



Share Bicycle for the First and the Last Mile Issue in NYC

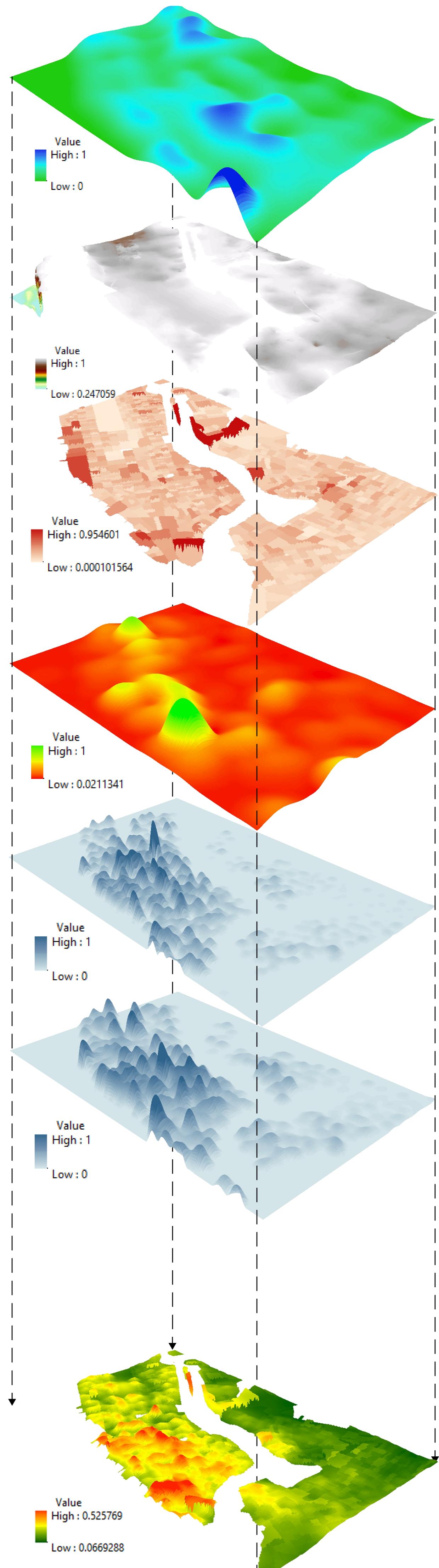
Introduction



Transit Oriented Development(TOD), is a method to constrain low density urbanization and suburbanization by focusing on providing transit service along with high density and mixed-use development to encourage transit ridership (Nasri and Zhang 2014). Tons of researches had been done to improve the ridership of the rapid transit, one big part of them is to enhance the accessibility from TOD catchment areas to the transit nodes by providing share bicycles. China, for instance, had almost 300 bicycle sharing programs and had surpassed Italy and Spain to become the country with the largest number of programs in 2015("Data Center - Climate, Energy, and Transportation | EPI" n.d.)

and the programs were mainly implemented around transit nodes to address the "first-mile" and "last-mile" problems(Ji et al. 2017). Recently, Bike sharing companies landed on New York City where they are trying to implement the mode they created in China(Danielle Furfaro 2017). This paper takes people's sentiment, bike lane condition, population density, Citi Bike's usage rate and accessibility to transit nodes as variables and tries to uncover where is the most suitable areas in NYC to put share bicycles.

Data and Method



Bike Route Density

New York City Open Data regularly publishes the bicycle lanes' feature data. Based on the level of traffic stress shown in Urban Bike Way Design Guide and ALTA Planning and Design, bike lanes are divided into 12 categories and appropriate scores are assigned to them.

Bike Route	Score	Bike Route	Score	Bike Route	Score
Greenway	5	Bike Friendly Parking	3	Side Walk	1
Protected Lane	4	Curbside	2	Signed Route	1
Velodrome	4	Pedestrian Plaza	2	Sharrows	1
Standard	3	Boardwalk	2	Dirt Trail	0.5

Elevation

10 meters DEM New York State data is used to measure the slope of NYC. Because NYC is a highly developed built environment, so the elevation factor to impact bicycle riding is pretty weak.

Population Density

Higher score is assigned to areas with high population density in NYC. We find out that places around central park have more higher score areas than other places like Brookline and Queens. Downtown Manhattan, to the south of central park, has relatively lower population density since there is few residential areas there .

People's Sentiment to Bicycles

People's attitudes, are calculated based on twitter data. We find out people living in lower Manhattan seems have the most positive attitude to Bicycles where also has the richest bike lane resources. People also hold positive attitude to cycling in central park, where is also a bicycle friendly area.

Bicycle Usage Rate

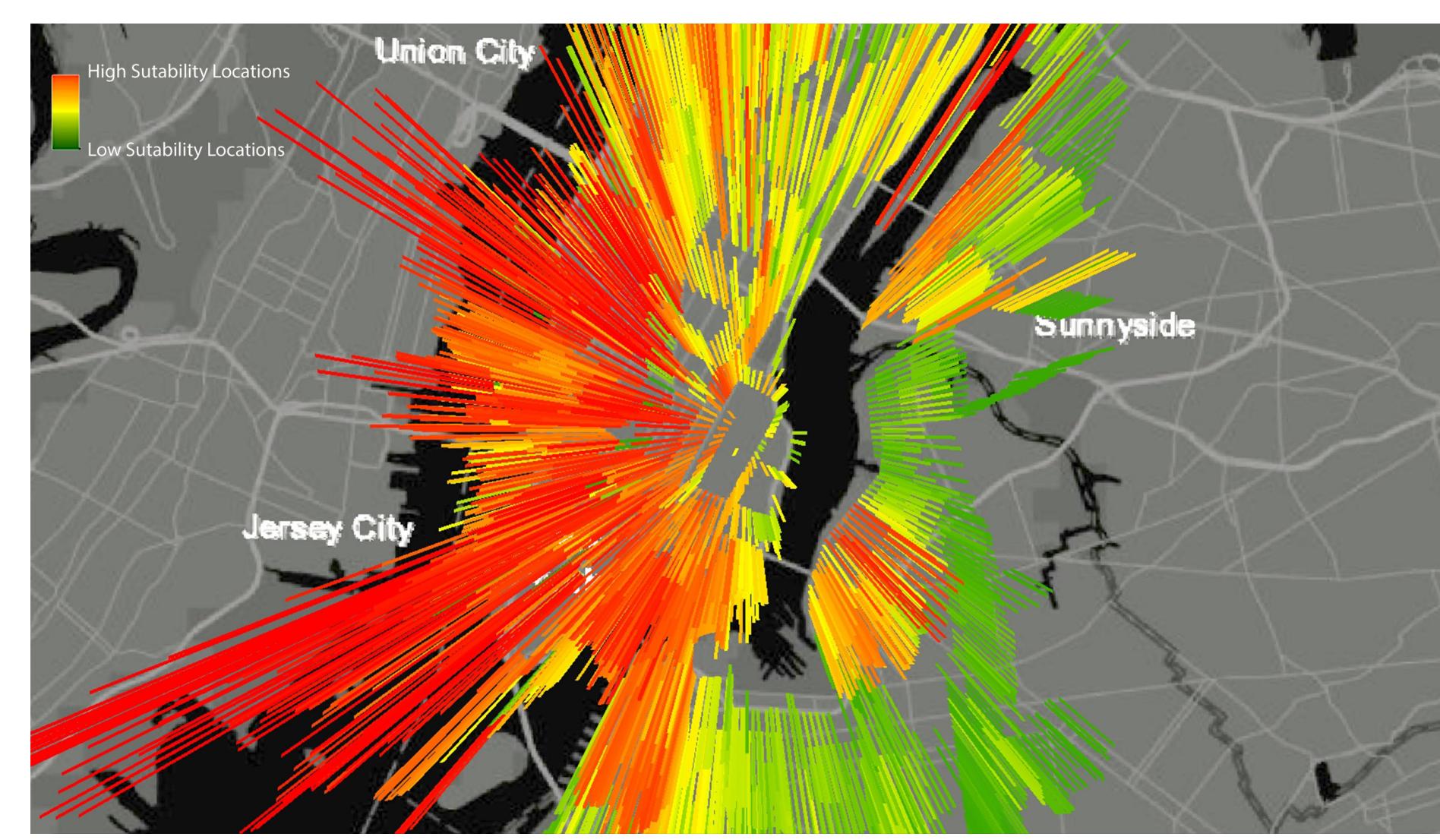
The ideal data to analyze the bicycle usage in transit zones will be the ground research and data collected on the streets. However, constrained by conditions and other issues, I chose the Citi Bike's data as my research basic data. Considering people's travel behavior may change when weekends come and the limitation of data processing capability, I chose June 1st 2016 and June 4th 2016's data to analyze the total usage of bicycles. For the Citi Bike usage rate from low to high, one to nine scores are assigned. In weekdays, high bicycle usage rate areas are shown as points in middle Manhattan, which means people seems prefer short trip during workday. On the other hand, in weekends, the dark blue areas are relatively bigger and gathered in Manhattan which means people travel farther and active in bigger areas on weekends than weekdays.

Suitability

suitability areas in general are calculated out by combining former layers, which are Fuzzy Members. The figure on the left, illustrates the hottest areas in NYC share bicycles may success. The weights assigned to each variables also shown in the table2. The most important variables is considered to be bike lane condition which evaluated as 25 percent important in suitability analysis. Weekday bicycle usage rate represent the ability bicycles can split the whole transportation system and population density can embody bicycle's usage potential, so 20 percent of the weights are given to each of them. People's attitudes and weekend bicycle usage both get 15% of the weights. Considering New York City is a highly developed space, so the slope can be very small, therefore, only 5 percent of the weights goes to the elevation factor. We can see in the figure, the most suitable areas to put share bicycles now are located in the middle Manhattan and lower Manhattan. Relatively suitable areas are distributed on the east side and the west side of central park. Brooklyn, Queens and Bronx are all out of suitable areas.

Table 2: Variables and Weights

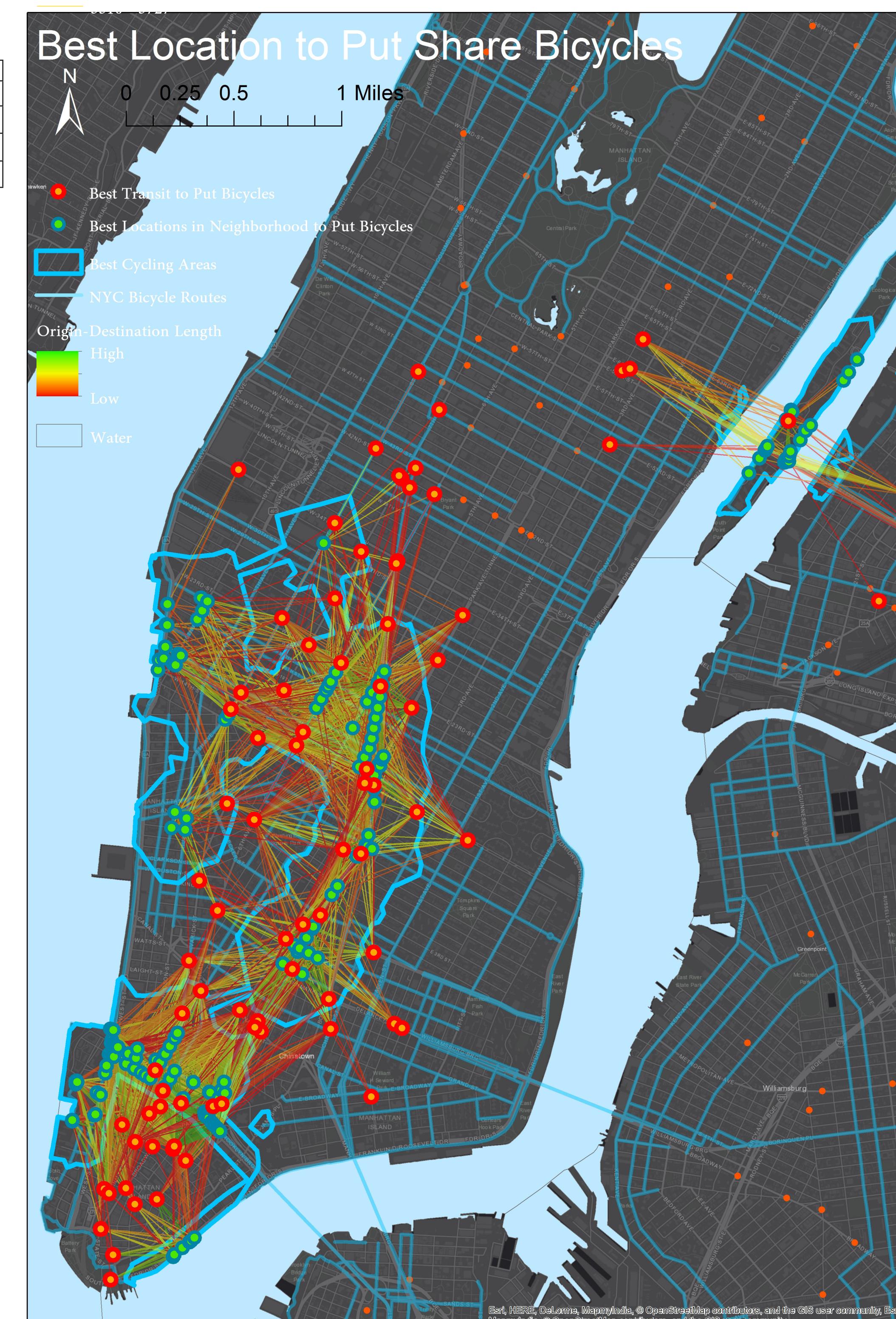
Variables	Weight
Weekday Bicycle Usage	20%
Weekend Bicycle Usage	15%
Population Density	20%
Bike Lane Condition	25%
People's Attitude	15%
Elevation	5%
Total	100%



Location Analysis

The junctions of the bicycle routes are the naturally candidate places to put the bicycles because they are easy for people to identify and access. After assigning the suitability score to those junctions, we can get the suitability score for each one of them. We find out the mean of them is 0.21 and the standard deviation is 0.068. Junctions with the top 5% score are considered to be the most suitable places to put the share bicycles, so the junctions with two standard deviation away from the mean are chosen. 175 points are selected to be the best locations to put share bicycles in NYC to solve the first mile problem. All of them are close to the residential areas and have relatively better riding conditions. Those places are also where people have relatively positive attitude to bicycles and bicycles are already popular there. Most of those junctions are located in the lower Manhattan and middle Manhattan. Others are aggregated in Roosevelt Island.

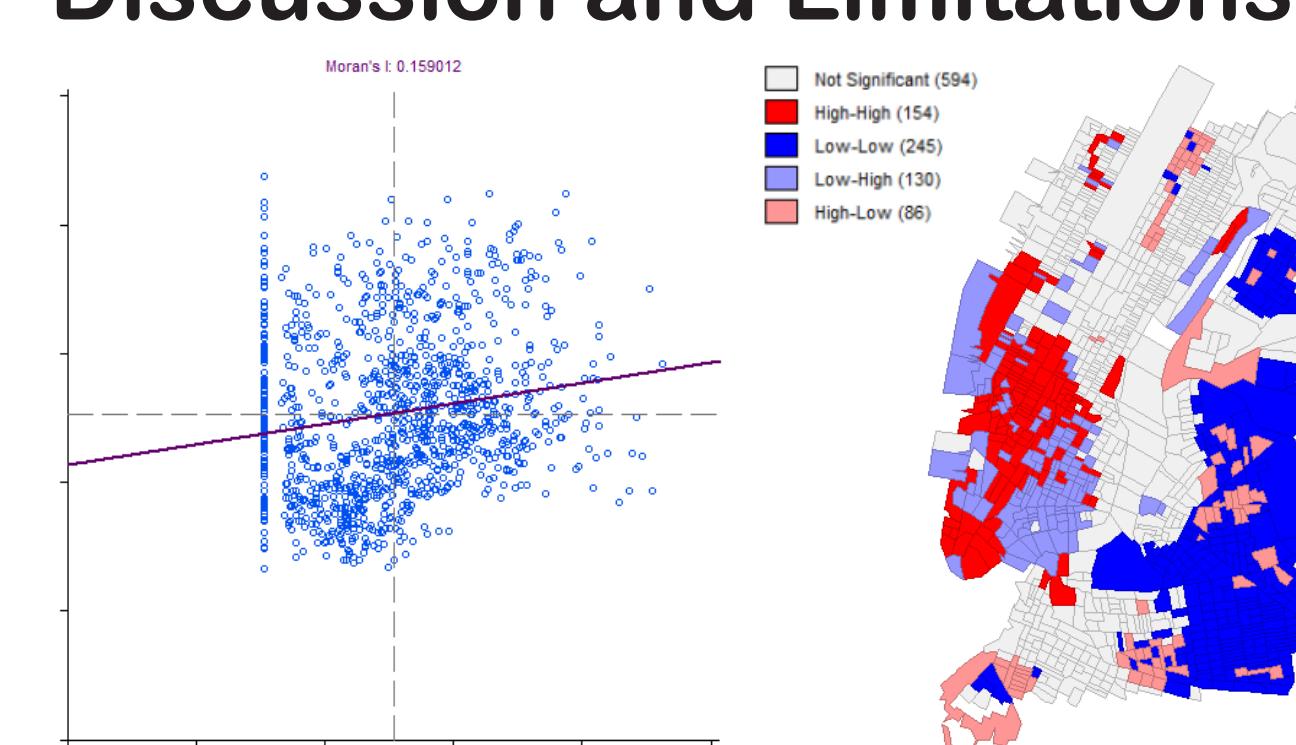
Results



175 junctions are selected to be the share bike parking points. In terms of the last mile issue, share bicycles can be fully used if we can locate them at the subway stations. People can travel from the stations to the junctions to park those share bicycles and walk to their homes. By using OD Cost Matrix based on distance from stations to the junctions, 84 transit stations are located. They are the ones located within one mile from those selected junctions and the ones to put share bicycles to solve the last mile issue. What's more, to find out where are the places in NYC not only have the best cycling conditions but also can solve both the last mile and the first mile problems. Two service areas are generated by the center of selected junctions and selected transit stations. The service radius of the junctions is designed to be 0.25 mile, since they are used to attract residents within walkable areas. 1 mile radius service area is used for transit stations. As shown in the figure Best Location to Put Share Bicycles, the circled blue line enclosed an area, Best Cycling Ar-

eas, can content those two standards. Also, we can see the lines connect the junctions and transit stations are categorized by travel distance. The greener the line is, the easier people can travel from a origin to a destination. Most of the green lines are encompassed by the best cycling areas.

Discussion and Limitations



Based on all the analysis above, we find out the best locations to put the share bicycles and the best places in New York City which can make share bicycles to be fully used to improve the city's public transportation, but if we take a step farther, we can find more issues show up.

• Only Rich People Can Ride a Bike

After assigning the suitability score and households' median income into block groups, we can find the high income and high suitability score

block groups are clustered together in middle Manhattan and lower Manhattan. Brooklyn and Queens, where poor people lives, are lacking of good cycling environment. Although the Local Moran's I is pretty low, which is about 0.15, still, it is significant because the P value is very near to 0. On the other hand, this research only considers the usage of bicycles. Residents living in those neighborhoods may originally travel more than people in other neighborhoods. So, other travel mode should be measured to see people's total travel behavior.

• Data Limitation

The Elevation data is come from New York State, but a small piece of Manhattan is missing, you will find that if you take a close look to my figures. So, the analysis is not complete. Moreover, the variables I choose probably not enough and they may have relationship between each other.