Site Location for Affordable Housing Development with Neighbourhood Analysis in Manchester

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Introduction

1. Project Background

Manchester is a city and metropolitan borough in Greater Manchester, England. The city has the country's fifth-largest population at 547,627 (as of 2018), and it is recently named as the UK's most liveable city, and in the top 50 in the world ahead of London, New York and Rome, Manchester has cemented itself as a desirable location to live.

The city is notable for its architecture, culture, musical exports, media links, scientific and engineering output, social impact, sports clubs and transport connections. Manchester is its own northern capital of culture. From sport to art, theatre, architecture and of course music, the city has more than made its cultural mark on the country. Historically a powerhouse of industry, Manchester has flourished under a sustained period of urban regeneration, all while retaining its own unique sense of identity.

Manchester City Council is the local government authority for Manchester, a city and metropolitan borough in Greater Manchester, England. It is composed of 96 councillors, three for each of the 32 electoral wards of Manchester.

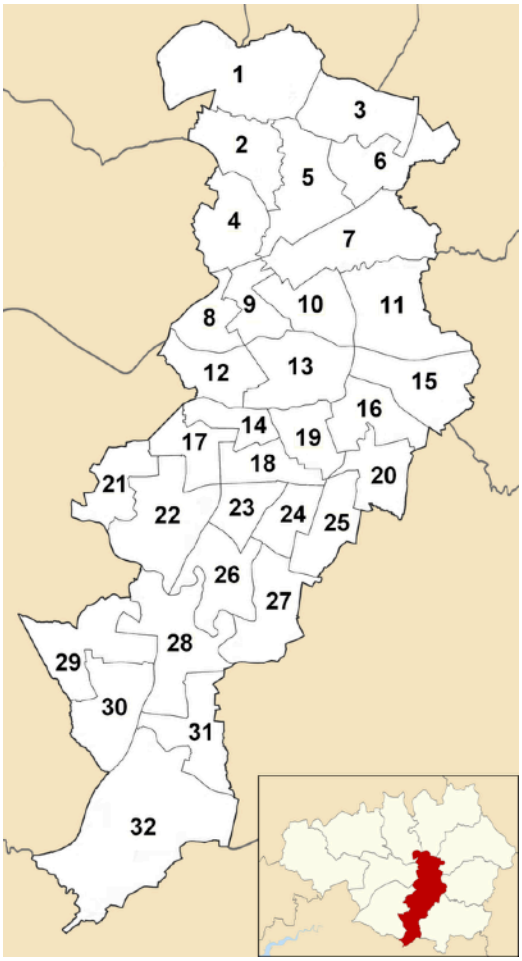

Figure 1. Manchester City Wards

2. Problem

Since 2015, 13,259 homes have been completed in the city - however, forecasting suggests that without intervention, the city may fall short of its affordable homes target, despite various successful partnerships with the city's registered providers where Council land is invested for affordable housing.

A new council-run house building company will be established in Manchester in a bid to boost the delivery of affordable homes. (*Manchester City Council, 2020*). The town hall is aiming to build overall 32,000 new houses by 2025, including 6,400 affordable home. By creating this company, the council will be able to control and set rent levels to better meet the needs of those on housing benefits. It is estimated that it could deliver around 1,800 new affordable homes, along with more than 1,000 homes for market sale and rent.

Figure 2. Manchester City Affordable Housing

3. Interest

It is expected that wards and areas, where there is a lower real estate cost and has a relatively lower density of local infrastructure and business, are preferred to achieve their goals. This can be due to various factors, not limited to but including:

- Delivery at least 500 homes per year hence location of lower average house price and lower average transactions
- Deliver a mix of affordable homes and market homes (with the latter helping to subsidise the affordable homes)
- Helping local community and small local business

By using the tools of data gathering and analysis, mapping and machine learning, the desire locations can be identified for the Manchester City Council house building company to back up their business case for planning permission application. The

clustering outcome and data visualisation will not just help identified site for affordable house building company, but also provide an opportunity for Manchester City Council to identify differences between each neighbourhood or electoral ward areas.

Data Gathering and Cleaning

1. Data Requirement

For the purposed of this project, which is to identify site for potential development location, the following data will be required to allow data analysis, mapping and clustering:

- Area boundaries and corresponding coordinates within the City of Manchester
- Existing available site locations
- Existing nearby venues and their features using Foursquare
- Recent mean and median housing price
- Recent house market transaction history

2. Data Sources and Feature Selection

Most of the data required can be obtained from the Manchester City Council site and Office for National Statistics (ONS). However due to the scope of this project and estimation purposes, some data will need to be manipulated to the form required using ArcGIS or QGIS (which is used in this project), before they are imported for analysis:

A. Area boundaries and corresponding coordinates within the City of Manchester

There is existing information of postal code area for Greater Manchester available on Wikipedia which can be scraped and used. However, the scope of this project will be focusing on the area of Manchester City instead of Greater Manchester, hence the 32 electoral ward areas within Manchester City will be used for area boundaries. This boundary information is available as shapefile from UK Ordnance Survey or as kmz file from Manchester City Council site. QGIS is used here to import the kmz file for centroid calculation and geoJSON which will be used for mapping during the analysis.

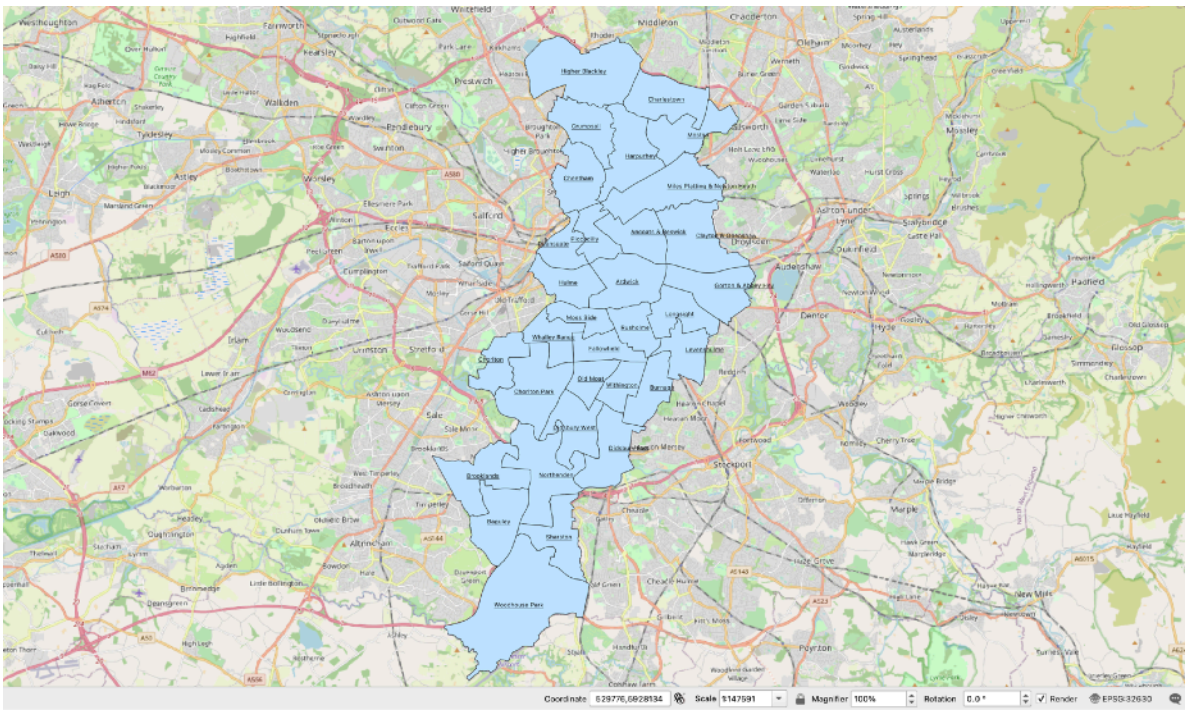

Figure 3. Ward Boundaries Imported to QGIS

B. Existing available site locations

Point data showing Brownfield land identified as being potentially available for housing development. Manchester's Local Plan and other frameworks and strategies, showing which areas within the city have the capacity to accommodate new housing. In addition it can be used by developers wanting to identify suitable sites for development in Manchester. These point data are also imported into QGIS in order to analyse which ward a site belongs to, as this action is spatial analysis based on ward boundaries, which is difficult to achieve within the notebook.

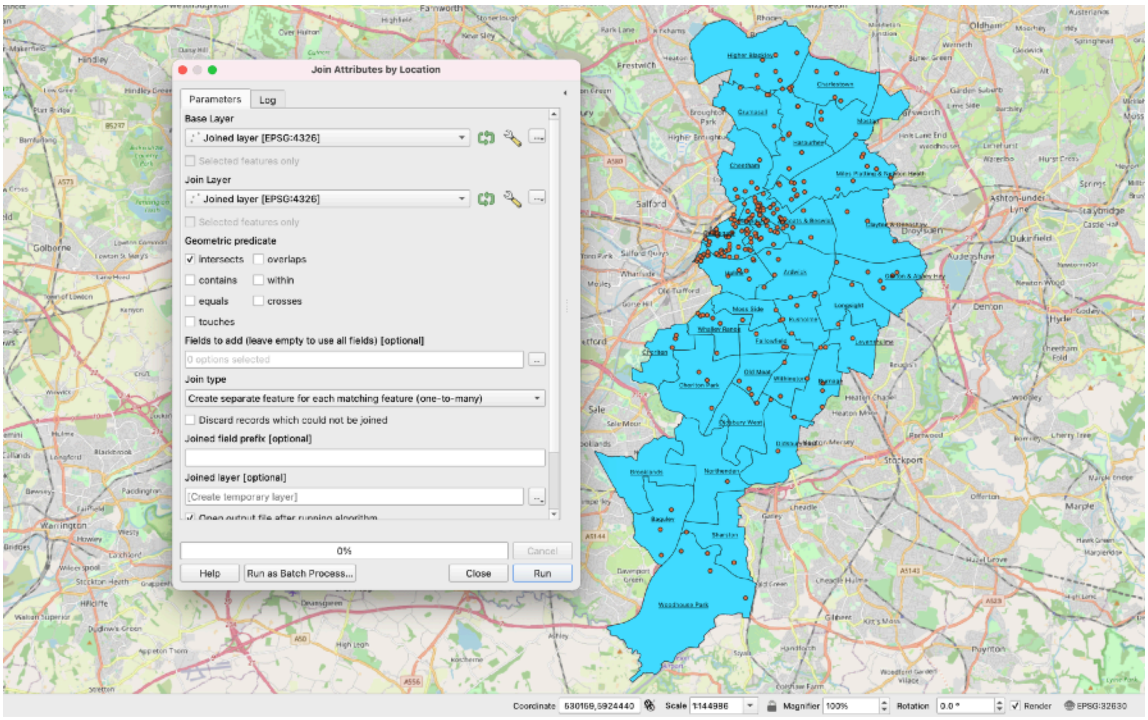

Figure 4. Intersecting and Matching Existing Sites with Local Ward

C. Existing nearby venues and their features using Foursquare

Using centroid coordinates of each ward in Manchester city, API calls to Foursquare can be used to get access to POI data for venues within each ward, and search rank venues and get real-time data access. Request package will be used to download venue content for features for each ward.

D. Recent mean and median housing price

Mean and median price paid for residential property in England and Wales, by property type and electoral ward. Annual data which is updated quarterly. These data are part of the House Price Statistics for Small Areas (HPSSAs) release, produced by Office of National Statistics and HM Land Registry. Statistics are reported for different types of dwelling including all types, detached, semi-detached, terraced houses and flats/ maisonettes as well as a newbuild / existing dwelling breakdown.

These statistics report the count, median price, mean price, lower quartile price and tenth percentile price of all dwellings sold and registered in a given period of four consecutive quarters. For the scope of this project, the most recent mean and median overall house price data in 2020, including the last quarter in 2019 will be used for analysis, as the sample data shown below:

Local authority name	Ward code	Ward name	Year ending Dec 2019	Year ending Mar 2020	Year ending Jun 2020	Year ending Sep 2020
Manchester	E05011350	Ancoats & Beswick	230,000	240,000	237,000	250,000
Manchester	E05011351	Ardwick	204,498	210,995	218,995	222,495
Manchester	E05011352	Baguley	152,750	155,500	158,000	160,000

Table 1. Example of Median House Price Data from National Statistics

Exploratory Data Analysis

1. Available Brownfield Site Distribution in Manchester

Point data showing Brownfield land identified as being potentially available for housing development. Manchester's Local Plan and other frameworks and strategies, showing which areas within the city have the capacity to accommodate new housing. In addition it can be used by developers wanting to identify suitable sites for development in Manchester. These point data are imported and plotted on a folium map to inspect their distribution.

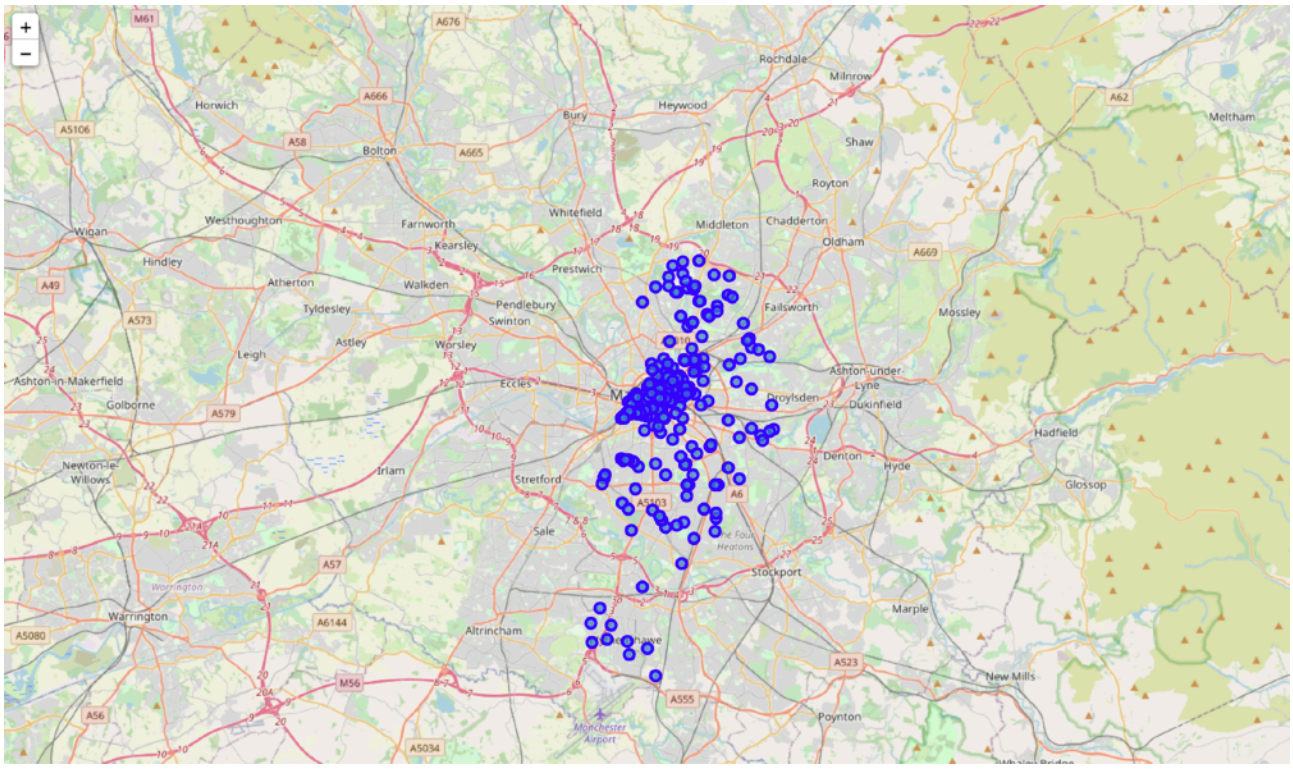

Figure 5. Brownfield Site Points on Folium Map

Base on the folium map, it looks like the city centre has the highest density of available site. The next step is to add ward to each site in QGIS as mentioned above. Below is the first 5 rows of site and ward data.

site_id	site_address	longitude	latitude	area	ward
62	102 Manchester Road	-2.277369	53.446061	1300.0	Chorlton
91	102 Manchester Road	-2.277369	53.446061	1300.0	Chorlton
150	Chorlton District Centre	-2.279022	53.443306	17500.0	Chorlton
166	Chorlton Baths	-2.276849	53.447113	2800.0	Chorlton
145	95 Palatine Road	-2.235446	53.425988	2600.0	Didsbury West

Table 2. Site and Wards in Manchester

A histogram showing distribution of them after grouping by wards is shown below. Note that from the data analysis there is one ward area Brooklands is found to have 0 available site within.

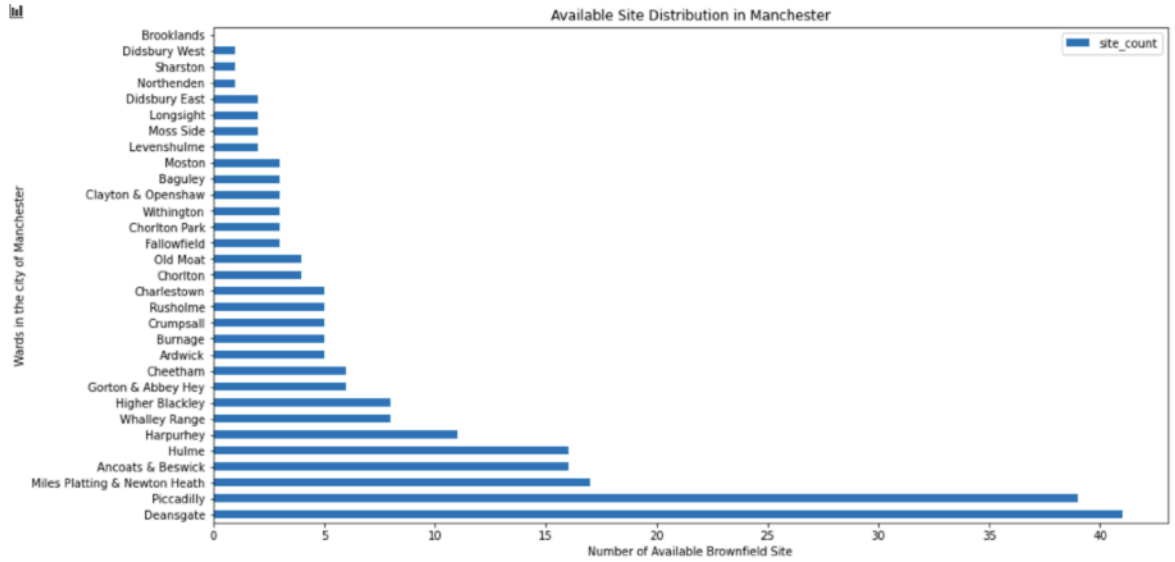

Figure 6. Site Distribution for each Ward

2. Collecting Nearby Venues for each Site from Foursquare

Foursquare API is utilised to explore each site and segment them. The limit of 100 venue and the radius 500 meter is used for each site from the corresponding latitude and longitude. Here is a head of the list Venues name, category, latitude and longitude informations from Forsquare API.

site_id	Ward	Site Latitude	Site Longitude	Venue	Venue Latitude	Venue Longitude	Venue Category
62	Chorlton	53.446061	-2.277369	Pi	53.446778	-2.277464	Bar
62	Chorlton	53.446061	-2.277369	Barbakan Delicatessen	53.445717	-2.277927	Deli / Bodega
62	Chorlton	53.446061	-2.277369	The Font	53.447314	-2.277344	Pub
62	Chorlton	53.446061	-2.277369	Unicorn Grocery	53.446759	-2.277328	Grocery Store
62	Chorlton	53.446061	-2.277369	The Beagle	53.443791	-2.278031	Gastropub

Table 3. Venues Information gathered from Foursquare

These information can be group to see how many venues available for each ward area, as summarised in the bar chart below. It is apparent that most of the venues concentrate in the centre of the city of Manchester. This may suggest the outskirt of Manchester is more residential and the city centre has many more venues and is commercial.

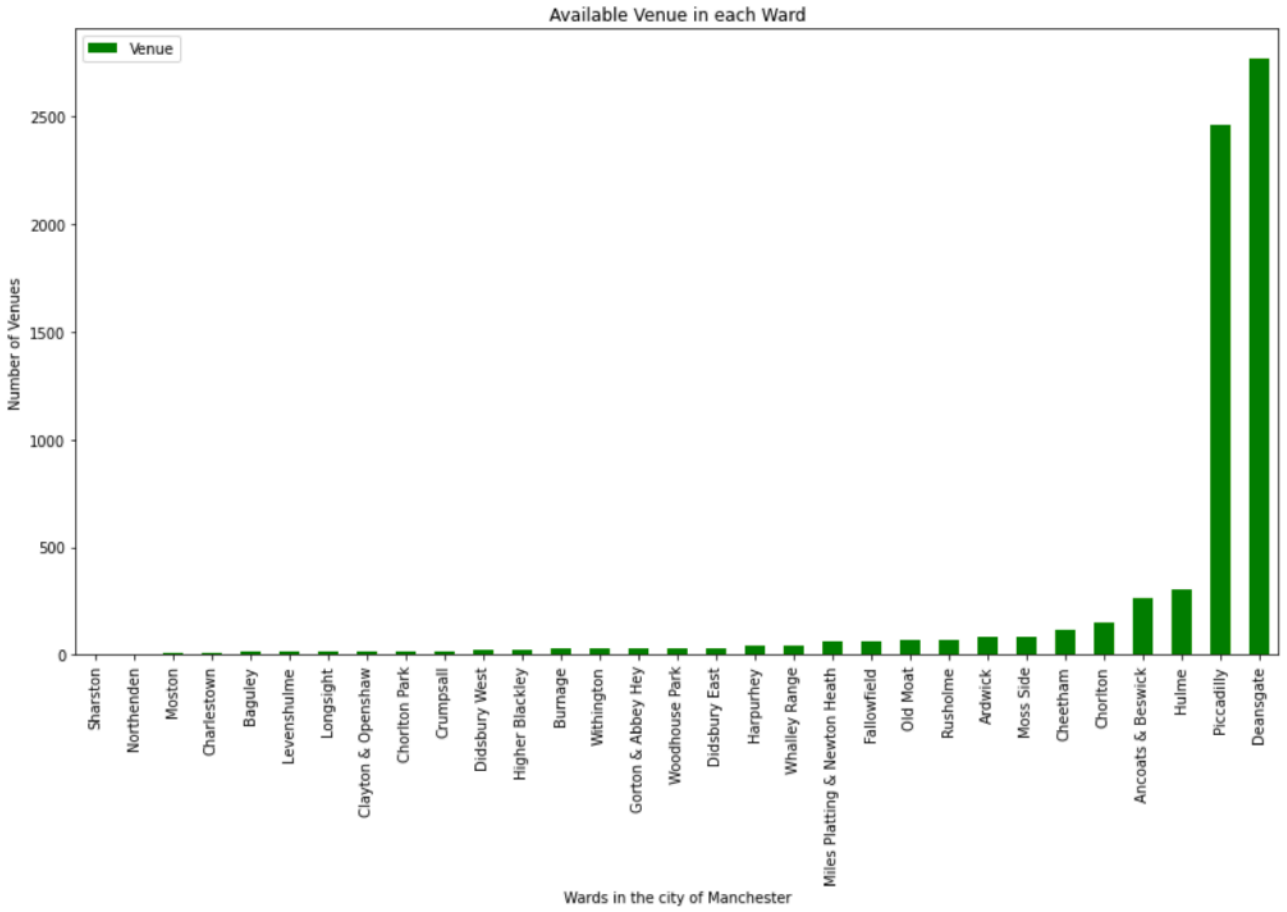

Figure 7. Distribution of Venues in Wards in Manchester

site id	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1	Pub	Adult Boutique	Performing Arts Venue	Music Venue	New American Restaurant	Nightclub	Office	Other Repair Shop	Outdoor Event Space	Outdoor Supply Store
2	Supermarket	Discount Store	Coffee Shop	Gym	Bus Stop	Gym / Fitness Center	Office	Other Repair Shop	Outdoor Event Space	Nightclub
3	Bar	Train Station	Grocery Store	Coffee Shop	Lake	Café	Dessert Shop	Other Repair Shop	Outdoor Event Space	Outdoor Supply Store
4	Coffee Shop	Italian Restaurant	Bar	Plaza	Sandwich Place	Café	Pub	Restaurant	Bookstore	Grocery Store

5	Music Venue	Bus Stop	Bar	Chinese Restaurant	Grocery Store	Coffee Shop	Supermarket	Café	Hotel	Museum

Table 4. Rank of Venues for each Site

3. Average House Price by Area in Manchester

The point data, after identify ward zone for each of them, are then joined with the average house price data from National Statistics. By plotting a histogram, the distribution of sites in different price range can be observed.

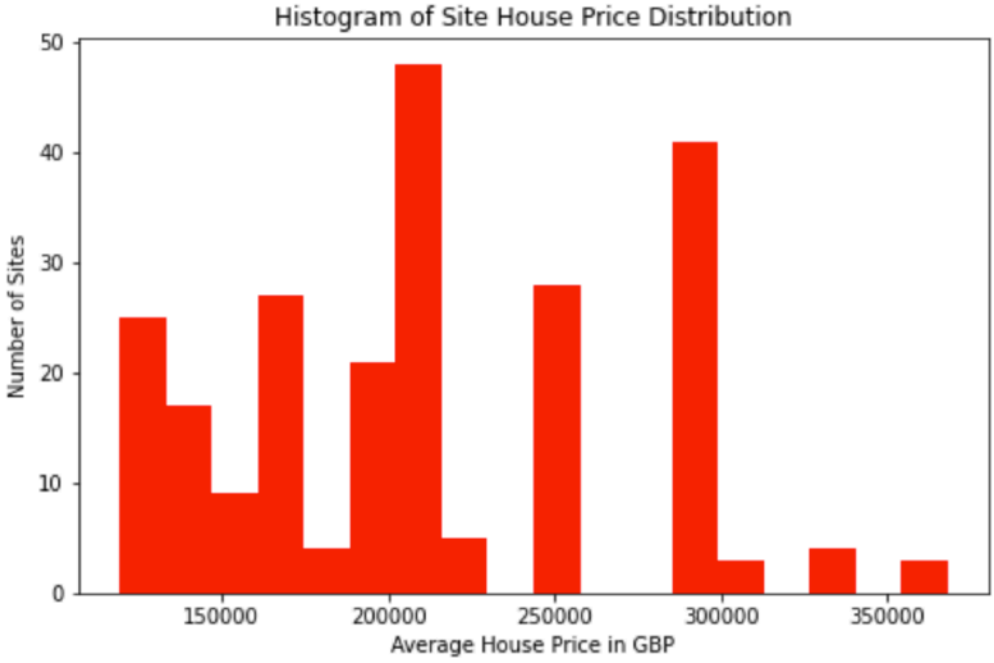

Figure 8. Distribution of Sites in Different House Price Ranges

To visualise price for each ward of Manchester City on a map, a geoJSON file for ward zones is exported from QGIS to import. The json file was cleaned to include ward areas that this project focuses on. A choropleth map was created shower different price ranges.

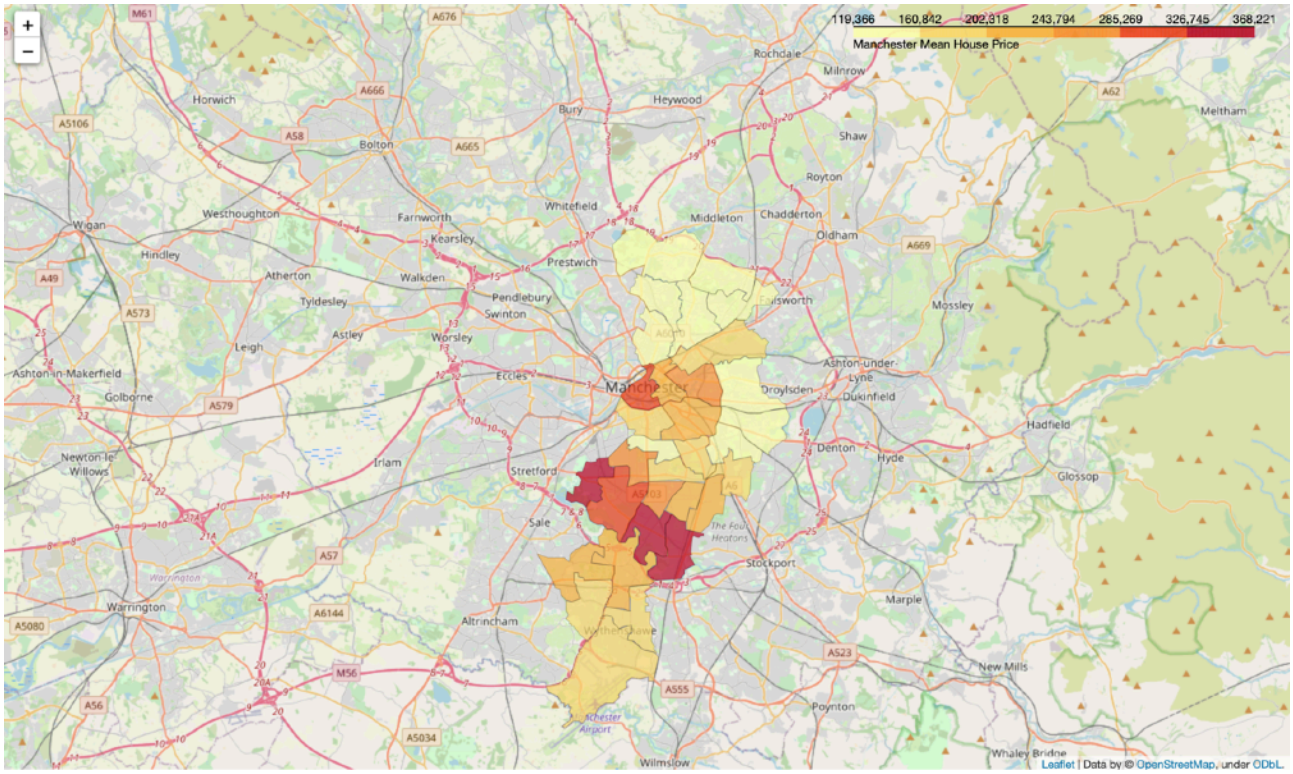

Figure 9. Average House Price by Wards in Manchester City

Methodology

In this project we will direct our efforts on detecting sites in Manchester that have low venues density, low existing house price.

During data collection, manipulation and data exploratory analysis above, the essential data is collected:

- Location and category of all the venues within 500m from each site
- Identified and calculate average house price in each ward and assign it to each site
- Distribution of site in each ward

avg_price	Adult Boutique	Antique Shop	Art Museum	Astrologer	Athletics & Sports	Australian Restaurant	BBQ Joint
163799.5	0.0	0.0	0.0	0.0	0.0	0.000000	0.0
139247.00	0.0	0.0	0.0	0.0	0.0	0.000000	0.0
226502.50	0.0	0.0	0.0	0.0	0.0	0.000000	0.0
290092.75	0.0	0.0	0.0	0.0	0.0	0.014085	0.0

Table 4. Example of Data Features Feed into Clustering

Next step in our analysis will be calculation and exploration of venue density between each brownfield site in Manchester - we will use k-means clustering to group similar site together with low number of venues and low in house price in general, and focus our

attention on those wards in Manchester. This will help to establish discussion with stakeholders. Map of all such site clusters of those locations to identify general zones/ sites addresses/wards which should be a starting point for local council planning permission.

Analysis

The dataset needs to be normalised before they are fed to the model as the average house price was used as one of the features. Normalisation is a statistical method that helps mathematical-based algorithms to interpret features with different magnitudes and distributions equally. “StandardScaler()” was used to normalise our dataset.

The Foursquare API return some common venue categories between sites. Therefore unsupervised learning K-means algorithm was used to cluster different sites. K-Means algorithm is one of the most common cluster method of unsupervised learning. Before deciding the k number, the desired number of clusters, the elbow method was used to ensured the optimum k was chosen.

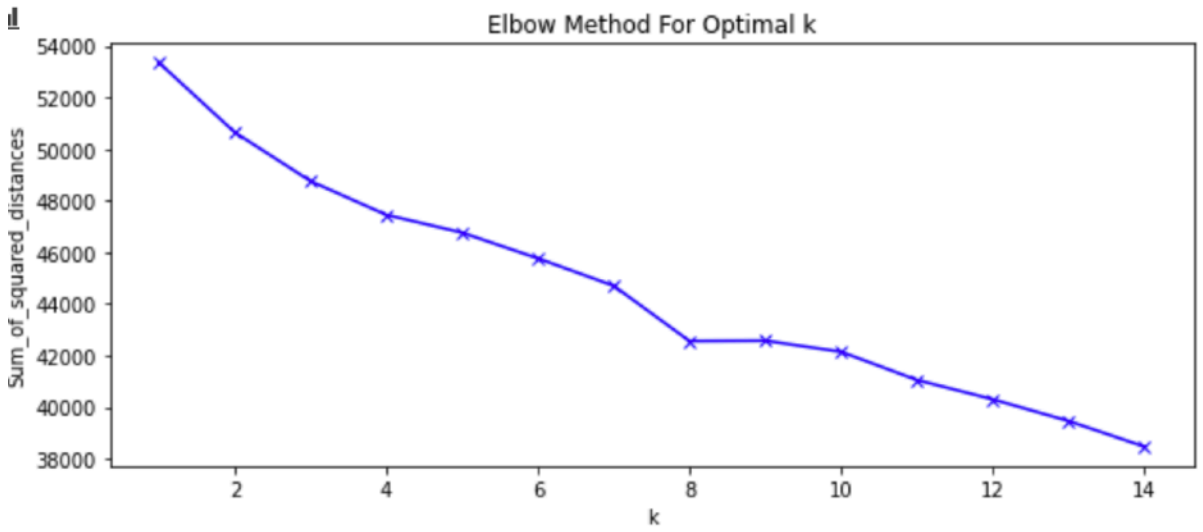

Figure 9. Elbow Method for Optimal k

But the problem is that with increasing the number of clusters, the distance of centroids to data points will always reduce. This means increasing K will always decrease the error. So, the value of the metric as a function of K is plotted and the elbow point is determined where the rate of decrease sharply shifts. Based on the line plot above the k_cluster of 4 is used.

	site_id	latitude	longitude	area	ward	avg_price	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue
0	62	53.446061	-2.277369	1300.0	Chorlton	337410.75	1	Bar	Pub	Grocery Store	Café	Pizza Place	Turkish Restaurant
1	91	53.446061	-2.277369	1300.0	Chorlton	337410.75	1	Bar	Pub	Grocery Store	Café	Pizza Place	Turkish Restaurant
2	150	53.443306	-2.279022	17500.0	Chorlton	337410.75	1	Bar	Pub	Grocery Store	Café	Pizza Place	Deli / Bodega
3	166	53.447113	-2.276849	2800.0	Chorlton	337410.75	1	Pub	Bar	Grocery Store	Gastropub	Pharmacy	Tea Room
4	145	53.425988	-2.235446	2600.0	Didsbury West	360035.75	1	Pub	Italian Restaurant	Indian Restaurant	Bar	Pizza Place	Deli / Bodega
5	68	53.523338	-2.242365	26800.0	Crumpsall	158125.75	1	Business Service	Construction & Landscaping	River	Sporting Goods Shop	Adult Boutique	Performing Arts Venue
6	104	53.511354	-2.225136	3300.0	Crumpsall	158125.75	1	Adult Boutique	Pool Hall	Museum	Music Venue	New American Restaurant	Nightclub
7	105	53.521111	-2.227360	2400.0	Crumpsall	158125.75	1	Café	Coffee Shop	Pharmacy	Grocery Store	Adult Boutique	Performing Arts Venue
8	126	53.516955	-2.251392	4200.0	Crumpsall	158125.75	1	Fried Chicken Joint	Gelato Shop	Halal Restaurant	Park	Pedestrian Plaza	Museum
9	227	53.521037	-2.228596	3800.0	Crumpsall	158125.75	1	Home Service	Pharmacy	Café	Health & Beauty Service	Coffee Shop	Outdoor Supply Store

Figure 10. Outcome Merged Data with Cluster Label and House Price

This merged results are presented on a choropleth map which has the below information:

- Site ID
- Cluster name
- Average House Price

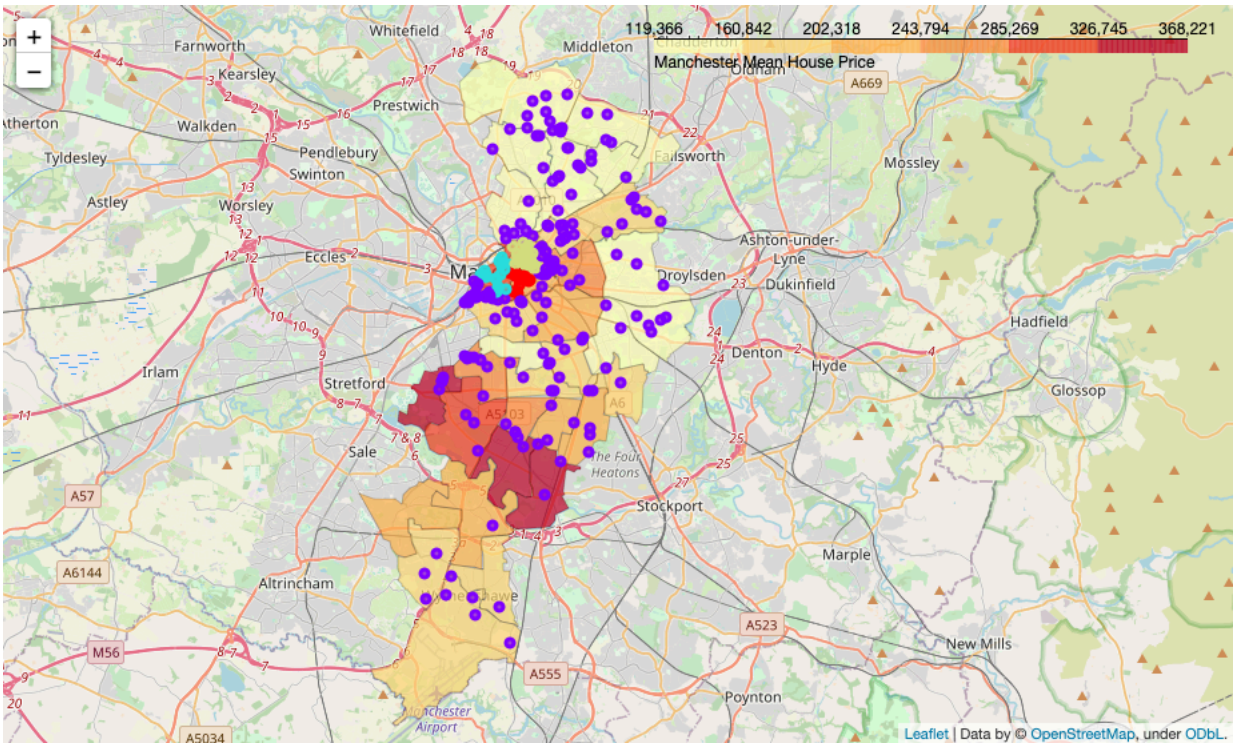

Figure 11. Chloropleth with Clustered Sites

Results and Discussion

Our analysis shows that although there is wide spread of data, the biggest cluster based on nearby venues and average house price wraps around the city centre. Highest concentration of venues available from Foursquare was detected found in the Manchester city centre, and therefore many sites in the Manchester city centre may share the same features during cluster analysis. The results are also reflected in the folium map distribution - that any site locations outside of the city centre forms the same cluster. This also matches what is observed in reality, that most of the Manchester city centre is for commercial, entertainment and offices. Hence sites in the outskirt cluster are suitable for our project aim. After inspecting each clusters the following summary is made for each cluster:

- Cluster 0 - top venues include coffee shop, hotels and bars. Based on the nearby venues, these site might be more commercial compare to the rest. This cluster locates within Manchester Picadilly area and the Picadilly ward has the third highest average house price in Manchester. Considering that most of the properties in city centre are apartments/flats, this suggests a higher value per square metre in this cluster.

- Cluster 1 - top venues include bars, pubs, mixture of groceries stores and takeaways. Based on the nearby venues, these site might be more residential compare to the rest. This cluster widely spread around Manchester and it is the biggest cluster. This suggests the outter skirt of Manchester, and sites locate within wards with reatively lower housr purchase price, might be more suitable for affordable housing construction

- Cluster 2 - again top venues include bars, pubs, mixture of groceries stores and takeaways. BHowever the average price is higher compare to cluster one. The folium map shows that this cluster locates in the heart of the city, between Deansgate and Picadilly. This cluster might not be suitable for affordable housing construction purposes.

- Cluster 3 - top venues include hotels, bars, gyms. The average price of this cluster is highest compare to the rest. The folium map shows that this cluster locates in the heart of the city at Deansgate, where most of the existing developments are commercial. This cluster might not be suitable for affordable housing construction purposes.

Based on the house price output on folium mapping, the relatively lower average house price ranges are £119,366 to £160,842 and £160,842 to 202,318. Therefore, sites within the desired cluster with ward average price lower than £202,318 can be selected as the recommendation - there are 103 sites match the criteria.

The wards that are suitable for affordable housing are:

- Crumpsall
- Fallowfield
- Harpurhey
- Rusholme

- Longsight
- Higher Blackley
- Charlestown
- Miles Platting & Newton Heath
- Moston
- Clayton & Openshaw
- Gorton & Abbey Hey
- Cheetham
- Baguley
- Sharston
- Moss Side
- Woodhouse Park
- Hulme
- Levenshulme

Conclusion

Purpose of this project was to identify site location in areas with relatively lower house price, not located within city center, and with low number of venues (especia) in order to aid stakeholders in narrowing down the search for optimal location for a new development site. By calculating venue density distribution from Foursquare data as well as average house price from UK Office of National Satistics, differnt brownfield sites are gouped together, and ranked by their frequency of occurance. Clustering of those locations was then performed in order to create areas/wards of interest (containing greatest number of potential locations) and addresses of those zone centers were created to be used as starting points for final exploration by stakeholders.

Final decission on optimal site location will be made by Manchester city council based on specific characteristics of neighborhoods and locations in every recommended brownfield site, taking into consideration additional factors like attractiveness of each location, surrounding environment, size of the brownfield sites, realistic availability of every neighborhood.

References

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Mancheser City Council. (2018). Ward boundaries. Retrieved May 2, 2021, from https://www.manchester.gov.uk/directory/157/ward_boundaries

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