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Introduction

With the impact of COVID-19 since 2020, a human living pattern has changed for coping with the pandemic. In Hong Kong, people are prohibited to have their meals inside a restaurant. After this decision, the media revealed that there were many outdoor workers eating their foods in limited public areas such as urban parks or even in public toilets (Lee, 2020). It indicates the shortage of public open spaces in this city of around 7.5 million people, Hongkongers do not have adequate public spaces to enjoy their meals over the pandemic.

In fact, Hong Kong has been discussing its space scarcity and the corresponding influences on citizen. Before the pandemic, Hong Kong was regarded as the world densest urban environment, with approximately one million of people per square meter (Murphy, 2017). The spatial problem derived several social issues and complaints from citizen. It raises some awareness that such space issues could be one of the critical factors of damaging Hongkongers' lifestyle. The poor urban planning leads to the limitation of accessing or finding public areas, it could have a negative impact on both physical and mental health for the citizen (Ng and Moon, 2017). Comparing to other similar sized cities where conducted appropriate urban planning for public spaces such as London and New York, there are relatively fewer social issues around the inadequate use of open spaces and other spatial problems in the society.

As several pieces of evidence showed that the availability of open spaces would be a determination of Hongkongers' living quality, as well as the intention to spend their leisure time. Meanwhile, crowdedness is another social issue that has been discussing in Hong Kong. These aspects have been the main consideration and direction for the Hong Kong government to govern. It is interesting to think whether more public open spaces attract Hongkongers to stay or visit nearby. Thus, it drives to the motivation of investigating the relationship between public spaces and population density.

Background

Hong Kong is a small city where is located in the south of China, with approximately 7.5 million of people. There are three main regions including Hong Kong Island, Kowloon, and New Territories, and these three regions are divided into 18 different districts (*District Council*, 2020).

Research Question

In this paper, it is going to investigate the significance of public spaces in relation to the population density in Hong Kong. In which, public spaces are those areas that publicly open for citizen and population density refers to the average number of people in certain districts.

In order to reach the answer to this question, three main objectives listed below are going to be achieved:

1. Investigate the population distribution and population density of 18 different districts in Hong Kong
2. Analysing the pattern of the public open spaces in Hong Kong
3. Analysing the results from population density and open spaces, and to compare with similar real-world cases

Literature Review

In this section, it is going to clarify the results in terms of the significance of public spaces and their relationship with population density from the academic. Furthermore, it will discover the research gap among these scholars.

Many authors stated that comprehensive urban planning would contain a reasonable proportion of public spaces, leading to the attractiveness to stay nearby. First of all, they concluded that public spaces would reach to the improvement in living quality. Some open areas such as urban parks would provide positive ecosystem services, such green spaces are likely to impact on people welling-being and leading to a better quality of life (Gobster and Westphal, 2004; Chen and Wang, 2013). For instance, it enables people to have a public space to conduct their leisure activities such as walking and running. Besides, the availability of open areas also provides another advantage to the location. On Richards, Passy and Oh (2017) investigation also found that, for example in Singapore, allocating more public spaces in urban planning could have a significant enhancement on the image and branding of its city, as well as the opportunity for recreation. Other papers provided another view on this argument. Bonilla (2013) mentioned that open areas could give a productive character. It claimed that these open spaces provide high flexibility and mobility for citizen to use, which could lead to high population density. For example, it is able to take advantages to sell goods or services in/ nearby the park, generating businesses through the availability of public areas. The author stated that such opportunity derived from the open spaces is likely to thrive the economy within the domestic environment. The example reflected the significance of public open spaces in light of enhancing crowdedness. Therefore, it is also the factor that public spaces bring to high population density.

In addition, several scholars mentioned the importance of the coverage of public spaces. They discovered that the level of coverage varies among cities, such as 11 percentage in Birmingham and 45 percentage in Sheffield (Fuller and Gaston, 2009). The consistent view they all came together was the significance of public spaces' coverage towards the benefits of surrounding residents. With the more accessibility of public areas, it found that the presence of open spaces has a strong effect on health (Maas *et al.*, 2006). People surrounded by public open spaces tend to be healthier mentally and physically. Also, in context to Hong Kong where is a small city with a crowded environment, urban stressors such as noises from traffic and crowding could increase residents' stresses. Several pieces of evidence demonstrated that the availability of public spaces helps to reduce stress. For example, an experiment observed how stress could reduce after completing demanding tasks (van den Berg, Hartig and Staats, 2007). The result showed that, with the treatments of 10 minutes seated-indoors phase and 50 minutes walking-outdoors phase, participants recorded a rapid decline in their blood pressures. Health benefits and lower anxiousness come with the degree of the accessibility of publicly open spaces. Such finding linked consistently with other authors who illustrated that the open spaces would benefit from a greater degree of social interaction and lower mental fatigue (Fuller *et al.*, 2007).

Despite the advantages that are followed by the accessibility of public spaces, there is a number of articles holding another point of views. Scholars believed that drawbacks and limitations could also occur. There main perspectives on this argument, including the scarcity of land, the increased house prices, and different geographical structure in other locations. Firstly, Gobster and Westphal (2004) mentioned that open spaces are a luxury resource that can improve the quality of life. Luxury resource from this article means that it is scarce to obtain and expensive to develop, although it has high level of spatial demand in term of urban development and citizen's needs. This statement was further explained by other papers. Brander and Koetse (2011) elaborated it with an estimation of economic values. They evaluated that some public spaces such as urban parks are more highly valued in general, leading to a large influence on the estimated values from both contingent valuation and hedonic pricing. Secondly, with the improvement in public areas, surrounding house prices could be increased inevitably. It found that locations with greater public spaces accessibility and maintenance level have a high implicit price, whereas negative implicit prices were discovered from insufficient neighbouring land-use (Panduro and Veie, 2013). Thirdly, Richards, Passy and Oh (2017) indicated that southern Asia cities have a different attribute in the geographic layout. They investigated that these cities tend to be high population density, lower open space coverage, and less green space per capita. It would cause different interpretation when comparing to western cities such as New York and London.

Narrowing it into the context of Hong Kong, public open spaces attract more population density in certain locations. Tillu and Ferreira Chair (2011) revealed that the open spaces attract both residents and non-residents to come, leading to higher population density. Due to the lack of open spaces, over 270,000 Filipina domestic workers in Hong Kong congregate every Sunday in urban parks or other public facilities. As a result, during the weekend, there is likely to have a higher population density around those locations with public spaces. The author also highlighted that such spatial problem is crucial in Hong Kong for both residents and foreign workers. The lack of open spaces causes issues and dissatisfaction. When spaces are not adequate, population density increases in those areas with limited public open areas. Consequently, conflicts are likely to occur under this situation. Rossini (2019) also agreed to this perspective but with a different angle. The author admitted the fact that Hongkongers have been raising their awareness in the needs of public open space due to scarcity. However, the urban planning of the government is not appropriate. The authority set several strict rules and guidelines on its public spaces such as prohibiting sitting and walking on the grass (Carlow, 2013). The limitation of the use is seen as reducing the population density for a location where is nearby a public facility.

Throughout the academic papers around this topic, there is a research gap in analysing Hong Kong public spaces and its significance of the population density specifically. Most of the scholars were discussing the impact of this relationship on a qualitative basis, such as a potential benefit on attracting more people nearby public spaces or possibly increase house prices. Rarely, this spatial problem is less likely to demonstrate with data visualisation. Thus, in the following sections, it is going to conduct a geographic analysis on the issue of “the significance of public spaces in relation to the population density in Hong Kong”.

Methodology

The data processing and visualisation are produced under the R programming language from RStudio. All the results are reproducible and relevant documents are publicly shared on the GitHub and RPubs hyperlink provided on the cover page.

The analysis below is based on four main data sets, including the Hong Kong population and population density by districts, the location of public open spaces in Hong Kong and the shapefile of the Hong Kong map. The first two data sets are obtained from the Hong Kong Census and Statistics Department website, the public open spaces data set is provided from Hong Kong Geodata Store, and the shapefile is from an OpenStreetMap database in Geofabrik.

The following data analysis is produced in three aspects (Figure 1). Firstly, it is to produce a histogram from Hong Kong population, investigating the data distribution according by districts and visualising the result on a map. Secondly, creating a histogram for population density data set and to conduct a clustering analysis based on its 2011 and 2016 data. The selection of these two years is due to the population by-census is undertaken every five years. These two steps aim to achieve the first research objective. Thirdly, it will visualise the location of public open spaces on a map. By using the results, to comparing with similar examples mentioned in the *Literature Review* section such as Southeast Asia or other similar sized cities. This step targets to investigate the second and third objectives.

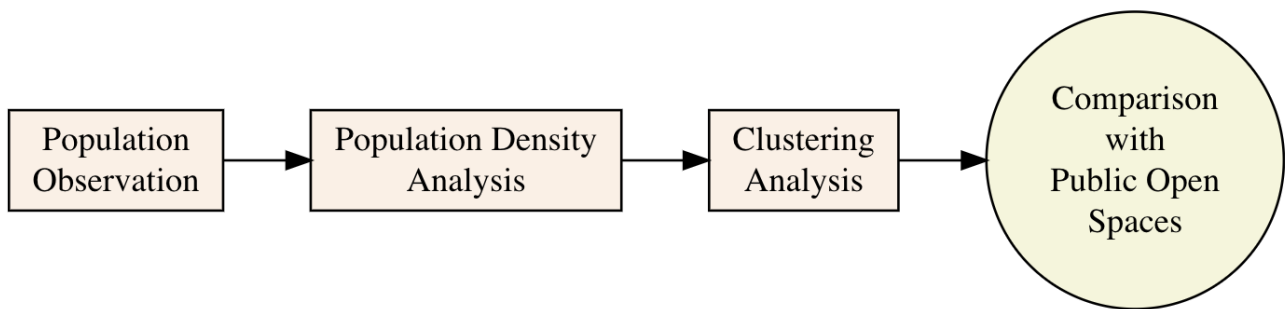


Figure 1: Methodology Flowchart

Results and Discussion

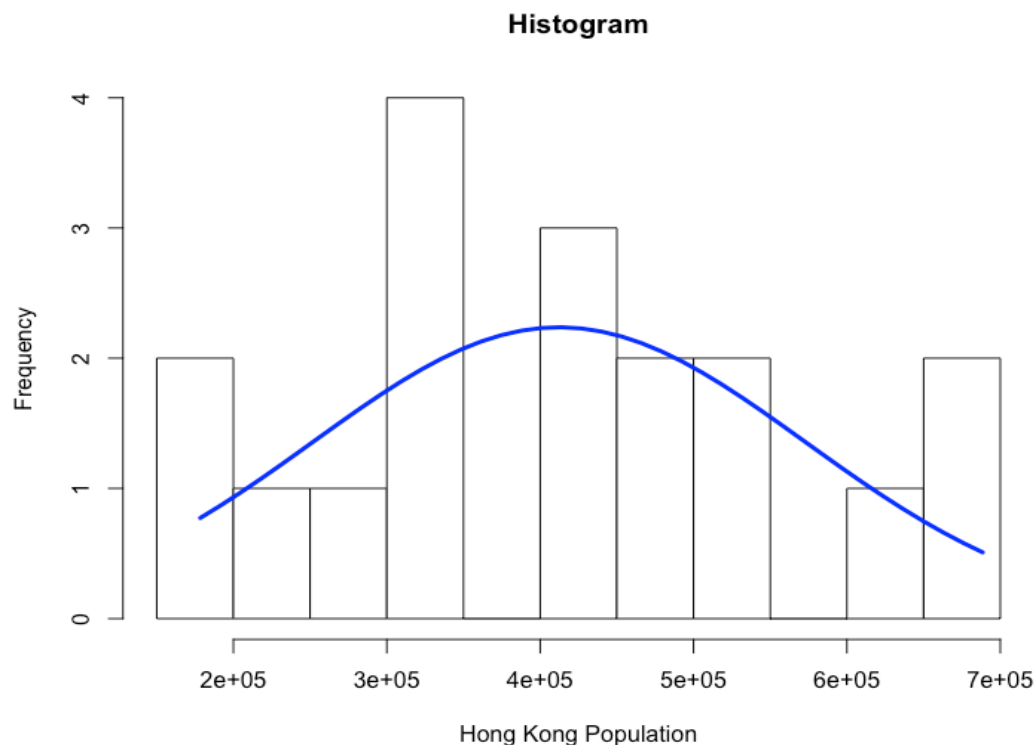


Figure 2: The Population Distribution by Districts in Hong Kong

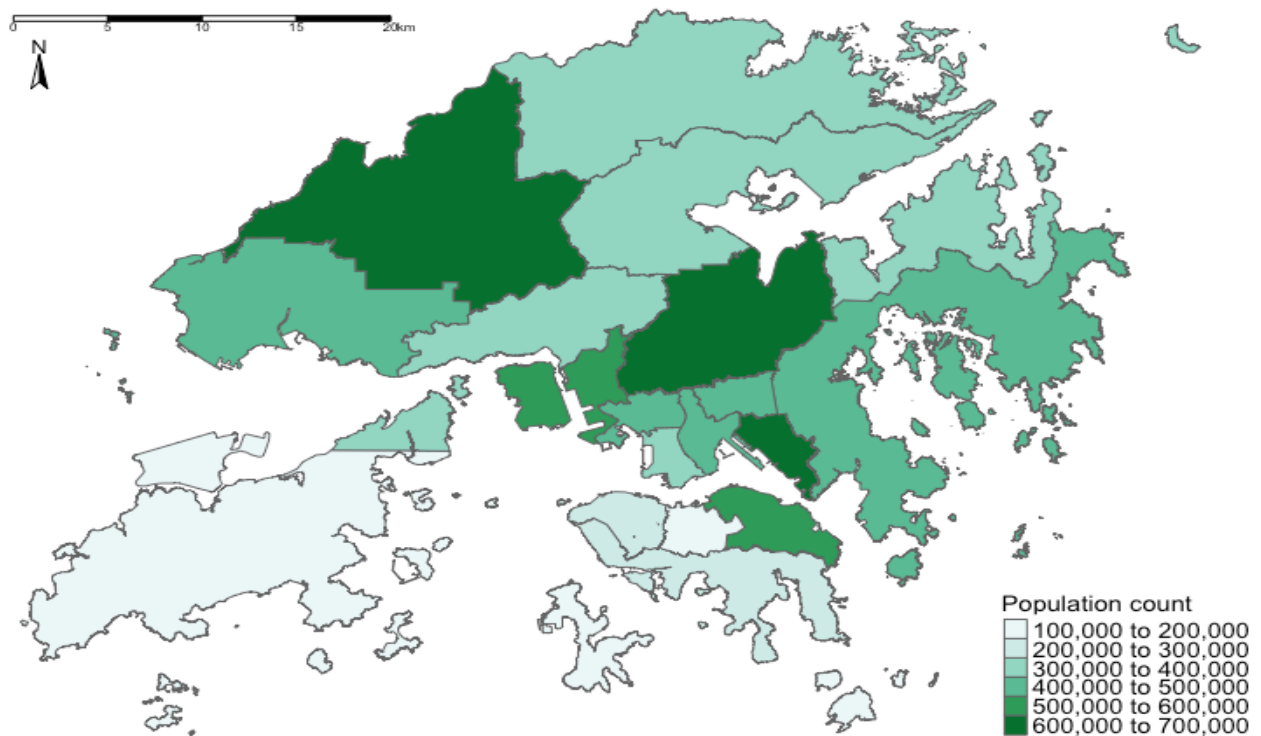


Figure 3: Population Visualisation

Figure 2 demonstrates how the number of individuals in the Hong Kong population in 2020 is distributed. As the blue line indicates that the population is a normal distribution, we can see that the number of populations by districts is concentrated in the middle of the data range. Most frequent patterns are recorded as approximately 300,000 people in a district with 4 frequencies, following by around 400,000 people with 3 frequencies. It is interesting to see that the highest and lowest populated districts share the same frequency, two frequencies for 200,000 and 700,000 people respectively. It revealed that there is an amount of districts holding either the lowest or highest population, indicating a slight population dispersion in Hong Kong.

Figure 3 further visualises the population data set on a Hong Kong map. By observing the population count, the population is heavily concentrated on three districts, including Kwun Tong, Yuen Long, and Sha Tin. The second most populated concentrations are from Eastern and Kwai Tsing. From the result of the population distribution, it is clear to see that the majority is from New Territories, where is the less urbanised. As a result, this outcome is consistent with the population pattern from Richards, Passy and Oh's paper indicating that, in Southeast cities, the larger population tends to come from low crowded areas and greater spacing.

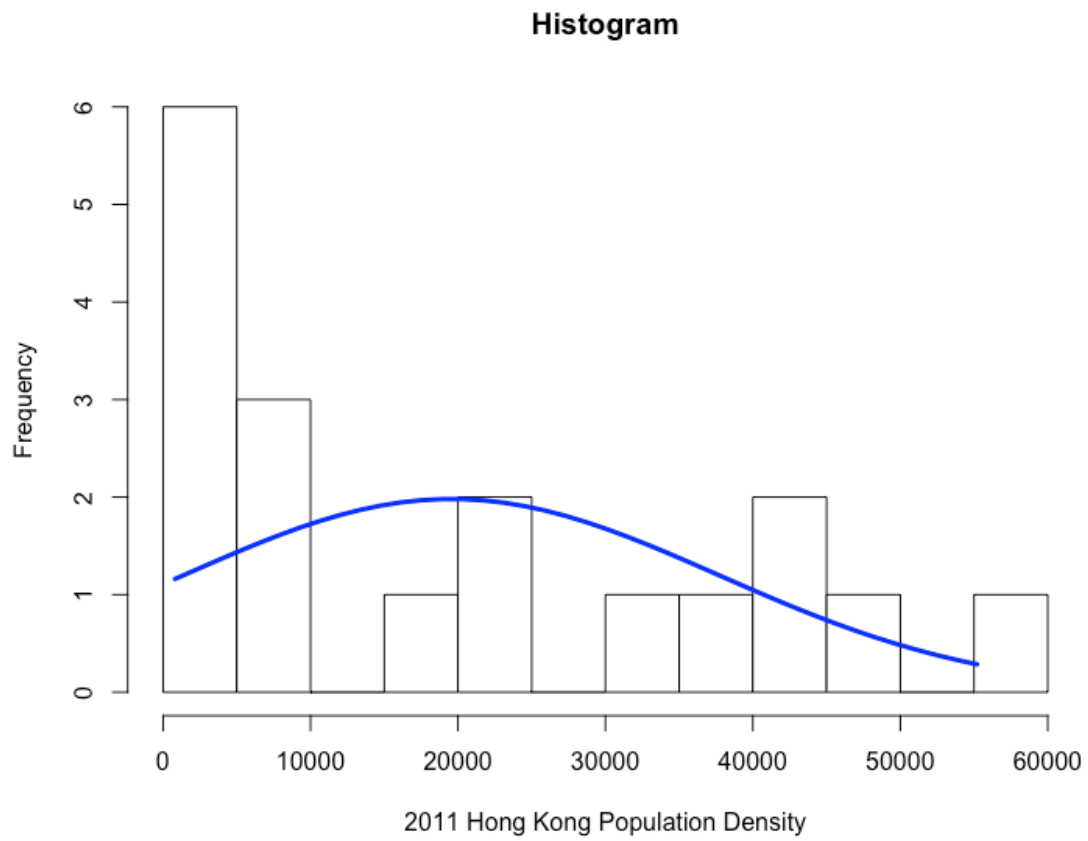


Figure 4: 2011 Hong Kong Population Density Distribution

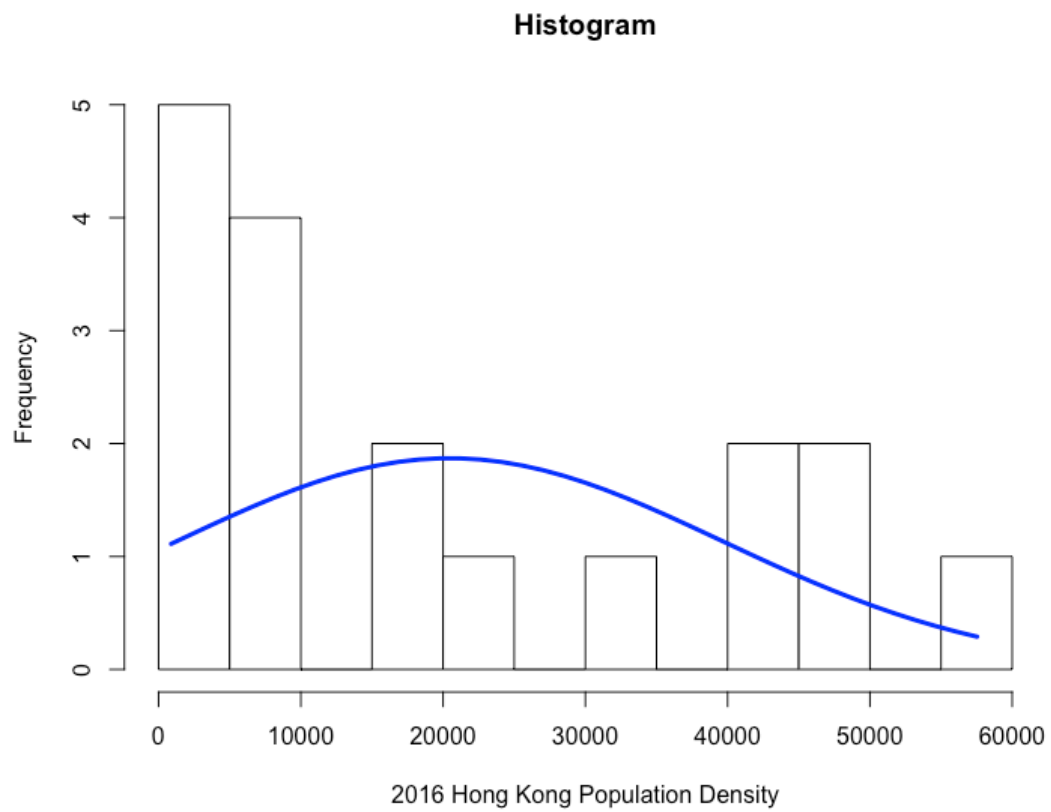


Figure 5: 2016 Hong Kong Population Density Distribution

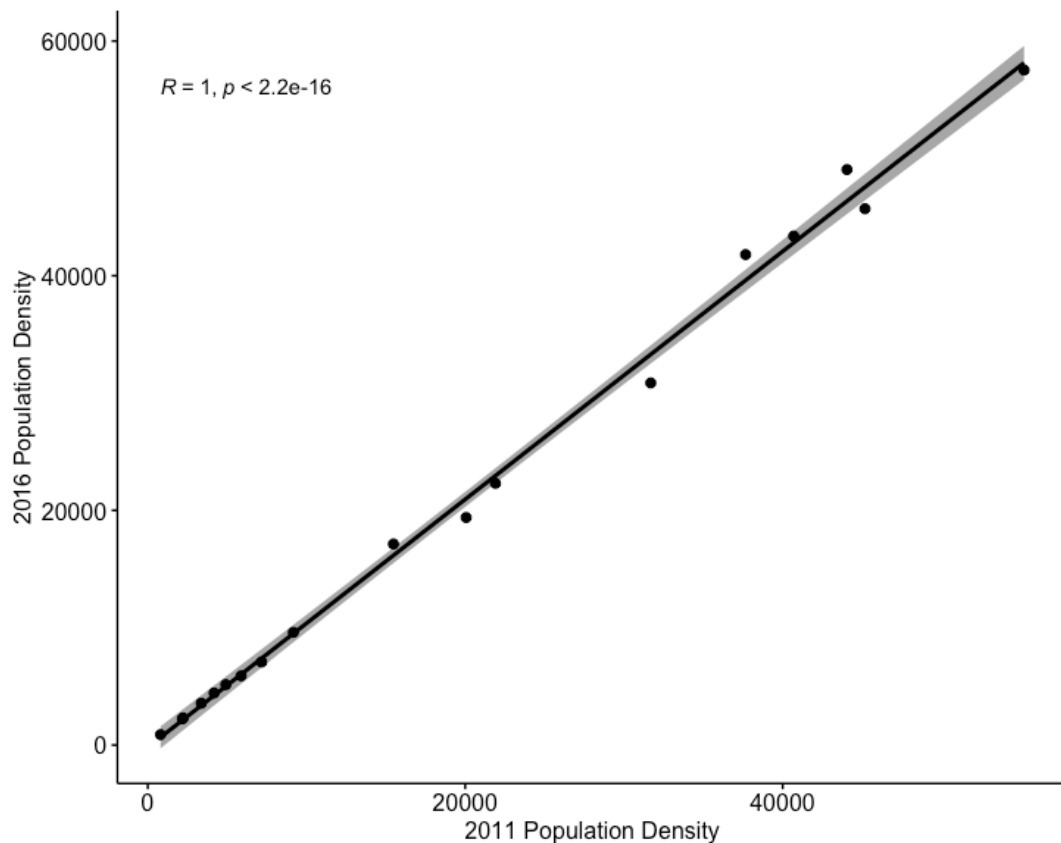


Figure 6: The Correlation of Hong Kong Population Density in 2011 and 2016

Extracting the population density data from previous years for further analysis, Figure 4 and 5 are the histograms that illustrate the distribution of population density by districts in 2011 and 2016. From observing the blue lines, it shows that both selected data sets represent a relatively normal distribution. Figure 6 demonstrates the correlation between two variables, 2011 and 2016 population density in Hong Kong. It illustrates that two variables hold an upward sloping linear relationship, and the p-value is extremely low with $2.2e-16$. Given these three figures, it can conclude that these two variables meet the requirement for conducting a clustering analysis. It is because both data are not highly correlated (low p-value), normally distributed (blue line), and on the same scale.

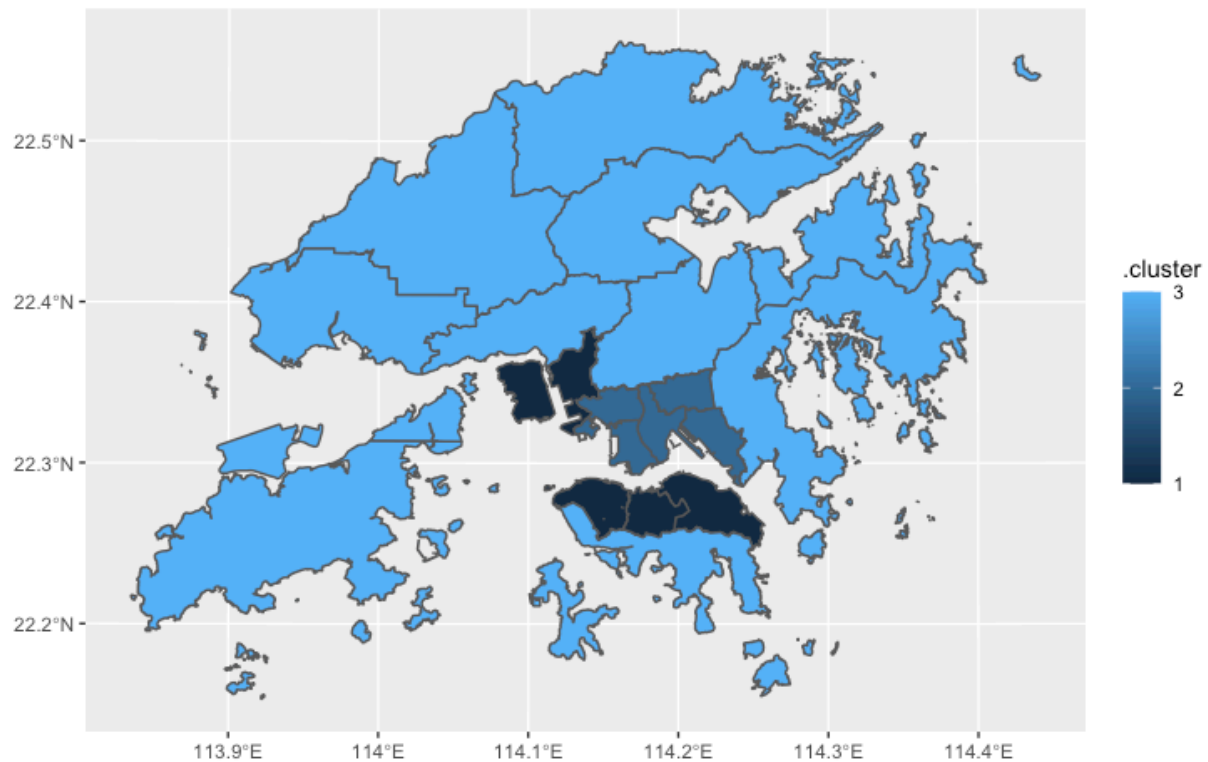


Figure 7: Clustering Analysis on the Hong Kong Population Density

Figure 7 shows the clustering outcome on Hong Kong population density for 2011 and 2016 data, under three main clusters. After computing and standardising the data, the classification and breakdown for each cluster are stated below:

	eleven	sixteen	size	withinss	cluster
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1	0.151	0.102	4	0.720	1
2	1.38	1.41	5	0.960	2
3	-0.834	-0.828	9	0.332	3

We can see that cluster 1 is concentrated around the centre of Hong Kong, cluster 2 is also surrounding there. Comparing to Figure 2 to 3, the clustering analysis discovered a slight difference in population distribution. Although the population in the centre of Hong Kong does not hold the largest population, these areas recorded a high level of population density. Referring to Tillu and Ferreira Chair's standpoint, this phenomenon could be explained by the entertainment in public spaces such as central urban parks. The public spaces are likely to attract people visiting or staying in these areas, leading to high population density. For further examining this hypothesis, it is going to verify it by observing the locations of public spaces in Hong Kong.

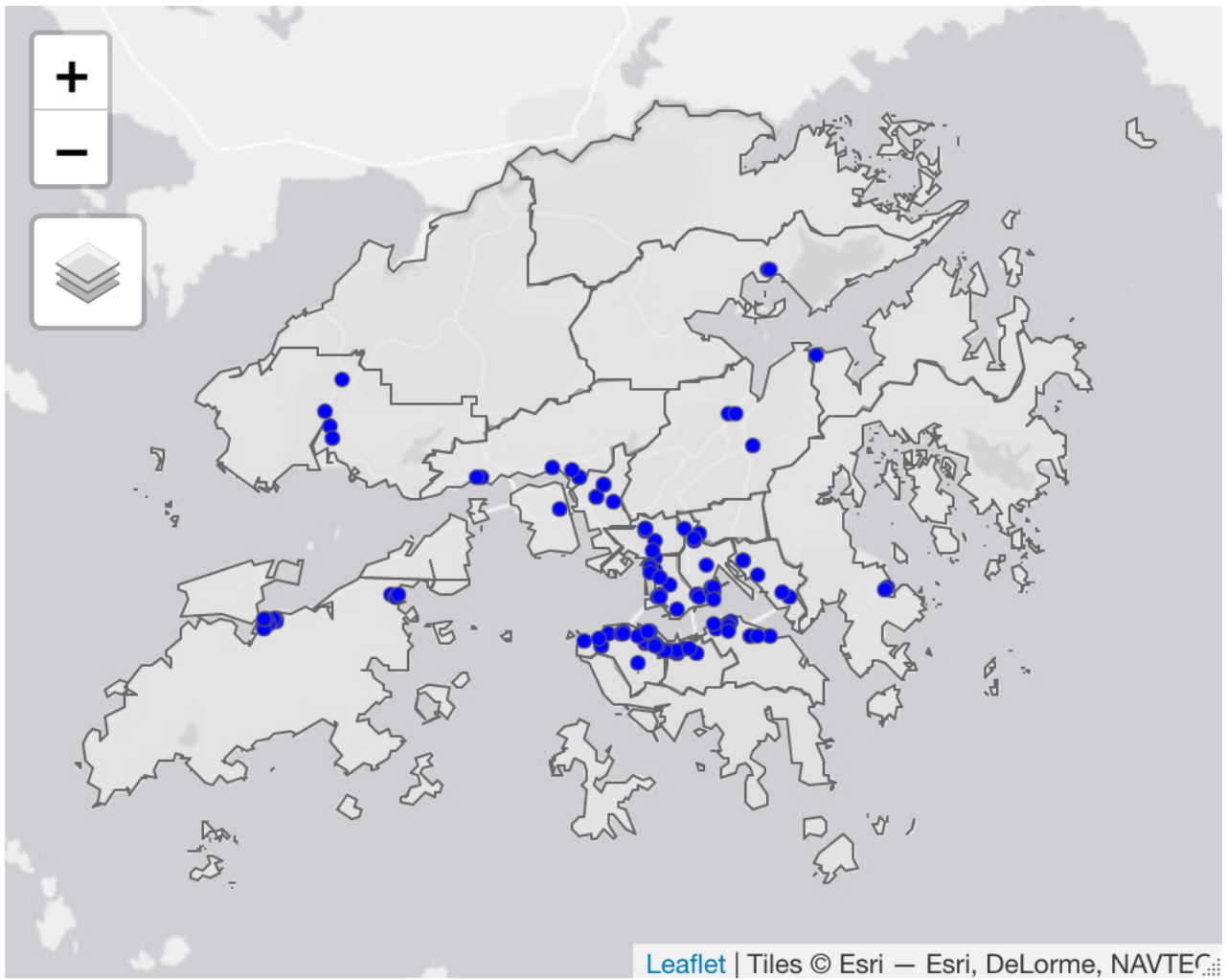


Figure 8: Public Open Spaces in Hong Kong

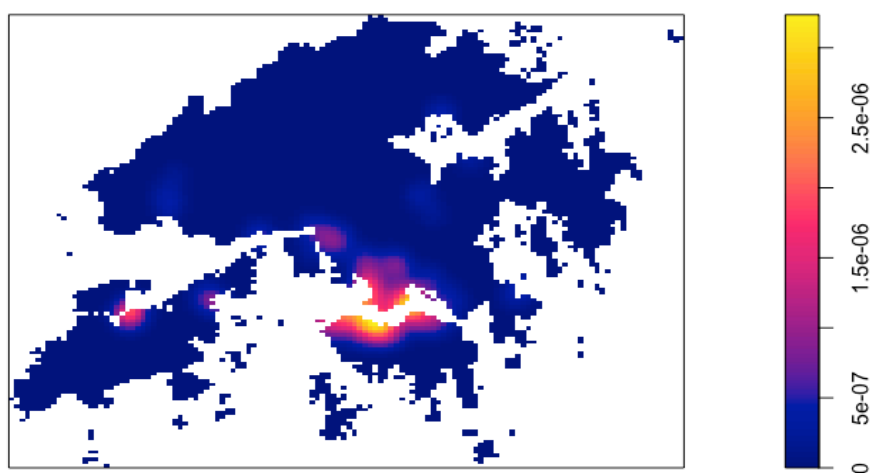


Figure 9: Public Spaces Kernel Density Estimation

Figure 8 provides a clear visualized picture of the public open spaces in Hong Kong, and Figure 9 is the same data presented by a Kernel Density Estimation method. We can observe that the government has established a number of public spaces and focused on the densest areas. From the overlapped results from clustering analysis and the public spaces finding, it can conclude that the significance of public spaces could have a relationship with population density. It can be also supported by the government purpose on providing more public spaces, which is to offer a place where “people chat with their neighbours and where community events are held” (Hong Kong Public Space Initiative, 2020).

Comparison

Given the results found and analysis conducted above, it can see that there is a relationship between the significance of public spaces and population density in Hong Kong. In fact, the improvement in public spaces also enhances the degree of population density in certain areas. For example, in New York, there was a finding supporting that the amount of public spaces is associated with high social satisfaction (Grove *et al.*, 2014). In other words, public spaces are likely to attract more people to have social activities, leading to high population density in near areas. The example of New York shows high similarity with the urban planning purposes in Hong Kong, which is to provide a public space for people gathering. Thus, it is also significant and related towards population density, affective in both western and eastern international cities.

Conclusion

To sum up, from the investigation of population and public spaces in Hong Kong, the spatial analysis above have demonstrated the significance of public spaces in relation to population density. By visualising the public spaces, the distributions are mostly concentrated in the centre of Hong Kong. Although the population is larger in less crowded areas, however in terms of population density, public spaces show a significance and similar pattern with population density. In the future study, since the population density was based on the 2011 and 2016 data, it would be recommended to use the up to date by-census data in investigating later pattern. Furthermore, it is interesting to investigate the potential consequences underneath this topic, which is the impacts that high population density brings to the neighbourhood.

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