Labs 5-7: GIS Analysis I

Polygon-Based Analysis using Socio-Economic Census Data (26/03)

Surface Interpolation from Randomly Spaced GPS Points (2/04)

Network Analyst (30/04)

GISC422

Introduction to GIS

Lab Stream 03 (Wednesday)

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1. LAB 5: POLYGON-BASED ANALYSIS USING SOCIO-ECONOMIC CENSUS DATA

1.1 Summary

1.1.1 Introduction

The purpose of the lab exercise was to explore how well the MetroStar bus route served university-aged people in Christchurch. The data used was the Statistics New Zealand data from the 2013 census, for university aged people in 2006 and 2013. The data is aggregated to census areas called Meshblocks and Area Units (aggregations of Meshblocks).

1.1.2 Methods

A pre-prepared ArcGIS Pro file was opened, containing the MetroStar and Orbiter bus routes, the UC campus, and the Christchurch Meshblock geography in 2013. The census data was wrangled and cleaned then joined with the Meshblock geography data to give the census data geographic context. The Meshblock data was aggregated into a lower resolution called Area Units, using the dissolve tool. A histogram of each aggregation was generated and from these, summary statistics were generated for each aggregation and year, along with the intersection of the MetroStar bus route. Four density maps were generated (each aggregation and year) and are presented below in the Graphics section (Figures 1-4).

1.1.3 Results

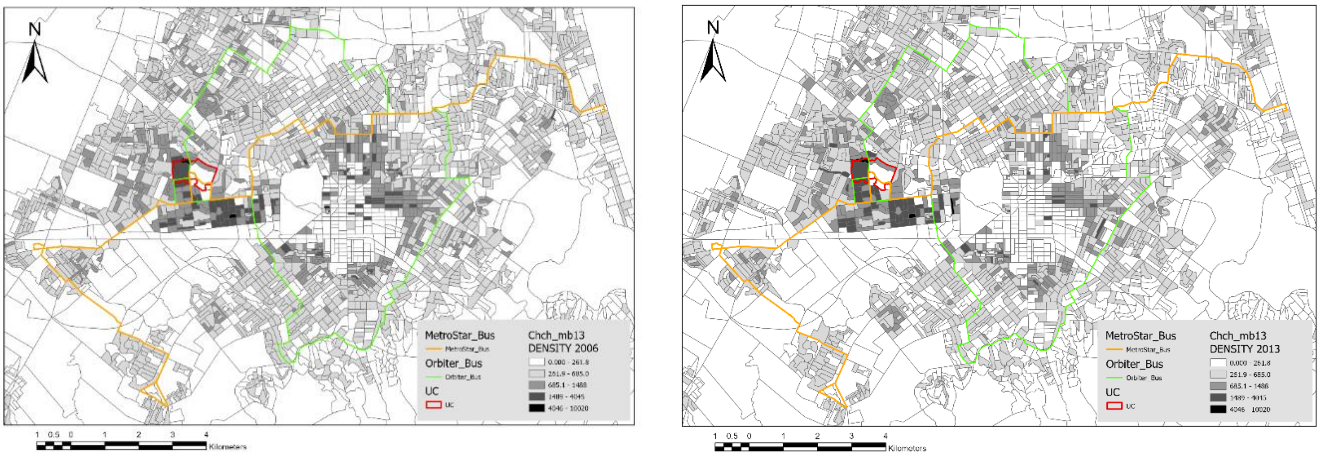
The density considering all of Christchurch has decreased by 6% between 2006 and 2013. The Meshblock areas that intersect the MetroStar bus route, however, have increased slightly by ~3%. At least one area has seen a large increase, evident by the increased maximum value. The mean for the areas that have an intersection with the bus route are higher than the mean for all of Christchurch, suggesting the bus route is appropriate. When considering Area Units, the density of those intersecting the bus route show a slight decrease of ~3% between 2006 and 2013.

1.1.4 Discussion

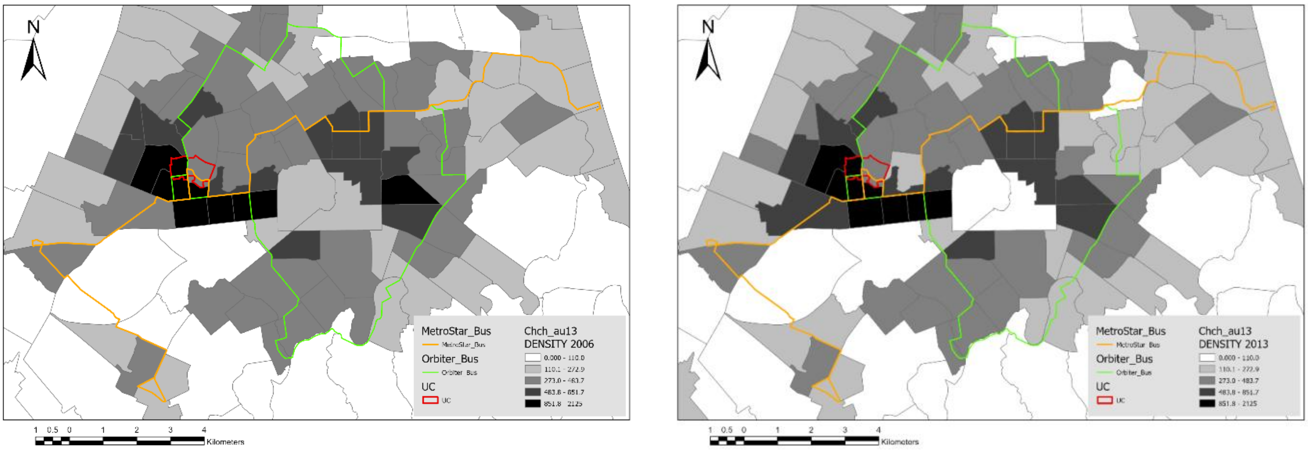
It is clear from the results that aggregating the Meshblock data to Area Unit level loses the detail, with the apparent conflicting results (6% increase vs. 3% decrease) This is an example of the scale effect of MAUP.

The effectiveness of the MetroStar bus route could be further investigated by considering proximity to other bus routes and accessibility to other transportation options like walking and cycling.

1.2 Graphics



Figures 1-2: *The population density of Christchurch, aggregated by the 2013 Census Meshblocks. The plot on the left shows the density distribution in 2006, and the right plot contains data for 2013. The bus route that is being assessed is the MetroStar, shown in orange.*



Figures 3-4: *The population density of Christchurch further aggregated to the Area Unit level. Again, the plot on the left represents data from 2006, and the right 2013. The bus route that is being assessed is the MetroStar, shown in orange.*

2. LAB 6: SURFACE INTERPOLATION FROM RANDOMLY SPACED GPS POINTS

2.1 Summary

2.1.1 Introduction

The aim of this laboratory exercise is to predict the geochemistry across the University of Canterbury (UC) campus via interpolation methods, given data at discrete GPS points from boreholes.

2.1.2 Methods

Two .csv files containing information on boreholes at UC, and the water table chemistry, were provided. These were cleaned to have valid column names working with ArcGIS Pro. An air photo of the UC campus was brought into ArcGIS Pro, providing spatial context and setting the coordinate system to New Zealand Transverse Mercator (NZTM). The boreholes were brought in from the .csv and displayed using the longitude and latitude values. This data was projected to NZTM. The water table chemistry table was joined to the borehole table, and interpolation methods IDW, Kriging, Nearest Neighbours, and Spline were used to create raster layers of likely barium levels (Figures 5-8). The IDW surface appeared to fit the sample values best, so a contour plot of the surface was presented along with the air photo for spatial context (Figure 9). A Scene (Figure 10) was created to visualise the IDW surface below the UC campus air photo. Vertical exaggeration was used to enhance the visualisation, and the boreholes were extruded through the air photo to clearly show the sample locations with spatial context.

2.1.3 Results

Each of the interpolation methods produced quite different results (Figures 5-8). In this context the IDW appeared to most closely fit the sample values and was within the range, so it was chosen for further visualizations.

2.1.4 Discussion

The values produced by the Kriging values are lower and seem to be biased based on direction. The Natural Neighbour values are in a similar range to the IDW method, but they don't extent to the boundaries of the study area. The Spline method had values that were too high or low, beyond the sample values, including some negative values which do not make sense when considering concentrations.

2.2 Graphics

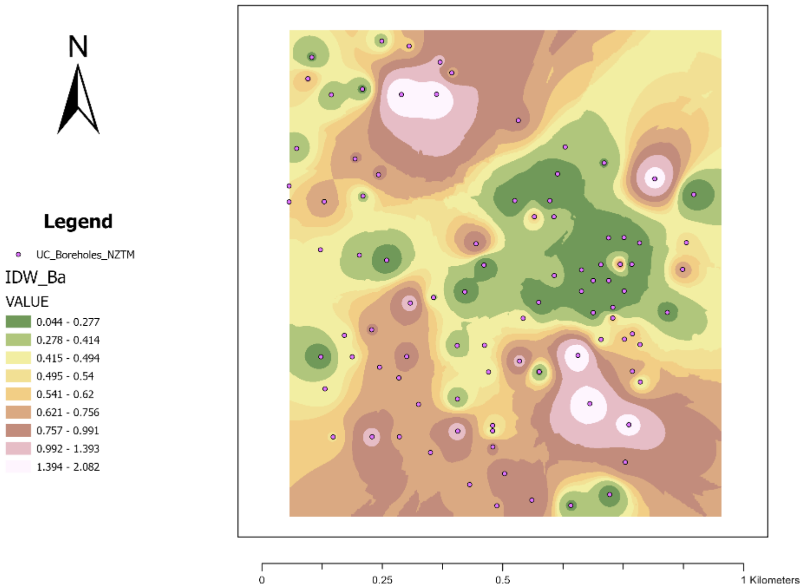


Figure 5: *A heatmap of interpolated concentrations of Barium in the water table on the UC campus. The IDW method of interpolation was used to generate the values. The NZTM boreholes provided sample values to interpolate from.*

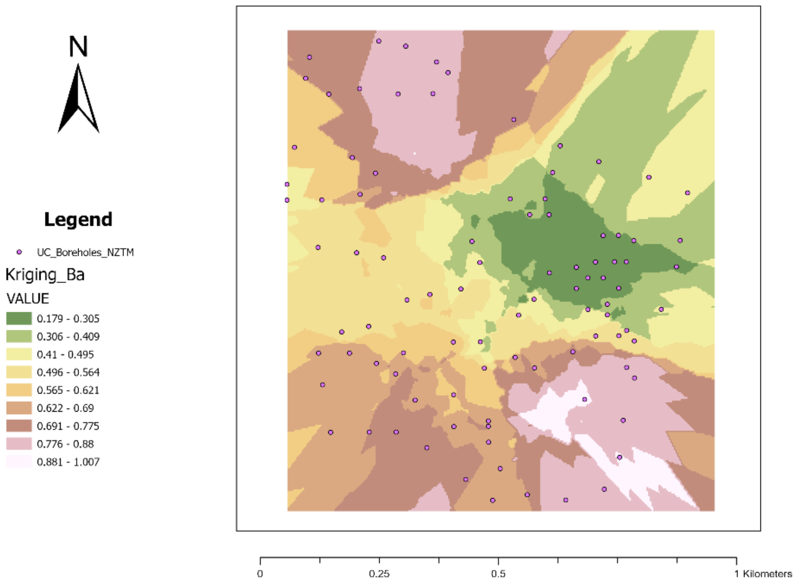


Figure 6: *A heatmap of interpolated concentrations of Barium in the water table on the UC campus. The Kringing method of interpolation was used to generate the values. The NZTM boreholes provided sample values to interpolate from.*

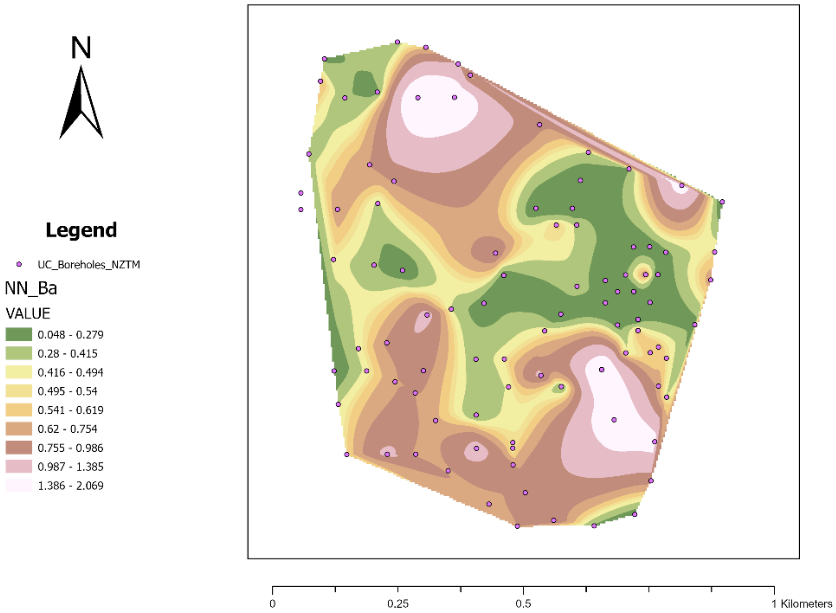


Figure 7: *A heatmap of interpolated concentrations of Barium in the water table on the UC campus. The Natural Neighbours method of interpolation was used to generate the values. The NZTM boreholes provided sample values to interpolate from.*

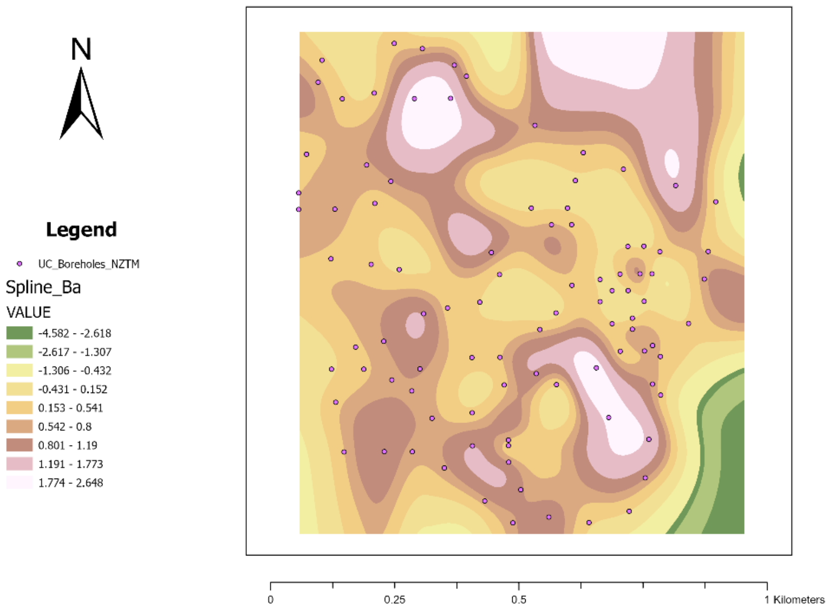


Figure 8: *A heatmap of interpolated concentrations of Barium in the water table on the UC campus. The Spline method of interpolation was used to generate the values. The NZTM boreholes provided sample values to interpolate from.*

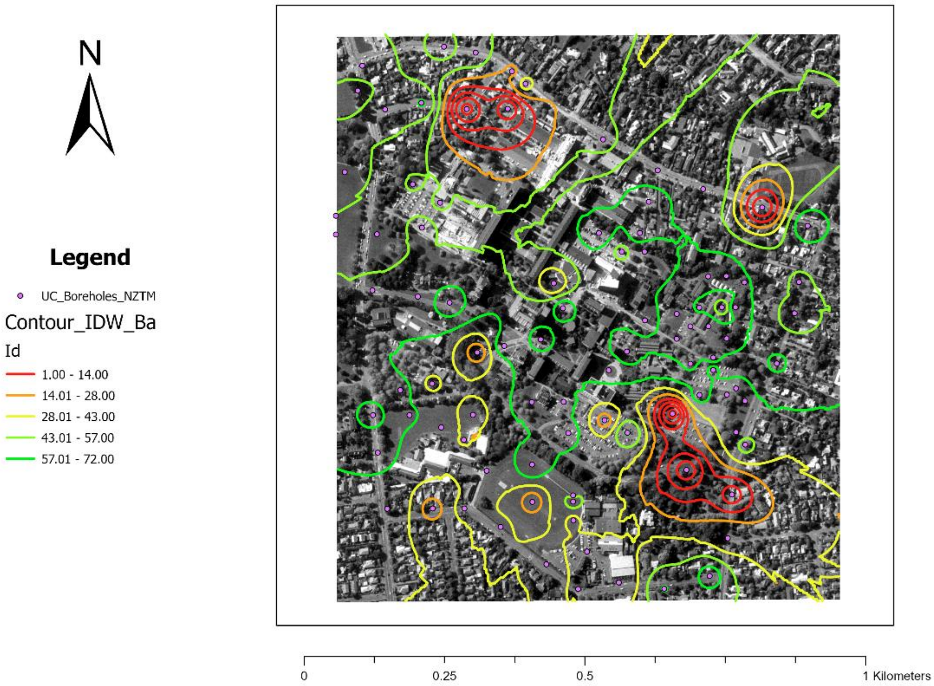


Figure 9: *An air photo of the UC campus with contour lines overlayed representing the IDW interpolated surface.*

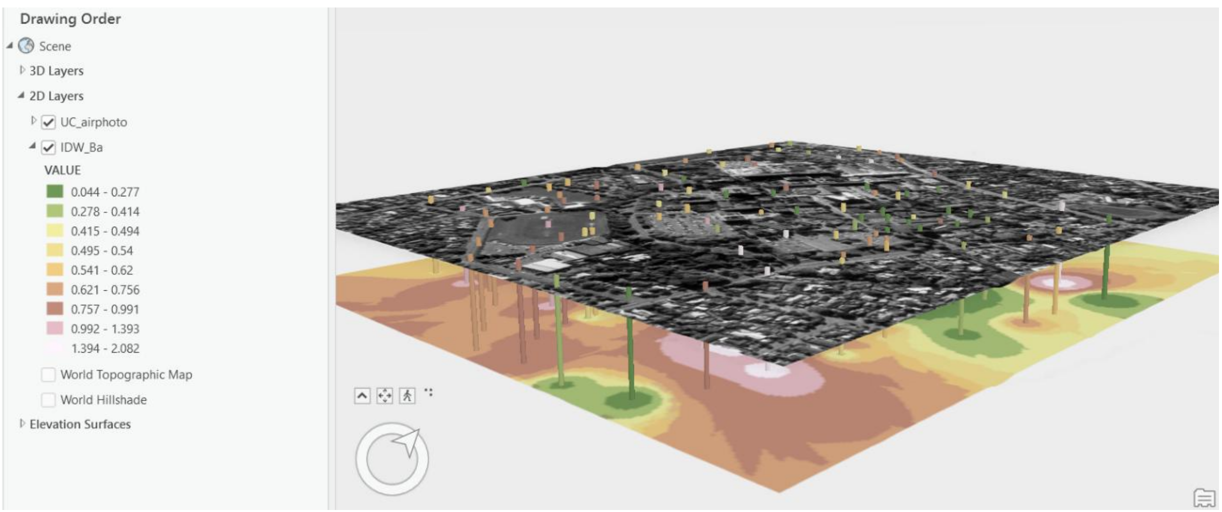


Figure 10: *An ArcGIS Pro 'Scene' showing the IDW interpolated surface below the UC campus air photo, with the borehole extruded through the air photo.*

3. LAB 7: NETWORK ANALYST

3.1 Summary

3.1.1 Introduction

Network Analysis was used to investigate four scenarios: the optimum route for a salesman, the closest fire station to an incident, the locations of warehouses servicing stores, and optimisation the servicing network.

3.1.2 Methods

On a map of the San Francisco street-network, the location of a salesman's hotel was added to a route network, followed by hospital locations, followed by the hotel again. The path taken by the salesman was optimised, shown in Figure 11. Barriers were added to see the resulting time and distance cost (Figure 12).

Fire stations were added to the map as facilities, and an address was added as an incident. The closest facilities analysis was run to find the three closest fire stations, shown in Figure 13.

In a map of Paris, the service area tool was used to find the 5-, 10-, and 15-minute service areas for six warehouses. It was then investigated if all stores could be serviced by moving one warehouse (Figures 14-15).

The location-allocation tool was used to find the minimum service time for all stores (Figure 16). The maximise coverage and minimise facilities tool was used to find the minimum number of warehouses required to service all stores (Figure 17). It was also explored to see if moving a warehouse could improve this when restricted to outside the ring road.

3.1.3 Results and Discussion

The optimum route was for the salesman was found to be ~40km and ~1hr 27min, and for the fire incident it was found that of the three closest fire stations, Station 39 was the closest, at 0.91 km and 2.60 minutes.

Moving one warehouse to inside the ring road allowed all the stores to be serviced within 15 minutes. Without moving warehouses, it was found that all stores could be serviced within 23 minutes, and all stores could be serviced by only three warehouses within that time. Moving a warehouse did not improve this when restricted to outside the ring road.

3.2 Graphics

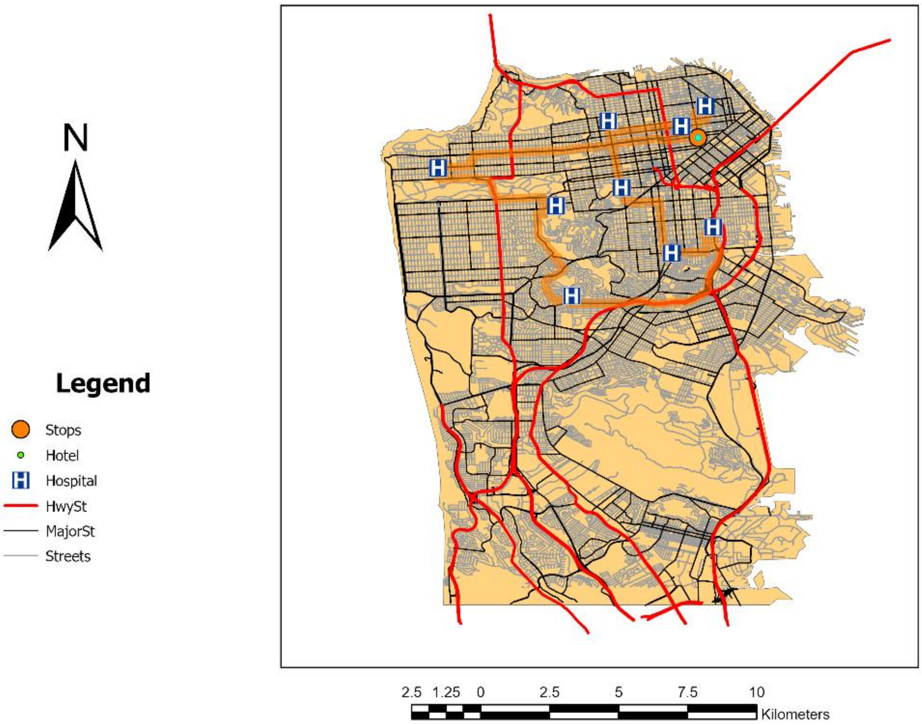


Figure 11: *The optimum determined route for the salesman travelling from their hotel to each of the hospitals and back again in San Francisco.*

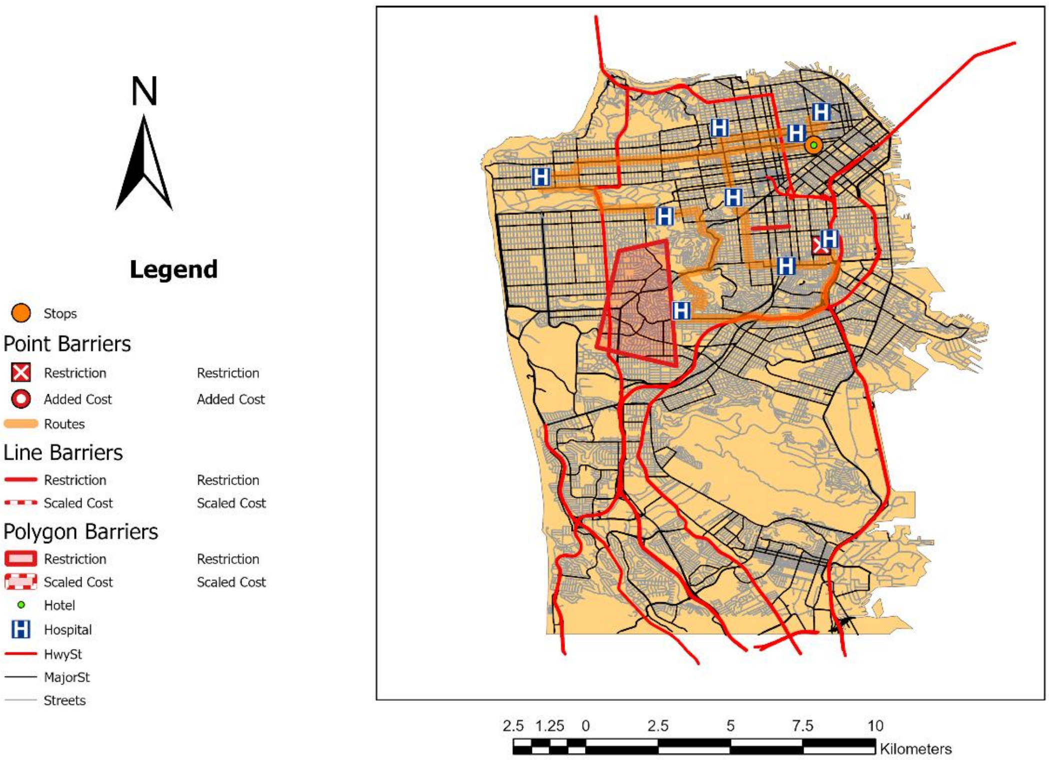


Figure 12: *The optimum route after adding various self-selected barriers over the original route.*

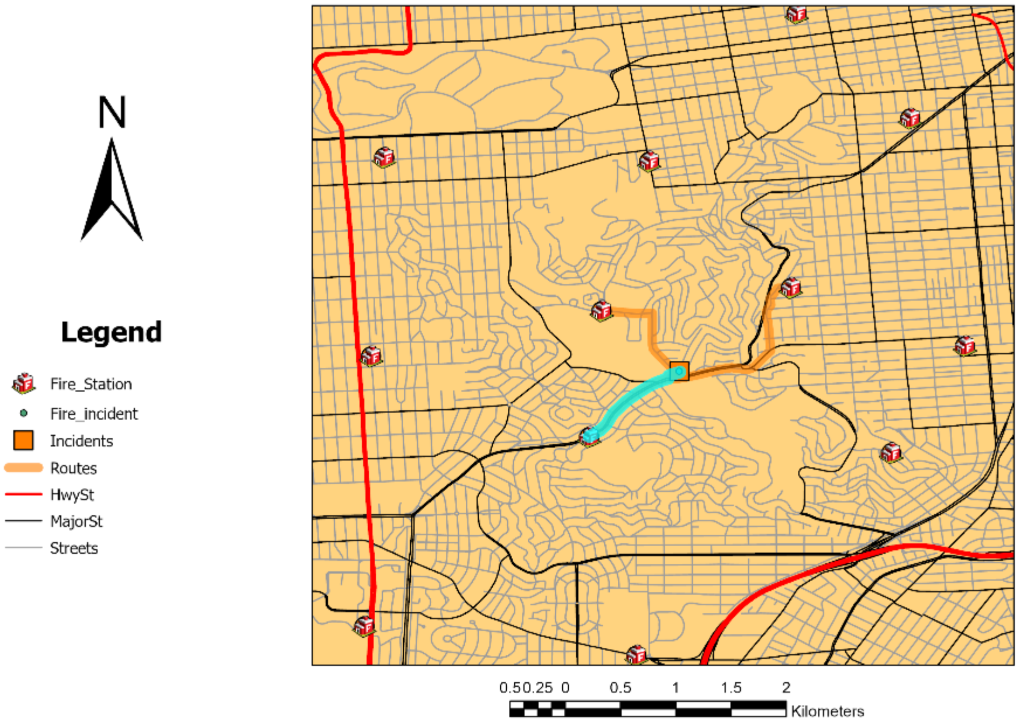
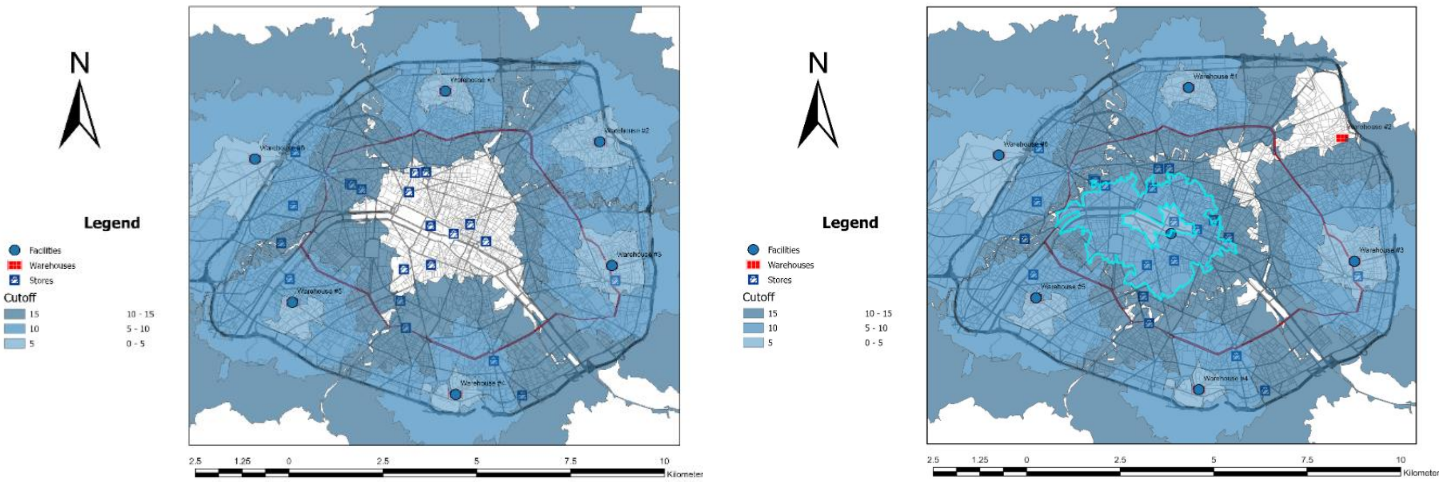


Figure 13: *Three routes from the three closest fire stations to the fire incident in San Francisco. The route from the closest fire station in both time and distance is selected.*



Figures 14 -15: *The 5-, 10-, and 15-minute service areas of six warehouses in Paris and the stores that they service, before and after shifting Warehouse #2 to the centre of the city.*

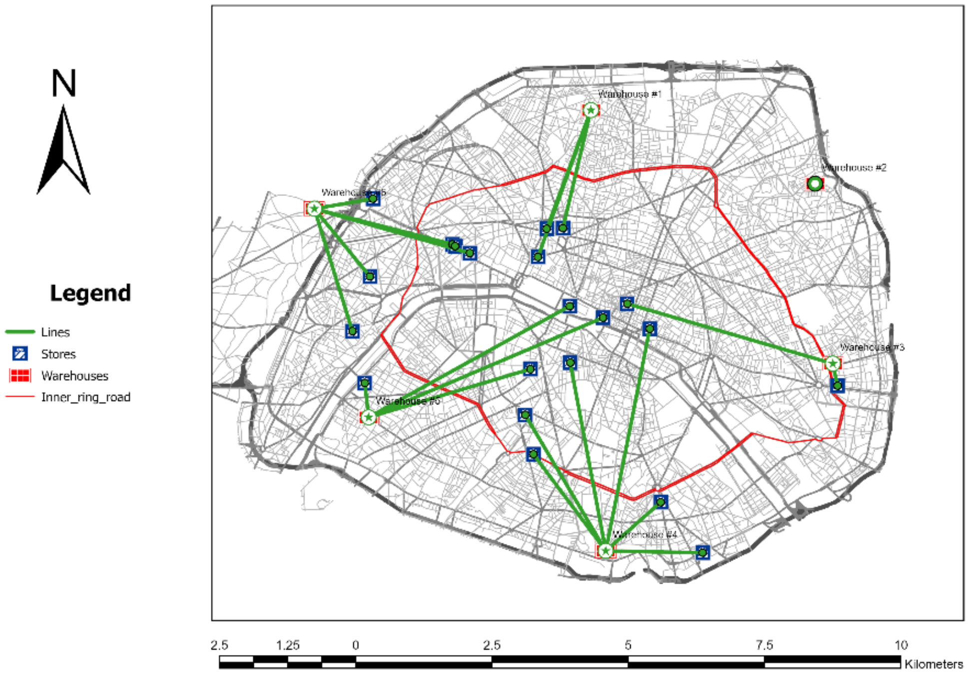


Figure 16: *A graphic showing that all the stores can be serviced within a time of 23 minutes, with the warehouses in their original locations.*

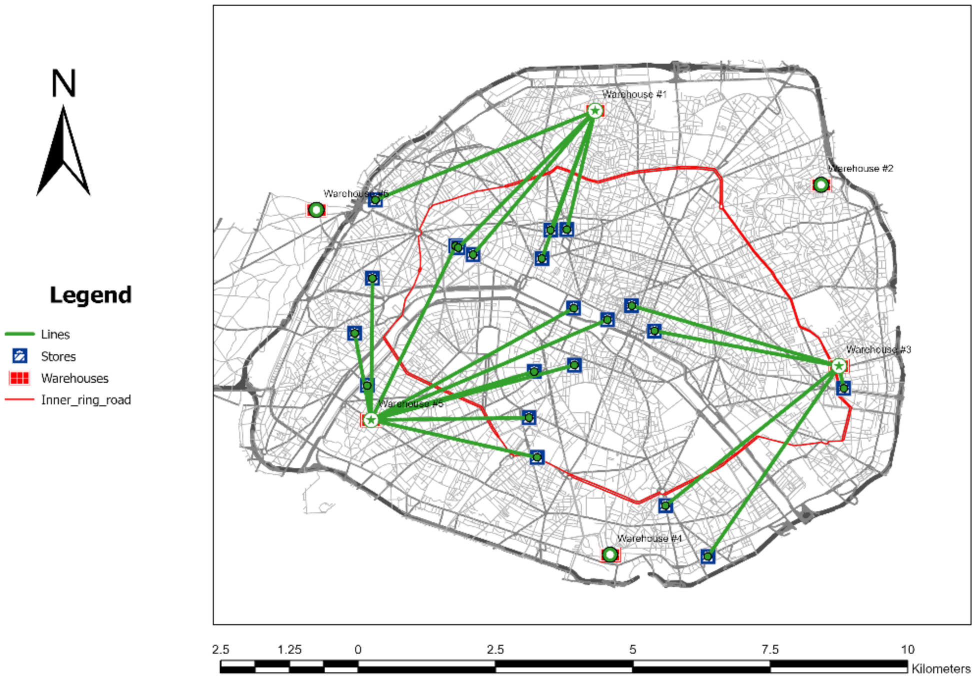


Figure 17: *A graphic showing that all stores can be serviced within 23 minutes by a minimum of three warehouses. Moving the warehouses does not reduce this when restricted to outside of the ring road.*