Improving Citi-Bike system in NYC from a social perspective

--- Civic Analytic & Urban Intelligence

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Abstract

The main objective of this research paper is to find out how Citi-Bike, the largest urban mobility innovation in USA could enlarge its impact in NYC. With Citi-Bike's on-going expansion plan, this research is structured from a data analysis perspective to potential recommendations for priority service area within the expansion scope. The research also examines different supposed factors which may affect the ridership, including the location of citi-bike stations and metro stations, short distance trips by taxi, and demographic features[1]. Then, based on the determined factors, one of the community districts in Queens is selected as a potential priority expansion area. Finally, both research and implementation limitations will be discussed for future study improvements.

Background

As one of the largest cities in the world, New York City has cumulatively over 8.5 million citizens across the five boroughs in 2019 and the population is still estimated to increase over 9 million by 2040 according to the NYC Population projection report (New York City Population Projections). The increase of population gives more constraint to NYC roadways especially due to the emergence of For-hire vehicles around 2010 and its exponential growth over the next decade. With the increasing use of for-hire vehicles, the auto travel speed in Central Business District has decreased by 21% and the city-wide bus speeds declined by 2.6% since 2010 (New York City Mobility Report). This trend indicates the choice of public transportation modes has become increasingly important. Fortunately, Citi Bike came into place as a pioneer in urban

[1] Demographic, age, income, etc.

micro-mobility innovation in 2013 for people to get around the city. Since its launch in 2013, Citi Bike has expanded to 12,000 bikes at more than 750 stations and has become a fun, affordable, and integral part of New York's public transportation network, with more than 70 million rides taken to date (Citi Bike, 2019). This program is particularly beneficial to New Yorkers for many reasons: low cost and no pollution; perfect for last mile traveling[2]; propelling the cycling trend and moved mobility forward; expand the mobility options for people cannot have a private bike at home (which might happen because the limited space in the city or inconvenience to carry the bikes to work) [Jack Schmidt]

Although the annual ridership is over 17 million in 2018, which is three times more than the year when citi bike was first launched, the citi bike program still only covers the tip of the iceberg of NYC population. According to a recent research published in July 2019 by McGill University, more than 76.8% of New Yorkers do not have access to citi bike system and the remaining 23.2% of the population are whiter, wealthier and more educated than the rest of the population (UPGO, 2019). The following table presented by McGill University shows the inequity of current Citi-Bike coverage intuitively (UPGO, 2019).

Bike sharing service	Total population	Median hh. income	Poverty rate	White population	Bachelor's degree	Subway service
Yes	1,988,000	$90,400	15.9%	51.8%	47.5%	95.3%
No	6,558,000	$54,700	20.3%	26.2%	19.0%	63.9%

Table 1: social characteristics between in-service and out-of-service area of Citi-Bike

One of the strategies to increase the coverage as well as the equity of citi bike program is to expand its service area to neighbourhoods that have lower-income, insufficeint accessibilities to .

[2] Defined as the movement from a public transportation hub to final destination in urban travel

public transportation, non-white population, etc. Based on an expansion plan revealed in 2018 by citi bike, NYC Department of transportation and Lyft are working together to expand the citi bike service area in four boroughs across the city including the Bronx, Queens, Manhattan and Brooklyn (Citi bike, 2019). According to Mayor de Blasio, the expansion will help NYC build a more fair and equitable city for all New Yorkers. Even more communities will have access to this low-cost, sustainable mode of transportation (Citi Bike, 2019). Therefore, we are interested in research on which neighbourhoods in those boroughs should citi bike prioritize as expansion locations.

Methodology

Based on the research question, hypothesized expansion areas should potentially consist of the following characteristics: low accessibility to alternative transportation modes (Citi-bike & metro service); high volume of short-distance taxi trips[3] which can be potentially replaced by Citi-Bike trips for sustainability purposes; high population density and in-service riderage[4] for appropriate usage rate; have median income below in-service income[5] for social equity purposes. All these factors will be examined with spatial visualization for a more intuitive interpretation.

Our goal for the analysis is to demonstrate which areas in the proposed expansion boroughs embody factors that were discussed previously. In order to do so, we looked at the Citi Bike current condition from average riderships in Q1 (Jan to March) and Q3 (June to Aug) by visualizing these data into Citi Bike service grid based on each station in ArcGIS (Map 2). Q1

[3] Taxi trips within 1 mile of distance

[4] Demographic age range that is within the current citi-bike rider age

[5] Median income within citi-bike current in-service area

and Q3 are chosen for analysis because based on the annual ridership trend, the ridership of those two quarters reveals a significant discrepancy from the average ridership.

Metro accessibility has been considered as one of the most important factors for New Yorkers which 37% people rely it on for daily transit (Wachsmuth & Basalaev-Binder et al. ,2019). In the analysis, we compare the metro accessibility with ridership to explore the relationship between those two transportation modes (Map 4,5) . Citi-Bike rider average age[6] is another factor we consider since it is necessary to ensure that the expansion areas consist of citizens whose average age is within the general citi-bike rider age for adequate usage rate(Map 6) . Population density will be included in the analysis for the same purpose.

It's found that NYC has over 2 million taxi trips with a trip distance lower than 1 mile every month, which is a significant number. To promote the sustainability modes of commute, NYC's extensive short-distance taxi and for-hire-vehicle trips should be potentially substituted by more sustainable transit tools for environmental and public health purposes. Based on the data from NYC Taxi & Limousine Commission, we want to figure out which taxi zones[7] have most taxi trip within 1 mile (named as short distance trip) that could potentially be replaced by bike trips. For-hire-vehicle is not included here due to no access to the data. Since the range of trips is too big, we standardize the data into normal distribution then visualize them on the map (Map 3) .

[6] Rider age is calculated by subtracting the rider birth-year disclosed in the citi bike ridership data from current year
[7] The boundary zones for taxi pickups as delimited by the New York City Taxi and Limousine Commission (TLC).

Key findings

By comparing the maps of short distance taxi trips and Citi-Bike station counts, some areas in Manhattan with lower number citi-bike station consists of higher short-distance taxi trips and vice versa. (Map 3) This pattern explains to some degree that in areas with high population density, accessibility to Citi-Bike does decrease the number of short-distance trips. Therefore, this find is used to select the priority expansion neighbourhood later in the research. From spatial visualization, we also found high metro accessible areas have relatively lower Citi-Bike ridership and vice versa. Such finding concludes that low metro accessibility areas might consist high social needs for Citi-Bike. (Map 4,5) Riderage analysis shows that upper west manhattan has higher riderage, Brooklyn and Queens consist younger riders. And the most riders are in their median ages between 35-40. (Map 6). Through transportation accessibility visualization (Map 7), areas that have easy access to metro stations are all covered by citi-bike service which is something that needs to be done to other areas as well to improve the overall connectivity for last mile trips purposes. With this being said, we can pay more attention on grey areas where it lacks metro accessibility (Map 9).

By overlapping different spatial findings, we highlighted several areas that have low accessibility to alternative transportation modes and consist of high volume of short-distance taxi trips with dotted lines (Map 10-12). Then incorporate demographic factors including in-service rider age, higher density of population, out-of-service median income. Combining all the findings, Queens 3 community district is selected as a priority area for new citi-bike station expansion. This area

consists of estimated 180,000 population (60,000 people per sq. mile), 46% of the total population with in-service age, 90% non-white population, below in-service income. (Map 13). With all the metrics being considered previously, we believed Queens Community District 3 contains major characteristics which need to be prioritized for citi-bike expansion from a social equality perspective.

Limitations

Research limitations

Bias still exist since our research only focused on the equity perspective (as we only consider areas with median income below the currently in-service area median income) of citi bike expansion while it might neglect areas that truly need micro mobility access. Considering some affluent areas close to major rail road stations in Brooklyn and Queens(such as long island railroad station), there might be a high demand of citi bike rides from people living in the close-by residential areas to commute a short distance to the train station. Also, bike lane condition could play a significant role in citi-bike expansion process as it is a safety assurance for riders who use citi-bike services. Therefore, people are supposedly to use bikes more often when there are bike lanes installed. According to NYC DOT, NYC's Prospect Park West protected bike lane saw a 190 percent increase in weekday ridership (NYC DOT, 2012). This factor should be considered as a part of the analysis in future studies.

Implementation limitation

In addition to social needs, policies are a crucial element in Citi-bike station as well as bike infrastructure implementation. According to Jack Schmidt, Citi-bike is a franchise of the city so

that the negotiation with city of implementing extra bike stations as well as bike lanes is unavoidable. However, the unquantifiable benefits of citi-bike and bike infrastructure could yield impediment to relevant policy making.

Furthermore, the expansion of bicycle network gives more stress on cycling safety as the number of bicyclist deaths so far this year is more than double the number in all of 2018 (Brown, 2019). Leah Shahum, executive director of the Vision Zero Network, said the deaths may be evidence that New York is not doing enough to keep pace with the city's growing number of cyclists. Besides, some bike lanes get worn down over time. It's dangerous that some marking is becoming barely visible or even disappear (Staff & Manskar, 2019). This might become the main concern for people who are inclined to bike more by are hindered by the limited connectivity of bike lane networks.

Future research

The factors that might influence the implementation of Citi-Bike service are way more than what we have discussed in the paper. Therefore, different factors should be assigned with their own weights and incorporate with an interactive software tool. This tool should also be accessible to the public as a crowd sourcing platform to generate social opinions and requests for bike related program which will be later used by city legislations to make better policy decisions. For example, people could use this platform to propose their ideal bike infrastructure locations or where they feel the bike service is beneficial to their daily commute (or other recreational purposes) and other citizens could vote on different ideas. Based on proposes and the opinion

poll, decision makers could integrate the public opinions and the weight measurements to prioritize areas with higher social need for cycling program.

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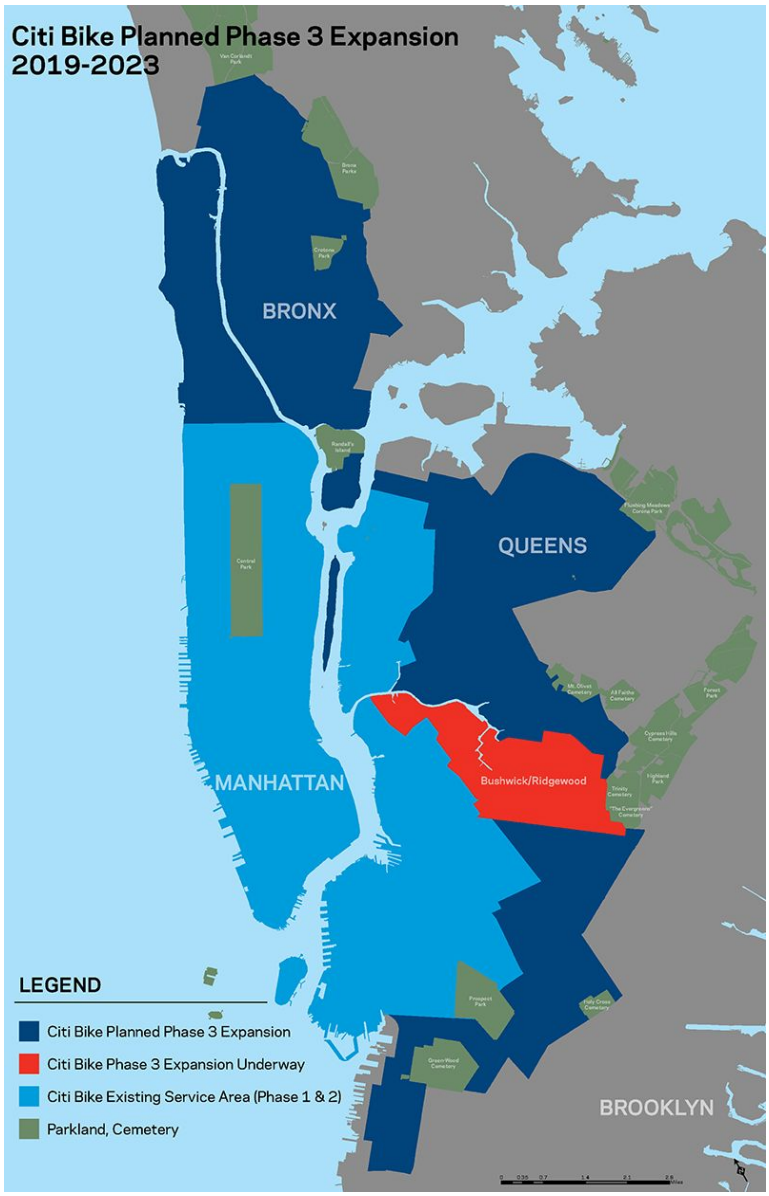
Appendix

Dataset

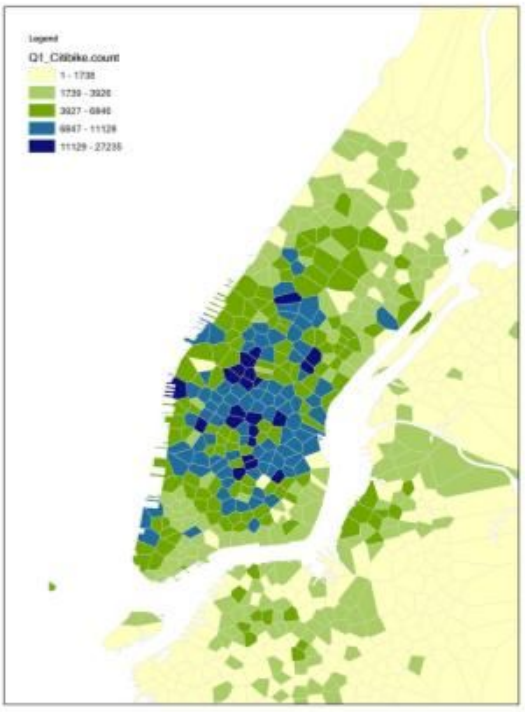
1. Citi bike station and ridership data in 2018 from Citi Bike data portal which includes aggregated ridership numbers and rider ages https://www.citibikenyc.com/system-data.
2. New York City Subway station data from NYC open data portal https://data.cityofnewyork.us/Transportation/Subway-Stations/arq3-7z49
3. New York City demographic data including income, population density, average age from NYC open data portal ()
4. TLC Trip Record Data including taxi drop off and pick up locations from https://www1.nyc.gov/site/tlc/about/tlc-trip-record-data.page

Maps

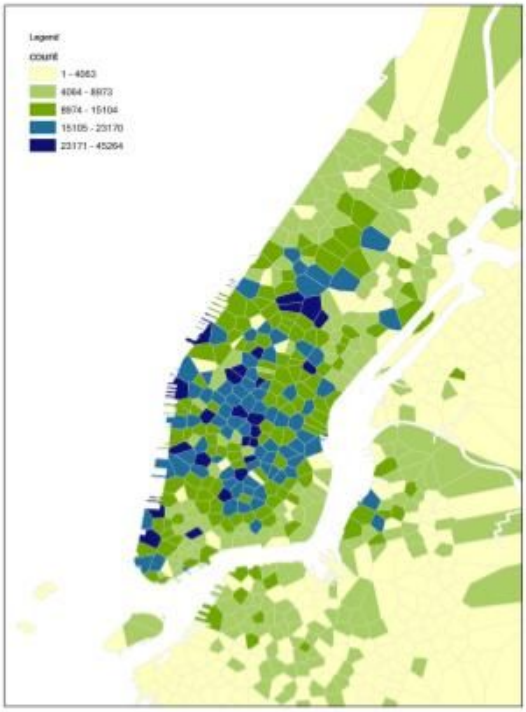
Map 1: Citi Bike Planned Phase 3 Expansion



Map 2: Citi-bike average ridership in winter and summer

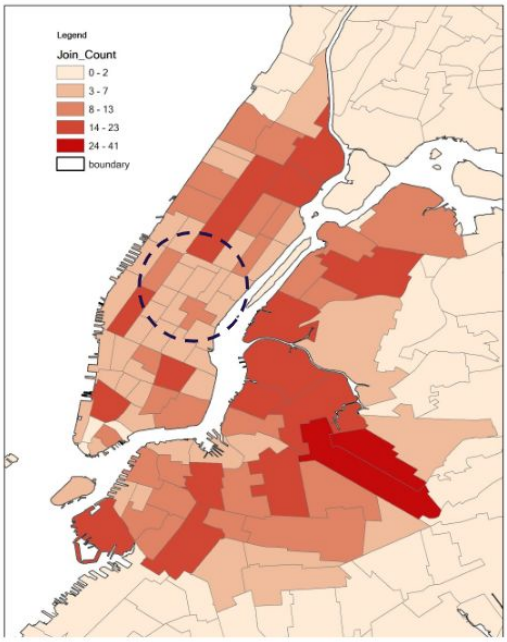


City Bike average ridership in winter (Jan, Feb and March)

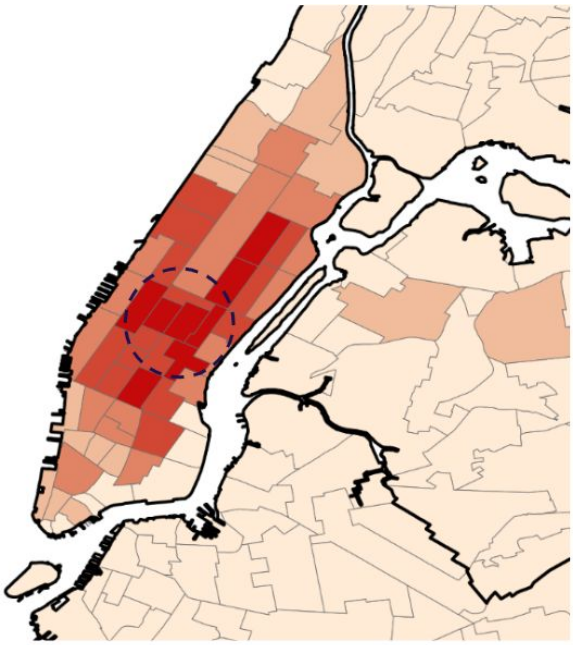


City Bike average ridership in summer (July, Aug and Sep)

Map 3: Short Distance Taxi Trips vs. Citi-bike station counts Analysis

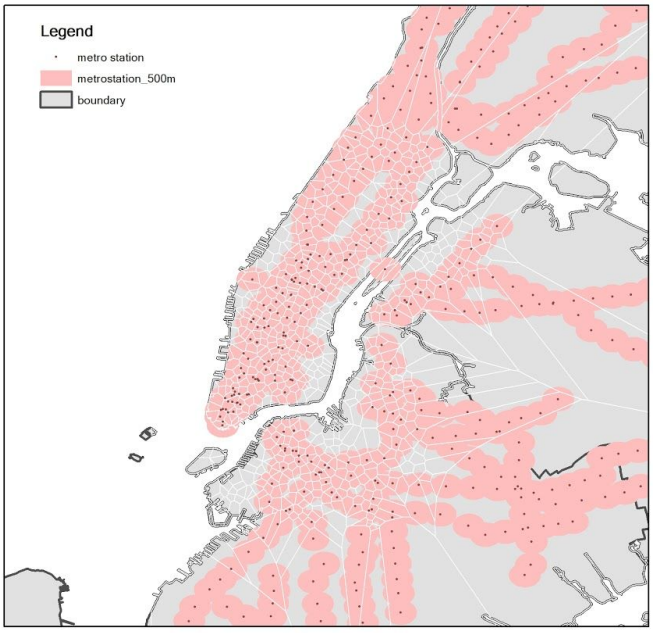


Citi Bike station counts in taxi zone

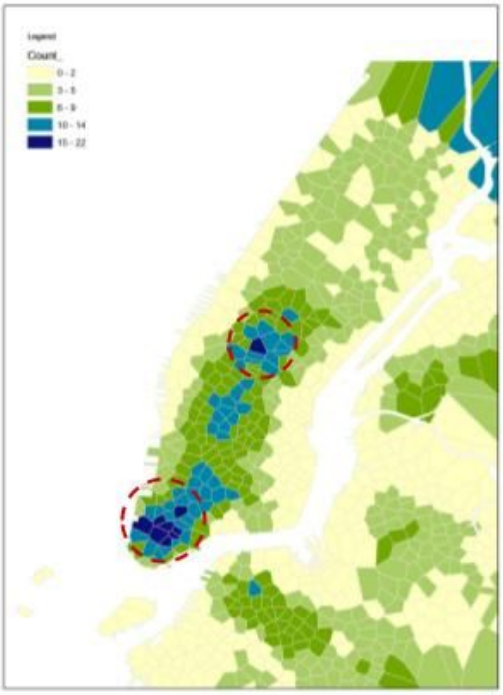


Taxi trips sum in taxi zone

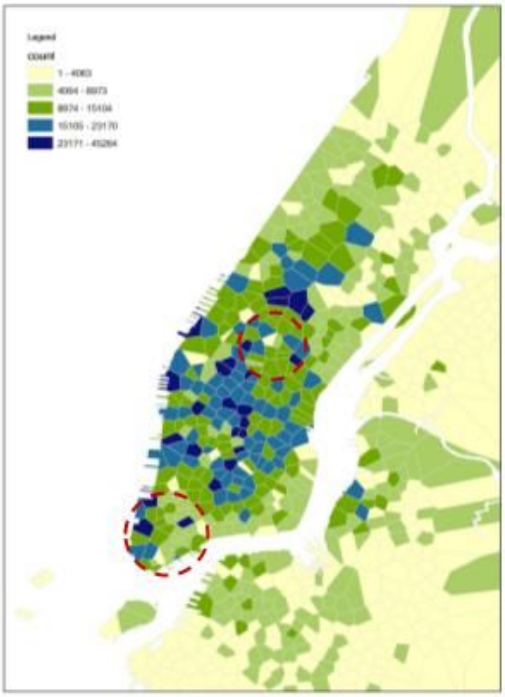
Map 4: NYC metro accessibility analysis



Map 5: NYC metro accessibility vs. Citi-bike average ridership Analysis

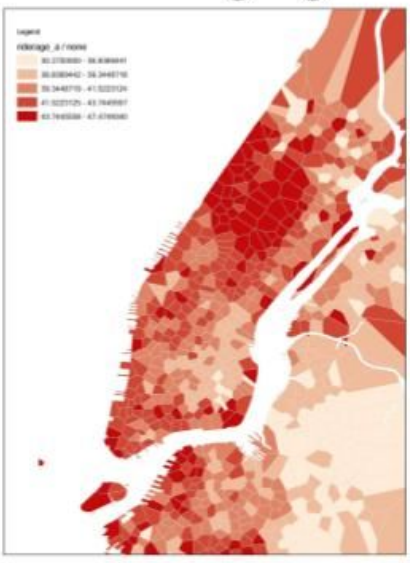


NYC metro station service areas in each grid

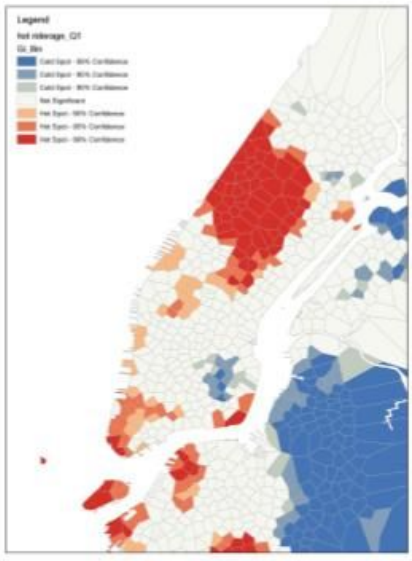


City Bike average ridership

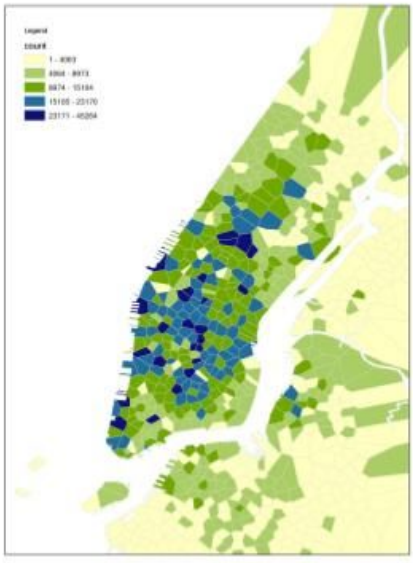
Map 6: Citi-bike average ages and hot spot vs. Citi-bike station counts Analysis



Average riderage

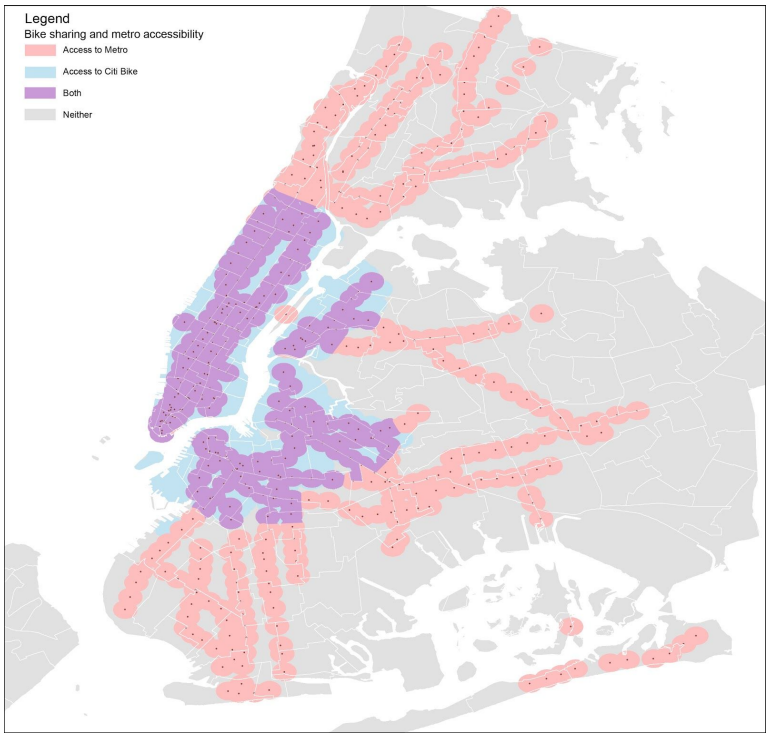


Hot spot analysis

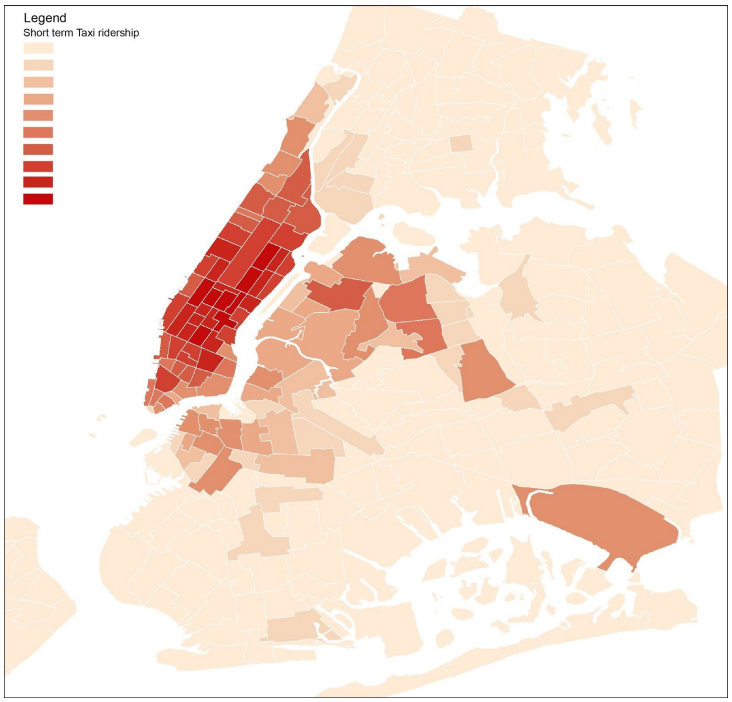


City Bike average ridership

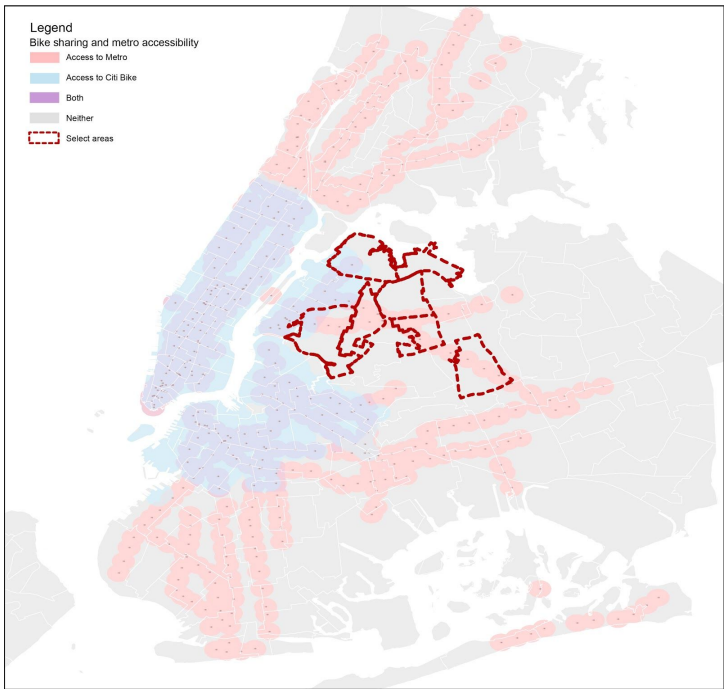
Map 7: Accessibility to public transportation



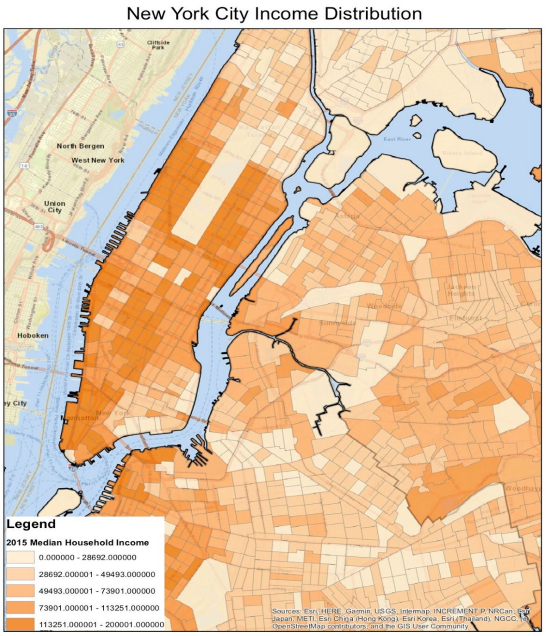
Map 8: Short distance taxi trips



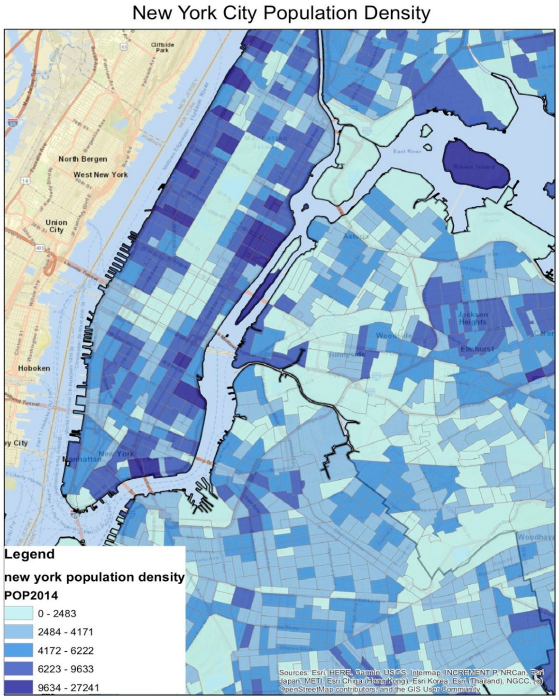
Map 9: Potential expansion area



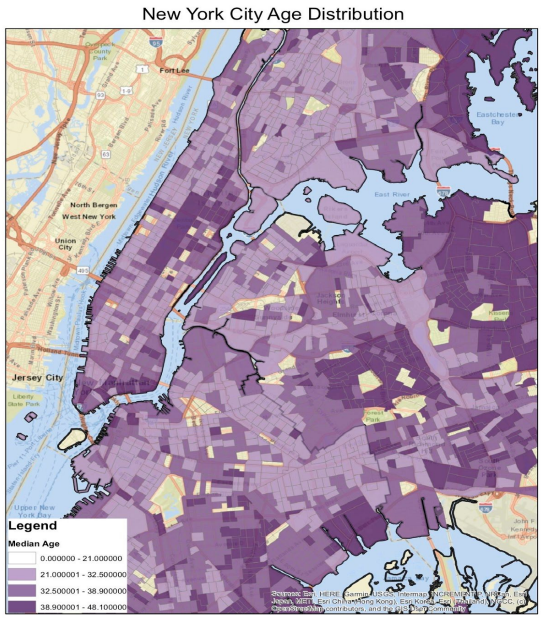
Map 10: Income distribution



Map 11: Population Density



Map 12: Age Distribution



Map 13: Specific location for further expansion