Uncovering Suitable Locations for EV Charging Carparks

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1. Introduction: Business Problem / Issue

There are challenges in coming up with suitable Electrical Vehicle (EV) Charging Point locations in Singapore which is land scarce and high density.

Unlike in the United States , most Singaporeans do not have the luxury of charging their EVs in their own garages. Hence the potential congestion caused many cars coming back from work to a HDB carpark could create serious bottlenecks as these cars wait for availability of limited charging units available. Furthermore, charging points in HDB carparks are likely be slow chargers which require time to charge.

An alternative strategy to charging while EV drivers sleep, could be charging while EV drivers are out running errands, fetching kids to enrichment classes, having a meal, doing grocery shopping or even when they are in the office on selected days.

The optimal distribution of EV charging points is just as important as their number as the perceived lack of convenient charging points for potential EV drivers based on a daily or regular routine around where they travel or live, could affect the perception of EVs as a viable and convenient alternative to internal combustion engine (ICE) cars and impact the overall adoption of EV cars in Singapore.

Hence, data analytics, including the leveraging of Foursquare location data will be undertaken to locate suitable EV Charging Point locations in HDB carparks.

Background

During the Budget 2021, the government announced the goal of achieving 60,000 EV charging points, at public carparks (40,000) and private premises (20,000) by 2030, as well as other measures to support the adoption of electric vehicles (EVs). These include lowering the Additional Registration Fee (ARF) floor for fully electric cars and adjusting road tax for electric cars.

By 2025, eight “EV-Ready Towns” across Singapore would be fitted with EV charging points (Ang Mo Kio, Bedok, Choa Chu Kang, Jurong West, Punggol, Queenstown, Sembawang and Tengah).These locations are well spread out across the island, and have a high concentration of car parks with existing electrical capacity to support the deployment of charging points.

Stakeholders

This issue of locating suitable charging points will be of concern to current and potential EV drivers as well as private sector industry players involved in shaping the EV charging ecosystem.

2. Data

Description of the data and how it will be used to solve the problem
In this project, seven data sets will be used to help solve the problem of locating suitable locations for EV Charging Points.

The common variable between most of the datasets is the Planning Areas.

To facilitate urban planning, the Urban Redevelopment Authority (URA) divides Singapore into planning regions, planning areas and subzones. The subzones within each Planning Area are usually centred around a focal point such as a neighbourhood centre or activity node. These planning areas are based on the Master Plan, a forward looking guiding plan for Singapore's development in the medium term over the next 10 to 15 years. Hence, planning boundaries may not coincide with existing developments for some areas.

The distribution of HDB Carparks will be visualized using their coordinates.

To locate the Planning Areas where EV Charging Points are most needed by drivers and potential drivers of EVs, we will be looking at areas with the most number of HDB dwelling units as well as employed residents who travel to work by car only, taking into account both their workplace and residential areas.

Planning Areas will also be analyzed by looking at demographics such as age range which could inform on the likelihood of these areas having current and potential EV car drivers.

Foursquare location data will also be used to locate the most common venues in these areas as well as those near HDB parking lots, which could inform on the convenience and practicality of allowing the car to be parked for a few hours in these locations.

The indicative polygon of subzone boundary in Singapore will be also be used in some of these visualizations.

The following data sets will be used in the analysis:

- Location of existing HDB carparks : hdb-carpark-information.csv
- Total number of unit dwellings by Planning Area : hdb-property-information.csv
- Total number of employed residents (who only use a car) by Planning Area(Workplace) : t111-118 .xlsx
- Total number of employed residents (who only use a car) by Planning Region of Residence : t111-118 .xlsx

- Total number and percentage of residents (aged 24-65 years) by Planning Area (Residence) : resident_population.xlsx
- Singapore Master Plan : master-plan-2019-subzone-boundary-no-sea-kml.geojson
- Foursquare location data of nearby places around carparks and within Planning Areas.

Related Links:

- https://www.lta.gov.sg/content/ltagov/en/industry_innovations/technologies/electric_vehicles.html/#ev_charger_deployment
- https://www.lta.gov.sg/content/ltagov/en/newsroom/2021/3/news-release/Accelerating_nationwide_deployment_of_electric_vehicle_charging_points.html
- https://www.lta.gov.sg/content/ltagov/en/newsroom/2021/4/news-releases/Launch_of_RFI_on_EV_charging_infrastructure.html
- https://vulcanpost.com/759064/why-some-singaporeans-are-still-saying-no-to-electric-vehicles/

3. Methodology

3.1 Data preparation

All data was downloaded from various websites. For carpark data, the x and y coordinates were converted to latitudinal and longitudinal. A new column on planning areas was also added to carpark data, using the respective street names associated with these planning areas. For resident data, selected columns are summed up to calculate the total number of residents from 24 to 65 years of age as well as percentage based on the proportion of this over total of all ages.

The various datasets (HDB carparks, HDB dwelling units, Employed resident population who only drive to work (by workplace and resident planning areas/regions and Resident population (aged 25-64 yrs) were cleaned and also standardized on the planning areas. As each planning area was quite large, where available (such as for resident population data, subzones were used to provide more specific information)

3.2 Data acquisition

To maximise the output from the free version of the Foursquare API, data was requested for each planning area separately. Columns were added to indicate planning areas as well as their respective longitudes and latitudes and the individual dataframes concatenated. This was carried out separately in the jupyter notebook 'Extracting Data Using Foursquare'.

The combined dataframe was then used to search for nearby venues of each planning area within a radius of 1000 meters. Data of nearby venues were plotted into a map alongside HDB carparks to observe their proximity. Venue names and venues categories were extracted

and the total number of venues in each category counted for each planning area and the top 5 and 10 venues of each neighborhood identified.

3.3 Data Analysis

This project is focused mainly on geospatial analysis of potential EV charging carparks within Singapore's planning areas (HDB towns)and also specifically the 8 EV charging towns, based on the number of HDB dwelling units, Employed resident population who only drive to work (by workplace and resident planning areas/regions and Resident population (aged 25-64 yrs). Data analysis was carried out mainly on Ang Mo Kio, Bedok, Choa Chu Kang, Jurong West, Punggol, Queenstown and Sembawang. Tengah was not included due to its undeveloped status.

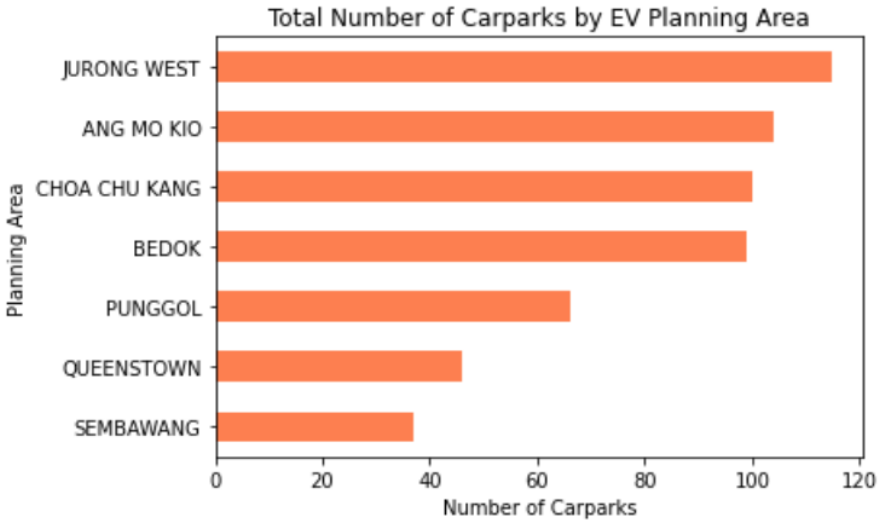
Data visualization was carried out using bar graphs in order to identify the following:

1) Planning areas with the highest number of car parks
2) Planning areas with the highest number of HDB dwelling units
3) Planning areas of workplace with the highest number of employed resident drivers who travel to work by car only
4) Regions of residence with the highest number of employed resident drivers who travel to work by car only
5) Planning areas with the highest number of residents (between 25 to 64 years of age)

Choropleth maps were used to spatially represent the above data across Singapore's geographical area. The distribution of carparks across Singapore was also visualized along with nearby venues scraped from Foursquare API.

KMeans clustering was used to cluster the planning areas into 5 Clusters and a dataframe created to include these clusters as well as the top 10 venues for each EV Town planning area.

i. Existing Supply Factors

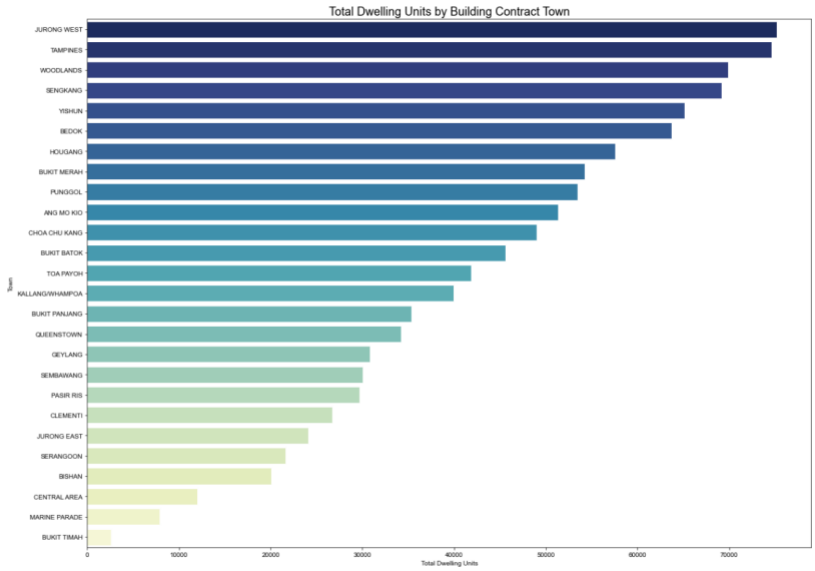


Top 3 planning areas within EV towns are:

1. Jurong West
2. Ang Mo Kio
3. Choa Chu Kang

Sembawang has about one third of carparks compared to Jurong West.

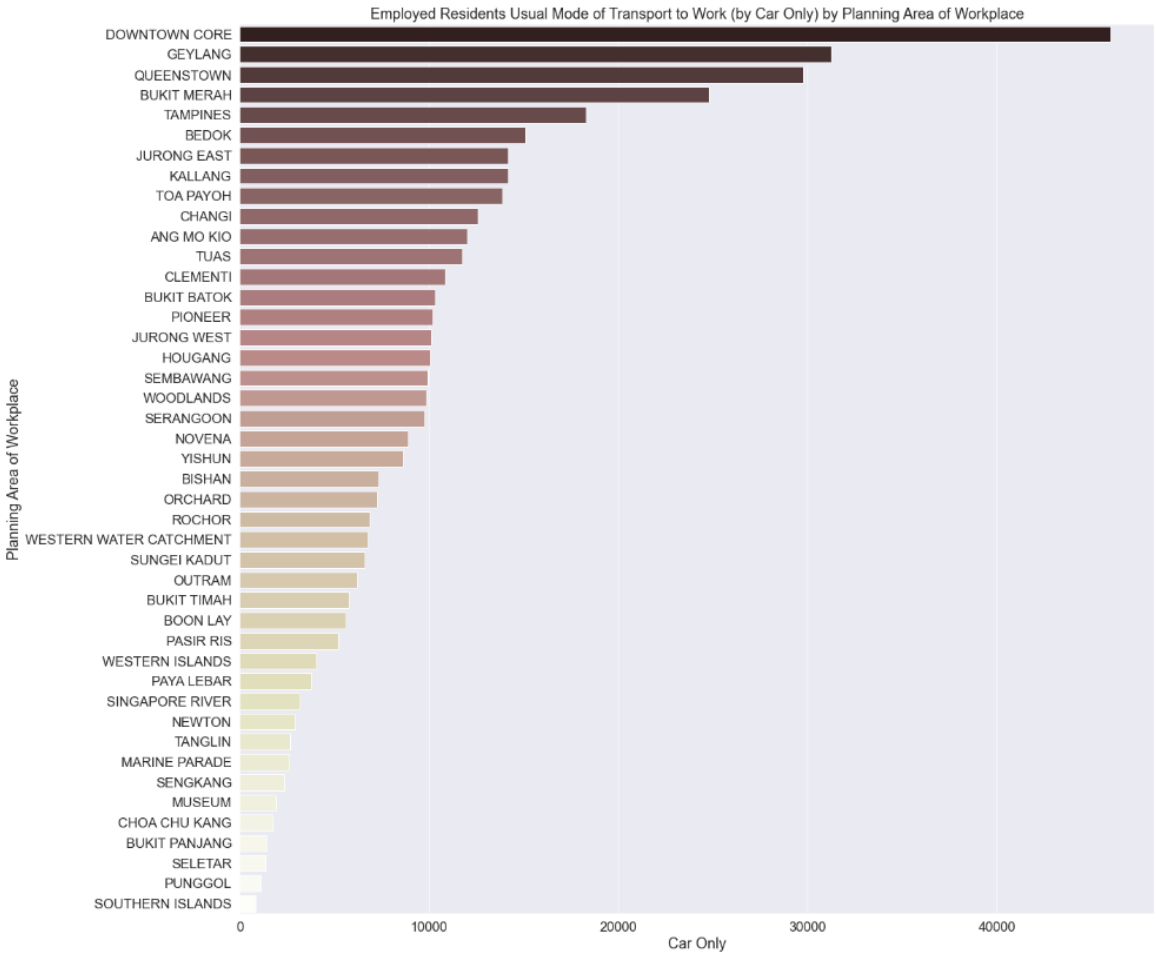
ii. Potential Factors Affecting the Demand for EV Carparks



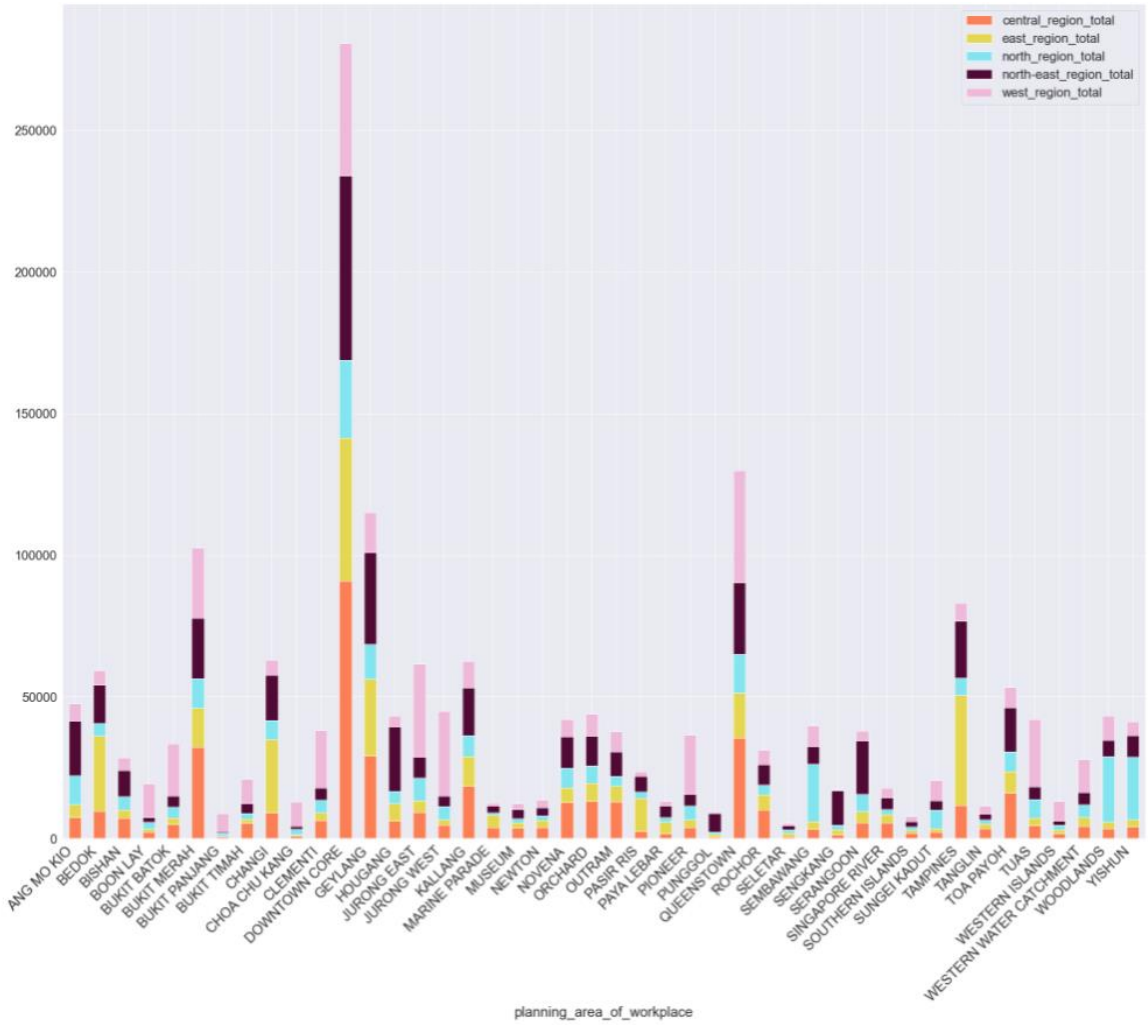
Among Top 10 Towns with highest number of HDB units , 4 are upcoming EV Towns .

1. Jurong West
2. Tampines
3. Woodlands
4. Sengkang
5. Yishun
6. Bedok
7. Hougang
8. Bukit Merah
9. Punggol
10. Ang Mo Kio

We note that 6 out of 10 of the most dense areas in terms of HDB units are located in the north or north eastern region of Singapore. Hence, there is a potential for future development in this area.

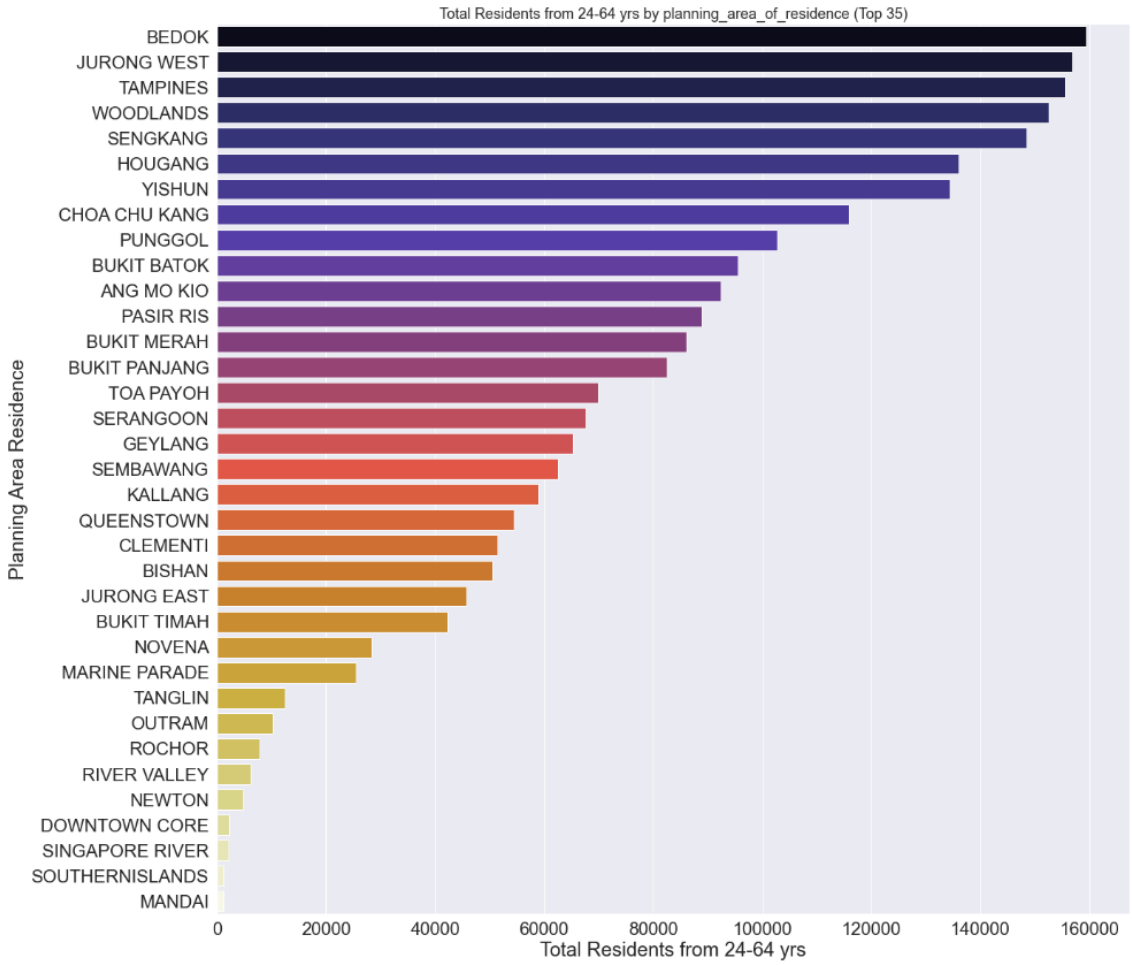


Most people who travel by car to work, also work in the central region . However, currently only 1 in 8 EV towns are located in this region. Hence central planning such as Bukit Merah, Bishan and Toa Payoh could also be considered in future.



Top 10 workplace planning areas with highest number of employed residents (who travel by car only):

The highest number of employed residents who travel by car only stay in the Western Region while the lowest number of employed residents stay in the North-East Region. Also in 24 out of 29 planning areas, a larger proportion of employed residents who work in a particular region, also stay in that region, indicating that employed residents who drive tend to work and stay in the same region. This suggests a shorter travel distance for this group drivers , less danger of range anxiety and less urgency in terms of EV charging points.

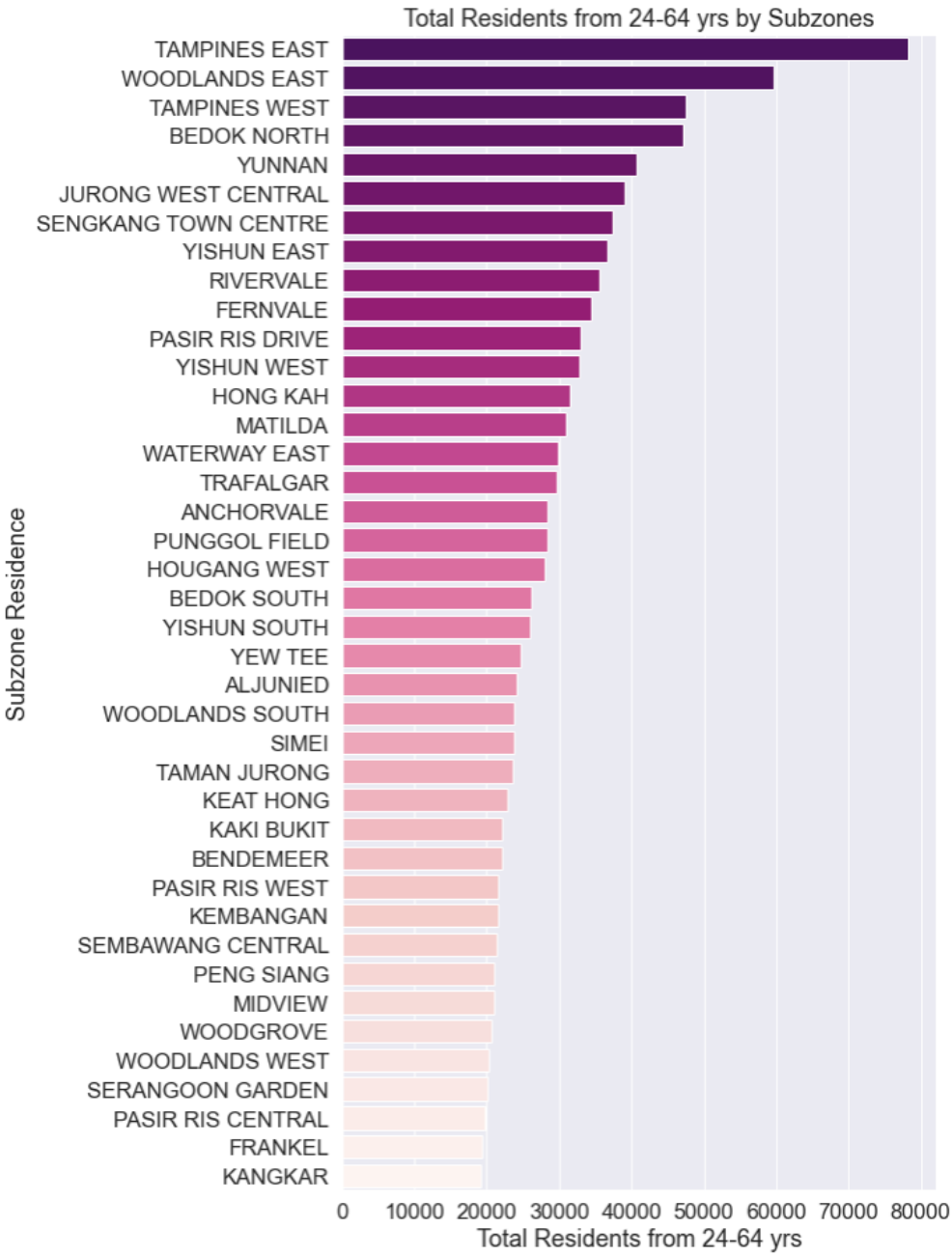


Top 10 planning areas with the highest number of residents aged 25-64 years:

- Bedok
- Jurong West
- Tampines
- Woodlands
- Sengkang
- Hougang
- Yishun
- Choa Chu Kang
- Punggol
- Bukit Batok

Similar to data on dwelling units 5 out of 10 are located in the north or north eastern region of Singapore with 4 out of 10 being EV towns. This further supports the potential

consideration for EV carparks development in the North and North Eastern Regions in the future.



Top 10 subzones with the highest number of residents aged 25-64 years:

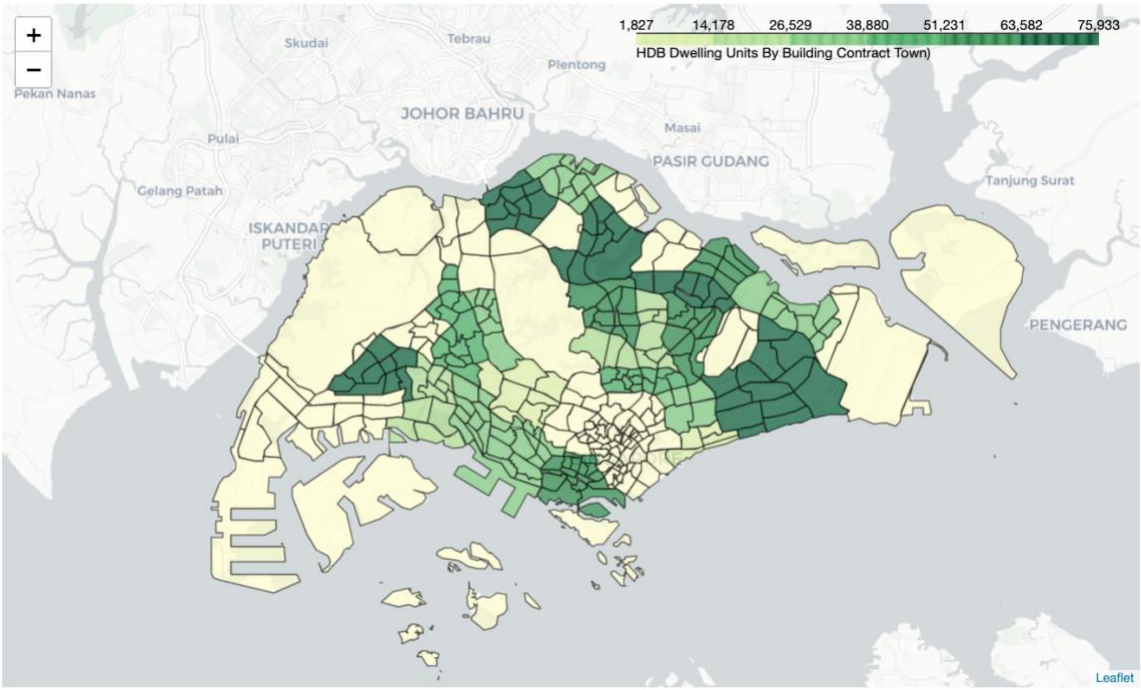
1. Tampines East
2. Woodlands East
3. Tampines West
4. Bedok North
5. Yunnan
6. Jurong West Central
7. Sengkang Town Centre
8. Yishun East
9. Rivervale
10. Fernvale

In terms of subzones, 3 out of 10 are in EV Towns (Bedok North, Yunan and Jurong West Central) are highly populated. These are potential carpark locations within EV Towns given the population.

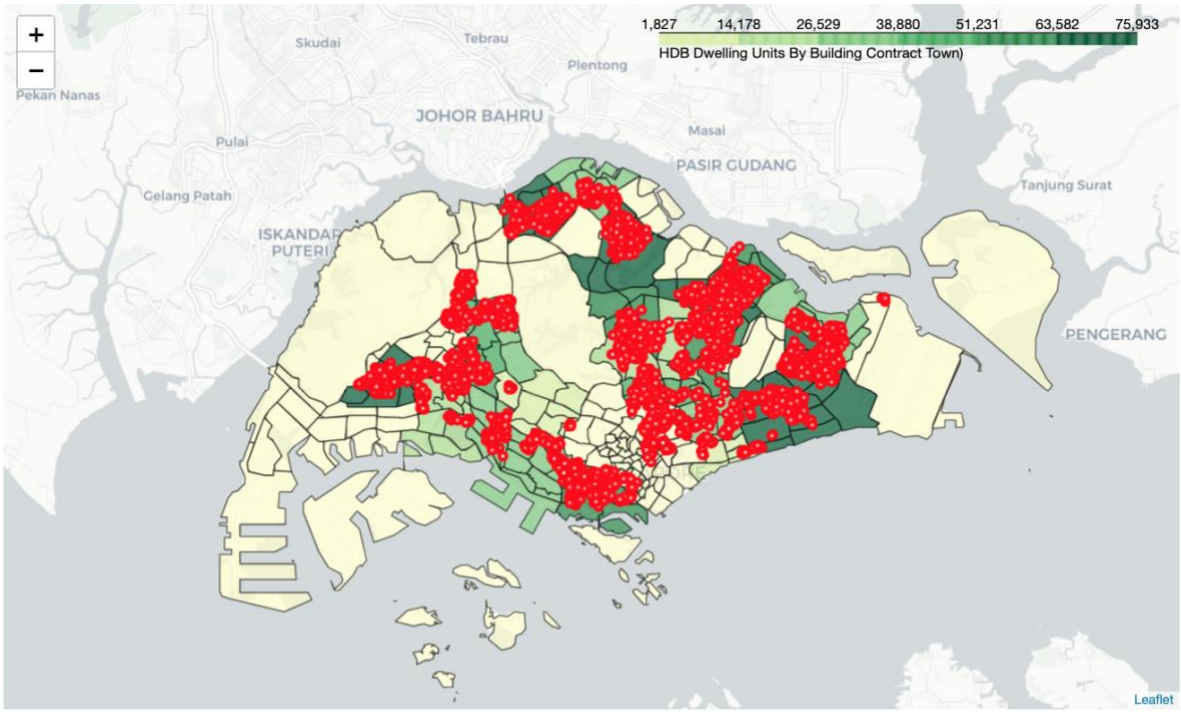
Geospatial Analysis

Based on Data on Demographics of Singapore Population

Data was used to analyze the demographics pattern of Singapore, such as which planning area has the highest population based on the likely age range group of drivers. This information was also used to plot a Choropleth Map to spatially relate and represent the data across Singapore's geographical area. This will be used to validate strategic locations for EV carparks due to the generally higher need from a larger population.



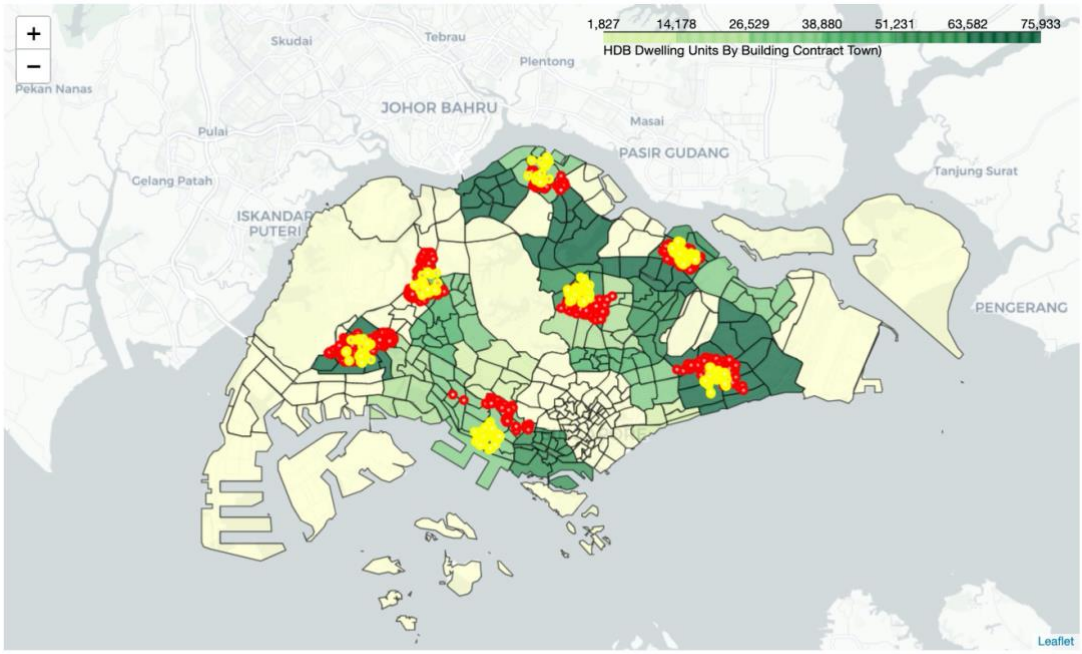
Based on Location Data of all HDB in Singapore



North-Eastern Region, such as Sengkang and Pongol are more densely populated with HDB carparks as compared to other planning areas.

It can be observed that HDB Carparks in newer estates such as Punggol and Sengkang appear to be more densely populated and better integrated among the existing blocks than older states such as Bedok and Jurong West where there could be pockets of areas without any HDB carparks.

Map of HDB Carparks in the 8 EV Towns and Nearby Venues



Pongol's nearby venues are well distributed and in close proximity to most of the HDB carparks within the planning area.

Narrowing the **focus on 7 of the EV Towns,** we plot the current the HDB carparks (red markers) within these planning areas and include nearby locations (yellow markers) extracted using Foursquare API. Grouping rows by EV town planning area and taking the mean of the frequency of occurrence of each category, the top 5 and 10 venues were located.

4. Results & Discussion Section

K-Means was run to Cluster the Neighbourhood into 5 Clusters based on the similarity of popular venues.

	planning_area	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue	10th Most Common Venue
0	ANG MO KIO	Food Court	Fast Food Restaurant	Bus Station	Pool	Convenience Store	Chinese Restaurant	Park	Electronics Store	Shanghai Restaurant	Dim Sum Restaurant
1	BEDOK	Coffee Shop	Chinese Restaurant	Food Court	Café	Supermarket	Noodle House	Asian Restaurant	Sandwich Place	Burger Joint	Japanese Restaurant
2	CHOA CHU KANG	Fast Food Restaurant	Coffee Shop	Food Court	Playground	Snack Place	Grocery Store	Café	Gym / Fitness Center	Gym	Convenience Store
3	JURONG WEST	Japanese Restaurant	Asian Restaurant	Fast Food Restaurant	Chinese Restaurant	Dessert Shop	Coffee Shop	Supermarket	Café	Grocery Store	Gym / Fitness Center
4	PUNGGOL	Chinese Restaurant	Fast Food Restaurant	Supermarket	Coffee Shop	Food Court	Bubble Tea Shop	Bakery	Clothing Store	Fried Chicken Joint	Steakhouse
5	QUEENSTOWN	Asian Restaurant	Coffee Shop	Café	Food Court	Fast Food Restaurant	Sandwich Place	Korean Restaurant	Gym	Chinese Restaurant	Indian Restaurant
6	SEMBAWANG	Coffee Shop	Fast Food Restaurant	Food Court	Bus Station	Shopping Mall	Buffet	Pharmacy	Harbor / Marina	Chinese Restaurant	Department Store

Cluster 0: (QUEENSTOWN) This cluster is characterised by Asian Restaurants, Coffee Shops and Cafes. The Gym is also the 8th most common venue.

Cluster 1: (SEMBAWANG) This cluster is characterised by Coffee Shops, Fast Food Restaurants and Food Court. Shopping Mall is also 5th most common venue.

Cluster 2: (ANG MO KIO) This cluster is characterised by Food Court, Fast Food Restaurant and the Bus Station. The Pool and Park are also the 4th and 7th most common venues.

Cluster 3: (BEDOK, PUNGOL, JURONG WEST) This cluster is characterized by Asian (Japanese, Chinese) Restaurants and Supermarkets.

Cluster 4: (CHOA CHU KANG) This cluster is characterised by Fast Food Restaurants, Coffee Shops, Food Courts, Playgrounds and Gym.

Cluster Results and Recommendations

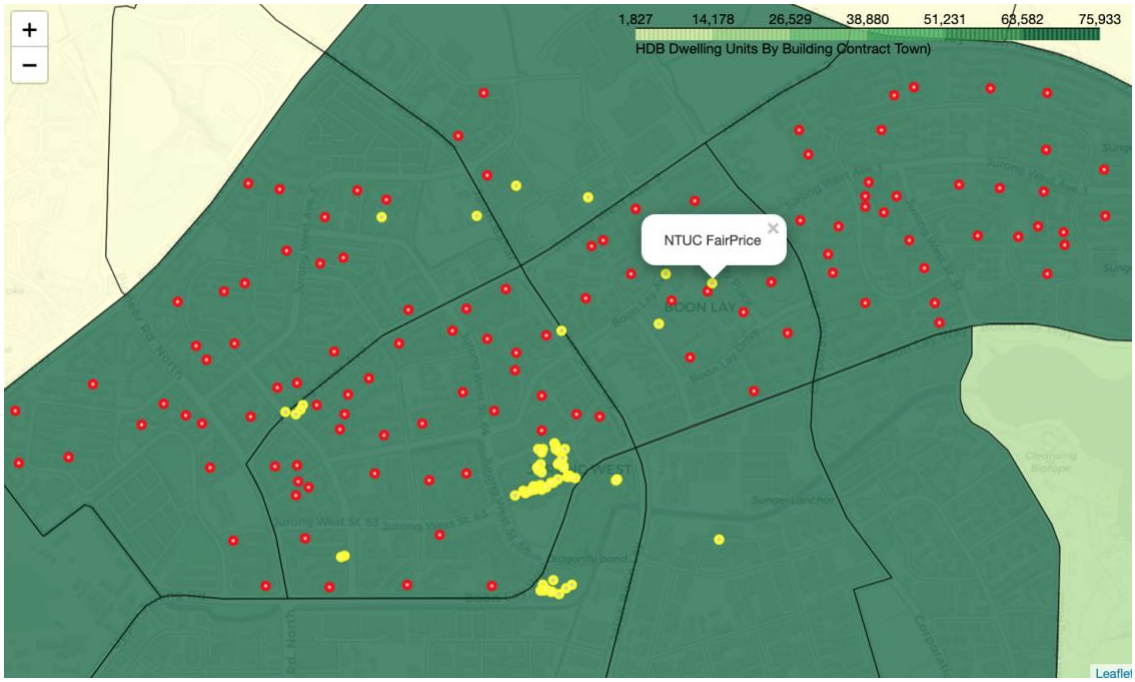
The planning areas were clustered based on the similarity in the categories of popular venues. It can be observed that most of the planning areas had common or similar categories such as coffee shops and restaurants.

Cluster 3 : (Bedok, Punggo & Jurong West) are characterised by the above categories, also has Supermarkets within its top 7 most common venues. From observation of geospatial data it

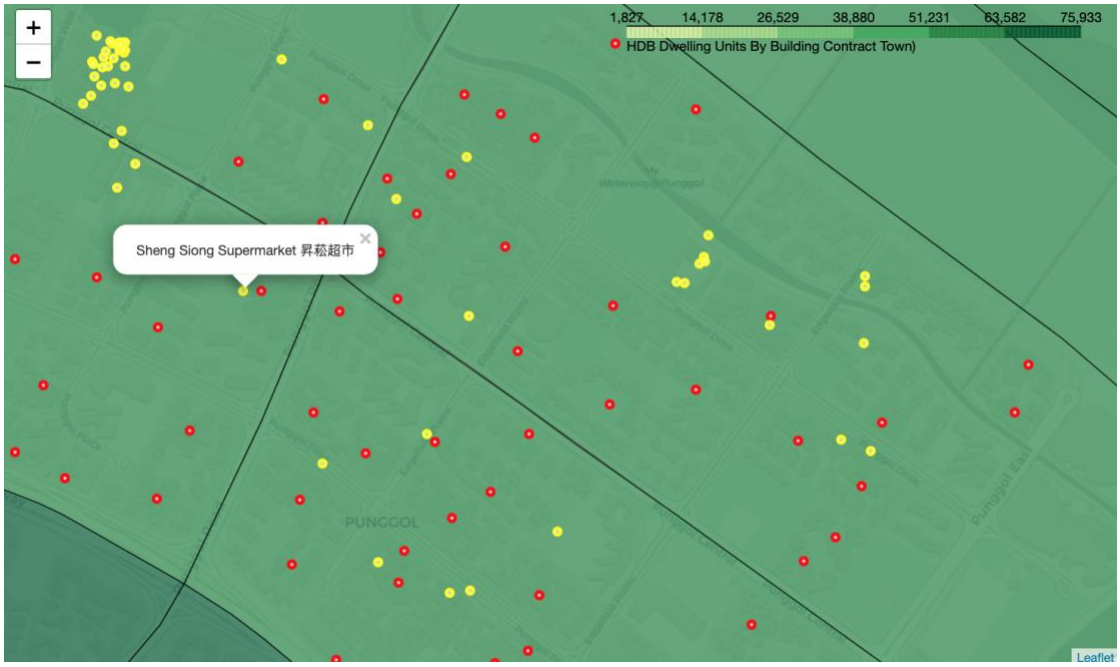
can be noted that these venues may not be equally distributed amongst the carpark locations. This is particularly so for older planning areas such as Bedok and Jurong West where certain areas could be without any nearby venues. It can further be observed that the Supermarkets can lie some distance away and on the fringe of the more densely populated venues. The carparks within the close proximity of these Supermarkets could be suitable venues for EV charging points, to serve the needs of drivers who reside away from the densely populated venues.

BEDOK

JURONG WEST

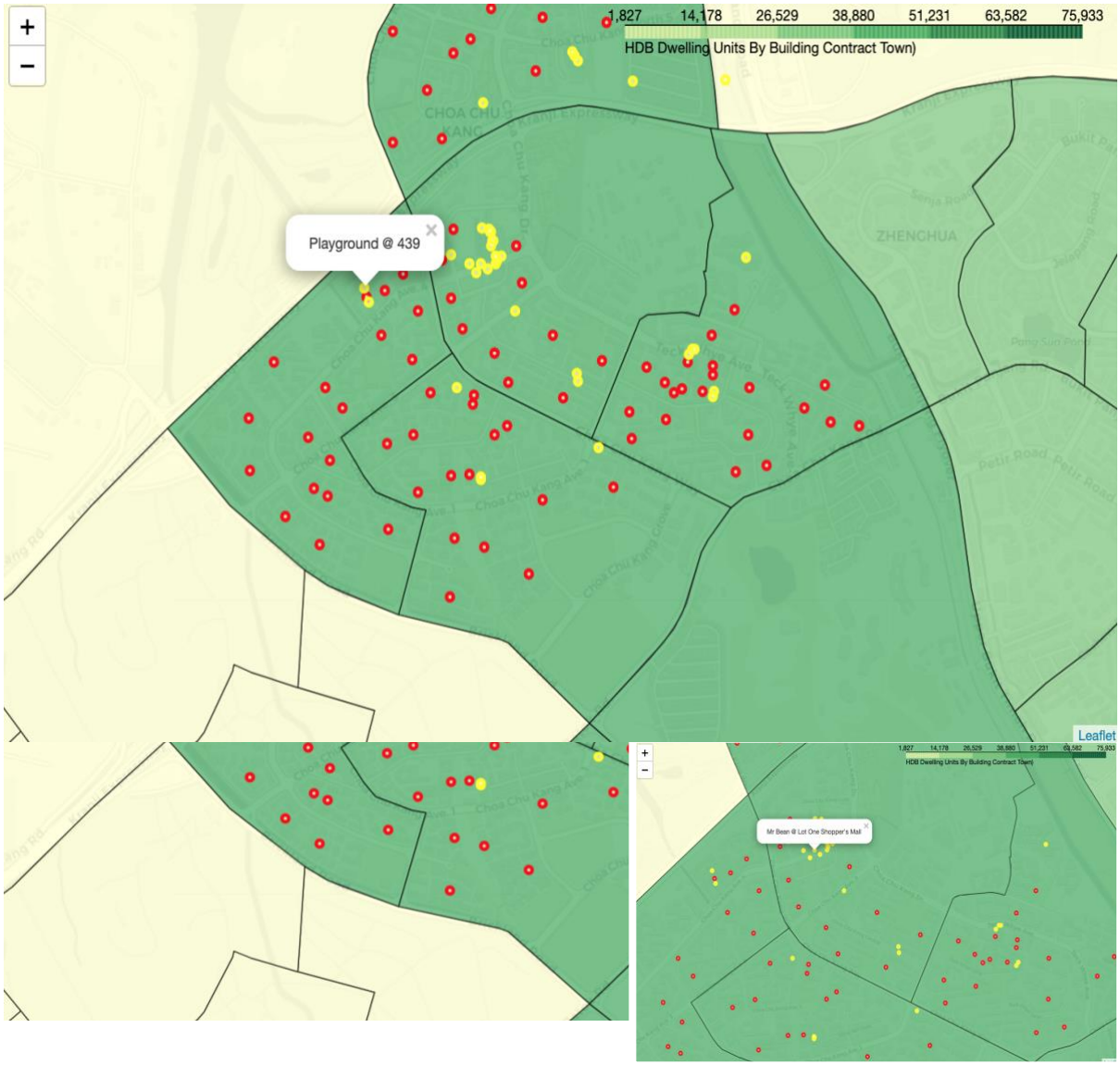


PUNGGOL



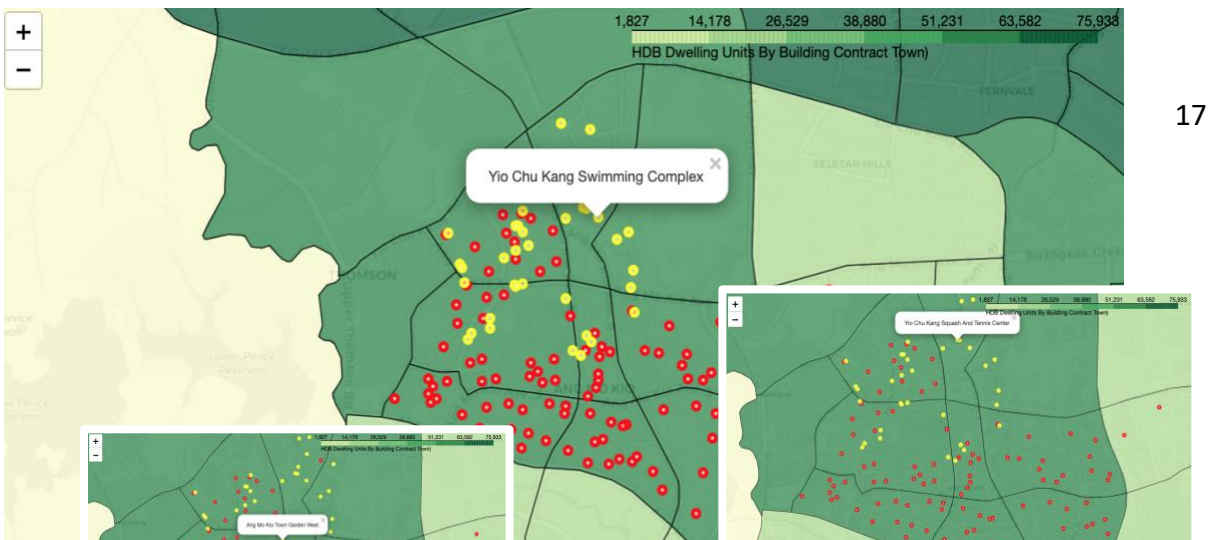
Cluster 0 : (Choa Chu Kang) also lacks venues nearby HDB carparks and has a Playground and Gym within its top 8 most common venues. These carparks around these locations are also around the Shopping Mall (Lot One) and could be suitable for EV charging points.

Choa Chu Kang



Cluster 2 : (Ang Mo Kio) nearby venues are not distributed evenly amongst the HDB carparks. There is a Pool, Gym, Squash and Tennis Sports enclave. Carparks around these locations could be suitable for EV charging points.

Ang Mo Kio



Despite Tampines, Woodlands and Sengkang being in the top 5 planning areas with the highest number of HDB dwelling units and highest number of residents (25 to 64 years of age), these are not among the 8 EV towns. Also half or more of these highly populated planning areas lie within the North and North-Eastern Region of Singapore. These planning areas including the subzones Tampines East, Woodlands East and Tampines West, which are the top 3 subzones with the highest number of residents from 25 to 64 years old could be considered as EV towns in the future.

Most employed residents who travel by car only to work, work in the Central Region. However, within the 8 EV towns, only one planning area (Queenstown) lies within the Central Region. Hence, central planning areas such as Bukit Merah, Kallang and Bishan could also be considered in the future.

For 24 out of 29 planning areas in which employed residents travel by car only to work, it can be observed that those who reside in the regions in which they also work are proportionately higher, with the exception of Bishan, Bukit Timah, Geylang, Paya Lebar and Queenstown. This suggests shorter daily travelling distance and possibly less range anxiety for these group of drivers.

5. Conclusion

In conclusion, we approached the business problem from the perspective of the driver's convenience whilst analyzing various data pertaining to demographics, number of dwelling units and data related to employed residents who travel by car only to consider the increased demand or urgency for EV chargers in certain planning areas.

Foursquare API was utilized to investigate the nearby venues of planning areas and specifically 7 EV towns. Geospatial analysis was also carried out to cluster these planning

areas and to locate suitable carparks that would allow drivers to be meaningfully engaged whilst waiting for their car to be charged.

A multi-pronged approach is needed to address the problem of maximizing the number of EV carparks. This project seeks to approach the problem from a different perspective that considers the charging experience and convenience for the driver. This project could be improved with more information and additional Machine Learning strategies.