# PRELIMINARY ASSESSMENT REPORT TO DETERMINE SUITABLE AREAS FOR NEW GREEN SPACES IN METROPOLITAN PARIS

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# Introduction

The world is facing today a sanitary crisis without precedents in the modern era, with the only exception of the Spanish flu in the early XXth century. After a year living with COVID-19, everyone feels a bit anxious at some point. Lockdowns, travel and movement restrictions, curfews, lack of social life are just a few reasons why we are eager to get out of our households as soon as we can and go to the forest or a nearby park or garden and get some fresh air.

According to the UN, today 55% of the world's population live in urban areas. By 2050, humans living in cities will represent around 68%. Hence, if urban areas are growing larger, how can we manage them so their citizens can get some fresh air (and this, in the middle of a pandemy)? I think the solution has a name: green spaces, that is, parks and gardens. However, this solution raises a new question. How can city or town halls manage the situation so these demanded areas get too crowded and hence, become new COVID-19 hotspots?

I moved to France almost two years ago, and I still remember the TV images of crowded parks and gardens of Paris right after a lockdown. Today, the curfew in France begins at 6pm and ends at 6am. That means that by good weather, people crowd in parks and gardens at lunch time or during weekends.

The aim of this study is to provide the members of the Paris City Hall and its policy makers a tool of analysis of their public green spaces, that is, parks and gardens. It will help to identify those neighbourhoods (arrondissement is its french equivalent) lacking of green areas regarding their density of population and evaluating their accesibility by public transport (bus and metro). Once neighbourhoods with low density of green areas are identified, we will provide a list with the candidates where to build a new park or garden in the lacking neighbourhood.

# Data

Data used for this study come from wikipedia and the Paris City Hall.

- https://fr.wikipedia.org/wiki/Arrondissements_de_Paris

- https://opendata.paris.fr/explore/dataset/arrondissements/information/?disjunctive.c_ar&disjunctive.c_arinsee&disjunctive.l_ar&dataChart=eyJxdWVyaWVzIjpbeyJjb25maWciOnsiZGF0YXNldCI6ImFycm9uZGlzc2VtZW50cyIsIm9wdGlvbnMiOnsiZGlzanVuY3RpdmUuY19hciI6dHJ1ZSwiZGlzanVuY3RpdmUuY19hcmluc2VlIjp0cnVlLCJkaXNqdW5jdGl2ZS5sX2FyIjp0cnVlfX0sImNoYXJ0cyI6W3siYWxpZ25Nb250aCI6dHJ1ZSwidHlwZSI6ImNvbHVtbiIsImZ1bmMiOiJBVkciLCJ5QXhpcyI6Im5fc3FfYXIiLCJzY2llbnRpZmljRGlzcGxheSI6dHJ1ZSwiY29sb3IiOiJyYW5nZS1jdXN0b20ifV0sInhBeGlzIjoibF9hciIsIm1heHBvaW50cyI6NTAsInNvcnQiOiIiLCJzZXJpZXNCcmVha2Rvd24iOiJzdXJmYWNlIn1dLCJoaW1lc2NhbGUiOiIiLCJkaXNwbGF5TGVnZW5kIjp0cnVlLCJhbGlnbk1vbnRoIjp0cnVlfQ%3D%3D&basemap=jawg.dark&location=12,48.85889,2.34692

We use scrapping techniques to obtain administrative information for each neighbourhood (arrondissement) in Paris from the wikepedia website. The data that we use in this study are shown in figure 1.

| | Nom | Pop_2015 | Dens_2015 | Arr |
|---|---|---|---|---|
| 10 | Popincourt | 149834 | 40827 | 11 |
| 17 | Buttes-Montmartre | 197580 | 32875 | 18 |
| 19 | Ménilmontant | 195556 | 32702 | 20 |
| 9 | Entrepôt, anciennement Enclos Saint-Laurent | 91770 | 31754 | 10 |
| 2 | Temple | 35049 | 29956 | 3 |
| 16 | Batignolles-Monceau | 168533 | 29724 | 17 |
| 14 | Vaugirard | 234994 | 27712 | 15 |
| 18 | Buttes-Chaumont | 185654 | 27342 | 19 |
| 8 | Opéra[note 1] | 59408 | 27251 | 9 |
| 12 | Gobelins | 183216 | 25625 | 13 |
| 13 | Observatoire | 139992 | 24821 | 14 |
| 4 | Panthéon | 59333 | 23359 | 5 |
| 11 | Reuilly (hors bois de Vincennes) | 142340 | 22345 | 12 |
| 1 | Bourse | 20796 | 21006 | 2 |
| 15 | Passy (hors bois de Boulogne) | 165487 | 20921 | 16 |
| 5 | Luxembourg | 42428 | 19734 | 6 |
| 3 | Hôtel-de-Ville | 27146 | 16966 | 4 |
| 6 | Palais-Bourbon | 54133 | 13235 | 7 |
| 7 | Élysée | 36694 | 9457 | 8 |
| 0 | Louvre | 16545 | 9041 | 1 |

*Figure 1. Administrative information by arrondissement sorted in descending order by population density*

Data from the Paris City Hall (open data) contain geographic information: id, names, geographic center and contour lines for each arrondissement, etc. Data can be gathered in different forms, such as shapefiles, json files, etc.

We extract the coordinates of the geographic center for each arrondissement from a json file. They were stored in a pandas dataframe (fig. 2).

| | Nom | Arr | Lat | Lon |
|---|---|---|---|---|
| 0 | Temple | 3 | 48.862872 | 2.360001 |
| 1 | Palais-Bourbon | 7 | 48.856174 | 2.312188 |
| 2 | Panthéon | 5 | 48.844443 | 2.350715 |
| 3 | Élysée | 8 | 48.872721 | 2.312554 |
| 4 | Reuilly | 12 | 48.834974 | 2.421325 |

*Figure 2. Geographic coordinates of the centers of the first 5 arrondissements*

We obtained the the contour lines for each neighbourhood/arrondissement from a shapefile. After that, the administrative information was added to the dataframe (fig. 3) so that the population density can be displayed when the neighbourhoods are plot on a map.

| | geoid | c_ar | geometry | Nom | Arr | Pop_2015 | Dens_2015 |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 3.0 | POLYGON ((2.36383 48.86750, 2.36389 48.86747, ... | Temple | 3 | 35049 | 29956 |
| 1 | 1 | 7.0 | POLYGON ((2.32090 48.86306, 2.32094 48.86305, ... | Palais-Bourbon | 7 | 54133 | 13235 |
| 2 | 2 | 5.0 | POLYGON ((2.36443 48.84614, 2.36484 48.84584, ... | Panthéon | 5 | 59333 | 23359 |
| 3 | 3 | 8.0 | POLYGON ((2.32584 48.86956, 2.32569 48.86954, ... | Élysée | 8 | 36694 | 9457 |
| 4 | 4 | 12.0 | POLYGON ((2.41388 48.83357, 2.41401 48.83357, ... | Reuilly | 12 | 142340 | 22345 |

*Figure 3. First 5 rows of the merged dataframe which contains the administrative and geographic information for each neighbourhood*

From the Foursquare API we obtain the coordinates of actual green areas and public transport (metro and bus) stops and stations (figs. 4 and 5).

| | Neighborhood | Neighborhood Latitude | Neighborhood Longitude | garden | lat_g | lon_g | Venue Category |
|---|---|---|---|---|---|---|---|
| 0 | Temple | 48.862872 | 2.360001 | Jardin des Archives Nationales | 48.859929 | 2.358660 | Garden |
| 1 | Temple | 48.862872 | 2.360001 | Jardin Anne Frank | 48.861695 | 2.354984 | Garden |
| 2 | Temple | 48.862872 | 2.360001 | Jardin de Sully | 48.854987 | 2.364055 | Garden |
| 3 | Temple | 48.862872 | 2.360001 | Jardin Francs Bourgeois-Rosiers | 48.857423 | 2.360201 | Garden |
| 4 | Temple | 48.862872 | 2.360001 | Jardin de l'Hôtel de Sens | 48.853842 | 2.358404 | Garden |

*Figure 4. Foursquare API results (5 first rows) for gardens and parks in Paris*

| | Neighborhood | Neighborhood Latitude | Neighborhood Longitude | station | lat_t | lon_t | Venue Category |
|---|---|---|---|---|---|---|---|
| 0 | Temple | 48.862872 | 2.360001 | Métro Arts et Métiers [3,11] | 48.864660 | 2.356177 | Metro Station |
| 1 | Temple | 48.862872 | 2.360001 | Métro République [3,5,8,9,11] | 48.867770 | 2.364521 | Metro Station |
| 2 | Temple | 48.862872 | 2.360001 | Métro Temple [3] | 48.866523 | 2.361497 | Metro Station |
| 3 | Temple | 48.862872 | 2.360001 | Métro Filles du Calvaire [8] | 48.863280 | 2.366521 | Metro Station |
| 4 | Temple | 48.862872 | 2.360001 | Métro Rambuteau [11] | 48.861265 | 2.353392 | Metro Station |

*Figure 5. Foursquare API results (first 5 rows) for public transport stations/stops in Paris*

# Methods

We create two dataframes, one with the administrative information of the neighbourhoods and another one their geographic information. Once we have gathered the information about gardens/parks and transport stations from the Foursquare API, we will be able to our data on a map.

Based on the locations of gardens, transport stations and population density, we could decide, first, which ones are the most suitables neighbourhoods, and then, the best areas within them. We are looking for areas with a low density of parks, and high population density and high density of public transport stops. We then represent this data on a heatmap and decide visually, which areas we will be focusing on.

We draw a systematic point grid for the arrondissements chosen. Points within this grid are spaced 0.002 degrees from each other. The point grid help us to determine which are our best options. The two conditions we set up are:

1. Areas with low density of green areas: no green areas (parks/gardens) closer than 500m.

2. Areas with a good public transport network: there must be a bus or metro station within a radius of 200m. Please note than the average adult can walk 4 to 5 km/hour. Hence, there should be a bus or metro stop within a 2 to 3 min walk.

After applying these “filters”, we obtain with those grid points showing the best locations for a new green area based on our two conditions. Finally, we will apply k-means method to group these points in several clusters. We provide, for each cluster, the geographic coordinates of its center and an approximative address. These clusters may provide the policy makers of the Paris City Hall with a first hint of where to start looking for the best locations for green areas.

## Results

Our starting point is a folium map (fig. 6) showing all the information gathered so far :

- Contour lines of each neighbourhood, with a color gradient by population density (blue dots are the centroid of the polygons representing the arrondissement/neighbourhood).
- Green dots represent the actual green areas in metropolitan Paris
- Black dots represent the public transport stations

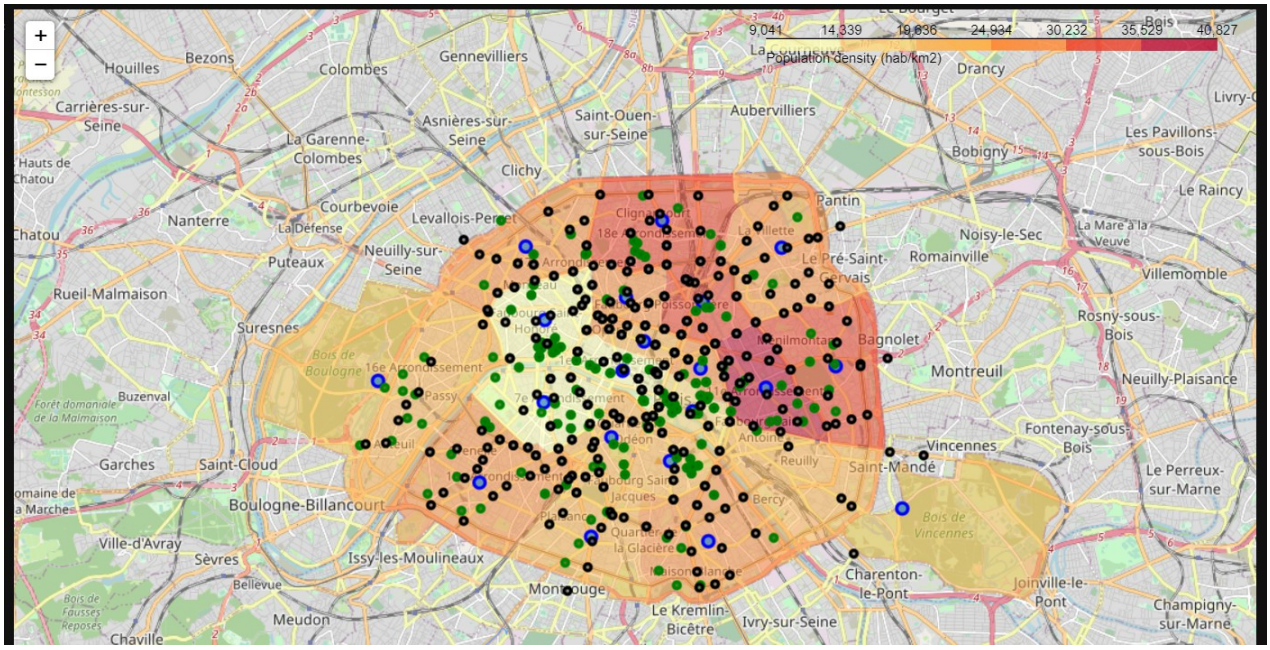


*Figure 6. Green areas and public transport station in Paris and population density data by arrondissement*

Before moving forward, let's have a closer look to the map to do a quick analysis.

To the east of Paris, there is the « Bois de Vincennes ». Population density data from wikipedia do not take into account the forest surface for its computation (see fig. 1). The same with the « Bois de Boulogne » to the west of the city. Therefore, we have to be careful when interpreting the data of population density of arrondissements 12 and 16. This fact can also explain why the density of parks is lower in these areas than in other parts of the city. The neighbours of these areas have an easier access to green areas compared to other arrondissements. Therefore, we will discard them as candidates for new green areas.

We can see that neighbourhoods to the north-east of Paris are more populated than the rest of the city. Popincourt, Buttes-Montmartre, Ménilmontant, Entrepôt et Temple are the most populated areas (fig.1).

We can also see from the map that in Paris, as in many other large cities, the public transport network densifies when we get to the city center. Popincourt is the most dense populated area in the city and it is relatively close to the city center. Entrepôt et Temple are contiguous to the Bourse

arrondissement, which was once home of the equivalent to Wall Street. Moreover, we obtained 0 results for green spaces in the Bourse from Foursquare API. We will select this four arrondissements for deeper analysis. In order to have a « more regular polygon » as a study zone, we decided to include Opéra with the other four. It is very close to the city center and it seems there are not too many green areas in it.

We will double check our first assumption with a closer look to a heatmap of green areas (fig. 7).

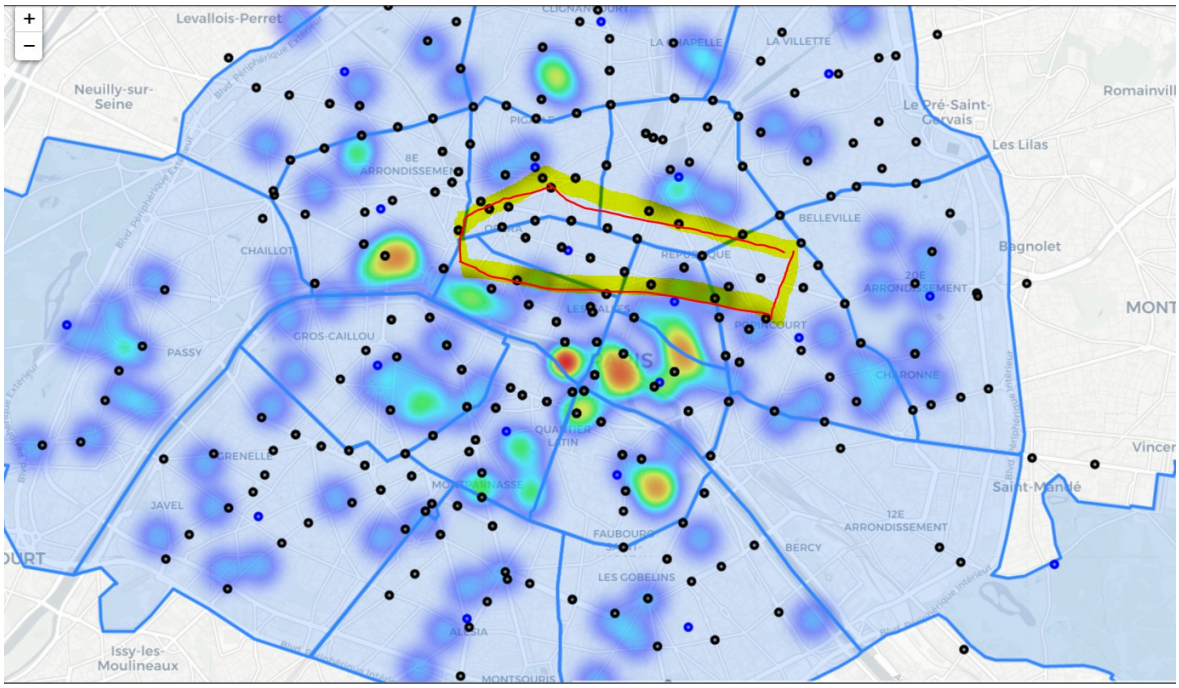


*Figure 7. Green spaces heatmap of Paris. Black dots represent the public transport stations/stops*

As we first assumed, there is a strip north-east of Paris city center (highlighted) which could be suitable to our purposes. This strip covers partially the neighbourhoods of Popincourt, Temple, Entrepôt, Bourse and Opéra. There are no gardens nearby and there seems to be a good public transport network in this area, which is closer than 2,5km from le musée du Louvre, considered as the geographic center of Paris.

We move forward with the design of a point grid over the five selected neighbourhoods which help us to decide the best spots for new green areas. The points in the grid are equally distributed every 0.002 degrees (fig. 8).

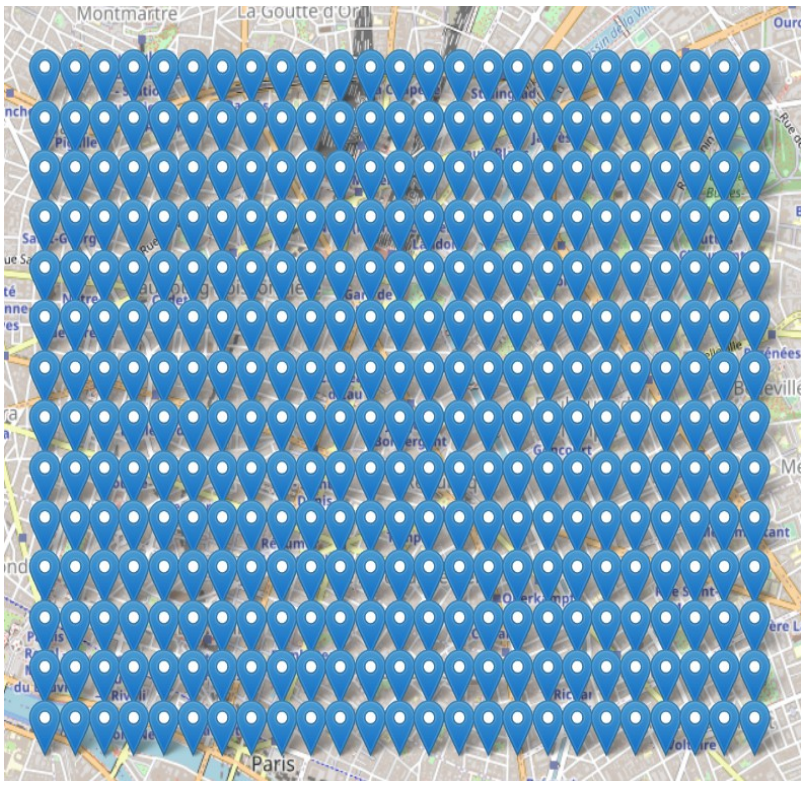


*Figure 8. Point grid over the Popincourt, Entrepôt, Temple, Bourse and Opéra neighbourhoods*

The two conditions for a point in the grid to be considered as a potential candidata are :

1. There are no gardens within a distance of 500m
2. There is a metro/bus stop or station closer than 200m

We calculate the distance for each point in the grid, first, to the closest green area and then, for the nearest metro/bus stop or station. We obtain two dataframes which will be then merged. After merging the data, we obtain 65 possible spots distributed within our area of interest (AOI). We remove three of them because they are too far away from the rest. Results are shown in figure 9.


*Figure 9. Map showing the 62 selected points which meet our requirements within our AOI*

Finally, we use k-means, the most popular clustering method when working with geographic data.

This way, we provide the policy makers on the Paris City Hall with specific locations of where to start looking for the most suitable places to place a new green area.

From the point distribution, we can observe more or less 10 well defined areas or clusters. Results from applying the k-means method can be seen in figure 10. The geographic coordinates of the cluster centers and approximative addresses are provided in figure 11.

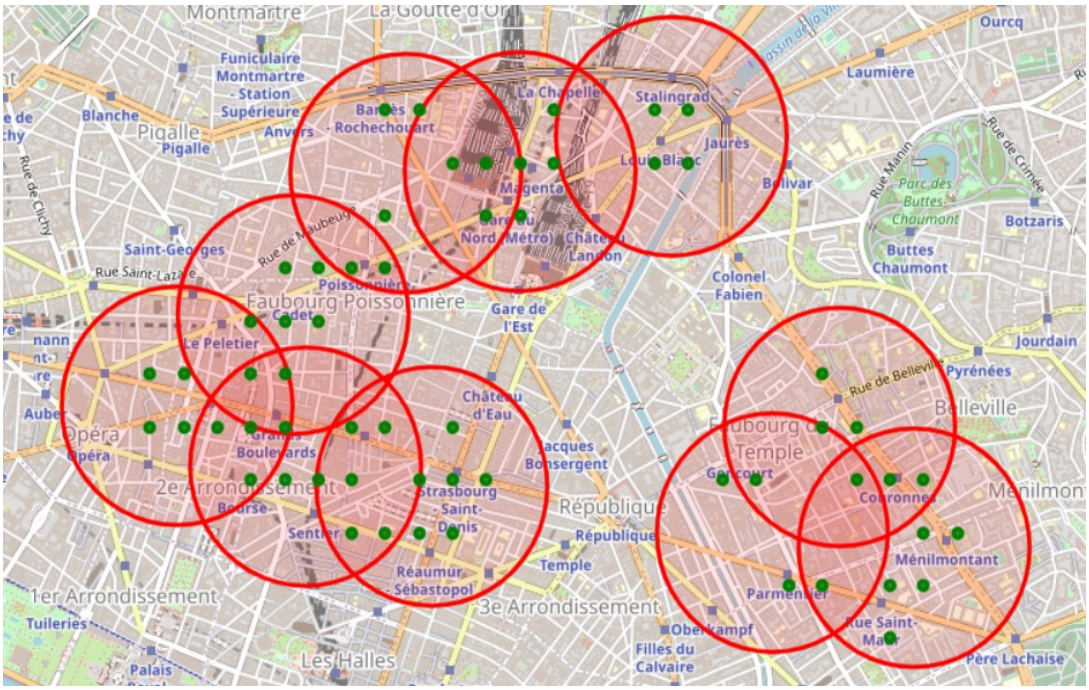

*Figure 10. Clusters generated by the k-means method*

| | lat | lon | address |
|---|---|---|---|
| 0 | 48.881 | 2.351 | (Les Demoiselles d'Honneur, Rue de Rocroy, Qua... |
| 1 | 48.866 | 2.381 | (Dèmonia, Avenue Jean Aicard, Quartier Saint-A... |
| 2 | 48.875 | 2.344 | (Grand Orient de France, 16, Rue Cadet, Quarti... |
| 3 | 48.870 | 2.345 | (Centre des Finances Publiques, Rue d'Uzès, Pa... |
| 4 | 48.882 | 2.367 | (231, Rue La Fayette, Quartier de l'Hôpital Sa... |
| 5 | 48.869 | 2.353 | (25, Rue Sainte-Apolline, Quartier des Arts-et... |
| 6 | 48.867 | 2.373 | (Relais Parmentier, Avenue Parmentier, Quartie... |
| 7 | 48.872 | 2.338 | (BNP Paribas, Rue Laffitte, Quartier du Faubou... |
| 8 | 48.881 | 2.358 | (no, Rue du Faubourg Saint-Denis, Quartier Sai... |
| 9 | 48.871 | 2.377 | (École maternelle Présentation, Rue de la Prés... |

*Figure 11. Geographic coordinates of the center of the 10 generated clusters and approximative adresses*

## Discussion

The first thing to do is a disclaimer about the results provided. Data provided by the Foursquare API are not 100% accurate. There are several green areas and public transport stations/stops which data are not provided. One can see this comparing our dataset with the background map.

Considering the methodology and the results there are, in my opinion, two main points to discuss about. The first one is the choice of the neighbourhoods and the second one is the conditions we set up to determine the most suitable spots for new green areas.

About the choice of the neighbourhoods, one could ask why not to choose other neighbourhoods. The main object of this preliminar study is to propose locations for green areas in the Paris metropolitan area. Around the districts in the city center, there are several large neighbourhoods. However, there are two of them which have forests nearby. For the residents in these areas, to get there should be much easier than having to commute to get to the city center. The other neighbourhoods were discarded simply because they have a lower population density ratio.

From the top 5 most dense populated areas in Paris, 3 are in our study. The reason why the other two arrondissements were not considered is just their location. Ménilmontant is located in the outer ring of the metropolitan area. Besides, the cemetery Père-Lachaise is in it. Eventhough it is not properly a park, its size and reputation (Jim Morrison and Oscar Wilde, among other celebrities, are buried there) makes of it a special place. I have been there it and I can say that it worths a visit, if you are in Paris. The same reason applies to Buttes-Montmartre. Its location in the outer skirt of the metropolitan area makes it of more complicated access for people living in the southern part of the city. In addition, the network of public transport stations does not seem as well developed as in other neighbourhoods.

A minimum distance of 500m to the nearest park or garden and a maximum of 200m to the nearest public transport station were set up as conditions to determine the most suitable locations for new green areas. These values have been selected having in mind that an average person can walk at a pace of 4 to 5 km/h. Hence a stroll to a nearby park of around 6-7 minutes (500m) can be considered as reasonable even for a big city as Paris. If the person is not lucky enough to have a park or garden within a reasonable radius, he or she might consider take the public transport to get to a green area. That is why a maximum distance of 200m to the closest green area was set up. Obvisouly, these conditions might be changed according to the requirements of the city counselors.

There are other topics which can be subject to discussion, such as the set up of the grid point or the k-means. I will be glad to discuss about these topics if you want to.

## Conclusion

The main purpose of this preliminary report is to provide locations for new green areas, that is, gardens and parks in metropolitan Paris. From the data gathered from internet, we draw a map which showed the most dense populated neighbourhoods/arrondissements in Paris, together with the location of green areas and public transports stops.

With the help of a heatmap of green areas, we selected 5 neighbourhoods with low density of green areas but with a large density population (three among the top5) and relatively close to the city center.

We then created a point grid for those areas and applied two conditions to select the best candidates. Areas with no green spaces within a distance of 500m but with a public transport stop (metro or bus) within a distance of 200m. We obtained 62 (65) potential spots.

Finally, with the help of the k-means clustering method, we grouped the most suitable locations in ten groups or clusters. Using reverse geocoding, we provided ten approximative addresses corresponding to the geographic coordinates for each cluster center.