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Exploring the Equality of Urban Community Greening: A Case Study of Guangzhou, China

Yujie Liu[1], Potong Yu[2]

[1]Singapore American School, Singapore 738547, Singapore

[2]High School Affiliated to South China Normal University, Guangzhou, 510000, China

ABSTRACT

This study focused on the Urban Heat Island (UHI) effect especially in Guangzhou, China. The UHI effect happens when urban areas trap more heat than their natural counterparts. Through field air temperature measurements of multiple areas with high and low tree canopy cover areas, this study strongly suggested the existence of the UHI effect in Guangzhou; it showed that areas with low tree canopy cover had a significant higher air temperature than areas with greater tree canopy cover. Another area of focus for this study is the correlation between greening rates in residential villages in Guangzhou, China, and apartment price per square meter. The study gathered numerous datapoints of residential villages Guangzhou and found that there was a moderate positive correlation. These factors warrant the necessary and timely incorporation of more greenspaces in the urban landscape.

KEYWORDS

UHI Effect, Greening Rate, Urban Trees.

1. INTRODUCTION

Have you ever wondered why the temperature feels much cooler when walking in nature than standing in a concrete car park? Have you noticed how the concrete slabs of buildings trap much more heat than nature parks? Due to global warming, our planet is getting hotter every year. This poses threats to marine life as well as land animals, such as humans. According to the United States Environmental Protection Agency, heat waves are increasing in frequency and intensity across major cities in the United States. Their frequency has increased steadily, from an average of two heat waves per year during the 1960s to six per year during the 2010s and 2020s. This poses a significant threat to humans since more heat waves cause more heat strokes and, in some cases, deaths. Therefore, it is essential to study how society can reduce the temperatures of our environment, especially our urban environment.

In 2018, 55% of the world's population live in urban areas. By the year 2050, projections show that 2.5 billion more people will be living in urbanized areas (UN, 2018). Expressing the sheer number of the planet's population who live in urban areas stresses the importance of minimizing the number of heat strokes in urban areas. To do this, the difference in temperature between urban and natural regions needs to be understood.

Dr. Brian R. Shmaefsky describes the Urban Heat Island (UHI) effect as "a situation in which the air in an urban area can be 2° to 5°C warmer than surrounding forested or suburban areas" (Shmaefsky, 2006). Although 2° to 5°C may not seem like much at first glance, this temperature difference could quickly push the human body over the edge into a heat stroke during a heat wave. Therefore, the UHI

effect must be understood well because of the increased frequency and intensity of heat waves as well as the considerable human population living in urban areas. Exposure to greenery has physical, mental, and social benefits (Keniger et al., 2013). Several studies have found that urban trees and urban greenspaces can provide cooling for cities and mitigate UHI effect (Kabisch et al., 2017; Fan et al., 2021).

Although there have been many research papers exploring the consequences of the urban heat island effect across the world, there are few studies that focused exclusively on the UHI effect in Guangzhou, China. This warranted the need for further research in this geographical area.

The research question that this study tried to answer are Part I: To what extent (if any) does the Urban Heat Island Effect exist in Guangzhou, China? Before initiating the research, the research team hypothesized that there will be a noticeable increase in temperature in areas which have low tree canopy cover for reasons discussed above. After, the study tried to explore: Part II: How does the apartment price correlate with greening rate of residential village? The research team then hypothesized that there will be a small to moderate positive correlation between these two variables.

2. 2 METHODS

2.1. 2.1 Study area

Guangzhou, located in southern China, has a humid subtropical climate, characterized by long, hot summers and mild winters. The city has high humidity levels throughout the year, with summer temperatures often reaching above 30°C, and discomfort humidity levels. Summers are also marked by frequent rain and occasional typhoons, especially from May to September.

Guangzhou's high humidity and urbanization contribute to the urban heat island effect, where densely built-up areas experience higher temperatures than surrounding rural areas. This makes it an typical city for studying on the cooling effect of trees and greenspace, as green spaces like tree-lined streets can help mitigate the heat by providing shade and reducing heat absorption. We selected an area close to Zhujiang new town of Tianhe district, Guangzhou for both field temperature measurement and online data collection.

2.2. 2.2 Data collected

2.2.1. 2.2.1 Field measurement

For field temperature measurement, we selected two nearby areas, plot A with higher tree canopy cover and plot B with lower tree canopy cover, in Zhujiang new town of Tianhe district, Guangzhou.

The data collection phase of this study spanned from July 31st to August 10th, a period selected to capture the peak heat of the summer. During this time, air temperature data was collected daily at around 2 p.m. For each plot, four specific points were selected for measurement, at 0 meters (directly under a tree), 2 meters (just outside the immediate tree cover), and 10 meters from the trees (further away from the trees), as well as an open area with no trees nearby. These points were chosen to assess the immediate and gradual cooling effect of trees as well as the ambient temperature in areas lacking any green coverage. UT333 Mini Temperature Humidity Meter was used to gather precise air temperature readings at each point. The device was positioned at a consistent height (about 1m) above the ground at all measurement locations to ensure uniform data collection. The temperature readings from both plots were recorded and analyzed to make data graphs and determine the effect of tree coverage on reducing air temperature in urban settings.

2.2.2. 2.2.2 Online data

Before the study explores the relationship between apartment price and greening rate, it needed to collect data from a database. The database that the research team used is Lianjia. Lianjia is an well-known real estate brokerage website in China. Its famousness puts high pressure on Lianjia to be legitimate and trustworthy.

We randomly selected tens of residential villages in an area close to Zhujiang new town of Tianhe district, to examine the greening rate and the apartment price per square meter. After choosing the residential villages, Lianjia would provide numbers on the greening rate (from 0% to 100%) and the apartment price per square meter. These numbers were recorded. Greening rate signifies the percentage of area of a residential village that is covered by greenery. A high greening rate would mean that there are many green spaces in the residential village while a greening rate of 0% means that there is no greenery. In total, 78 data points were collected in the study.

3. 3 RESULTS

3.1. 3.1 The cooling effect of urban trees

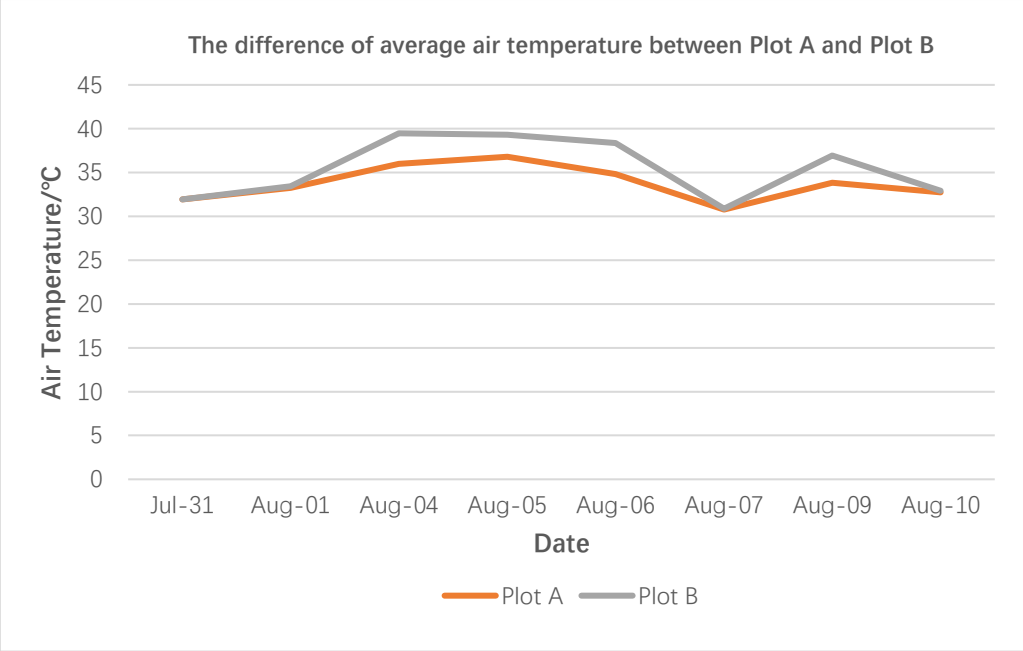

Figure 1 The difference of average air temperature between Plot A and Plot B

This graph shows that the difference of average air temperature between the two plots from July 31st to August 10th. The orange line (Plot A) consistently remains lower than the gray line (Plot B), especially between August 1st and August 7th. Between August 1st and August 7th, the temperature in Plot B peaks around 40°C while Plot A remains closer to 35°C. This suggests that areas with more trees (Plot A) are consistently cooler than areas with fewer trees (Plot B), demonstrating that urban trees reduce the air temperature by providing shade and facilitating evaporative cooling through transpiration.

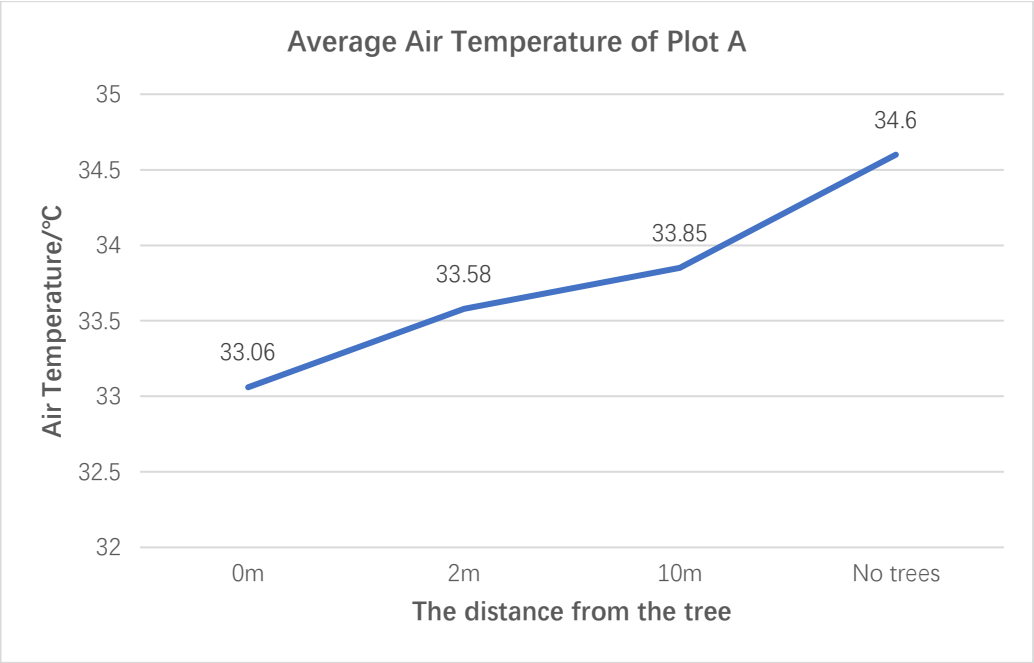

Figure 2 Average air temperature of Plot A

This graph illustrates how the average air temperature in Plot A changes based on the distance from the trees. At 0 meters, the average air temperature is 33.06°C. As moving 2 meters away from the trees, the average temperature rises slightly to 33.58°C, and at 10 meters, it further increases to 33.85°C. In areas with no trees, the temperature rises to 34.6°C. This illustrates a strong and positive relationship between the distance from the tree and the average air temperature: the closer to the trees, the cooler it is. The temperature difference between the area with trees (33.06°C) and the area without trees (34.6°C) is around 1.5°C.

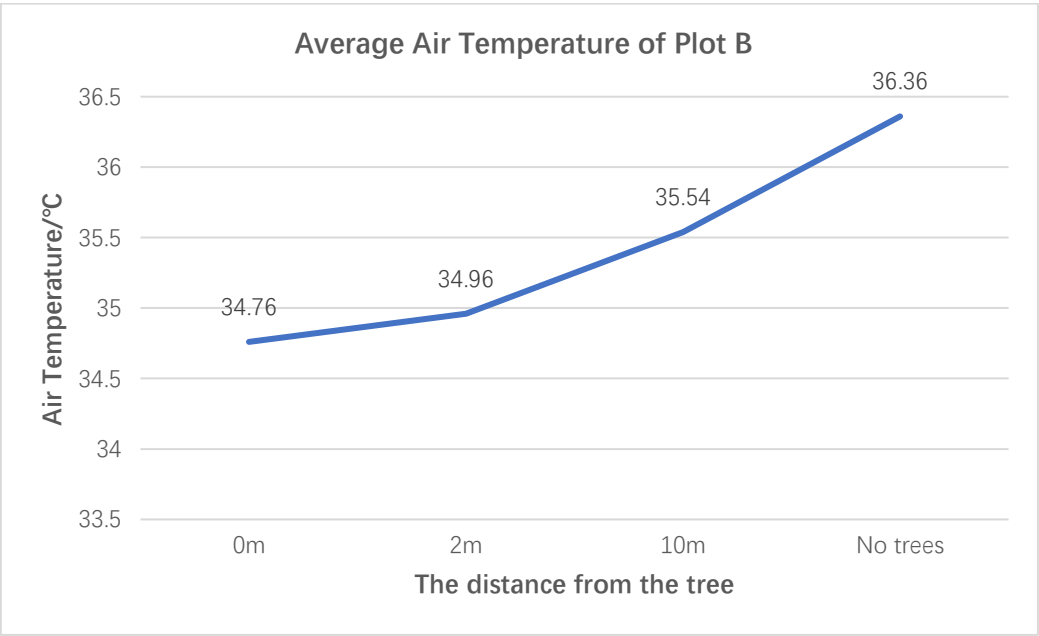

Figure 3 Average air temperature of Plot B

This graph offers a positive and strong relationship between the average air temperature of plot B and the distance from the trees. At the closest point (0m), the temperature is significantly lower at 34.76°C, indicating the immediate cooling effect of the trees. This effect diminishes with distance, but even at 10 meters away, there is a noticeable difference in temperature compared to the area with no trees. This suggests that the average air temperature of plot B increased with the increasing distance from the trees.

3.2. 3.2 The relationship between apartment price and greening rate

The correlation between the apartment price per square meter and the greening rate of a residential village is quantified using a linear regression model.

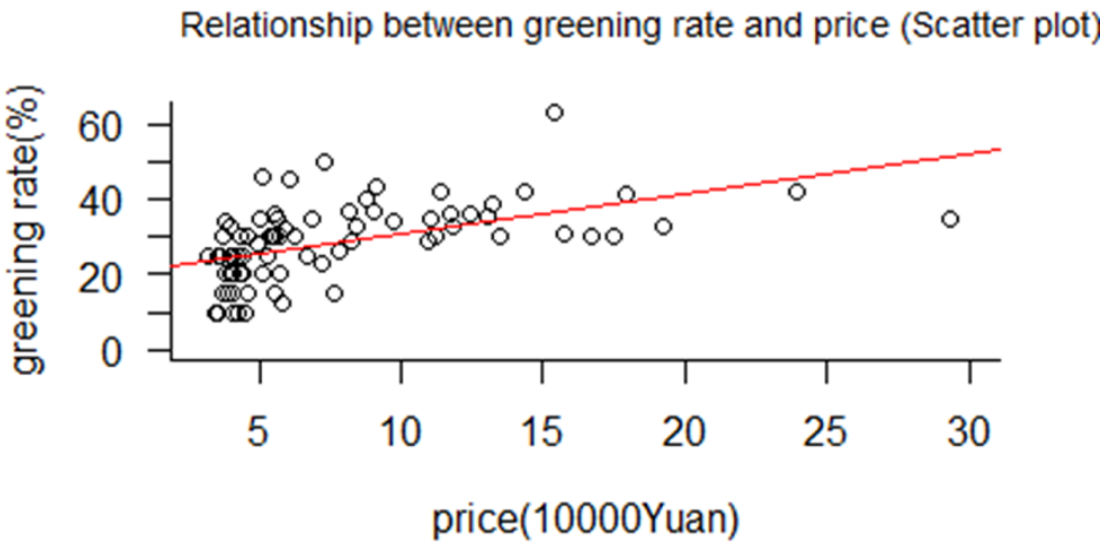

Figure 4 The relationship between greening rate of residential villages and their apartment price per square meter

Figure 4 shows a clear positive correlation between the price per square meter of an apartment in Guangzhou and its greening rate. This means that as the apartment price increases, greening rates increase concurrently. In fact, the coefficient of determination—the R2 value—obtained from this model was 26.5%.

Granted, there is an uneven distribution of data points across the domain of the graph. Linear regression is the most appropriate choice when analyzing the data because there seems to be a linear trend. When a linear regression line is applied, the residuals seem to follow a normal distribution.

4. 4 CONCLUSION AND DISCUSSION

This study explored the urban heat island effect in Guangzhou. It strongly suggested the presence of the UHI effect and that there is a temperature difference between areas with high tree canopy cover and areas with low tree canopy covers. Furthermore, this study explored the relationship between apartment price per square meter and its greening rate; it found a moderate positive correlation and that around 26.5% of the variation in greening rates can be explained through apartment pricing.

The UHI effect may have many causes. For example, in areas with high vegetation and tree canopy coverage, evapotranspiration may take place. This is when plants release water vapor during respiration; it is also when water from leaves evaporate into the atmosphere. Since evaporation is an endothermic process, the system will become significantly cooler when a lot of evaporation occurs. However, without vegetation and greenery, little evaporation can take place since urban areas do not retain much water on its surface. This means that impervious surfaces such as rooftops do not facilitate much evaporation, so they will become hotter. Another possible factor for the UHI effect is the low reflectivity and high heat retention seen in construction materials. Materials such as concrete and asphalt do not reflect much solar radiation; instead, they have relatively high specific heat capacity, meaning they are able to retain a lot of heat per its mass. Lastly, urban areas cause a lot of human-caused heating. For example, roads are a source of a lot of car exhaust, and the backs of buildings could have many exhausts of air-conditioning units. All of these factors will increase the temperature of its surroundings. Therefore, it can be concluded that urban areas have a tendency to be hotter than natural areas because of its ability to produce, absorb, and retain heat. Consequently, it is crucial to explore ways to cool the urban landscape because many lives are at stake.

The relationship of greening rate and apartment pricing is also the product of various factors. Factors include the human attraction toward green spaces (thus increasing its demand) and the increased complexity of green buildings. Humans receive numerous health benefits from green spaces such as improved cognitive function, happier mood, and enhanced physical health (Keniger et al., 2013). These benefits will increase the demand and therefore increase the pricing of the real estate. This shows that, since people have high sensitivity pertaining to living conditions, the UHI effect, though somewhat subtle, can impact many decisions about where to live, which is why buildings with green spaces are preferred.

The understanding of the urban heat island effect is not enough. The understanding should be applied for there to be a difference in the world. Therefore, some possible future actions that can be taken is the implementation of more green spaces, green buildings, and urban parks. Furthermore, architects can gain a competitive edge against other building designs if they incorporate more environmentally friendly elements in their designs.

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