The IUCN Urban Nature Indices

A Methodological Framework

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INTERNATIONAL UNION FOR CONSERVATION OF NATURE

ARCADIA
A CHARITABLE FUND OF
LISBET RAUSING & PETER BALDWIN

IUCN Urban Alliance

URBAN BIODIVERSITY HUB

About IUCN

The International Union for Conservation of Nature (IUCN) is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together.

Created in 1948, IUCN is now the world's largest and most diverse environmental network, harnessing the knowledge, resources and reach of more than 1,400 Member organisations and some 15,000 experts. It is a leading provider of conservation data, assessments and analysis. Its broad membership enables IUCN to fill the role of incubator and trusted repository of best practices, tools, and international standards.

IUCN provides a neutral space in which diverse stakeholders including governments, NGOs, scientists, businesses, local communities, indigenous peoples organisations and others can work together to forge and implement solutions to environmental challenges and achieve sustainable development.

www.iucn.org

About Arcadia, a charitable fund of Lisbet Rausing and Peter Baldwin

Arcadia supports work to preserve endangered cultural heritage, protect endangered ecosystems, and promote access to knowledge. The fund aims to defend the complexity of human culture and the natural world, so that coming generations can build a vibrant, resilient and green future.

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About Urban Biodiversity Hub

The Urban Biodiversity Hub (UBHub) helps cities around the world to measure and promote their biodiversity and assess their biodiversity strategy. UBHub works with municipal and other local governments and their partners to improve the efficiency and effectiveness of their biodiversity planning, according to the goals they set for themselves. This is achieved by consolidating information on urban biodiversity planning activities and guidelines in one website, and through a dedicated forum and other resources providing access to the latest practices for urban biodiversity planning.

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Contents

Executive summary

The IUCN Urban Alliance—a broad coalition of IUCN constituents concerned with urban dimensions of nature conservation—has unveiled a new knowledge product for measuring the ecological performance of cities: the IUCN Urban Nature Indices (UNI).

Comprising a set of 30 indicator topics nested across six themes, the UNI is intended to help cities understand their impacts on nature, set science-based targets for improvement, and monitor progress accordingly. By enhancing environmental transparency and accountability, and by facilitating goal setting, the UNI aims to catalyse local action for nature.

Financed by Arcadia – a charitable fund of Lisbet Rausing and Peter Baldwin, the UNI was developed over a two-year period entailing surveys, workshops, and webinars. Technical support was provided by a team of consultants at Urban Biodiversity Hub, some 30 experts drawn from IUCN Members and Commissions, and representatives of 26 local governments. Piloting was performed in six cities, namely, Curridabat, Lagos, Mexico City, Paris, Saanich and Singapore.

The UNI can be differentiated from other urban sustainability indices by its unique scope and framing. Recognising that the ecological impacts of cities extend far beyond their boundaries, the scope of UNI is intentionally broad, encompassing urban, bioregional, and global spheres of impact. Recognising the dynamism and complexity of urban systems, the UNI uses the Driver-Pressure-State-Impact-Response framework to identify and address root causes of ecological problems.

IUCN Members have expressed political support for the UNI by way of the Marseille Manifesto—the key outcome document of the recent IUCN World Conservation Congress. The manifesto comprises a bold commitment “to expand universal access to high-quality green spaces and to enhance urban biodiversity in 100 cities, representing around 100 million citizens by 2025, and assessing their impact according to the IUCN Urban Nature Index.”

IUCN is now building an interactive digital platform to present the indicators, provide implementation guidance, and share the results of participating cities. While the UNI is primarily intended for use by local governments, the results generated will be of interest to anyone concerned with the relationship between cities and nature, and its implications for human health and wellbeing.

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Introduction

Measuring and monitoring are essential to the effective management of natural capital by cities. Qualitative and quantitative indicators can convey valuable information on the status and trends of natural capital stocks, the flows of services they generate, the efficacy of conservation measures, and the impacts of urban consumption on nature globally. In recent years, a plethora of monitoring systems have been developed with different methodologies and approaches. This has resulted in a 'paradox of choice' and limited meaningful comparison of measurements over space and time.

To streamline data collection and optimise data utility, there is a need for greater harmonisation and standardisation of indicators. There is a need for a comprehensive system of indicators, flexible enough to cater to a wide range of users, but firm enough to facilitate comparative measurement. The need is somewhat urgent given the accelerated loss of biodiversity worldwide, the extraordinary potential for cities to ameliorate or exacerbate the crisis, the imperative to strengthen urban resilience in the face of climate change, and the necessity for all institutions to make measurable contributions to targets in the post-2020 global biodiversity framework. As a standard-setting organisation with a broad membership base, the International Union for Conservation of Nature (IUCN) is well placed to lead such a process.

In September 2018, the International Union for Conservation of Nature (IUCN) launched the Urban Alliance – a broad coalition of IUCN constituents working towards "a world in which nature thrives in cities, delivering solutions to multiple environmental, social and economic challenges." With the financial support of Arcadia – a charitable fund of Lisbet Rausing and Peter Baldwin, the IUCN Urban Alliance committed to developing the IUCN Urban Nature Indices (UNI) to measure the ecological performance of cities. The UNI was intended to bring together existing indicators and data sources to create a single coherent yet flexible tool of value to local governments.

A two-year development process ensued. It entailed multiple workshops, webinars, and consultations. It involved scores of experts from local governments and IUCN constituencies. From the process, emerged 30 indicator topics nested within six themes, constituting the first public version of the UNI and the subject of this report.

While local governments are the primary intended users, the results generated will be of interest to anyone concerned with the relationship between cities and nature, and its implications for human health and wellbeing.

To expedite the rollout of the UNI, IUCN is now building an interactive digital platform to present the indicators, provide implementation guidance, and share the results of participating cities.

Methodology

The UNI was developed using a mix of deductive and inductive methods. Firstly, a scoping exercise was undertaken to identify existing tools, standards and frameworks of relevance to urban ecological performance. These included, but were not limited to, the Singapore Index on Cities' Biodiversity (Chan *et al.*, 2021), the World Bank Urban Sustainability Framework (GPSC, 2018), the Sustainable Development Goals, the New Urban Agenda, the City Prosperity Index, the International Ecocity Framework and Standards, the Science-based Framework for Building Urban Biodiversity, the 'zero draft' of the post-2020 Global Biodiversity Framework, and various standards prescribed by the International Organisation for Standardisations. From these, a long list of over 450 indicators was compiled. Secondly, a review of the academic literature on conceptual frameworks and indicators for measuring urban drivers, pressures, status, and impacts of ecological health was conducted to identify the latest approaches and best practices.

Then, in accordance with recommended methods for index creation, the long list was substantially reduced by applying a set of recognised criteria: salience, legitimacy, credibility, and feasibility (van Oudenhoven *et al*., 2018; Füssel, 2010; OECD, 2009). A tentative short list of indicators emerged. This was further refined based on feedback received from IUCN scientific advisors, a survey of 24 cities, deliberations at a series of international workshops, and pilot testing within six cities.

Conceptual frameworks

The UNI is informed by two pre-existing frameworks: the Driver-Pressure-State-Impact-Response (DPSIR) model (US Environmental Protection Agency (USEPA), 2015) (see Figure 1) and the Urban Bioshed Impact Areas model (Pierce, 2022) (see Figure 2).

According to Bradley and Yee (2015), the DPSIR model is useful for conveying complex environmental issues. As a systems-thinking framework, it considers the component parts of a system and how they relate to and interact with one another and other systems. The DPSIR model is commonly used in environmental management contexts to demonstrate the cause-and-effect relationship between the interacting components of social, economic and environmental systems. Bradley and Yee (2015) describe the five distinct components of the DPSIR model as follows:

- ***Drivers*** are the social and economic imperatives that seek to fulfil basic human needs by creating the necessary conditions and, through material consumption, support wellbeing, health, security, and freedom. The provisions for supporting life include food and raw materials, water, shelter, health, culture, security, and infrastructure.

- ***Pressures*** are human activities that induce changes to the environment, for instance, the discharge of chemical, physical or biological agents, or land use changes. The intensity of the pressures depends on the technology and extent of activities that vary across geographic regions and spatial scales.

- ***State*** refers to the physical, chemical, and biological components of the natural environment (i.e., the living and non-living components). More specifically, the abiotic state reflects the magnitude, frequency, and concentration of abiotic components (e.g., climate, air and sea temperature, salinity, pH, contaminants, buildings, and roadways) of the environment, while the biotic state reflects the biological components (e.g., habitats, plants, animals, and microorganisms) of an ecosystem and their interactions.

- ***Impacts*** are the resulting changes in the quality and functioning of the ecosystem that influence living things including the production of ecosystem goods and services.

- ***Responses*** are actions taken through policies and regulations to prevent, compensate, ameliorate, or adapt to changes in the state of the environment.

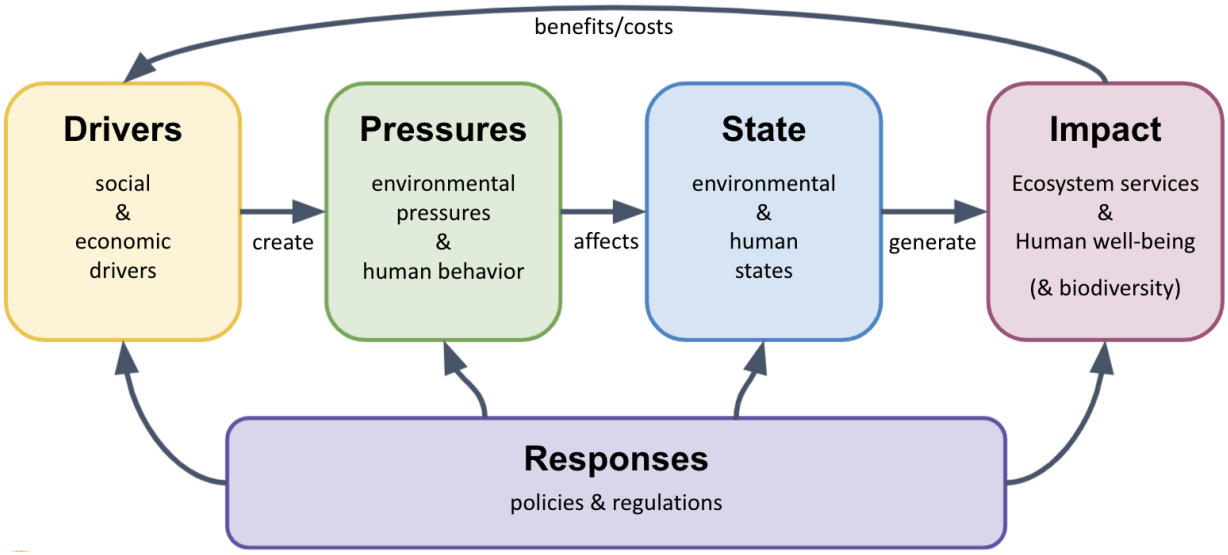

Figure 1. DPSIR model for environmental impacts adapted from the USEPA.

The Urban Bioshed Impact Areas model (Figure 2) helps to conceptualize the wide and varied ecosystems that can be harmed or protected by activities in cities. Harmful activities include permitting ecologically destructive urban sprawl or fostering excessive consumption of products obtained via destructive mining practices. Protective activities include the restoration of watersheds via payments for ecosystem services (PES) schemes, or the procurement of certified sustainably harvested products.

Such activities can directly or indirectly impact on ecosystems over areas many times larger than the city itself. As such, the three scales shown in the diagram—in-boundary, hinterland, and global—encourage cities to consider impact areas outside their borders that result from regional resource flows and cycles (e.g., watersheds, airsheds, and nitrogen) and trade (e.g., industrial activities, resource extraction, and the forces of supply and demand that generate them).

The in-boundary scale is defined as the politically defined boundary of the urban area, which can be problematic as political boundaries rarely align with ecological or other functional borders. The hinterland scale is the nearby territory adjacent to the urban political boundary that has a direct economic or other functional link to the city such as farmlands that deliver food products to the city. The global scale refers to the impacts that a city has in distant locations, connected by transportation lines, cultural influence, or other forces of globalization. The three impact areas serve to remind cities of the indirect drivers they can influence, such as market forces, supply chains, and societal norms of consumption.

Lastly, at the centre of the Urban Bioshed Impact Areas model is the notion of equity and justice, underscoring the need for transformational systems that actively oppose the oppression of both human and non-human beings.

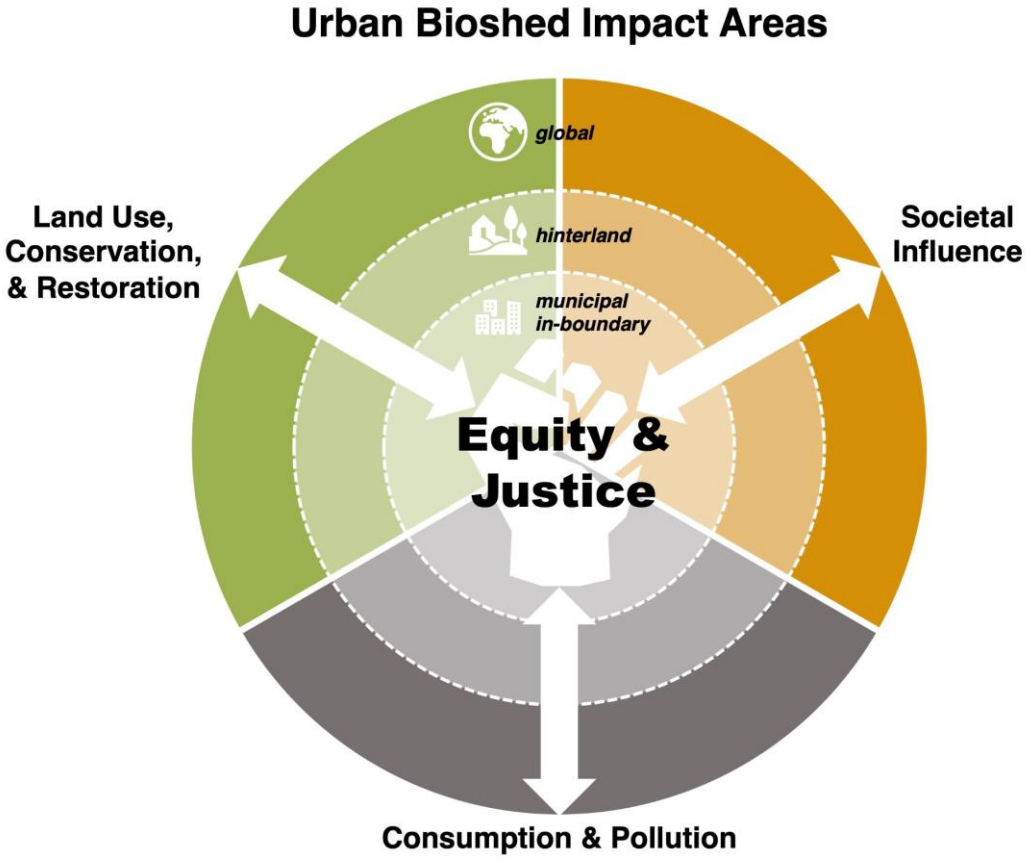

Figure 2. Urban Bioshed Impact Area Model (Pierce, 2022).

Scope and structure

The UNI can be subdivided into six themes: consumption drivers, human pressures, habitat status, species status, nature's contributions to people, and governance responses. Each theme contains five indicator topics amounting to 30 in total. As depicted in Table 1 below, collectively, these indicator topics link to almost every Sustainable Development Goal, span local (in-boundary), regional (hinterland), and global spheres of influence, and comprise strong equity dimensions.

Table 1. Scope and structure of the UNI.

Theme	ID	Indicator Topics	Equity	Local	Hinterland	Global	SDG
1 Consumption Drivers	**1.1**	Material Consumption			x	x	12, 11.6
	1.2	Harmful Harvest & Trade			x	x	12
	1.3	GHG Emissions from Energy				x	7, 13
	1.4	Unsustainable Diets	x			x	2
	1.5	Water Withdrawal		x	x		6
2 Human Pressures	**2.1**	Sprawl			x		15
	2.2	Water Pollution		x	x	x	6, 12.4
	2.3	Noise Pollution		x			14, 15
	2.4	Light Pollution		x	x		15
	2.5	Invasive Species		x	x		14, 15
3 Habitat Status	**3.1**	Land Use/Protection		x	x		15
	3.2	Ecosystem Restoration		x	x		15
	3.3	Shorelines & River Banks		x	x	x	14
	3.4	Vegetation		x			13, 11.6
	3.5	Connectivity		x	x		14, 15
4 Species Status	**4.1**	Animal Species		x	x	x	14, 15
	4.2	Plant Species		x	x	x	14, 15
	4.3	Functional Diversity		x			14, 15
	4.4	Microbiota		x	x		14, 15
	4.5	Endemic Species		x	x	x	14, 15
5 Nature's Contributions to People	**5.1**	Exposure to Nature		x			11.7
	5.2	Access to Nature	x	x			10, 11.7
	5.3	Human Health	x	x		x	3
	5.4	Livelihoods	x	x	x		1, 8, 9
	5.5	Sacred Natural Sites	x	x	x	x	11.4
6 Governance Responses	**6.1**	Planning		x	x	x	11
	6.2	Law & Policy		x	x	x	16
	6.3	Education		x	x	x	4, 12.8
	6.4	Management	x	x			11
	6.5	Incentives & Participation		x	x	x	17

Recommended implementation

The UNI is designed for use by local governments operating in an urban context. It may be completed by staff representing a city, metro area, or other local government, or by an outside entity on behalf of a local government.

Participating cities are asked to complete the UNI every 1-5 years. For each period, the cities will select indicators from the UNI within each of the six themes. The recommended number of indicators for a participating city to complete is determined by the city's capacity level as per Table 2.

Table 2. Recommended number of indicators to adopt based on capacity level.

Capacity	Required Indicators	Indicator Level	Quantity of Indicators
Low	Fulfil at least 1 indicator topic from each theme.	Basic	**6**
Medium	Fulfil at least 2 indicator topics from each theme.	Basic	**12**
High	Fulfil at least 3 indicator topics from each theme.	Advanced	**18**
Mega	Fulfil at least 4 indicator topics from each theme.	Advanced	**24**
Champion	Fulfil all indicators	Advanced	**30**

Cities may choose to complete indicators at a more advanced level and may exceed the minimum indicated for their category by either completing additional indicators and/or by completing indicators at a higher level. Note that the Champion level is not set by the capacity, but rather an option for cities who wish to achieve the highest level of completion. Cities are strongly advised to select and track the same set of indicators over time so that trends can be established for the selected indicators.

Under some indicator topics, there will be a 'basic' option that is easier to implement and an 'advanced' option that requires additional effort but is more accurate and/or comprehensive.

A city wishing to determine its level of capacity and by extension the recommended number of indicators to implement, may find the Capacity Assessment Questionnaire helpful. This questionnaire is based on a review of city typologies and capacity for sustainable action (Chubarov, 2015; Sluka, 2019; Uchiyama, 2019), as well as feedback from the UNI pilot cities.

1. *What is the population size of your city or town?*
    a. Less than 1 million people
    b. Between 1 and 3 million people
    c. Above 3 million people

2. *What is the GDP per capita in your city or town?*
    a. €21,000 or less
    b. Between €21,000 and €31,000
    c. €31,000 or higher

3. *Have you completed an assessment of ecological characteristics in your city before, such as in a biodiversity report?*
    a. Never
    b. Once
    c. More than once

4. *How many full-time equivalent staff work on biodiversity-related initiatives (including planning, management, outreach, and implementation) and who are also trained in a related field (such as ecology or urban forestry)?*
    a. Up to 2 full-time staff persons
    b. 2-6 staff persons
    c. more than 6 staff persons

5. *What is the municipal funding status for biodiversity-related initiatives (other than staff salaries)?*
    a. None - reliant on external funding
    b. Variable annual funding is provided
    c. Dedicated regular funding is budgeted (such as annually)

6. *How would you rate the political priority of biodiversity and/or nature in your city?*
    a. *Not a priority*
    b. Medium priority
    c. Top priority

7. *How long ago was your local biodiversity office/unit established?*
    a. Less than 2 years ago
    b. 2-5 years ago
    c. More than 5 years ago

After attributing 1 point for “a” answers, 2 points for “b” answers, and 3 points for “c” answers, a tally can be calculated to determine the capacity level using Table 3 below.

Table 3. Capacity level as determined by answers to the Capacity Assessment Questionnaire.

Points	Capacity	Completion Requirements	Indicator Level
7-9	**Low**	At least one indicator topic per theme.	basic
10-13	**Medium**	At least two indicator topics per theme.	basic
14-17	**High**	At least three indicator topics per theme.	advanced
18-21	**Mega**	At least four indicator topics per theme.	advanced
Any	**Champion**	Complete all indicator topics.	advanced

How are the indicators assessed?

Once a user has determined which indicators to adopt, with a minimum of one per theme, an initial baseline assessment can be undertaken. In the absence of historical data, it will not be possible to discern trends at this stage. However, over successive rounds of implementation—recommended at a frequency of once every three years—trends should begin to emerge. The assessment should be based on indicator trends (target achieved, improving, static, or worsening) and could potentially also consider efforts made (efforts being made or no efforts currently underway). The precise scoring system is still under development.

The indicators

This section presents the 30 indicator topics, their intent, calculation instructions, suggested resources and tentative scoring system.

1.1 Material Consumption

Intent	Estimate consumption of goods per person by measuring waste produced.
Instructions	Calculate the average daily volume of solid waste produced by household, commercial, and industrial sectors, divided by total population. Include estimates for any solid waste that is not collected by government services.
Alternatives	A consumption-based ecological footprint calculation per capita may be used instead of the above option.
Resources	www.ecocityfootprint.org www.footprintnetwork.org
Scoring	Score this indicator as follows:

++ Multi-year decreasing trend established
+ Decreasing trend observed
• Baseline measured, trend undetermined
- Increasing trend observed
-- Data deficient

1.2 Harmful Harvest & Trade

Intent	Assess trade that directly harms species or ecosystems, whether legal or illegal.
Instructions	1. Identify at least 1 endangered species (plant or animal) or unsustainably harvested resource that is particularly harmful to biodiversity or ecosystems and that is connected to trade originating in, flowing through, or terminating in, the boundary of your local government. Examples include: • Old growth wood • Pangolins and pangolin-derived products • Fish farmed using harmful practices 2. Measure the amount of harvest or trade occurring (imports, exports, or both) to determine the trend over time.
Alternatives	None
Resources	WILDLEX provides access to case-law, legislation, literature and training materials on illegal wildlife trade.
Scoring	Score this indicator as follows:

++ Harmful trade eradicated or at sustainable levels
+ Harmful trade in decline
• Baseline measured, trend undetermined
- Harmful trade unmanaged or growing
-- Data deficient

1.3 Greenhouse Gas (GHG) Emissions from Energy

Intent	Estimate greenhouse gas emissions per person that result from energy use.
Instructions	1. Calculate total energy use by the city by energy source, including fuel, for industrial and household use. 2. Convert energy use from each source to greenhouse gas emissions according to emission factors for your location by energy source as provided by the IPCC Emission Factor Database (EFDB). For simplicity, any sources that are responsible for less than 5% of total energy use can optionally be converted using the average of the emission factors for the other sources.
Alternatives	Report total greenhouse gas emissions per capita following the calculation method indicated in the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).
Resources	https://www.ipcc-nggip.iges.or.jp/EFDB/main.php https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities
Scoring	Score this indicator as follows: **++ Multi-year decreasing trend established** **+ Decreasing trend observed** **• Baseline measured, trend undetermined** **- Increasing trend observed** **-- Data deficient**

1.4 Unsustainable Diets

Intent	Measure of diet sustainability according to land use and overharvesting concerns.
Instructions	Select one of the approaches listed below: 1. Calculate the total amount (weight) of red meat and seafood consumed by local, nonindigenous populations (where applicable), and divide by total nonindigenous population per year. Red meat is defined as any non-poultry meat source. 2. Measure the proportion of food travelled farther than 200 miles from where it was produced.
Alternatives	Apportion out the consumption-based ecological footprint calculation due to food consumed per capita.
Resources	https://attra.ncat.org/product/food-miles-background-and-marketing/ www.ecocityfootprint.org
Scoring	Score this indicator as follows: **++ Multi-year decreasing trend established** **+ Decreasing trend observed** **• Baseline measured, trend undetermined** **- Increasing trend observed** **-- Data deficient**

1.5 Water Withdrawal

Intent	Measure of water consumption as compared to locally sustainable levels.
Instructions	1. Determine sustainable water withdrawal rates for your local government area plus any protected watersheds managed by or on behalf of the local government. 2. Compare this sustainable rate with current total water withdrawal, minus desalinated seawater and harvested rainwater.
Alternatives	Calculate total water use (household, industrial, and agricultural) per capita, other than intentionally recycled water, harvested rainwater, and desalinated seawater.
Resources	None
Scoring	Score this indicator as follows:

++ Multi-year decreasing trend established
+ Decreasing trend observed
• Baseline measured, trend undetermined
- Increasing trend observed
-- Data deficient

2.1 Sprawl

Intent	Assess level of ongoing sprawl.
Instructions	Calculate the average population density of developed land (i.e. excluding undeveloped and restored/naturalized land) within the boundaries of the local government.
Alternatives	Calculate the ratio of the annual land consumption rate to the annual population growth rate (as per SDG Indicator 11.3.1). Land consumption is a measure of the urbanized land area. In the case of selecting this alternative, the scoring would be based on decreasing trends (the inverse of the base option such that a decreasing trend is desirable). A metro area scale measurement may alternatively be used.
Resources	https://unhabitat.org/sites/default/files/2020/07/metadata_on_sdg_indicator_11.3.1.pdf
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

2.2 Water Pollution

Intent	Assess the level of pollutants in aquatic ecosystems.
Instructions	Cities should select the most appropriate measure from the options below, depending on the significance of at least 3 local water bodies. Artificial and/or channelized water bodies may be considered as appropriate. For streams: Measure the difference in nutrient retention (Carbon, Nitrogen, and Phosphorus) from raw water samples taken at set upstream and downstream sampling locations of primary* streams in the city. For coastal areas and lakes: Measure total area of eutrophication for coastal areas and large lakes.
Alternatives	Measures of solid waste particles, such as plastics, may alternately be considered as appropriate.
Resources	USEPA Technical Guidance Manual for nutrient retention measurement in streams Methods for satellite imagery analysis of water color as a measure of eutrophication rates as described in http://www.cearac-project.org/cearac-project/integrated-report/Annex_A5_Peter.pdf
Scoring	Score this indicator as follows: **++ Multi-year decreasing trend established** **+ Decreasing trend observed** **• Baseline measured, trend undetermined** **- Increasing trend observed** **-- Data deficient**

2.3 Noise Pollution

Intent	Assess the level of noise pollution that may adversely impact wildlife.
Instructions	Identify areas of concern where sources of noise (ports, underwater acoustic deterrents, pile driving, busy streets, airports, railways, industry, etc.) are near to natural habitats, including marine habitats. Count occurrences of noise above a 55 decibel threshold in at least 5 outdoor locations within the areas of concern in the city for at least 30 minutes each during the most noisy time period of a typical day (Benlıay et al., 2019).
Alternatives	A noise map of the areas of concern can be used in lieu of these measurements.
Resources	https://www.eea.europa.eu/airs/2018/environment-and-health/environmental-noise ISO standard 37120:2018:8.8 https://www.researchgate.net/publication/262047792_Marine_noise_pollution_-_increasing_recognition_but_need_for_more_practical_action
Scoring	Score this indicator as follows: **++ Multi-year decreasing trend established** **+ Decreasing trend observed** **• Baseline measured, trend undetermined** **- Increasing trend observed** **-- Data deficient**

2.4 Light Pollution

Intent	Assess the level of light pollution that may adversely impact wildlife.
Instructions	Calculate Average Night Sky light pollution levels on the Sky Quality Meter (SQM) Scale, based on at least 1 measurement point per square kilometer and no less than 20 measurements.
Alternatives	The Bortle scale may alternatively be used.
Resources	For more information, see https://www.globeatnight.org/maps.php Guidelines on how to conduct a Sky Quality Survey by the International Dark-Sky Association.
Scoring	Score this indicator as follows: **++ Multi-year decreasing trend established** **+ Decreasing trend observed** **• Baseline measured, trend undetermined** **- Increasing trend observed** **-- Data deficient**

2.5 Invasive Species

Intent	Assess threat level of invasive species that may adversely impact other wildlife.	
Instructions	According to the local context, select invasive species of interest. Determine the status of each invasive species in the city by measuring their range, total population, or impact as appropriate.	
	Basic: At least 1 species	Advanced: At least 3 species
Alternatives	None	
Resources	None	
Scoring	Score this indicator as follows:	

++ All invasive species eradicated or in decline
+ Majority of invasive species eradicated or in decline
• Baseline measured, trend undetermined
- Majority of invasive species unmanaged or growing
-- Data deficient

3.1 Land Use/Protection

Intent	Assess land use and regulatory protections against harmful development patterns.
Instructions	1. Classify land into the categories below as a percentage of total land area. Categories should not overlap. 2. Calculate the protected land factor by summing all but the last category using the following calculation: $L_F + 0.75\ L_N + 0.5\ L_P + 0.25\ L_I$ = protected land factor

Category	Examples
L_F = % of land that is undeveloped and protected primarily for nature conservation or indigenous and local traditional use.	Green belts, protected watershed areas, local co-managed forests, botanical gardens, and protected ecological parks. Includes IUCN protected area categories Ia, Ib. May also include land outside of the local government boundary that is connected to the city via agreements such as "Payment for Ecosystem Services" (PES).
L_N = % of land that is natural and protected or conserved but allows for sustainable use and/or access.	Natural areas within public parks (vegetated and unmowed), protected riparian zones in a residential zone, or sustainably managed and protected forests. Includes IUCN protected area categories II, III, IV, V, VI. May also include land outside of the local government boundary that is connected to the city via agreements.
L_P = % of land that requires conservation development approaches.	Conservation development zones, clustered development areas, or areas that require some natural restoration or protection when development occurs.
L_I = % of land with incentives encouraging conservation-friendly development.	Same as L_P above, except with a non-mandatory approach. May also include disincentives such as requiring an environmental assessment or riparian permit.

Alternatives	None
Resources	None
Scoring	Score this indicator as follows:

++ Multi-year positive trend established
+ Positive trend observed
• Baseline measured, trend undetermined
- Negative trend observed
-- Data deficient

3.2 Ecosystem Restoration (Terrestrial)

Intent	Measure restoration of terrestrial and wetland habitats.
Instructions	1. Establish targets for ecosystem restoration in terms of land area. Collaborative regional restoration efforts may be included if the local government is at least a supporting partner. 2. Sum up the land area of terrestrial and/or wetland habitats that have undergone restoration efforts in the last year. The types of restoration are indicated below:* ● Restoring a degraded or damaged ecosystem to its former state ● Replacing a destroyed ecosystem with one of the same kind ● Transforming an irreversibly altered ecosystem to another type from the same bioregion ● Substituting a novel ecosystem where site conditions no longer allows any of the naturally occurring ecosystems from the bioregion ● Substituting a potential replacement ecosystem when no reference ecosystem exists
Alternatives	Complete Singapore Index indicator 7 (based on 2021 version).
Resources	The Society for Ecological Restoration International (SER) defines restoration, its principles and implementation, including how ecological restoration and livelihoods can be maintained. Bonn Challenge for restoring degraded and deforested lands. IUCN Forest landscape restoration projects and guiding principles.
Scoring	Score this indicator as follows: **++ Targets fully met and new targets established** **+ Targets partially met** **• Targets established** **- Targets not met** **-- Data deficient**

3.3 Shorelines & Riverbanks

Intent	Proxy measure for the health and restoration of aquatic ecosystems.
Instructions	Calculate the ratio of shoreline that is naturalized compared to engineered for freshwater streams, lakes and marine areas in the city. All streams of at least fourth order in size and lakes of at least 4 hectares in area should be included. **Naturalized shorelines** include natural vegetated soil/sandy/rocky shores and tidal pools and includes restored or artificial shorelines with the same characteristics. **Engineered shorelines** include hardscape such as concrete or riprap edge, mowed lawn, channelized, or culverted. In the case of streams, calculate both sides of the stream bank as one unit equivalent in length to a single marine or other type of shoreline.
Alternatives	None
Resources	None
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

3.4 Vegetation

Intent	Assess vegetation prevalence throughout the local government land area.
Instructions	Complete the advanced or basic indicator as follows:

Basic:	Advanced:
Use the free iTree online tool to estimate the percentage of land area that is vegetated, based on canopy cover.	1. Determine Normalized Difference Vegetation Index (NDVI) in GIS using Landsat 8 remote sensing imagery. 2. Determine which NDVI threshold is most appropriate for your native ecosystem: 0.2 to 0.5 = partial vegetation (shrubland, desert, alpine ecosystems, etc.) 0.5 to 1.0 = vegetated (forested, jungle ecosystems, etc.) 3. Calculate the % land area of the city meeting the appropriate NDVI threshold.

Alternatives	Additional wall area or planted area of vertical green walls or vertical forests may be added if preferred to the % as appropriate.
Resources	NDVI corresponds to the annual net primary productivity of vegetation and is sensitive to temperature and water availability (Tucker 1979). A comprehensive review of NDVI applications is available by Kerr and Ostrovsky (2003) and Pettorelli et al. (2005). This can be done in QGIS (free and open source) or ESRI's ArcGIS Image Analysis toolbar. A QGIS tutorial for this analysis is available here: https://towardsdatascience.com/remote-sensing-with-qgis-calculate-ndvi-c2095f0de21b Worldwide Landsat 8 satellite data is available for free at earthexplorer.usgs.gov
Scoring	Score this indicator as follows:

++ Multi-year positive trend established
+ Positive trend observed
• Baseline measured, trend undetermined
- Negative trend observed
-- Data deficient

3.5 Connectivity

Intent	Assess habitat connectivity throughout the local government's land area.
Instructions	Complete the advanced or basic indicator as follows:

Basic:	Advanced:
Calculate the effective mesh size or refer to the explanation in the Singapore Index indicator 2 (based on 2021 version).	Calculate the connectivity metric for your city following the "graph theory" framework. You may import spatial data into the free, open source Graphab tool to calculate this. Include nearby regional habitat areas if feasible.

Alternatives	Alternative approaches with similar robustness may alternatively be used or combined, such as the Biodispersal plug-in for qGIS, the landscapemetrics R package, or a fragmentation index. Take care that the approach differentiates between habitat amount and connectivity.
Resources	For more information on effective mesh size, see Deslauriers et al., "Corrigendum to: Implementing the connectivity of natural areas in cities as an indicator in the City Biodiversity Index (CBI)" *Ecological Indicators.* 2018, vol. 19 part 2. https://doi.org/10.1016/j.ecolind.2017.09.037 Other resources for alternative methods include: Wang, Blanchett, and Koper, "Measuring habitat fragmentation: An evaluation of landscape pattern metrics," *Methods in Ecology and Evolution*. 2014. https://doi.org/10.1111/2041-210X.12198 Hesselbarth et al., "landscapemetrics: an open-source R tool to calculate landscape metrics," *Ecography*. 2019. https://doi.org/10.1111/ecog.04617
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

4.1 Animal Species

Intent	Proxy measure of citywide animal species diversity through careful selection of indicator species.
Instructions	1. Select at least 3 of the following taxonomic categories: • Birds • Mammals • Aquatic animals and molluscs (cnidaria, porifera, fish, mollusca) • Invertebrates • Herpetofauna (reptiles and amphibians) 2. Identify at least 3 native species from each category, using endangered* species as appropriate, referred to as indicator species.

Basic:	Advanced:
Determine presence/absence of at least 3 indicator species in at least 5 representative locations each, distributed throughout the city (total minimum of 45 data points). Count 1 point for the presence of each species in each location, then divide by the maximum possible points for the time period of interest (at least one year) resulting in a %.	Map observed distribution of at least 5 indicator species throughout the city. Calculate the total distribution area of each species (by adding up all distribution areas), then divide by the number of species mapped over the time period of interest (at least one year). For example, species A is found in two locations, a 500 m^2 area and a 1km^2 area. Species B is found in one 2.5 km^2 area. The area for species A is therefore 1.5 km^2 and for B is 2.5 km^2. The total area is therefore 4km^2 which is divided by 2 (for 2 species) for a result of 2. Note that overlapping areas may be counted multiple times, once for each species.

Alternatives	Complete either the UBIF program or Singapore Index indicators 3, 5, and 6 (based on 2021 version).

Resources	Endangered species are classified as endangered or critically endangered on the IUCN Red List, listed in CITES appendix I, listed in the Convention of Migratory Species appendix I, and/or equivalent local/national species lists.
	
	Data sources for species observations and distribution estimates:
	• Databases such as GBIF or national data repositories
	• Verified citizen science observations such as such as iNaturalist or eBird
	• Original data gathered by local organizations, staff, or trained volunteers using, for example:
	  ○ Traps,
	  ○ Transect walks/dives,
	  ○ Automatic trail cameras,
	  ○ DNA assessments (soil, water, invertebrates), and
	  ○ Systematic surveys/observations

Scoring	Score this indicator as follows:

++ Multi-year positive trend established
+ Positive trend observed
• Baseline measured, trend undetermined
- Negative trend observed
-- Data deficient

4.2 Plant Species

Intent	Proxy measure of citywide plant species diversity through careful selection of survey locations.
Instructions	1. Select at least 5 areas* that together represent plant diversity in your city. 2. Assay an area totaling at least 100 square meters per location by designating transects or plots. 3. Record the presence of native vascular plants in each location. 4. Count the total number of vascular plant species across all locations. 5. Repeat this count to establish a trend, every 1-5 years.
Alternatives	Complete Singapore Index indicator 4 (based on 2021 version).
Resources	None
Scoring	Score this indicator as follows:

++ Multi-year positive trend established
+ Positive trend observed
• Baseline measured, trend undetermined
- Negative trend observed
-- Data deficient

4.3 Functional Diversity

Intent	Measure functional diversity of interest, depending on local context.
Instructions	1. Identify a species group (may be a mix of taxa) according to an ecological function of interest such as: • pollinators • predators • ecosystem engineers • in situ bioremediation • water or air biofiltration 2. Select from the example choices below or determine your own local measure of this function. 3. Measure this function across at least 5 representative locations across the city.

Example 1:	Example 2:
Pollination services can be estimated by counting the visitation rate of flowers in each location over a fixed set of time (Fijen and Kleijin, 2017, https://doi.org/10.1016/j.baae.2017.01.004), or the rate of pollinated fruit/seed set in each location.	Mosquito predation services can be estimated by placing artificial oviposition habitats for mosquitos in each location and then removing and counting daily egg clutches in the habitat (Reiskind and Wund, 2009, doi: 10.1603/033.046.0510)

Alternatives	A custom option can be determined, as appropriate.
Resources	Schmitz, O. J., Hawlena, D., y Trussell, G. C. 2010. Predator control of ecosystem nutrient dynamics. Ecology Letters, 13(10): 1199-1209). https://doi.org/10.1111/j.1461-0248.2010.01511.x Reports by the UN Food and Agricultural Organization: Rapid assessment of pollinators' status (2008, English) and Principios y avances sobre polinización como servicio ambiental para la agricultura sostenible en países de Latinoamérica y El Caribe (2014, Spanish).
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

4.4 Microbiota

Intent	Proxy measure for the health of soils and microbiotic systems in aquatic and terrestrial areas.	
Instructions	1. Select at least 5 representative sites across your city, including both terrestrial and aquatic ecosystems. 2. Measure decomposition rates in each location. 3. Calculate an average rate of decomposition across all 5 sites.	
	In **terrestrial locations**, decomposition rates can be estimated by measuring the loss in mass of leaf litter decomposition in terrestrial locations (Karberg et al., 2008).	In **aquatic locations**, they can be estimated by placing leaf litter or cotton strips in bags affixed to a location and measuring the decomposition rates of the material over time.
Alternatives	None	
Resources	None	
Scoring	Score this indicator as follows:	

++ Multi-year positive trend established
+ Positive trend observed
• Baseline measured, trend undetermined
- Negative trend observed
-- Data deficient

4.5 Endemic Species

Intent	Assess the richness of endemic species (endemicity is based on context, and may be regional or local).
Instructions	Complete the advanced or basic indicator as follows:

Basic:	Advanced:
Measure richness by counting the total number of endemic species present and their conservation status. Calculate your score based on species counts (S) with a multiplier according to conservation status: $0*S_{EX} + .2*S_{EW} + .4*S_{CR} + .6*S_{EN} + .8*S_{VU} + .9*S_{NT} + S_{LC}$ Status per the IUCN Red List (EX = extinct, EW = extinct in the wild, CR = critically endangered, EN = endangered, VU = vulnerable, NT = near threatened, LC = least concern) or equivalent local/national lists.	1. Measure abundance by estimating the total local population of at least 3 species endemic to your area (local or regional). 2. Calculate the growth rate for each species, then average this growth rate across all measured endemic species.

Alternatives	None
Resources	None
Scoring	Score this indicator as follows:

++ Multi-year positive trend established
+ Positive trend observed
• Baseline measured, trend undetermined
- Negative trend observed
-- Data deficient

5.1 Exposure to Nature

Intent	Measure overall exposure to nature by urban residents and visitors.
Instructions	Calculate the total annual number of visitors to vegetated and/or natural open areas (including vegetated parks and botanical gardens). Counts or estimates are accepted.
Alternatives	None
Resources	None
Scoring	Score this indicator as follows:

++ Multi-year positive trend established
+ Positive trend observed
• Baseline measured, trend undetermined
- Negative trend observed
-- Data deficient

5.2 Access to Nature

Intent	Measure increasing access to natural areas for all members of vulnerable urban communities.	
Instructions	Complete the advanced or basic indicator as follows:	
	Basic: Calculate the percentage of residents living within a walkable distance (300 metres) of a public, open access natural area.	Advanced: Calculate the percentage of residents in the lowest income quintile (lowest 20%) living within a walkable distance (300 metres) of a public, open access natural area.
Alternatives	Complete Singapore Index indicator 13 (based on the 2021 version).	
Resources	None	
Scoring	Score this indicator as follows:	

++ Multi-year positive trend established
+ Positive trend observed
• Baseline measured, trend undetermined
- Negative trend observed
-- Data deficient

5.3 Human Health

Intent	Measure aspects of human health that are directly related to ecosystem services and/or biodiversity.
Instructions	Select from the measures listed below that link human health with environmental conditions, as appropriate to your local context: 1. Air quality measures (choose no more than one of these) • Childhood asthma rates • Nitrogen dioxide concentration • PM 2.5 concentration (such as SEEA air emissions accounts) • The European Green Capital Award section 2.6 Air Quality indicators • The North American Air Quality Index for PM 2.5. • Bioindicators such as lichens or bryophytes 2. Rates of disorders and diseases linked to exposure to dangerous substances such as lead poisoning, birth defects, cancer, neurological, endocrinological, thyroid, obesity, and cardiovascular problems 3. Rates of zoonotic communicable disease outbreaks and/or presence of resistant bacterial strains 4. Rates of human microbiome diversity-related conditions such as autoimmune diseases, type 1 diabetes, multiple sclerosis, allergic disorders, eczema, inflammatory bowel diseases, and Crohn's disease
	Basic: Select 1 measure. / Advanced: Select 3 measures.
Alternatives	None
Resources	IUCN information paper on Biodiversity and Human Health, 2018. Report: Connecting Global Priorities: Biodiversity and Human Health by WHO and CBD, 2015.
Scoring	Score this indicator as follows: ++ **Multi-year decreasing trend established** + **Decreasing trend observed** • **Baseline measured, trend undetermined** - **Increasing trend observed** -- **Data deficient**

5.4 Livelihoods

Intent	Measure support for livelihoods stemming from conservation and sustainable management.
Instructions	1. Select from the categories below (see advanced and basic options for more information): • Vocational training intended to transition or otherwise funnel workers into green-collar jobs • Green-collar work (full-time equivalent receiving at least an effective hourly compensation that is equal to or above the local median wage rate) • Payment for ecosystem services (PES) or other direct monetary incentives for the stewardship or sustainable management of natural resources. Ecosystem services are not limited to those within the city boundary. 2. Calculate the total number of individuals that received one or more of the items you selected.

Basic:	Advanced:
Select one of the categories listed. Choose at least one industry or sector from which to gather data, if applicable.	Select at least two of the categories listed. Choose at least two industries or sectors from which to gather data, if applicable.

Alternatives	None
Resources	Green collar jobs are within a green industry, for a green institution, or in a position responsible for increasing the sustainability of goods or services (define this for yourself as appropriate in the local context). Green Jobs Assessment Reports by country by the International Labour Organization Measuring Green Jobs? Report by Norden
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

5.5 Sacred Natural Sites

Intent	Measure the recognition and shared custodianship of local sacred natural sites.
Instructions	Calculate the total number of Sacred Natural Sites that are: ● Recognized and/or protected for sacred use, and ● Managed to suit spiritual purposes in partnership with appropriate local communities or indigenous leaders.
Alternatives	None
Resources	Sacred Natural Sites are areas of land or water having special spiritual significance to peoples and communities (IUCN, 2008). They may be recognized by Man and the Biosphere Programme, the Convention on Wetlands, the World Heritage Convention, the Convention on Biological Diversity, the Convention for the Safeguarding of Intangible Cultural Heritage, the Declaration on the Rights of Indigenous Peoples, or an equivalent local recognition program.
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

6.1 Planning

Intent	Assess local government planning efforts for biodiversity and ecosystem services.
Instructions	Local government adoption of one or more local plans that together address each of the 6 themes in this index, with specific indicators, actions and goals. Score the advanced or basic indicator as follows:
	Basic: Partial adoption or implementation (of at least one indicator under a minimum of three themes) is required for scoring. Advanced: Complete adoption or implementation (of at least one indicator under each of the six themes) is required for scoring.
Alternatives	Complete Singapore Index indicator 17 and 18 (based on 2021 version).
Resources	Urban Biodiversity Hub database of biodiversity plans.
Scoring	Score this indicator as follows: **++ Plan(s) currently being implemented** **+ Plan(s) adopted but not yet implemented** **• Policies or plans proposed but not yet adopted** **- Incomplete or out of date policies or plans** **-- Data deficient**

6.2 Law & Policy

Intent	Assess government regulatory efforts for biodiversity and ecosystem services.
Instructions	Government adoption of local policies and bylaws (together referred to as regulations) that commit to the enforcement, implementation, or direct support needed to improve the indicators measured in each of the themes of this index. Note that plans are not covered here, but are rather in the previous indicator topic. Score the advanced or basic indicator as follows:
	Basic: Supporting regulations for at least one indicator under a minimum of three themes are required. Advanced: Supporting regulations for at least one indicator under each of the six themes are required.
Alternatives	None
Resources	IUCN's World Commission on Environmental Law (WCEL), World Declaration on the Environmental Rule of Law and Framework for Assessing and Improving Law for Sustainability, ECOLEX environmental law database.
Scoring	Score this indicator as follows: **++ Local bylaws for each theme actively enforced** **+ Progress made on adoption of local bylaws** **• Overarching policy commitment only** **- No current commitment** **-- Data deficient**

6.3 Education

Intent	Assess depth of educational programs for biodiversity and ecosystem services.
Instructions	Total number of hours members of the public have spent participating as leaders, or learners in educational programs (formal or informal) covering any of the themes listed in this index including citizen science, guided nature walks, student research, formal classes, or primary/secondary education.
Alternatives	None
Resources	IUCN Commission on Education and Communication CBD Communication, Education and Public Awareness (CEPA) programme, including Biodiversity Education resources
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

6.4 Management

Intent	Assess government-supported management of natural spaces and resources.
Instructions	Measure the total hectares of natural areas in the city with at least one of the following: ● An officially adopted sustainable management plan that encourages integrated pest management while reducing or eliminating: ○ Fertilizers ○ pesticide application (including rodenticides), and ○ Motorized mowing and other motorized tool use ● An active co-management program with local community groups ● Stewardship by local indigenous group(s)
Alternatives	Complete Singapore Index indicator 19 (based on 2021 version). Protected Area Management Effectiveness (PAME) methodologies may alternately be used.
Resources	None
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

6.5 Incentives & Participation

Intent	Assess government-supported incentives and initiatives for visionary and sustainable lifestyles.
Instructions	Calculate the total number of direct participants in local government-supported programs (other than education) with their primary purpose being to contribute to any of the themes listed in this index, including: • Events • Awards or funding • Volunteer work, including restoration • Collaborative programs
Alternatives	None
Resources	None
Scoring	Score this indicator as follows: **++ Multi-year positive trend established** **+ Positive trend observed** **• Baseline measured, trend undetermined** **- Negative trend observed** **-- Data deficient**

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