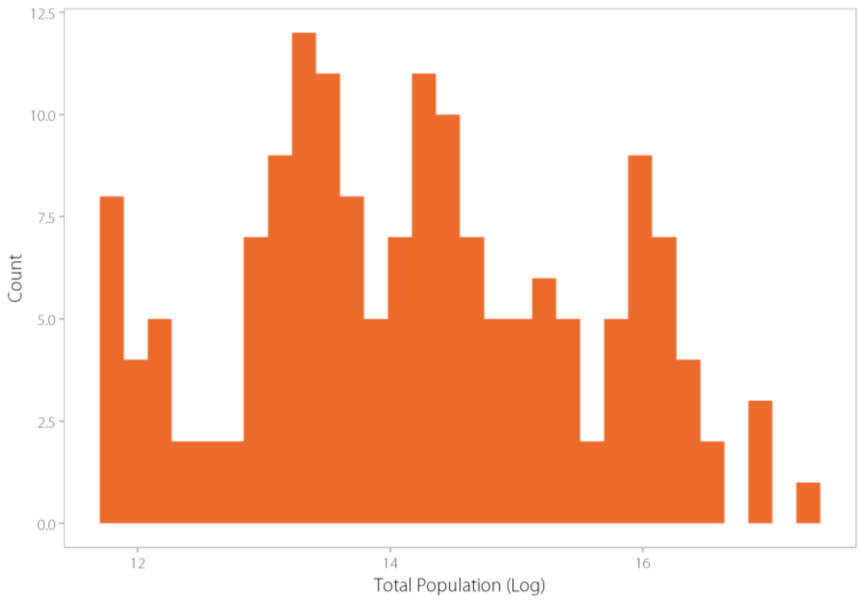
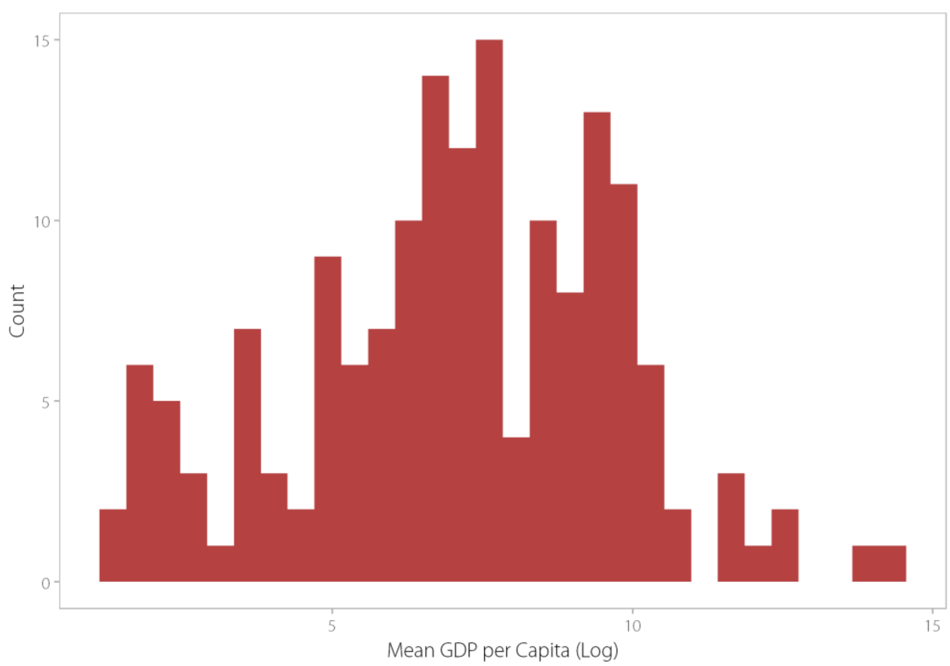
Supplementary Materials

(1) Pilot city characteristics



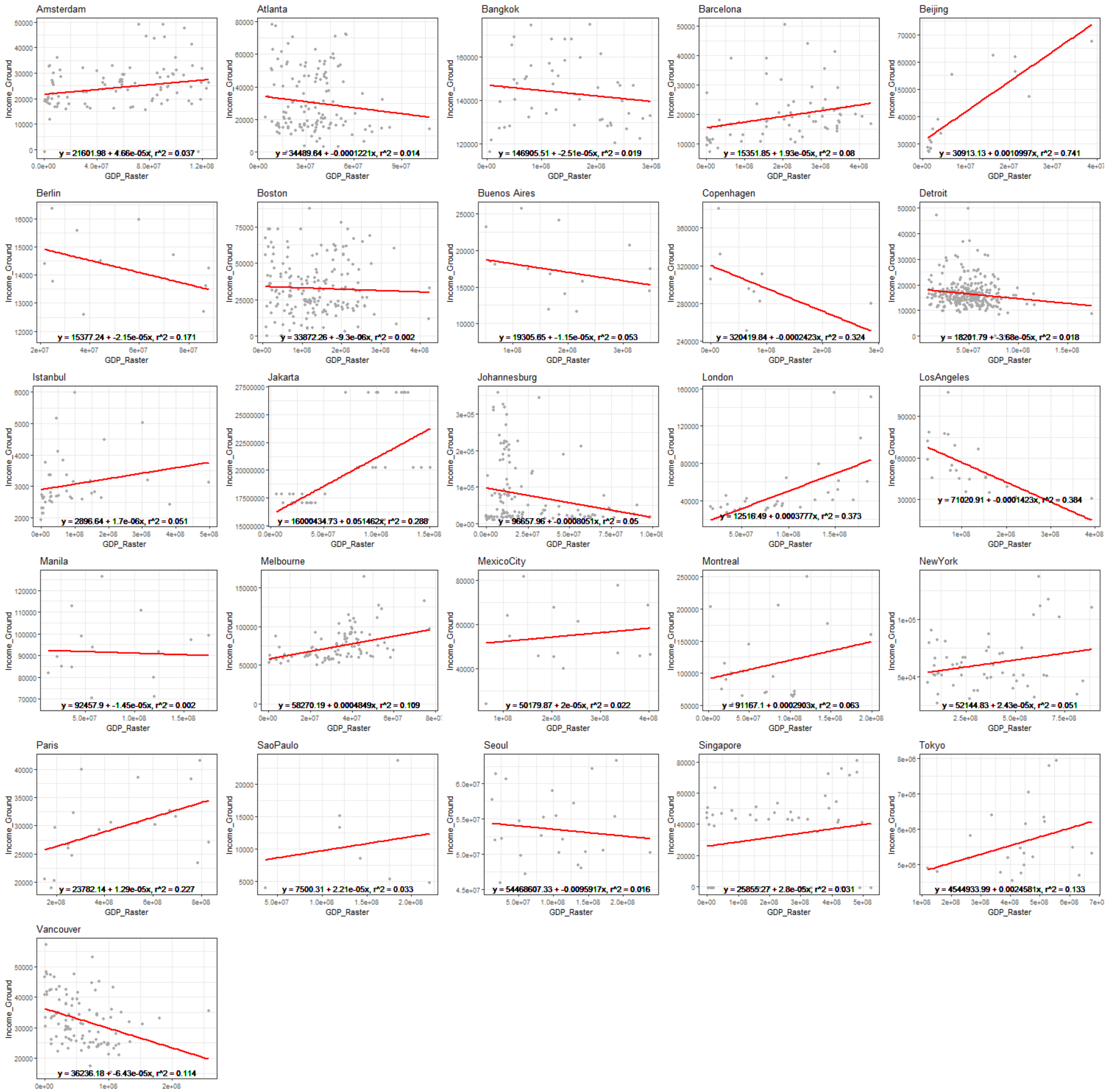
Supplementary Figure 1. Histogram of Total Population (Log) for all cities included in the UESI



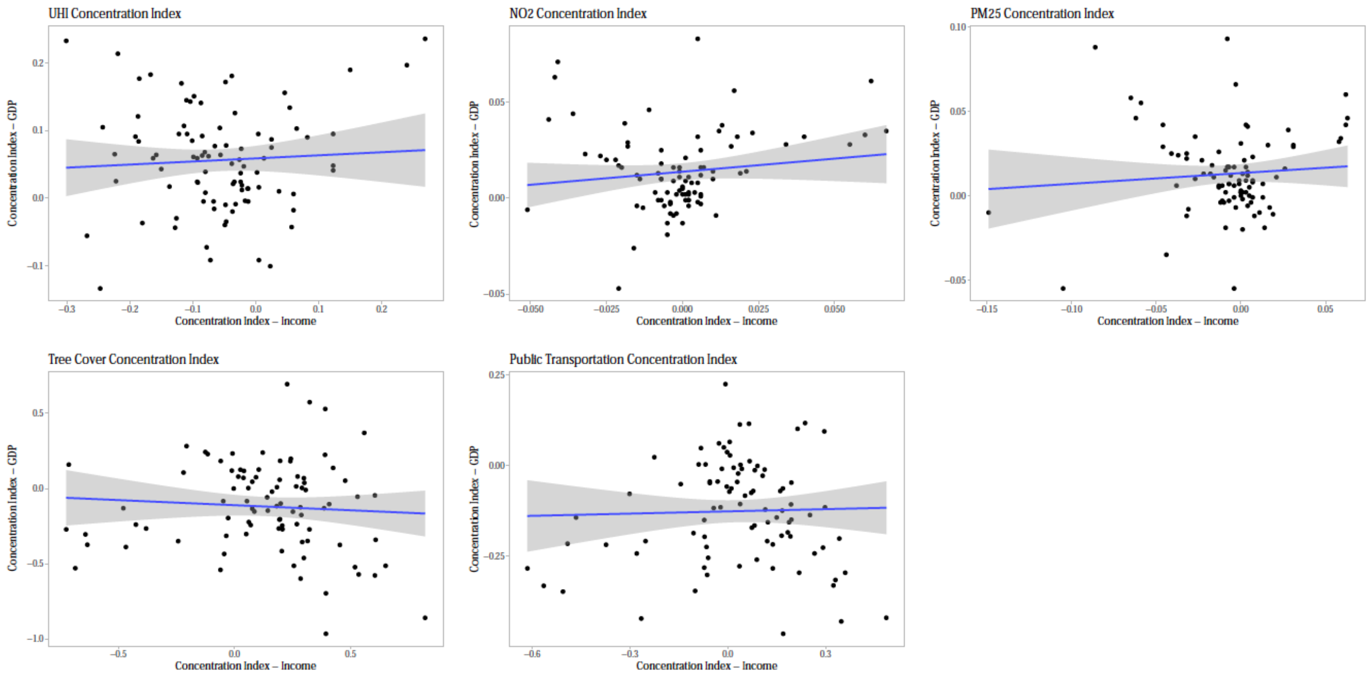
Supplementary Figure 2. Histogram of Mean Gross Domestic Product per capita (Log) for all cities included in the UESI

(2) Tier I and Tier II city classifications

Supplementary Figure 3 compares neighborhood-level income results using the Tier I (y-axis) and Tier II (x-axis) approaches in 26 UESI cities. The relationships vary significantly across different cities, suggesting there is no consistent relationship between census data and the proxy of GDP per capita data across all cities, and that the proxy is stronger in some locations than in others. Many factors might explain variation across these two approaches, including the year census data collection (many reflecting older data), and the spatial resolution of the GDP per capita data, which may not fully account for local variation between neighborhoods. Although we do not find a systematic bias between the census- and satellite-derived proxies for income, the lack of consistent association suggests that the results for the Tier II cities have higher uncertainty, which could be reduced when more accurate data sources become available.

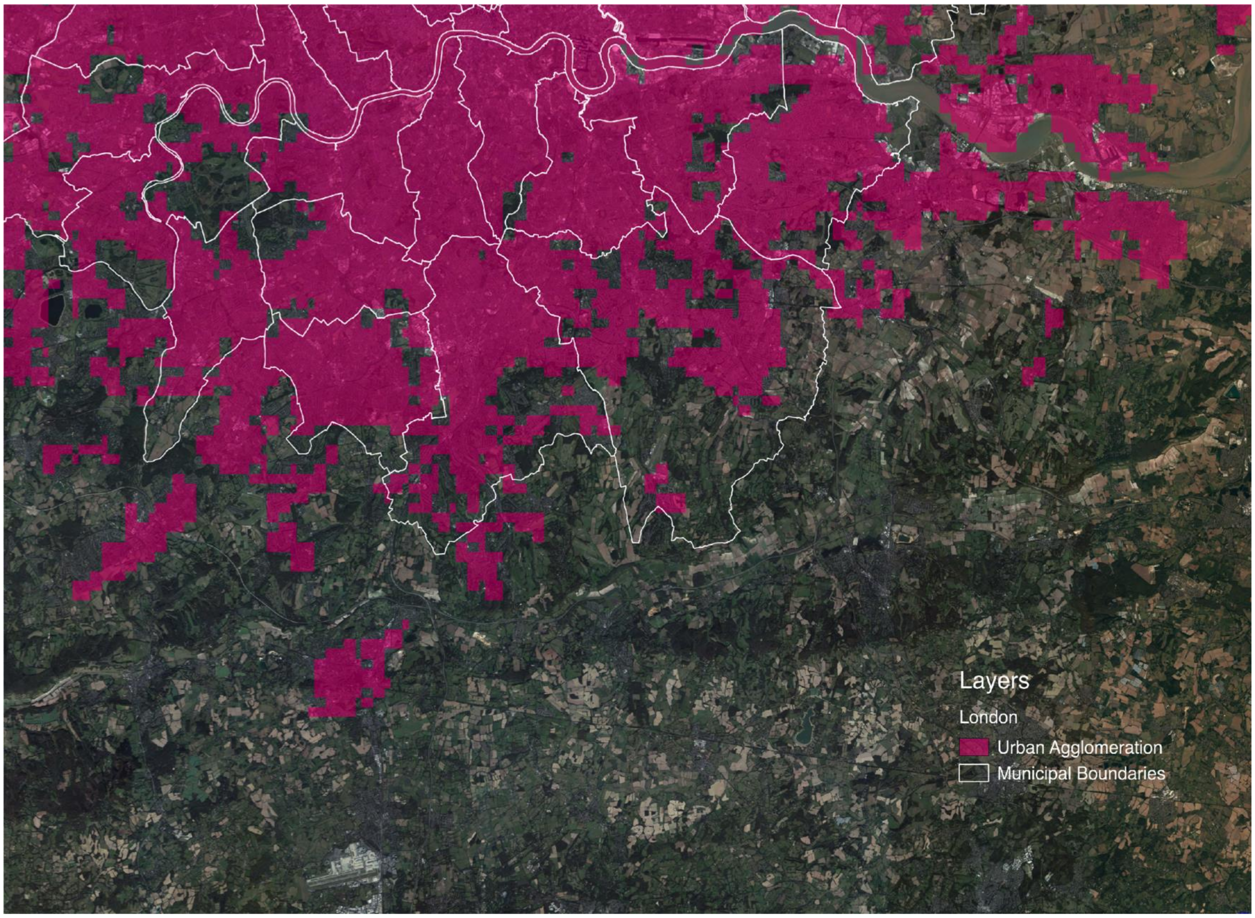


Supplementary Figure 3. Comparison of neighborhood-level income data in 26 UESI cities. The figures compare the income results according to the Tier I approach (using neighborhood-level income per capita and population data; y-axis) and the Tier II approach (using GDP per capita data from Kummu et al. (2018) as a proxy for district-level income per capita; x-axis).

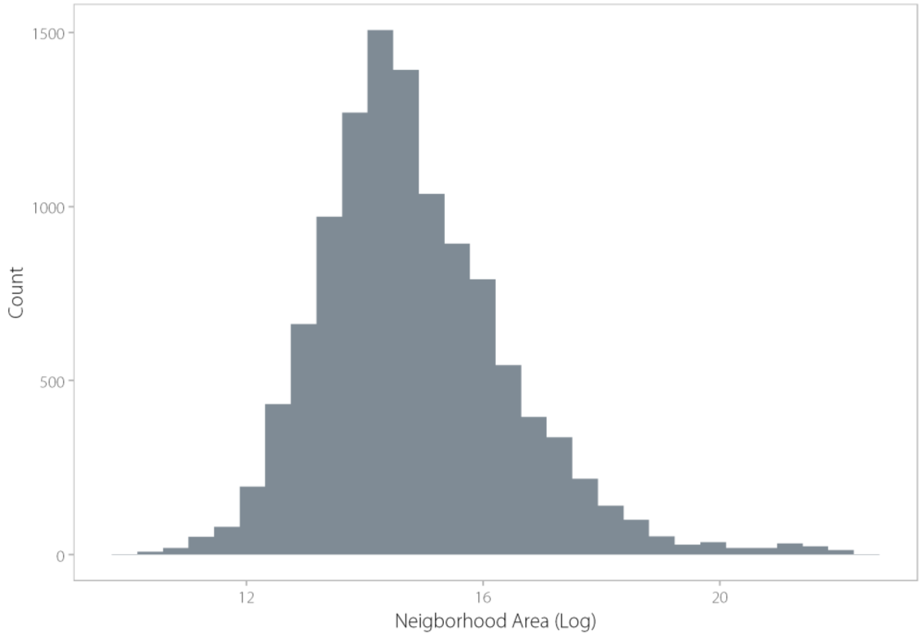


Supplementary Figure 4. A comparison of the Environmental Concentration Index results for environmental indicators, generated by using the Tier I approach (neighborhood-level income per capita and population data; x-axis) and the Tier II approach (GDP per capita data from Kummu et al. (2018) as a proxy for neighborhood-level income per capita; y-axis) to determine neighborhood-level income.

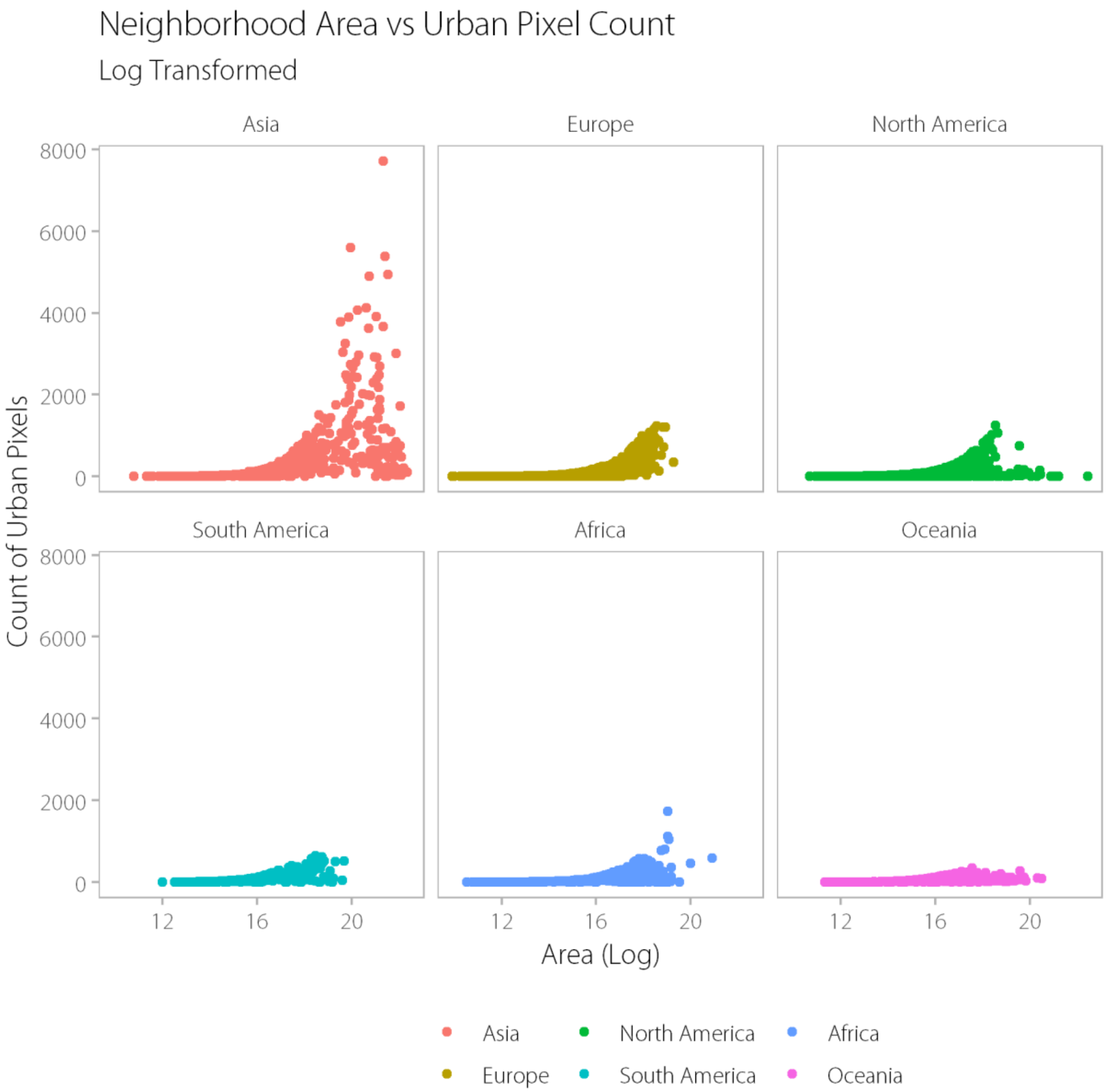
(3) Comparing urban boundary definitions: urban pixel and non-urban pixel count



Supplementary Figure 5. Comparison of London's municipal boundary and remotely-sensed urban extent based on 500-m resolution MODIS and 30-m resolution Landsat-8 data to develop a land-use classification of urban text for London.



Supplementary Figure 6. Histogram of Neighborhood Area (Log) for all neighborhoods of cities in the UESI.



Supplementary Figure 7. Scatterplots for all UESI cities, comparing the relationship between total area (Log) and urban pixels count by continent. While a positive association can be seen between both variables -- indicating that district boundaries for the cities are indeed primarily urban -- certain differences can be seen in some regions such as Asia, where official administrative boundaries incorporate non-urban land.

Supplementary Table 1. Selected UESI Results for Figures 3, 5, 6 and 7

City	continent	cluster	Concentration_Index	UESI.zscore	income.zscore
addisababa	Africa	3	-0.1	-0.9	-1.0
albuquerque	North America	2	-0.2	0.6	0.2
alexandria	Africa	4		1.1	0.6
alger	Africa	1	-0.02	-0.1	-0.6
amsterdam	Europe	4	-0.001	0.7	0.3
anchorage	North America	2	-0.1	0.7	-0.6
asuncion	South America	1	-0.04	-0.4	0.1
athens	Europe	4		0.7	-0.1
atlanta	North America	2	-0.03	0.9	0.6
baltimore	North America	4	-0.1	0.8	1.0
bamako	Africa	4	-0.03	0.8	-2.4
bangalore	Asia	3	0.02	-2.0	-0.7
bangkok	Asia	3	0.1	-1.4	-0.5
barcelona	Europe	4	-0.1	-0.2	0.5
beijing	Asia	3	0.2	-2.2	-2.6
berlin	Europe	1	-0.1	0.3	-1.1
billings	North America	2	-0.2	1.2	-0.8
bogota	South America	1	0.004	-0.6	-0.7
boston	North America	4	-0.03	1.0	1.1
bratislava	Europe	1	-0.04	0.1	-0.6
bridgeport	North America	2	-0.1	1.0	0.6
brisbane	Oceania	4	-0.02	0.9	-0.6
brussels	Europe	1	-0.1	0.3	1.6

bucharest	Europe	1	0.2	0.1	-1.3
budapest	Europe	1	-0.1	-0.1	-0.7
buenosaires	South America	1	-0.05	-0.6	-0.5
cairns	Oceania	2	-0.1	0.8	-1.7
caracas	South America	4	0.02	0.7	-1.9
casablanca	Africa	1	0.1	-0.2	-0.9
charleston	North America	2	-0.03	0.9	-0.3
charlotte	North America	2	-0.02	1.2	0.1
chelyabinsk	Europe	1	-0.01	-0.4	-1.3
chengdu	Asia	3	0.2	-2.0	-2.7
chennai	Asia	3	0.03	-1.6	-1.7
chicago	North America	4	0.01	0.5	0.2
chongqing	Asia	3	0.2	-1.4	-2.8
ciudaddeguatemala	North America	4	-0.004	0.3	0.1
ciudaddepanama	North America	4	0.2	-0.2	-0.6
cleveland	North America	4	-0.004	0.8	0.8
coimbra	Europe	2	-0.03	1.4	-0.3
conarky	Africa	2	0.1	0.4	-1.9
copenhagen	Europe	4	-0.1	1.2	-0.5
dakar	Africa	4	-0.05	-0.02	-1.0
dalian	Asia	3	-0.004	-1.5	-2.8
darwin	Oceania	4	0.02	1.0	-1.8
delhi	Asia	3	0.02	-1.9	-1.7
denver	North America	4	-0.1	1.1	0.4
detroit	North America	4	-0.01	1.0	1.0
dodoma	Africa	2	-0.02	0.3	-1.5
dublin	Europe	4	-0.01	1.4	0.3

edinburgh	Europe	4	-0.1	1.0	-0.5
evansville	North America		-0.1	0.7	0.2
fargo	North America	2	-0.2	0.7	-0.3
fortaleza	South America	4	0.1	0.3	-0.3
freetown	Africa	2	0.2	0.8	-2.2
guangzhou	Asia	3	0.2	-1.8	-2.9
hamburg	Europe	1	-0.1	0.8	0.3
hangzhou	Asia	3	0.2	-1.8	-2.8
harare	Africa	2	0.1	0.3	-1.2
hobart	Oceania	4	-0.1	1.2	-0.9
hochiminh	Asia	1	0.2	-1.6	-1.3
hongkong	Asia	1	-0.1	-0.5	-1.0
honolulu	Oceania	4	-0.2	0.5	0.6
houston	North America	2	-0.1	0.6	0.3
istanbul	Asia	1	0.2	-0.7	-1.2
jakarta	Asia	3	-0.04	-2.2	-0.9
johannesburg	Africa	3	-0.1	-1.1	-0.8
kabul	Asia	3	-0.1	-1.2	-1.9
kampala	Africa	3	-0.1	-1.4	-1.0
kiev	Europe	1	0.2	-0.2	-1.4
kigali	Africa	3	-0.03	-1.0	-1.7
kinshasa	Africa	3	0.1	-1.6	-2.6
kolkata	Asia	3	0.04	-2.1	-0.3
lagos	Africa	3	0.1	-1.1	-2.0
lasvegas	North America	4	-0.1	-0.2	0.4
lima	South America	3	-0.1	-1.7	-1.0
lisbon	Europe	4	-0.001	1.0	0.8
lome	Africa	1	0.2	-0.4	-1.4
london	Europe	1	0.02	0.5	-0.8
losangeles	North America	1	-0.2	-0.5	-0.6

louisville	North America	4	-0.1	0.8	0.2
luanda	Africa	3	0.04	-1.2	-2.0
lyons	Europe	1	-0.02	0.4	-0.3
madrid	Europe	4	-0.2	1.0	-0.4
malaga	Europe	4	0.2	0.8	-1.1
managua	North America	4	-0.03	0.8	-1.5
manaus	South America	2	0.1	-0.1	-0.4
manila	Asia	1	-0.01	-0.8	-1.2
maputo	Africa	2	0.03	0.1	-1.9
marseille	Europe	4	0.02	0.4	0.1
medellin	South America	4	0.1	0.1	-0.6
melbourne	Oceania	4	-0.02	1.1	0.02
mexico	North America	1	0.04	-0.9	-0.7
miami	North America	4	-0.2	0.6	0.8
milan	Europe	1	-0.01	-0.4	-0.3
milwaukee	North America	2	-0.1	0.9	0.7
minneapolis	North America	4	-0.1	1.1	0.7
monrovia	Africa	2	0.1	0.5	-0.9
montevideo	South America	2	0.2	0.5	-0.2
montreal	North America	4	-0.1	0.6	-0.2
moscow	Europe	1	0.02	-0.5	-0.4
munich	Europe	1	0.1	0.4	-0.4
nairobi	Africa	4	0.01	0.2	-0.9
nanjing	Asia	3	0.2	-1.8	-2.7
nashville	North America	2	-0.1	0.8	0.1
newyork	North	4	-0.1	0.8	-0.1

	America				
niamey	Africa	2	-0.1	0.5	-2.4
nizhny	Europe	1	0.1	-0.01	-1.1
nouakchott	Africa	2	-0.05	0.1	-1.3
novosibirsk	Asia	1	0.1	-0.2	-1.3
omaha	North America	2	-0.1	0.7	0.1
oslo	Europe	4	-0.1	0.4	-0.4
ottawa	North America	4	-0.2	0.9	-0.8
paris	Europe	1	-0.1	-0.02	0.3
paterson	North America	2		0.9	0.8
perth	Oceania	2	0.001	0.9	-0.4
philadelphia	North America	4	-0.1	0.8	0.9
phnompenh	Asia	3	-0.02	-1.6	-1.5
phoenix	North America	4	-0.1	-0.1	0.3
portland	North America	4	-0.1	0.9	0.1
porto	Europe	4	-0.03	1.2	0.3
qingdao	Asia	3	-0.02	-1.9	-3.1
quito	South America	4	0.1	-0.2	-0.4
reykjavik	Europe			0.2	-1.0
riodejaneiro	South America	1	0.1	-0.8	-0.2
saintpetersburg	Europe	1	0.1	-0.4	-0.6
saltlakecity	North America	4	-0.2	0.4	-0.1
sanfrancisco	North America	4	-0.1	0.5	0.8
sanjose	North America	4	0.1	0.8	-0.1
sansalvador	North America	2	-0.03	0.9	-1.0

santiago	South America	1	0.2	-1.9	-0.8
santodomingo	North America	4		0.4	-0.03
saopaulo	South America	1	0.2	-1.1	-0.3
seattle	North America	4	-0.1	1.4	0.5
seoul	Asia	1	-0.01	-0.6	-1.0
seville	Europe	4	0.1	0.5	0.2
shanghai	Asia	3	0.2	-2.2	-2.1
shenzhen	Asia	3	-0.02	-1.3	-2.7
singapore	Asia	1	-0.04	-0.9	0.6
siouxfalls	North America	2	-0.1	0.7	-0.5
stlouis	North America	4	0.01	0.7	0.6
stockholm	Europe	4	0.04	1.4	0.4
sydney	Oceania	4	-0.1	0.8	-0.1
tehran	Asia	1	0.1	-0.5	-1.1
telaviv	Asia	4	0.05	0.3	0.7
tianjin	Asia	3	0.2	-2.0	-2.6
tokyo	Asia	1	-0.1	0.4	-0.3
toowoomba	Oceania	2	-0.1	1.4	-1.1
toronto	North America	4	-0.1	1.0	-0.5
tulsa	North America	2	-0.1	0.8	0.1
tunis	Africa	4	0.01	0.4	-0.9
valencia	Europe	4	-0.1	-0.1	0.5
vancouver	North America	4	-0.1	0.7	0.4
vienna	Europe	1	-0.1	0.1	-0.2
vientiane	Asia	3	-0.004	-1.8	-2.3
warsaw	Europe	1	0.1	-0.2	-1.1
wellington	Oceania	4	-0.1	1.4	-0.6
wichita	North	2	-0.1	1.1	0.1

	America				
wuhan	Asia	3	0.2	-2.0	-2.7
yangon	Asia	1	0.1	-0.8	-2.0
yaounde	Africa	3	-0.04	-1.2	-1.8
zagreb	Europe	1	0.1	-0.3	0.2
zhenjiang	Asia	3	0.1	-1.7	-2.7
zurich	Europe	4	-0.1	0.7	0.1

References

Kummu, M., Taka, M., and Guillaume, J. H. (2018). Gridded global datasets for gross domestic product and Human Development Index over 1990–2015. Scientific data, 5, 180004.

(5) Summary of Indicators

Descriptions of each indicator and its underlying methodology and data sources follow below.

Summary of Indicators

Issue Category	Long Name	Short Name	Unit	Page
Air	Average Exposure to Fine Particulate Matter ($PM_{2.5}$)	PM25	micrograms/m^3	12
	Average Exceedance of Fine Particulate Matter ($PM_{2.5}$) Targets	PM25EX	percent/proportion	14
	Average Exposure to Nitrogen Dioxide (NO_2)	NO2	ppb	16
Climate	Urban Heat Island – Day and Night	UHI, UHINIGHT	degrees C	18
	Land Surface Temperature – Day and Night	Day_LST_XXXX, Night_LST_XXXX	degrees C	18
	Trend in fossil-fuel carbon dioxide (CO2) emissions	CO_2	mean annual percent increase in CO_2 emissions	20
Water	Water Stress	WATSTRESS	ratio	27
Transportation	Distance to Public Transit	PUBTRANS	distance (m)	29
	Access to Public Transit	TRANSCOV	percentage of population	31

Tree Cover	Tree Cover Loss	TREELOSS	percent/proportion	33
	Tree Cover per Capita	TREECAP	m^2/per person	35
	Tree Cover per Neighborhood	TREEPROP	percent/proportion	37
Equity	Population reported from Cities	POP	persons	39
	Mean income (based on census data) per capita or per household - by neighborhood (INCOME_CEN) and by city (INCOME_MEAN)	INCOME, INCOME_CEN, INCOME_MEAN	local currencies	41
	Gross Domestic Product per capita (Purchasing Power Parity)	GDPpc	constant 2011 international USD (in 2015)	42
	Satellite-derived physical characteristics of cities	NDVI, NDBI, ALBEDO, ELEVATION	meters (elevation only)	43
All environmental indicators	Proximity-to-target scores	CO2.UESI NO2.UESI PM25.UESI PM25EX.UESI PUBTRANS.UESI TRANSCOV.UESI	1-100 score	44

		TREECAP.UESI TREELOSS.UESI UHI.UESI WATSTRESS.UESI WATTREAT.UESI		
Equity	Gini coefficient of income inequality between city neighborhoods	INC_GINI	ratio	45
All spatially-disaggregated environmental indicators	Environmental Concentration Index	PUBTRANS_CONC PM25_CONC NO2_CONC UHIEQ_CONC TREECAP_CONC	ratio	46

Indicator: $PM_{2.5}$ Average Exposure

Code: PM2.5

Objective / Issue Category: Air Pollution

What it Measures: Air Pollution - Average Exposure to $PM_{2.5}$ (fine particulate matter in micrograms per cubic meter (μg/m^3).

Rationale for Inclusion: Suspended particulates contribute to acute lower respiratory infections and other diseases such as cancer. Fine particulates or $PM_{2.5}$ (particulates with a diameter of 2.5 microns and smaller) lodge deep in lung tissue and are far more injurious to health than coarser particulates. Average annual concentrations of greater than 10 micrograms per cubic meter are known to be injurious to human health.

INDICATOR CREATION

Unit of Measurement: Population weighted exposure to $PM_{2.5}$ in micrograms per cubic meter
Method / Description: These data were derived from a model that was parameterized by data on Aerosol Optical Depth (AOD) from NASA's MODIS, SeaWiFS, and MISR satellite instruments, and the GEOS-Chem chemical transport model. The model covered all areas south of 70-degree north Latitude and north of 70-degree south latitude. van Donkelaar et al. estimated annual global surface PM2.5 concentrations at a 1 x 1 km spatial resolution.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark: 10 micrograms/m^3 Low Performance Benchmark: 95th percentile (42.5 micrograms/m^3)
Target Source: N/A
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: van Donkelaar, et al. (2016) "Global Estimates of Fine Particulate Matter using a Combined Geophysical-Statistical Method with Information from Satellites, Models, and Monitors," Environmental Science & Technology, 50(7): 3762-3772.

Variable / Units: μg/m³
Method: These data were derived from a model that was parameterized by data on Aerosol Optical Depth (AOD) from NASA's MODIS, SeaWiFS, and MISR satellite instruments, and the GEOS-Chem chemical transport model. The model covered all areas south of 70-degree north Latitude and north of 70-degree south latitude. van Donkelaar et al. estimated annual global surface PM2.5 concentrations at a 10 x 10 km spatial resolution, and then created three year moving averages from 2000 to 2014. Population-weighted average exposure values were calculated using population data from the Global Rural Urban Mapping Project (2011) database.
Year of Publication: 2017
Covered Time: 2000-2016
URL: https://pubs.acs.org/doi/abs/10.1021/acs.est.5b05833
Date Data Obtained: 2017
Data Type: Gridded

Indicator: Air - $PM_{2.5}$ Exceedance

Code: PM25EXBL

Objective / Issue Category: Air Quality

What it Measures: Average percentage of the population whose exposure to $PM_{2.5}$ is above the interim health targets of 10, 15, 25, and 35 μg/m^3.

Rationale for Inclusion: Rationale for Inclusion: Suspended particulates contribute to acute lower respiratory infections and other diseases such as cancer. Fine particulates or $PM_{2.5}$ (particulates with a diameter of 2.5 microns and smaller) lodge deep in lung tissue and are far more injurious to health than coarser particulates. Average annual concentrations of greater than 10 micrograms per cubic meter are known to be injurious to human health. The World Health Organization has also set three interim health targets of 15, 25 and 35 (μg/m^3).

INDICATOR CREATION

Unit of Measurement: Population weighted exposure to $PM_{2.5}$ in micro-grams per cubic meter
Method / Description: These data were derived from a model that was parameterized by data on Aerosol Optical Depth (AOD) from NASA's MODIS, SeaWiFS, and MISR satellite instruments, and the GEOS-Chem chemical transport model. The model covered all areas south of 70-degree north Latitude and north of 70-degree south latitude. van Donkelaar et al. estimated annual global surface $PM_{2.5}$ concentrations at a 1 x 1 km spatial resolution.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: High performance benchmark: 0 Low performance benchmark: 99th percentile (100 percent), proportion of the population exposed to $PM_{2.5}$ thresholds
Target Source: N/A
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: van Donkelaar, et al. (2016) “Global Estimates of Fine Particulate Matter using a

Combined Geophysical-Statistical Method with Information from Satellites, Models, and Monitors," Environmental Science & Technology, 50(7): 3762-3772.
Variable / Units: μg/m3
Method: These data were derived from a model that was parameterized by data on Aerosol Optical Depth (AOD) from NASA's MODIS, SeaWiFS, and MISR satellite instruments, and the GEOS-Chem chemical transport model. The model covered all areas south of 70-degree north Latitude and north of 70-degree south latitude. van Donkelaar et al. estimated annual global surface PM2.5 concentrations at a 1 x 1 km spatial resolution, and then created three year moving averages from 2000 to 2016. Population-weighted average exposure values were calculated using population data from the Global Rural Urban Mapping Project (2017) database.
Year of Publication: 2017
Covered Time: 2000-2016
URL: https://pubs.acs.org/doi/abs/10.1021/acs.est.5b05833
Date Data Obtained: 6/1/17
Data Type: Gridded

Source (2) Citation: Center for International Earth Science Information Network - CIESIN - Columbia University. 2017. Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 10. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H4DZ068D. Accessed 12/8/2017
Variable / Units: Human population density (number of persons per square kilometer)
Method: N/A
Year of Publication: 2017
Covered Time: 2000, 2005, 2010, 2015, 2020 (2015 data used in UESI)
URL: https://doi.org/10.7927/H4DZ068D
Date Data Obtained: 12/08/2017
Data Type: Geospatial

Indicator: NO_2

Code: NO2

Objective / Issue Category: Air Quality

What it Measures: Average exposure to NO_2

Rationale for Inclusion: The result of fossil fuel combustion, nitrogen dioxide can irritate the lungs and lower resistance to respiratory infections such as influenza. Nitrogen oxides contribute to ozone formation, which is also known to contribute to smog and human health impacts.

INDICATOR CREATION

Unit of Measurement: Average exposure, in ppb
Method / Description: The authors used observations of NO_2 tropospheric column densities from three satellite instruments in combination with chemical transport modeling to produce a global 17-year record of ground-level NO_2 at 0.1° x 0.1° resolution. We calculated linear trends in population-weighted annual mean NO_2 (PWMNO2) concentrations in different regions around the world as defined by the Global Burden of Disease Study.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark: 0 Low Performance Benchmark: 11.3 (99th percentile)
Target Source: N/A
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: Geddes, J. A., Martin, R. V., Boys, B. L., & van Donkelaar, A. (2015). Long-term trends worldwide in ambient NO_2 concentrations inferred from satellite observations. Environmental health perspectives, 124(3), 281-289.
Variable / Units: average exposure, in ppm
Method: The authors used observations of NO_2 tropospheric column densities from

three satellite instruments in combination with chemical transport modeling to produce a global 17-year record of ground-level NO_2 at 0.1° x 0.1° resolution. We calculated linear trends in population-weighted annual mean NO_2 (PWMNO2) concentrations in different regions around the world as defined by the Global Burden of Disease Study.
Year of Publication: 2015
Covered Time: N/A
URL: http://ehp.niehs.nih.gov/1409567/
Date Data Obtained: N/A
Data Type: Gridded

Indicator: UHI intensity

Code: UHI and UHINIGHT; Day_LST_XXXX and Night_LST_XXXX

Objective / Issue Category: Climate

What it Measures: Daytime and nighttime urban heat island intensity

Rationale for Inclusion: Urban areas are warmer than their surroundings, known as the urban heat island (UHI) effect. This increases heat stress in urban areas, adds to the impact of global climate change, enhances heat waves, increases electricity consumption, and also leads to enhanced production of secondary air pollutants. Therefore, the UHI negatively affects human health and is an important adverse consequence of urbanization.

INDICATOR CREATION (UHI)

Unit of Measurement: Kelvin
Method / Description: For the UHI intensity indicator, measurements of Land Surface Temperature (LST) are derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on board the Aqua satellite and measurements of land cover are derived from the European Space Agency's Climate Change Initiative land cover product. Day_LST_XXXX and Night_LST_XXXX refer to the daytime and nighttime land surface temperature of a specific year, from the AQUA satellite data. The MODIS satellite gathers daytime values at 1:30 pm local time (to inform the UHI indicator), and nighttime values at 1:30 am local time (to inform the UHI_NIGHT indicator). For the UESI, we only consider the cloud-free MODIS pixels with an uncertainty of less than 3 °C for 2016. For each city, the reference LST is defined as the mean of the non-urban, non-water pixels. This reference value is subtracted from the mean LST of all the urban pixels in each neighborhood to get the UHI of the neighborhoods of a city. The method used in the UESI is a modified version of the simplified urban-extent (SUE) algorithm adjusted for neighborhood-level UHI detection.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark: 0 Low Performance Benchmark: negative (no exact value)
Target Source: N/A

Target Citation: N/A

INDICATOR CREATION (UHINIGHT)

Unit of Measurement: Kelvin
Method / Description: For the UHI intensity indicator, measurements of Land Surface Temperature (LST) are derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on board the Aqua satellite and measurements of land cover are derived from the European Space Agency's Climate Change Initiative land cover product. Day_LST_XXXX and Night_LST_XXXX refer to the daytime and nighttime land surface temperature of a specific year, from the AQUA satellite data. The MODIS satellite gathers daytime values at 1:30 pm local time (to inform the UHI indicator), and nighttime values at 1:30 am local time (to inform the UHI_NIGHT indicator). For the UESI, we only consider the cloud-free MODIS pixels with an uncertainty of less than 3 °C for 2016. For each city, the reference LST is defined as the mean of the non-urban, non-water pixels. This reference value is subtracted from the mean LST of all the urban pixels in each neighborhood to get the UHI of the neighborhoods of a city. The method used in the UESI is a modified version of the simplified urban-extent (SUE) algorithm adjusted for neighborhood-level UHI detection.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: N/A (ideally 0)
Target Source: N/A
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: T. Chakraborty & X. Lee, (2019) "A simplified urban-extent algorithm to characterize surface urban heat islands on a global scale and examine vegetation control on their spatiotemporal variability", International Journal of Applied Earth Observation and Geoinformation. 74, 269-280, 2019. doi: https://doi.org/10.1016/j.jag.2018.09.015"
Variable / Units: Kelvin
Method: The SUE algorithm estimates the UHI of an urban cluster by finding the difference between the LST of the urban pixels and the LST of the non-water pixels

without explicitly defining buffers around the urban area. The algorithm was modified for the UESI such that the rural reference was same for all the neighborhoods and based on the non-urban, non-water pixels within the entire urban shapefile, while the urban LST of a neighborhood was computed using all the pixels of the neighborhood. Finally, those neighborhoods with no pixels (due to extremely small size) were removed from the analysis.
Year of Publication: 2019
Covered Time: 2016
URL: https://doi.org/10.1016/j.jag.2018.09.015
Date Data Obtained: 2018
Data Type: Gridded

Indicator: Trend in fossil fuel carbon dioxide emissions

Indicator: Trend in fossil fuel CO_2 emissions

Code: CO_2

Objective / Issue Category: Climate

What it Measures: It measures the mean annual percentage change in fossil-fuel carbon dioxide (CO_2) emissions of a city during the time-period 2000-15.

Rationale for Inclusion: Cities account for a majority of the total greenhouse gas emissions and fossil-fuel CO_2 emissions form a large share of the total greenhouse gas emissions. Therefore, urgent climate action is a key sustainable development goal and city performance in reducing CO_2 emissions is an important indicator of environmental sustainability.

INDICATOR CREATION

Unit of Measurement: This indicator uses a normalized score between 0-100 to measure city performance. A higher score indicates higher percentage reduction (or lower percentage increase) in fossil-fuel CO_2 emissions of the city in comparison to the baseline emissions in the city in the year 2000.

Method / Description:

1. We use three spatial datasets on fossil-fuel CO_2 emissions with relatively high spatial resolution to estimate total CO_2 emissions by city: EDGAR (Crippa et al., 2019; Crippa et al., in review), FFDAS (Asefi-Najafabady et al., 2014; Rayner et al., 2010), and ODIAC (Oda & Maksyutov, 2011; Oda, Maksyutov, & Andres, 2018). The year 2000 was chosen as the baseline while the year 2015 was chosen as the terminal year as EDGAR, FFDAS, and ODIAC all provide data for that timeframe. The pairwise correlation between city-level estimates from the three datasets was high (and statistically significant): 0.88 for EDGAR-FFDAS, 0.84 for EDGAR-ODIAC, and 0.94 for FFDAS-ODIAC.

2. We compare the computed city-level CO_2 emissions to a global dataset of CO_2 emissions for 343 cities (Nangini et al., 2019). Out of the 169 cities, 61 cities are present in the global dataset. The pair-wise correlation for the self-reported Scope-1 CO_2 emissions of these cities with the fossil-fuel CO_2 emissions estimated using EDGAR, FFDAS, and ODIAC was 0.50, 0.66, 0.74, respectively. However, the absolute CO_2 emissions computed using spatial datasets were up to 150-300 percent higher than the self-reported Scope-1 CO_2 emissions (also see Gately & Hutyra, 2017; Gurney et al., 2019; Hutchins et al., 2017; Oda et al., 2019).

3. It is challenging to "ground truth" the data as self-reported CO_2 emissions, even where available, differ significantly in purpose, scope, protocol, and quality (Nangini et al., 2019). Therefore, we focus on the trend in CO_2 emissions and measure the mean annual percentage increase (or reduction) in CO_2 emissions during 2000-15, in comparison to the baseline emissions in the year 2000. In addition, we average the trend computed using EDGAR, FFDAS, and ODIAC instead of selecting one amongst them for constructing the CO_2 indicator.

4. In addition, we examine the 'uncertainty' in the annual percentage change in CO_2 emissions based on the range estimated using the three datasets. We find that the uncertainty is, in general, higher in case of cities in low- and middle-income countries than in case of those in high-income countries. This difference is likely to be the result of: (i) less reliable data on point sources of emissions in low- and middle-income countries during this period (see, for example, Oda et al. 2018); and (ii) greater percentage change in emissions in low- and middle-income countries during this period due to a low base and/or relatively rapid economic development.

References:

Asefi-Najafabady, S., P. J. Rayner, K. R. Gurney, A. McRobert, Y. Song, K. Coltin, J. Huang, C. Elvidge, and K. Baugh (2014), A multiyear, global gridded fossil fuel CO2 emission data product: Evaluation and analysis of results, J. Geophys. Res. Atmos., 119, doi:10.1002/2013JD021296.

Crippa, M., Oreggioni, G., Guizzardi, D., Muntean, M., Schaaf, E., Lo Vullo, E., Solazzo, E., Monforti-Ferrario, F., Olivier, J.G.J., Vignati, E., Fossil CO2 and GHG emissions of all world countries - 2019 Report, EUR 29849 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-11100-9, doi:10.2760/687800, JRC117610.

Crippa, M., Solazzo, E., Huang, G., Guizzardi, D., Koffi, E., Muntean, M., Schieberle, C., Friedrich, R., Janssens-Maenhout, G.: High resolution temporal profiles in the Emissions Database for Global Atmospheric Research (EDGAR), Nature Scientific Data, 2019, submitted.

Gately, C. K., & Hutyra, L. R. (2017). Large Uncertainties in Urban-Scale Carbon Emissions. *Journal of Geophysical Research: Atmospheres, 122*(20), 11,242-211,260. doi:10.1002/2017jd027359.

Gurney, K. R., Liang, J., O'Keeffe, D., Patarasuk, R., Hutchins, M., Huang, J., . . . Song, Y. (2019). Comparison of Global Downscaled Versus Bottom-Up Fossil Fuel CO2 Emissions at the Urban Scale in Four U.S. Urban Areas. *Journal of Geophysical Research: Atmospheres, 124*(5), 2823-2840. doi:10.1029/2018jd028859.

Hutchins, M. G., Colby, J. D., Marland, G., & Marland, E. (2017). A comparison of five high-resolution spatially-explicit, fossil-fuel, carbon dioxide emission inventories for the United States. *Mitigation and Adaptation Strategies for Global Change, 22*(6), 947-972. doi:10.1007/s11027-016-9709-9.

Nangini, C., Peregon, A., Ciais, P. et al. A global dataset of CO2 emissions and ancillary data related to emissions for 343 cities. Sci Data 6, 180280 (2019). https://doi.org/10.1038/sdata.2018.280.

Oda, T., Bun, R., Kinakh, V., Topylko, P., Halushchak, M., Marland, G., . . . Horabik-Pyzel, J. (2019). Errors and uncertainties in a gridded carbon dioxide emissions inventory. *Mitigation and Adaptation Strategies for Global Change, 24*(6), 1007-1050. doi:10.1007/s11027-019-09877-2.

Oda, T., & Maksyutov, S. (2011). A very high-resolution (1 km×1 km) global fossil fuel CO₂ emission inventory derived using a point source database and satellite observations of nighttime lights. *Atmos. Chem. Phys., 11*(2), 543-556. doi:10.5194/acp-11-543-2011

Oda, T., Maksyutov, S., & Andres, R. J. (2018). The Open-source Data Inventory for Anthropogenic CO2, version 2016 (ODIAC2016): a global monthly fossil fuel CO2 gridded emissions data product for tracer transport simulations and surface flux inversions. *Earth Syst. Sci. Data, 10*(1), 87-107. doi:10.5194/essd-10-87-2018

Rayner, P. J., M. R. Raupach, M. Paget, P. Peylin, and E. Koffi (2010), A new global gridded data set of CO2 emissions from fossil fuel combustion: Methodology and evaluation, J. Geophys. Res.,115, D19306, doi:10.1029/2009JD013439.

Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark (raw data): 95th percentile Low Performance Benchmark (raw data): 5th percentile
Target Source: N/A
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: Crippa, M., Solazzo, E., Huang, G., Guizzardi, D., Koffi, E., Muntean, M., Schieberle, C., Friedrich, R., Janssens-Maenhout, G.: High resolution temporal profiles in the Emissions Database for Global Atmospheric Research (EDGAR), Nature Scientific Data, 2019, submitted.
Variable / Units: kg C/m^2/s
Method: N/A
Year of Publication: 2019
Covered Time: 1970-2018
URL: https://edgar.jrc.ec.europa.eu/overview.php?v=50_GHG
Date Data Obtained: 29 January 2020
Data Type: NetCDF

Source (2) Citation: Asefi-Najafabady, S., P. J. Rayner, K. R. Gurney, A. McRobert, Y. Song, K. Coltin, J. Huang, C. Elvidge, and K. Baugh (2014), A multiyear, global gridded fossil fuel CO2 emission data product: Evaluation and analysis of results, J. Geophys. Res. Atmos., 119, doi:10.1002/2013JD021296.
Variable / Units: kg C/m^2/year
Method: API
Year of Publication: 2018
Covered Time: 1997-2015
URL: http://ffdas.rc.nau.edu/Data.html
Date Data Obtained: 29 January 2020
Data Type: NetCDF

Source (3) Citation: Oda, T., Maksyutov, S., & Andres, R. J. (2018). The Open-source Data Inventory for Anthropogenic CO2, version 2016 (ODIAC2016): a global monthly fossil fuel CO2 gridded emissions data product for tracer transport simulations and surface flux inversions. *Earth Syst. Sci. Data, 10*(1), 87-107. doi:10.5194/essd-10-87-2018.
Variable / Units: ton C/grid cell/month
Method: N/A
Year of Publication: 2019
Covered Time: 2000-18
URL: http://db.cger.nies.go.jp/dataset/ODIAC/DL_odiac2019.html

Date Data Obtained: 23 December 2019
Data Type: GeoTIF

Indicator: Water stress

Code: WATSTRESS

Objective / Issue Category: Water resources

What it Measures: Water stress measures the annual ratio of surface water withdrawn, relative to the total annual natural availability of surface water available, in key sub basins of interest.

Rationale for Inclusion: Water stress reflects a city's vulnerability to drought, pollution events, and other shocks or threats to water availability.

INDICATOR CREATION

Unit of Measurement: Annual water withdrawal relative to water availability
Method / Description: For each grid cell on the Earth's surface, information from the Water GAP model calculates the ratio of water withdrawals upstream to the surface water available at that grid cell.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark (raw data): Below 0.4 ratio of annual surface water use: annual surface water availability. Low Performance Benchmark: Above 0.4 ratio of annual surface water use: annual surface water availability.
Target Source: McDonald, R. I., Weber, K., Padowski, J., Flörke, M., Schneider, C., Green, P. A., ... & Boucher, T. (2014). Water on an urban planet: Urbanization and the reach of urban water infrastructure. Global Environmental Change, 27, 96-105.
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: McDonald, R.I. and D. Shemie, Urban Water Blueprint: Mapping conservation solutions to the global water challenge. 2016, The Nature Conservancy: Washington, D.C. (Updated data for 2016; report originally published in 2014)
Variable / Units: Ratio of surface water use/available surface water per year

Method: For each grid cell on the Earth's surface, information from the Water GAP model calculates the ratio of water withdrawals upstream to the surface water available at that grid cell.
Year of Publication: Published in 2014; interactive display updated in 2016 (2016 data shared by TNC)
Covered Time: Annual data (2016).
URL: http://water.nature.org/waterblueprint/#/section=overview&c=3:6.40265:-37.17773
Date Data Obtained: 11/27/17
Data Type: Tabular

Indicator: Distance to Public Transit (PPT)

Code: PUBTRANS

Objective / Issue Category: Sustainable Public Transportation

What it Measures: This indicator is represented as the mean distance required for residents to reach a public transit stop. The mean distance required for residents to reach a public transit stop is weighted by the neighborhood's residential population density.

Rationale for Inclusion: Public transportation poses potential benefits to fuel efficiency compared with other modes of transportation. Along with sound land use controls encouraging density near transit stops, public transit access contributes to sustainable urban form.

The Sustainable Development Goals (SDGs) identify the improvement of public transit as key to address climate change and development. Sustainable Development Target 11.2 calls for "safe, affordable, accessible and sustainable" public transit to help deliver resilient and inclusive cities.

Transportation also facilitates social inclusion and connects populations within a city, providing access to essential services, such as schools, grocery stores, and health facilities, job sites, and recreational facilities.

INDICATOR CREATION

Unit of Measurement: distance in meters (m)
Method / Description: Using OpenStreetMap data, identify locations of transportation access, buffer these points and calculate the percentage of the neighborhood within the buffers.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark (raw data): 1.2 km Low Performance Benchmark (raw data): 95th percentile (2,350 m)
Target Source: While most urban planning literature cites a "catchment zone" (i.e., a geographic area encompassing all possible riders for a mode of public transit) of 0.25 to 0.5 miles (0.4 to 0.8 km), Durand et al. (2016) found in a survey that riders express willingness to travel further. We therefore adopted a target of 1.2 km.

Target Citation: Durand, C. P., Tang, X., Gabriel, K. P., Sener, I. N., Oluyomi, A. O., Knell, G., & Kohl III, H. W. (2016). The association of trip distance with walking to reach public transit: data from the California household travel survey. Journal of transport & health, 3(2), 154-160.

DATA SOURCE(S)

Source (1) Citation: OpenStreetMap contributors. (2018) Planet dump [Data file from August 28, 2018]. Retrieved from https://planet.openstreetmap.org.
Variable / Units: N/A
Method: API
Year of Publication: 2018
Covered Time: 2015
URL: https://www.openstreetmap.org/#map=4/38.01/-95.84
Date Data Obtained: 8/28/2018
Data Type: Geospatial

Indicator: Access to Public Transit - Transportation Coverage (PCT)

Code: TRANSCOV

Objective / Issue Category: Sustainable Public Transportation

What it Measures: The ratio of neighborhood area within walking distance to a transit stop. Walking distance is defined as a radius of 420 meters (approximately 0.25 miles) for bus stops and 1.2 kilometers (approximately 0.75 miles) for train stops.

Rationale for Inclusion: Public transportation poses potential benefits to fuel efficiency compared with other modes of transportation. Along with sound land use controls encouraging density near transit stops, public transit access contributes to sustainable urban form.

The Sustainable Development Goals (SDGs) identify the improvement of public transit as key to address climate change and development. Sustainable Development Target 11.2 calls for "safe, affordable, accessible and sustainable" public transit to help deliver resilient and inclusive cities.

Transportation also facilitates social inclusion and connects populations within a city, providing access to essential services, such as schools, grocery stores, and health facilities, job sites, and recreational facilities.

INDICATOR CREATION

Unit of Measurement: Percentage of population in a neighborhood with access to public transportation.
Method / Description: Using OpenStreetMap data, identify locations of transportation access, buffer these points and calculate the percentage of the neighborhood within the buffers.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark (raw data): 50th percentile (80 percent) Low Performance Benchmark (raw data): 5th percentile (4 percent)
Target Source: Expert evaluation
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: OpenStreetMap contributors. (2018) Planet dump [Data file from August 28, 2018]. Retrieved from https://planet.openstreetmap.org.
Variable / Units: N/A
Method: API
Year of Publication: 2018
Covered Time: 2015
URL: https://www.openstreetmap.org/#map=4/38.01/-95.84
Date Data Obtained: 8/28/2018
Data Type: Geospatial

Indicator: Tree Cover Loss

Code: TREELOSS

Objective / Issue Category: Urban Tree Cover/Green Space

What it Measures: The Tree Canopy Cover Loss Indicator describes the total area (in square kilometers) of urban tree loss from 2001 to 2016, benchmarked against the tree cover baseline extent in 2000. The term *tree cover loss* is a stand-replacement disturbance, or a change from a forest to non-forest state, such as the removal or death of trees, regardless of the cause and inclusive of all types of tree cover. This often occurs for a range of causes including anthropogenic deforestation, natural and anthropogenic forest fires, clearing trees for agriculture, logging, plantation harvesting, and tree mortality due to natural causes.

Rationale for Inclusion: Reduction in the extent of urban tree cover has significant negative implications for ecosystem services and habitat protection.

INDICATOR CREATION

Unit of Measurement: Percentage - Tree cover loss plus tree cover gain, as compared to 2000 levels (unitless)
Method / Description: Hansen et al. (2013) used 650,000 Landsat 7, 30-meter resolution satellite images to quantify the area of forest loss. As defined in Hansen et al. (2013), trees were defined as all vegetation taller than 5m in height. Forest loss was defined as a standard-replacement disturbance or the complete removal of tree cover canopy at the Landsat pixel scale.
Additional Notes: According to Hansen et al. (2013), there are discrepancies between the FAO Forest Resources Assessment country statistics when compared to the satellite-derived estimates. These discrepancies are due to: (i) inconsistent methods between countries; (ii) defining "forest" based on land use instead of land cover, thereby obscuring the biophysical reality of whether tree cover is present; (iii) forest area changes reported only as net values; and (iv) forest definitions used in successive reports have changed over time.
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark: 0 Low Performance Benchmark: 95th percentile (14.53 percent)
Target Source: Expert opinion, lack of globally agreed upon targets for urban tree cover loss

Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. “Hansen/UMD/Google/USGS/NASA Tree Cover Loss and Gain Area.” University of Maryland, Google, USGS, and NASA. Accessed through Global Forest Watch in August 2015. www.globalforestwatch.org.
Variable / Units: Tree cover loss plus gain as compared to 2000 levels
Method: Hansen et al. (2013) used 650,000 Landsat 7, 30-meter resolution satellite images to quantify the area of forest loss. As defined in Hansen et al. (2013), trees were defined as all vegetation taller than 5m in height. Forest loss was defined as a stand-replacement disturbance or the complete removal of tree cover canopy at the Landsat pixel scale. Results were disaggregated by reference percent tree cover stratum (e.g. >30% crown cover to ~0% crown cover) and by year.
Year of Publication: 2015
Covered Time: 2000-2016
URL: http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.2.html
Date Data Obtained: 8/20/17
Data Type: Tabular

Indicator: Tree Cover per Capita

Code: TREECAP

Objective / Issue Category: Urban Tree Cover/Green Space

What it Measures: The Tree Cover Extent indicator measures how much tree cover (in square kilometers) is available in an urban neighborhood.

Rationale for Inclusion: Tree cover and green space help cool cities and creates habitat that supports biodiversity. Access to green space also enhances the social, physical, and economic health of a community.

INDICATOR CREATION

Unit of Measurement: Tree cover per capita in m^2 per person
Method / Description: Hansen et al. (2013) used 650,000 Landsat 7, 30-meter resolution satellite images to quantify the area of forest loss. As defined in Hansen et al. (2013), trees were defined as all vegetation taller than 5m in height.
Additional Notes: According to Hansen et al. (2013), there are discrepancies between the FAO Forest Resources Assessment country statistics when compared to the satellite-derived estimates. These discrepancies are due to: (i) inconsistent methods between countries; (ii) defining "forest" based on land use instead of land cover, thereby obscuring the biophysical reality of whether tree cover is present; (iii) forest area changes reported only as net values; and (iv) forest definitions used in successive reports have changed over time.
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark: 15 meters Low Performance Benchmark: 5th percentile (0)
Target Source: UN Habitat City Prosperity Index
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "Hansen/UMD/Google/USGS/NASA Tree Cover Loss and Gain Area." University

of Maryland, Google, USGS, and NASA. Accessed through Global Forest Watch in August 2015. www.globalforestwatch.org.
Variable / Units: square meters
Method: Hansen et al. (2013) used 650,000 Landsat 7, 30-meter resolution satellite images to quantify the area of forest loss. As defined in Hansen et al. (2013), trees were defined as all vegetation taller than 5m in height.
Year of Publication: 2017
Covered Time: 2000-2016
URL: http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.2.html
Date Data Obtained: 8/20/17
Data Type: Tabular

Indicator: Tree Cover per Neighborhood

Code: TREEPROP

Objective / Issue Category: Urban Tree Cover/Green Space

What it Measures: The Tree Cover Extent indicator measures the percentage of a neighborhood with tree cover canopy.

Rationale for Inclusion: Tree cover and green space help cool cities and creates habitat that supports biodiversity. Access to green space also enhances the social, physical, and economic health of a community.

INDICATOR CREATION

Unit of Measurement: Percentage: neighborhood area with tree cover canopy/total neighborhood area
Method / Description: Hansen et al. (2013) used 650,000 Landsat 7, 30-meter resolution satellite images to quantify the area of forest loss. As defined in Hansen et al. (2013), trees were defined as all vegetation taller than 5m in height.
Additional Notes: According to Hansen et al. (2013), there are discrepancies between the FAO Forest Resources Assessment country statistics when compared to the satellite-derived estimates. These discrepancies are due to: (i) inconsistent methods between countries; (ii) defining "forest" based on land use instead of land cover, thereby obscuring the biophysical reality of whether tree cover is present; (iii) forest area changes reported only as net values; and (iv) forest definitions used in successive reports have changed over time.
Transformation Needed for Aggregation: N/A
Target: High Performance Benchmark: 15 meters Low Performance Benchmark: 5th percentile (0)
Target Source: UN Habitat City Prosperity Index
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013.

"Hansen/UMD/Google/USGS/NASA Tree Cover Loss and Gain Area." University of Maryland, Google, USGS, and NASA. Accessed through Global Forest Watch in August 2015. www.globalforestwatch.org.
Variable / Units: square meters
Method: Hansen et al. (2013) used 650,000 Landsat 7, 30-meter resolution satellite images to quantify the area of forest loss. As defined in Hansen et al. (2013), trees were defined as all vegetation taller than 5m in height.
Year of Publication: 2017
Covered Time: 2000-2016
URL: http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.2.html
Date Data Obtained: 8/20/17
Data Type: Tabular

Indicator: Population reported from Cities

Code: POP

Objective / Issue Category: Equity

What it Measures: Population of cities at neighborhood/district/ward levels

Rationale for Inclusion: Used as an input variable for equity analysis

INDICATOR CREATION

Unit of Measurement: persons Note: separate for population data generated through GRUMP
Method / Description: Import of population data from official and publicly available sources. The data sources for specific cities are available upon request.
Additional Notes: Specific sources for UESI pilot cities listed below.
Transformation Needed for Aggregation: N/A
Target: N/A
Target Source: N/A
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: City neighborhood population data from census reports, public resources, and direct requests to municipal agencies
Variable / Units: Persons by neighborhood
Method: Collection from census data, publicly available information, or direct outreach to city officials
Year of Publication: Varies according to data source
Covered Time: Varies according to data source
URL: Varies according to data source

Date Data Obtained: 28/08/2018
Data Type: Tabular

Source (2) Citation: Center for International Earth Science Information Network - CIESIN - Columbia University. 2017. Gridded Population of the World, Version 4 (GPWv4): Population Density, Revision 10. Pal1isades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H4DZ068D. Accessed 12/8/2017
Variable / Units: human population density (number of persons per square kilometer)
Method: N/A
Year of Publication: 2017
Covered Time: 2000, 2005, 2010, 2015, 2020 (2015 data used in UESI)
URL: https://doi.org/10.7927/H4DZ068D
Date Data Obtained: 12/8/17
Data Type: Geospatial

Indicator: Mean income per capita or per household by neighborhood

Code: INCOME, INCOME_CEN, INCOME_MEAN

Objective / Issue Category: Equity

What it Measures: Income per capita or per household by neighborhood in each city, based on national denomination and currency, and census data. INCOME_CEN refers to the mean income by neighborhood, and INCOME_MEAN refers to mean income per capita for a city.

Rationale for Inclusion: Used as an input variable for equity calculations

INDICATOR CREATION

Unit of Measurement: local currencies
Method / Description: Mean income values are adopted from census data where applicable. In cities where only income brackets are available, mean income is calculated from income brackets. In cities where mean income is unavailable, median income is used. The income data is then standardized to 2016 US dollar values, adjusting for inflation. The data sources for specific cities are available upon request.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: N/A
Target Source: N/A
Target Citation: N/A

Indicator: Gross Domestic Product per capita (Purchasing Power Parity) (proxy for income)

Code: GDPpc

Objective / Issue Category: Equity

What it Measures: If income per capita/per household by neighborhood data is not available, the UESI uses GDP per capita to measure income distribution across a city's neighborhoods.

The UESI classifies cities as Tier I (i.e., cities that have income per capita data available) and Tier II (i.e., cities where we use GDP per capita) to designate potential differences when comparing these cities' equity indicators.

Rationale for Inclusion: Used as an input variable for equity calculations

INDICATOR CREATION

Unit of Measurement: Gross Domestic Production per capita (purchasing power parity), in constant 2011 international USD, as reported in the year 2015
Method / Description:
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: N/A
Target Source: N/A
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: Kummu, M., Taka, M., & Guillaume, J. H. (2018). Gridded global datasets for gross domestic product and Human Development Index over 1990–2015. Scientific data, 5, 180004.
Variable / Units: Gross Domestic Production per capita (purchasing power parity)
Method: N/A
Year of Publication: 2018

Covered Time: 1990-2015
URL: N/A
Date Data Obtained: 2020
Data Type: Spatial

Indicator: Satellite-derived physical characteristics of cities

Code: NDVI, NDBI, ALBEDO, ELEVATION

Objective / Issue Category: Overall

What it Measures: NDVI (Normalized Difference Vegetation Index) is a proxy for the green vegetation on the surface NDBI (Normalized DIfference Built-up Index) is a proxy for built-up surfaces ALBEDO is the reflectivity of solar radiation from the surface ELEVATION is the height of the terrain.

Rationale for Inclusion: The physical characteristics of the city may mitigate or exacerbate the environmental performance.

INDICATOR CREATION

Unit of Measurement: Unitless for NDVI, NDBI, and ALBEDO. ELEVATION is in meters
Method / Description: These datasets are based on satellite measurements. The albedo is the broadband shortwave black-sky albedo, which is the reflectivity of the surface to direct beam shortwave radiation, derived from the MODIS MCD43B3.005 16-day satellite products available at 1 km x 1 km resolution (Wanner et al. 1997). The NDVI and NDBI are measures of surface greenness and built-up index, respectively, and are derived from landsat 7 data available at 30 m x 30 m resolution. Finally, the elevation is from the Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) dataset at 7.5 arc seconds (Danielson et al. 2011). To keep all the datasets consistent with the elevation data, which is only available for 2010, the other physical characteristics were also calculated for 2010.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: N/A
Target Source: N/A
Target Citation: N/A

DATA SOURCE(S)

Source (1) Citation: N/A
Variable / Units: N/A
Method: N/A

Year of Publication: N/A
Covered Time: N/A
URL: N/A
Date Data Obtained: N/A
Data Type: N/A

Indicator: Proximity-to-target scores

Code: CLIMPOL.UESI, NO2.UESI, PM25.UESI, PM25EX.UESI, PUBTRANS.UESI, TRANSCOV.UESI, TREECAP.UESI, TREELOSS.UESI, UHI.UESI, WATSTRESS.UESI, WATTREAT.UESI

Objective / Issue Category: All environmental issue areas

What it Measures: Targets are set by policy goals (e.g., in the case of the Tree Cover per capita target that uses a UN SDG goal of 15 meters per capita), established scientific thresholds (e.g., in the case of the PM2.5 indicator that uses the World Health Organization's 10 microgram/m^3 limit for exposure), or an analysis of the top performers (e.g., the top 5th percentile of the distribution of scores). Each indicator is transformed given a score from a scale of 0 (worst performer or those at the low performance benchmark) to 100 (best performer or those at the top performance benchmark).

Rationale for Inclusion: Scores convey analogous meaning across indicators, policy issues, and throughout the UESI.

INDICATOR CREATION

Unit of Measurement: 0-100 score (specified in more detail in each indicator description)
Method / Description:
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: N/A

Target Source: N/A
Target Citation: N/A

Indicator: Income Inequality

Code: INC_GINI

Objective / Issue Category: Overall

What it Measures: Gini coefficient of income inequality between neighborhoods.

Rationale for Inclusion: The income distribution of a city – represented in the Gini value – reflects the level of homogeneity in the allocation of economic resources obtained by a household, resources that are used to provide an adequate standard of living for its inhabitants. Including this indicator makes it possible to understand relationships between how un/equally a city's income is distributed and how un/equally a city's environmental benefits and burdens are distributed.

INDICATOR CREATION

Unit of Measurement: Unitless; a Gini coefficient value can range from 0 (signifying perfect equality, where everyone receives the same income) to 1 (signifying perfect inequality, where all income is received by a single entity).
Method / Description: N/A
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: N/A
Target Source: N/A
Target Citation: N/A

Indicator: Environmental Concentration Index

Code: PUBTRANS_CONC, PM25_CONC, NO2_CONC, UHIEQ_CONC, TREECAP_CONC

Objective / Issue Category: Overall

What it Measures: this metric numerically represents the distribution of the environmental outcome in relation to a scenario of perfect equity (e.g., an environmental version of a Gini coefficient).

Rationale for Inclusion: To determine how un/equitably a city's environmental benefits and burdens are distributed across a city's neighborhoods.

INDICATOR CREATION

Unit of Measurement: Unitless; a concentration index value can range from -1 (i.e, the environmental burden is allocated to the poorest individual) to 1 (i.e., the environmental burden is allocated to the wealthiest person).
Method / Description: See the Equity and Social Inclusion issue profile in the UESI (http://datadrivenlab.org/urban/issue-profiles/equity/) for a detailed description of the methodology used to calculate this indicator.
Additional Notes: N/A
Transformation Needed for Aggregation: N/A
Target: N/A
Target Source: N/A
Target Citation: N/A