**Calculation of the Borough score for environmental factors (BSE)**

In order to calculate the Borough Score for environmental factors, we will use the following variables for each borough:

* Greenspace
* Noise pollution
* Air pollution (NOx CO2, PM2.5, PM10)

After the data processing of each variable, we will obtain scores between 0 and 1 for each variable (in the case of air pollution, the scores will be individual for each greenhouse gas). To achieve this values, we will normalise the data using the following equation:

**X-Xmin/Xmax-Xmin**

Equation 1: Data normalization formula

**Air Pollution**

The data contains the CO2, NOx, PM10 and PM2.5 emissions in tonnes per year per borough, for the year 2016. To obtain the air pollution score we will process the data:

1. First we divide the emissions per borough between the surface of each borough, (as a bigger surface will emit more pollutants), to get the emissions per square km.
2. We normalize the emissions per km2 (using equation 1) so the data is between 0 and 1.

After ordering the boroughs from highest to lowest score, we can observe that City of London is the borough with the most emissions overall, followed by Hillingdon. Regarding individual values for each pollutant, for CO2 and NOx, Hillingdon is the most polluting borough, while for PM2.5 and PM10 it is City of London. The borough with the least emissions is Haringey, which scored 0 for all four pollutants through normalization.

Chart, bar chart

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Figure 1: Air pollution score per London borough in 2016.

**Greenspace**

The data used to obtain the greenspace score consists of the km2 of public greenspace each borough has. To obtain the greenspace score we will process the data:

1. First we will divide the area of greenspace each borough has between the total area of the borough, to get the area of greenspace per km2.
2. We normalize the area of greenspace per km2 (using equation 1) so the data is between 0 and 1.
3. In this particular case, we will invert the data, as in our study the higher the score the least environmentally friendly a borough is. However, through the previous calculations, boroughs with a high score have a bigger area of greenspace per km2, therefore being more environmentally friendly. To invert the data, we will apply (1-x) to all the scores obtained.

After ordering the boroughs from highest to lowest score, we can observe that City of London is the borough with the least area of greenspace per km2, followed by Islington. The borough with the most area of greenspace per km2 is Havering.

Chart

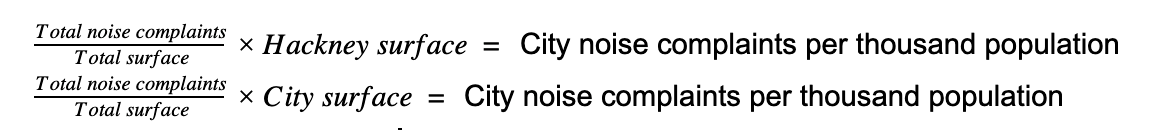
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Figure 2: Greenspace score per London borough.

**Noise pollution**

The data contains the number of complaints about noise per thousand population per borough, for the year 2019. To obtain the noise pollution score we will process the data:

1. First we will have to generate the data for the boroughs Hackney and City, as in the chosen dataset the data on noise complaints for these two boroughs was merged. To generate them we will use the surface of each borough and the total noise complaints:



The limitations of this data will be further discussed in the limitations section.

1. After, we normalize the number of noise complaints per thousand population for each borough (using equation 1) so the data is between 0 and 1.

After ordering the boroughs from highest to lowest score, we can observe that Westminster is the borough with the most noise complaints per thousand population, followed by Kensington and Chelsea. The borough with the least noise pollution score is City of London.

A picture containing timeline

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Figure 3: Noise pollution score per London borough in 2019.

**TOTAL BSE**

In conclusion, for the Borough Score on environmental factors, we can conclude that City of London is the least environmentally friendly borough, with the biggest scores on emissions and lack of greenspace, followed by Hillingdon. When we represent this data in a box plot, only these two boroughs stand out from the data as outliers over the higher tukey fence.

Chart

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|  |  |  |
| --- | --- | --- |
| **Table 2: Boxplot values** | | BSe |
| Boxplot  Statistics | Minimum | 0.15 |
| Maximum | 2.88 |
| Lower quartile | 0.96 |
| Upper quartile | 1.82 |
| Interquartile range | 1.26 |
| Lo. outlier limit | 0.15 |
| Hi. outlier limit | 2.88 |
| Tukey fences | Lo. Tukey fence (LQ - 1.5 \* IQR) | - 0.93 |
| Hi. Tukey fence (UQ + 1.5 \* IQR) | 3.71 |
| Outliers | City and Hillingdon | |

Figure 4: Borough Scores for environmental factors for all London boroughs.

Figure 5: Boxplot with borough Scores for environmental factors for all London boroughs.

**Calculation of the Borough score for health factors (BSH)**

In order to calculate the Borough Score for environmental factors, we will use the following variables for each borough:

* Self reported well-being (anxiety)
* Self reported well-being (low happiness)
* Life expectancy
* Healthy life expectancy

After the data processing of each variable, we will obtain scores between 0 and 1 for each variable. To achieve these values, we will again normalise the data using equation 1.

**Life expectancy**

The data contains the life expectancy for males and females separately per borough, for the year 2017. This dataset was missing a value for the borough City of London, so we added the value from the City of London health profile (2017). To obtain the life expectancy score we will:

1. Normalize the data separately for males and females using equation 1.
2. Invert the data, as in our study the higher the score the least healthy a borough is. However, without the inversion, the high values correspond to the boroughs with a higher life expectancy. To correct this, we will perform (1-x) to each value, so that boroughs with a higher life expectancy have a lower score.

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Figure 6: Male Life expectancy score per London borough.

Figure 7: Female Life expectancy  score per London borough.

After the normalization, we can observe that the borough with the highest life expectancy score is Barking and Dagenham, for both males and females. However, the second highest score belongs to different boroughs depending on the gender; Islington for females and Lewisham for males. For both genders, the two boroughs with the lowest score, and highest life expectancy, are Westminster and City of London

**Healthy life expectancy (HLE)**

The data contains the healthy life expectancy (HLE) for males and females separately per borough, for the year 2017. This dataset was missing a value for the borough City of London, so we calculated it in the following way:

In order to estimate the City of London’s HLE we will use two values, the life expectancy and the percentage of residents with very good health (taken from the 2011 Census: Health and disability in London) for the City of London borough. As we observed in our previous analysis on life expectancy, City of London was the borough with the highest life expectancy. Regarding the percentage of healthy residents, City of London is the borough with the highest percentage, with 88% of residents. Considering that City of London is the borough with both the healthiest residents and the residents with the biggest life expectancy, we can estimate that it will be the borough with the highest HLE as well.

Thanks to the normalization, we do not have to award this borough a particular age for the HLE value, but it will be sufficient to award it with the 0 value after the process of normalization. However, because of this, it will not be part of the normalization process, so another borough will be the Xmin and therefore have a score of 0 as well.

After we have all the values, we will:

1. Normalize the data separately for males and females using equation 1.
2. Invert the data, as in our study the higher the score the least healthy a borough is; (as explained in the Life expectancy section).

Chart

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The boroughs with the lowest healthy life expectancy and therefore highest scores in this category are Newham for females and Barking and Dagenham for males, followed by Hackney for both genders. For each gender, there are two boroughs with the lowest score: City (as we previously explained) and Brent for females and Richmond for males.

**Self reported well-being (anxiety and low happiness)**

The data contains the overall self reported well-being in relation to high anxiety and low happiness for each London borough for the year 2015. To obtain the self reported well-being scores we will simply:

1. Normalize the data separately for males and females using equation 1.

Chart, bar chart

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The boroughs with the lowest healthy life expectancy and therefore highest scores in this category are Newham for females and Barking and Dagenham for males, followed by Hackney for both genders. For each gender, there are two boroughs with the lowest score: City (as we previously explained) and Brent for females and Richmond for males.

**TOTAL BSH**

After obtaining the scores for each variable, to calculate the Borough Score for health factors we simply add up all the individual scores for each borough:

Chart

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|  |  |  |
| --- | --- | --- |
| **Table 2: Boxplot values** | | BSe |
| Boxplot  Statistics | Minimum | 0.89 |
| Maximum | 5.83 |
| Lower quartile | 2.56 |
| Upper quartile | 3.85 |
| Interquartile range | 3.27 |
| Lo. outlier limit | 0.89 |
| Hi. outlier limit | 4.78 |
| Tukey fences | Lo. Tukey fence (LQ - 1.5 \* IQR) | - 2.34 |
| Hi. Tukey fence (UQ + 1.5 \* IQR) | 8.75 |
| Outlier | Barking and Dagenham | |

The borough with the highest Borough score for health factors, and therefore the borough with the least overall health is Barking and Dagenham, followed by Hackney and Lewisham. On the other hand, the borough with the lowest score and highest health is City of London, followed by Richmond and Thames.