Does the degree of environmental impact differ with distance from the CBD, and type of CBD, in Singapore?

Word Count: 2475

Contents

Table of Figures

Acronyms (21 words):

Environmental Impact Assessment **EIA**

Environmental Impact **EI**

Central Business District **CBD**

Orchard Road **OR**

Jurong East **JE**

Coronavirus Disease 2019 **COVID-19**

Introduction (211 words):

From the syllabus, this investigation links to Option G, subtopic 4. Building sustainable urban systems for the future. Singapore aims to become a more resilient city to tackle urban problems like climate change by becoming a biophilic[1] city. To target urban regeneration, environmental impact (EI) is investigated.

Research Question: Does the degree of environmental impact differ with distance from the CBD[2], and type of CBD, in Singapore?

Hypotheses:

H_1: The EI is lower at JE than OR

H_2: The EI decreases with distance from the CBD

Justification of Hypotheses and Theory:

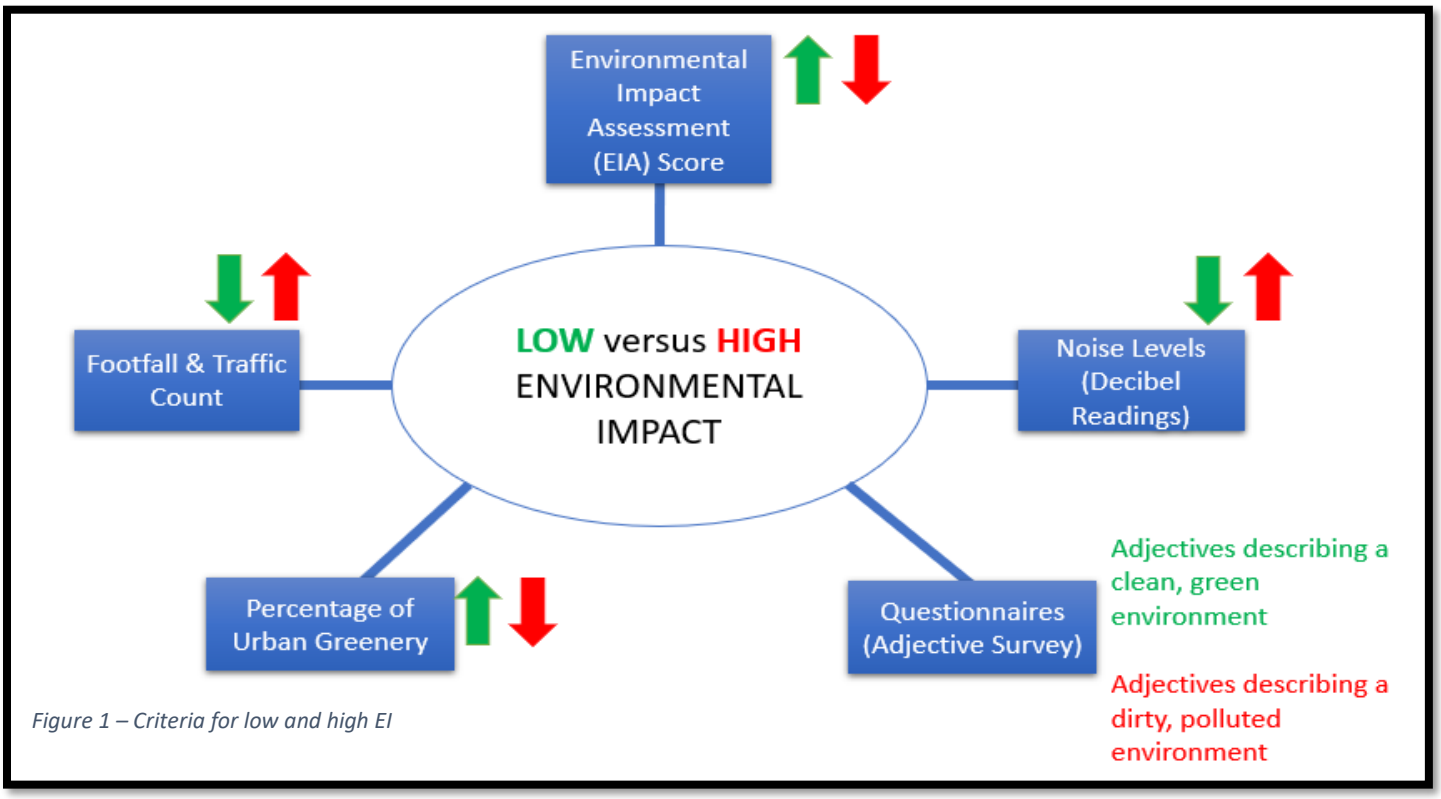


Figure 1 – Criteria for low and high EI

[1] To love living things (Lim)

[2] Central Business District

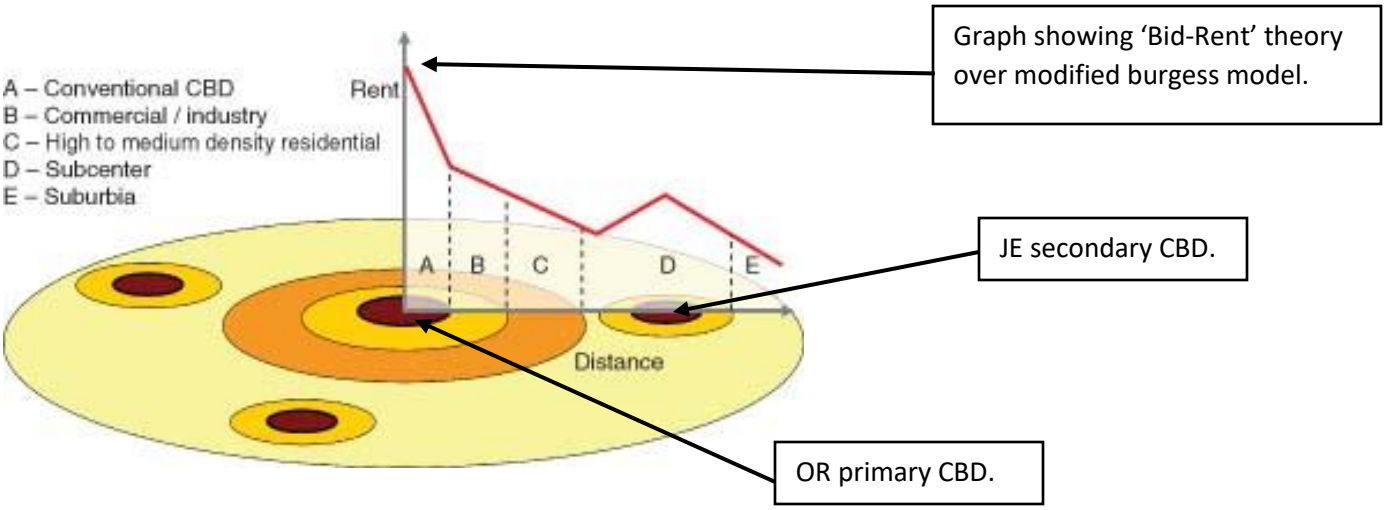


Figure 2 – Bid-Rent on modified Burgess model (Pun-Cheng)

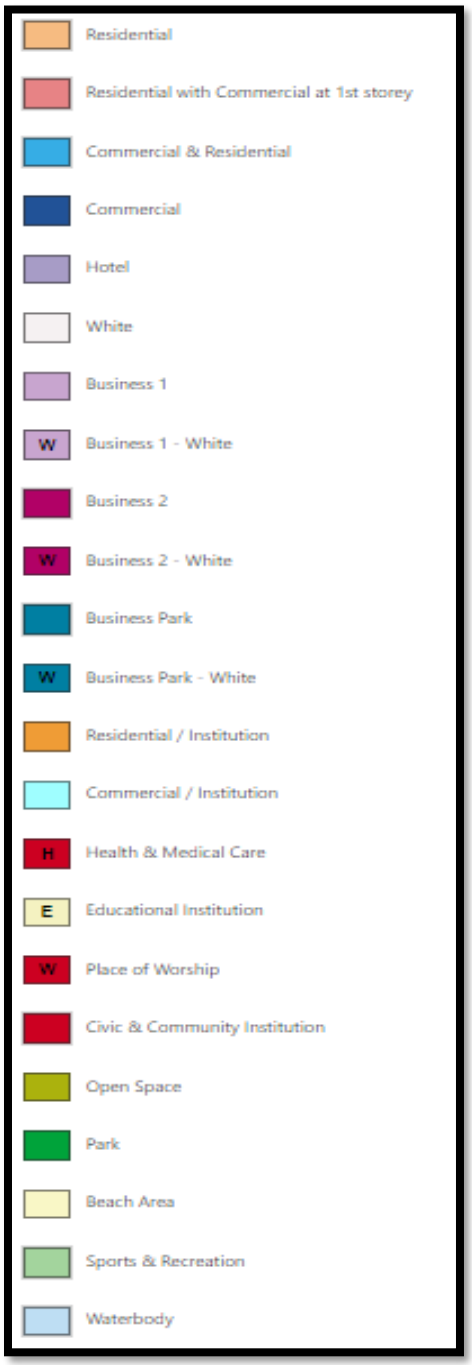


Figure 3 – Key for figs. 4 to 7

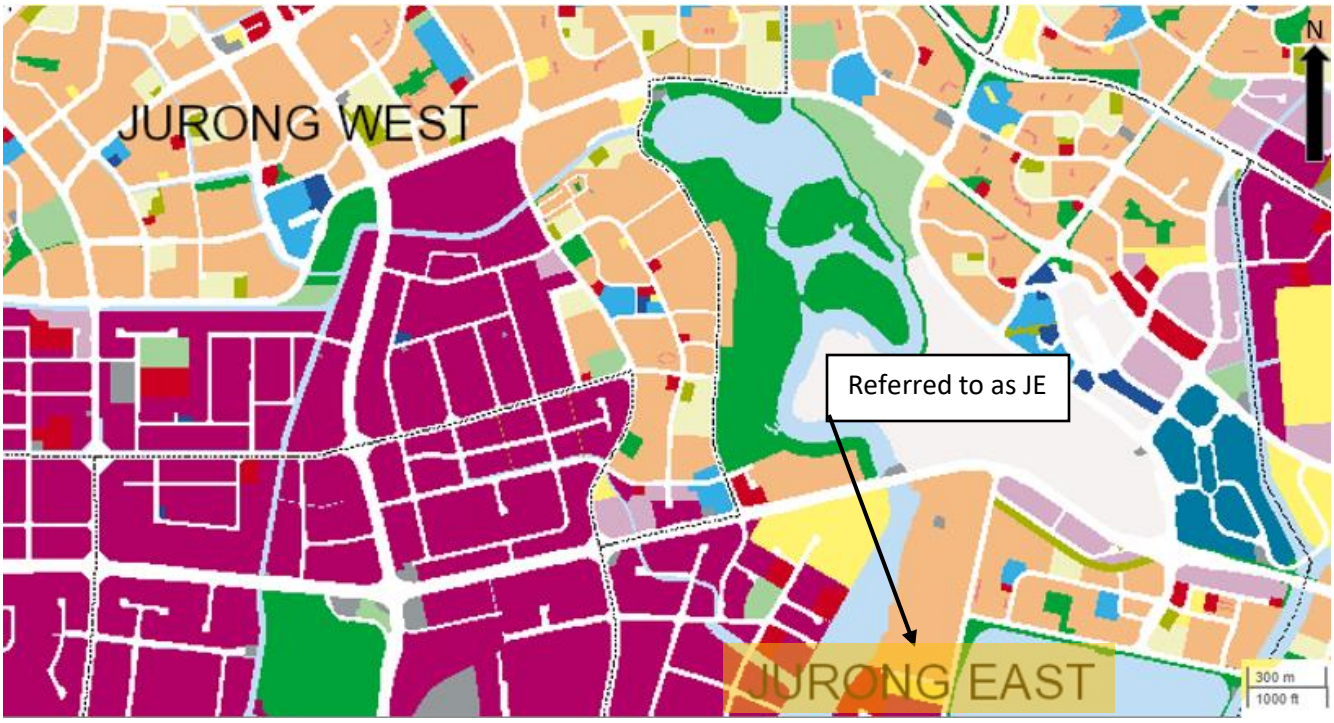


Figure 4 – URA map of JE and surroundings (URA)

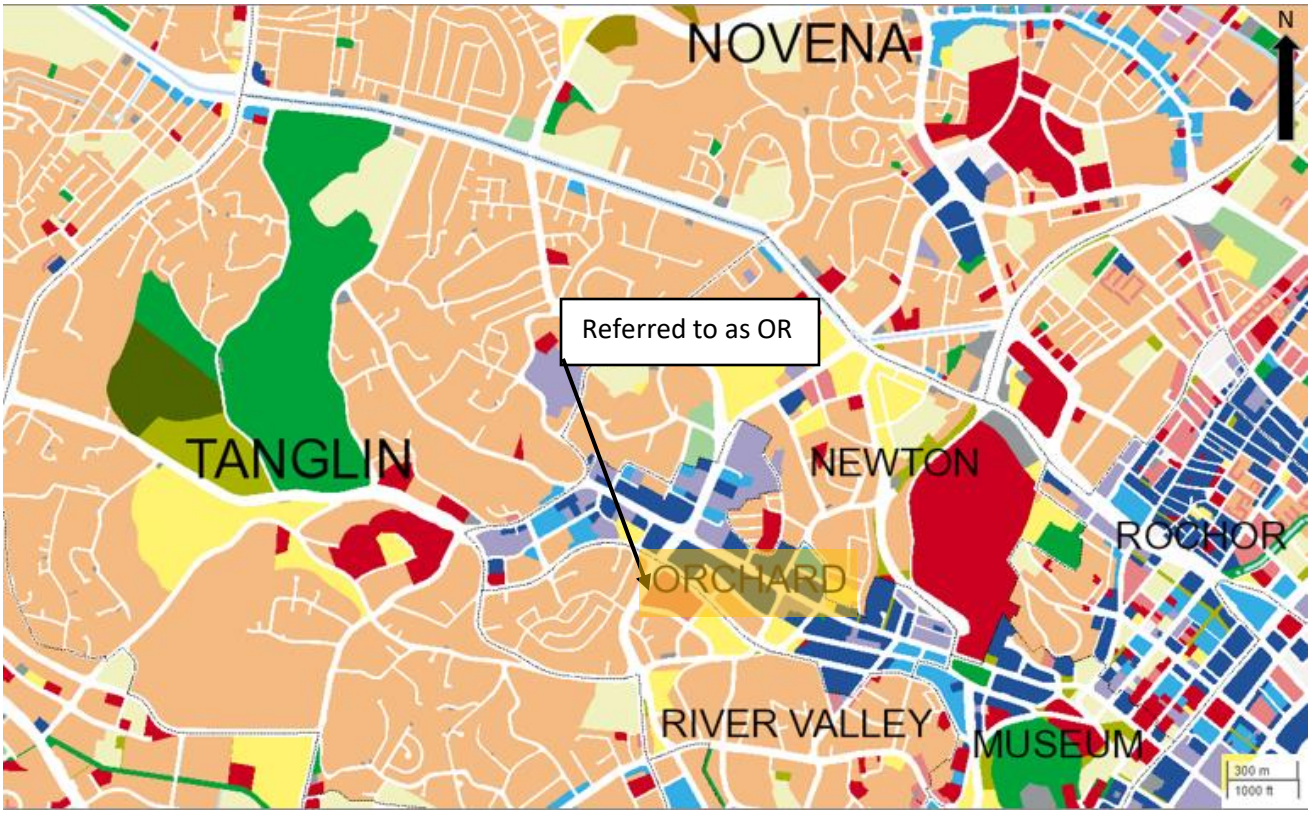


Figure 5 - URA map of OR and surrounding area (URA)

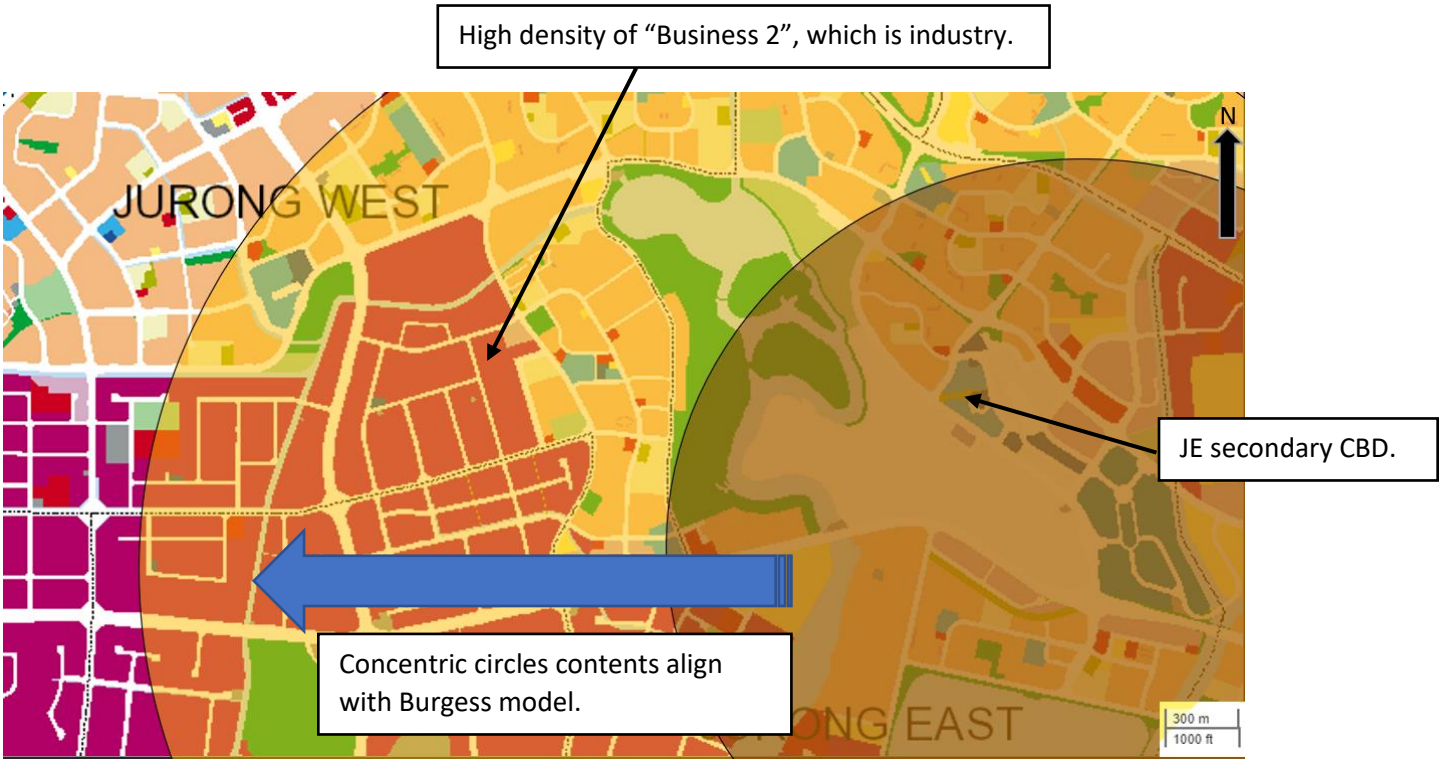


Figure 6 - conventions of fig.2 applied to JE (URA)

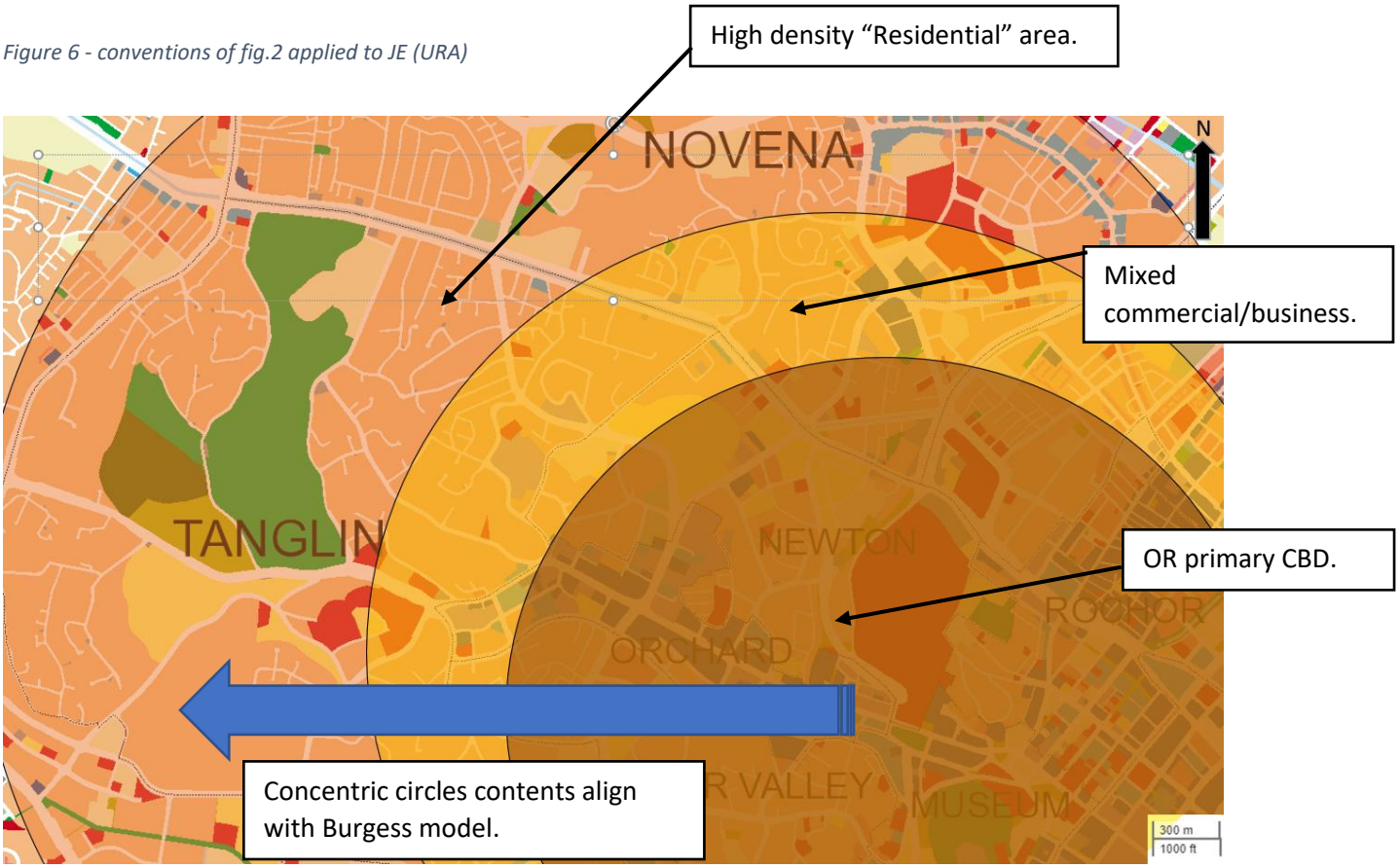
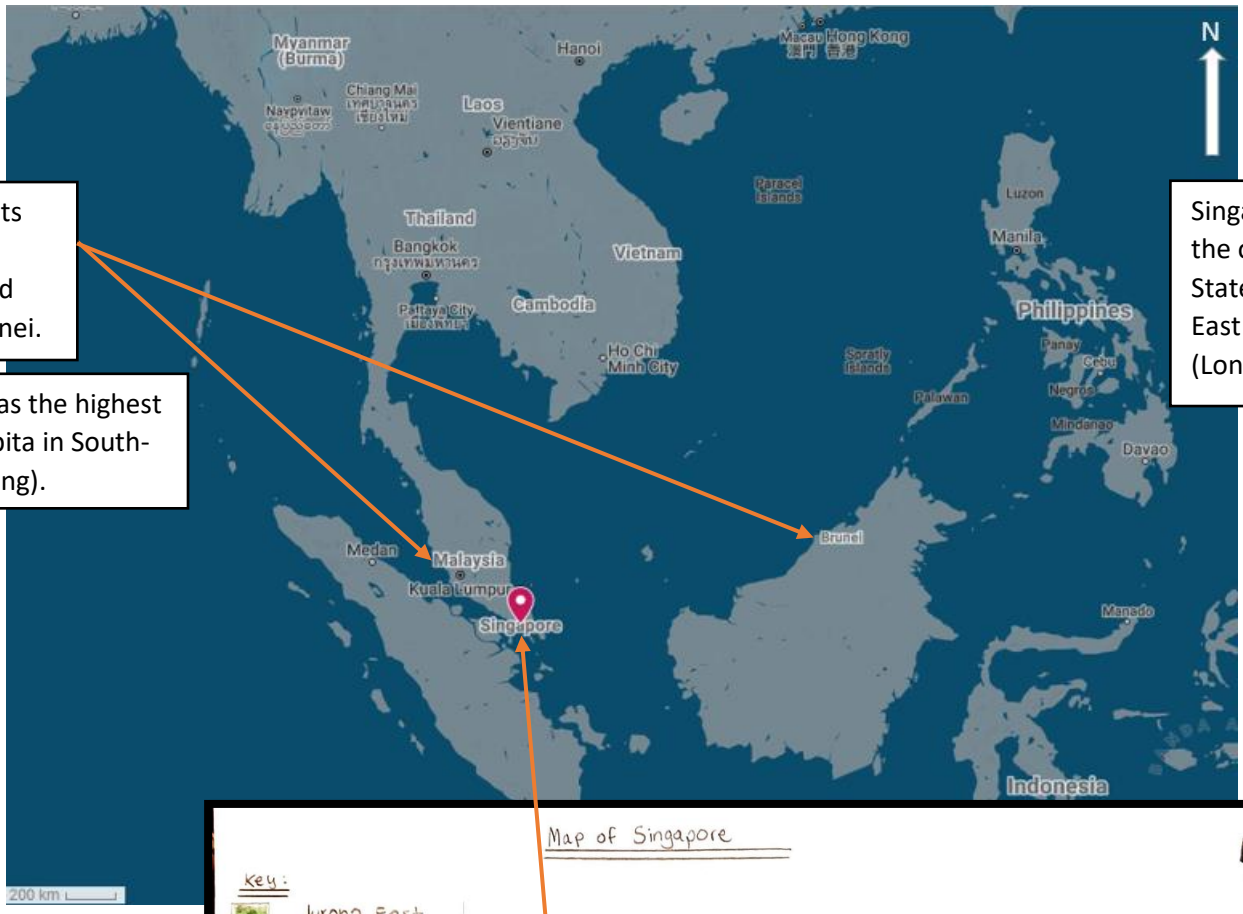


Figure 7 - conventions of fig.2 applied to OR (URA)

A higher bid-rent theory in the CBDs suggests that only high-order goods businesses can afford to be situated there, shown by point ‘A’ in respect to ‘B’ and ‘C’, and point ‘D’ in respect to ‘E’ (fig.2). What this means is that CBD land will be more frequently used by people in immediate and far areas. Therefore, towards the CBD, the EI will be greater, and thus away from the CBD the EI will decrease. With ‘A’ representing OR, and ‘D’ representing JE, it can be seen with that JE has a lower rent value (fig.2). This suggests that low-order goods and services can be found, consequently less use of the area and lower EI in JE than OR.

Spatial Context:



Singapore sits South of Malaysia and West of Brunei.

Singapore has the highest GDP per Capita in South-East Asia (Ding).

Singapore is the only City-State in South-East Asia (Longley).

Figure 8 - Map of South-East Asia, pinning Singapore (Google)

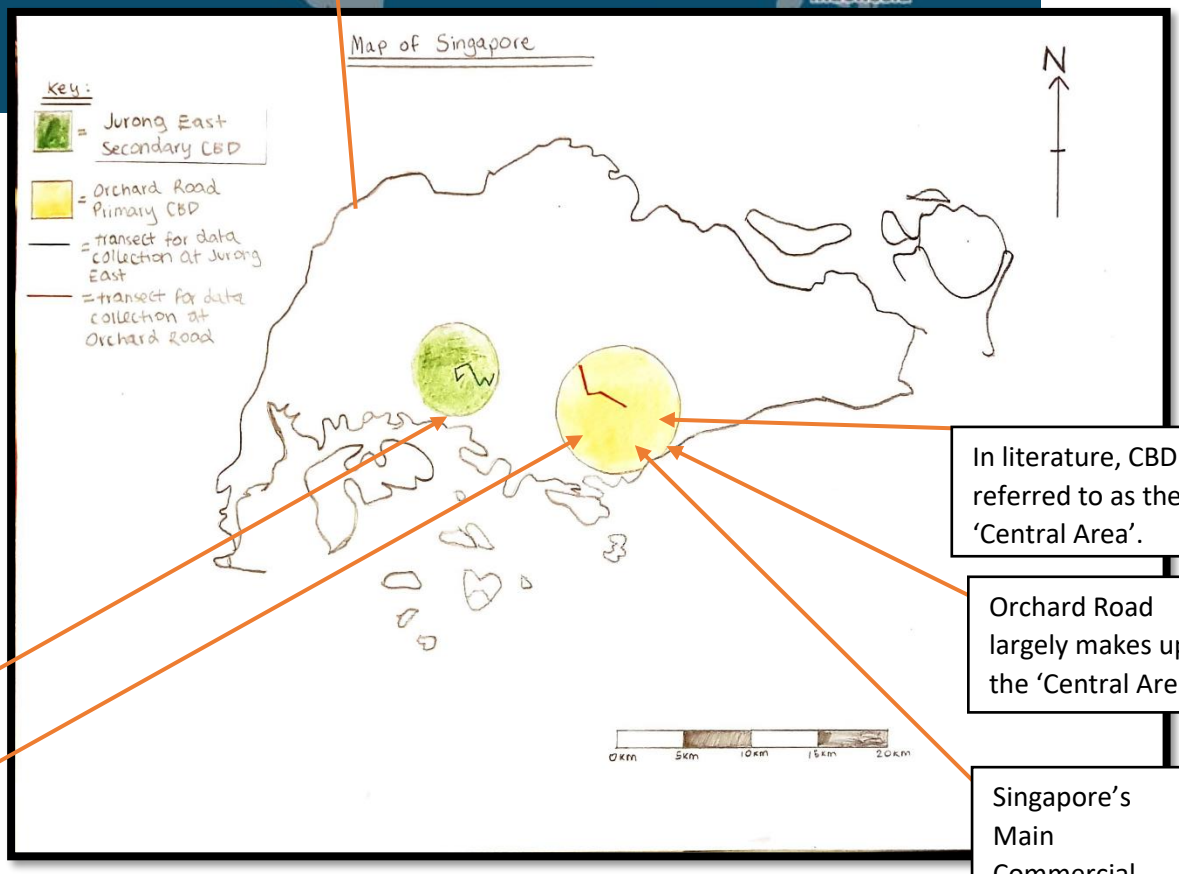


Figure 3

Figure 4

In literature, CBD is referred to as the 'Central Area'.

Orchard Road largely makes up the 'Central Area'.

Singapore's Main Commercial Hub.

Figure 9 – Hand drawn map of Singapore by candidate

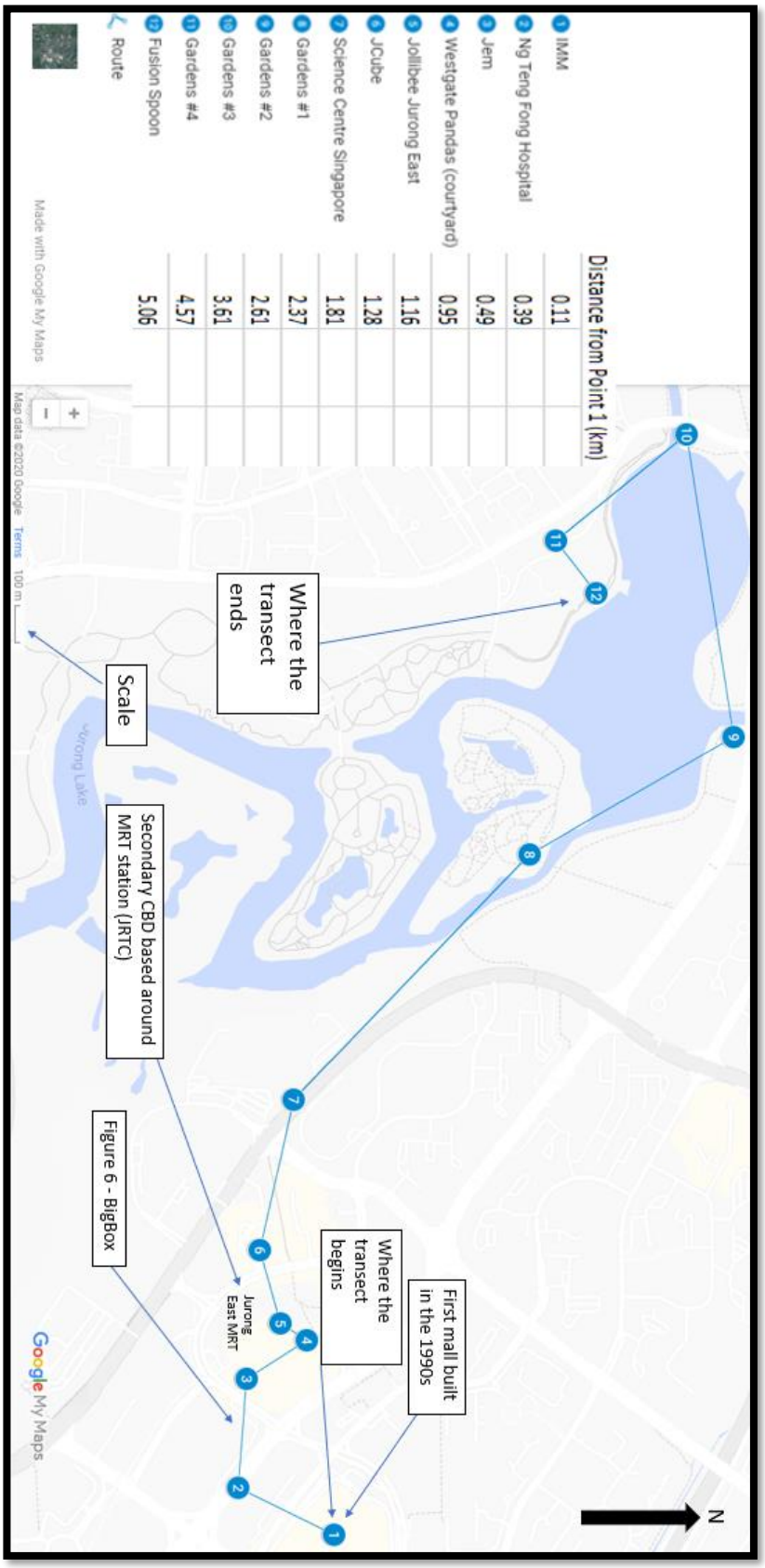


Figure 10 - Data Transect for JE (Google)

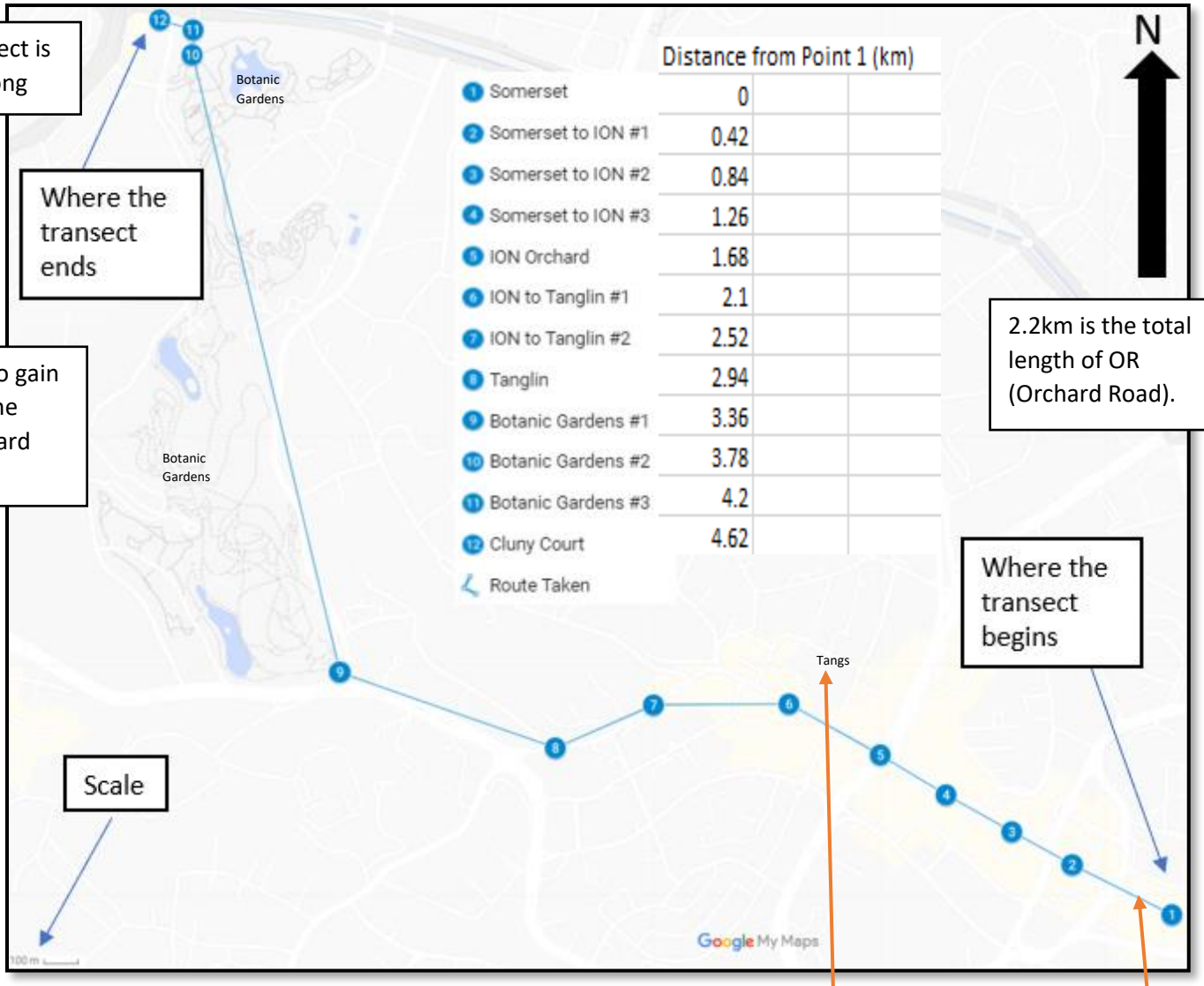


Figure 11 - Data Transect for OR (Google)

Figure 5

Figure 12 - Photograph of Somerset at OR (Roberts)

Figure 13 - Photograph at BigBox, JE (Palaniappan)

Methods of Investigation (220 words):

21st and 22nd August (both on the weekend) were chosen so EI didn't differ significantly by day.

Data Collection Methods:

1. Urban Questionnaires at 4 popular places for **JE** (Westgate, JEM, JCube and Jurong Lake Gardens) and **OR** (Somerset, ION orchard, Tanglin, Cluny Court): asking for 3 adjectives (H_1)

2. Environmental Impact Assessment (EIA)* (H_1 and H_2)

3. Decibel Readings* (H_1 and H_2)

4. Footfall and Traffic Surveys* (H_1 and H_2)

5. Urban Greenery Quadrats* (H_1 and H_2)

** Note: to be taken across transects in OR (Somerset to Cluny Court) (fig.11) and JE (Westgate to Jurong Lake Gardens) (fig.10), where transects were decided based on accessible travel and intended direction*

Data Collection Procedure:

Systematic sampling is used for all methods. This is advantageous as it is easy to carry out and ensured reduced sampling bias. For the questionnaire, it meant approaching every third person. 0.4km and 0.35km intervals were attempted to some extent but due to variation in place of data collection, this did not happen entirely. Recent understanding of the CBD is needed to make interval decisions, a disadvantage of this sampling.

Safety considerations

- maintaining social distancing to reduce transmission of COVID-19[3].
- not using large quadrats or indicating poles for method 4 to avoid injury to pedestrians.

Ethical considerations

- informing questionnaire participants on use of their responses.

[3] Coronavirus Disease 2019

Method 1

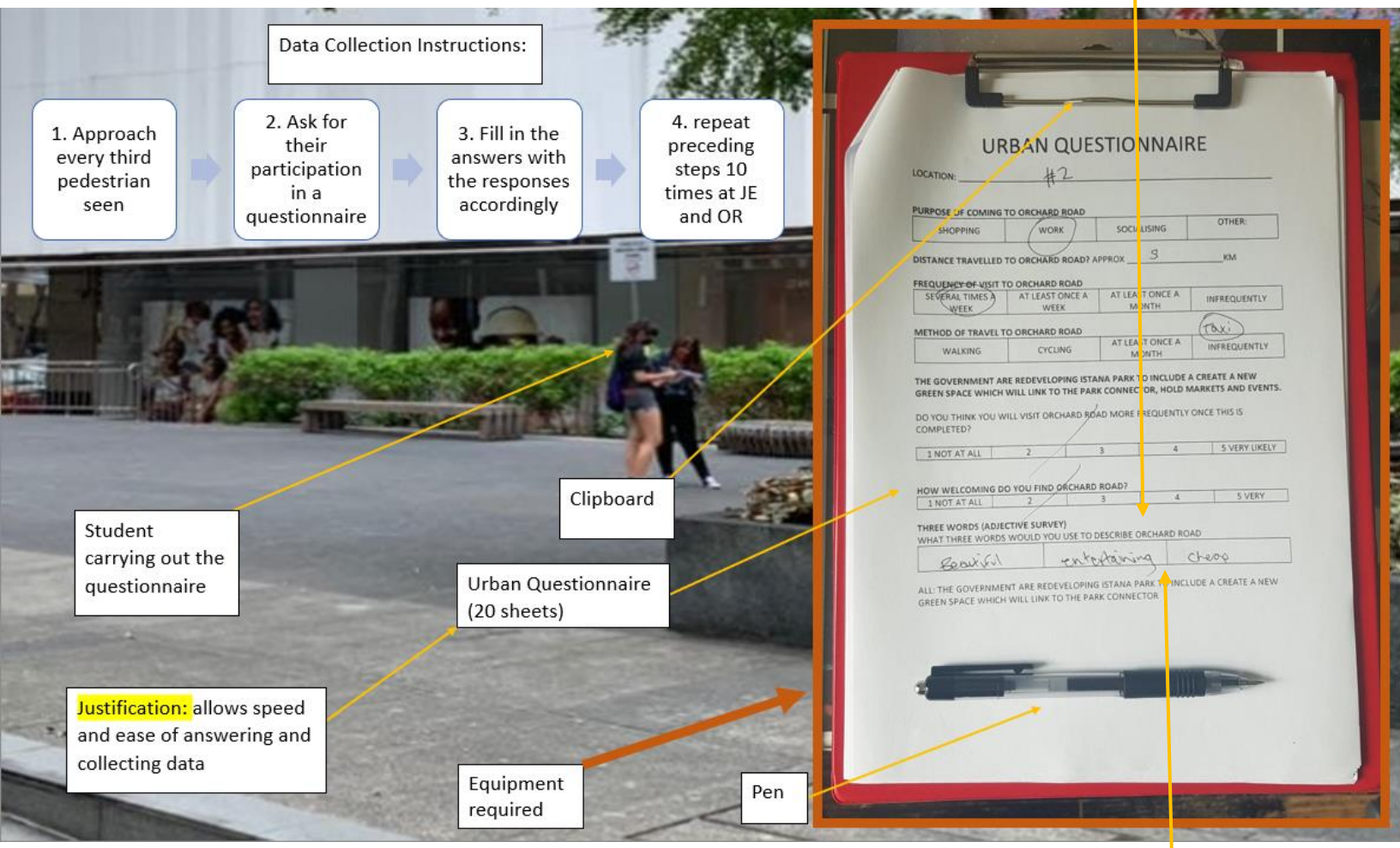


Figure 14 - Collage showing questionnaire data collection and equipment required (Palaniappan) (Roberts)

Method 2

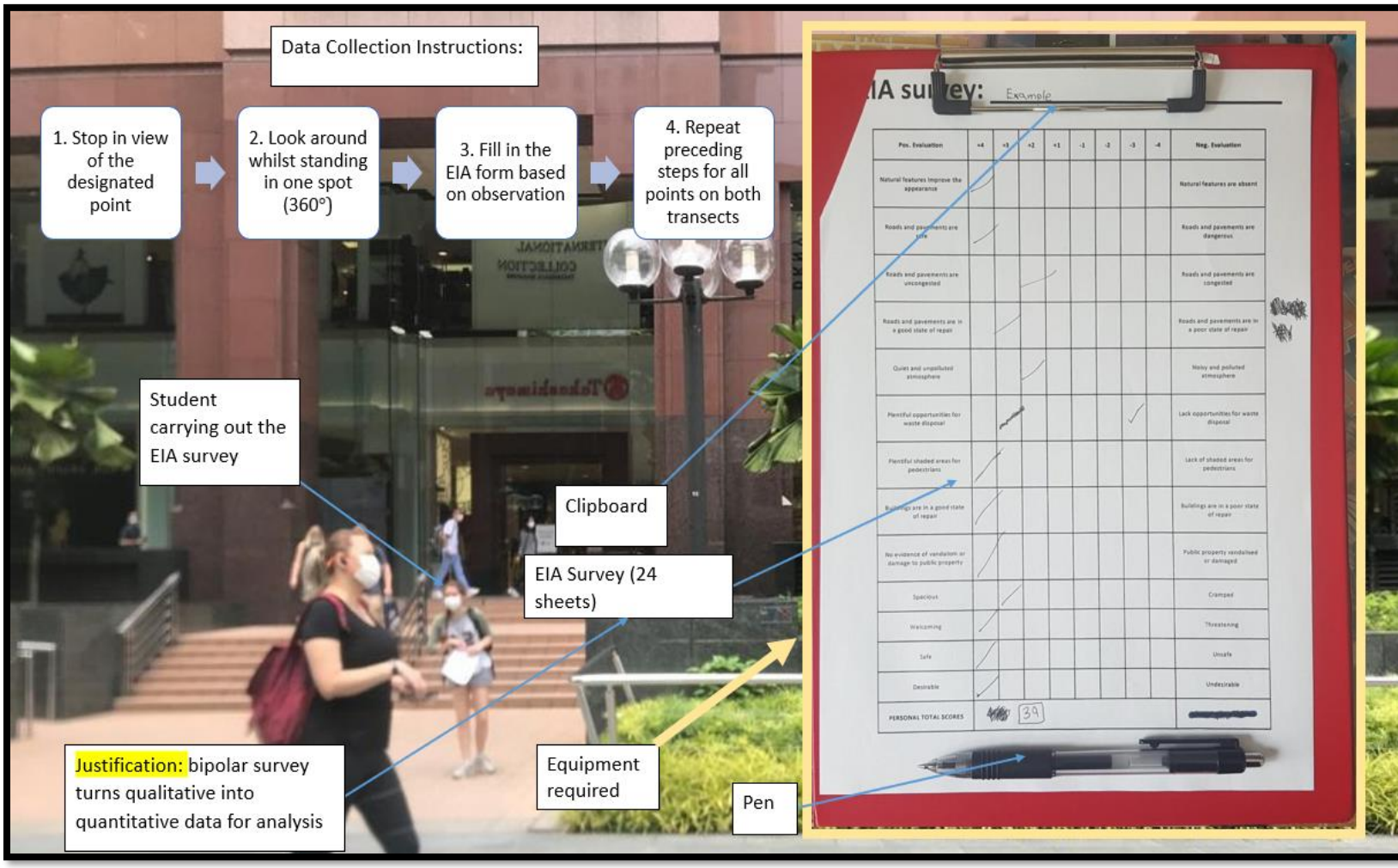
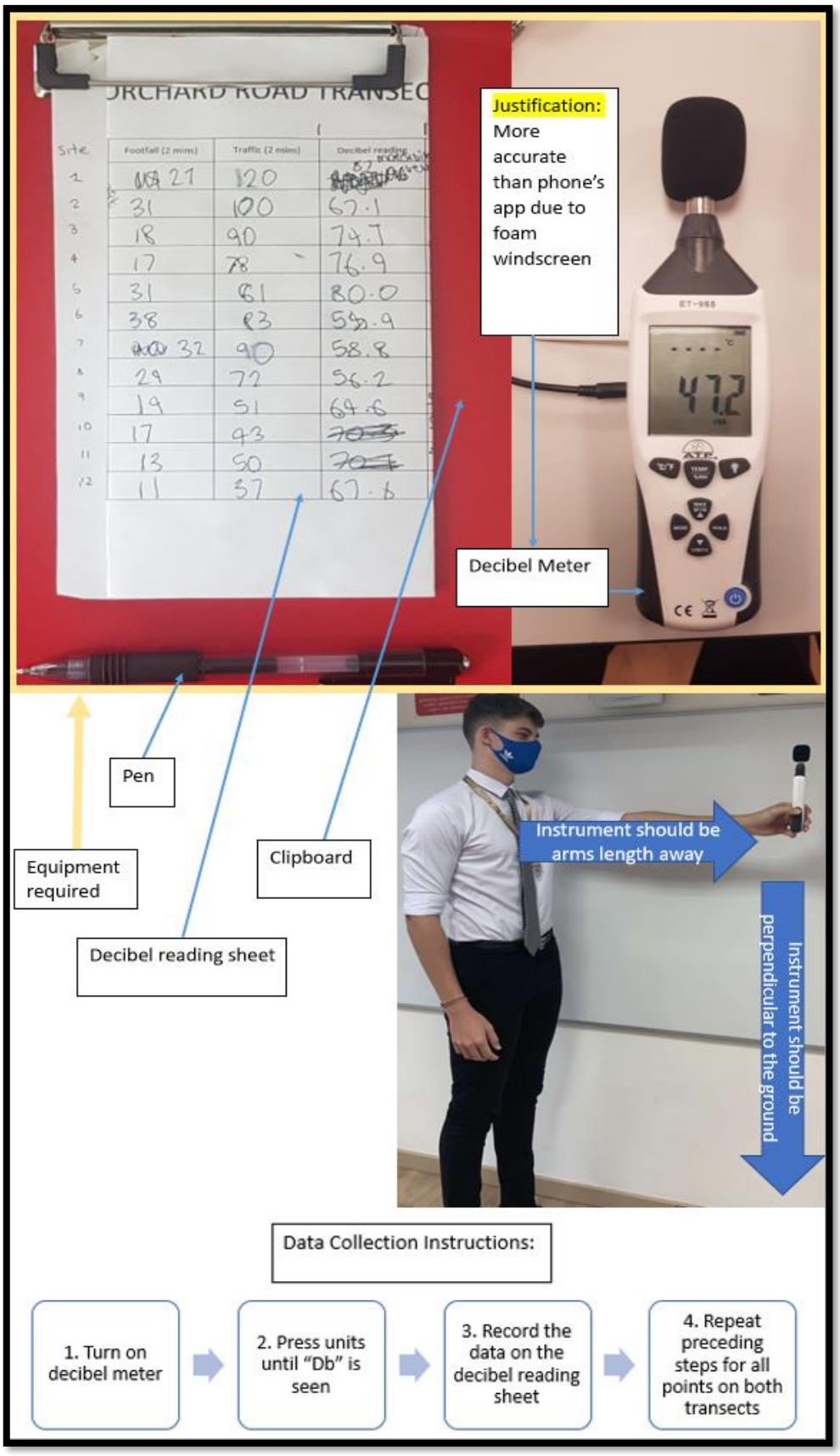
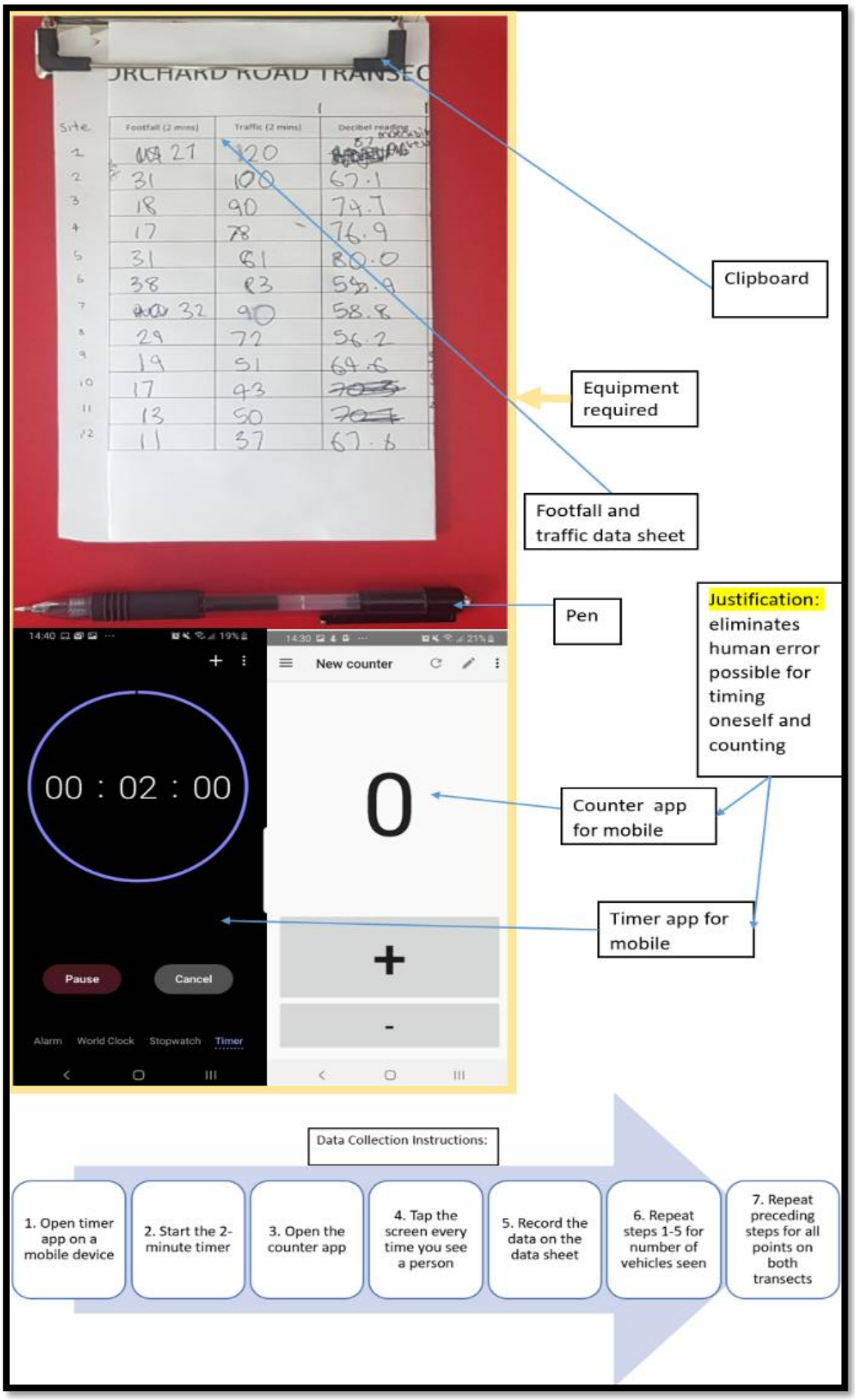


Figure 15 - Collage showing EIA data collection and equipment required (Roberts) (Palaniappan)

Method 3

Figure 16 - Collage showing decibel reading data collection and equipment required (Roberts) (Palaniappan)





Method 4

Figure 17 - Collage showing footfall and traffic count data collection and equipment required (Palaniappan)

Method 5

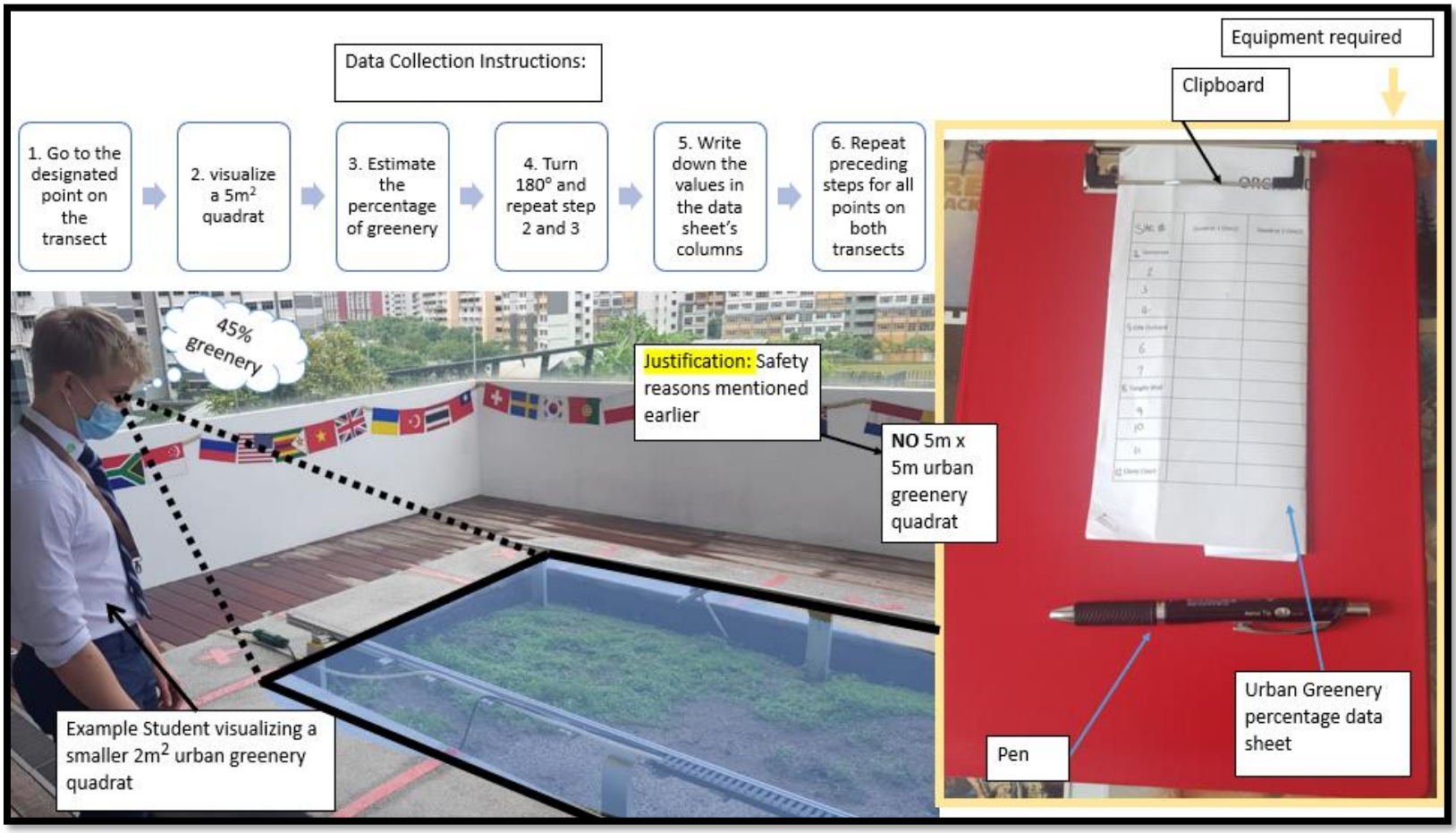


Figure 18 – Collage showing urban greenery percentage estimation method and equipment required (Palaniappan)

Quality and Presentation of Data (1405 words):

Data for Methods 1 to 5 are found in the appendix in the respective value i.e. method 1's data is in A1

Example Mann Whitney Calculation

Mann-Whitney U test finds if two sets of data have significance or not. The example takes the EIA values of JE and OR. (fig. 19) No statistical significance is present between the two sets of data; difference may have occurred by chance.

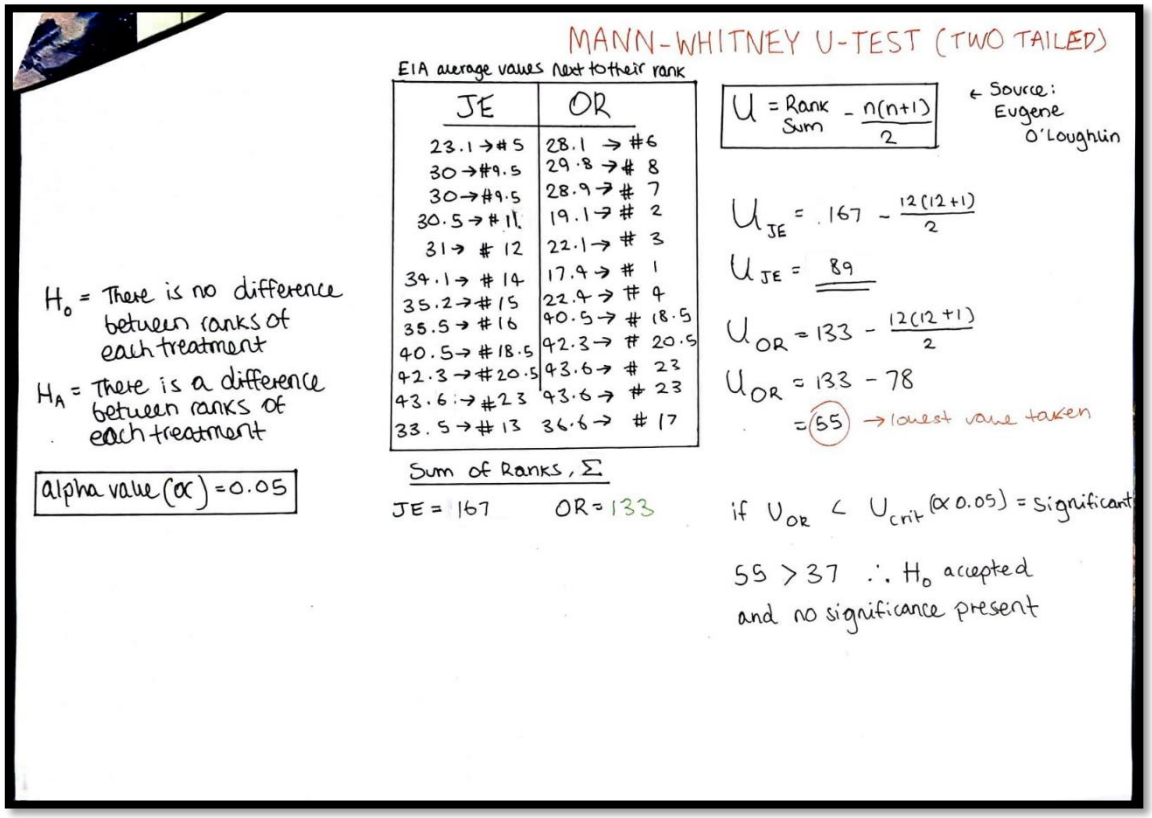


Figure 19 - Handwritten Mann-Whitney calculation

Figure 20 - Critical Values Table (Zaiontz)

Alpha = .05 (two-tailed)

n1\n2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2							0	0	0	0	1	1	1	1	1	2	2	2	2
3				0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
4			0	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	14
5		0	1	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20
6		1	2	3	5	6	8	10	11	13	14	16	17	19	21	22	24	25	27
7		1	3	5	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
8	0	2	4	6	8	10	13	15	17	19	22	24	26	29	31	34	36	38	41
9	0	2	4	7	10	12	15	17	20	23	25	28	31	34	37	39	42	45	48
10	0	3	5	8	11	14	17	20	23	26	29	33	36	39	42	45	48	52	55
11	0	3	6	9	13	16	19	23	26	30	33	37	40	44	47	51	55	58	62
12	1	4	7	11	14	18	22	26	29	33	37	41	45	49	53	57	61	65	69
13	1	4	8	12	16	20	24	28	33	37	41	45	50	54	59	63	67	72	76
14	1	5	9	13	17	22	26	31	36	40	45	50	55	59	64	69	74	78	83
15	1	5	10	14	19	24	29	34	39	44	49	54	59	64	70	75	80	85	90
16	1	6	11	15	21	26	31	37	42	47	53	59	64	70	75	81	86	92	98
17	2	6	11	17	22	28	34	39	45	51	57	63	69	75	81	87	93	99	105
18	2	7	12	18	24	30	36	42	48	55	61	67	74	80	86	93	99	106	112
19	2	7	13	19	25	32	38	45	52	58	65	72	78	85	92	99	106	113	119
20	2	8	14	20	27	34	41	48	55	62	69	76	83	90	98	105	112	119	127

'.05' is the probability of rejecting null hypothesis when true

'.05' is the standard significance level used in this test.

Both sets of data have 12 values, hence 12 chosen.

Example Spearman's Rank Calculation

Spearman's Rank measures the strength of correlation between two variables. Here data is taken for distance and EIA score from OR.

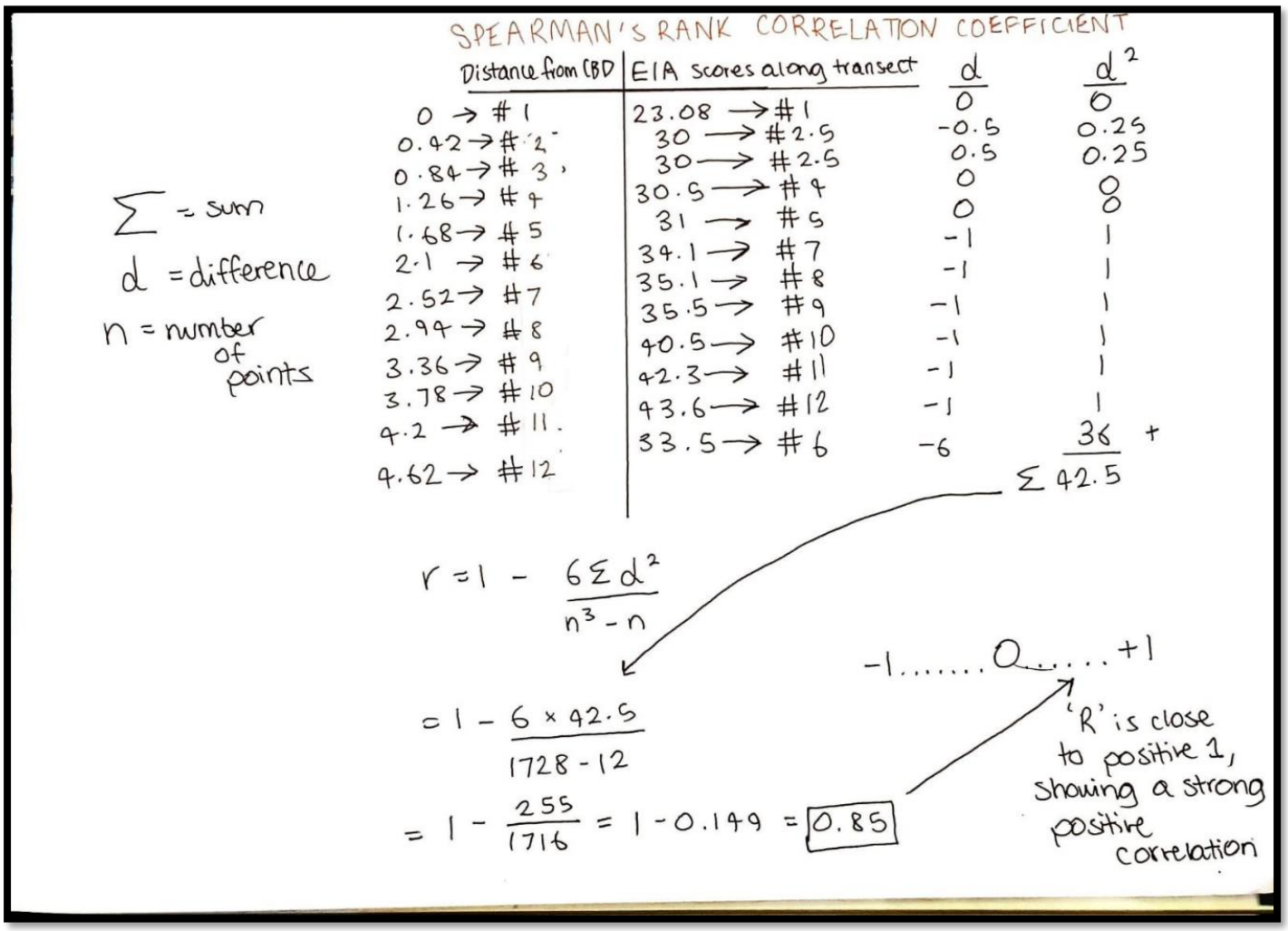


Figure 21 - Handwritten Spearman's Rank calculation

Questionnaires (Adjective Survey)

Figure 22 - Wordle of frequent adjectives at OR

Figure 23 - Wordle of frequent adjectives at JE

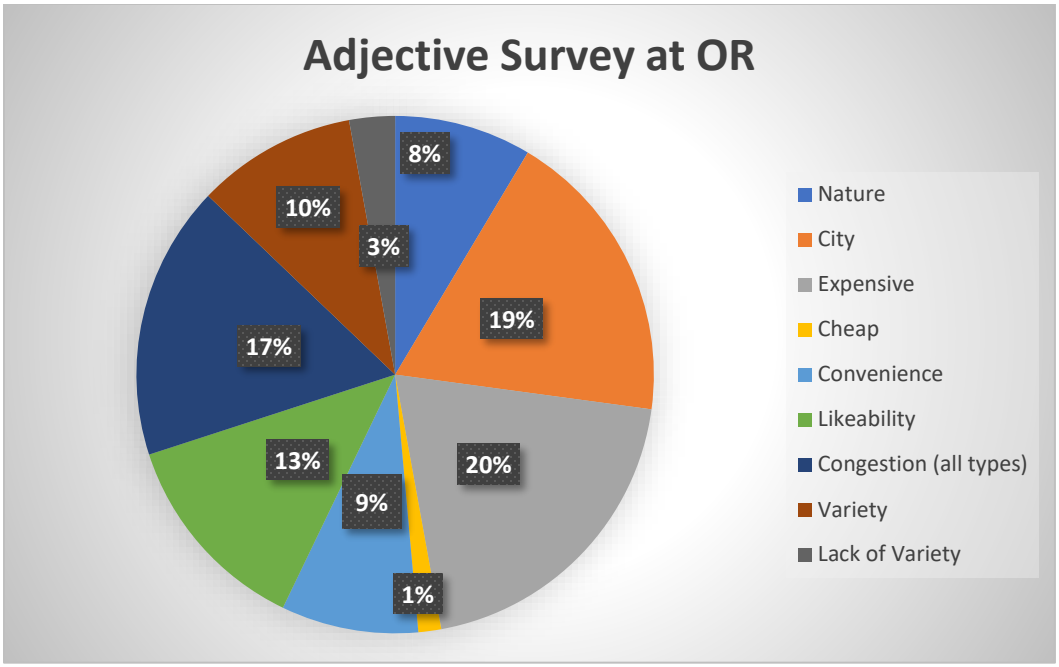


Figure 24 - Pie chart of adjectives frequency by category at OR

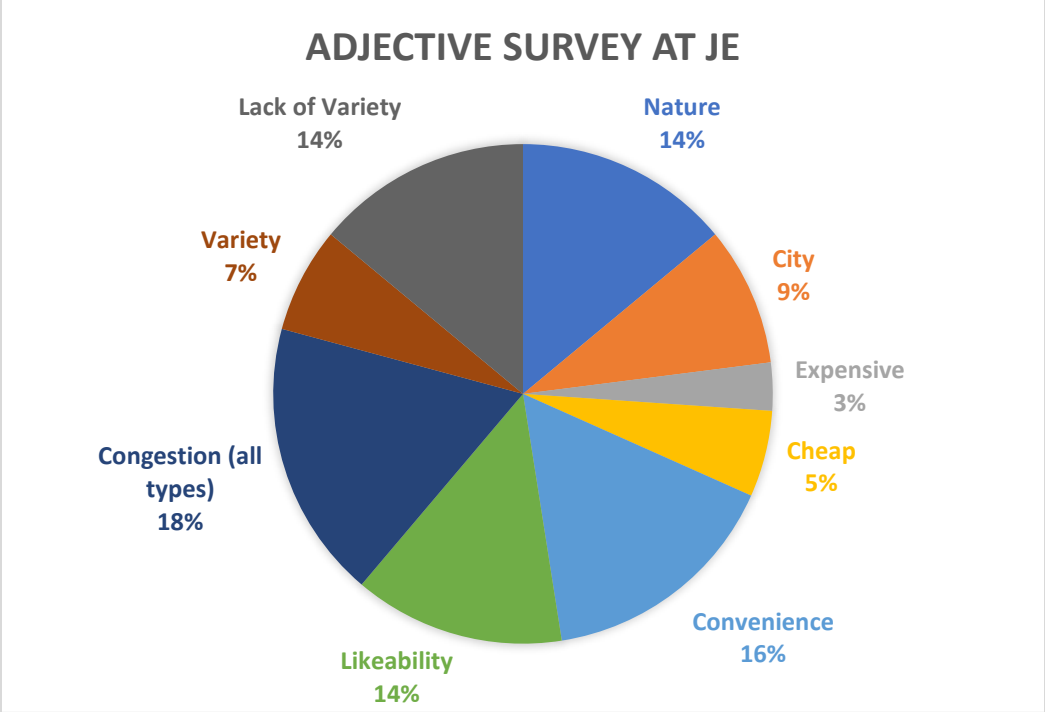


Figure 25 - Pie chart of adjectives frequency by category at OR

To support H_1 the data for adjectives must show JE having greater attribution to being green and clean. The wordles (figs. 22, 23) display the adjectives that questionnaire participants said frequently however

this does not group the words into categories. ‘Green’ is larger in JE than OR, and ‘Clean’ seems to be the same in both. The limitation being it doesn’t consider synonymous phrasing, only exact words. This presentation of data does not accurately conclude, so pie charts (figs. 24, 25) will be used. A category for ‘clean’ is not seen as there was not enough frequency to constitute as a category, it is a part of ‘likeability’. ‘green’ is present in ‘nature’. At JE, ‘likeability’ and ‘nature’ are greater by 1% and 6% than OR, respectively. Therefore, **adjective surveys from questionnaires support H_1**. Because JE has a lower bid-rent, there should be fewer users of the area and lower necessity for office or mall buildings hence more integration of greenery. This is the case when popular places like ION at OR look like fig.26. After discussion of these results with peers, it was found that some participants were asked twice by different groups, thereby invalidating this evidence to some extent. **Nonetheless, the support for H_1 by adjective surveys still stands.**

Figure 26 - Photograph of ION orchard at OR (Roberts)

Environmental Impact Assessment

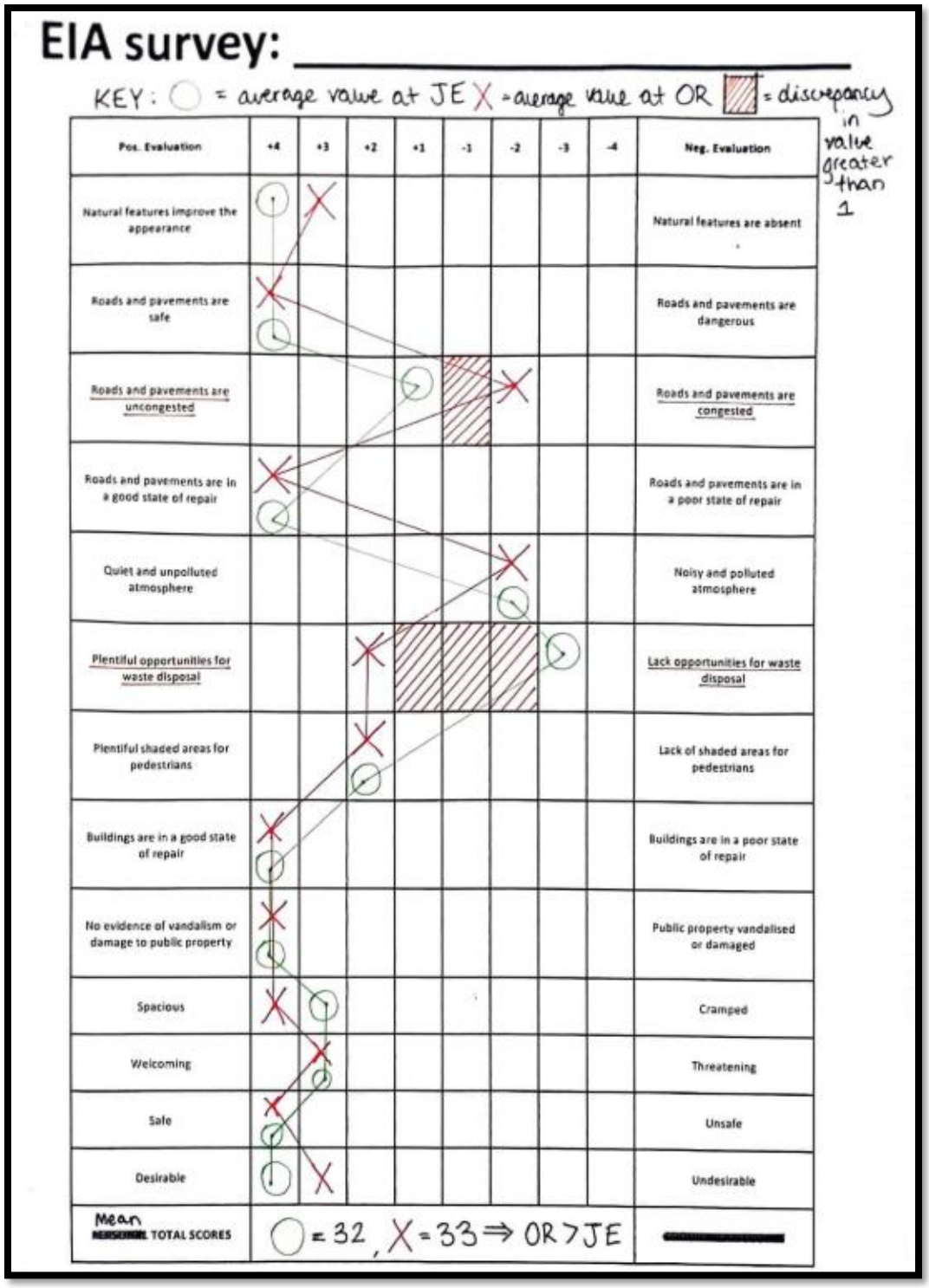


Figure 27 - Average EIA survey for both sites in bipolar presentation

The bipolar survey shows the discrepancies present on an individual level, because the EIA comprises of multiple factors, a bar graph would not show individual discrepancies. Fig.22 shows that OR has a greater EIA than JE. A higher EIA score means **less** environmental impact. Although there may have been multiple smaller discrepancies, opportunities for waste disposal is the main difference. This factor was included to provide an understanding of the potential for litter. Because less waste disposal opportunities lead to littering, effectively increasing the EI. Theory suggests that because of JE's lower rent, there will be less littering as fewer people will travel to low-order good shops. This data disproves that. There is photographic evidence to support this data. Randomly selected photos (using a random number generator) show that opportunities for waste are present in OR and not JE. This has visually shown that the EIA for OR is greater than JE, **which does not support H_1**, as greater EIA shows lower EI. However, a Mann-Whitney test (fig.21) conducted suggests that there is statistical insignificance present. Meaning this discrepancy in value may have happened by chance. Because 32 and 33 are similar (fig.22), it seems possible that their difference can be attributed to chance.

Figure 28 - photograph at JE (Roberts)

Figure 29 – photograph at OR (Roberts)

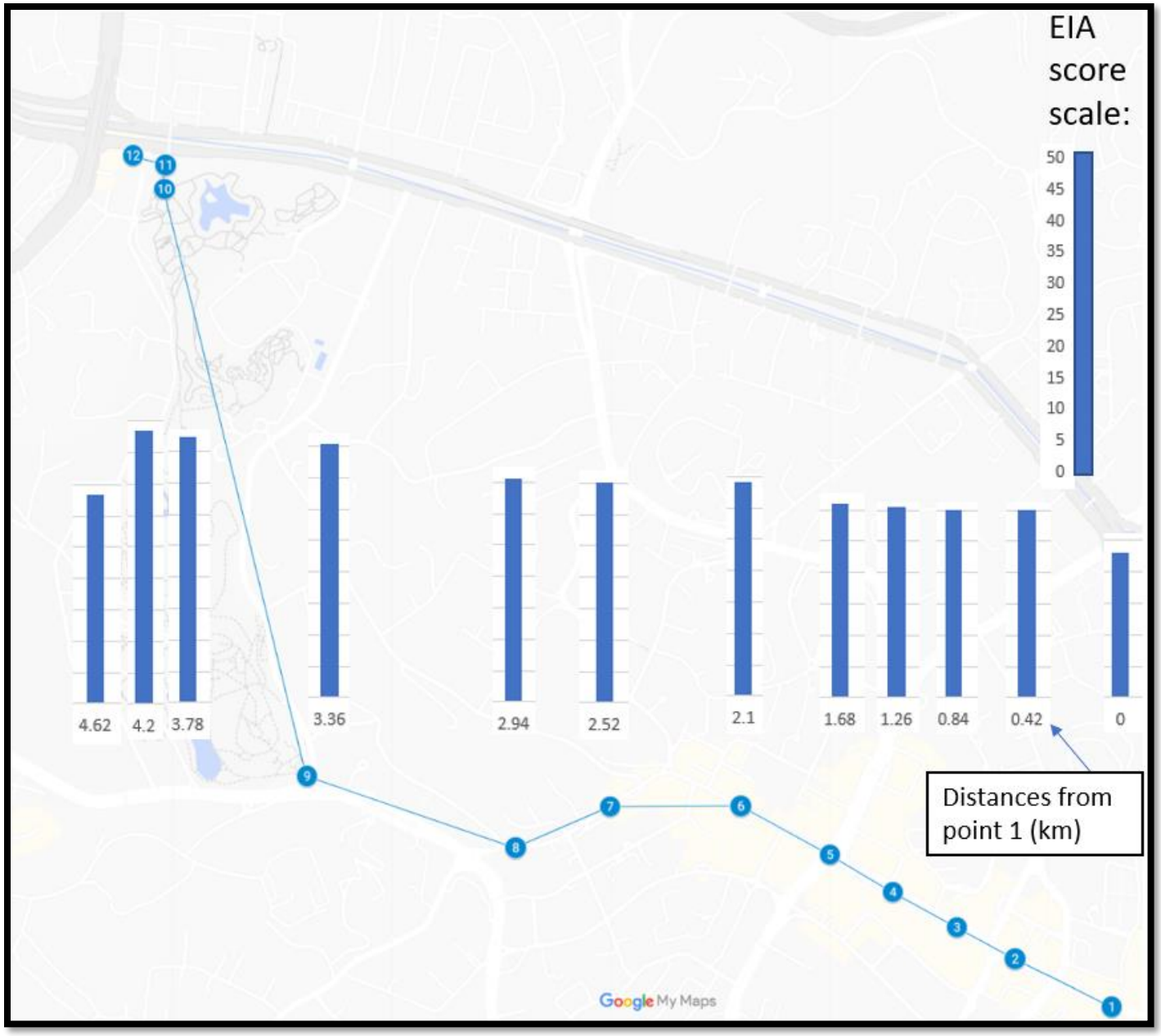


Figure 30 - located bar chart for EIA score against distance for OR (Google)

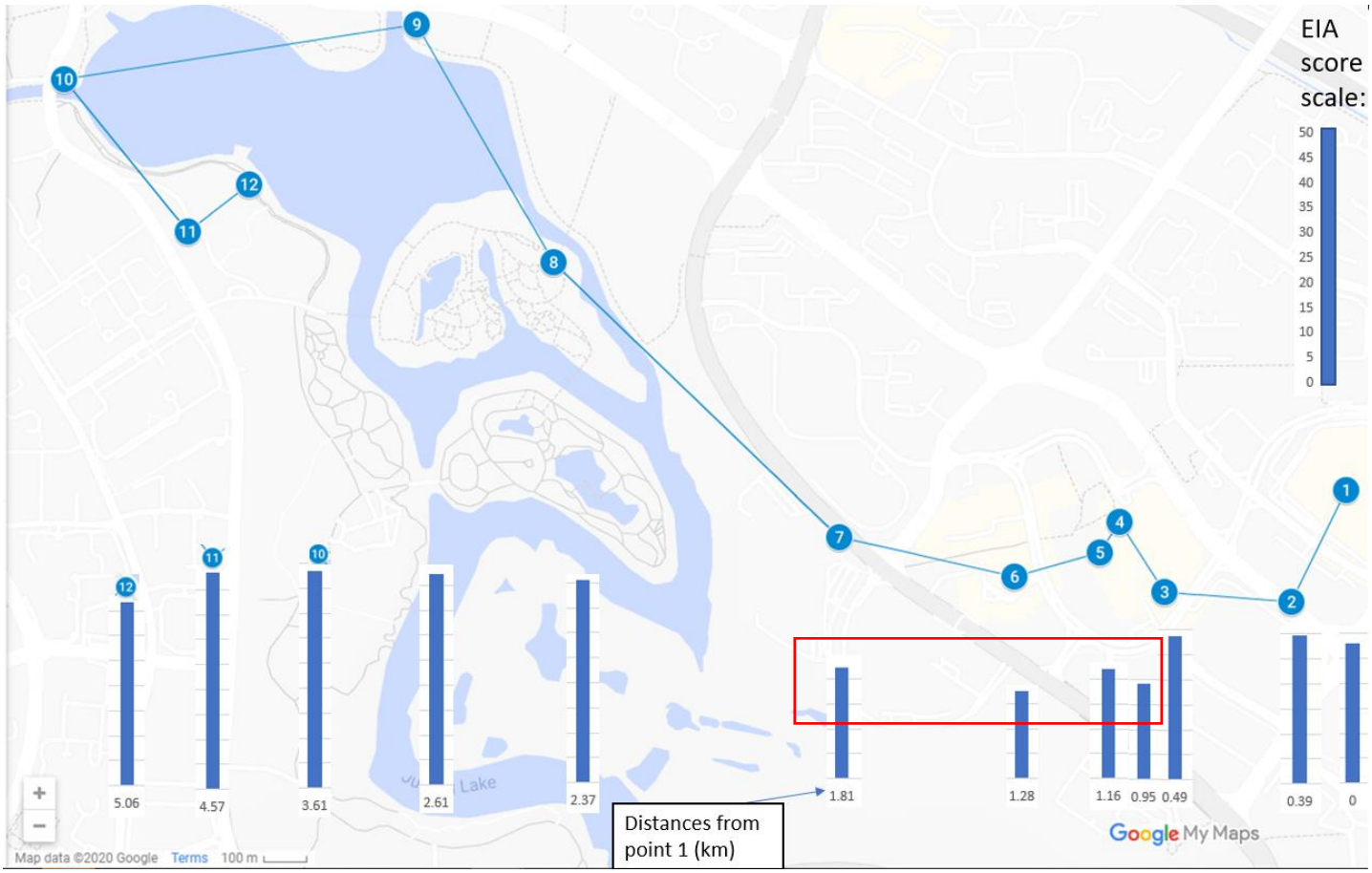


Figure 31 – located bar chart for EIA score against distance for JE (Google)

Figures 30 and 31 show increasing EIA score with distance from point 1, which in this instance is the center of the CBD. This is because of the overall positive trend of both charts. However, the bars in the red box (fig.31) show values different from the rest, anomalous results that don't fit with the general increasing trend. To see the strength of the trends Spearman's Rank was conducted for both. It was found that the R-values for OR and JE were 0.85 and 0.61, respectively. Because these values are positive, the correlations are positive. Furthermore, values above 0.7 are generally considered strong, showing that the correlation was strong positive for OR and weak positive for JE. Had the anomalous result not been included for JE, R = 0.75, therefore a strong correlation. Reflecting, the EIA scores for those 4 points had been collected whilst inside due to rain, therefore lower perceptions of the EIA factors, leading to an overall lower score. With or without anomalous points, the EIA score increases with distance from the CBD in both OR and JE and **hence H_2 is supported by this evidence**, as EI decreases with distance from the CBD.

Decibel Readings

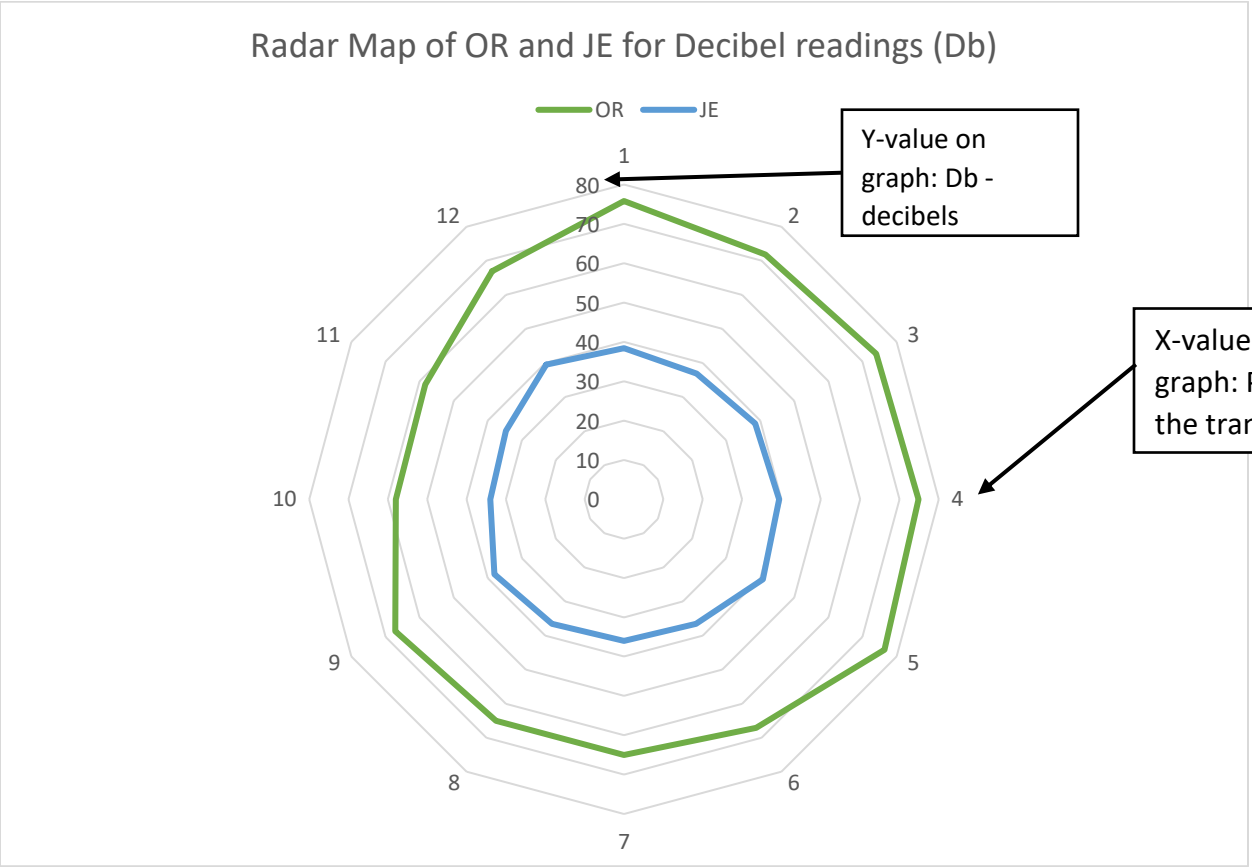


Figure 32 - Radar Map of OR and JE for Decibel readings (Db)

Radar map is used as it allows one to see where overlap between values take place (in this case none).

Figure 32 clearly shows OR is greater than JE in terms of decibel readings at each point on the transect. JE's entire radar is encompassed by OR's radar. **This evidences H_1** which suggests the EI is lower at JE than OR because lower decibel reading contributes to a lower environmental impact. If the land value is lower in Jurong east, fewer people/vehicles will be prompted to journey to that land, as its contents are more low-order. No major anomalies, or dips in radar, are noted as the patterns are seemingly uniformly circular.

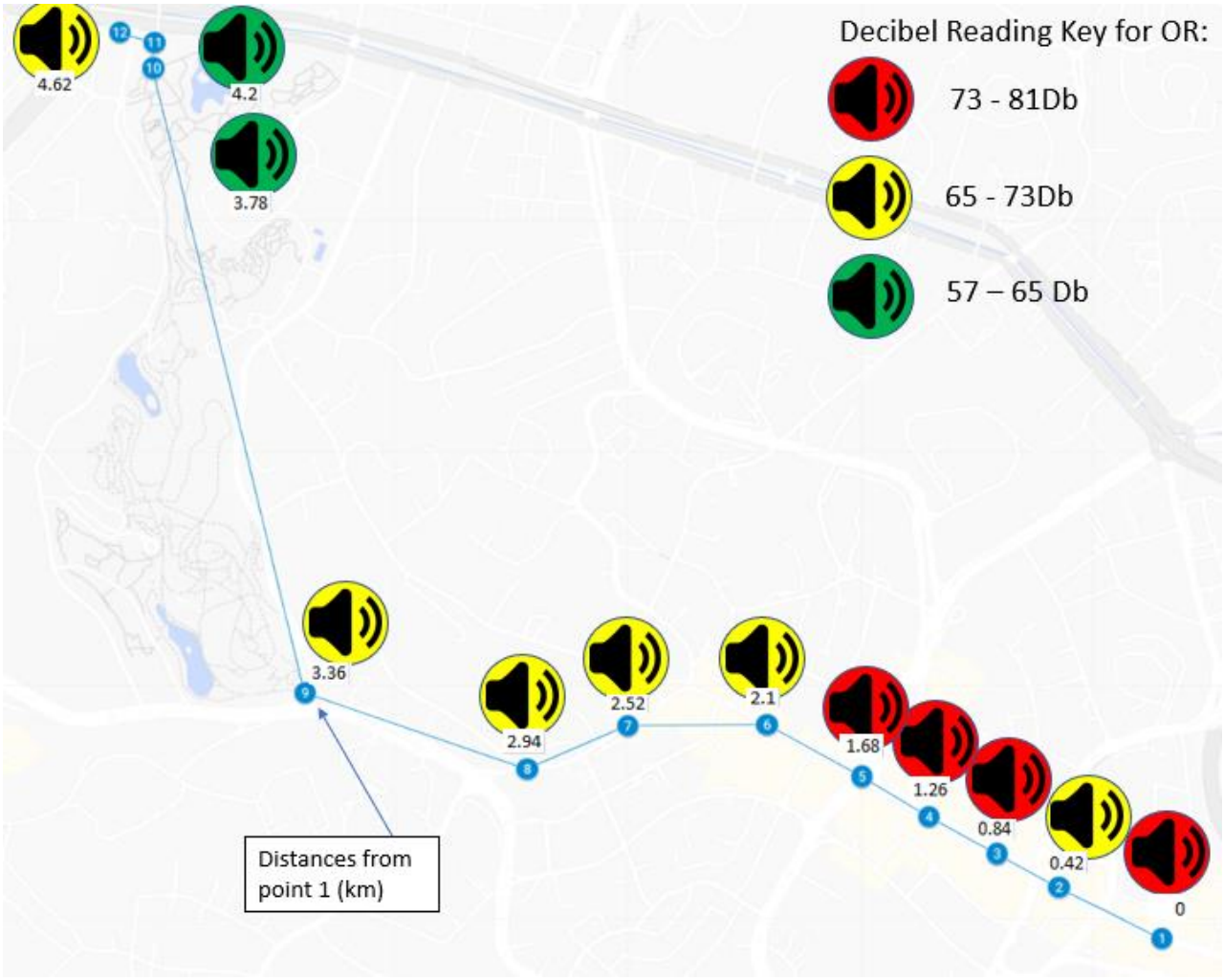


Figure 33 - Proportional symbol distribution for decibel readings at OR (Google)

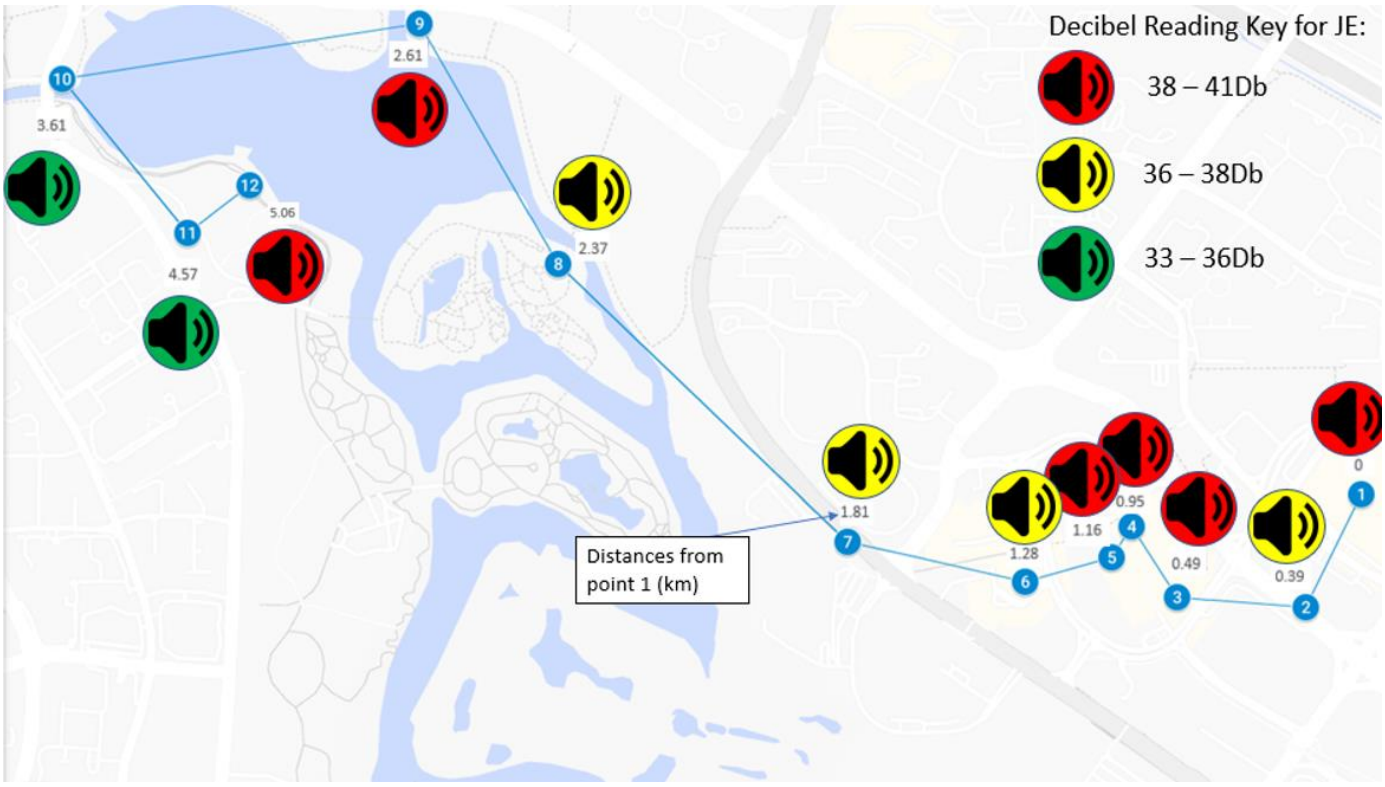


Figure 34 - Proportional symbol distribution for decibel readings at JE (Google)

Figure 33 and 34 employ proportion symbols, using colour, to show the levels of sound pollution. This was used because of the accessibility of drawing conclusive patterns using spatial context. The decibel readings are classed into 3 groups. Figure 33 shows as distance increases the decibel reading generally falls, this is because the frequency of red symbols diminishes whilst the yellow and green symbols increases. On figure 34 however, for JE, a clear trend cannot be distinguished because of the presence of anomalies toward the end of the transect (point 9, 10) and at the very start (point 9, 12). Anomalous results may simply be due to the hypersensitive nature of the equipment. To identify a trend statistically, spearman's rank will be used. After calculation it was found that R = -0.35. This suggests that as distance from the CBD increases, the decibel reading falls. The negative sign shows a negative correlation, and because the modulus value is less than 0.7 it can be considered weak. Conclusively this is a weak negative correlation. For example, the reading may spike if a single car passes the student during data collection. **Considering H_2, this data supports it** due to negative correlation observed in both figs. 33 and 34.

Urban Greenery Percentage

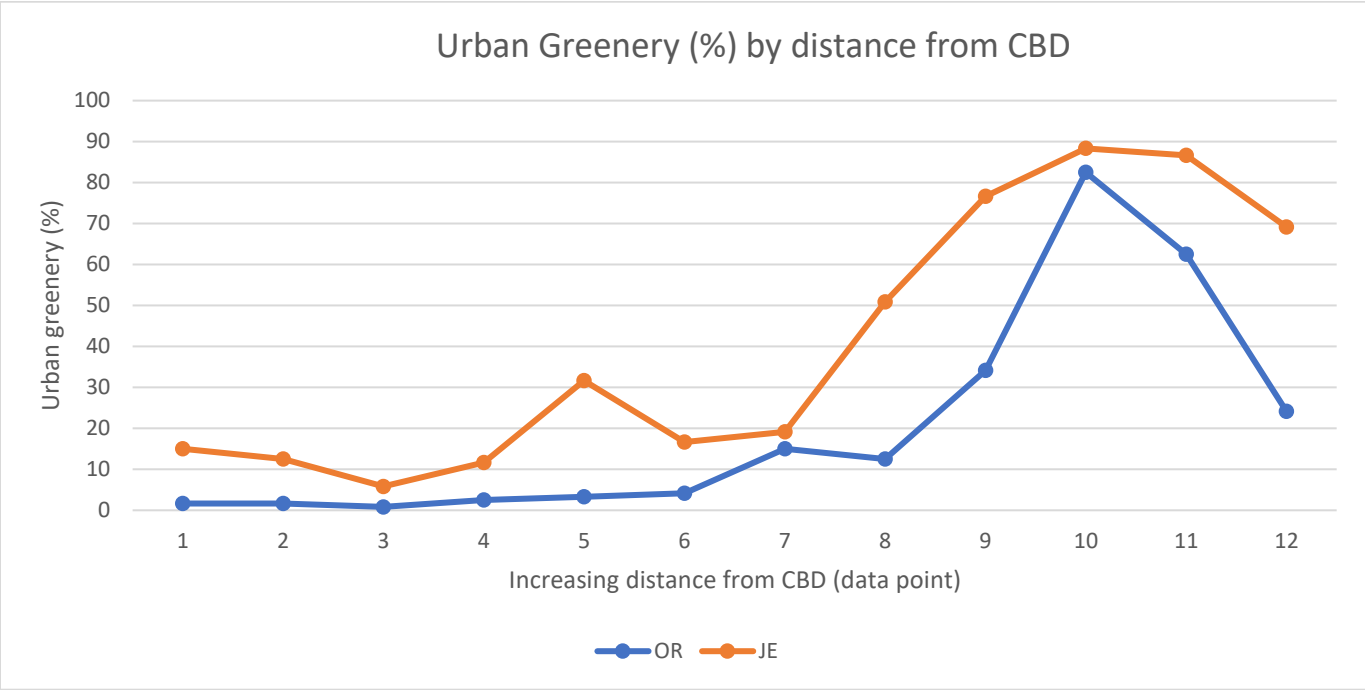


Figure 35 – Line graph showing Urban Greenery (%) by distance from CBD

Line graph is used to compare the trends without losing clarity on the individual points, to spot anomalies during analysis.

H_1 and H_2 can be evidenced by figure 35. For H_1 urban greenery at JE is always greater than OR, the line graph clearly shows this as the orange line is always above the blue. The degree at which there is a difference in urban greenery percentage varies throughout but the data still **supports H_1**.

Although as distance increases from the CBD there seems to be a positive trend overall, at point 9 for both transects a negative correlation can be seen. From theory, this may be linked to the Burgess model. After the CBD, a ring of a mix of industry, commercial and residential land can be seen, perhaps this dip decrease can be attributed to industrial action along both transects. However, when looking at the respective maps, points 9 and onwards are near gardens for both transects. These anomalies may be because of the fact 3 different groups collected data, the threshold for urban greenery percentage may be different for some, suggesting that more data is not necessarily beneficial if it is dependent on opinion. Because JE both trends support urban greenery percentage increasing with distance from the CBD, **H_2 is supported**.

Footfall and Traffic Surveys

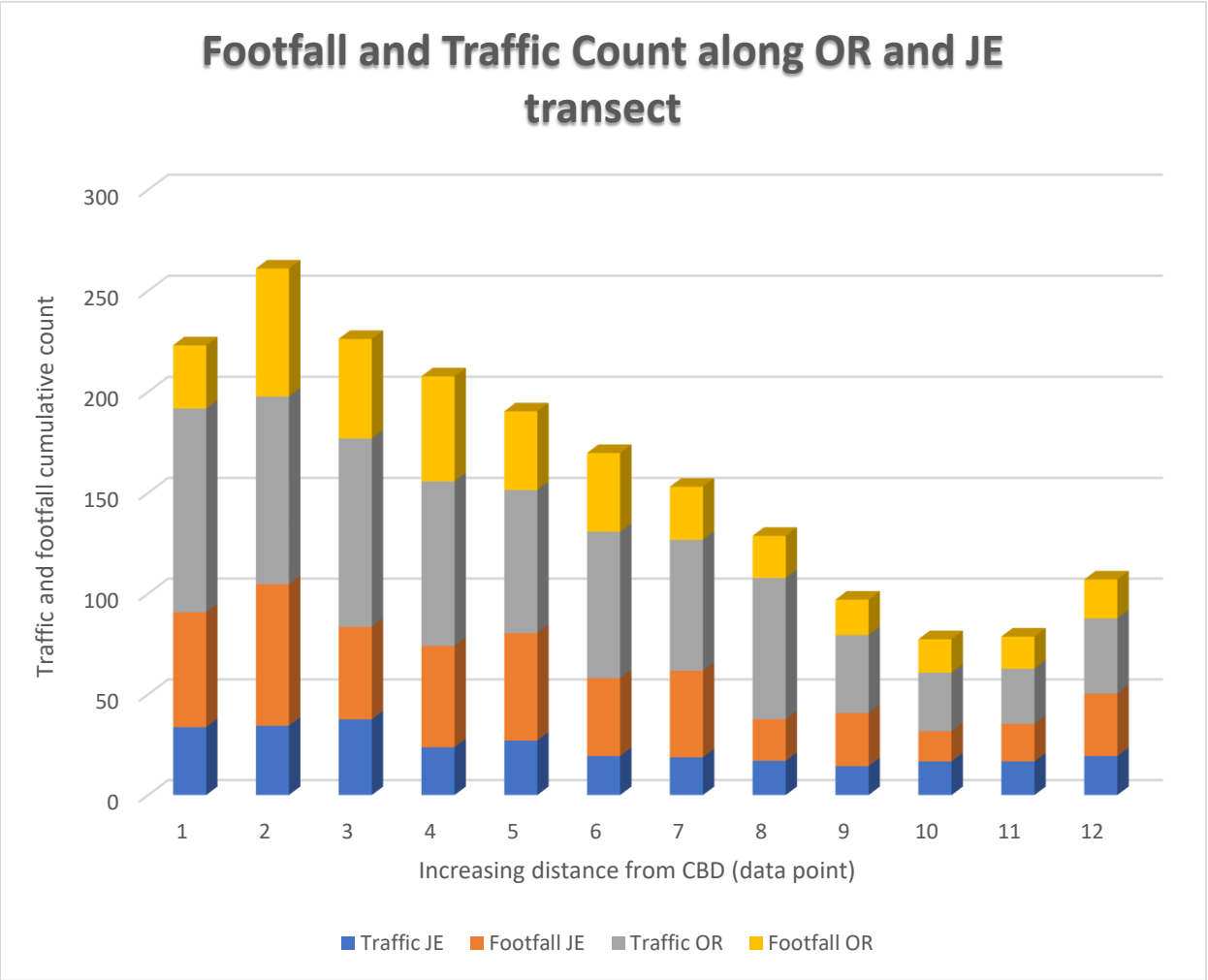


*Figure 36 – Compound bar graph showing **Footfall and Traffic Count along OR and JE transect***

Compound bar graph was chosen to represent both hypotheses whilst being able to make a distinction between the constituents of the final values.

Figure 38 shows the cumulative values for the footfall and traffic count at both transects. The overall trend is downwards showing that with increased distanced there is decreased traffic and footfall. With greater distance from the CBD, there will be fewer people present as the area is less "exclusive". In the sense that people will travel from far away using vehicles to mostly visit the CBD rather than the surrounding areas, thereby having a lesser environmental impact on the surrounding areas. Footfall and traffic surveys are in **support of H_2** due to the general decreasing trend. Proportionally speaking it is also clear to see that with the blue and orange columns (JE traffic and footfall) marginally make up the cumulative values in fig.38. This suggests that the footfall and traffic on average is lower in JE than OR,

supporting H_1. This data may reflect the fact that because OR is the primary CBD and has a higher rent, according to the Bid-Rent theory, more vehicles and people are seen.

Conclusion (195 words):

Does the degree of environmental impact differ with distance from the CBD, and type of CBD, in Singapore? ***Yes.***

H_1: The EI is lower at JE than OR

All factors of a lower EI were attributed to JE rather than OR when a comparison was made, except for EIA. Urban greenery percentage was greater in JE than OR, furthermore, the adjective survey showed JE was more attributed to 'Green' and 'Clean'. The traffic, footfall, and decibel readings were lower in JE than OR, possibly attributed to lower rent values from the Bid-Rent theory. EIA was the only factor which did not support this hypothesis, the overwhelming support from other areas causes this hypothesis to be accepted.

H_2: The EI decreases with distance from the CBD

With increasing distance, factors of the EI changed accordingly with the theory outlined in the introduction. Though the strength of some of the trends was not the highest (0.61 for EIA) and showed weak correlations, they supported the hypothesis nevertheless based on if the correlation was positive or negative. Overwhelming support from all factors for this hypothesis causes its acceptance.

Since the hypotheses are accepted, the research question is answered.

Evaluation (469 words)

Strengths of Methodology

- Reliable as 3 "repeats" of data collection
- Accurate data as appropriate use of digital equipment like decibel meter
- Sites on transect chosen to reflect both hypotheses
- Sites were all outside, making them suitable for looking at environmental impacts

Limitations and Weaknesses

1. Weather disallowed perception of factors in the EIA, for example having to make a judgement from afar due to thundery showers.
2. Not using quadrats, this may have caused significant human error due to poorly estimated $5m^2$ area.
3. 2 transects didn't provide sufficient variability of population, causing the same people to be questioned.
4. Sampling method could not be carried out.
5. Lack of expected data for analysis.
6. No analysis of error.

Respective Improvements

1. Collecting data on 4 to 5 days, rather than 2, so that data with similar weather conditions can be used for comparison.
2. Instead of imagining quadrats, 4 brightly coloured poles can be used to indicate the area of data collection whilst maintaining safety.
3. 6 transects should be carried out, with each of the 3 groups taking on 2 of them.
4. Stratified sampling could not be carried out in the questionnaire due to the worry of COVID-19, to improve this a QR code may be shown, so people can answer the questionnaire from afar. Furthermore, this would automatically transfer data online, so less human error would be involved.
5. Comparing results with published data may have provided an insight into the nature of the data collected. Consequently, expected data could have been used in the Chi-squared test to quantitatively show the differences in published and collected data.

6. Error only could have been measured for the decibel readings; it would have been useful to analyze this as the potential for variability of data could have been seen. Overlap in error bars could have been discussed, potentially invalidating some claims.

Extension

I found that wind and temperature was changing along both transects, imploring the research question to change to 'Do climatic conditions differ with distance from the CBD, and type of CBD, in Singapore?'.

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Appendix

A1

		OR
Nature	Nature	36
City	City	78
Expensive	Expensive	84
Cheap	Cheap	6
Convenience	Convenie	36
Likeability	Likeabilit	54
Congestion (all type	Congestic	72
Variety	Variety	42
Lack of Variety	Lack of Va	12

		JE
Nature	Nature	45
City	City	29
Expensive	Expensive	10
Cheap	Cheap	18
Convenience	Convenie	51
Likeability	Likeabilit	44
Congestion (all type	Congestic	58
Variety	Variety	22
Lack of Variety	Lack of Va	45

A2

	EIA data along transect for OR												
distance		Student 1	Student 2	Student 3	Student 4	Student 1	Student 2	Student 3	Student 4	Student 1	Student 2	Student 3	Student 4	Average
0	Somerset	23	26	24	22	27	20	18	23	29	22	24	19	23.08333
0.42	S to ION #	31	27	30	37	36	32	19	37	30	24	28	29	30
0.84	S to ION #	36	28	25	32	34	27	33	31	34	25	32	23	30
1.26	S to ION #	40	32	27	31	34	26	35	29	31	28	29	24	30.5
1.68	ION	37	31	32	35	36	38	24	26	29	27	31	26	31
2.1	I to Tang #	35	30	32	32	36	43	38	38	31	32	30	32	34.08333
2.52	I to Tang #	36	30	40	31	35	34	36	31	39	30	40	40	35.16667
2.94	Tanglin M	46	41	42	43	32	31	30	27	34	34	34	32	35.5
3.36	Botanic 1	41	40	39	44	42	41	40	39	38	41	38	43	40.5
3.78	Botanic 2	43	44	43	42	45	42	43	41	40	39	40	46	42.33333
4.2	Botanic 3	46	44	41	43	43	45	44	45	46	45	38	43	43.58333
4.62	Cluny	39	40	36	37	27	30	29	25	39	32	34	34	33.5

A3

	OR	JE
1	75.8	38.4
2	71.833	36.917
3	73.967	38.483
4	74.867	39.433
5	76.433	40.717
6	67.133	36.567
7	65	36
8	65.067	36.533
9	67.133	38.067
10	57.967	33.983
11	58.367	34.683
12	66.967	39.483

A4

OR	JE
1.6667	15
1.6667	12.5
0.8333	5.8333
2.5	11.667
3.3333	31.667
4.1667	16.667
15	19.167
12.5	50.833
34.167	76.667
82.5	88.333
62.5	86.667
24.167	69.167

A5

Traffic JE	Footfall J	Traffic OI	Footfall OR
33.667	57	101	31.333
34.333	70.333	93	63.333
37.5	46	93.333	49.333
23.667	50.333	81.667	52
27	53.333	71	39
19.333	38.667	72.667	39
18.667	43	65	26.333
17	20.667	70	21
14.333	26.333	38.667	17.667
16.667	15	29	16.667
16.667	18.667	27.333	16
19.333	31	37.333	19.333