



Mapping Urban Green Cover



Implemented by
giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

On behalf of:
 Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety
of the Federal Republic of Germany

In Cooperation of
 Federal Ministry
of the Interior, Building
and Community
of the Federal Republic of Germany


Ministry of Housing
and Urban Affairs
Government of India


Smart City
MISSION TRANSFORM-NATION



Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

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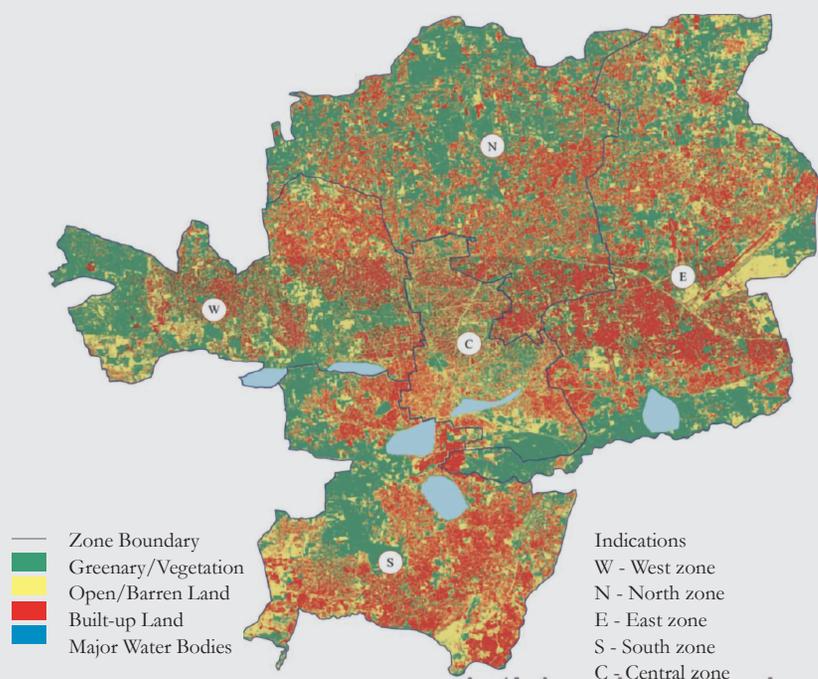
Green cover in urban spaces

Green cover is defined as natural or planted vegetation covering a certain area of terrain, functioning as protection against soil erosion, protecting the fauna, and balancing the temperature. Green areas are defined as man-made city level and zonal/ district level greens; and reserved/ protected areas as per MoHUA's "Urban Greening Guidelines", 2014 and protected areas under the Wildlife Protection Act, 1972. ClimateSmart Cities Framework Assessment 2.0 published by Ministry of Housing and Urban Affairs, GoI, 2021. It also highlights the importance of green cover for sustainable urban centres.

Need to map green cover

Green cover is an important environmental resource which needs to be preserved for ecological well-being of every city, improvement of health, quality of life for its residents and most importantly as a guard against extreme climate change impacts. It is important for every city to understand the proportion, quantity and quality of green cover so that policies can be formulated and actions can be taken to ensure its adequacy and the accessibility of green space for each citizen.

Figure 1: Land classification analysis of ArcGIS showing green cover in Coimbatore



In GIZ's green cover study for Coimbatore, the definition was modified to include all visible green as seen from the satellite which broadly include forests, agriculture, vegetation along water bodies, streets, dedicated parks-gardens, reservations on plots and vegetation on building roofs or vertical surfaces.

Source: Mobilisation of green spaces by intensifying recreational use in urban area. Study by Tamil Nadu Institute of Urban Studies (2019)

Spatial mapping of green cover can be done on a periodic basis to find out the reasons behind depletion of green cover or find out what strategies are leading to increase in green cover.

Distribution of green cover across the entire city is vital and hence, each zone or ward level mapping can be done to indicate where green cover in the city is lacking and where green strategies need to be strengthened.

Percentage of green cover in the city can be calculated using a simple formula =

$$\frac{\text{Green cover in sq.km}}{\text{Municipal area in sq.km}} \times 100$$

Green cover measurement can be done by remote sensing on GIS based software like ArcGIS, QGIS or Google Earth Engine.

Table 1: Hierarchy of recreational spaces at various scales.

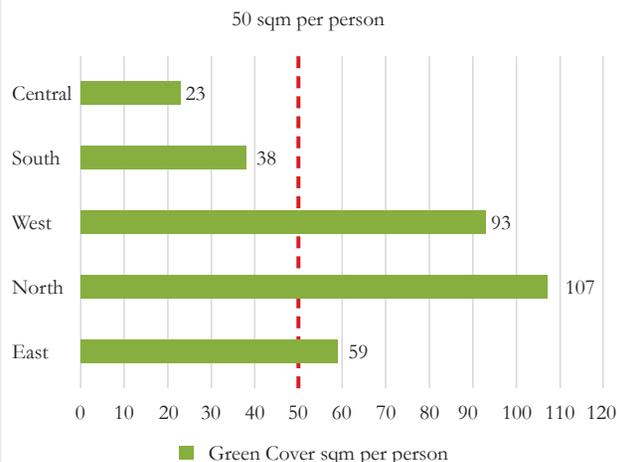
S.no.	Category	Population served per unit	Area Requirement(Ha)
1.	Housing Area Park	5000	0.50
2.	Neighbourhood Park	15000	1.00
3.	Community Park	1 lakh	5.00
4.	District Park	5 lakh	25.00
5.	Sub city Park	10 lakh	100.00

Source: Urban and Regional Development Plans. Formulation and Implementation Guidelines. Ministry of Urban Development, GoI (2016)

There is also a need to have adequate number and sizes of recreational spaces which are distributed across the city at various scales to make sure that different types of green spaces are equally spread in a city and accessible to all.

Per capita availability of green cover is also an important indicator to determine whether green cover is sufficient for each person in the city. Zones in which population density is extremely high, appropriate measures need to be taken to make sure that adequate green cover is available per person. Please refer Standards of World Health Organisation, which prescribes minimum 9 sqm green cover per person and an ideal of 50 sqm per person.

Figure 2: Urban green cover study of Coimbatore showing area of green cover per person in each zone. South and Central zone do not reach the benchmark of 50 sqm pp and hence greening strategies in those zones are recommended.



Source: Urban Green Cover Framework in Coimbatore. Report prepared by GIZ (2020)

Geo Spatial tools to map green cover

Mapping green cover can be done remotely through the 'Land Classification Analysis' method using remote sensing tools available in desktop-based platforms like ArcGIS, Q-GIS or Google Earth Engine. This method of mapping green cover is 85% accurate hence further ground truthing methods are needed to determine the accuracy in data.

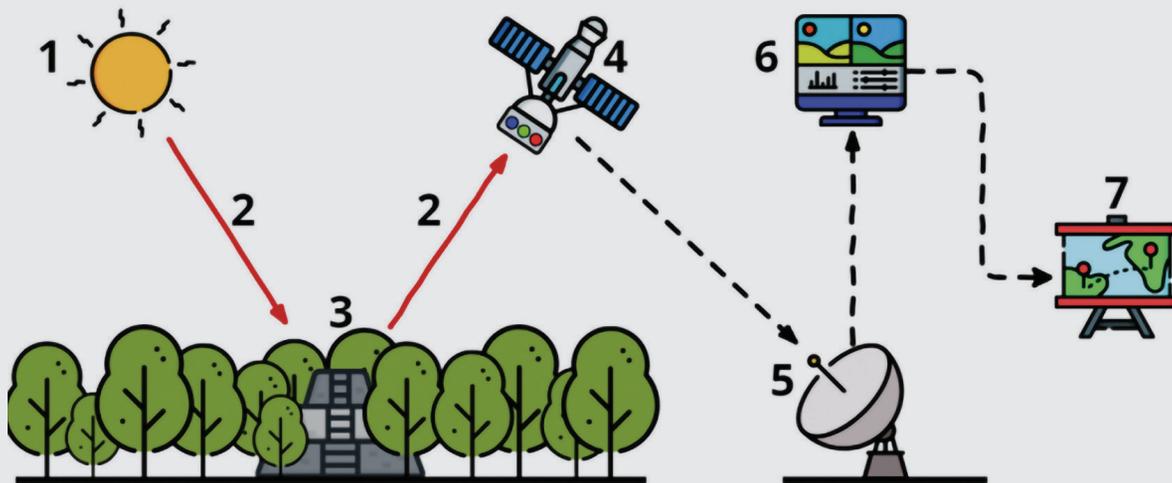
Cameras with specialised sensors attached to drones are used for a much more granular vegetation mapping. Detailed vegetation and species level mapping on ground is done using data collection apps on Smart Phone which are GPS enabled.

Green cover data collection through remote sensing

Remote sensing is a technique used to collect data about the earth without taking a physical sample of the earth's surface.

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth. Figure 3 shows the process of capturing remote sensing data for urban green cover map.

Figure 3: Process of capturing remote sensing data



Usage of Remote sensing

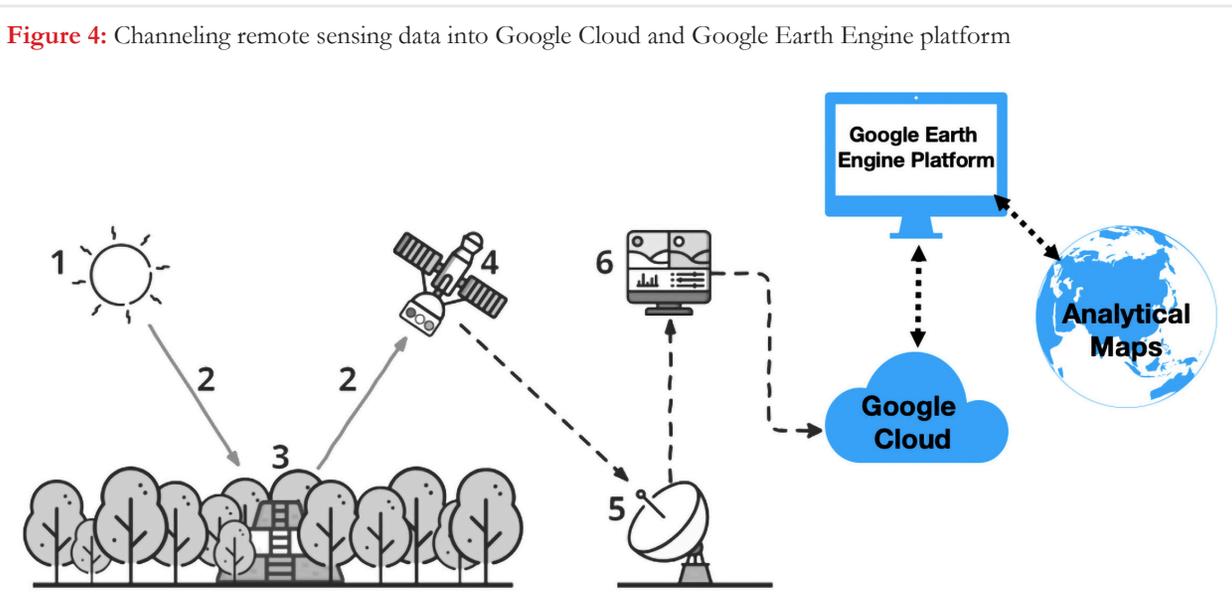
- Tracking the growth of a city and changes in farmland or forests over several years or decades
- Large forest fires can be mapped from space, allowing rangers to see a much larger area than what is possible from the ground
- Tracking clouds to help predict the weather or watching erupting volcanoes, and watching for dust storms
- Discovery and mapping of the rugged topography of the ocean floor (e.g., huge mountain ranges, deep canyons, and the “magnetic striping” on the ocean floor)

Architecture of Google Earth Engine

The Google Earth Engine is a cloud-based platform for geospatial analysis that is open-source access and free of cost for all users. The platform requires a simple online application and google user account to access the Earth Engine. Figure 4 shows how remote sensing data can be used in the Google Earth Engine. The Google Earth Engine uses the programming language Javascript code editor platform which is also shown in a separate table, Figure 7. The purpose of Earth Engine is to:

- Provide an interactive platform for geospatial algorithm development and
- Enable high-impact, data-driven science

Figure 4: Channeling remote sensing data into Google Cloud and Google Earth Engine platform



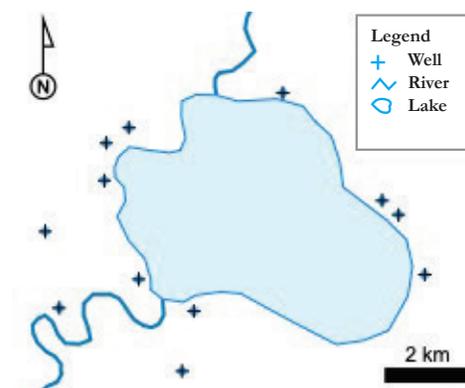
Spatial representation using Shapefile

The shapefile is a geospatial vector data storage format for storing the location, shapes and associated attributes of geographic features for geographic information system software.

The main file (.shp) contains the geometry data. This format should not be confused with the AutoCAD shape font source format, which shares the .shp extension.

The shapefile format stores the data as primitive geometric shapes like points, lines, and polygons, as shown in Figure 5. These shapes, together with data attributes are linked, creating the representation of the geographic data. The term “shapefile” is quite common, but the format consists of a collection of files with a common filename prefix, stored in the same directory. The three mandatory files have filename extensions .shp, .shx, and .dbf. The actual shapefile relates specifically to the .shp file, but if distributed alone it will be incomplete, it needs the other supporting files for distributing.

Figure 5: Example of shapefile consisting of points, lines and polygon geospatial vector information for Coimbatore City Municipal Corporation that can be uploaded into Google Earth Engine platform.



Source: <https://en.wikipedia.org/wiki/Shapefile>

These files are used on desktop and web GIS based software such as ArcGIS, Quantum GIS, GeoBase, GRASS GIS, SAGA GIS and Google Earth Engine among other products.

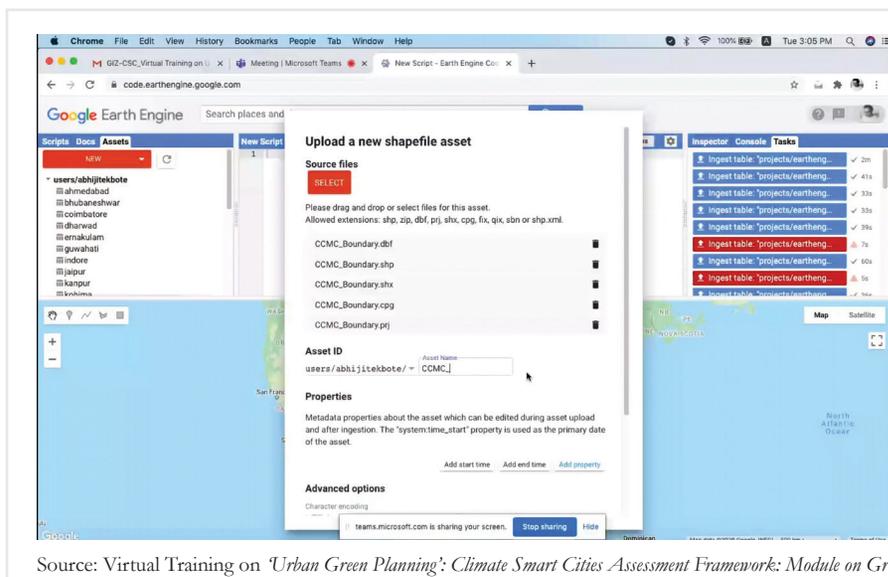


Figure 6: Example of Coimbatore City Municipal Corporation boundary shapefile assets that was uploaded into Google Earth Engine platform

Source: Virtual Training on 'Urban Green Planning': Climate Smart Cities Assessment Framework: Module on Green Cover. Prepared by GIZ (2020).

Data repository to access shapefiles of cities

The shapefiles for each city have to be created by their own local administration on a GIS platform to ensure its accuracy in determining the city boundary. Figure 6 shows Coimbatore City Municipal Corporation boundary shapefile assets that was uploaded into Google Earth Engine platform.

Some online platforms have made these shapefiles available for cities in India. However, the accuracy of the boundary can only be ascertained by the local administration.

Some of these sources include:

1. <https://www.diva-gis.org/gdata>
2. https://github.com/datameet/Municipal_Spatial_Data

JavaScript Application for Google Earth Engine

JavaScript is mainly used for web-based applications and web browsers. JavaScript is used to manipulate the contents of a web page and to allow users to interact with web pages without reloading the page.

JavaScript improves the user experience of the web page by converting it from a static page into an interactive one.

The Javascript can be used in Google Earth Engine (<https://code.earthengine.google.com/>) to load and visualise the satellite imagery and also carry out geostatistical and geospatial operations on the available imagery of the city.

Figure 7 shows how a webpage like Google Earth Engine, has space on the same window to type and run a JavaScript and the effects of the script can be simultaneously seen

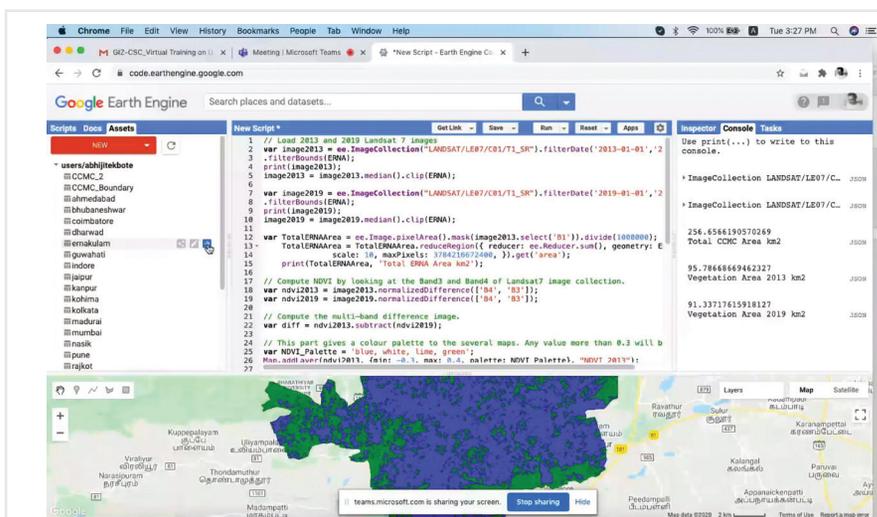


Figure 7: Example of webpage of Google Earth Engine where JavaScript is needed to run and view the result of the script on the same webpage

Source: Virtual Training on 'Urban Green Planning': Climate Smart Cities Assessment Framework: Module on Green Cover. Prepared by GIZ (2020)

reflected in the map window below it. This type of simultaneous operation on a single webpage can only be done using JavaScript.

No specialized skills are needed to learn JavaScript. One can learn this scripting language by taking up a professional course. Several books are available to learn the language for both beginners and advanced developers. Some recommended books include *A Smarter Way to Learn JavaScript* by Mark Myers and *JavaScript for Kids: A Playful Introduction to Programming* by Nick Morgan.

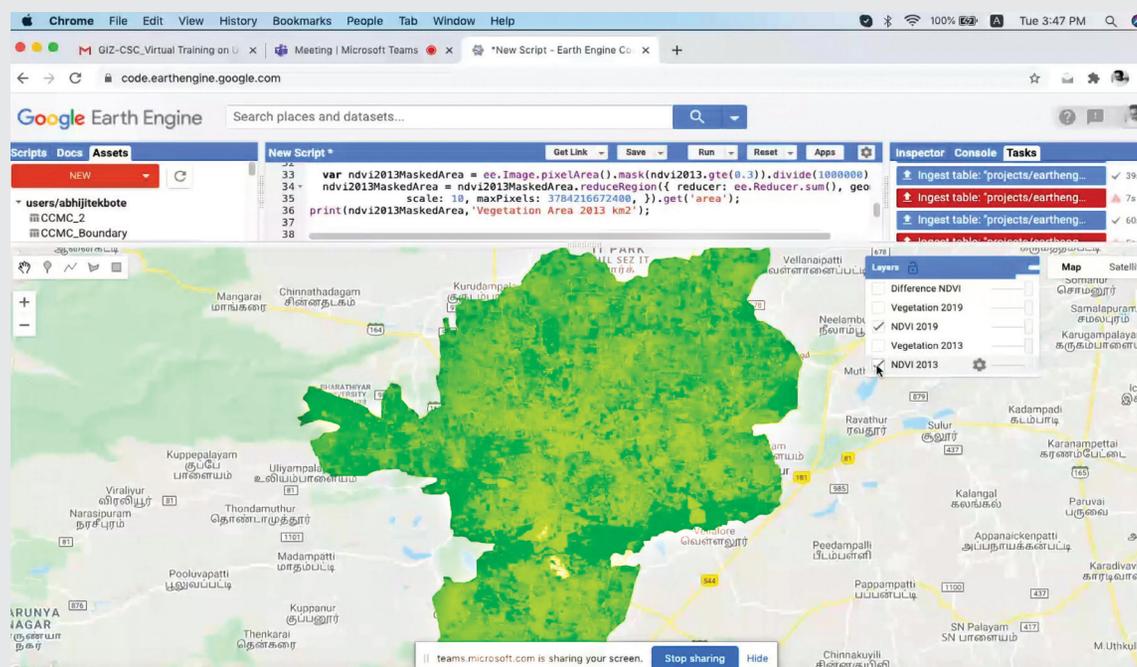
It is not necessary to formally learn JavaScript to work with Google Earth Engine.

NDVI: Normalised Difference Vegetation Index and its application

The Normalized Difference vegetation Index(NDVI) is most widely used remote sensing (Satellite Imagery) spectral index to track the vegetation cover changes around the surface. In Figure 8 Coimbatore City Municipal Corporation computes NDVI by looking at the band 3 and band 4 of Landsat 7 image collection in 2013 & 2019.

The traditional formula for NDVI compares near-infrared light and red-light radiations reflected or absorbed by

Figure 8: Coimbatore City Municipal Corporation computes NDVI by looking at the band 3 and band 4 of Landsat 7 image collection

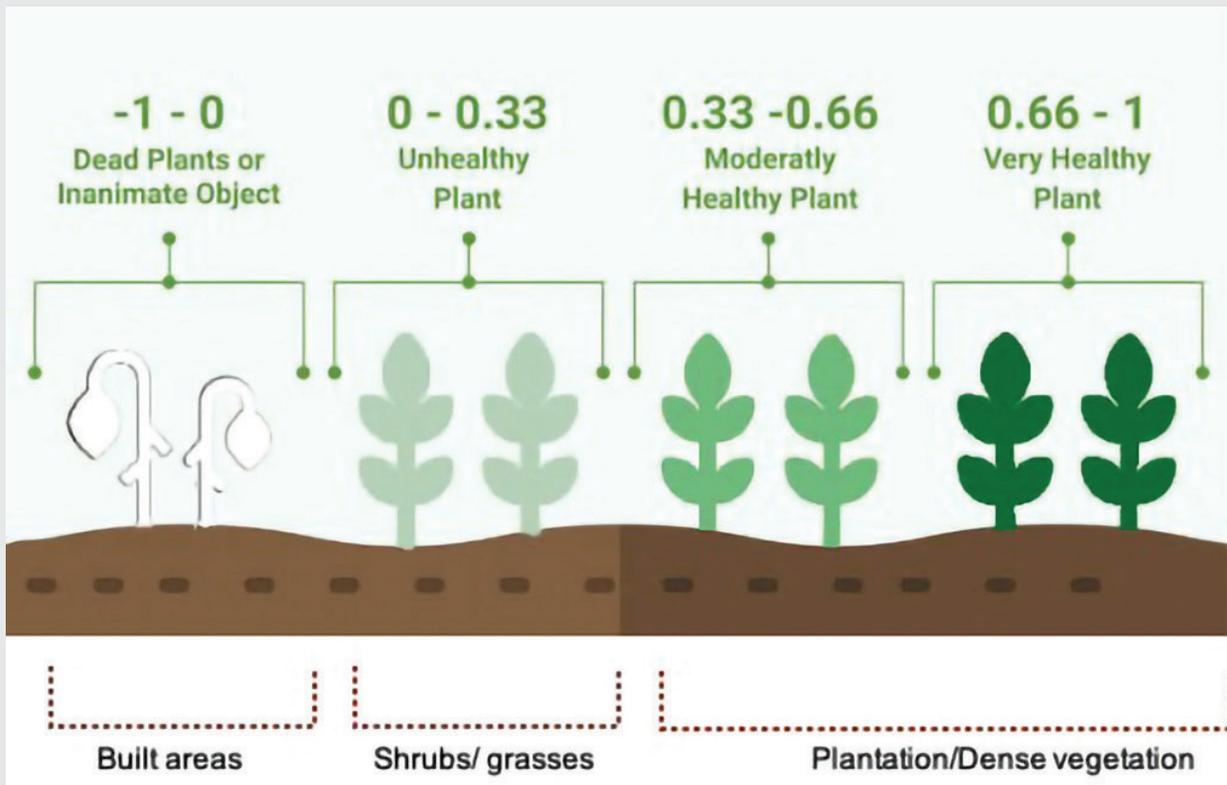


Source: Virtual Training on 'Urban Green Planning': *Climate Smart Cities Assessment Framework: Module on Green Cover*. Prepared by GIZ (2020)

vegetation with use of satellite sensors in space. Near-infrared light is a wavelength that exists through sun's radiation wavelength and is reflected by vegetation on earth; that value is captured by the satellite say as 'value A'. The red-light is a wavelength from the sunlight that is absorbed by vegetation and its value is captured by the satellite too, say as 'value B'.

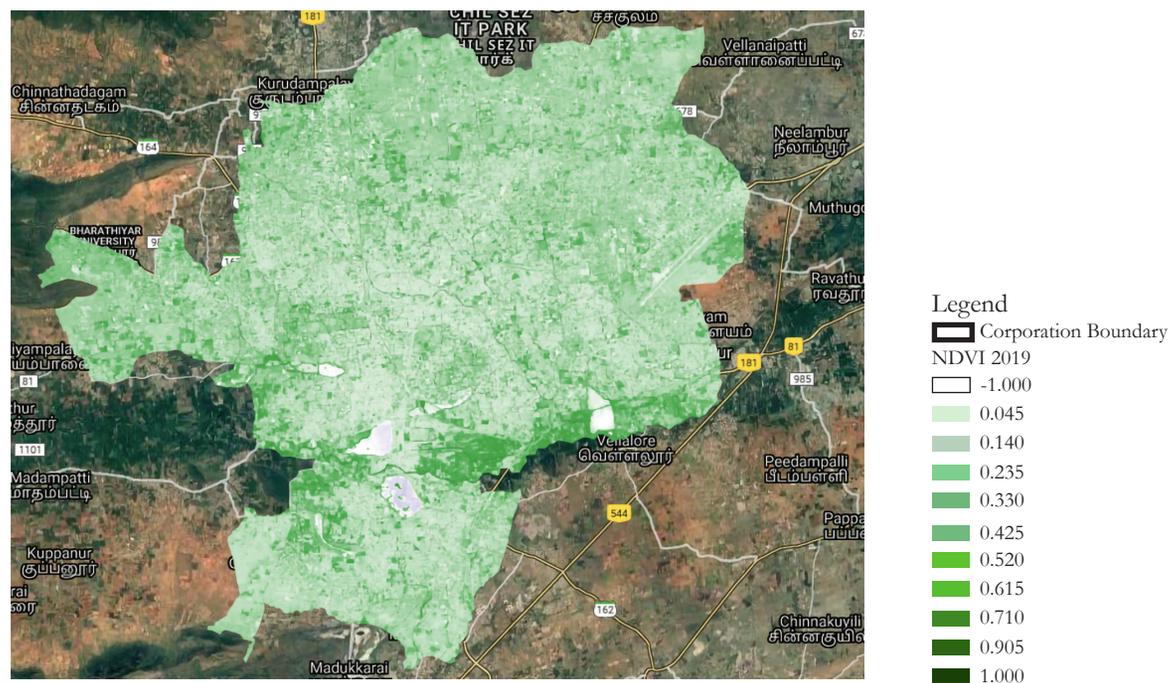
The difference between 'value A' and 'value B' gives a measure of health of the vegetation over a wide range of conditions. The effective value ranges from -1 to 1 and the in-between ranges determine the health of greenery of the vegetation. This effective value index is known as NDVI. Figure 9 below shows the various indices for range of vegetation which are dead, unhealthy, moderately healthy and very healthy plants.

Figure 9: NDVI values for various health conditions of vegetation. The labelling below this diagram determines what type of land use or plantation type is usually observed corresponding to the various indices



NDVI changes seasonally, hence it is imperative to map it during the same seasons across years to understand the pattern of change. Figure 10 shows the NDVI map of Coimbatore City Municipal Corporation as an annual composite data of 2019.

Figure 10: NDVI map showing varying vegetation across Coimbatore City Municipal Corporation



Source: *Urban Green Cover Framework in Coimbatore*. Report prepared by GIZ (2020)

Difference between NDVI and green cover

NDVI is the varying vegetation condition that ranges from no-vegetation, dead-vegetation to moderately healthy and extremely health vegetation. Whereas, green cover is all the visible natural and planted area of vegetation as is

visible from the satellite. The values below 0.3 cannot be considered to be vegetation for calculating the area of green cover because it can include dead plants and also built cover or bare soil. For all practical purposes, values of all green cover from an NDVI map which are greater than 0.3 are considered to be substantial vegetation for calculating the city's green cover.

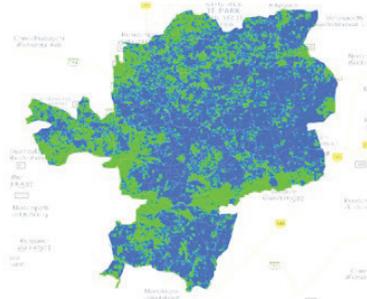
The Figure 11 shows the difference between these two concepts in a spatial map and corresponding legends for the city of Coimbatore.

Figure 11: Difference between NDVI map and Green Cover Map

2013 : NDVI



2013 : Green Cover



All values greater than 0.3 are considered to be substantial vegetation

Source: Virtual Training on 'Urban Green Planning'. Prepared by GIZ (2020)

Land Surface Temperature

Land surface temperature is measured by recording how hot the “surface” of the Earth would feel to touch at a particular location. From a satellite’s point of view, the “surface” is whatever it sees when it looks through the atmosphere to the ground.

It could be snow and ice, the grass on a lawn, the roof of a building, or the leaves in the canopy of a forest.

(Land Surface Temperature. Retrieved from Earth observatory: https://earthobservatory.nasa.gov/global-maps/MOD_LSTD_M. NASA,2020).

Increase in Land Surface temperature in a city is caused due to various reasons including vegetation being replaced by asphalt and concrete (impervious surfaces) for roads, buildings and paved public places. Exposed bare soil, dried agricultural or open plots and large-scale infrastructure projects also cause this surface temperature rise. Overall

global warming due to greenhouse gas emissions are also responsible for increased land surface temperature.

The correlation between green cover and land surface temperature

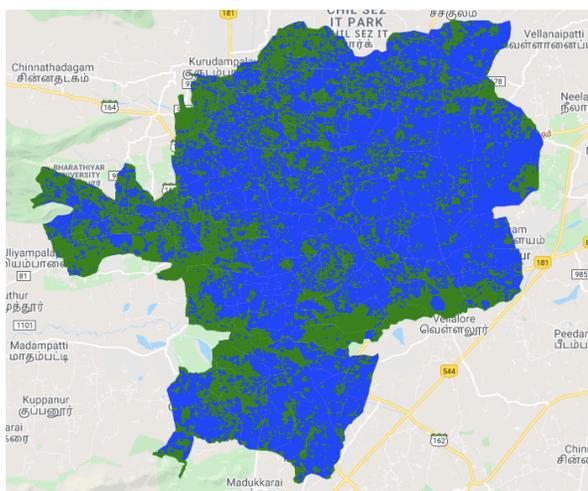
Land surfaces which are covered by green or tree cover reflect heat; lower the surface temperature by providing shade and through evapotranspiration. Research demonstrates that increasing vegetation produces cooling effect for neighbourhoods apart from reducing surface temperatures.

Likewise, loss of green cover due to urbanisation gives rise to increase in land surface temperature. Warmth rising off earth's surface influences weather and climate patterns. Frequent hot days, disasters such as storms, floods and droughts due to changing precipitation patterns and many other irreversible changes to the ecosystem are a result of the rising land surface temperatures.

Green cover study in Coimbatore reveals that in 2013 the vegetation in the city occupied an area of 95.75 sqkm. Due to a growth in urbanisation, large infrastructure projects and increase in built area, in 2019 the vegetation area has decreased to 91.33 sqkm. Hence there is a 4 sqkm loss of vegetation over 6 years which amounts to 5.4% reduction in vegetation, as shown in Figure 12.

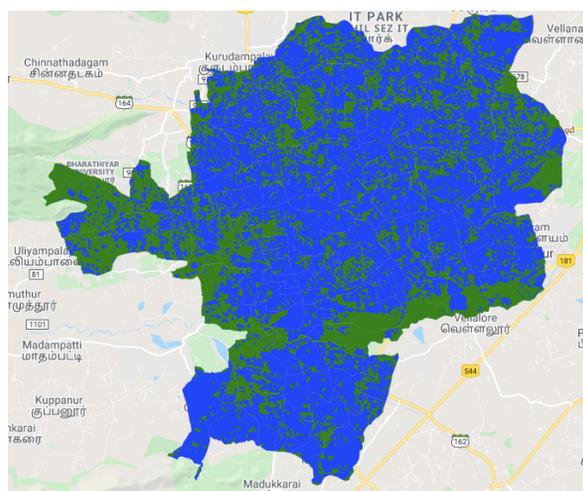
Figure 12: Change in Vegetation in Coimbatore City Municipal Corporation from 2013 to 2019

2013



Vegetation area: 95.75 sq.km.

2019



Vegetation area: 91.33 sq.km.

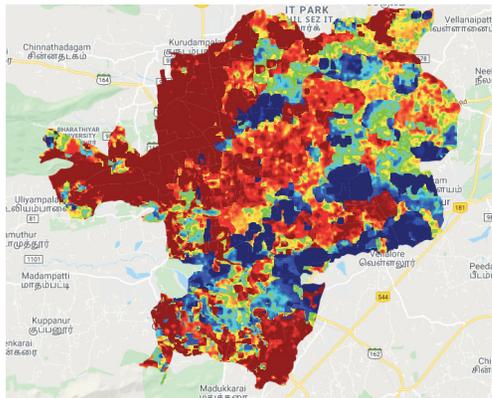
Source: Virtual Training on 'Urban Green Planning': Climate Smart Cities Assessment Framework: Module on Green Cover. Prepared by GIZ (2020)

Whereas, the land surface temperatures during the same period was 26.43 degrees Celcius (mean across the entire year) in 2013 and was 29.31 degrees Celcius in 2019, as shown in Figure 13. This concludes that for a vegetation loss of 5.4%, there is a rise of 2.8 degrees Celcius in the maximum temperature over the last 6 years.

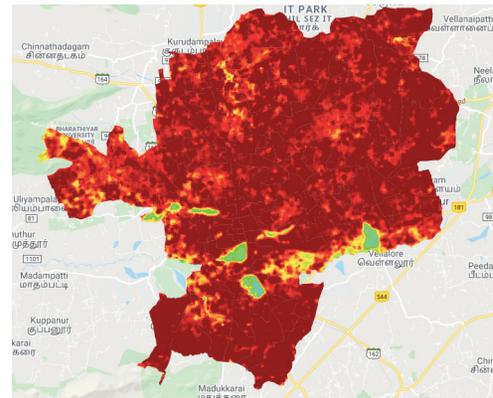
The GIZ study concludes that there is a direct correlation between the vegetation/green cover and land surface temperature.

Figure 13: Change in land surface temperature in Coimbatore City Municipal Corporation from 2013 to 2019

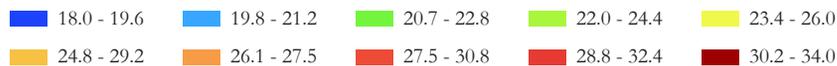
2013: 26.43°C (mean temp.)



2019: 29.31°C (mean temp.)



LAND SURFACE TEMPERATURE



Source: Virtual Training on 'Urban Green Planning': Climate Smart Cities Assessment Framework: Module on Green Cover. Prepared by GIZ (2020).

Conclusion

Sufficiently large and protected green spaces reduce the impact of human activities on environment. The urban green spaces not only makes the city aesthetically pleasing but increase its resilience. This advisory will help the city managers to calculate green cover spaces, its increasing/decreasing trends. City managers can also identify the areas for priority and immediate actions with respect to depleting green cover. This will help the city managers to strategize and incorporate green cover improvement either in City Level Climate Action Plan or City Biodiversity Plans.

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