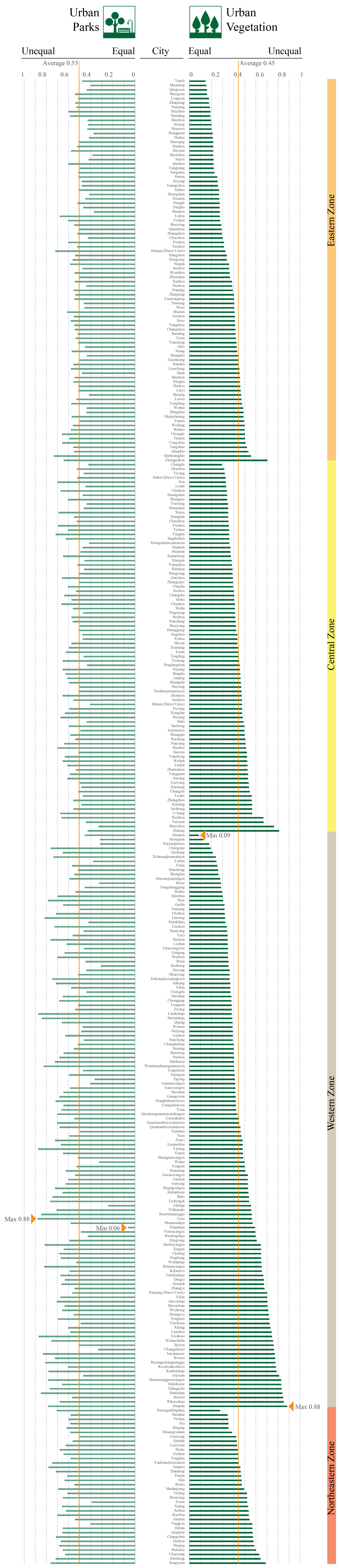
(Un)equal Territory of Accessing Urban Green Spaces

A Comparative Study of 341 Prefecture-level Chinese Cities Using Multiple Open-source Big Data

Longfeng Wu, Seung Kyum Kim

Equality Indexes (Gini) of Accessing to Urban Green



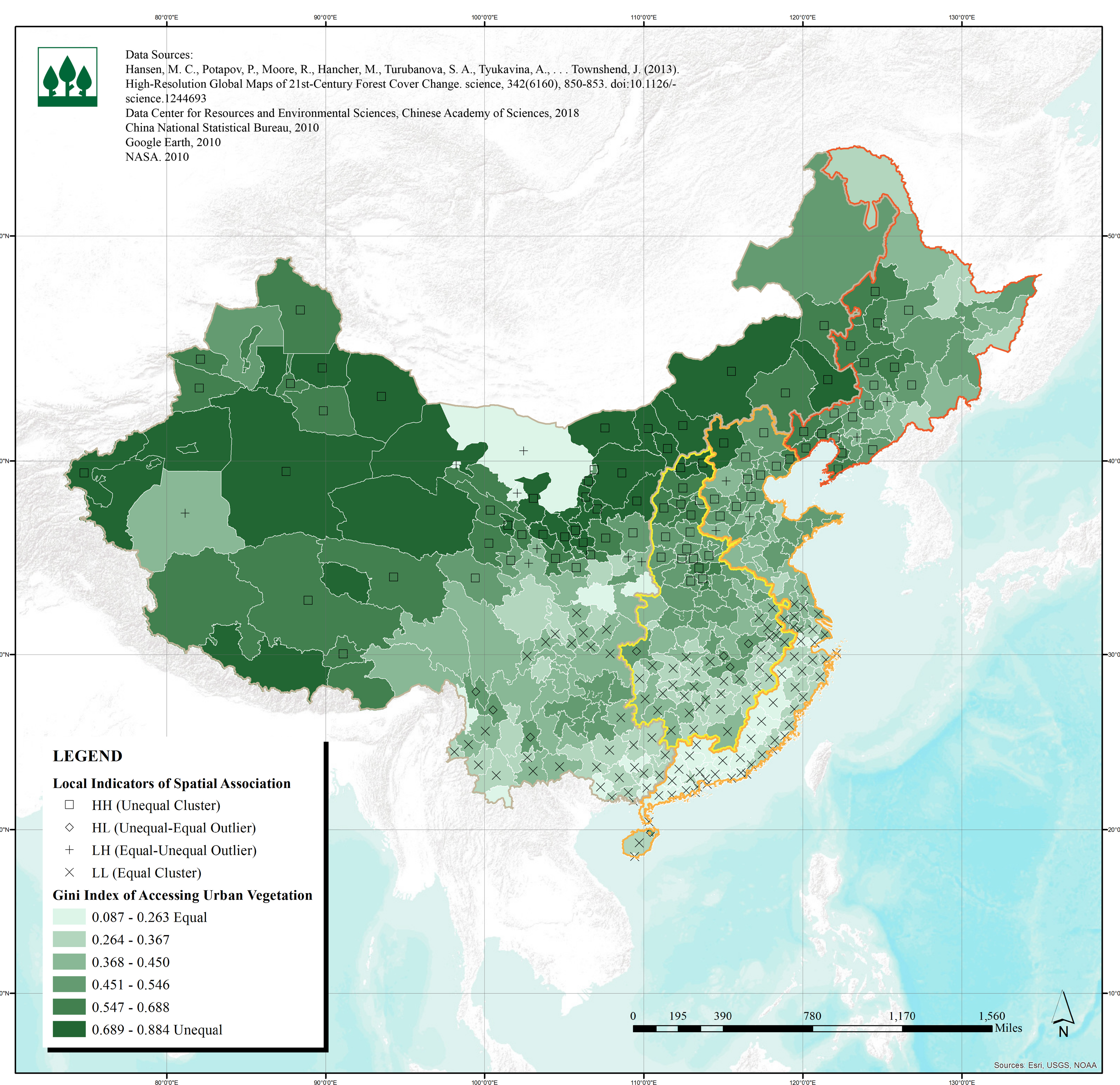
Project Introduction

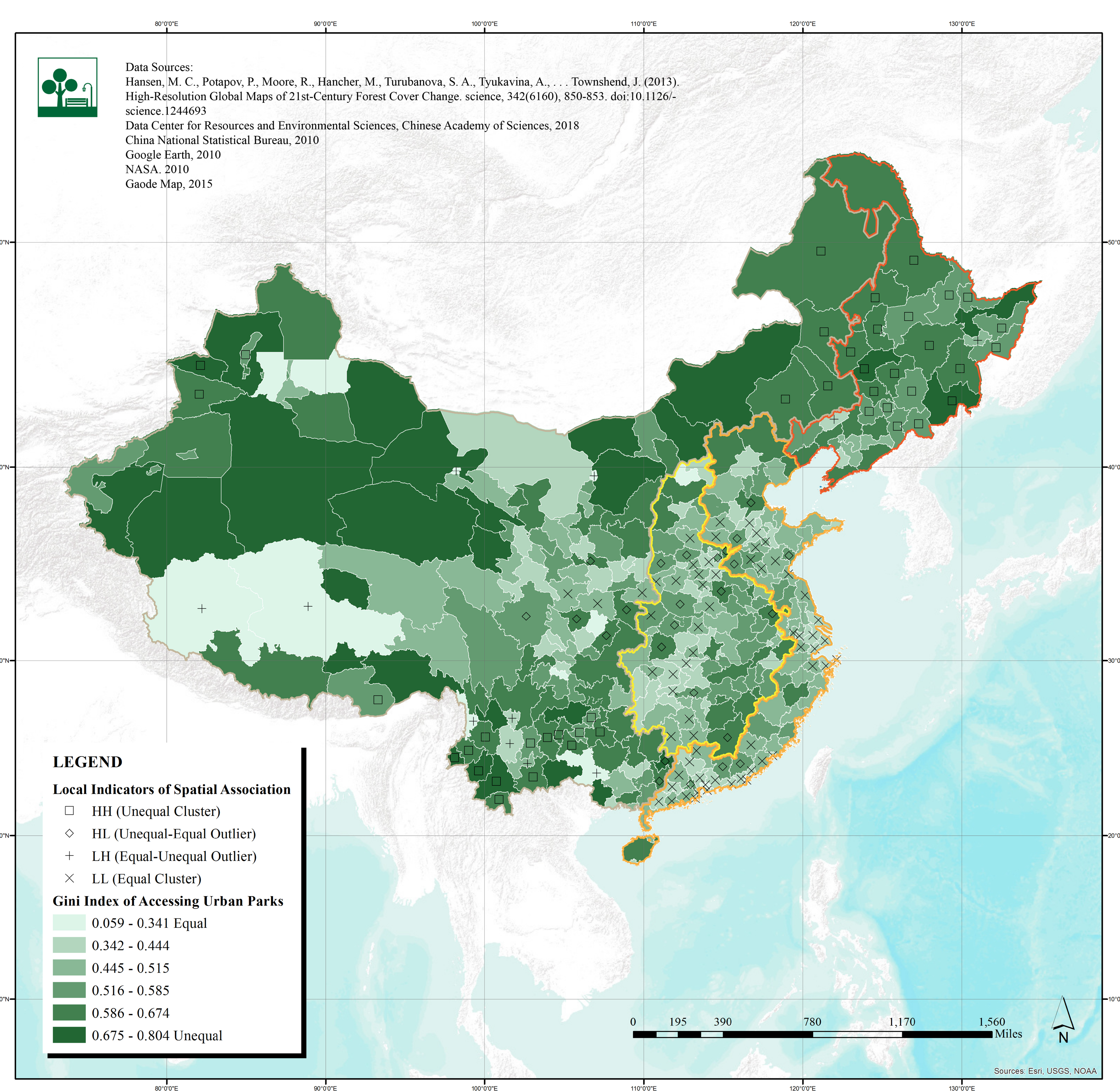
Urban green spaces (UGS) provide multiple ecosystem services to residents, including recreation, air cooling and cleaning, storm runoff mitigation, soil preservation and carbon sequestration, and more. In Chinese cities, typically in dense urban built-up areas, green spaces are often limited due to ongoing processes of rapid urbanization which deprioritizes UGS development. This often leads to the unequal provision of UGS among a city's residents, which results in a number of negative consequences for both social integrity and sustainable development at a boarder scale. Though a limited number of studies investigate spatial mismatches of UGS in individual cities, it is difficult to compare the results across many distinct cities due to the varying definitions, scales, and evaluation methods employed within each. Fueled by contemporary development of big-data, this study develops two useful urban green space equality indexes based on the Gini-coefficient to compare the green space-related inequality among multiple cities. One is an urban green space equality index (UGSE) measuring the equitable distribution of overall urban vegetation within a city; and the other is an urban public green space equality index (PGSE) focusing on public's access to vegetated spaces.

The UGSE and PGSE at the national scale are 0.459 and 0.631, respectively (higher means more unequal). Strong disparities have been found in urban green space provision within the 341 case study cities. The UGSE ranges from 0.087 (Alashan) to 0.884 (Jiuquan), and the PGSE ranges from 0.059 (Naqu) to 0.884 (Lasa). Statistical analysis confirmed a significant association between urban green space equality and socio-economic statuses of a given city. Cities with a greater percentage of highly educated residents tend to have a higher level of inequality of accessibility to urban green spaces and parks. The average housing area per capita of a city is negatively associated with urban green space inequality. A city with a higher share of urban hukou residents (often considered to be advantaged residents of a city) provides more equal distribution of both urban green spaces and public green spaces. These findings can help decision makers evaluate regional disparities in urban green space inequality thereby providing important information for urban green space provisioning, policy, and planning.

Key words

Urban vegetation, Urban public green space, Spatial Inequality, Gini index, Chinese Cities, Comparative Study, Big data, Point of Interest





Analytical Methods

Two indexes based on Gini-coefficient are invented to measure the inequality of accessing urban green spaces: one is UGSE for measuring the inequality of accessing urban vegetation and the other is PGSE for measuring the inequality of accessing urban parks. Gini-coefficient is commonly used in measuring income disparities, but it is also plausible to detect other inequality such as access to green spaces and transportation (Jang, An, Yi, & Lee, 2016; Wüstemann, Kalisch, & Kolbe, 2017; Yao, Liu, Wang, Yin, & Han, 2014). LISA uses Anselin Local Moran's I index to interpret spatial clustering. LISA can identify two types of clusters and two types of outliers of census units (ESRI 2017).

For Gini index of accessing urban green spaces:

$$Equality\ Index_{city} = 1 - \sum_{n=1}^{N_{city}} \frac{P_n}{P_{city}} * (\theta_n^{gs} - \theta_{n-1}^{gs})$$

$$for\ \theta_n^{gs} = \frac{\alpha_n^{gs}}{\alpha_{city}^{gs}}$$

Where:
α_n^{gs}: access to urban vegetation or parks of 1km population grid n.
P_n: population of 1km population grid n of a city

Formula for LISA is:

$$I_i = \left(\frac{z_i}{\sum_i z_i^2}\right) \sum_j W_{ij} Z_j$$

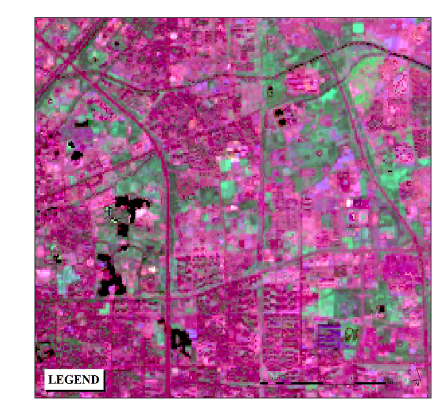
z_i and z_j : deviation from the mean
W_{ij} : the spatial weight matrix

An interactive visualization website based on CartoDB is also available here:
https://anonymous-participant.carto.com/builder/b4792b72-6518-45c6-9057-0092db82fc85/embed

Measuring Accessibility to Urban Vegetation

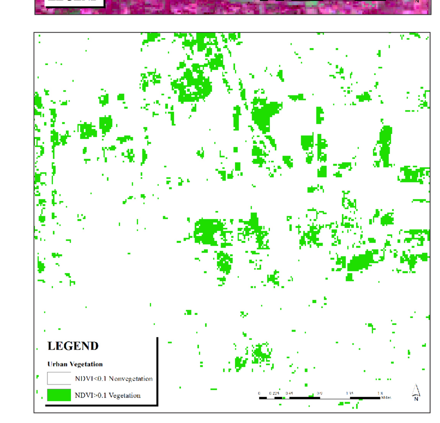
1) Calculate NDVI

NDVI value comes from growing season Landsate8 Images.



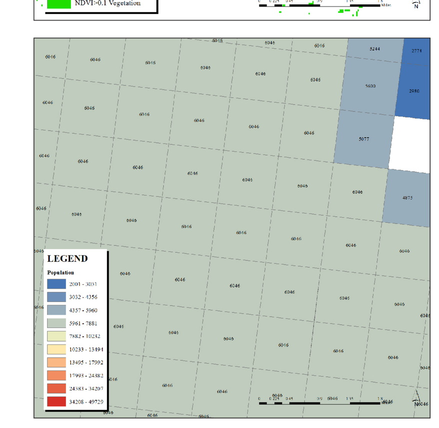
2) Extract Urban Vegetation

Extract vegetation area based on preprocessed NDVI map by setting the threshold value at 0.1 following the methods in previous study (Nesbitt et al., 2019).



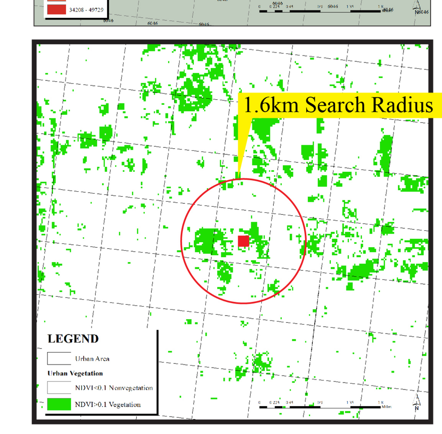
3) Population of Urban Areas

The 1km resolution population density grids with value higher than 2000 people are extracted to be considered as urban areas (Mao et al., 2015).



4) Calculate Accessibility to Vege

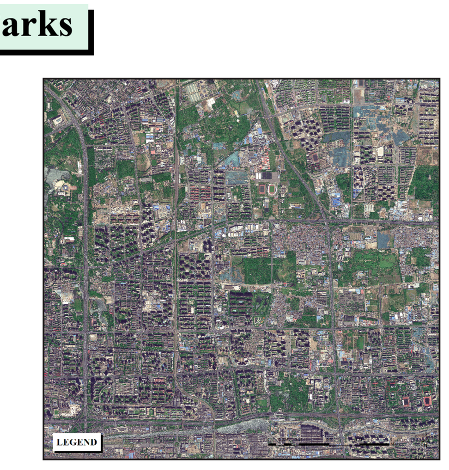
The total area of vegetation in 1.6 km from the centroid of each 1km population grid is calculated.



Measuring Accessibility to Urban Parks

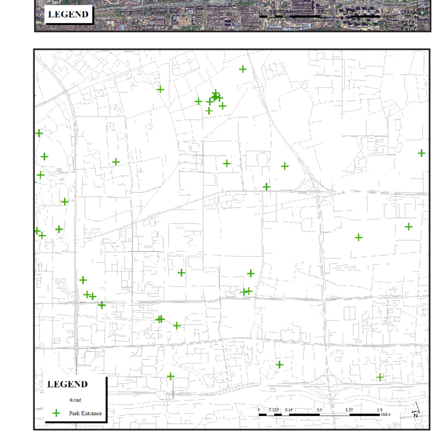
1) Extract Point of Interests

Point of Interest of parks and public spaces are extracted from Gaode map, and then the areas and entrances of each parks are obtained from high-resolution satellite maps of the same sources.



2) Identify Parks and Roads

The road network vectors also come from the Gaode map along with processed park entraces using as destination of parks.



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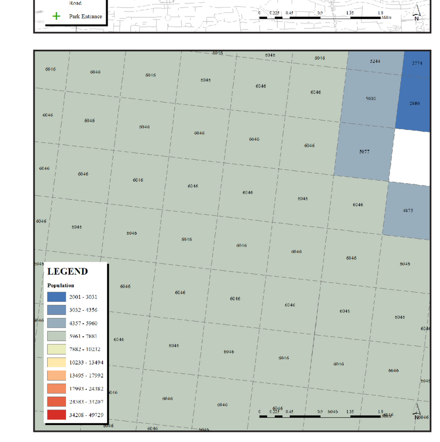

4) Calculate Accessibility to Parks

The accessibility to parks is measured by accumulated areas of parks (weighted by distance) within 1.6km walking distance from centroid of each 1km population grid.