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98

HANDBOOK ON THE SINGAPORE INDEX ON CITIES' BIODIVERSITY

(also known as the City Biodiversity Index)

UN environment programme

Convention on Biological Diversity

NATIONAL PARKS
LET'S MAKE SINGAPORE OUR CITY IN NATURE

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TABLE OF CONTENTS

Preface by Mrs. Elizabeth Maruma Mrema iv

Foreword by Mr. Desmond Lee v

Introduction 1

The Singapore Index on Cities' Biodiversity 9

Part I: Profile of the City 10

Part II: Indicators of the Singapore Index on Cities' Biodiversity 12

Indicator 1: Proportion of Natural Areas in the City 14
Indicator 2: Connectivity Measures or Ecological Networks to Counter Fragmentation 15
Indicator 3: Native Biodiversity in Built Up Areas (Bird Species) 16
Indicator 4: Change in Number of Native Vascular Plant Species 17
Indicator 5: Change in Number of Native Bird Species 18
Indicator 6: Change in Number of Native Arthropod Species 19
Indicator 7: Habitat Restoration 20
Indicator 8: Proportion of Protected Natural Areas 21
Indicator 9: Proportion of Invasive Alien Species 22
Indicator 10: Regulation of Quantity Of Water 23
Indicator 11: Climate Regulation – Benefits of Trees And Greenery 24
Indicator 12: Recreational Services 25
Indicator 13: Health and Wellbeing – Proximity/Accessibility to Parks 26
Indicator 14: Food Security Resilience – Urban Agriculture 27
Indicator 15: Institutional Capacity 28
Indicator 16: Budget Allocated to Biodiversity 29
Indicator 17: Policies, Rules and Regulations – Existence of Local Biodiversity Strategy and Action Plan 30
Indicator 18: Status of Natural Capital Assessment in the City 31
Indicator 19: State of Green and Blue Space Management Plans in the City 32
Indicator 20: Biodiversity-Related Responses to Climate Change 33
Indicator 21: Policy and/or Incentives for Green Infrastructure as Nature-Based Solutions 34
Indicator 22: Cross-Sectoral & Inter-Agency Collaborations 35
Indicator 23–24: Participation and Partnership 36
Indicator 25: Number of Biodiversity Projects Implemented by the City Annually 37
Indicator 26: Education 38
Indicator 27: Awareness 39
Indicator 28: Community Science 40

Acknowledgements 43

Annex A
Discussions and Outcomes of the First, Second and Third Expert Workshops on the Development of the Singapore Index on Cities' Biodiversity as well as the Workshop on the Review of the Singapore Index on Cities' Biodiversity.. 45

Annex B
List of Participants for the Workshops Held to Discuss the Development and Revision of the Singapore Index on Cities' Biodiversity... 55

Annex C
Proposed format for submission of application of the Singapore Index on Cities' Biodiversity 60

Annex D
Illustration of the calculation of effective mesh size of natural areas for indicator 2......................... 62

Annex E:
Illustration Explaining Effective Impervious Area.. 63

Annex F
Guide to Measuring Proximity and Accessibility... 64

Annex G
Examples of Green Infrastructure 66

Annex H
References 68

PREFACE

The City Biodiversity Index, developed through contributions and critical reviews from hundreds of global practitioners and experts, was launched by Singapore in 2008 at the eighth Conference of the Parties to the Convention on Biological Diversity (CBD). It has been used as a viable tool for planning and monitoring by dozens of cities, development organizations and academic networks.

Its further development and refinement have benefited from exchanges held with relevant agencies and networks managed by Singapore's National Parks Board. Consequently, this handbook offers indicators whose design and application combine credible and careful science with widespread policy development, implementation and evaluation. The CBD Secretariat welcomes the opportunity to publish this update on its use and application as part of the CBD Technical Series.

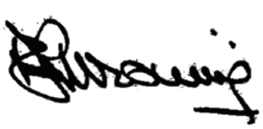
The wide implications of Sustainable Development Goal 11 to the UN Agenda for Sustainable Development and the objectives of the Rio Conventions (United Nations Framework Convention on Climate Change, United Nations Convention to Combat Desertification and the Convention on Biological Diversity) are evident. Likewise, by recognizing the critical role of urbanization in the fifth *Global Biodiversity Outlook* (GBO-5), metrics for the management of the manifold impact of cities on biodiversity and vice-versa will be critical in the years to come.

Even beyond the foreseen direct impacts of the expansion of cities and human settlements, affecting over 15 per cent of all biodiversity hotspots and key areas over the next ten years, the footprint and urban-rural linkages of the consolidated production and consumption of conurbations globally is several times larger.

The Singapore Index remains the most comprehensive index on this topic. This updated and revised handbook includes wider coverage of the services biodiversity and ecosystems provide to people. It also simplifies measuring and evaluation tools and enhances advice on the application of its expanded series of indicators.

As the Secretariat of the Convention continues to foster cooperation among Parties, local and subnational governments, agencies and other partners on this important subject, I am confident that the Index will provide a readily available resource. Equally, it will encourage cities to evaluate and monitor their biodiversity efforts, assist them in implementing the post-2020 global biodiversity framework, and ensure a good quality of life for its urban citizens.

I invite users of the handbook to share their views and comments with the Secretariat, to allow us to better serve CBD Parties and their critical partners in leveraging the power of cities for nature and people.



Elizabeth Maruma Mrema
Executive Secretary, Convention on Biological Diversity

FOREWORD

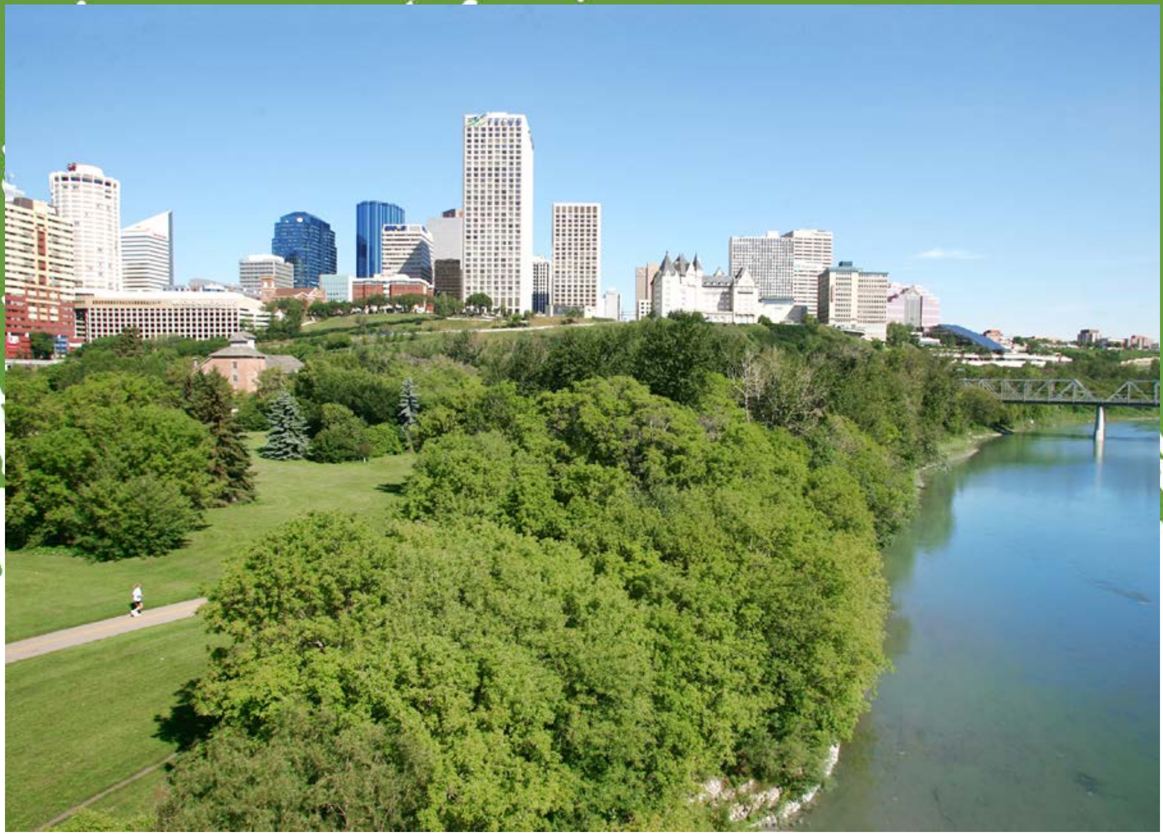
Since the Singapore Index on Cities' Biodiversity was launched in 2008, it has been used by many cities around the world to evaluate and monitor the progress of their biodiversity conservation efforts. The Singapore Index covers a broad range of indicators such as native biodiversity, ecosystem services, and the governance and management of biodiversity. Cities, which have applied the Singapore Index, have found the framework useful in building their capabilities in biodiversity conservation, setting priorities for conservation actions and budget allocation.

Nevertheless, in recent years, climate change has accelerated the rate of biodiversity loss across the globe. Conservation of protected areas alone is insufficient to counter this. We need to complement these efforts by restoring ecosystems, enhancing ecological connectivity, and greening our infrastructure. We also need to intensify the use of innovative nature-based solutions, which are anchored in science. With this in mind, a workshop was convened in October 2019 to enhance the Singapore Index, so that it continues to be relevant for cities around the world. Incorporating suggestions by experts and cities which had applied the Singapore Index, the revised indicators now include habitat restoration, park accessibility, urban agriculture, nature-based solutions for infrastructure and the regular assessment of natural capital, among others. As modern technologies such as satellite images, spatial analysis software, camera-traps, and molecular genetics tools have become more accessible, cities would now be better able to quantify these indicators and apply the Singapore Index more accurately and efficiently.

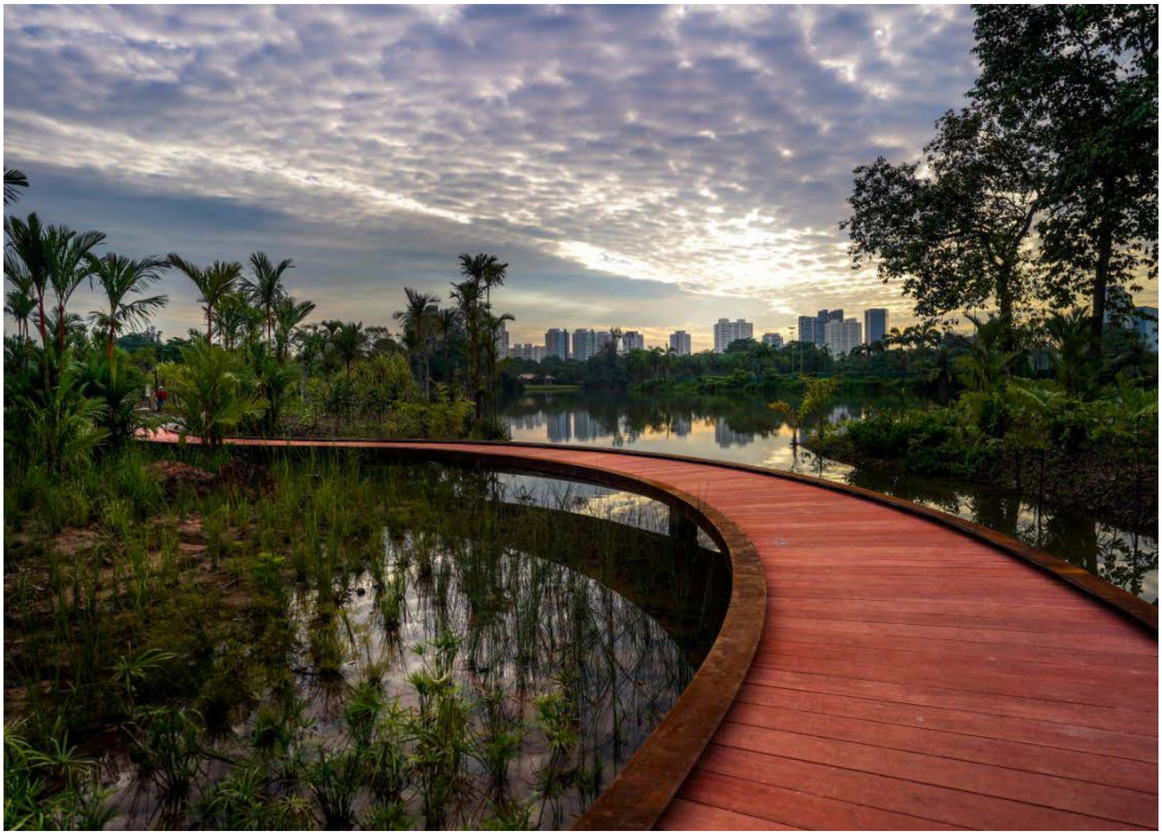
The development and enhancement of the Singapore Index underscore Singapore's commitment to mitigate the effects of urbanisation and climate change, and to protect our rich biodiversity. Under the Singapore Green Plan 2030 – a national movement for sustainable development – we are making a concerted push to transform Singapore into a City in Nature. To achieve this aspiration, we are extending and enhancing our natural capital island-wide. This will be done through four key moves: expanding our nature park network to better protect and buffer our nature reserves, intensifying nature in our gardens and parks, integrating nature into the urban environment, and strengthening connectivity between important green spaces. The indicators of the Singapore Index mirror several of these strategies.

I hope cities will find this enhanced Singapore Index useful in helping you assess and strengthen your efforts to conserve biodiversity within your cities.

Desmond Lee
Minister for National Development and Minister-in-charge of Social Services Integration, Singapore



The North Saskatchewan River weaves through Edmonton, Canada. © City of Edmonton



A restored freshwater swamp ecosystem in the Jurong Lake Gardens, Singapore. © National Parks Board

INTRODUCTION

Why Biodiversity is Crucial for Human Survival

1. City governments have many competing priorities – from the economic to social spheres – and have difficulty in appropriating the right amount of resources to biodiversity conservation. This is largely due to the lack of policy tools that take into account the value of biodiversity and the ecosystem services they provide. Nature is often viewed as an aesthetic luxury that few can afford. However, nature comprises ecosystems that regulate the quantity and quality of water and air which are essential to the well-being of a city's residents. Furthermore, ecosystems have the ability to moderate ambient and surface temperatures of cities which are often plagued by the phenomenon termed the urban-heat island effect. Most of a city's water supply usually comes from catchment areas within natural ecosystems that play a significant role in purifying the water. Urban greenery within the city replenishes oxygen, sequesters carbon, reduces air pollution, regulates ambient and surface temperature in urban landscapes, provides habitat for animals, reduces soil erosion, in addition to many other intangible benefits. Most of our foods are derived from biodiversity. Furthermore, parks and natural areas create recreational spaces and educational opportunities for residents, contributing to the overall liveability of the city. Studies have shown that frequent contact with nature is essential for our psychological and mental well-being. This ecosystem service provided by nearby natural areas and parks is most appreciated during COVID-19 lockdown periods in many cities. Biodiversity can thrive without *Homo sapiens* but our survival and quality of life are totally dependent on biodiversity. However, the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) (2019) highlighted that nature is declining at an unprecedented rate in human history, with grave impacts to people around the world. Human activity has put increasing strains on the world's biodiversity with 75% of terrestrial ecosystems severely altered with up to one million species threatened with extinction and more than a 100% growth of urban areas since 1992.

Biodiversity and Cities

2. The future world's population will continue to grow and live predominantly in urban areas (United Nations, 2019). Hence, it is exigent for cities to be involved in efforts to halt, and eventually reverse global biodiversity loss exacerbated by the effects of climate change.

3. Decision X/22 by the Parties of the Convention on Biological Diversity (CBD) requested the Executive Secretary of the Secretariat of the CBD to prepare an assessment of the links and opportunities between urbanization and biodiversity. Ten key messages were articulated in the publication, Cities and Biodiversity Outlook (Secretariat of the Convention on Biological Diversity, 2012):

    a. Urbanization is both a challenge and an opportunity to manage ecosystem services globally;
    b. Rich biodiversity can exist in cities;
    c. Biodiversity and ecosystem services are critical natural capital;
    d. Maintaining functioning urban ecosystems can significantly enhance human health and well-being;
    e. Urban ecosystem services and biodiversity can help contribute to climate-change mitigation and adaptation;
    f. Increasing the biodiversity of urban food systems can enhance food and nutrition security
    g. Ecosystem services must be integrated in urban policy and planning;
    h. Successful management of biodiversity and ecosystem services must be based on multi-scale, multi-sectoral, and multi-stakeholder involvement;
    i. Cities offer unique opportunities for learning and education about a resilient and sustainable future;
    j. Cities have a large potential to generate innovations and governance tools and therefore can – and must – take the lead in sustainable development.

4. These ten messages are as relevant today as a decade ago. In fact, with the adverse effects of rapid deterioration of natural ecosystems compounded by the mounting negative impacts of climate change, it is imperative that cities must rise to the occasion to counter them in an integrated manner.

5. Linking this with the United Nations Sustainable Development Goal (SDG) 11, i.e., "Make cities inclusive, safe, resilient and sustainable", Targets 11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage and Target 11.7: By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities, are most pertinent in this current context. IPBES recognises the importance of cities and suggested "Integrated Approaches for Sustainable Cities", where Chapter 6.3.5 highlighted "Nature-based solutions and green infrastructure" as one of the approaches.

What Cities Can Do to Conserve Biodiversity

6. In the light of a cornucopia of goods and services that biodiversity offers to cities, more attention should be accorded to urban biodiversity conservation.

7. First, cities need to carefully analyse the costs and benefits of urban development. The expansion of cities and their infrastructure have come at the expense of natural ecosystems and their inhabitants. The growing number of building and infrastructure projects such as transportation systems, airports, port facilities, sewage systems, water systems, communication networks, etc., incur huge environmental costs. Yet, when implemented prudently, these projects are able to bring about a wide range of economic and social benefits. Therefore, cities have the responsibility to carefully weigh the pros and cons of urban development in order to achieve sustainable development for the benefit of a diverse group of people while ensuring that biodiversity and the ecosystem services that they provide are not adversely affected.

8. Secondly, cities should start to be cognizant of trends that lead to sustainable growth that is sensitive to their ecological context. Designing biophilic and climate-resilient cities, leveraging on nature-based solutions, building nature-sensitive road networks and incorporating green infrastructure design to the urban planning approach are some of the ways in which cities are able to contribute significantly to the overall global biodiversity conservation effort.

9. Thirdly, mainstreaming of and incorporating biodiversity into the city planning process are crucial for biodiversity conservation to be effective.

10. Fourthly, applying the wisdom that "if you can't measure it, you can't manage it", it logically follows that a monitoring and evaluation framework comprising relevant indicators that measure biodiversity and efforts to conserve it is essential and must be developed. The Singapore Index on Cities' Biodiversity (Singapore Index or SI) was designed as a quantitative scoring tool to serve this purpose.

Evolution of the Singapore Index on Cities' Biodiversity

11. The development of an index for cities to measure their biodiversity conservation efforts was first mooted at the high-level segment of the ninth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 9) by Mr. Mah Bow Tan, former Minister for National Development of Singapore. The first version of the Singapore Index was developed through a series of three technical expert workshops conducted from 2009 to 2011 that involved representatives from academia, international organisations and cities. Ten years later in 2019, a fourth workshop was convened to update the SI by drawing on the rich experiences that were accrued with the application of the SI by cities, academics and consultancies. It is also timely and opportune to add pertinent indicators of topical relevance like biodiversity and climate change, as well as align and synergise with discussions on the post-2020 global biodiversity framework and leverage on the diverse expertise on biodiversity conservation and modern technology that have evolved in the interim period.

An Index to Measure Urban Biodiversity

12. The first step that was taken to develop an index to measure urban biodiversity was to start with stock-taking and identifying baselines, followed by regular monitoring of conservation initiatives. Prior to the development of the Singapore Index, existing environmental and sustainability indices for cities and local authorities covered broader environmental issues and where biodiversity was considered, it typically formed only a minor component of the composite scores. In addition, indices that focussed specifically on biodiversity were targeted at the national level, which made local application challenging.

13. Following the proposal at the high-level segment of COP9, the National Parks of Singapore (NParks), in partnership with the Secretariat of the Convention on Biological Diversity (SCBD) and the Global Partnership on Local and Subnational Action for Biodiversity, organised a series of expert workshops in 2009, 2010 and 2011 to develop and fine-tune a biodiversity index for cities. The workshops, attended by technical experts on urban biodiversity and ecology, international organisations and city officials, discussed and identified indicators that would enable cities to monitor and evaluate their urban biodiversity conservation efforts. The User's Manual on the Singapore Index on Cities' Biodiversity (Chan *et al*., 2014) was published to guide and assist cities in the application of the Singapore Index. NParks recently hosted a fourth workshop in October 2019 to revise the Singapore Index to take into account current issues. The current publication is an updated revised version of the above-mentioned publication. All discussions and outcomes of the workshops are summarised in **Annex A.** The participants for the four workshops are listed in **Annex B**.

14. When it was first developed, the Singapore Index was a pioneering, self-assessment tool designed to help cities better understand how they could improve their biodiversity conservation efforts over time, i.e., a measurement of a city's biodiversity efforts benchmarked against itself over time. Cities should make an initial baseline measurement; identify policy priorities based on their measurements and then monitor again at periodic intervals. It was not specifically or originally planned as a tool for comparing and contrasting the performance of different cities nor is it a tool to be used only once. However, organisations have used some indicators of the Singapore Index for comparative purposes.

15. The Singapore Index helps cities to accomplish their biodiversity goals via three interrelated mechanisms, which are vital to positive policy outcomes. First, the Index is a tool that allows cities to create baseline measurements of their current biodiversity profiles and then monitor and assess them over time. Second, it serves as a public platform upon which biodiversity awareness raising exercises can be launched. Finally, the Index acts as portal among various departments within city governance, academics, NGOs, schools, the public and businesses, hence, encouraging better communication,

stronger networks and more co-operation, through data collection and sharing of mutual goals. This is aimed at ultimately resulting in better policy outcomes. Its indicators can serve as important policy tools in the measurement of economic, social and environmental variables.

16. The Singapore Index encourages cities to complete a baseline assessment of their biodiversity and then monitor this over time. As a tool, this provides cities with valuable information that they might not otherwise have and can aid in the decision-making process as it helps to identify strengths, weaknesses and trends over time. The Municipality of León in the State of Guanajuato, Mexico, found the Singapore Index to be useful in the preparation of its biodiversity document.

> **"I am pleased to inform you that the Municipality of León in the State of Guanajuato, through the Municipal Planning Institute (IMPLAN) and the Environment Directorate, concluded the Singapore Index – Urban Biodiversity Index for the city above mentioned. It is also worth mentioning that the guide and indicators provided, proved a very valuable instrument to determine our current IBU."**
>
> —Mr. Jaime Samperio Vázquez, Director of the Department of Sustainable Development of IMPLAN, Mexico.

17. The Singapore Index also serves as a valuable method of awareness-raising allowing cities to mobilise their citizenry in efforts to protect and enhance locally important populations of species and ecosystems. Studies have shown that involvement of local people in monitoring and data collection often results in better policy and implementation outcomes (Danielsen *et al*., 2010). The Index provides opportunities for citizen and city collaboration and potential media exposure which can help cities create momentum behind biodiversity conservation efforts. In a study conducted by Corporate Knights[1] on good sustainable development practices in Canadian cities, Edmonton and Montreal scored a perfect score for their biodiversity monitoring efforts, attributing their performance to the use of the Singapore The Urban Biodiversity Hub has been evaluating indices on urban biodiversity and their findings are given below:

> **"…based on our research comparing frameworks on urban biodiversity, the Singapore Index remains the most comprehensive index on this topic, and we feel that this latest revision has even more potential for cities who are committed to biodiversity."**
>
> —Jennifer Rae Pierce and Mika Tan, Urban Biodiversity Hub

18. The Singapore Index has also been instrumental in helping local, national and regional government departments to exchange information and ideas on measuring biodiversity. This creates a new network of policy actors around the issue of biodiversity and further embeds the idea into policy discourse. There has been growing participation of NGOs, universities and consultancy firms and this has benefited biodiversity policy in the cities that applied the Index by presenting new policy opportunities that might not have readily existed without the synergies created by the networks involved in data collection. For example, in Lisbon, Portugal, the application of the Singapore Index led to the development of a Local Biodiversity Strategy and Action Plan. It has also been creatively used in Singapore by city planners in the master planning of new districts and the Building and Construction Authority in their Green Mark for Districts scheme. Here, the Index helped to create new networks of stakeholders who came together to formulate policies that would not have been possible otherwise.

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1 *Corporate Knights* is a quarterly Canadian magazine dedicated towards advocating responsible business practices within Canada and promoting sustainable development globally.

Local Action, Global Reach

19. Biodiversity conservation and climate change have transboundary and inter-generational implications. Hence, concerted efforts must be all-inclusive and taken at multiple levels, involving everyone from individuals to communities, municipals, cities, subnational governments, states, provinces, countries, regional and global scale.

20. For the past decade and a half, cities have been coming together to form partnerships, share experiences and seek solutions. The timeline below highlights some of the efforts by cities.

2006 Cape Town, South Africa

ICLEI – Local Governments for Sustainability (ICLEI) General Assembly:

Attended by more than 300 representatives of ICLEI member cities and local authorities.

Established ICLEI-LAB – a pilot project on Local Action for Biodiversity.

March 2007 Curitiba, Brazil

Cities and Biodiversity: Achieving the 2010 Biodiversity Target Meeting.

Global Partnership on Cities and Biodiversity initiated to:

- support cities in the sustainable management of urban biodiversity resources;
- provide assistance in the implementation of national and international strategies; and
- serve as a platform for cities to share best practices.

May 2008 Bonn, Germany

Ninth Meeting of the COP to the CBD (COP 9)

It was first time cities spoke at the highest level forum of a UN environmental convention: Mayors of the Steering Committee (Bonn, Curitiba, Montreal and Nagoya) addressed ministers and high-ranking officials from Parties during the high-level segment.

Announcement of the Singapore Index: Former Minister for National Development of Singapore, Mr Mah Bow Tan, proposed the establishment of an index to measure biodiversity in cities

Decision IX/28[2] adopted:
This marked a watershed in efforts to recognise the role of cities and local authorities in stemming global biodiversity loss; the decision encourages national governments to engage cities in the implementation of the CBD. Decision IX/28 provided leverage for cities, subnational governments and local authorities to be more involved in CBD's programme of work on local authorities.

February 2009 Singapore

First Expert Workshop on the Development of the Singapore Index

Format of the index and its components were decided on.

2010

Global Partnership on Local and Subnational Action for Biodiversity.

Global Partnership on Cities and Biodiversity was expanded and renamed the "Global Partnership on Local and Subnational Action for Biodiversity" to include other levels of local and subnational authorities such as the Network of Regional Governments for Sustainable Development[3] (nrg4sd).

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2 Paragraph 6 of Decision IX/28 reads, "*Invites* Parties to engage their cities and local authorities, where appropriate, in: (a) The application of relevant tools and guidelines developed under the Convention with a view to contributing to the achievement of the three objectives of the Convention and its goals and targets; and (b) The compilation of information on biodiversity status and trends, including communicating to National Governments any commitments and activities that will contribute to the targets of the Convention on Biological Diversity."

3 The Network of Regional Governments for Sustainable Development (nrg4sd) is an international partnership comprising 50 subnational governments from 30 countries facilitated by the Secretariat of the Convention on Biological Diversity (SCBD). Nrg4sd engages other city networks such as the World Mayor's Council on Climate Change, the Biophilic Cities Project, as well as scientific networks on urban biodiversity such as the Urban Biosphere Network (URBIS), and the Urban Biodiversity and Design Network (URBIO).

July 2010 Singapore

Second Expert Workshop on the Development of the Singapore Index

Indicators of the index fine-tuned according to comments given by cities that tested the indicators.

18-29 October 2010 Nagoya, Japan

Tenth Meeting of the COP to the CBD (COP 10)

The City Biodiversity Index was formally endorsed as the Singapore Index on Cities' Biodiversity in recognition of Singapore's leadership and contributions to the development of the index

Decision X/22 on the Plan of Action on Subnational Governments, Cities and Other Local Authorities for Biodiversity adopted which:

- supports the implementation of the Strategic Plan for Biodiversity 2011-2020 at the national and local levels by providing recommendations to national governments on how they can engage local authorities and translate national strategies to the local context
- encourages the use of the Singapore Index as a monitoring tool to assist local authorities to evaluate their progress in urban biodiversity conservation, which can be further included in national reports.

October 2011 Singapore

Third Expert Workshop on the Development of the Singapore Index

Scoring ranges for indicators finalised and ways to expand the use of the Singapore Index were deliberated.

2012 Hyderabad, India

Eleventh Meeting of the COP to the CBD (COP 11)

Attended by approximately 6,000 delegates representing national governments, UN agencies, intergovernmental organisations, non-governmental organisations (NGOs), academia, private sector and local authorities.

Adopted Decision XI/8 where Parties to the CBD welcomed the report on the implementation of the Plan of Action and further encouraged the Biodiversity Indicators Partnership to use the Singapore Index to monitor the progress of urban settlements in achieving the Aichi Biodiversity Targets.

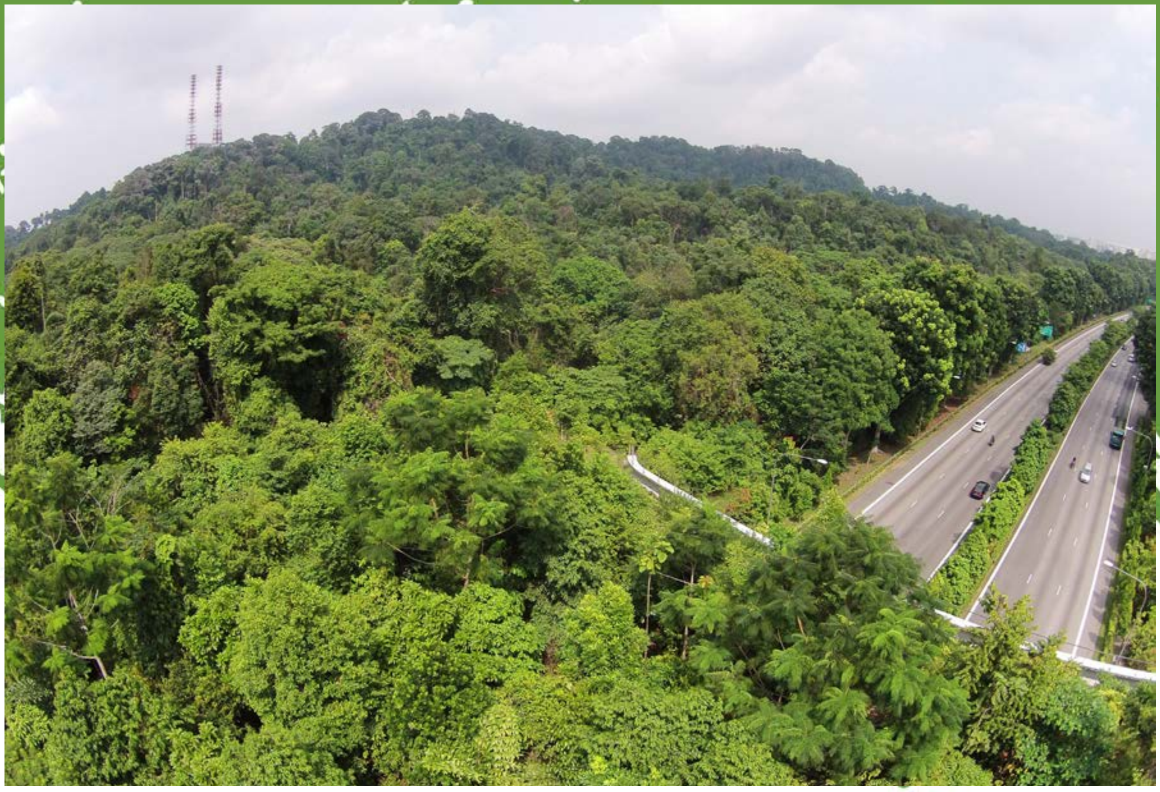
October 2019 Singapore

Workshop on the Review of the Singapore Index

The Singapore Index was revised and updated to reflect current trends in biodiversity conservation and climate change, as well as to take alignment from discussions on the post-2020 global biodiversity framework.

A Call to Action

21. We encourage you to apply the Singapore Index to your city – capture your baseline data; promote biodiversity actions and create new policy and implementation networks that will further your biodiversity conservation and restoration efforts. If you need further information or clarifications regarding the application of the Singapore Index, please contact Singapore_Index@nparks.gov.sg and/or secretariat@cbd.int.



The Ecolink@BKE reconnects the Bukit Timah Nature Reserve and Central Catchment Nature Reserve which were fragmented by the Bukit Timah Expressway. Within 10 years, the establishment of the native flora in this ecological corridor has enhanced the connectivity between the two nature reserves and facilitated wildlife crossing.
© National Parks Board.

This is an oblique view of the 65.5 hectare Waiwhakareke Natural Heritage Park in Kirikiriroa-Hamilton, New Zealand.
© David G. Schmale III

THE SINGAPORE INDEX ON CITIES' BIODIVERSITY

1. The Singapore Index on Cities' Biodiversity serves as a self-assessment tool for cities to benchmark and monitor the progress of their biodiversity conservation efforts against their own individual baselines. This updated version of the Singapore Index aims to help cities toward a development trajectory where biodiversity and people can thrive in harmony, while addressing biodiversity loss and climate change based on the latest science available for the past decade.

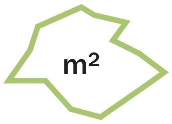
2. The framework of the Singapore Index is presented in Table 1. It comprises two parts: first, the "Profile of the City" provides background information on the city; and second, 28 indicators that measure native biodiversity, ecosystem services and governance and management of biodiversity in the city. Each indicator is assigned a scoring range between zero and four points, with a maximum score of 112 points. Cities will have to conduct a baseline scoring in the first application of the SI and conduct subsequent application every 3 – 5 years to allow sufficient time between applications for the results of biodiversity conservation efforts to materialise.

PART I: PROFILE OF THE CITY

3. The profile of the city will include important general information on the city, and in particular, details of the biodiversity found within, in order to set the background of the city and to place the city's evaluation for the Index in the proper perspective. It is important that other information not captured in the indicators be provided to give a more holistic picture of the native biodiversity that can be found in the city. Annex C provides a proposed format for submission of city profiles and subsequent calculations/references used in the application of the Index.The data and information including images of native flora, fauna and ecosystems in cities should be included in this section which will be used for the computation of the indicators. The information could include (but need not be limited to) the following:

(i) **Location** (geographical coordinates (latitudes and longitudes); climate (temperate or tropical etc.); temperature (range and average); rainfall/precipitation (range and average); other relevant information)

(ii) **Size** (land area, illustrated with Google maps or satellite images with clearly defined city boundaries; number of administrative units within the city or local authorities)



(iii) **Population** (including total population and population density of the city; the population of the region could also be included if appropriate, for the purpose of placing it in the regional context)

(iv) **Economic parameters** (Gross Domestic Product (GDP), Gross National Product (GNP), per capita income, key economic activities, economic drivers and pressures on biodiversity)

(v) **Physical features** of the city (geography, altitude of the city, area of impermeable surface, information on brownfield sites, etc.)

(vi) **Biodiversity features** and characteristics such as:

- Ecosystems found in the city
  - Mandatory: Cities should list ecosystems present within the city when they first apply the Index. The IUCN Habitat Authority File (http://intranet.iucn.org/webfiles/doc/SSC/RedList/AuthorityF/habitats.rtf) can be used as the reference list for cities to select the ecosystems that occur within their city boundaries.
  - Optional: Maps which show the location of ecosystems, if available.
- Species found in the city (data will be used for the calculation of indicators 3, 4, 5, 6, and 9).
  - Mandatory species: Number of species of vascular plants, birds and arthropods. The data from the first year of participating in the Index will form the baseline for future monitoring.
  - Optional species: Cities can also list the total number of species for other taxonomic groups if they have the data. This would give a more complete picture of the species diversity in the cities.
- Quantitative data on populations of key species of local importance. These include quantitative data on major taxonomic groups which are used to determine the conservation status of the species.
- Relevant qualitative biodiversity data. These include write-ups on the natural history of the cities, ecological rehabilitation and restoration initiatives, special biodiversity features, re-introduction of native species, etc.

(vii) **Administration** of biodiversity (relevant information may include a list of agencies and departments responsible for biodiversity; how natural areas are protected (through national parks, nature reserves, forest reserves, secured areas, parks, etc.) with information such as what categories of natural areas there are in your city, where the protected areas are located, what is the size of the protected areas, what are the aims of conserving these areas and functions of these areas etc.)

(viii) **Links** to relevant websites including the city's website, environmental or biodiversity specific websites and websites of agencies responsible for biodiversity.

PART II: INDICATORS OF THE SINGAPORE INDEX ON CITIES' BIODIVERSITY

Table 1: Framework of the Singapore Index on Cities' Biodiversity

SINGAPORE INDEX ON CITIES' BIODIVERSITY	
PART I – PROFILE OF THE CITY	**Location** and size (geographical coordinates (latitudes and longitudes); climate (temperate or tropical, etc.); rainfall/precipitation (range and average); including maps or satellite images where city boundaries are clearly defined)
	Physical features of the city (geography, altitude, area of impermeable surfaces, information on brownfield sites, etc.)
	Demographics (including total population and population density; the population of the region could also be included if appropriate, and for the purpose of placing it in the regional context)
	Economic parameters (Gross Domestic Product (GDP), Gross National Product (GNP), per capita income, key economic activities, drivers and pressures on biodiversity)
	Biodiversity features (ecosystems within the city, species within the city, quantitative data on populations of key species of local importance, relevant qualitative biodiversity data)
	Administration of biodiversity (relevant information includes agencies and departments responsible for biodiversity; how natural areas are protected (through national parks, nature reserves, forest reserves, secured areas, parks, etc.)
	Links to relevant websites including the city's website, environmental or biodiversity themed websites, websites of agencies responsible for managing biodiversity

SINGAPORE INDEX ON CITIES' BIODIVERSITY

PART II – INDICATORS

Core Components	Indicators	Maximum Score
Native Biodiversity in the City	1. Proportion of Natural Areas in the City	4 POINTS
	2. Connectivity Measures or Ecological Networks to Counter Fragmentation	4 POINTS
	3. Native Biodiversity in Built Up Areas (Bird Species)	4 POINTS
	4. Change in Number of Vascular Plant Species	4 POINTS
	5. Change in Number of Native Bird Species	4 POINTS
	6. Change in Number of Native Arthropod Species	4 POINTS
	7. Habitat Restoration	4 POINTS
	8. Proportion of Protected Natural Areas	4 POINTS
	9. Proportion of Invasive Alien Species	4 POINTS
Ecosystem Services provided by Biodiversity	10. Regulation of Quantity of Water	4 POINTS
	11. Climate Regulation – Benefits of Trees and Greenery	4 POINTS
	12. Recreational Services	4 POINTS
	13. Health and Wellbeing – Proximity/Accessibility to Parks	4 POINTS
	14. Food Security Resilience – Urban Agriculture	4 POINTS
Governance and Management of Biodiversity	15. Institutional Capacity	4 POINTS
	16. Budget Allocated to Biodiversity	4 POINTS
	17. Policies, Rules and Regulations – Existence of Local Biodiversity Strategy and Action Plan	4 POINTS
	18. Status of Natural Capital Assessment in the City	4 POINTS
	19. State of Green and Blue Space Management Plans in the City	4 POINTS
	20. Biodiversity Related Responses to Climate Change	4 POINTS
	21. Policy and/or Incentives for Green Infrastructure as Nature-based Solutions	4 POINTS
	22. Cross-sectoral and Inter-agency Collaborations	4 POINTS
	23. Participation and Partnership: Existence of Formal or Informal Public Consultation Process Pertaining to Biodiversity Related Matters	4 POINTS
	24. Participation and Partnership: Number of Agencies/Private Companies/NGOs/Academic Institutions/International Organisations with which the City is Partnering in Biodiversity Activities, Projects and Programmes	4 POINTS
	25. Number of Biodiversity Projects Implemented by the City Annually	4 POINTS
	26. Education	4 POINTS
	27. Awareness	4 POINTS
	28. Community Science	4 POINTS
	Native Biodiversity in the City (Sub-total for indicators 1-9)	**36 points**
	Ecosystem Services provided by Biodiversity (Sub-total for indicators 10-14)	**20 points**
	Governance and Management of Biodiversity (Sub-total for indicators 15-28)	**56 points**
	Maximum Total:	**112 points**

INDICATOR 1

PROPORTION OF NATURAL AREAS IN THE CITY

RATIONALE FOR SELECTION OF INDICATOR

Natural ecosystems harbour more species than disturbed or human-altered landscapes, hence, the higher the percentage of natural areas compared to that of the total city area gives an indication of the amount of biodiversity there. However, a city by definition has a high proportion of modified land area and this is hence factored into the scoring.

Taking into account the inherent differences in the richness in biodiversity of tropical versus temperate regions, new versus mature cities, large versus small cities, developing versus developed countries, it was agreed at the Third Expert Workshop on the Development of the City Biodiversity Index that the working definition of “natural areas” is as follows:

> **Natural areas comprise predominantly native species and natural ecosystems, which are not, or no longer, or only slightly influenced by human actions, except where such actions are intended to conserve, enhance or restore native biodiversity.**

Natural ecosystems are defined as all areas that are natural and not highly disturbed or completely human-altered landscapes. Some examples of natural ecosystems are forests, mangroves, freshwater swamps, natural grasslands, streams, lakes, etc. Parks, golf courses, roadside plantings are not considered as natural. However, natural ecosystems within parks where native species are dominant can be included in the computation.

The definition also takes into account restoration of existing native dominated habitat remnants, the reconstruction or recreation of native dominated habitats, and enhancement or manipulation of areas dominated by naturalised species towards dominance by native species, in recognition of efforts made by cities to increase the natural areas of their city. Restoration, particularly with native species, helps increase natural areas in the city and cities are encouraged to restore their impacted ecosystems.

HOW TO CALCULATE INDICATOR

(Total area of natural, restored and naturalised areas) ÷ (Area of city) × 100%

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data on natural areas include government agencies in charge of biodiversity, city municipalities, urban planning agencies, biodiversity centres, nature groups, universities, publications, etc. Google maps and satellite images can also provide relevant information for calculating this indicator.

BASIS OF SCORING

Based on the assumption that, by definition, a city comprises predominantly human-altered landscapes, the maximum score will be accorded to cities with natural areas occupying more than 20% of the total city area.

0 POINTS: < 1.0%

1 POINT: 1.0% – 6.9%

2 POINTS: 7.0% – 13.9%

3 POINTS: 14.0% – 20.0%

4 POINTS: > 20.0%

INDICATOR 2

CONNECTIVITY MEASURES OR ECOLOGICAL NETWORKS TO COUNTER FRAGMENTATION

RATIONALE FOR SELECTION OF INDICATOR

Fragmentation of natural areas usually occurs due to development of grey or built infrastructures such as roads, residential and commercial buildings, public amenities, etc. It is increasingly being proven that connectivity is a vital element of landscape structure (Taylor *et al*., 1993). Accepting the reality that fragmentation is a common consequence of urbanization, it has been selected as an indicator to chart possible future trends.

It is recognised that the fragmentation of natural areas affects different species differently. For example, a road may not be a barrier for birds but it can seriously fragment a population of arboreal primates. A strip of urbanisation may not affect the dispersal of wind-pollinated plants but a plant that depends on small mammals for dispersal will be adversely affected. While these differences have been considered, a pragmatic approach towards the calculation of this indicator is adopted, as reflected in the formula used here. Furthermore, to encourage positive actions to increase connectivity or reduce barriers to connectivity, it would be more meaningful to measure connectivity rather than fragmented plots. This indicator's score can be improved when more of the fragments are connected.

While it is recognised that the effective mesh size serves as a more intuitive measure for a city's connectivity, the coherence measure would be used to account for a city's physical size in the scoring. This would take into account the large variance in physical size of cities, thereby enhancing the applicability of this indicator for scoring.

It is only recently that research papers have indicated that small patches can play a crucial role in biodiversity conservation and serve as important stepping stones. This role can be reflected in the metric only if they also have a buffer as well.

HOW TO CALCULATE INDICATOR

The calculation of Indicator 2 involves a 2-step process, i.e., calculating the effective mesh size, followed by coherence that will normalise for the size of the city.

First, calculate effective mesh size[4] (EMS)

where: $EMS = \frac{1}{A_{\text{total}}}\left(A_{\text{G1}}^2 + A_{\text{G2}}^2 + A_{\text{G3}}^2 + \cdots + A_{\text{Gn}}^2\right)$

- A_{total} is the total area of all natural areas
- A_{G1} to A_{Gn} are the sizes of each group of connected patches of natural area that are distinct from each other (i.e., groups are more than or equal to 100m apart, as agreed upon by the participants of the 3rd Expert Workshop on the Development of the City Biodiversity Index, 11-13 October 2011)
- n is the total number of groups of connected patches of natural area.

A_{G1} to A_{Gn} may consist of areas that are the sum of two or more smaller patches which are connected. In general, patches are considered as connected if they are less than 100m apart. This equation was derived from Deslauriers *et al.* (2018). EMS includes between-patch connectivity and within-patch connectivity Spanowicz & Jaeger (2019).

However, exceptions to the above rule includes anthropogenic barriers such as:

- Roads (15m or more in width; or are smaller but have a high traffic volume of more than 5000 cars per day)
- Rivers that are highly modified and other artificial barriers such as heavily concretised canals and heavily built up areas
- Any other artificial structures that the city would consider as a barrier

Details**,** references and illustrations of how the EMS may be calculated are included in **Annex D** and are also available in Deslauriers *et al*. (2018).

Second, calculate coherence: $Coherence = \frac{Effective\ Mesh\ Size}{A_{\text{total}}}$

where A_{total} is the total area of all natural areas.

WHERE TO GET DATA FOR CALCULATIONS

Satellite images can be used in the computation of this indicator.

BASIS OF SCORING

To take into account varying physical size of cities, the coherence measure will be used as a basis of scoring. The coherence measure will take a value between 0 to 1 (i.e. between 0 % and 100 %).

0 POINTS: < 20.0%
1 POINT: 20.0% – 39.9%
2 POINTS: 40.0% – 59.9%
3 POINTS: 60.0% – 79.0%
4 POINTS: >79.0%

4 The effective mesh size is an expression of the probability that two points randomly chosen within the natural areas of a city are in the same patch or are considered connected (< 100m between the patches with no major barrier between). It can also be interpreted as the ability of two animals of the same species placed randomly in the natural areas to find each other. The more barriers in the landscape, the lower the probability that the two locations will be connected, and the lower the effective mesh size. Therefore, larger values of the effective mesh sizes indicate higher connectivity. The effective mesh size would be the most understandable measure of connectivity as it gives cities an idea of its largest group of patches of connected natural area.

INDICATOR 3

NATIVE BIODIVERSITY IN BUILT UP AREAS (BIRD SPECIES)

RATIONALE FOR SELECTION OF INDICATOR

It is acknowledged that cities comprise largely of built up areas and brownfield sites with anthropogenic green spaces and minimal natural features. However, it should be recognised that built up areas and brownfield sites do harbour biodiversity, e.g., birds, like swallows and swiftlets, nest under roofs of buildings; plants grow on buildings; butterflies rely on shrubs and grassy patches for food, dragonflies breed in water features, etc. Some built up areas and brownfield sites have more biodiversity than others. By enhancing certain features in such areas, the biodiversity could be improved. Hence, native biodiversity in built up areas and brownfield sites should be an indicator.

Most cities have data on bird species, hence, this taxonomic group will be used as an indicator. The number of native bird species in built up areas and anthropogenic green spaces is inevitably lower than that found in sites with natural ecosystems; however, implementing appropriate measures such as planting trees and shrubs which produce fruit or nectar bearing flowers may attract birds into built up areas of the city.

The percentage of native bird species in built up areas and anthropogenic greenery and green spaces relative to the total number of bird species in the city is a reflection of how well biodiversity has been integrated with the urban matrix of the city.

Although the presence of native bird species in built up areas of the city indicates the availability of food and suitable habitats, high percentages of such species in highly urbanised areas may be indicative of habitat fragmentation or encroachment or loss of natural habitats. The scoring range was moderated based on this understanding.

HOW TO CALCULATE INDICATOR

Percentage of the number of native bird species in built up areas relative to the total number of native bird species where built up areas include impermeable surfaces like buildings, roads, drainage channels, etc., and anthropogenic green spaces like roof gardens, roadside planting, golf courses, private gardens, cemeteries, lawns, urban parks, etc. Areas that are counted as natural areas in indicator 1 should not be included in this indicator.

(Number of native bird species found in built-up areas) ÷ (Total number of native bird species in the city) × 100%

WHERE TO GET DATA FOR CALCULATIONS

City councils, universities, NGOs, citizen scientists, amateur naturalists, students, etc.

BASIS OF SCORING

The scoring is based on the reality that the built-up areas of cities have fewer diversity of natural eco-systems and hence, a lesser number of native bird species would be found in them.

0 POINTS: < 6.0%

1 POINT: 6.0% – 10.9%

2 POINTS: 11.0 – 15.9%

3 POINTS: 16.0 – 20.0%

4 POINTS: >20.0%

INDICATOR 4

NATIVE BIODIVERSITY

CHANGE IN NUMBER OF NATIVE VASCULAR PLANT SPECIES

RATIONALE FOR SELECTION OF INDICATOR

As this is an index focussing on biodiversity in cities, it is essential that the native flora and fauna diversity be incorporated as indicators. At the Workshop on the Review of the Singapore Index on Cities' Biodiversity, the participants decided that the number of taxonomic groups to be monitored should be reduced from five to three as it was too onerous to monitor five taxonomic groups.

Vascular plants have been selected as one of the taxonomic groups to monitor as they represent more than 90% of the earth's vegetation, are ubiquitous and are well researched and documented.

To ensure that these three indicators on species are unbiased against any city based on its geographical location, ecological history, size, land use, etc., it was decided that:

- All cities and local authorities are requested to list the number of native species of a) vascular plants, b) birds, c) any taxonomic group belonging to arthropods.
- The indicators will measure the change in number of species over time rather than the absolute number of species as ecosystems in the tropics generally support more species than temperate regions.
- The first year of application will be taken as the baseline year for the species count. The net change in species numbers (increase in number of species due to re-introduction or restoration efforts minus the number of species that went extinct) will be incorporated in the subsequent calculations of the Singapore Index.

Conducting more surveys on the target groups (to document new species or rediscoveries), implementing species recovery programmes and reintroducing locally extinct native species would help to increase the number of extant native species. These are some positive actions that can be taken to document and increase native biodiversity in cities.

HOW TO CALCULATE INDICATORS

The change in number of native vascular plant species is used for indicator 4.

Data from the first application of the Singapore Index that are recorded in Part I: Profile of the City will be used as the baseline for the calculation in the change in number of native vascular plant species.

Net change in species from the previous survey to the most recent survey is calculated as:

Total increase in number of vascular plant species (as a result of re-introduction, rediscovery, new species found due to more intensive and comprehensive surveys, etc.).

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include government agencies in charge of biodiversity, city municipalities, urban planning agencies, biodiversity centres, nature groups, universities, publications, citizen scientists, amateur naturalists, students etc.

BASIS OF SCORING

Data listed in Part I: Profile of the City will be used to measure change in species diversity. The cities' first application will be considered as the baseline information for all subsequent monitoring. In their subsequent applications of the Index, cities will calculate the net change in species for the respective taxonomic groups.

The scoring range below is based on the rationale that it is not easy to recover or re-introduce species successfully over a short period of time. However, species recovery, re-introduction and restoration efforts must be given due recognition. Since there are more plant and arthropod species than bird species, the scoring thresholds for plants and arthropods are set higher.

0 POINTS: A decrease in the number of species

1 POINT: Maintaining the same number of species or less than 6 species increase

2 POINTS: 6 species increase

3 POINTS: 7 species increase

4 POINTS: 8 species or more increase

INDICATOR 5

CHANGE IN NUMBER OF NATIVE BIRD SPECIES

RATIONALE FOR SELECTION OF INDICATOR

As this is an index focussing on biodiversity in cities, it is essential that the native flora and fauna diversity be incorporated as indicators. At the Workshop on the Review of the Singapore Index on Cities' Biodiversity, the participants decided that the number of taxonomic groups to be monitored should be reduced from five to three as it was too onerous to monitor five taxonomic groups.

Birds have been selected as one of the taxonomic groups to monitor as they are watched and well-studied by academics as well as amateur naturalists worldwide, they are sensitive to environmental and habitat changes and they are comparatively easy to observe and count.

To ensure that these three indicators on species are unbiased against any city based on its geographical location, ecological history, size, land use, etc., it was decided that:

- All cities and local authorities are requested to list the number of native species of a) vascular plants, b) birds, c) any taxonomic group belonging to arthropods.
- The indicators will measure the change in number of species over time rather than the absolute number of species as ecosystems in the tropics generally support more species than temperate regions.
- The first year of application will be taken as the baseline year for the species count. The net change in species numbers (increase in number of species due to re-introduction or restoration efforts minus the number of species that went extinct) will be incorporated in the subsequent calculations of the Singapore Index.

Conducting more surveys on the target groups (to document new species or rediscoveries), implementing species recovery programmes and reintroducing locally extinct native species would help to increase the number of extant native species. These are some positive actions that can be taken to document and increase native biodiversity in cities.

HOW TO CALCULATE INDICATORS

The change in number of native species is used for indicator 5 for birds.

Data from the first application of the Singapore Index that are recorded in Part I: Profile of the City will be used as the baseline for the calculation in the change in number of native bird species.

Net change in species from the previous survey to the most recent survey is calculated as:

Total increase in number of native bird species (as a result of re-introduction, rediscovery, new species found due to more intensive and comprehensive surveys, etc.).

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include government agencies in charge of biodiversity, city municipalities, urban planning agencies, biodiversity centres, nature groups, universities, publications, citizen scientists, amateur naturalists, students, etc.

BASIS OF SCORING

Data listed in Part I: Profile of the City will be used to measure change in species diversity. The cities' first application will be considered as the baseline information for all subsequent monitoring. In their subsequent applications of the Index, cities will calculate the net change in species for the respective taxonomic groups.

The scoring range below is based on the rationale that it is not easy to recover or re-introduce species successfully over a short period of time. However, species recovery, re-introduction and restoration efforts must be given due recognition. Since there are more plant and arthropod species than bird species, the scoring thresholds for plants and arthropods are set higher.

0 POINTS: A decrease in the number of species

1 POINT: Maintaining the same number of species or 1 species increase

2 POINTS: 2 species increase

3 POINTS: 3 species increase

4 POINTS: 4 species or more increase

NATIVE BIODIVERSITY

INDICATOR 6

CHANGE IN NUMBER OF NATIVE ARTHROPOD SPECIES

RATIONALE FOR SELECTION OF INDICATOR

As this is an Index focussing on biodiversity in cities, it is essential that the native flora and fauna diversity be incorporated as indicators. At the Workshop on the Review of the Singapore Index on Cities', the participants decided that the number of taxonomic groups to be monitored should be reduced from five to three as it was too onerous to monitor five taxonomic groups.

Arthropods have been selected as one of the taxonomic groups to monitor as they represent high functional and biological diversity, some arthropods are well-studied (e.g., spiders, Lepidoptera, carabid beetles, etc.), and they are commonly encountered in a wide range of terrestrial ecosystems globally.

To ensure that these three indicators on species are unbiased against any city based on its geographical location, ecological history, size, land use, etc., it was decided that:

- All cities and local authorities are requested to list the number of native species of a) vascular plants, b) birds, c) any taxonomic group belonging to arthropods.
- The indicators will measure the change in number of species over time rather than the absolute number of species as ecosystems in the tropics generally support more species than temperate regions.
- The first year of application will be taken as the baseline year for the species count. The net change in species numbers (increase in number of species due to re-introduction or restoration efforts minus the number of species that went extinct) will be incorporated in the subsequent calculations of the Singapore Index.

Conducting more surveys on the target groups (to document new species or rediscoveries), implementing species recovery programmes and reintroducing locally extinct native species would help to increase the number of extant native species. These are some positive actions that can be taken to document and increase native biodiversity in cities.

HOW TO CALCULATE INDICATORS

The change in number of native species is used for indicator 6 for any group within arthropods (e.g. butterflies, dragonflies, beetles, bees, spiders, etc.)

Data from the first application of the Singapore Index that are recorded in Part I: Profile of the City will be used as the baseline for the calculation in the change in number of native arthropod species.

Net change in species from the previous survey to the most recent survey is calculated as:

Total increase in number of native arthropod species (as a result of re-introduction, rediscovery, new species found due to more intensive and comprehensive surveys, etc.).

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include government agencies in charge of biodiversity, city municipalities, urban planning agencies, biodiversity centres, nature groups, universities, publications, citizen scientists, amateur naturalists, students etc.

BASIS OF SCORING

Data listed in Part I: Profile of the City will be used to measure change in species diversity. The cities' first application will be considered as the baseline information for all subsequent monitoring. In their subsequent applications of the Index, cities will calculate the net change in species for the respective taxonomic groups.

The scoring range below is based on the rationale that it is not easy to recover or re-introduce species successfully over a short period of time. However, species recovery, re-introduction and restoration efforts must be given due recognition. Since there are more plant and arthropod species than bird species, the scoring thresholds for plants and arthropods are set higher.

0 POINTS: A decrease in the number of species

1 POINT: Maintaining the same number of species or less than 6 species increase

2 POINTS: 6 species increase

3 POINTS: 7 species increase

4 POINTS: 8 species or more increase

INDICATOR 7

HABITAT RESTORATION

RATIONALE FOR SELECTION OF INDICATOR

These indicators are aligned with the UN Decade on Ecosystem Restoration from 2021-2030. The expansion and development of cities almost always lead to the degradation of habitats found within and along the peripheries of cities' boundaries. Furthermore, habitats found in and around cities are often degraded. These indicators would measure city efforts to restore original, enhance or rehabilitate existing habitats to a level of good ecological functioning. Diversity in the types of habitats being restored within the city would not only increase ecological resilience, but also lead to higher species biodiversity.

It is strongly recommended that habitat restoration projects be well-thought through with clear objectives, robust experimental design, appropriate scientific methodology and equipment and monitoring system to track progress. Implementation and logistic constraints like availability of funding, technical expertise, human resources including volunteers, etc., should be factored in the project plan. References with examples and explanations on habitat restoration including Clarkson & Kirby (2016), Elliot, Blakesley & Hardwick (2013), and Walsh, Fletcher & Ladson (2005), can be found in the **Annex H**.

HOW TO CALCULATE INDICATORS

The calculation for both scoring options (7A) and (7B) should include habitats that are currently being restored and the ones that have been restored (i.e., cumulative restoration efforts). Indicator 7A measures the quantitative effort while indicator 7B measures the qualitative progress.

A. Proportion of area of habitat restored (in %) to good ecological functioning.

(Area of habitat restored*) ÷ (Area of original habitat that is degraded**) × 100%

**The area of habitat restored should factor in areas of habitats restored to good ecological functioning from the baseline year onwards. The criteria for evaluating good ecological functioning should be defined by city officials in the objectives of their projects as the specific details differ for various ecosystems, diverse geographical regions, etc.*

#The denominator, i.e., the area of original habitat that is degraded will be considered as the baseline area used for subsequent applications to measure habitat restoration improvement.

AND/OR

B. Proportion of habitat types restored/enhanced/created

(Number of habitat types restored) ÷ (Number of habitat types present now within the city) × 100%

The city can refer to the habitat types recognised in the IUCN Habitats Classification Scheme (Version 3.1) to determine the number of habitat types undergoing restoration.

WHERE TO GET DATA FOR CALCULATIONS

City agencies in charge of biodiversity, nature groups, NGOs, biodiversity centres, universities, etc.

BASIS OF SCORING

The city is to score itself using either options (7A) or (7B) or both, depending on data availability. Scoring ranges (7A) and (7B) are set to make this indicator an aspirational target, with the goal of 100% habitats restored to good ecological functioning.

Scoring range for (7A)

0 POINTS: < 20.0% area restored to good ecological functioning

1 POINT: 20.0% – 39.9% area restored to good ecological functioning

2 POINTS: 40.0% – 59.9% area restored to good ecological functioning

3 POINTS: 60.0% – 79.9% area restored to good ecological functioning

4 POINTS: ≥ 80.0% area restored to good ecological functioning

Scoring range for (7B)

0 POINTS: < 20.0% of habitat types restored

1 POINT: 20.0% – 39.9% of habitat types restored

2 POINTS: 40.0% – 59.9% of habitat types restored

3 POINTS: 60.0% – 79.9% of habitat types restored

4 POINTS: 80.0% – 100.0% of habitat types restored

INDICATOR 8

PROPORTION OF PROTECTED NATURAL AREAS

RATIONALE FOR SELECTION OF INDICATOR

Protected or secured natural areas indicate the city's commitment to biodiversity conservation. Hence, the proportion of protected or secured natural areas is an important indicator.

The definition of protected natural areas should be broadened to include legally protected, formally secured areas, and other administratively protected areas, as different cities have different terminologies and means for protecting their natural areas.

At the 10th Meeting of the Conference of the Parties to the Convention on Biological Diversity, Target 11 of the Aichi Biodiversity Targets, i.e., "By 2020, at least 17 per cent of the terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes" was negotiated and adopted in 2010 (www.cbd.int). This indicator takes reference from this Aichi Target 11.

HOW TO CALCULATE INDICATOR

(Area of protected or secured natural areas) ÷ (Total area of the city) × 100%

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include government agencies in charge of biodiversity, city municipalities, urban planning agencies, biodiversity centres, nature groups, universities, publications, etc.

BASIS OF SCORING

Taking into consideration that cities, by definition, are urbanised centres with predominantly built-up areas (see Indicator 1), therefore the scoring for proportion of protected natural areas will have to factor in that most cities would have less than 20% of the city area covered by natural areas. The scoring is determined based on ensuring congruency with Indicator 1 and taking into account Target 11 of the Aichi Biodiversity Targets.

0 POINTS: <1.0%

1 POINT: 1.0% to 6.0%

2 POINTS: 6.1% to 11.0%

3 POINTS: 11.1% to 17.0%

4 POINTS: >17.0%

INDICATOR 9

PROPORTION OF INVASIVE ALIEN SPECIES

RATIONALE FOR SELECTION OF INDICATOR

Invasive alien species out-compete native species and, thus, threaten the survival of native species and the integrity of ecosystems. As cities are very open to influx of alien species, this indicator measures the status of this threat.

The definition of invasive alien species (IAS) follows that accepted by the CBD, which is stated in COP decision VI/23 as:

"An alien species whose introduction and/or spread threatens biological diversity (For the purposes of the present guiding principles, the term "invasive alien species" shall be deemed the same as "alien invasive species" in Decision V/8 of the Conference of the Parties to the Convention on Biological Diversity)". (https://www.cbd.int/invasive/)

It is inevitable for cities, which are open to external influences, to have alien species. Alien species which are not invasive or detrimental to native species are not considered in this indicator. In fact, exotic or alien species enhance the diversity in many cities.

Cities can decide on the taxonomic group(s) which are most problematic for their city or where most data are available and can choose to provide more information on IAS if they are monitoring more than one taxonomic group.

HOW TO CALCULATE INDICATOR

To ensure that the comparison of invasive alien species with that of native species is meaningful, it would have to be a comparison of identical taxonomic groups.

(Number of invasive alien species in a taxonomic group) ÷ (Total number of native species of the same taxonomic group + number of invasive alien species) × 100%

Cities can decide on the most appropriate and relevant level of taxonomic group(s), i.e., Genus, Family, Order or Class to apply for this indicator.

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include government agencies in charge of biodiversity, city municipalities, urban planning agencies, biodiversity centres, nature groups, universities, publications, citizen scientists, amateur naturalists, students, etc.

BASIS OF SCORING

The scoring range is based on the premise that the more invasive alien species that are in the city; the more destructive impact will be to the native species.

0 POINTS: > 30.0%

1 POINT: 20.1% – 30.0%

2 POINTS: 11.1% – 20.0%

3 POINTS: 1.0% – 11.0%

4 POINTS: < 1.0%

INDICATOR 10

REGULATION OF QUANTITY OF WATER

RATIONALE FOR SELECTION OF INDICATOR

Impervious areas alter the hydrologic cycle in cities, affecting both water quality and quantity. In addition, climate change is in many places predicted to result in increased variability in precipitation which in urban landscapes may translate into high peaks in water flow and damage to construction, business and transport, as well as lower ecological quality of receiving waters. Vegetation has a significant effect in reducing the rate of flow of water through the urban landscape, e.g., through presence of forest, parks, lawns, roadside greenery, streams, rivers, waterbodies, etc.

In addition, engineered vegetated systems can mitigate the effect of surface sealing by reducing "effective impervious areas" (EIA) or "directly connected impervious areas", i.e., impervious areas that are directly connected to the traditional "piped" drainage system. Impervious areas that drain to pervious areas or engineered vegetated systems (e.g., biofilters or raingardens) are not considered in EIA since they do not contribute to the stormwater problem.

HOW TO CALCULATE INDICATOR

There are 2 options for calculating this indicator, i.e., 10A that measures permeable surface coverage or 10B that calculates the "effective impervious areas". Cities can apply either of the indicators.

(10A) Proportion of all permeable areas (including areas identified in indicator 1 plus other parks, roadside, etc. to total terrestrial area of city (excluding marine areas under the city's jurisdiction).

(Total permeable area) ÷ (Total terrestrial area of the city) × 100%

OR

(10B) An alternative option to score this indicator is to calculate the proportion of all effective impervious areas (i.e., impervious areas that are not draining to pervious areas or stormwater vegetated systems such as biofilters).

(Total effective impervious area) ÷ (Total terrestrial area of the city) × 100%

Please refer to **Annex E** for an infographic illustrating effective impervious areas.

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include government environmental agencies, city municipalities, urban planning, water and land agencies, satellite images, etc. Practical guidance on how to calculate EIA can be found in the references, including, Ebrahimian, Wilson & Gulliver (2016a), Ebrahimian, Wilson & Gulliver (2016b), Fletcher, Andrieu & Hamel (2013), Hwang, Rhee & Seo (2017), and King et al. (2011) listed in **Annex H**.

BASIS OF SCORING

The city is to score itself using either criteria (10A) or (10B).

Scoring range for (10A)

The following points are awarded for the respective proportions of permeable areas in the city a) based on the rationale that cities have impermeable surfaces due to residential, commercial, transport, other infrastructural requirements; and b) to ensure that it is consistent with the scoring of Indicator 1 for natural areas:

0 POINTS: <30%
1 POINT: 30.0% – 39.9%
2 POINTS: 40.0% – 49.9%
3 POINTS: 50.0% – 59.9%
4 POINTS: > 60%

Scoring range for (10B)

The following points are awarded for the respective proportions of effective impervious areas in the city based on analyses of data from the scientific articles in the previous column which suggest that effectively protecting stream health requires EIA<1.

0 POINTS: > 25.0%
1 POINT: 24.9% – 10.0%
2 POINTS: 9.9% – 5.0%
3 POINTS: 4.9% – 1.0%
4 POINTS: < 1.0%

INDICATOR 11

CLIMATE REGULATION – BENEFITS OF TREES AND GREENERY

ECOSYSTEM SERVICES

RATIONALE FOR SELECTION OF INDICATOR

Trees and greenery provide many benefits especially in climate regulation.

Two important aspects of climate regulation services are carbon storage and cooling effects provided by vegetation, in particular, tree canopy cover. Climate regulation services are affected by many factors, including the size of trees, the different characteristics of tree species, and other variables.

Canopy cover of trees, which includes those that are naturally occurring and planted in a city, is adopted here as an indirect proxy measure of the carbon sequestration and storage services. With regards to carbon storage, plants capture carbon dioxide during photosynthesis, hence, capturing carbon that is emitted by anthropogenic activities.

Plants, through shading, evapotranspiration, and decreasing the proportion of reflective surfaces, reduce the ambient heat in the air and the surface temperature in the urban landscape. It has been well documented that an increase in vegetation cover can reduce surface and ambient temperatures (Ziter P. *et al.,* 2019).

Trees can also filter air pollution, replenish oxygen supply, lower greenhouse gas emissions, protect top soil, decrease surface runoffs, reduce noise pollution, improve water quality, provide habitats for native fauna and contribute numerous other biodiversity benefits. Planting of native trees to increase the canopy cover, hence, serves multiple functions and is strongly encouraged.

The planting of trees will create a rewilding habitat for other flora and fauna, and over time will evolve into natural ecosystems.

While Indicator 11 measures the percentage of tree canopy cover in the city, Indicator 19 tracks the state of greenery management plans in the city. These two indicators synergise with and complement each other.

Cities in the desert or arid zones or other ecological zones, where it is not feasible to maintain extensive tree canopy cover, should explore relevant indicators that offer a similar range of ecosystem services.

HOW TO CALCULATE INDICATOR

(Tree canopy cover) ÷ (Total terrestrial area of the city) × 100%

WHERE TO GET DATA FOR CALCULATIONS

City councils, parks departments, research institutions, universities, land cover maps and satellite images.

BASIS OF SCORING

The MIT Treepedia project calculated the Green View Index (GVI) based on tree canopy cover of street trees in over 28 cities globally. The highest GVI score is 36.1%. Since the GVI only focusses on street trees, the scoring for this indicator should be increased to a higher but achievable aspirational level.

0 POINTS: < 10.0%

1 POINT: 10.1% – 24.9%

2 POINTS: 25.0% – 39.9%

3 POINTS: 40.0% – 54.9%

4 POINTS: ≥ 55%

INDICATOR 12

ECOSYSTEM SERVICES

RECREATIONAL SERVICES

RATIONALE FOR SELECTION OF INDICATOR

It has been increasingly recognized that urban green parks, nature conservation areas and other green spaces with a high quality of biological diversity provide invaluable recreational, spiritual, cultural and educational services. They are essential for human physical and psychological health.

Experiences from the COVID-19 pandemic response have shown that visits to urban parks, green spaces and interactions with biodiversity help people cope with the psychological toll and stress that the pandemic and the resulting government measures (lockdown, closure of businesses etc.) bring.

HOW TO CALCULATE INDICATOR

(Area of parks, nature conservation areas and other green spaces with natural areas and protected or secured accessible natural areas) /1000 persons

WHERE TO GET DATA FOR CALCULATIONS

City councils, planning departments

BASIS OF SCORING

The scoring is based on the widely accepted standard of 0.9 ha of urban green space per 1000 persons.

0 POINTS: < 0.1 ha/1000 persons

1 POINT: 0.1 – 0.3 ha/1000 persons

2 POINTS: 0.4 – 0.6 ha/1000 persons

3 POINTS: 0.7 – 0.9 ha/1000 persons

4 POINTS: > 0.9 ha/1000 persons

INDICATOR 13

HEALTH AND WELLBEING – PROXIMITY/ ACCESSIBILITY TO PARKS

ECOSYSTEM SERVICES

RATIONALE FOR SELECTION OF INDICATOR

A sizeable and growing body of literature has shown that access to green spaces is positively correlated to residents' mental and physical well-being. This indicator is distinguished from Indicator 12, in that whereas Indicator 12 captures park provision, Indicator 13 measures residents' proximity to these green spaces. They are complementary.

With the upward trend of a globally aging population, it is good forward planning to ensure that this segment of the population has easy access to parks and green spaces for their recreation and exercise.

We learn from the COVID-19 pandemic that 1) visits to parks and connecting with nature are antidotes to quarantine and anxiety and 2) exercising outdoors frequently in the local area enables residents to keep healthy as well as ensures compliance with safe distancing measures.

Increasing accessibility to parks is an excellent, if not an essential insurance for our physical, mental and psychological health in preparation for safeguarding against the highly unpredictable future.

HOW TO CALCULATE INDICATORS

(13A) Proximity is measured in terms of the proportion of the households living within 400m from a park or green space.

Straight line distances are used to determine whether households fall within 400m from a park or green space. Details and illustrations on how this indicator may be calculated can be found in **Annex F**.

(Population of city living within 400m from a park/green space) ÷ (Total population of city) × 100%

OR

(13B) Accessibility is measured in terms of the proportion of the population living within walking distance (400m) from a park or green space. This distance takes into account obstacles and routes within the street network system, differing from the calculation of proximity. Details and illustrations on how this indicator may be calculated are appended below.

Spatial analysis software such as ArcGIS will be helpful to calculate this indicator.

(Population of city living within walking distance (400m) from a park/green space) ÷ (Total population of city) × 100%

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include GIS software, satellite images, city government agencies in charge of land, planning departments, tertiary institutions, academic institutions, think tanks, etc

BASIS OF SCORING

The city is to score itself using either criteria (13A) or (13B), depending on data availability.

Some cities have used the highest score of 90-100% as their planning target.

Scoring range for (13A)

0 POINTS: < 30.0%

1 POINT: 30.0 – 49.9%

2 POINTS: 50.0 – 69.9%

3 POINTS: 70.0 – 89.9%

4 POINTS: 90.0 – 100.0%

Cities are encouraged to use (13B) for this indicator as residents' accessibility to parks will provide a more accurate measure of parks that are available to residents.

Scoring range for (13B)

0 POINTS: < 46.1%

1 POINT: 46.1 – 55.7%

2 POINTS: 55.8 – 64.8%

3 POINTS: 64.9 – 72.0%

4 POINTS: > 72.0%

INDICATOR 14

ECOSYSTEM SERVICES

FOOD SECURITY RESILIENCE – URBAN AGRICULTURE

RATIONALE FOR SELECTION OF INDICATOR

This indicator measures the state of Urban Agriculture (UA) plans, policies, guidelines and practices in the city. UA is defined as the production of crop and livestock goods within cities and their outskirts including highly heterogeneous production systems (Lin *et al*. 2017).

UA increases city´s resilience by providing food that, if consumed locally, significantly reduces the energy and carbon footprint. During the lockdown period caused by COVID-19, food supply chains were seriously disrupted. However, those cities that practised UA could supplement their food requirements. Cities should start initiating UA for forward planning. Moreover, if local varieties and breeds are favoured, the genetic variability is conserved, increasing resilience even further.

With the promotion of sustainable farming procedures, biodiversity will increase (including soil biodiversity, plants, arthropods and birds that serve as pollinators and dispersal agents). These will add new high value elements to the city´s green infrastructure system and increase ecological connectivity (Lin *et al*. 2017).

UA offers other important ecosystem services such as carbon storage, nitrogen fixation and reduced storm water run-off while, at the same time strengthens social resilience by allowing a closer relationship with nature and food production for citizens living nearby and/or taking active part in community gardening. In this regard, both biodiversity and citizen´s health/wellbeing improvements are associated with the practice of UA (Dennis & James, 2016).

HOW TO CALCULATE INDICATOR

UA will be assessed qualitatively based on the institutionalisation of policies, plans, guidelines and implementation by the city. See the basis of scoring.

WHERE TO GET DATA FOR CALCULATIONS

City council, research centres, NGOs, citizen associations, farmers associations, food markets, etc.

BASIS OF SCORING

As UA is a new growing trend, the proposed basis of scoring is designed to provide guidance to cities on the life cycle of how to initiate UA, from policy to plan, to detailed guidelines, and finally implementation.

0 POINTS: No policy, plan or guidelines on urban agriculture.

1 POINT: Policy, plan and guidelines on urban agriculture are being prepared but do not include biodiversity conservation or community engagement.

2 POINTS: Policy, plan and guidelines on urban agriculture that include biodiversity conservation and community engagement are being prepared.

3 POINTS: Policy, plan and guidelines on urban agriculture that include some basic elements of biodiversity conservation and community engagement are being implemented.

4 POINTS: Policy, plan and guidelines on urban agriculture that include predominantly biodiversity conservation practices like planting native species, promoting periphery planting that includes biodiversity-attracting plants which support native insects and birds as pollinators and dispersal agents, encouraging organic farming methods such as companion planting, crop rotation amongst others, organic integrated pest management and community engagement are being implemented.

INDICATOR 15

INSTITUTIONAL CAPACITY

GOVERNANCE AND MANAGEMENT

RATIONALE FOR SELECTION OF INDICATOR

Institutions are necessary for the effective implementation of projects and programmes. The documentation of biodiversity found in the city needs to be supported by the technical expertise. Hence, the existence of biodiversity-focussed and biodiversity-related institutions will greatly enhance biodiversity conservation in a city.

Some of the essential institutions include a well-managed biodiversity centre, herbarium, zoological garden or museum, botanical garden, arboretum, insectarium, centres for climate change, think tanks that focus on biodiversity-related issues and nature-based solutions, etc. It is more important to measure whether the functions of these institutions exist rather than the physical existence of these institutions. Hence, if an herbarium is situated in a botanical garden, then two functions exist in the city under one institution.

HOW TO CALCULATE INDICATOR

Number of essential biodiversity related functions* that the city uses, provides and/or supports. Please provide a list of functions when reporting on the application of the SI.

**The functions could be carried out by a biodiversity centre, botanical garden, herbarium, zoological garden or museum, arboretum, insectarium, centres for climate change, think tanks that focus on biodiversity-related issues and nature-based solutions, etc. These functions can reside in government, tertiary institutions, academic institutions, research organisations, private sector or NGOs.*

BASIS OF SCORING

0 POINTS: No functions
1 POINT: 1 function
2 POINTS: 2 functions
3 POINTS: 3 functions
4 POINTS: > 3 functions

INDICATOR 16

BUDGET ALLOCATED TO BIODIVERSITY

GOVERNANCE AND MANAGEMENT

RATIONALE FOR SELECTION OF INDICATOR

This indicator evaluates the financial commitment of city governments towards the maintenance and enhancement of biodiversity.

The relative amount spent on biodiversity related administration by a city can be seen as a representation of the city's commitment towards nature stewardship. It is recognised that there are numerous other factors affecting the amount allocated towards biodiversity, but in general the greater the proportion of the total city's budget allocated, the greater the level of commitment by the city.

HOW TO CALCULATE INDICATOR

(Amount spent on biodiversity related administration) ÷ (Total budget of city) × 100%

Wherever possible, by direct accounting or by suitable estimation, amounts should relate to biodiversity-related funds specifically, and not to those related to the environment in general. If not possible, this should be noted.

Computation should also include the city's or municipality's operational (e.g., staff/employees' salaries) and capital budget and biodiversity-related project expenditures. However, amounts should relate to existing and allocated amounts, and may include projects where funding is realistically expected to exist at the time of measurement. Avoiding projects for which funding is aspirational or subject to challenging circumstances, increases the indicator's accuracy.

The budget for biodiversity-related administration also includes procurement of services from the private sector or government linked companies for biodiversity conservation work. Funding that comes in through private sector contributions can also be counted in the biodiversity budget (e.g., developer contributions).

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include government agencies responsible for biodiversity conservation and finance or performance tracking departments, and municipal council expenditure records. For cities where the budgets of government linked organisations and/or companies are included, annual reports of those companies can provide relevant data.

BASIS OF SCORING

The following points are awarded for the respective proportions of the city budget allocated to biodiversity. This is based on existing data from cities that have applied the SI:

0 POINTS: < 0.4%

1 POINT: 0.4% – 2.2%

2 POINTS: 2.3% – 2.7%

3 POINTS: 2.8% – 3.7%

4 POINTS: > 3.7%

GOVERNANCE AND MANAGEMENT

INDICATOR 17

POLICIES, RULES AND REGULATIONS – EXISTENCE OF LOCAL BIODIVERSITY STRATEGY AND ACTION PLAN

RATIONALE FOR SELECTION OF INDICATOR

It is increasingly being recognised that cities, subnational governments and other local authorities can play a pivotal role in the implementation of the objectives of the CBD. For the Post-2020 Global Biodiversity Framework to be successfully implemented, the involvement of cities, subnational governments and other local authorities in assisting national governments, is vital.

To facilitate the implementation of biodiversity management, policies, rules and regulations must be put in place, guided by biodiversity strategies and action plans. This section evaluates the existence of policies, rules and regulations relevant to biodiversity, in particular if they are aligned with the national agenda and CBD's initiatives, like the National Biodiversity Strategy and Action Plan (NBSAP) and/or the correspondent subnational strategies.

Some of the CBD initiatives include both thematic and cross-cutting issues. For example, plant conservation, forest biodiversity, global taxonomy initiative, invasive species programme, marine biodiversity conservation, protected areas, etc. The initiatives might not be termed "Local Biodiversity Strategy and Action Plan" (LBSAP) as long as the city can justify that a similar plan exists.

HOW TO CALCULATE INDICATOR

Status of LBSAP (or any equivalent plan); number of associated CBD initiatives.

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include city councils, CBD national focal points, ICLEI-Local Governments for Sustainability LAB Initiative, CitiesWithNature, United Nations University and IUCN or CBD websites and publications.

BASIS OF SCORING

To ensure that biodiversity is conserved in a city, it is advisable to formulate and implement an LBSAP (or any equivalent plan). This needs to be aligned with the NBSAP so that biodiversity conservation efforts are synchronised and synergised.

0 POINTS: No LBSAP*

1 POINT: LBSAP not aligned with NBSAP

2 POINTS: LBSAP incorporates elements of NBSAP and includes at least one CBD initiative

3 POINTS: LBSAP incorporates elements of NBSAP, and includes two CBD initiatives

4 POINTS: LBSAP incorporates elements of NBSAP, and includes three or more CBD initiatives

** LBSAP or equivalent.*

*** The thematic programmes of work and cross-cutting issues of the CBD are listed in www.cbd.int/programmes*

INDICATOR 18

STATUS OF NATURAL CAPITAL ASSESSMENT IN THE CITY

GOVERNANCE AND MANAGEMENT

RATIONALE FOR SELECTION OF INDICATOR

The quality of the natural environment contributes significantly to economic performance and liveability. However, numerous challenges exist in attempts at including biodiversity factors into decision and policy making. While the economic benefits of urban development are easier to calculate, comparable information for natural assets (termed natural capital) are harder to measure and quantify. However, with the recognition of the importance and significance of natural capital assessment, escalating efforts have been accorded to research in this area. This indicator aims to measure cities' capabilities and efforts in factoring and incorporating of the ecosystem services of the natural environment into their development planning and processes.

Economic valuation has its technical and inherent limitations. Hence, it should not be over-emphasised. On the other hand, if natural assessments were not carried out, decisions would be made without taking into account the value of ecosystem services. On the whole, even a partial valuation of a cities' natural capital would enable cities to take into account the monetised and non-monetised value of their natural capital.

A practical guide on how to carry out natural capital assessments at the national and sub-national level has been published (Brown *et al*., 2016).

HOW TO CALCULATE INDICATORS

The World Forum on Natural Capital states that "Natural capital can be defined as the world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible." (www.naturalcapitalforum.com)

BASIS OF SCORING

The scoring evaluates the progressive application and implementation of the natural capital assessment in the city in a qualitative approach.

0 POINTS: No plans for natural capital assessment for the city

1 POINT: Natural capital assessment is being considered or planned for

2 POINTS: Natural capital assessment is being prepared

3 POINTS: Natural capital assessment has been completed at least once

4 POINTS: Natural capital assessment is carried out regularly every three to five years

GOVERNANCE AND MANAGEMENT

INDICATOR 19

STATE OF GREEN AND BLUE SPACE MANAGEMENT PLANS IN THE CITY

RATIONALE FOR SELECTION OF INDICATOR

This indicator measures the state of urban greenery and blue space management plans in the city. The existing indicators cover the provision of green and blue spaces in the city (i.e., Indicators 1, 8 and 12), but the ecosystem-based management[5] of such green and blue spaces is not included in other indicators. In terms of green and blue spaces providing ecosystem services, a green or blue space with natural vegetation would perform this function better than a highly manicured green space or sterile blue space. As such, this indicator measures whether management plans encourage incorporating natural elements into green and blue spaces via an ecosystem-based management approach which makes for quality spaces. In addition to aims and objectives, plans which include targets as clear benchmarks are more successful than plans without targets.

Examples of ecosystem management approaches include:

I. the restoration of degraded ecosystems;
II. the re-construction of natural ecosystems such as river restoration in urban areas;
III. the implementation of hybrid green-grey infrastructure solutions that combine ecological infrastructure with built infrastructure (e.g., water retention ponds, green roofs and vertical greenery);
IV. the use of green roofs, porous pavements and urban parks that serve as natural retention areas for flood water to adapt to the effects of climate change by improving storm water management, reducing flood risk in cities and moderating the urban heat-island effect;

HOW TO CALCULATE INDICATOR

Green and blue space management plans will be assessed qualitatively by the city.

WHERE TO GET DATA FOR CALCULATIONS

City councils, agencies responsible for greenery management, landscape industry, housing developers, CitiesWithNature, etc.

BASIS OF SCORING

This indicator is scored based on the quality and degree of complexity of the city's green and blue space management plans.

0 POINTS: No green and blue space management plan

1 POINT: Green and blue space management plans exist, but lack aims for improving the quality of green and blue spaces

2 POINTS: Green and blue space management plans exist and express aims for improving the quality of green and blue spaces

3 POINTS: Green and blue space management plans exist and express aims for improving and the quality of green and blue spaces via an ecosystem-based management approach

4 POINTS: Green and blue space management plans exist and include aims and benchmarks for improving the quality of green and blue spaces via an ecosystem-based management approach

5 An ecosystem approach is defined by the UN Convention on Biological Diversity as a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, the application of the ecosystem approach will help to reach a balance of the three objectives of the Convention: conservation, sustainable use, and the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

GOVERNANCE AND MANAGEMENT

INDICATOR 20

BIODIVERSITY-RELATED RESPONSES TO CLIMATE CHANGE

RATIONALE FOR SELECTION OF INDICATOR

The adverse effects of climate change are intensifying worldwide with communities bearing the brunt of it. A comprehensive, multi-prong approach comprising a diverse array of adaptation, mitigation and ecological resilience solutions must be designed and implemented to counter climate change. As nature has long been in existence across earth's spectrum of climatic conditions, the lessons we can glean from it are invaluable and we should tap on it for solutions to the issue of climate change.

Biodiversity-related responses involve the use of biodiversity, including flora, fauna and other living organisms, to address challenges such as climate change, and often provide co-benefits for health, society and the environment. These responses are often more cost-effective alternatives to hard/grey infrastructure while also providing or enhancing ecosystem services upon their implementation.

Biodiversity-related responses to climate change should include these areas:

- **Adaptation**, as defined by the Intergovernmental Panel on Climate Change (IPCC), is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
- **Mitigation** involves actions taken to reduce emissions and enhance carbon sinks, as referred to by the United Nation's Framework Convention on Climate Change (UNFCCC).
- **Ecological resilience** refers to the ability of a system to absorb impacts of anthropogenic activity before it is permanently altered or damaged (Gunderson, 2000).

The definitions mentioned above can be found in CBD Technical Series No. 43: Forest Resilience, Biodiversity and Climate Change (Thompson, 2009).

HOW TO CALCULATE INDICATOR

Cities are to review the status of their plans for biodiversity-related responses that address climate change in the areas of adaptation, mitigation and ecological resilience.

WHERE TO GET DATA FOR CALCULATIONS

City councils, tertiary institutions, academic institutions, think tanks, NGOs, CitiesWithNature, etc.

BASIS OF SCORING

The scoring for this indicator charts the biodiversity approach that cities can adopt to help them to meet the challenges of climate change in the areas of adaptation, mitigation and ecological resilience.

0 POINTS: **No plans** for biodiversity-related responses in the areas of adaptation, mitigation or ecological resilience to climate change has been developed.

1 POINT: At least one plan for biodiversity- related responses to address climate change in the areas of adaptation, mitigation or ecological resilience has been developed.

2 POINTS: **One plan** for biodiversity-related responses to address climate change in the areas of adaptation, mitigation or ecological resilience has been implemented.

3 POINTS: **Two plans** for biodiversity- related responses to address climate change in the areas of adaptation, mitigation or ecological resilience have been implemented.

4 POINTS: **Three plans** for biodiversity- related responses to address climate change in the areas of adaptation, mitigation or ecological resilience have been implemented.

GOVERNANCE AND MANAGEMENT

INDICATOR 21

POLICY AND/OR INCENTIVES FOR GREEN INFRASTRUCTURE AS NATURE-BASED SOLUTIONS

RATIONALE FOR SELECTION OF INDICATOR

Nature-based solutions (NbS) is an umbrella term referring to actions that protect, manage and restore natural capital in ways that address societal challenges effectively and adaptively. These include structural and non-structural actions, ranging from ecosystem restoration to integrated resources management and green infrastructure (Browder *et al.* 2019). Green infrastructure is the most relevant form of NbS for cities.

Green infrastructure is defined as a solution that strategically preserves, conserves, enhances, or restores elements of a natural system to help produce higher quality, more resilience, and lower-cost infrastructure services. Infrastructure service providers can integrate green infrastructure into built systems (Browder *et al.* 2019).

The Municipal Natural Assets Initiative (MNAI) of Canada published a decision-maker summary report titled "What are municipal natural assets: Defining and scoping municipal natural assets" (Ogden, Wilson & Cairns, 2019). It listed categories and examples of green infrastructure such as a) 'natural assets' like wetlands, forests, parks, lakes/rivers, soils, etc., b) enhanced assets like urban trees, urban parks, bioswales, etc., and c) engineered assets like permeable pavement, green roofs, green walls, etc. The implementation of green infrastructure can bring about benefits such as the mitigation and adaptation to effects of climate change and increases in quality of life for the community. Examples of Green Infrastructure can be found in **Annex G**.

Densely built cities may lack space to increase ground-level greenery. Cities can introduce greenery into their landscape through incorporating rooftop gardens and green elements onto infrastructure. These pockets of green spaces and surfaces can help to mitigate Urban Heat Island effects and provide areas of refuge for small animals such as birds, reptiles, amphibians and insects, enabling densely built cities to support biodiversity.

HOW TO CALCULATE INDICATOR

Status of policies, regulations and incentives to promote and support the implementation of green infrastructure as nature-based solutions in cities.

WHERE TO GET DATA FOR CALCULATIONS

City councils, planning departments, architecture firms, landscape industry, building industry, housing development industry, tertiary institutions, academic institutions, think tanks, NGOs, CitiesWithNature, etc.

BASIS OF SCORING

The scoring of this indicator is based on the accordance of high importance to policies, regulations and incentives to drive the adoption of green infrastructure as nature-based solutions in cities. The stepwise progression allows time for industry and private developers to adjust and implement such measures.

0 POINTS: No policies, regulations or incentives provided for green infrastructure as nature-based solutions; none are planned.

1 POINT: Plans for policies and regulations on green infrastructure as nature-based solutions to support either local industry competency or building owners/developers within the next 5 years.

2 POINTS: Provision of policies and regulations on green infrastructure as nature-based solutions to support either local industry competency or building owners/developers have been finalised.

3 POINTS: Provision of policies, regulations and incentives on green infrastructure as nature-based solutions to support either local industry competency or building owners/developers have been finalised.

4 POINTS: Green infrastructure as nature-based solutions in compliance with the policies, regulations and incentives for building owners/ developers to install green infrastructure have been implemented.

INDICATOR 22

CROSS-SECTORAL & INTER-AGENCY COLLABORATIONS

GOVERNANCE AND MANAGEMENT

RATIONALE FOR SELECTION OF INDICATOR

Many biodiversity issues are cross-sectoral and, hence, necessitate the involvement of inter-agency efforts. The evaluation of inter-agency coordination is an important indicator of the success of biodiversity conservation, especially in a city where it is more compact. Indicator 22 ensures and promotes the mainstreaming of biodiversity within the government while Indicator 24 looks at collaboration among players beyond government.

HOW TO CALCULATE INDICATOR

Number of city or local government agencies involved in inter-agency co-operation pertaining to biodiversity matters.

WHERE TO GET DATA FOR CALCULATIONS

City councils and local governments.

BASIS OF SCORING

The number of government agencies that cooperate on biodiversity matters indicates the level of mainstreaming and the awareness of biodiversity implications in the work of other sectors.

0 POINTS: 1 or 2 agencies* cooperate on biodiversity matters

1 POINT: 3 agencies cooperate on biodiversity matters

2 POINTS: 4 agencies cooperate on biodiversity matters

3 POINTS: 5 agencies cooperate on biodiversity matters

4 POINTS: More than 5 agencies cooperate on biodiversity matters

** Agencies could include departments or authorities within the government that are responsible for biodiversity, planning, water, finance, transport, development, infrastructure, housing, tourism, health, industry, defence, etc.*

INDICATOR 23 & 24

GOVERNANCE AND MANAGEMENT

PARTICIPATION AND PARTNERSHIP

RATIONALE FOR SELECTION OF INDICATOR

Indicator 23 evaluates the existence and the state of formal or informal public consultation process pertaining to biodiversity related matters. This indicator ensures that the public has an opportunity to provide inputs to developments that have an impact on biodiversity.

Indicator 24 measures the extent of informal and/or formal partnerships, or collaboration with other entities. As it is impossible for any single agency to carry out all the activities, responsibilities, projects and programmes that have biodiversity implications, it is inevitable that engagement of all levels of the population must be facilitated. These include the private sector, NGOs, academic institutions, international organisations., etc.

Such partnerships should have substantial and long-term involvement on the part of the city officials, such as programmes like Payments for Ecosystem Services (PES).

HOW TO CALCULATE INDICATOR

Indicator 23:

Existence and state of formal or informal public consultation process pertaining to biodiversity related matters.

Indicator 24:

Number of agencies/private companies/NGOs/academic institutions/international organisations with which the city is partnering in biodiversity activities, projects and programmes.

Instances of inter-governmental agency co-operation listed in Indicator 22 should not be listed here again as this indicator measures the partnership, cooperation and collaboration between city officials and other external agencies.

WHERE TO GET DATA FOR CALCULATIONS

City councils, local governments, tertiary institutions, academic institutions, private sector, NGOs, citizen scientists, amateur naturalists, students, research institutions, etc.

BASIS OF SCORING

Indicator 23:

While it is recognised that public consultation is important, the scoring for Indicator 23 acknowledges that it could be implemented by a formal or informal process.

- **0 POINTS:** No routine formal or informal process
- **1 POINT:** Formal or informal process being considered as part of the routine process
- **2 POINTS:** Formal or informal process being planned as part of the routine process
- **3 POINTS:** Formal or informal process ready for implementation as part of the routine process
- **4 POINTS:** Formal or informal process has been implemented as part of the routine process

Indicator 24:

Partnerships with other entities besides government agencies are crucial for inclusivity. The scoring reflects the principle that the wider and more diverse the composition of the partnership, the more successful is the mainstreaming of biodiversity within the workings of the city.

- **0 POINTS:** No formal or informal partnerships
- **1 POINT:** City in partnership with 1-6 other private companies/NGOs/academic institutions/international organisations
- **2 POINTS:** City in partnership with 7-12 other private companies/NGOs/academic institutions/international organisations
- **3 POINTS:** City in partnership with 13-19 other private companies/NGOs/academic institutions/international organisations
- **4 POINTS:** City in partnership with 20 or more other private companies/NGOs/academic institutions/international organisations

INDICATOR 25

NUMBER OF BIODIVERSITY PROJECTS IMPLEMENTED BY THE CITY ANNUALLY

GOVERNANCE AND MANAGEMENT

RATIONALE FOR SELECTION OF INDICATOR

This indicator measures the number of biodiversity-related projects and programmes that the city authorities are involved in, either as the main player or in partnerships with other entities where the city is a key collaborator.

Programmes and projects are not limited to the conservation of protected areas but could include those pertaining to species conservation (e.g., plants, birds and butterflies), species recovery, biodiversity surveys, biodiversity enhancement projects, restoration projects, conservation education, procurement of green services, etc.

For a project or a programme to be included in this indicator, biodiversity must be an important consideration in the stated objectives. A programme designed to conserve species that are non-native to the city, but threatened elsewhere (e.g., zoo species conservation projects and botanical gardens for *ex situ* conservation of flora) can be considered as well.

This indicator measures collaboration between city councils and municipalities to collaborate with and partner citizens, NGOs, universities, schools, private sector, etc., to carry out biodiversity-related programmes or projects.

As people become more inclined to using technology, projects and programmes are increasingly going online using digital platforms. The COVID-19 pandemic has led to the burgeoning of the use of this form of communication. Leveraging on these platforms can help cities to kick-start projects/programmes in the community.

HOW TO CALCULATE INDICATOR

Number of programmes and projects that are being implemented by the city authorities, possibly in partnership with private sector, NGOs, etc. per year per 1,000,000 residents. To better engage the youths and cognizant of the trend forced by COVID-19, most projects and programmes will be conducted through digital platforms. Hence, programmes and projects that are conducted online or through digital platforms should be included.

(Number of programmes and projects implemented by the city per year)/1,000,000 residents.

Cities can decide their level of "granularity" in counting the projects but should be consistent when applying the index over the years. Since this is a monitoring tool, the number of programmes and projects are not cumulative but evaluating whether the city has increased the number of programmes/projects per year per 1,000,000 residents as compared to the previous evaluation period.

WHERE TO GET DATA FOR CALCULATIONS

Possible sources of data include city authorities, tertiary institutions, academic institutions, think tanks, private corporations and NGOs that conduct such activities, citizen scientists, amateur naturalists, students, etc.

BASIS OF SCORING

The scoring is based on the data provided by cities that have applied the SI from 2011 – 2019. This has been normalised for population size.

0 POINTS: < 8.0 programmes/projects per year per 1,000,000 residents

1 POINT: 8.0 – 23.9 programmes/projects per year per 1,000,000 residents

2 POINTS: 24.0 – 56.9 programmes/projects per year per 1,000,000 residents

3 POINTS: 57.0 – 101.9 programmes/projects per year per 1,000,000 residents

4 POINTS: ≥ 102.0 programmes/projects per year per 1,000,000 residents

INDICATOR 26

GOVERNANCE AND MANAGEMENT

EDUCATION

RATIONALE FOR SELECTION OF INDICATOR

Education can be divided into two categories, formal through the school curriculum or informal. Two aspects will be evaluated, i.e., formal education and public awareness. Indicator 26 highlights whether biodiversity is included in the school curricula at all levels. The current thinking is that the best way to instil an ethos that appreciates and values biodiversity is through the education, from preschool to tertiary levels. Incorporating biodiversity into the school curricula demonstrates a commitment at an institutional level and also ensures equity of access of biodiversity knowledge to the majority.

Most cities have no jurisdiction over school curricula. The incorporation of this indicator creates opportunities for city officials to collaborate with education officers and explore ways of including biodiversity at pre-school, primary, secondary and tertiary levels.

HOW TO CALCULATE INDICATOR

The key question for this indicator is whether biodiversity or nature awareness is included in the school curricula (e.g., biology, geography, etc.).

Cities that have included biodiversity education into the school curricula may want to share more details on how it has been implemented.

WHERE TO GET DATA FOR CALCULATIONS

Education department, pre-school boards, schools, junior colleges, high schools, universities, city councils, NGOs

RATIONALE FOR SELECTION OF INDICATOR

The scoring, while leading to the mandatory inclusion of biodiversity in the school curricula, allows for the flexibility of approaches.

0 POINTS: Biodiversity or elements of it are not covered in the school curricula.

1 POINT: Biodiversity or elements of it are being considered for inclusion in the school curricula or biodiversity curricula exist in an *ad hoc* manner but are not supported by the local government.

2 POINTS: Biodiversity or elements of it have been planned for inclusion in the school curricula.

3 POINTS: Biodiversity or elements of it are in the process of being implemented in the school curricula.

4 POINTS: Biodiversity or elements of it have been fully implemented in the school curricula at all levels.

INDICATOR 27

AWARENESS

RATIONALE FOR SELECTION OF INDICATOR

Indicator 27 looks at the informal aspect of education. This indicator focusses on the public awareness component by tracking the number of outreach or public awareness events held per year per 1,000,000 residents.

The event should either be organised entirely by the city authorities, or there should be some involvement of the city authorities before the event can be considered for inclusion in the indicator. This encourages collaboration between the city authorities and the public and NGOs. If there are currently many events organised by various local NGOs, organizations and institutions, city administrations should reach out to them so that there is a common platform for the coordination and monitoring of all biodiversity related public awareness events and programmes occurring in the city. Resources would, hence, be utilised more optimally.

Digital and online media are being used increasingly in outreach efforts. Hence, outreach and public awareness campaigns using new media should be included along with traditional methods.

HOW TO CALCULATE INDICATOR

Number of outreach or public awareness events held in the city per year per 1,000,000 persons.

To better engage the youths and cognizant of the trend forced by COVID-19, most of the outreach and public awareness organisers have tapped on the use of digital and online media to run their online campaigns. Hence, outreach and public awareness events that are conducted online or through digital media should be included.

Cities are encouraged to include a full list of the events included in the calculation for indicator 27. If available, information, data and figures on the number of people who attended the event or were targeted could also be included as extra information/ statistics.

WHERE TO GET DATA FOR CALCULATIONS

Education department, city councils, NGOs, private sector, citizen scientists, amateur naturalists, students, etc.

BASIS OF SCORING

The scoring is based on the feedback given by cities that have applied the SI. This has been normalised for population size. For cities that have less than one million residents, they could scale down accordingly.

0 POINTS: < 7 outreach events/year per 1,000,000 persons

1 POINT: 7 – 81 outreach events/year per 1,000,000 persons

2 POINTS: 82 – 220 outreach events/year per 1,000,000 persons

3 POINTS: 221 – 393 outreach events/year per 1,000,000 persons

4 POINTS: > 393 outreach events/year per 1,000,000 persons

GOVERNANCE AND MANAGEMENT

INDICATOR 28

COMMUNITY SCIENCE

RATIONALE FOR SELECTION OF INDICATOR

Engaging the community in biodiversity conservation and monitoring projects can help a city to address gaps in biodiversity information as well as to enhance a city's capacity for data collection on its biodiversity, thereby increasing the quantity and improving the quality of the state of knowledge on a city's biodiversity. Involving the community in biodiversity conservation and monitoring efforts also opens a door to active connection with flora and fauna, hence, nurturing an affiliation with nature and instilling biophilia. Biophilia is defined as an innate love for living things.

HOW TO CALCULATE INDICATOR

Number of community scientists contributing towards biodiversity conservation efforts and research normalised for population size.

(Number community scientists) ÷ (Total population in city/1,000,000 persons)

WHERE TO GET DATA FOR CALCULATIONS

Biodiversity centres, NGOs, organisations dealing with biodiversity, city agencies in charge of biodiversity, nature groups, online platforms such as iNaturalist, citizen scientists, amateur naturalists, students, CitiesWithNature, etc

BASIS OF SCORING

The scoring of the community scientists' range was based on quantiles applied to the cities' dataset from iNaturalist, normalised for population size. The results of the calculation of Indicator 28 have been rounded to the nearest whole number.

0 POINTS: < 2 community scientists/1,000,000 population

1 POINT: 2 – 9 community scientists/1,000,000 population

2 POINTS: 10 – 48 community scientists/1,000,000 population

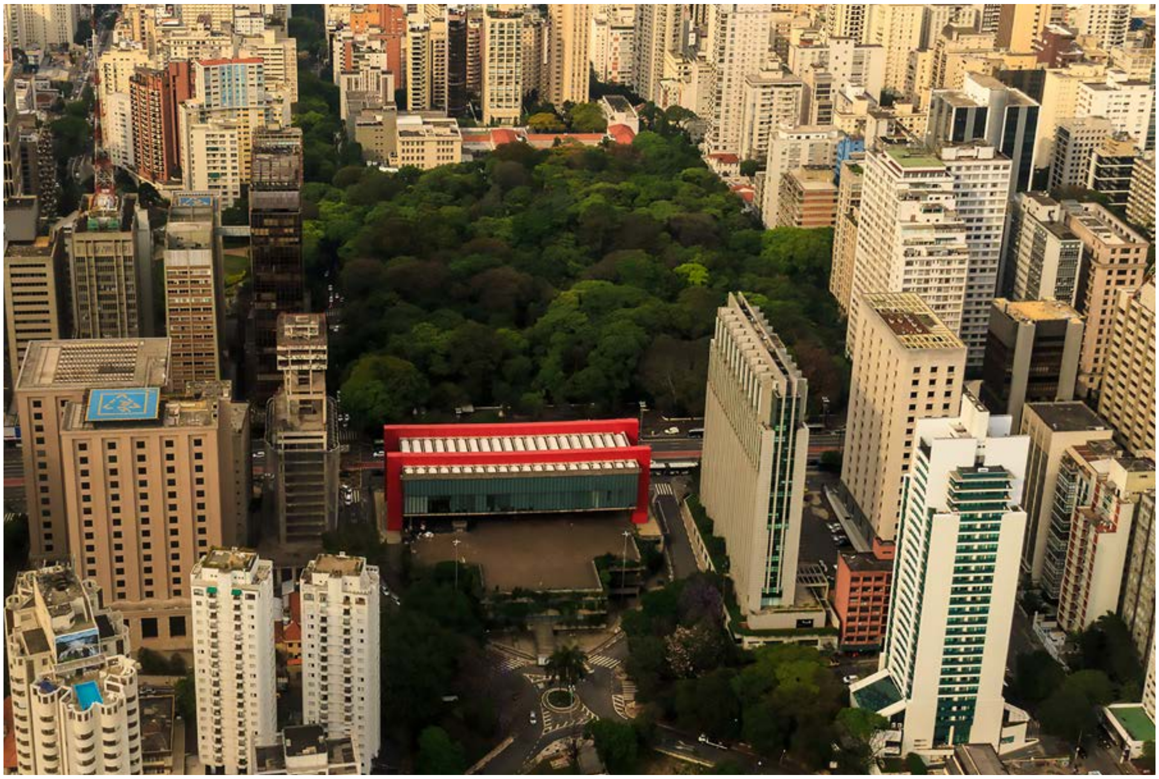
3 POINTS: 49 – 117 community scientists/1,000,000 population

4 POINTS: > 117 community scientists/1,000,000 population

Kirikiriroa-Hamilton, the fourth largest city in New Zealand, straddles the Waikato River. *© Hamilton City Council.*

This restored freshwater wetland forest ecosystem lies within the Learning Forest at the Singapore Botanic Gardens. Besides being a well-curated botanical conservation site of native plants, it is also home to several faunal species, including otters, birds, reptiles, amphibians, dragonflies, butterflies, etc. *© National Parks Board.*

The eye-catching green facade decorates the European Congress Centre in Vitoria-Gasteiz, Spain. © *Quinta fotógrafos*



Aerial view of Tenente Siqueira Campos Park – Trianon, a remnant of the original Atlantic Forest and one of the most visited central parks in the city of São Paulo. The creation of the park was essential to preserve the vegetation, in addition get together numerous cultural attractions and works of arts along to the visitations. While you walk in the park you can see heterogeneous forest, garden areas and vegetable garden. 73 vascular species have already been registered, of almost two are threatened with extinction and 34 species of birds can be observed.
© Joca Duarte, SVMA Collection, São Paulo, Brazil.

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The Parkroyal on Pickering, with lush greenery on several floors, is a hotel located in the heart of the business district in Singapore. *© National Parks Board.*

The Living Roof – Headquarter for butterflies. City of Edinburgh Council, Headquarters, Waverly Court, Scotland. *© Susan Falconer*

ANNEX A

Discussions and Outcomes of the First, Second and Third Expert Workshops on the Development of the Singapore Index on Cities' Biodiversity as well as the Workshop on the Review of the Singapore Index on Cities' Biodiversity

1. Singapore organised and hosted four expert workshops to develop, refine and revise the indicators of the Singapore Index on Cities' Biodiversity. The reports of the workshops are available on the Convention on Biological Diversity (CBD) website. This annex highlights the key discussions and outcomes of the four workshops.

    - First Expert Workshop on the Development of the City Biodiversity Index, 10-12 February 2009 (UNEP/CBD/EW.DCBI/1/3; www.cbd.int/doc/?meeting=EWDCBI-01)
    - Second Expert Workshop on the Development of the City Biodiversity Index, 1-3 July 2010 (UNEP/CBD/EW.DCBI/2/3; www.cbd.int/doc/?meeting=EWDCBI-02)
    - Third Expert Workshop on the Development of the City Biodiversity Index, 11-13 October 2011 (UNEP/CBD/EW.DCBI/3/2; www.cbd.int/doc/?meeting=EWDCBI-03)
    - Workshop on the Review of the Singapore Index on Cities' Biodiversity, 15-17 October 2019

First Expert Workshop on the Development of the City Biodiversity Index, 10-12 February 2009

2. The key objectives of the workshop were to develop the City Biodiversity Index (CBI) as a self-assessment tool to:

    (i) assist national governments and local authorities in benchmarking biodiversity conservation efforts in the urban context; and

    (ii) help evaluate progress in reducing the rate of biodiversity loss in urban ecosystems.

3. A total of 17 technical experts on biodiversity indicators as well as city executives and representatives responsible for implementation and/or management of biodiversity and urban projects and programmes attended the workshop. These included four cities (Curitiba, Montreal, Nagoya, and Singapore), experts from the London School of Economics, Stockholm Resilience Centre, Institute of Housing and Environment (Germany), National University of Singapore, the International Union for Conservation of Nature (IUCN), ICLEI – Local Governments for Sustainability's Local Action for Biodiversity (LAB) Initiative and the East Asian Seas Partnership Council. From the Secretariat of the Convention on Biological Diversity (SCBD), Mr. Oliver Hillel, Programme Officer for Sustainable Use, Tourism and Island Biodiversity, attended the workshop.

4. Over the three-day workshop, the experts deliberated on the format of the Index and agreed that it should comprise three components, that is:

    (i) native biodiversity in the city,

    (ii) ecosystem services provided by native biodiversity in the city, and

    (iii) governance and management of native biodiversity in the city.

5. The first component focuses on different aspects of native biodiversity, in particular what native biodiversity are found in the city, how they are conserved, what are the threats to native biodiversity, etc. The second component concentrates on the ecosystem services provided by native biodiversity in the city, including those pertaining to regulation of water, carbon storage, and recreational and educational services. The third component is concerned with the governance and management of biodiversity, encompassing budget allocation, institutional setups, number of biodiversity related projects, public awareness programmes, administrative procedures, etc.

6. The experts, divided into three groups, discussed in depth each of the components and decided on 26 indicators[6].

7. A technical task force, comprising Dr. Nancy Holman (London School of Economics), Mr. Peter Werner (Institute of Housing and Environment, Darmstadt, Germany), Professor Thomas Elmqvist (Stockholm Resilience Centre), Mr. Andre Mader (ICLEI-Local Governments for Sustainability LAB Initiative), Ms. Elisa Calcaterra (IUCN), Mr. Oliver Hillel (SCBD) and Dr. Lena Chan (NParks) was delegated to prepare the User's Manual.

Second Expert Workshop on the Development of the City Biodiversity Index, 1-3 July 2010

8. The objectives of the workshop were to:

   (i) review comments by cities which have test-bedded the Index;

   (ii) refine and improve the indicators of the CBI based on the essence of the components that was agreed at the First Expert Workshop (paragraph 4); and

   (iii) finalise the User's Manual for the CBI.

9. Thirty-two participants, including the SCBD, the technical task force, representatives from ASEAN Working Group on Environmentally Sustainable Cities, Brussels Capital Region, Curitiba, Edmonton, Montpelier, Montreal, Nagoya, Waitakere City and Singapore, resource experts, representatives from Aichi-Nagoya COP-10 CBD Promotion Committee and international organisations attended the workshop.

10. The participants examined the general approach to the selection of the indicators, crafting of the measurement of the indicators, and scoring of the indicators. Special attention was paid to ensure that the selection and scoring of the indicators were unbiased. Written feedback given was shared at the workshop and any concerns that were brought to the attention of the technical task force were addressed at the workshop. The decisions made during the workshop on the amendment of the indicators were incorporated into the revised indicators.

11. The following issues pertaining to the general approach to the formulation of the CBI were discussed extensively:

   (i) Issue: It was recognised that cities in the temperate region have inherently a lower diversity than cities in the tropical region. The age of the cities, human intervention and other processes of succession could also be factors affecting the biodiversity of cities. The size of the cities too is an important factor in determining the biodiversity richness of the city.

   Discussion and Conclusion: To ensure fairness and reduce bias, a number of amendments were made. First, it was agreed that the total number of ecosystems and total number of specific

6 Twenty-six indicators were identified at the First Expert Workshop. As two of the indicators were very similar, one of them was removed during the preparation of the User's Manual for the CBI, resulting in a total of 25 indicators in the November 2009 version.

species be listed in the Profile of the City. The net change in species over time, where the first year of application is set as the baseline year, has been identified as an indicator to replace the total number of species. Secondly, statistical analysis based on the data from cities would be carried out. For the statistical analysis to be reliable, data input would be required from at least 20 cities. For scoring range with a maximum of 4 points, the mean from data given by the cities will be calculated and used as reference for the '2-point' score.

As the CBI is developed primarily as a self-assessment tool, the actual score of the indicators is secondary to the change in the score over time. Hence, the differences in the scores by cities in different ecological biomes should not be a cause for concern as cities are comparing how well they did in relation to their own past scores over a time period. The comparison among cities arose due to the availability of the data but comparison was never an intended result in the development of the CBI.

(ii) Issue: The validity of a single score based on the summation of the scores of a diverse range of indicators was questioned. Another system, segregating different characteristics of the indicators into five sectors, i.e., A, B, C, D and E, and summing up scores of the different elements separately was counter-proposed.

Discussion and Conclusion: The participants deliberated on the merits and drawbacks of the single score and the counter-proposal. The consensus of the workshop was that a single score, which was a total of the scores for all the indicators, was preferred as long as the indicators were fair.

(iii) Issue: It was suggested that the ecological footprint of the cities should be included in the Index.

Discussion and Conclusion: The participants were informed that this issue had been raised at the previous workshop. Since many other indices like the World Economic Forum's 2005 Environmental Sustainability Index and 2008 Environmental Performance Index, WWF's Living Planet Report 2008 deal with ecological footprints and no other indices for cities, in particular, focus on biodiversity related parameters, it was agreed that this Index should concentrate on native biodiversity, ecosystem services provided by biodiversity, and governance and management of biodiversity. By creating this niche, the Index could provide biodiversity related indicators for other indices that lack these specialised but important parameters.

(iv) Issue: For many of the cities, the extinction of species occurred more than a hundred years ago. It was beyond the control of the present generation.

Discussion and Conclusion: While it was accepted that the extinction of species had taken place, it was not productive to dwell on it by focusing on extinct species. Positive steps need to be taken and these should be incorporated into the Index to encourage proactive activities that would result in the restoration and rehabilitation of ecosystems and re-introduction of species. All the indicators, where necessary, have been revised to reflect this approach.

(v) Issue: There was feedback from several parties that insufficient attention was given to biodiversity in built up areas, considering most cities comprise built up areas and semi-natural cultural landscapes. The characteristics of built up areas and brownfield sites differ in different cities and there was a need to arrive at a common understanding of these land use features.

Discussion and Conclusion: The participants agreed with the above observation. The indicator on native biodiversity in built up areas, i.e., number of bird species, attempts to address this issue. One of the motivations of this Index was to promote the increase in native biodiversity in cities so as to reduce the rate of biodiversity loss. It has been increasingly shown that many cities could have higher biodiversity than the countryside which are heavily sprayed with herbicides and pesticides. The Index is seen as dynamic and evolving in nature. Positive indicators that aim to increase biodiversity like restoration, rehabilitation and re-introduction initiatives would most likely be added at a later date.

(vi) Issue: It was highlighted that for ecosystem services, it was difficult to isolate the services provided only by native biodiversity. Similarly, on governance and management, such actions are often directed at biodiversity in general. However, it is recognised that actions directed at the conservation and utilisation of native biodiversity should be encouraged.

Discussion and Conclusion: Therefore, components two and three were amended accordingly:

- ecosystem services provided by biodiversity in the city, and
- governance and management of biodiversity in the city

12. Specific changes in the CBI, resulting from the deliberations at the workshop, include:

(i) To standardise throughout the Index, proportions are used rather than percentages[7].

(ii) The scoring will be based on normalising the data provided by the cities. The statistical treatment of the cities' data would ensure a scientific basis for the scoring, fairness and objectivity. Statistical analysis will be applied to indicators 2 (Connectivity), 3 (Native biodiversity in built up areas), 9 (Proportion of protected areas), 11 (Regulation of water quantity), 12 (Climate regulation: carbon storage and cooling effect of vegetation), 15 (Budget allocated to biodiversity), and 16 (Number of biodiversity projects that are implemented by the city).

(iii) Indicator 2: Diversity of ecosystems in the 21 November 2009 version. This indicator has been deleted in the present version as it was not likely that the number of ecosystems would change significantly over a medium time period, which is the reporting time frame of the Index. However, information on the number of ecosystems in cities is still deemed important and hence, it will be recorded under the Profile of the City.

(iv) Indicator 3: Fragmentation in the 21 November 2009 version. To emphasise the positive solution approach of the Index, this indicator, re-numbered as indicator 2, will measure the connectivity measures or ecological networks efforts to counter fragmentation.

(v) Indicators 5, 6, 7, 8 and 9: Number of native species in the 21 November 2009 version. The numbers of these indicators have been changed to 4, 5, 6, 7 and 8, respectively, in this current version, due to the deletion of the indicator on ecosystems. It was agreed that to be fair to all the cities (see paragraph 11(i) above), the indicators should measure change in species number rather than the absolute number of species. 2010[8] has been identified as the baseline year and cities would record the number of species of the mandatory taxonomic groups of vascular plants, birds and butterflies and two other taxonomic groups of the city's choice in the Profile of the City.

(vi) Indicator 12: Freshwater services in the 21 November 2009 version. Many cities had problems with this indicator, hence the need to revise it. This indicator has been re-numbered as indicator 11: Regulation of Quantity of Water. As a result of climate change, there is increased variability

7 A decision was subsequently made by NParks to use percentages in the scoring ranges for the indicators, as it was felt that percentages provide a more intuitive figure than proportions.

8 Due to cities having different years in which they first applied the Singapore Index, it was subsequently decided that the first year of application would be considered the baseline year, rather than 2010. This would also enable cities to apply the Singapore Index even if they do not have data from 2010 for their baseline year.

of the quantity of precipitation and impermeable surfaces will further aggravate the problem. Hence, this is an indicator that highlights the importance of permeable surfaces, in particular wetlands and natural ecosystems, that would help regulate and moderate the flow of water due to extreme climatic conditions.

(vii) Indicator 13: Carbon storage in the 21 November 2009 version. While cities were agreeable with the number of trees in principle, there were issues that were difficult to resolve, like species of trees, girth size of trees, trees planted by the city council or should it include trees in private land, etc. The indicator has been re-numbered as indicator 12 and uses the proportionate area of tree canopy cover to the total area of the city as an indirect measure of both carbon storage and the cooling effect of vegetation.

(viii) Indicator 14: Recreation and educational services as in the 21 November 2009 version. This indicator measuring number of visits per person per year was deleted as there were differences in the desired number for different types of areas. For example, the carrying capacity of nature reserves and national parks are lower than that of parks. Achieving high and increasing numbers of visitors is not a desired outcome for nature reserves and national parks but would be for horticultural parks with less natural ecosystems.

13. While it is recognised that there are some other indicators that could be included in the CBI, due to the urgency of completing the CBI for submission to COP-10 in October 2010, minimum additions were made to the current version. Indicators that measure cities' efforts at restoring native biodiversity and habitats, ecosystem services, native biodiversity in landfill sites, green roofs and vertical greening initiatives, proximity to nature parks, and brownfield sites, etc., have been identified as important gaps that need to be addressed. Further revisions will include indicators that address these unrepresented areas.

14. The development of the CBI is a dynamic process, evolving for the better continuously so as to be more useful, to allow it to be applicable to more cities and to be more scientifically robust. The strengths of the CBI are that:

(i) it is the only Index that focuses on biodiversity;

(ii) its coverage is diverse and comprehensive, incorporating indicators on biodiversity, ecosystem services, and good governance and management;

(iii) cities can do their own assessment, hence, building their capacity in biodiversity conservation and databases;

(iv) the scores are quantitative, hence, it is objective and it is possible to monitor change over time; and

(v) a diverse range of experts and stakeholders contributed to the design of the CBI.

15. The weaknesses of the CBI are that:

(i) it is difficult to select indicators that all cities have data on;

(ii) the scoring of some of the indicators is difficult due to the different ecological zones that cities are located in; and

(iii) indicators for ecosystem services are difficult to design as this a new field of study.

Third Expert Workshop on the Development of the City Biodiversity Index, 11-13 October 2011

16. The objectives of the workshop were to:

    (i) finalise the scoring of the indicators of the Singapore Index on Cities' Biodiversity (Singapore Index)[9];

    (ii) discuss the roadmap on the contribution of the Singapore Index to the Eleventh Meeting of the Conference of Parties to the CBD (COP-11);

    (iii) define ways to further expand the use of the Singapore Index for cities (such as in planning and baseline setting) and for other levels of subnational government;

    (iv) discuss the documentation on cities' experiences on the application of the Singapore Index; and

    (v) provide inputs to the first edition of the Cities and Biodiversity Outlook.

17. A total of 26 technical experts on urban biodiversity conservation and planning as well as city representatives responsible for the implementation and/or management of biodiversity and urban projects and programmes attended the workshop. The participants noted that only 13 cities provided data for the establishment of scoring ranges for the seven indicators. To ensure a robust statistical normalisation exercise, the participants proposed that data from at least 50 cities was required. Participants also reviewed all 23 indicators of the Singapore Index and where necessary, suggested improvements to provide greater clarity in the data that were required.

18. The following issues were deliberated in greater detail:

    (i) For accountability and standardisation of reporting, it was agreed that the reporting of the implementation and scoring of the Singapore Index should be performed by the city officials. Universities, non-governmental organisations (NGOs), consultants, etc. can carry out the data collection and analyses but the reporting will have to be channelled through the city officials. Cities can report on their results and experiences to the SCBD, National Parks Board of Singapore (NParks) and ICLEI. The reports and case studies will be posted on the SCBD website.

    (ii) The meeting agreed that the indicators should not be changed as experts from diverse disciplines had worked on them during the last two workshops and further inputs had been provided by cities.

    (iii) In our efforts to maintain a high standard of scientific credibility, the methods for calculating the indicators should be reviewed stringently. Cities were requested to record in detail how the calculations were done and the assumptions made to ensure standardisation of methodology. Extensive improvements were made in particular on indicator 2: Connectivity measures or ecological networks to counter fragmentation.

    (iv) Based on feedback from several cities, clearer definitions were set for many of the indicators, including indicators, 1, 2, 4, 5, 6, 7, 8, 11, 15, 16, 17, 18, and 23, which are captured in the updated User's Manual of the Singapore Index.

    (v) Seven of the indicators, i.e., indicators 2, 3, 9, 11, 12, 15 and 16, required statistical normalisation. Cities were requested to give their data to NParks so that the statistical normalisation exercise would be more stringent with a greater sample size.

9 In recognition of Singapore's leadership in the technical development of the Index, the City Biodiversity Index became commonly known as the Singapore Index on Cities' Biodiversity, or Singapore Index.

(vi) In recognition that some cities might not have all the data and to facilitate participation by a diverse range of cities, the implementation of the Singapore Index could be done stepwise, i.e., cities can initially start with indicators that they have data on. They can plan to collect data on other indicators progressively. Cities are also encouraged to share any ideas on how they can improve on the application of the indicators to make them more relevant in their own geographical context. For example, using tree canopy cover in indicator 12 might not be suitable for cities in the desert or arid zones. Taking all these into consideration, cities are encouraged to apply all the 23 indicators.

(vii) It is emphasised that the Singapore Index is designed as a self-assessment tool. Hence, if it is used for comparative purposes, stratifications would have to be applied for more meaningful comparisons. Cities would have to be grouped according to geographical location, size, historical age, etc.

19. Mr. Andre Mader (ICLEI-Local Governments for Sustainability LAB Initiative) and Ms. Elisa Calcaterra (IUCN), both members of the Technical Task Force have left ICLEI and IUCN respectively. Ms. Shela Patrickson from ICLEI-Local Governments for Sustainability LAB Initiative attended the Third Expert Workshop and will replace Mr. Andre Mader in the Technical Task Force. The Technical Task Force now comprises six members: Dr. Nancy Holman (London School of Economics), Mr. Peter Werner (Institute of Housing and Environment, Darmstadt, Germany), Professor Thomas Elmqvist (Stockholm Resilience Centre), Ms. Shela Patrickson (ICLEI-Local Governments for Sustainability LAB Initiative), Mr. Oliver Hillel (SCBD) and Dr. Lena Chan (NParks).

Third Expert Workshop – After Note

20. It is observed during the collation of cities' results for indicator 14 that the data and methodology does not fit the scoring range. The conventional approach is to take the total number of visits and divide it by the total number of students below 16 years old. This results in a number that may not fall within the scoring range. To get around this problem, Hamilton adopted a novel approach – Hamilton city authorities sampled schools with students of varying age groups (below 16) to obtain an estimated number that is representative of the student populous. We would also like to hear from other cities if they have alternative approaches in measuring indicator 14.

21. Data on the six indicators with no scoring ranges (i.e., indicators 3, 9, 11, 12, 15 and 16) were received from cities for normalization of the scoring ranges. These data were then compiled, and the cut off points for each indicator were determined using percentiles: the top 20% of cities scored 4 points, the next 20% scored 3 points and so on, with the lowest 20% of cities scoring 0 points based on the preferred method as indicated during the Third Expert Workshop and in ongoing consultation with the technical task force. The methodology for indicator 2 was changed during the Third Expert Workshop. Hence few cities were able to return their calculations based on the revised indicator since then. The scoring range for indicator 2 was established in consultation with Dr. Jochen Jaeger who proposed the method adopted for the calculations of this indicator. The final suite of indicators also utilises percentages rather than proportions, as the final result will be more intuitive.

Workshop on the Review of the Singapore Index on Cities' Biodiversity, 15-17 October 2019

22. The objectives of the workshop were to:

    (i) Review the current suite of indicators of the Singapore Index on Cities' Biodiversity (SI) to reflect current and emerging trends in biodiversity and climate change, as well as to take reference from the discussions on the post-2020 Global Biodiversity Framework;

    (ii) Review the indicators of the SI to address the needs and feedback of cities;

23. Thirty-one participants from a total of 29 organisations, including municipal governments, academia, and international organisations, attended the fourth expert workshop for a three-day technical review of the index.

24. The meeting agreed that the SI could be applied once every five years or a longer period deemed more appropriate, rather than the previous recommendation of three years. The meeting also noted that cities would stand to benefit from a dedicated digital platform to facilitate sharing and discussion of the SI among city applications. Lastly, the meeting noted the process of applying the index has the potential to pool together a network of stakeholders needed to kick start meaningful biodiversity conservation work in cities.

25. Each existing indicator in the index was reviewed, and the following indicators were revised:

    (i) <u>Indicator 3: Native biodiversity in built up areas (bird species) in the original SI.</u> Participants deemed it fairer for the indicator to account for differences in number of species in different geographical regions. Hence, it was decided that the number of native bird species found in built-up areas of the city be calculated as a proportion of the number of native bird species in the city.

    (ii) <u>Indicator 6: Change in number of native butterfly species in the original SI.</u> Cities raised the issue that the collection of data for five native taxonomic groups was too onerous. The removal of two taxa was agreed on, and the taxon of butterflies was broadened to arthropods. Retaining 3 species indicators would be sufficient to reflect the different levels of the ecological web.

    (iii) <u>Indicator 10: Proportion of invasive alien species (IAS) in the original SI.</u> Terms within this indicator were further clarified, where the "Total number of species" used in the calculation of the proportion should include the number of Invasive Alien Species (IAS).

    (iv) <u>Indicator 11: Regulation of quantity of water in the original SI.</u> Cities were concerned that the data for this indicator would be costly to collect but acknowledged that this indicator was important to measure the regulation of water in the city as a key ecosystem service provided by biodiversity. To provide a more accurate gauge of a city's hydrology and water quality, an alternative method using the percentage of effective impervious area (EIA) was suggested as a step-up option for cities to calculate indicator 11.

    (v) <u>Indicator 12: Climate regulation: Carbon Storage and cooling effect of vegetation in the original SI.</u> The title of the indicator was revised to "Climate regulation: Benefits of trees and greenery", to more accurately reflect the wide range of ecosystem services trees and greenery can provide.

    (vi) <u>Indicator 15: Budget allocated to biodiversity in the original SI.</u> This indicator was revised to accommodate various cities' contexts. The importance of consistently applying the SI was emphasised as cities agreed to include developer contributions as a component of the biodiversity budget.

(vii) Indicator 16: Number of biodiversity projects implemented by the city annually in the original SI. This indicator was normalised to account for varying city population sizes. The meeting agreed to have this indicator reflect number of biodiversity projects implemented by the city annually per 1,000,000 persons.

(viii) Indicator 18: Number of essential biodiversity related functions that the city uses in the original SI. The meeting initially agreed to include digital platforms in the scoring basis. However, digital platforms were later deemed not to be an essential biodiversity-related function. The meeting agreed to keep the original version of Indicator 18.

(ix) Indicator 23: Number of outreach or public awareness events held in the city per year in the original SI. This indicator was normalised to account for varying city population sizes. Cities were reminded that the purpose of this indicator was to measure a city's efforts in raising awareness among its citizens on biodiversity-related matters, and that cities should have autonomy in applying this indicator while bearing in mind the importance of applying this indicator consistently. The meeting agreed to have this indicator reflect the number of outreach/public awareness events implemented by the city annually per 1,000,000 persons.

26. The following indicators were removed: Indicators 7-8: Change in number of native species (optional taxonomic groups) and Indicator 14: Average number of formal education visits. These indicators were dropped as the data was too onerous to obtain. Professor Bruce Clarkson suggested for cities to include information on additional taxonomic groups into the city's profile.

27. New indicators were also added to the index. These new indicators include:

(i) Habitat restoration. Two options were proposed for this indicator – one measures the proportion (%) of habitat area restored to good ecological functioning and the other the proportion (%) of habitat types restored in the city. For the latter option, the meeting decided to standardise the type of habitats considered for the indicator using the IUCN Habitats Classification Scheme. Cities are free to choose to apply either one of these two options.

(ii) Urban agriculture. The meeting considered including an indicator which could contribute to a city's biodiversity and bolster its food security at the same time. It tasked Dr Aitor Albaina and Mr Oliver Hillel to further develop this indicator.

(iii) Health and wellbeing – proximity/accessibility to parks. The meeting deliberated between "accessibility" and "proximity", agreeing that "accessibility" was more effective as an indicator. The discussion concluded that proximity should only be considered if it was not feasible for all cities to calculate accessibility which would require more technical capabilities in geospatial information systems. The NParks team eventually developed the "accessibility" and "proximity" options for cities to calculate this indicator.

(iv) Status of natural capital assessment in the city. The meeting discussed the distinction between a 'natural capital assessment' or an 'natural capital accounting' of biodiversity or ecosystem services within a city, before deciding upon the use of the term 'natural capital assessment'. It was noted that a city would likely have most of the work done for the assessment if they completed most of the existing 23 indicators in the previous version of the Singapore Index.

(v) State of greenery management plans in the city. This indicator is intended to ensure that cities have quality management plans that focus on biodiversity when planning for the development or enhancement of their green spaces.

(vi) Biodiversity-related responses to climate change that enhance biodiversity. The original proposal of this indicator looked at the number of trees being planted as a proxy for measuring efforts to mitigate climate change while enhancing biodiversity. The meeting agreed that that a scoring basis on the implementation of nature-based responses against climate change was more suitable than one on the number of trees planted.

(vii) Policy and/or incentives for green infrastructure as nature-based solutions. The meeting agreed that this was a good aspirational indicator that should be looked into for cities to enhance biodiversity in built-up areas. The meeting suggested for the indicator to focus on improving grey infrastructure with greenery.

(viii) Community science. The meeting discussed the possibility of counting the number of hours as a measure of community's effort in biodiversity conservation but eventually settled on number of community scientists as a more sustainable way of collecting data. The word 'community' was chosen over 'citizen' as the intent of this indicator would be to engage not just the city's citizens but all residents living in that city.

Workshop on the Review of the SI – After Note

28. The meeting report was circulated to the participants on 21 November 2019. Several participants and experts of specialised topics a) provided invaluable data and write-ups on the revised and new indicators, and b) advised on the quantitative scoring of the indicators.

29. The compiled revised indicators were circulated to the participants and other independent experts for their comments and feedback on 23 March 2020. Due to the COVID-19 pandemic situation, responses were delayed.

30. Substantive work was put in to make the Handbook on the Singapore Index on Cities' Biodiversity more robust. The indicators were re-ordered so that they were clustered more appropriately and flowed more logically.

ANNEX B

List of Participants for the Workshops Held to Discuss the Development and Revision of the Singapore Index on Cities' Biodiversity

First Expert Workshop on the Development of the City Biodiversity Index, 10-12 February 2009

S/N	Name	Organization
1	Mr. Oliver Hillel (Co-Chair & SI Technical Task Force)	Secretariat of the Convention on Biological Diversity
2	Dr. Lena Chan (Co-Chair & SI Technical Task Force)	National Parks Board, Singapore
3	Prof. Thomas Elmqvist (SI Technical Task Force)	Stockholm Resilience Center, Stockholm University, Sweden
4	Mr. Peter Werner (SI Technical Task Force)	Institute of Housing and Environment, Darmstadt, Germany
5	Dr. Nancy Holman (SI Technical Task Force)	London School of Economics, England
6	Ms. Elisa Calcaterra (SI Technical Task Force)	IUCN/Countdown 2010, Belgium
7	Mr. Andre Mader (SI Technical Task Force)	ICLEI/LAB, South Africa
8	Dr. Ryo Kohsaka	Nagoya City, Japan
9	Mr. Seiichi Kawada	Nagoya City, Japan
10	Mr. Alfredo Trindade	Technical expert/manager from the City of Curitiba, Brazil
11	Ms. Michele Picard	City of Montreal, Canada
12	Mr. Daniel Hodder	City of Montreal, Canada
13	Prof. Peter Ng	National University of Singapore, Singapore
14	Prof. Richard Corlett	National University of Singapore, Singapore
15	Dr. Chua Thia Eng	PEMSEA, Philippines
16	Dr. Tan Puay Yok	National Parks Board, Singapore
17	Dr. Geoffrey Davison	National Parks Board, Singapore

Second Expert Workshop on the Development of the City Biodiversity Index, 1-3 July 2010

S/N	Name	Organization
1	Mr. Oliver Hillel (Co-Chair & SI Technical Task Force)	Secretariat of the Convention on Biological Diversity
2	Dr. Lena Chan (Co-Chair & SI Technical Task Force)	National Parks Board, Singapore
3	Mr. Andre Derek Mader (SI Technical Task Force)	ICLEI – Local Governments for Sustainability
4	Ms. Elisa Calcaterra (SI Technical Task Force)	IUCN Regional Office for Europe
5	Dr. Nancy Elizabeth Holman (SI Technical Task Force)	London School of Economics and Political Science
6	Mr. Peter Werner (SI Technical Task Force)	Institut Wohnen und Umwelt GmbH (Institute for Housing and Environment)
7	Prof. Thomas Elmqvist (SI Technical Task Force)	Stockholm Resilience Centre
8	Ms. Machteld Gryseels	Region of Brussels Capital
9	Mr. Alfredo Vicente de Castro Trindade	Municipal Secretariat of Environment, Curitiba-Paraná-Brasil
10	Mr. William Grant Pearsell	Asset Management and Public Works Dept, City of Edmonton
11	Mr. Daniel Hodder	Development and Partnerships, Large Parks and Greening, City of Montréal
12	Mr. Masashi Kato	Environmental Affairs Bureau, City of Nagoya
13	Dr. Graeme Campbell	Strategic Planning, Waitakere City Council
14	Prof. Bruce Clarkson	University of Waikato
15	Ms. Gwendolyn Hallsmith	City of Montpelier
16	Ms. Liana Bratasida	Ministry of Environment Republic of Indonesia
17	Prof. Peter Ng	Tropical Marine Science Institute, National University of Singapore
18	Prof. Richard Thomas Corlett	Dept. of Biological Science, National University of Singapore
19	Dr. Tan Puay Yok	Centre for Urban Greenery and Ecology (CUGE), National Parks Board
20	Mr. Chikara Hombo	Secretariat of the Convention on Biological Diversity
21	Dr. Christopher Nicholas Hideo Doll	United Nations University, Institute of Advanced Studies (UNU-IAS)
22	Mr. Joffre Hj. Ali Ahmad	Ministry of Industry and Primary Resources
23	Dr. Jose Antonio Puppim de Oliveira	United Nations University, Institute of Advanced Studies (UNU-IAS)
24	Mr. Mahmud Hj. Yussof	Ministry of Industry and Primary Resources

S/N	Name	Organization
25	Mr. Masashi Aoyama	Aichi-Nagoya COP 10 CBD Promotion Committee
26	Dr. Raquel Moreno-Peñaranda	United Nations University, Institute of Advanced Studies (UNU-IAS)
27	Dr. Ryo Kohsaka	Aichi-Nagoya COP 10 CBD Promotion Committee
28	Mr. Stephen Richards	Asia-Pacific Region, Conservation International
29	Mr. Takashi Inoue	Kyoto University, Graduate School of Global Environmental Studies
30	Mr. Tsuyoshi Ito	City Summit Group, Aichi-Nagoya COP 10 CBD Promotion Committee
31	Assoc. Prof. Mark Jeffrey McDonnell	Australian Research Centre for Urban Ecology (ARCUE)
32	Prof. Xiangrong Wang	Fudan University

Third Expert Workshop on the Development of the Singapore Index on Cities' Biodiversity, 11-13 October 2011

S/N	Name	Organization
1	Mr. Oliver Hillel (Co-Chair & SI Technical Task Force)	Secretariat of the Convention on Biological Diversity
2	Dr. Lena Chan (Co-Chair & SI Technical Task Force)	National Parks Board, Singapore
3	Ms. Shela Patrickson (SI Technical Task Force)	Cities Biodiversity Center, ICLEI – Local Governments for Sustainability
4	Dr. Nancy Elizabeth Holman (SI Technical Task Force)	London School of Economics and Political Science
5	Mr. Peter Werner (SI Technical Task Force)	Institut Wohnen und Umwelt GmbH (Institute for Housing and Environment)
6	Prof. Thomas Elmqvist (SI Technical Task Force)	Stockholm Resilience Centre
7	Ms. Supaporn Kittiwarodom	Department of Environment, Bangkok Metropolitan Administration
8	Vinicius Abilhoa	Municipal Secretariat of Environment, City of Curitiba
9	Mr. William Grant Pearsell	Urban Planning and Environment, Sustainable Development, City of Edmonton
10	Dr. Resurreccion (Rex) Bitoon Sadaba	University of the Philippines Visayas
11	Ms. Mariana Cabral Cardoso	University of Lisbon
12	Dr. Nicholas Ian White	Natural England, London, United Kingdom
13	Dr. Juan Arturo Rivera Rebolledo	Ministry of the Environment, Mexico City
14	Mr. Philippe Croze	City of Montpellier, France

S/N	Name	Organization
15	Ms. Sabine Courcier	Large Parks and Greening Department, City of Montréal
16	Dr. Ryo Kohsaka	Graduate School of Economics, Nagoya City University
17	Ms. Aida Fitriyani	Environmental Management Agency, West Java Province
18	Ms. Lina Rahayu Suardi	Environmental Management Agency, West Java Province
19	Prof. Bruce Clarkson	Faculty of Science and Engineering, University of Waikato
20	Dr. Jochen A.G. Jaeger	Department of Geography, Planning and Environment, Concordia University Montréal
21	Prof. Richard Thomas Corlett	Dept. of Biological Science, National University of Singapore
22	Dr. Tan Puay Yok	Centre for Urban Greenery and Ecology (CUGE), National Parks Board
23	Mr. Andrew Rudd	UN Habitat
24	Dr. Christopher Doll	United Nations University, Institute of Advanced Studies (UNU-IAS)
25	Mr. Sunandan Tiwari	ICLEI – Local Governments for Sustainability
26	Ms. Silke Wissel	German Environmental Aid (Deutsche Umwelthilfe e.V., DUH

Workshop on the Review of the Singapore Index on Cities' Biodiversity Index, 15-17 October 2019

S/N	Name	Organization
1	Mr. Oliver Hillel (Co-Chair & SI Technical Task Force)	Secretariat of the Convention on Biological Diversity
2	Dr. Lena Chan (Co-Chair & SI Technical Task Force)	National Parks Board, Singapore
3	Mr. Peter Werner (SI Technical Task Force)	Institute for Housing and Environment GmbH
4	Dr. Nancy Holman (SI Technical Task Force)	London School of Economics
5	Mr. Russell Galt (SI Technical Task Force)	International Union for Conservation of Nature (IUCN)
6	Ms. Ingrid Coetzee (SI Technical Task Force)	Cities Biodiversity Center, ICLEI Local Governments for Sustainability
7	Prof. Thomas Elmqvist (SI Technical Task Force)	Stockholm Resilience Centre
8	Dr. Aitor Albaina	Environmental Studies Centre, Vitoria-Gasteiz City Council
9	Mr. Akshay Nachane	Terracon EcoTech
10	Mr. Andrew Rudd	UN Habitat

S/N	Name	Organization
11	Ms. Anni Parkkinen	Department of Environmental Sciences, University of Helsinki
12	Prof. Bruce Clarkson	University of Waikato
13	Mr. Cameron McLean	eThekwini Municipality
14	Mr. Chandra Mohan Reddy	Andhra Pradesh Greening and Beautification Corporation
15	Mr. Fernando Louro Alves	Lisbon City Council
16	Mr. William Grant Pearsell	Urban Form and Corporate Strategic Development, City Planning, Edmonton
17	Ms. Julie Dewar	City of Edinburgh Council
18	Ms .Karina Avila	Dirección General de Medio Ambiente
19	Mr. Kono Tomonari	Environmental Affairs Bureau, City of Nagoya
20	Mr. Luis Andres Orive	Environmental Studies Centre, Vitoria-Gasteiz City Council
21	Dr. Mas Dojiri	LA Sanitation
22	Ms. Mika Tan	ASEAN Centre for Biodiversity Urban Biodiversity Hub (UBHub)
23	Mr. Nappy Navarra	College of Architecture, University of the Philippines
24	Dr. Perrine Hamel	Nanyang Technological University, Singapore
25	Prof. Peter Kanowski	Fenner School of Environment and Society
26	Ms. Rongrong Duriyapunt	Chiang Mai Municipality
27	Mr. Salman Faruq	Bandung
28	Dr Tan Puay Yok	Singapore Botanic Gardens, National Parks Board
29	Dr. Theresa Mundita	ASEAN Centre for Biodiversity
30	Dr. Vinícius Abilhoa	Museu de História Natural Capão da Imbuia, Curitiba, Brazil
31	Dr .Yuta Uchiyama	Nagoya University Graduate School of Environmental Studies

ANNEX C

Proposed format for submission of application of the Singapore Index on Cities' Biodiversity

PART I: PROFILE OF THE CITY

1. Submission of the results should include a short write up with a basic description of the features of your city. Relevant maps, photos, charts or figures may also be included in this portion. As a guide, the following information can be put in, but the write up need not be limited to the following fields:

(i) Basic information about your city

a. Location
b. Climate
c. Temperature
d. Rainfall/precipitation
e. Other relevant information

(vi) Size (land area, defined by city boundaries)

(vii) Population

(viii) Economic parameters

(ix) Physical features of the city

(x) Biodiversity features and characteristics such as ecosystems and species found in the city, including quantitative data on populations as well as any other qualitative information

(xi) Administration of biodiversity

(xii) Links to relevant websites:

a. city's website
b. environmental or biodiversity specific websites
c. websites of agencies responsible for biodiversity

PART II: INDICATORS OF THE SINGAPORE INDEX ON CITIES' BIODIVERSITY

2. For the calculations of the Index proper in Part II, submissions should detail the calculations that were made to arrive at the final figure, and cite the source of the figures wherever possible. The following table is a suggested format that may be used for the submission.

INDICATOR	CALCULATION Cities to indicate how the result was calculated	SOURCE Please provide any references where the information was obtained	SCORE
Native Biodiversity in the City			
1			
2			
3			
4			
5			
6			
7			
8			
9			
Ecosystem Services Provided by Biodiversity in the City			
10			
11			
12			
13			
14			
Governance and Management of Biodiversity in the City			
15			
16			
17			
18			
19			
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28			

ANNEX D

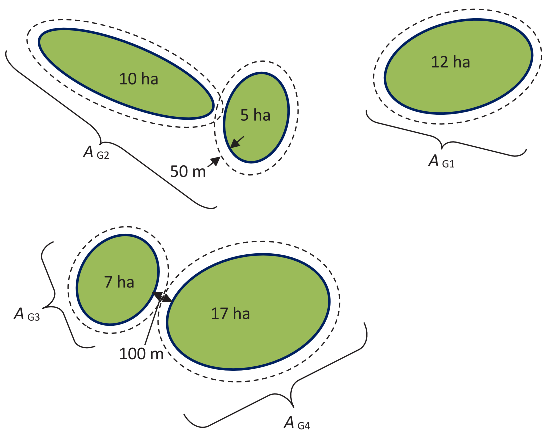
Illustration of the calculation of effective mesh size of natural areas for indicator 2

Indicator 2: Connectivity Measures or Ecological Networks to Counter Fragmentation

Formula: $Indicator\ 2 = \frac{1}{A_{\text{total}}}\left(A_{\text{G1}}^2 + A_{\text{G2}}^2 + A_{\text{G3}}^2 + \cdots + A_{\text{G}n}^2\right),$

where n denotes the number of groups of connected patches of natural area; A_{G1} to $A_{\text{G}n}$ represent the sizes of each group of connected patches of natural area, from group 1 (A_{G1}) to group n ($A_{\text{G}n}$), and A_{total} is the total area of all natural areas in the city (Deslauriers *et al*. 2018).

Example:



Calculation steps:

There are five patches in this landscape. We first add a buffer of 50 m around each patch to find out which patches are within 100m of each other: when the buffers overlap, the distance between the patches is less than 100m. The patch on the right (12 ha in size) is not connected to any other patches, and we name the patch A_1 (or A_{G1}; area = 12 ha). The two patches on the upper left are connected. Therefore, their areas have to be added, and we give this group of patches the name A_{G2} (area = 10 ha + 5 ha = 15 ha). The two patches at the bottom are exactly 100m apart and therefore they are not considered connected and we give them the names A_{G3} (area = 7 ha) and A_{G4} (area = 17 ha). A_{total} is the sum of A_{G1}, A_{G2}, A_{G3} and A_{G4}, i.e. $A_{\text{total}} =$ 12 ha + 15 ha + 7 ha + 17 ha = 51 ha. We can now calculate the value of the effective mesh size for indicator 2 as

$$Indicator\ 2 = \frac{1}{A_{\text{total}}}\left(A_{\text{G1}}^2 + A_{\text{G2}}^2 + A_{\text{G3}}^2 + A_{\text{G4}}^2\right)$$

$$= \frac{1}{51\text{ ha}}\left(12\text{x}12\text{ ha}^2 + 15\text{x}15\text{ ha}^2 + 7\text{x}7\text{ ha}^2 + 17\text{x}17\text{ ha}^2\right) = \frac{707}{51}\text{ha} = 13.86\text{ ha}.$$

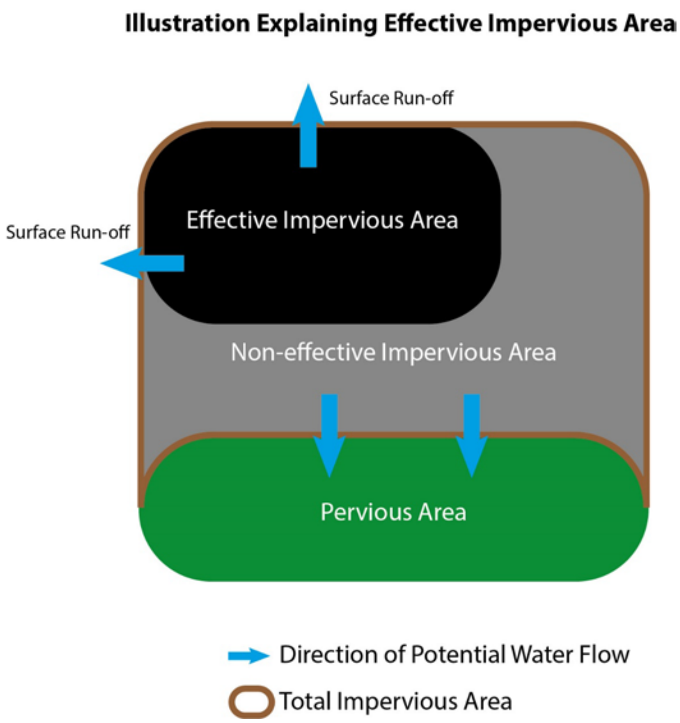
Background on this indicator and the calculations can be found in the following papers: Deslauriers *et al*. (2018), Jaeger (2000), Jaeger, Bertiller & Schwick (2007), Jaeger et al. (2008) and Spanowicz & Jaeger (2019).

Cities with difficulties in calculating this indicator may contact Dr. Jochen Jaeger, Email: jochen.jaeger@concordia.ca; Tel.: (+1) 514 - 848-2424 extension 5481.

ANNEX E

Illustration Explaining Effective Impervious Area

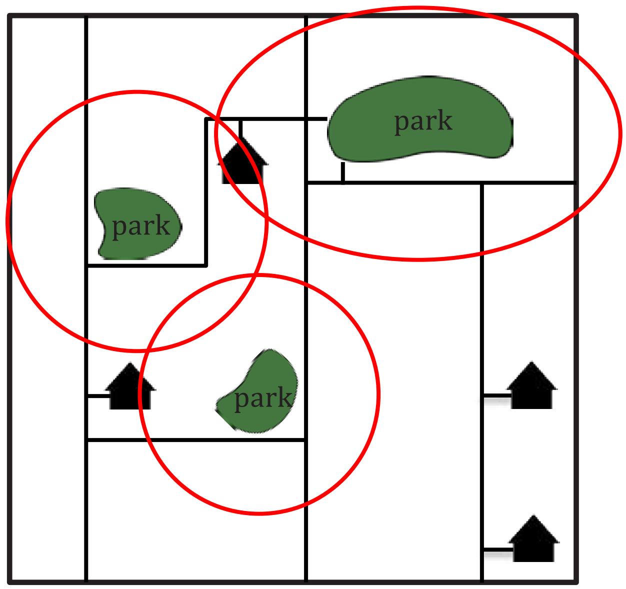
Indicator 10: Regulation of Quantity of Water



ANNEX F

Guide to Measuring Proximity and Accessibility

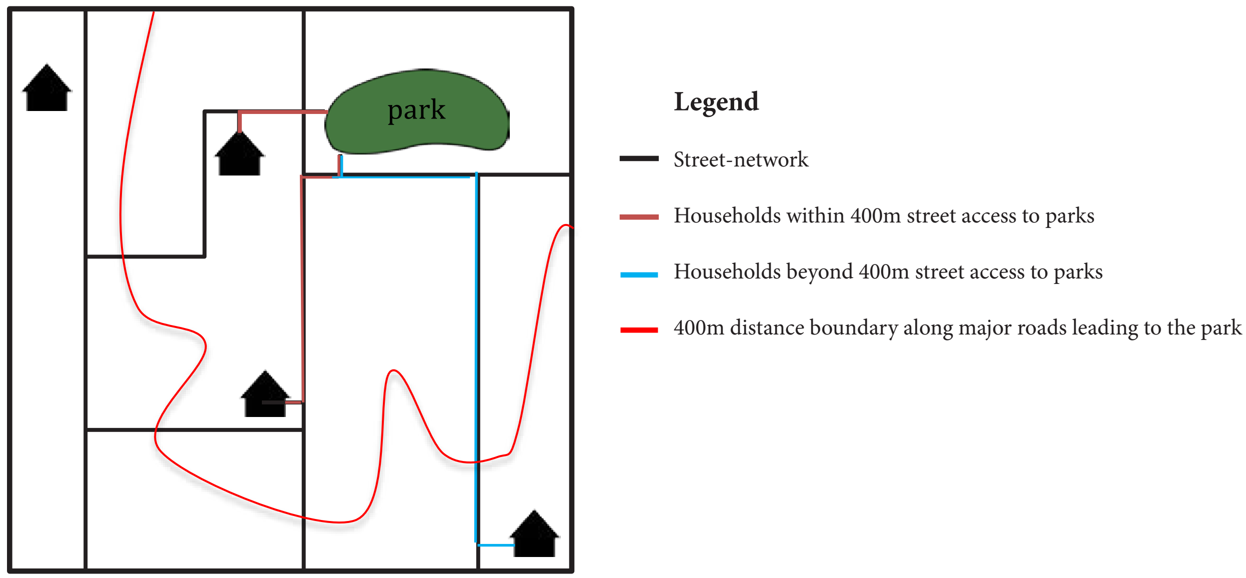
<u>Indicator 13a: Health and Wellbeing – Proximity to Parks</u>



Note: There is no need to have street network layer for calculation of household proximity to parks

1. Parks in the locale are mapped out using ArcGIS.
2. A 400m area buffer is be applied to each of the parks, represented by the red oblongs.
3. If any part of a household polygon falls within the 400m area buffer of the parks, the corresponding household will be counted as one that falls within 400m proximity to a park.
4. Proximity for indicator 13a is calculated by taking the number of households that fall within 400m proximity to a park against the total number of households in the city.
5. In this simple illustration, park accessibility is calculated to be 50.0% (2 of the 4 households are within 400m proximity to a park).

Indicator 13b: Health and Wellbeing – Accessibility to Parks

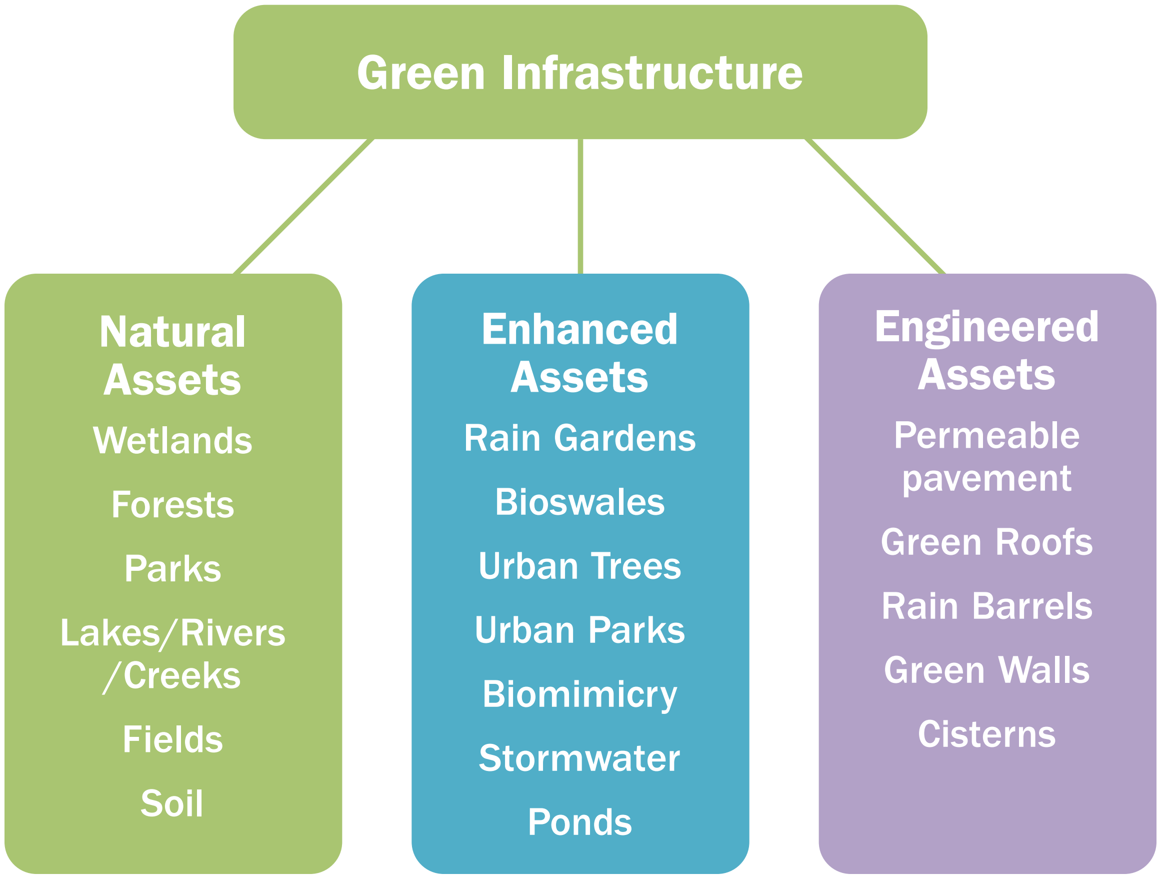


1. The illustration above represents an identified section of a neighbourhood with a single park.
2. The street network and parks located in the neighbourhood are mapped out on ArcGIS.
3. A 400m distance boundary is generated along major roads leading to the park, such that any household within this boundary is within 400m walking distance of the park
4. Accessibility for indicator 13b is calculated by taking the number of households that fall within the 400m street access to a park buffer area against the total number of households.
5. In this simple illustration, park accessibility is calculated to be 50.0% (2 of the 4 households are within 400m street access to a park).

ANNEX G

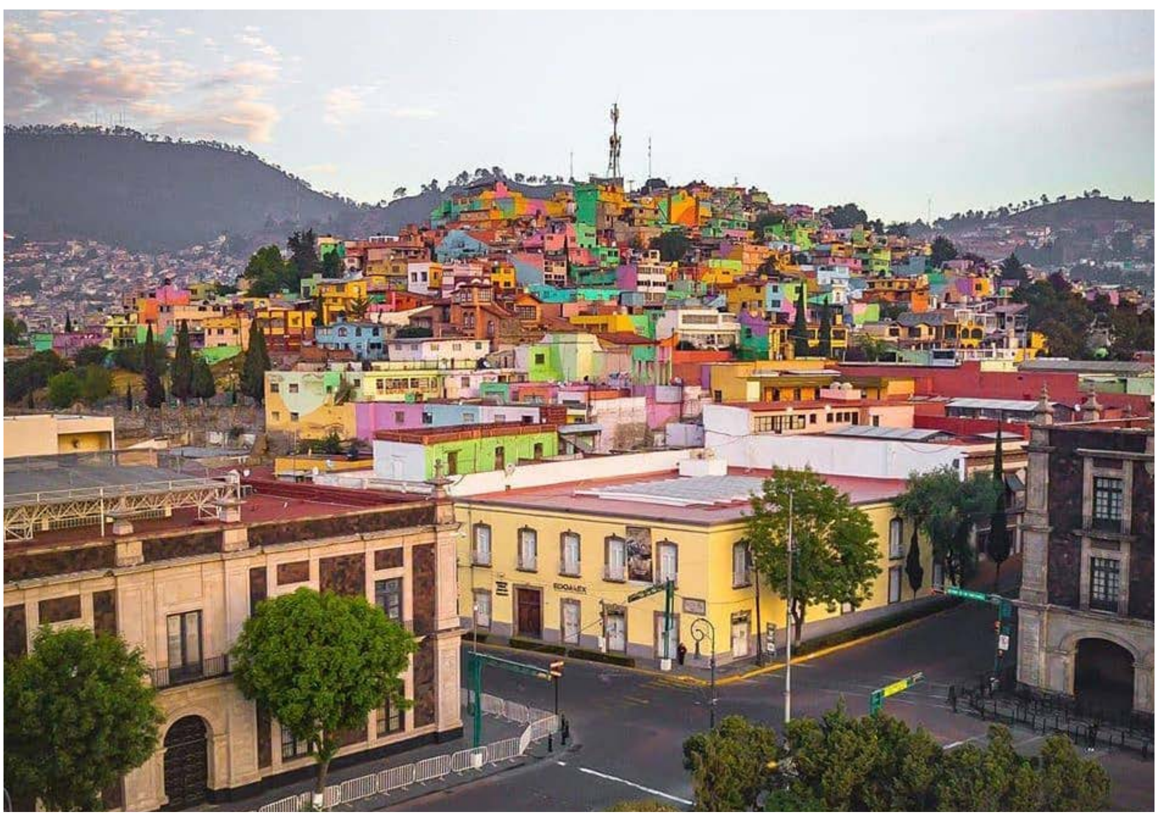
Examples of Green Infrastructure

Indicator 21: Policy and/or Incentives for Green Infrastructure as Nature-based Solutions



Elements of Green Infrastructure. Enhanced assets are generally those assets which have been designed to act like natural assets, whereas engineered assets are generally those which have been designed to function like natural assets but are new designs not found in nature.
—Ogden et al. (2019)

An aerial view of the closed canopy of the lowland dipterocarp forest in the Bukit Timah Nature Reserve which is surrounded by nature parks buffering it from residential areas in Singapore. © National Parks Board



The traditional colourful neighbourhoods of Toluca, Mexico, are interspersed with greenery. © Gonzalo Padilla Aguilar

ANNEX H

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A naturalised restored stream that used to be a concrete drain rans through the Bishan-Ang Mo Kio Park. As a drain, it used to serve the sole function of flood control but with the restoration of this section of the Kallang River, this freshwater ecosystem now provides numerous ecosystem services like drought amelioration, flood mitigation, recreation, education, biodiversity conservation, etc. This popular park in Singapore is home to otters, over 100 species of birds, 40 species of dragonflies and damselflies, more than 50 species of butterflies and moths, more than 10 species of native riverine plants, etc. © National Parks Board

Brilliant colours light up the skyline of the city of Edmonton, Canada. © City of Edmonton

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