

GREEN CITY

Introduction

When one wants to Quantify How Green a Metropolitan City like Istanbul, London, Mumbai etc are, Then the First Most Important Question that arises is “What is it that makes a City Green?” or put another way - **What is a “Green City”?**

To understand what a Green City is let us look at a couple of definitions by Authoritative figures within the Sustainable development ecosystem.

1. *“Green cities have clean air and water and pleasant streets and parks. Green cities are resilient in the face of natural disasters, and the risk of major infectious disease outbreaks in such cities is low. Green cities also encourage green behavior, such as the use of public transit, and their ecological impact is relatively small.” - [Khan](#), 2006*
2. *“The concept of ‘Green City’ or ‘Green Development’ is not new. Previously couched within the term ‘sustainable development,’ it seeks to integrate environmental, social, and economic considerations within the city's development processes. A Green City or Green Development is an extension of this concept but is understood within the frame of a city's actions and how these actions contribute to a city or urban area advancing as green and sustainable. Green Development considers how to improve and manage the overall quality and health of water, air, and land in urban spaces; its correlation with hinterlands and wider systems; and the resultant benefits derived by both the environment and residents.” - [Lewis](#), 2015*

I believe it is important to understand what is the definition of green city, primarily because it further leads us to understand and figure out the ways through which we can measure the “*greenness of any city*”, which is the task at hand.

From a sample of definitions I came across through my research, it seems that a green city can be generically summarized as follows:

“A ‘Green City’ is a city that takes responsible political and societal action in order to achieve high environmental quality, which by itself contributes to human well-being.”

Now that we have a fair understanding of what the “*Greenness*” means in the context of Sustainability development, the next obvious question to ask is *How can the “greenness” of a city be assessed?*

On Evaluating the Greenness of a City

According to the United Nations, the proportion of the world population living in cities is expected to increase upto 68% by 2050. As the cities become more densely populated, sustainable development is more indispensable than ever and the green metrics play an important role within these arguments.

From my Understanding while I researched this Question I have come across Numerous Studies and Research articles that have tried to measure a cities’ “greenness” through the use of urban indicators, indices, and rankings. They cover a large number of categories such as energy, transport, water, waste, air quality, etc.

Each of these rankings uses different indicators to assess the cities’ degree of “greenness,” so that their final results are not comparable. Furthermore, they are based on quantitative and qualitative indicators. The presence of the latter, though, without a specific unit of measure, doesn’t allow to monitor cities’ performances over time and thus to understand their real progress or decline in terms of being green.

But Nonetheless there have been almost 25 - 56 different metrics that various stakeholders pursuing sustainable development goals have used at various periods of time Since 2006 to measure the “Greenness” of any City across the World.

However as we stand today, the Huge spectrum of metrics/Indicators based on a wide range of factors have been condensed and solidified into 13 different Indicators/Metrics that are currently defined based on which one measures the “Greenness of a City” by the United Nations at the [SDG11](#) Conference held by UNGA in 2015.

The factors which are used to measure the Greenness of a city as per SDG11 are:

1. CO2
2. Air quality
3. Energy
4. Buildings
5. Transport
6. Water
7. Waste
8. *Green areas and land use*
9. Acoustic Environment
10. Health and Safety
11. Education
12. Equity
13. Participation

Most of these factors/Indicators can be measured Quantitatively by various Scientific Techniques, with the exception of an Indicator like ‘Participation’, a detailed explanation of how these Indicators are measured can be found at the SDG11 website.

Out of all these Indicators, one of the most important Indicator that we are interested to measure is “*Green areas and land use*”

This Indicator is a significant one that can be used to measure the Overall Greenness of a city, However it does not Provide a complete Holistic Picture, Unless we consider the other factors as well, But it can be argued that the Quantification of Urban Canopy Cover can Serve as a good proxy to understand the Bigger picture of any Metropolitan City as it might be directly suggestive of other Indicators within the SDG11 recommendations.

Based on this we can reframe our further Exploration as “How can we use Green area and land use Indicators of a city to measure it’s Greenness?”

Measuring the Greenness of Cities based on Urban Canopy Cover

To Account for how green a Metropolitan city is, multiple indicators and their measuring methodologies have been developed, From my understanding this can further be broken down into four different levels of measurement and the method we pick, further determines the type of data necessary to actually measure it.

The Question which determines the type of data which can be useful for green measurement of a city is “At what level do we want to measure the Greenness of a city?” The answer to the above question can be either “Top-Down” or “Eye-level Perspective” . depending on which one chooses there are few different metrics one can use to measure the greenness of a city.

The top Metrics used in general are NDVI, GVI, sGVI, PGVI, FGV

Here's a quick summary of my understanding of these different metrics:

Metric Type	Dataset Source	Description	Works Best For
GVI (Green View Index)	Colored pictures/ Street View images at different angle	Measure the proportion of green pixels in each image	Site Level
sGVI (Standardised Green View Index)	Colored pictures/ Street View images at different angle	Measure the proportion of green pixels in each image	Street+Area Level
PGVI (Panoramic Green View Index)	Street View panoramas	Measure the proportion of green pixels in each panorama	Street Level
FGVI (Floor Green View Index)	NDVI and 3D building model from LiDAR	Measure green patches seen from building floors in 3D city model	Floor Level
NDVI (Normalized Difference Vegetation Index)	Satellite images	Normalize the difference of red and near infrared bands	Area Level

1. **GVI** is an indicator that is designed to capture the greenness based on the visibility of greenery at a **street view level**. However, as GVI is point-based estimation, when aggregated at an area-level by mean or median, it is **sensitive to the location of sampled sites**, overweighting the values of densely located sites.
2. To make estimation at **area-level** more robust, GVI has been adapted into what is called as **sGVI**. It has been found that sGVI is **better at capturing the vegetation better at the city centres**, whereas the NDVI is better at capturing the vegetation better where there are parks, Sanctuary etc
3. The amount of greenness in a given area is traditionally quantified by land use data with green coverage or the Normalized Differential Vegetation Index (NDVI) derived from satellite imagery and the use of infrared light.
4. To account for greenness underestimated by land use data or the NDVI, such as urban forests, the Green View Index was proposed, which makes use of colored pictures to assess street-level visibility of green vegetation. This index is further elaborated by developing an automated program to estimate the visibility of greenness using the **Google Street View API**, enabling large area coverage.
5. Apart from street-level visibility, the Floor Green View Index measures green patches seen from a building floor, using LiDAR and 3D modeling

data for buildings and NDVI for vegetation. The floor GVI focuses on the visibility of greenness from a building, without considering physical interaction with vegetation.

6. *Greenness in well-developed neighborhoods tend to be underestimated by NDVI.* but it can be captured well by using sGVI.

Measuring the Greenness of a city with Machine Learning.

As I've summarised in the last section there are multiple green metrics to measure the greenness of a city based on different views, Now from the point of this task since it is described that we utilize the Maps dataset, we can use the *google street view image dataset to estimate the GVI* of various sites within the cities and extrapolate it to bigger areas. Something along the lines of the treepedia dataset.

In terms of measuring the greenness, we can treat this problem as a *Semantic Segmentation problem* and we can design an end to end ML model(something like DCNN architecture) and the green pixels are identified using the spectral information of GSV images As *green vegetation has high reflection at green band and low reflection at red and blue band.*

Further we can Extrapolate the GVI from site level to Area level via Something like sGVI Since simple stats like mean/median might be biased as it might get skewed towards areas where there are more samples of the sites.

Conclusion

To conclude, I would Measure the How green a city is based on Urban cover estimation as a primary technique, although this might not be the most accurate way to do this, However it gives a fair idea.

Within this I would use the street-level view based metrics GVI/sGVI as the green metric. The problem itself would be framed as Semantic segmentation task with google street view datasets.

A possible Exploration further would be to try to combine the NDVI and sGVI together, since NDVI is good at certain types of locations (large swaths of greenery like parks etc) and GVI based metrics are good at mostly densely packed city center type locations to get a better measurement.

Reference

1. [Global Sustainable Development Report](#)
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4. [Assessing street-level urban greenery using Google Street View and a modified green view index](#)
5. [Using deep learning to examine street view green and blue spaces and their associations with geriatric depression in Beijing, China](#)
6. [Standardized Green View Index and Quantification of Different Metrics of Urban Green Vegetation](#)
7. [Green City Concept and a Method to Measure Green City Performance over Time Applied to Fifty Cities Globally: Influence of GDP, Population Size and Energy Efficiency](#)
8. [Green City Development Toolkit](#)
9. [IASS Review of Existing Indicators and approaches on How green is a green city?](#)