderer using a Natural Breaks (Jenks) classification and a sequential colour ramp, distinguishing areas of higher and lower healthcare facility density.

5.6 Kernel Density Estimation Surface

A continuous facility-density raster is generated by kernel density estimation, with the search radius and pixel size scaled to the boundary's own extent so the surface remains meaningful regardless of the area's size, and the computation extent is padded to the boundary rather than the points' bounding box so no part of the boundary is left uncalculated. The raster is masked to the boundary shape and styled with a continuous yellow-to-red colour ramp.

5.7 User Interface and Feedback

All operations above are exposed through a single plugin dialogue, requiring the user only to select an administrative boundary layer and execute the tool. A progress bar and status messages provide real-time feedback throughout the pipeline, and errors at any stage are surfaced through QGIS's message bar.

6. Result and Discussion

Fig. 6.1: HealthOSM Plugin interface

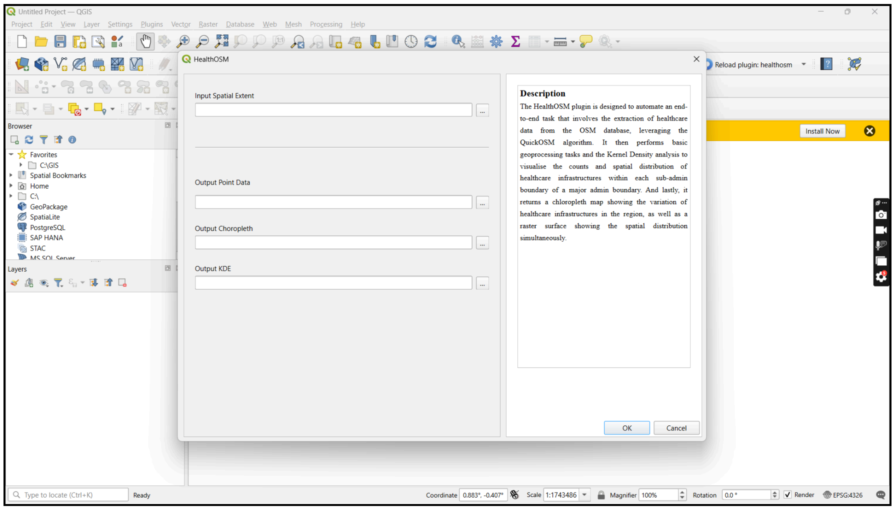


Fig. 6.2: Point data result

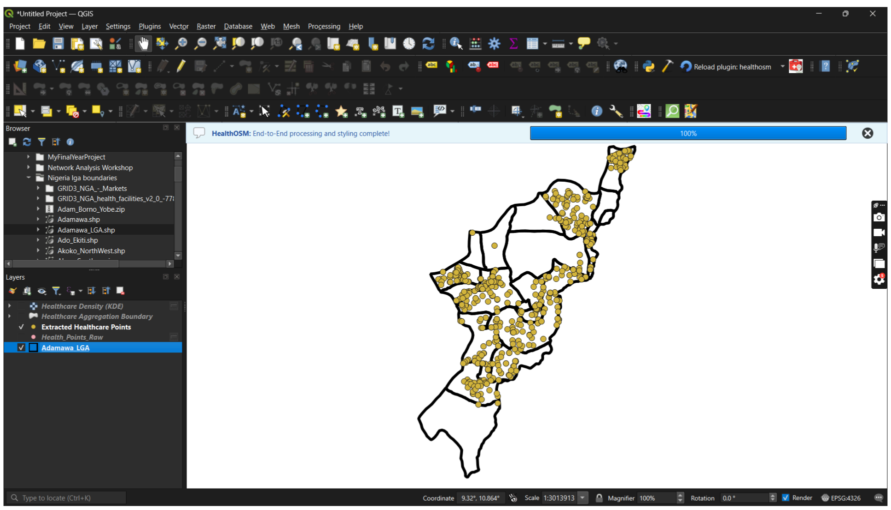


Fig. 6.3: Choropleth Visualization

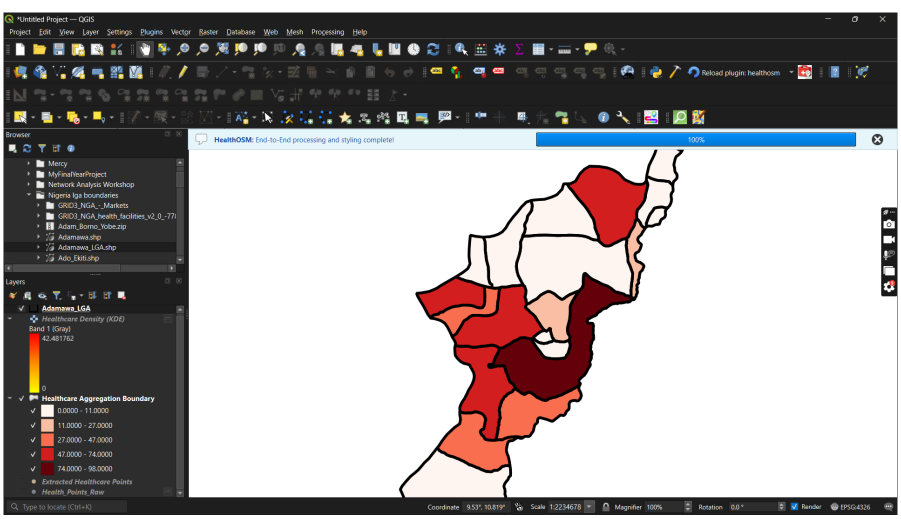
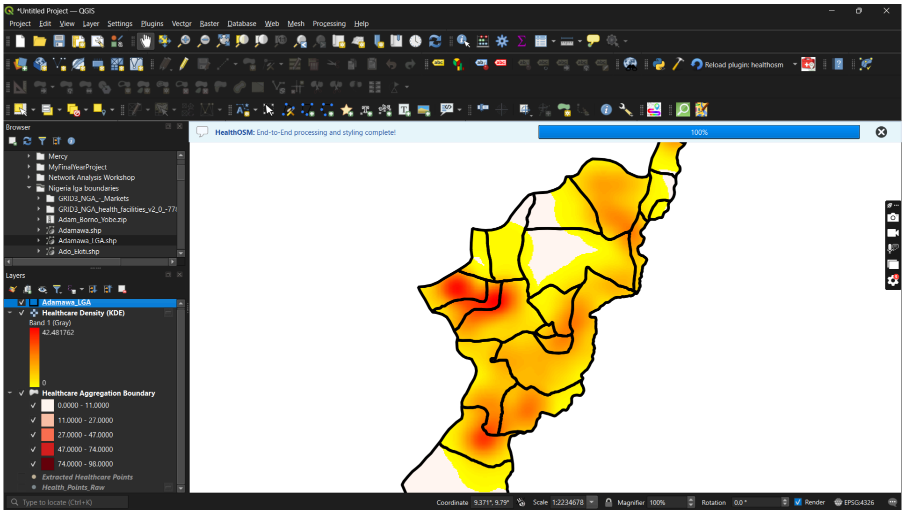


Fig. 6.4: Kernel Density Estimation



7. Conclusion

This work set out to automate a previously manual, multi-step QGIS and OpenStreetMap healthcare-mapping workflow that, while effective as a training exercise, was not efficiently replicable across regions. By packaging automatic tag-based query building, spatial clipping, point-in-polygon density computation, choropleth styling, and kernel density estimation into a single QGIS plugin, HealthOSM is designed to substantially reduce the time and technical expertise required to generate healthcare-accessibility maps from open OSM data. In doing so, the plugin builds on the demonstrated value of open, volunteered geospatial data (Haklay & Weber, 2008), the growing ecosystem of open-source GIS plugins (Duarte & Teodoro, 2021), and the specific public health case for accessible, reproducible healthcare facility data (South et al., 2021; healthsites.io, n.d.). Future work will focus on completing plugin testing and validation across multiple regions, generating an interactive web map output for non-GIS personnel to interact with the results, and publishing the plugin to the official QGIS Plugin Repository for broader community use.

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This video link explains the manual version of carrying out the analysis for which this plugin was designed. It also cites more sources for open-source data linked together with OSM and how these data can be used to generate insights to better understand the spatial distribution of these infrastructures and to facilitate informed decision- and policy-making.

Acknowledgment

The source code for this plugin was generated by Claude but refined by the author.