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Urban green space inequality across urban scales

Keywords: Urban green space, NDVI, Satellite image, Inequality, Gini index

Extended Abstract

Green space is an essential factor that people need to live a better life. Many studies have shown that green space benefits human life in various ways, such as the environment, health [1, 2], happiness [3], and housing prices [4]. However, industrial development and urbanization are damaging vegetation in urban areas, and the need for green space has emerged. Consequently, many countries try to increase green space by planting street trees and constructing parks. However, these urban green spaces are not equally distributed to people. We analyze whether people with different socioeconomic statuses are equally affected by green space with such diverse advantages. The difference in the amount of green space according to income level causes inequality in many benefits of green space and varies from each region.

We analyze the correlation between income levels and the amount of urban green space in the top 20 Metropolitan Statistical Areas (MSA) with the largest population in the United States. We choose Census Block Group (CBG) as the minimum unit of our analysis, then focus on the green space inequality inside the cities. We did not compare urban green space between cities due to different climate conditions.

We calculate the total amount of urban green space with the Normalized Difference Vegetation Index (NDVI) in a built-up area. NDVI quantifies an amount of vegetation from the difference between the near-infrared and red bands of the Sentinel-2 satellite image. To focus on the urban green space, we multiply the percentage of the built-up area from Copernicus Land Cover data. Then we can calculate NDVI for each pixel as follows:

$$NDVI = \frac{NIR - RED}{NIR + RED} \times A_{built\ up}, \tag{1}$$

where NIR and RED are near-infrared and red bands respectively, and $A_{builtup}$ is a percentage of the built-up area. Finally, we normalize NDVI by built-up area to analyze the average effects of urban green space UGS on the area where people live (Fig. 1a).

$$UGS^{cbg} = \frac{NDVI^{cbg}}{A^{cbg}_{built\ up}} \tag{2}$$

Note that we calculate the UGS at the CBG level.

We calculate the UGS of each CBG and compare it with median income to find out the correlation between green space distribution and socioeconomic status in each MSA. As a result, every 20 MSA has a positive correlation between UGS and median income (Fig. 1b). This result corresponds with the results in previous studies that show the accessibility of green space is relatively low in areas with low income [5]. Although every city presents a positive correlation between green space and socioeconomic status, the strength of the relationship, represented by the slope in the regression, varies from high (Philadelphia MSA) to low (Dallas MSA).

We measure the green space inequality with the UGS Gini index and compare it with the characteristic values of MSA. We calculate the Gini index of UGS in the level of CBG for

each MSA to acquire the UGS Gini index. First, we analyzed the relationship between the UGS Gini index and the total UGS in MSA. As a result, they show a negative correlation (Fig. 1c), which suggests an abundant amount of UGS in the city resolves green space inequality to some extent. Moreover, Fig. 1 displays that the UGS Gini index and income Gini index have a positive correlation (Fig. 1d). This result indicates that green space inequality and economic inequality hold an association with each other.

In order to understand the relationship between green space and people within the MSA connected by geographical and economic, the amount of green space was calculated using satellite images and compared with the variables about income that are most closely related to people socioeconomically. This analyzes that all MSA have a positive correlation between UGS and income, and this trend is more pronounced in MSA with lower UGS. In addition, the green area is unevenly distributed in MSA, where income is unequal. Analyzing the cause of this phenomenon reduces inequality related to the distribution of green space, especially, in regions with a lack of green space. Furthermore, low-income households can gain positive effects through green space.

References

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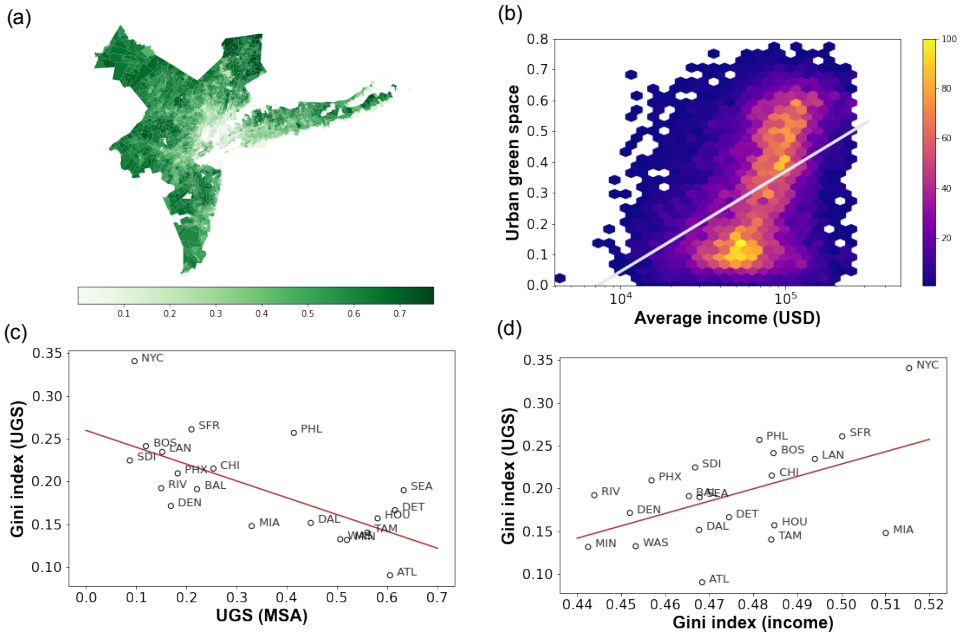

Figure 1: (a) UGS of New York MSA. (b) Hexbin plot of average income and UGS across CBGs in New York MSA. (c) Scatter plot of total UGS in each MSA and UGS Gini index. (d) Scatter plot of income Gini index and UGS Gini index.