CORPORATE KNIGHTS

SUSTAINABLE CITIES INDEX REPORT

2023

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Report authors:
Ralph Torrie
Nadia Morson, PhD

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INTRODUCTION

In the last year, there were 10 extreme weather events that caused billions of dollars in damage each, impacted millions of people, displaced thousands, and killed dozens.[1] These events included, but were not limited to, severe droughts in Europe, China, and Brazil, torrential floodings in China, East Australia, Pakistan and South Africa, and devastating hurricanes in the Caribbean, Canada, and the United States. It is estimated that 4.3 billion people live in urban areas[2] which are often located near coastlines, rivers, and floodplains, and are exposed to the impacts of climate change.[3] Unfortunately, the poorest and most marginalized populations are disproportionately affected by climate change and do not have the financial resources to mitigate risk or build resilience to increasingly frequent and severe climate disasters. The sustainable development of urban areas in planning, design, and investment in mitigation of climate change impacts is imperative to the well-being of billions of urban dwellers worldwide.

Corporate Knights publishes a quantitative, indictors-based index to assess the sustainable development of global cities. The index focuses on the environmental aspects of sustainability and has newly introduced the Corporate Knights Socio-Economic Adjustment Factor (CKSEAF) to account for socio-economic differences that impact the sustainability of environmental factors. The Sustainable Cities Index is outcome-focused, with 11 of its 12 indicators consisting of physical measurements of particulate air pollution, access to and consumption of potable water, waste generation, automobile dependence and road density, transit and active transportation mode shares, open space, both local and consumption-based greenhouse gas emissions, and resilience to climate change impacts. The 12th indicator is policy-focused and covers a city's commitments to renewable energy, reduced greenhouse gas emissions, and clean transportation. For a detailed description of the selection and methodology behind each indicator, please see Appendix A. This edition of the index covers 20 new cities, for a total universe of 70 cities (see Figure 1), including the most populous cities of the world as well as several mid-sized cities with established reputations for sustainability leadership. A unique feature of the Corporate Knights Sustainable Cities Index is an online data hub; city officials are invited to add their cities to the index by registering on the hub and providing a short list of key data points by visiting data.corporateknights.com.

As with all Corporate Knights rating and ranking systems, the following design principles have been applied in the development of the Sustainable Cities Index:

- **Relevance:** The index and ranking are meant to be representative of sustainable cities in the current context.
- **Transparency:** The precise methodology of ranking and results of the process are fully disclosed.
- **Objectivity:** Cities are assessed using quantitative data and performance indicators.
- **Public data:** The ranking relies primarily on data points that are in the public domain and mostly accessible from free databases.
- **Comparability:** Cities are compared on the same indicators.
- **Engagement:** Cities selected for the inaugural ranking were informed prior to publication and invited to review data.
- **Stakeholders:** Stakeholder feedback is actively solicited throughout the project.

(1) World Economic Forum (2022). "10 costliest climate disasters of 2022." Retrieved from weforum.org/agenda/2023/

(2) Ritchie, H. & Roser, M. (2018). "Urbanization." Retrieved from ourworldindata.org/urbanization.

(3) Kacyira, A. K. (2022). "Addressing the sustainable urbanization challenge." Retrieved from un.org/en/chronicle/article/.

Canada

1. Calgary
2. Edmonton
3. Halifax
4. London, ON New
5. Montréal
6. Ottawa
7. Saskatoon New
8. Toronto
9. Vancouver
10. Winnipeg New

United States

11. Boston New
12. Chicago
13. Houston
14. Los Angeles
15. Minneapolis
16. New York City
17. Philadelphia New
18. San Francisco
19. Seattle
20. Washington, D.C.

Central & South America

21. Arequipa New
22. Belen New
23. Bogotá
24. Buenos Aires
25. Curitiba
26. Medellín
27. Mexico City
28. Providencia New
29. Rio de Janeiro
30. São Paulo

Europe

31. Amsterdam New
32. Berlin
33. Copenhagen
34. Istanbul
35. Lahti
36. London
37. Madrid
38. Oslo
39. Paris
40. Stockholm

China & Taiwan

41. Beijing
42. Hong Kong New
43. Hsinchu New
44. Guangzhou
45. Pingtung New
46. Shanghai
47. Shenzhen
48. Taichung New
49. Taipei New
50. Tianjin

Africa

51. Abidjan New
52. Accra
53. Cape Town
54. Dakar New
55. Dar es Salaam
56. Johannesburg
57. Lagos
58. Nairobi New
59. Yaounde New

Asia-Pacific

60. Auckland New
61. Canberra
62. Dhaka
63. Dubai New
64. Quezon City New
65. Karachi New
66. Mumbai
67. Singapore
68. Seoul
69. Sydney
70. Tokyo

Figure 1. Map of 50 cities in the inaugural 2022 Sustainable Cities Index. Cities are grouped into 7 regions.

THE INDICATORS AND SOCIO-ECONOMIC ADJUSTMENT

Each year, the index is reviewed and revised or augmented, based on feedback from participating cities. The review of social, governance, and economic aspects of urban sustainability led to the conclusion that these factors are deeply connected to environmental metrics. For the 2023 index, we have created the Corporate Knights Socio-Economic Adjustment Factor (CKSEAF) to understand and compare environmental performance indicators and the underlying social and economic dimensions of sustainability. For example, indicators such as per capita greenhouse gas emissions or per capita water consumption will be low in higher income countries and cities if water conservation and efficiency are priorities, but they will also be low in lower income countries and cities because of poverty and limited access to fuels, electricity, and potable water. The CKSEAF discounts ten environmental indicator scores to the extent they coincide with unsustainable social and economic conditions. Further information on CKSEAF can be found in Appendix B.

Engaging with participating cities is a core design principle for the Corporate Knights Sustainable Cities Index, and suggestions and feedback are encouraged on both the present set of environmental indicators and for possible future improvements to the index.

DATA COLLECTION AND METHODOLOGY

Data for each of the 12 indicators was collected from the most credible international sources, including CDP Cities,[4] the World Bank,[5] and the UN-Habitat Urban Indicators Database,[6] among others. All 70 cities included in the Sustainable Cities Index were contacted to review and revise any data collected from these external databases with data from internal databases – in some cases with data that is not publicly available. The initial research to populate the index has resulted in a database of more than 600 data points; the ranges of values and outliers for each of the 12 indicators are illustrated in Figure 2. City officials around the world are invited to log on to the Corporate Knights Data Hub at data.corporateknights.com and submit 15 data points to be included in the cities universe for analysis and to receive sustainability scorecards for their cities

The Sustainable Cities Index currently evaluates city boundaries as reported by cities to the CDP Open Data Portal,[7] resulting in most cities selected being core urban communities, which have different sustainability profiles than their corresponding metropolitan regions. As data availability improves, urban agglomerations will be added to the index, and representatives of metropolitan governments are encouraged to visit the Corporate Knights Data Hub and add their cities to the index to achieve this objective.[8]

For each indicator, cities are scored out of 1.0 relative to the best sustainability outcome for each indicator among the 70 cities in the index. For environmental indicators, 10 of 12 total indicators, the city's scores are then multiplied by the CKSEAF. The CKSEAF-adjusted scores for each indicator are illustrated in Figure 5 and Figure 6, plotted against national per capita GDP purchasing power parity (PPP) of the countries in which the cities are located.

Percentile ranking was applied to indicator data to score each city based on the relative best practice for that indicator. Further, letter grades were assigned to scores for easy comparison between indicators and cities. The method for converting the indicator data points to scores and letter grades, and for weighting the different indicators to generate the overall letter grade for each city, is described in detail in a companion report available on the Corporate Knights website.

(4) CDP Cities (2022). Retrieved from cdp.net/en/cities.

(5) World Bank Data Indicators (2023). Retrieved from data.worldbank.org/indicator.

(6) UN Habitat Urban Indicators Database (2023). Retrieved from data.unhabitat.org.

(7) CDP Open Data Portal (2022). Retrieved from data.cdp.net.

(8) Corporate Knights Data Hub (2023). Retrieved from data.corporateknights.com.

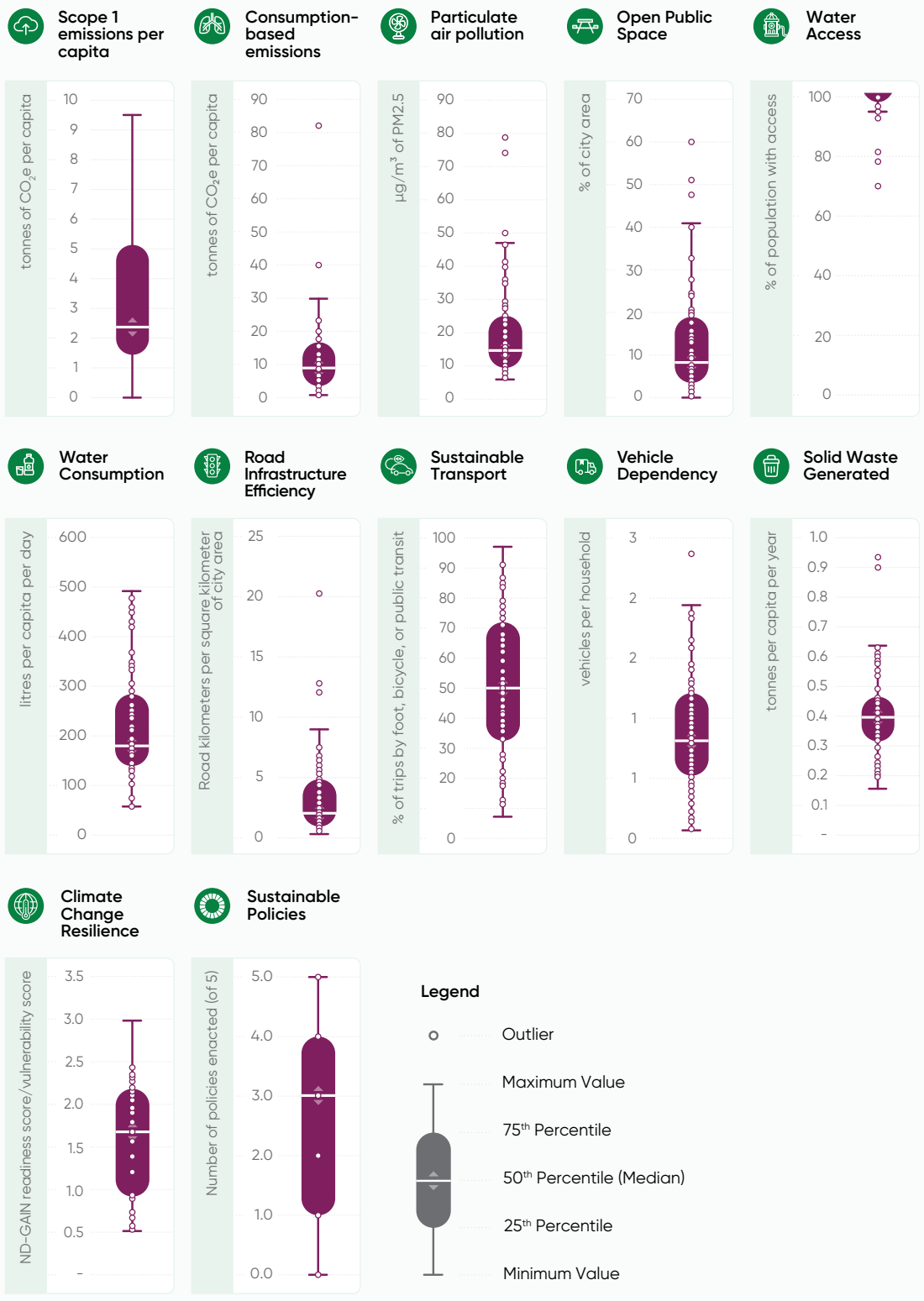

Figure 2. The distribution of data obtained for each indicator for the 70 cities in the initial release of the Corporate Knights Sustainable Cities database.

RESULTS OF THE 2023 SUSTAINABLE CITIES INDEX

Table A. 2023 Corporate Knights Sustainable Cities Index results.

2023 Rank	2022 Rank	City	Country	Region	Population	Overall Score
1	1	**Stockholm**	Sweden	Europe	1,679,000	A+
2	2	Oslo	Norway	Europe	699,027	A
3	3	Copenhagen	Denmark	Europe	644,425	A
4	4	Lahti	Finland	Europe	120,093	A
5	5	London	United Kingdom	Europe	8,982,000	A
6	New	**Auckland**	New Zealand	Asia-Pacific	1,680,500	A
7	26	Sydney	Australia	Asia-Pacific	214,851	A
8	10	Berlin	Germany	Europe	3,677,472	A
9	New	**Winnipeg**	Canada	Canada	778,489	A
10	8	Vancouver	Canada	Canada	662,248	A
11	18	Halifax	Canada	Canada	460,274	A
12	7	Tokyo	Japan	Asia-Pacific	14,016,946	A
13	9	Madrid	Spain	Europe	3,305,408	B
14	20	Montreal	Canada	Canada	2,069,849	B
15	11	Toronto	Canada	Canada	2,794,356	B
16	17	Paris	France	Europe	2,210,875	B
17	23	Calgary	Canada	Canada	1,306,784	B
18	25	Seoul	Korea	Asia-Pacific	9,736,027	B
19	13	Ottawa	Canada	Canada	1,046,440	B
20	21	Edmonton	Canada	Canada	1,321,255	B
21	16	**San Francisco**	United States	United States	873,965	B
22	New	Boston	United States	United States	654,776	B
23	New	**Taipei**	Taiwan*	China & Taiwan	2,683,257	B
24	19	New York City	United States	United States	8,804,190	B
25	New	Amsterdam	Netherlands	Europe	903,399	B
26	New	Taichung	Taiwan	China & Taiwan	2,787,070	B
27	New	**Arequipa**	Peru	Central & South America	1,008,290	B
28	39	Minneapolis	United States	United States	429,954	B
29	New	London, ON	Canada	Canada	494,069	B
30	35	Canberra	Australia	Asia-Pacific	453,324	B
31	22	Washington	United States	United States	690,093	B

32	29	Los Angeles	United States	United States	3,819,538	B
33	New	Philadelphia	United States	United States	1,576,251	B
34	33	Shenzhen	China	China & Taiwan	11,908,000	C
35	32	Seattle	United States	United States	737,015	C
36	40	Houston	United States	United States	2,304,580	C
37	34	Buenos Aires	Argentina	Central & South America	3,078,836	C
38	New	Hong Kong	China	China & Taiwan	7,413,100	C
39	New	Pingtung	Taiwan	China & Taiwan	829,939	C
40	41	Chicago	United States	United States	2,746,388	C
41	30	Mexico City	Mexico	Central & South America	9,041,395	C
42	46	Istanbul	Turkey	Europe	15,840,900	C
43	15	Curitiba	Brazil	Central & South America	1,871,789	C
44	27	Medellín	Colombia	Central & South America	2,612,958	C
45	New	Saskatoon	Canada	Canada	282,900	C
46	New	Quezon City	Philippines	Asia-Pacific	2,960,048	C
47	New	Providencia	Chile	Central & South America	120,079	C
48	44	Singapore	Singapore	Asia-Pacific	5,453,566	C
49	New	Belén	Costa Rica	Central & South America	24,000	C
50	31	Beijing	China	China & Taiwan	18,590,000	C
51	48	Guangzhou	China	China & Taiwan	15,305,900	C
52	24	Rio de Janeiro	Brazil	Central & South America	6,775,561	C
53	12	**Cape Town**	South Africa	Africa	4,678,900	C
54	36	Bogotá	Colombia	Central & South America	7,181,469	C
55	42	São Paulo	Brazil	Central & South America	12,330,000	C
56	49	Shanghai	China	China & Taiwan	24,153,000	C
57	New	Abidjan	Côte d'Ivoire	Africa	6,110,642	C
58	50	Tianjin	China	China & Taiwan	12,784,000	C
59	14	Accra	Ghana	Africa	2,036,889	D
60	New	Nairobi	Kenya	Africa	4,500,000	D
61	47	Johannesburg	South Africa	Africa	6,020,000	D
62	New	Hsinchu	Taiwan	China & Taiwan	552,169	D
63	37	Dhaka	Bangladesh	Asia-Pacific	10,278,000	D
64	New	Dubai	United Arab Emirates	Asia-Pacific	3,478,300	D
65	45	Mumbai	India	Asia-Pacific	12,875,213	D
66	New	Yaoundé	Cameroon	Africa	2,766,000	D
67	New	Dakar	Senegal	Africa	1,438,725	D
68	38	Lagos	Nigeria	Africa	24,600,000	D
69	43	Dar es Salaam	Tanzania	Africa	6,400,000	D
70	New	Karachi	Pakistan	Asia-Pacific	16,024,894	D

*Taiwan is not recognized as a country by the United Nations.

Overall ranking

The highest-scoring city on the 2023 Sustainable Cities Index ranking is Stockholm, followed by Oslo, Copenhagen, Lahti, and London (Table A), which is the same top five as last year's index despite the addition of 20 new cities and the incorporation of CKSEAF. New to this year's index is Auckland, New Zealand, ranked sixth overall and first among cities in Asia-Pacific, followed closely by Sydney, Australia, in seventh. The top city in Canada is the new addition of Winnipeg, then Vancouver and Halifax, ranking ninth, 10th, and 11th, respectively. As last year's index showed, Canadian cities are sustainability leaders when compared to their American neighbours, where San Francisco was the top-ranking American city, at 21, and Boston, a new addition to the index, at 22. The best-performing city in Central and South America is another new addition: Arequipa, Peru, in 27th. The highest-scoring city in Africa was Cape Town, South Africa, ranking 53rd overall. New to this year's index are four Taiwanese cities, with Taipei and Taichung topping the China and Taiwan group, at 23rd and 26th, respectively.

Figure 3. Sustainable Cities Index rank vs. population.

As illustrated in Figure 3, cities with smaller populations generally score higher than more populous cities in the Corporate Knights Sustainable Cities Index, and some of the most populous cities are among the lowest-ranking, including São Paulo in Brazil, Lagos in Nigeria, and Shanghai in China (Table A). However, London (population eight million) and Tokyo (13 million) rank in the top 12, illustrating that megacities can achieve high sustainability performance. London and Tokyo both score well in indicators such as particulate air pollution, sustainable transport modes, water access, and renewable energy policy.

The goal of introducing the CKSEAF was to capture socio-economic differences in cities. By indexing GDP per capita, the Gini index (a metric of unequal income distribution), and the Human Development Index (HDI), the CKSEAF allowed us to discount environmental indicator scores to the extent they coincide with unsustainable social and economic conditions. Cities in Africa, Central and South America, and Asia-Pacific were most affected by CKSEAF, reflecting the high socio-economic disparities in these regions. The majority (53%) of cities included in the 2023 Sustainable Cities Index are in high-income countries and the remainder (47%) are in middle-income countries. Despite the near even split, most (88%) of the top 35 cities on the index are in high-income countries, and most (83%) of the bottom half of cities in middle-income countries. Income disparity impacts sustainability performance which is evident through performance on the climate change resilience indicator and others. Climate change will exacerbate low access

to safe drinking water, force migration due to land loss in coastal regions, increase food security risks, and negatively affect human health.[9] It is imperative to reduce global poverty while concurrently strengthening the capacity of those living in poverty to adapt to climate change.

Regional rankings

Cities in Europe are among the highest performers in the 2023 Sustainable Cities Index, with eight in the top 20, and the top four all in Scandinavian countries. European cities received top scores for particulate air pollution, sustainable transport, water consumption, sustainable policies, and climate change resilience.

Canadian cities are the next highest-scoring group, with Winnipeg, a new addition to the city universe, landing the top spot in the group. Canadian cities score well on the particulate air pollution and sustainable policies indicators but have room for improvement on the indicators for greenhouse gas emissions and sustainable transportation.

Cities in the Asia-Pacific group are the third-highest performers in the index, with another new addition, Auckland, in the top group spot. This group is largely represented by cities in high-income countries like New Zealand, Australia, Korea, Japan, United Arab Emirates, and Singapore. The smaller fraction of this group consists of cities in lower- to middle-income countries like the Philippines, Bangladesh, India, and Pakistan. As a result of the income distribution in this group, CKSEAF-adjusted scores have further spread the final ranking of cities. Despite their differences, cities in this group earn high scores in GHG emissions indicators, sustainable transport, and sustainable policies.

American cities exhibit average sustainability performance when compared to cities in other regions. Among the top performers are San Francisco, Boston, New York City, and Minneapolis, all ranking in the top half of the index. American cities score well in sustainable policies, which will hopefully lead to improved environmental outcomes.

The China and Taiwan group, previously just represented by Chinese cities, now includes four Taiwanese cities: Taipei, Taichung, Pingtung, and Hsinchu. Taipei and Taichung are the top-scoring cities of the group, earning high scores in GHG emissions, sustainable transport, and sustainable policies. Taiwanese cities generally rank higher than Chinese cities.

The cities most affected by the application of the CKSEAF are in Central and South America. Arequipa is a new addition to the 2023 universe and tops its group with high scores in consumption-based emissions. Urban sustainability leaders like Buenos Aires and Curitiba earn top scores for enacting the most sustainable policies. However, income disparities and low per capita GDP result in lower scores on environmental performance, reflecting the reality that social and economic factors play a key role in sustainability.

The final group consists of African cities, where Cape Town captures the top spot. Again, cities in Africa are among the most affected by the incorporation of CKSEAF: income inequality and low per capita GDP reflect unsustainable conditions. Despite these challenges, African cities stand out as the lowest producers of GHG emissions in the index, in part due to socio-economic challenges, but also because of a low-consumption lifestyle. Cape Town also stands out as a leader of sustainable policies among its African cohorts.

(9) OECD (2002). "Poverty and Climate Change." Retrieved from oecd.org/env/cc/2502872.pdf.

Indicator rankings

GREENHOUSE GAS EMISSIONS

For both Scope 1 GHG emissions per capita and consumption-based emissions per capita, the cities in high-income countries score poorly, reflecting high levels of direct emissions (large homes, large vehicles) and high levels of consumption-based emissions that have historically been associated with high levels of income. For example, even after the CKSEAF adjustment, cities like Chicago (6.4 tonnes of carbon dioxide equivalent, or CO_2e, per capita), Edmonton (7.1 tonnes CO_2e per capita), and Shanghai (9.0 tonnes CO_2e per capita) score quite low for Scope 1 emissions per capita. On the other hand, cities like Abidjan in Cote d'Ivoire and Yaoundé in Cameroon, which have 0.7 tonnes CO_2e per capita Scope 1 GHG emissions, score quite well, even after the CKSEAF adjustment. South American cities Arequipa, Peru, and Belén, Costa Rica, are among the highest-scoring cities for consumption-based GHG emissions per capita (3 and 3.4 tonnes CO_2e per capita, respectively), and Australian cities Canberra and Sydney are among the lowest, with consumption-based emissions over 20 tonnes CO_2e per capita.

The average distribution of sources of consumption-based GHG emissions for the cities in the index is illustrated in Figure 4, a pattern that is similar to those found in other analyses of consumption-based emissions in cities.[10] Roughly half of urban consumption-based GHG emissions in cities originate in the nation's domestic economy (including in the city itself), with the remainder split between emissions embodied in goods imported from other countries and emissions resulting from the fuel and electricity use and waste generation of households and personal transportation within the city. However, compared to last year's analysis, we noticed that the COVID-19 pandemic had an impact on consumption behaviours. Compared to 2019, the consumption-based emissions decreased as did global emissions. Additionally, the portion from the nation's domestic economy increased 2% (from 55 to 57%), and the consumption of international goods decreased 3% (from 22 to 19%). As international trade slowed, urban residents relied more heavily on their domestic economy than previous years.

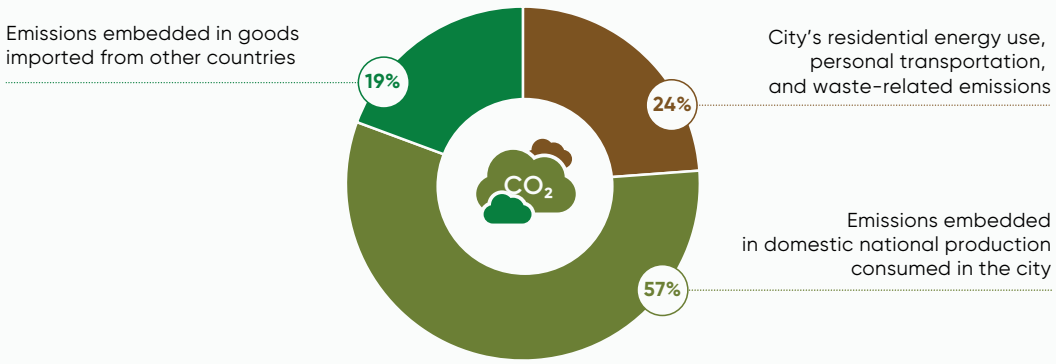

Figure 6. Origin of consumption-based emissions for cities in the Corporate Knights Sustainable Cities Index (for details of method, see corporateknights.com/2023-Sustainable-Cities-Methodology)

(10) C40 (2018). "Consumption-based GHG emissions of C40 cities." Retrieved from c40knowledgehub.org/s/article/Consumption-based-GHG-emissions-of-C40-cities?language=en_US

Figure 5. Distribution of indicator scores vs. GDP per capita

Figure 6. Distribution of indicator scores vs. GDP per capita.

PARTICULATE AIR POLLUTION

The World Health Organization guideline of five micrometres per cubic metre is adopted as the benchmark in the Corporate Knights Sustainable Cities Index, which is more stringent than last year's 10 micrometres per cubic metre, the previously recommended minimum.[11] The only region with consistently acceptable air quality is Canada. Cities in Asia and Oceania – especially Dhaka, Bangladesh, and cities in China – have the poorest air quality, which causes negative health effects on inhabitants of those cities. In addition to its use in power generation, coal burned directly for cooking, heating, and industrial applications is a significant contributor to urban air pollution, as is wood and biomass combustion. Diesel engines are another significant source of small particle pollution. Reducing the use of or mitigating the emissions from coal, diesel, and biomass combustion is one of the most effective measures for improving urban air quality. Forest fires are an additional contributor to negative air quality, and are often a result of climate change, and result in lower air quality in cities such as Canberra, Australia.[12] Further, top-scoring cities like Winnipeg and Vancouver can expect challenges to their currently low particulate air pollution as forest fires in western Canada become more frequent and more severe as climate change impacts continue to intensify.

OPEN PUBLIC SPACE

To achieve UN Sustainable Development Goal 11, "sustainable cities and communities," a minimum of 45% of city area that is considered open public space is recommended.[13] While very few cities in the 2023 Sustainable Cities Index approach this target, Taiwanese cities Taichung (60%), Pingtung (51%), and Hsinchu (51%) were the highest-scoring for open public space. Increasing the percentage of open space is an opportunity for improvement for many cities.

TRANSPORTATION AND MOBILITY ACCESS

American cities like Los Angeles and Houston are heavily dependent on vehicles and road infrastructure for personal transportation, with few trips by sustainable transport modes such as walking, cycling, or public transit. The opposite is true of many cities in the Global South, such as Quezon City in the Philippines, Singapore, and Medellín in Colombia, whose residents have lower vehicle dependence and take more trips using sustainable modes of transport.

The three transportation indicators included in the Corporate Knights Sustainable Cities Index (road infrastructure efficiency, sustainable transport, vehicle dependence) together provide powerful insight into the extent to which urban form, transportation infrastructure, and residents' motivations and behaviour contribute to the overall sustainability performance of the city. North American cities are the worst-performing in the index on these three transportation indicators. Sustainable transportation modes such as trips by foot, bicycle or on public transit are 75% or greater in ten cities across Africa, China and Taiwan, Asia-Pacific, Europe, and Central and South America, comparable to the City of Copenhagen's target level at 70%.[14]

(11) World Health Organization (2022). "WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide." Retrieved from apps.who.int/iris/handle/10665/345329.

(12) In 2019, wildfires resulted in high levels of PM2.5 pollution over Canberra, and this had a negative effect on the city's air quality score.

(13) Deloitte (2021). "Green planning of public spaces." Retrieved from www2.deloitte.com/global/en/pages/public-sector/articles/urban-future-with-a-purpose/green-planning-of-public-spaces.html.

(14) Copenhagen Urban Development (2022). "Mobility – How we get around in the city." Retrieved from

Regarding vehicle dependence, cities in Canada, the United States, and some cities in Central and South America are highly dependent on personal vehicles for transportation, with more than one vehicle per household. Over the entire group of cities in the index, only 60% have fewer than one vehicle per household, which is less than last year's analysis, and more than 18% of cities have 0.5 vehicles per household or fewer, down from last year. Leadership for this indicator is demonstrated by cities like Madrid, Hong Kong, and Singapore, which have fewer than 0.5 vehicles per household.

Road infrastructure efficiency, measured as road density, is an indicator of sustainable development and design of the city for road transportation. Once again, cities in Canada and the United States have the highest road density, whereas cities in China and Taiwan (Guangzhou, Pingtung, Beijing, Shenzhen, Tianjin, and Shanghai) and Europe (Lahti, Oslo, Copenhagen, and Istanbul) have highly efficient road infrastructure, with road densities less than one kilometre per square kilometre.

WATER AND WASTE

Indicators for water consumption and potable water access reveal that in Canadian and American cities the average consumption of water is 305 litres per capita per day. Some cities in high-income countries – Copenhagen, Berlin, and Lahti – have been very successful in reducing per capita water consumption to less than 120 litres per day. In contrast, several cities in Africa are consuming less than 100 litres of water per capita, which is often indicative of water shortages or challenges in water supply and is unsustainable. Further challenging the sustainability of water resources, some residents of these African cities have no access to potable water. The city of Dhaka in Bangladesh has the lowest percentage of population with access to potable drinking water, at only 69% – which means that 3,720,000 of the city's residents lack access to a safe water source.

The amount of solid waste generated varied over a wide range of cities in the index because it is largely influenced by the local municipal management of waste, including recycling and composting programs. High-performing cities include three in Canada: London, Ottawa, and Halifax, with less than 350 kilograms generated per capita per year. Low-performing cities include Washington, D.C., Singapore, and Dubai at the bottom, with 900 kilograms generated per capita per year.

SUSTAINABLE POLICIES

To achieve the transition to fossil-fuel-free cities, many cities around the world, including Vancouver, Sydney, and San Francisco, have adopted 100% renewable energy targets. This ambitious goal requires supporting policy to achieve step-wise progress toward 100% renewable-energy-powered cities with net-zero GHG emissions and electric vehicles. Twenty percent of the 2023 city universe have enacted all five policies for (i) renewable energy target, (ii) electric vehicle target, (iii) emission reduction target, (iv) net-zero GHG target, and (v) renewable energy enabling policy. Leading cities for this indicator include Taipei, Curitiba, Sydney, Seoul, Pingtung, Berlin, London (U.K.), Toronto, Quezon City, Vancouver, Montreal, Buenos Aires, Calgary, and Canberra. Another 23% of cities have four of the five, totalling 30 of 70 cities that have policies in place to achieve a decarbonized future.

urbandevelopmentcph.kk.dk/node/13#:~:text=Copenhagen%20has%20a%20goal%2C%20that,metro%20and%20better%20traffic%20management.

CLIMATE CHANGE RESILIENCE

Climate change resilience, an indicator that reflects both vulnerability to and readiness to adapt to climate change, is highest for Oslo, Norway. A very high score indicates that the country has low vulnerability to climate change impacts and is highly adaptable in the case that climate change disasters affect inhabitants. It is no surprise that the lowest-scoring cities are in countries in Africa, Central and South America, and Asia and Oceania, which are both geographically vulnerable to severe climate impacts and often face economic challenges in adapting to and coping with climate disasters when they do occur.

TARGETS FOR CITY SUSTAINABILITY PERFORMANCE

The Corporate Knights Sustainable Cities Index ranks cities based on their performance relative to other cities in the index. Through the Sustainable Cities Index, we collect a globally representative sample of city sustainability data that enables us to identify urban sustainability performance targets. In Table B, we identify targets for what would constitute exemplary performance for each of the 12 indicators. The targets are determined with reference to the best-performing cities on each indicator in the Corporate Knights Sustainability Index and on the sustainability literature.

In the case of indicators of greenhouse gas emissions, the target is set to zero, reflecting the need to eliminate GHG emissions to avoid catastrophic climate change impacts. Stockholm has the lowest Scope 1 GHG emissions per capita – 0.83 tonnes CO_2e – but its total GHG footprint, as represented by its consumption-based emissions, is 9 tonnes CO_2e per capita. Consumption-based emissions are the best indicator of per capita GHG emissions and the best basis for comparison between cities. Of the 70 cities in the 2023 Corporate Knights Sustainable Cities Index, consumption-based inventories have an average of 12 tonnes CO_2e per capita, with cities in high-income countries averaging 17 tonnes CO_2e per capita and cities in middle-income countries averaging 6.5 tonnes CO_2e per capita. It is important to note that these statistics are identical to the consumption emission behaviours of high- and middle-income cities in the 2022 index. Behaviour patterns are difficult to break; for a quantifiable decrease in consumption-based emissions, major shifts must occur in attitudes and behaviours of consumption around the world. However, there are clear differences in the scale of consumption-based emissions and where the majority of behavioural changes must originate, which is in the high-income cities that currently consume more than twice as much as middle-income cities.

Table B. Ideal benchmark values for indicators in Sustainable Cities Index.

Sustainable Cities Index Indicator	Target	Units	Average for cities in high-income countries	Average for cities in low-income countries
Scope 1 GHG Emissions	0	tonnes CO_2e/capita	4.5	2.3
Consumption-Based Emissions	0	tonnes CO_2e/capita	17.1	6.4
Particulate air pollution (PM2.5)	< 5	µg/m^3	10.5	27.8
Open Public Space	45	%	12	14.5
Water Access	100	%	100	95
Water Consumption	100-150	litres/capita/day	254	182
Road Infrastructure Efficiency	< 1	km/km^2	3.9	2.2
Sustainable Transport Mode Share	75	%	42	60
Automobile Dependence	< 1	vehicles/household	1.0	0.7
Solid Waste Generated	< 0.3	tonnes/capita/year	0.44	0.37
Climate Change Resilience	> 3	ratio	2.1	1.0
Renewable Energy Policy	5	/5	3.7	2.2

CONCLUSION

The 2023 Corporate Knights Sustainable Cities Index highlights that the perfect city does not exist. There are instances of exemplary sustainability performance among mid-sized cities and megacities, in the Global North and Global South, in middle-income and high-income countries. Any city, regardless of size or location, can improve its sustainability performance by looking to and learning from the policies and practices of the leaders on the sustainability indicators in this index.

The Sustainable Cities Index is focused on outcomes, and it is our goal that the annual trend analysis of city sustainability drives tangible and meaningful outcomes that improve the quality of life of inhabitants and reduce the impacts of climate change.

APPENDIX A: THE INDICATORS

It is possible to identify dozens, and even hundreds, of indicators of urban sustainability, but the Corporate Knights Sustainable Cities Index is designed to be accessible, robust, and streamlined. The following 12 indicators were selected because data are widely available for them and because they address the key dimensions of urban environmental sustainability.

1. Scope 1 greenhouse gas emissions per capita

Scope 1 greenhouse gas emissions occur within the city boundaries and consist primarily of the chimney, smokestack, and tailpipe emissions of greenhouse gases from fossil fuel combustion in buildings, vehicles, and industrial establishments. All else being equal, Scope 1 emissions will be higher in cities with larger buildings, bigger vehicles, and more energy-intensive industries but will be moderated in cities with high levels of energy efficiency or a high share of electricity in their energy end-use mix. Emissions from the generation of electricity are not included in the definition of Scope 1 emissions. Scope 1 emissions will also be higher in cities with significant use of coal because, compared with gas or oil, coal has a higher emission intensity and the technologies for burning coal are generally less efficient than those for burning oil or gas.

2. Consumption-based emissions per capita

Cities are concentrated areas of consumption of goods and services, and the greenhouse gas emissions associated with the production of those goods and services often occur outside the city boundaries, either elsewhere in the domestic economy or embedded in imports from other countries. Cities also export goods and services, and the emissions from that production, while included in the Scope 1 emissions as described above, are related to consumption that occurs outside the city. A consumption-based inventory of greenhouse gas emissions takes these factors into account by combining three categories of emissions: (1) emissions that are the direct result of final consumption in the city, primarily from residential energy use and personal transportation, (2) emissions that are "embedded" in food and other goods and services that are produced by the city and the domestic economy and consumed in the city, and (3) emissions that are embedded in goods and services that are imported from other countries and consumed in the city. The consumption-based emissions inventory therefore represents a complete picture of the greenhouse gas emissions associated with a city's production and consumption. For additional information on our methodology for estimating consumption-based emissions, visit corporateknights.com/resources/sustainable-cities-resources.

3. Particulate air pollution

The indicator of air pollution in this index is the annual average concentration of "PM2.5" in the city's air – the fine particulate matter (PM) that is equal to or less than 2.5 micrometres in diameter and that is the single biggest threat to human health; consistent exposure to PM2.5 pollution can cause death. To reduce the burden of disease from these breathable particles, the World Health Organization (WHO) has published guidelines that set limits at an annual average of less than 5 micrometres of PM2.5 per cubic metre of air.[15] This fine particulate pollution is formed during fuel

(15) World Health Organization (2021). "WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide." Retrieved from apps.who.int/iris/handle/10665/345329.

combustion (including from wildfires) and from chemical reactions in the atmosphere and can be distributed by strong winds into neighbouring cities and countries. Major sources include fuel combustion from motor vehicles, industrial processes, wood burning, and forest fires and other wildfires.[16]

4. Open public space

One of the indicators for measuring UN Sustainable Development Goal 11, titled "sustainable cities and communities," is a measure of open public space, which includes all city areas that are parks, recreation areas, greenways, and other areas accessible to the public. Open public spaces have multifactorial benefits on inhabitants and city sustainability performance. Open spaces benefit inhabitants mentally and physically through recreational activity, improved social interaction, and community cohesiveness.[17][18] In addition, open space reduces noise, provides shade and habitats for wildlife, reduces flooding, and reduces air pollution.[19][20][21] To improve performance on this indicator, cities can create more high-quality open public space by introducing native vegetative species to reduce irrigation needs and support indigenous wildlife.

5. Access to potable water

The percentage of the urban population with access to potable water is one of two indicators related to water in the Sustainable Cities Index. Access to safe water is an essential for life, whether it is used for drinking, domestic use, or food preparation. The United Nations Sustainable Development Goal target 6.1 calls for equitable and universal access to safe drinking water. Yet in 2020, two billion people did not have access to safe drinking water.

6. Water consumption per capita

Universal access to safe water is also tightly linked to efficient water consumption. High and extremely low levels of per capita water consumption are not sustainable. As the world becomes more urbanized, there will be a significant increase in the demand on cities for safely managed drinking water services, sanitation, and wastewater treatment.[22] The additional demand on water in urban areas can exacerbate competition for water and the depletion of aquifers and

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(16) Ontario Ministry of Environment, Conservation and Parks (2022). "Fine particulate matter." Retrieved from airqualityontario.com/science/pollutants/particulates.php#:~:text=PM2.5%20material%20is%20primarily,agricultural%20burning%20and%20forest%20fires.

(17) Sandifer, P. A., Sutton-Grier, A. E., & Ward, B.P. (2015). "Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation." *Ecosystem Services* 12, 1–15, doi: 10.1016/j.ecoser.2014.12.007.

(18) James, P., Banay, R. F., Hart, J. E., & Laden, F. (2015). "A review of the health benefits of greenness." *Current Epidemiology Reports* 2(2):131–142. doi: 10.1007/s40471-015-0043-7.

(19) Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). "Urban greening to cool towns and cities: A systematic review of the empirical evidence." *Landscape and Urban Planning*, 97(3), 147–155. doi: 10.1016/j.landurbplan.2010.05.006.

(20) Depietri, Y., Renaud, F.G., & Kallis, G. (2012). "Heat waves and floods in urban areas: A policy-oriented review of ecosystem services." *Sustainability Science* 7, 95–107. doi: 10.1007/s11625-011-0142-4.

(21) Nowak, D. J., Hirabayashi, S., Bodine, A., & Greenfield, E. (2014). "Tree and forest effects on air quality and human health in the United States." *Environmental Pollution*, 193, 119–129. doi: 10.1016/j.envpol.2014.05.028.

(22) World Health Organization (2022). "Drinking-water." Retrieved from who.int/news-room/fact-sheets/detail/drinking-water.

other water sources, all of which will create issues of water security.[23] It is of critical importance that inhabitants of urban areas have sufficient and readily accessible safe drinking water to support the basic requirements of life, but also that they are not over-consuming or wasting water.

7. Automobile ownership per household

The number of registered motor vehicles per household is the first of three indicators in the index that are related to the sustainability of access and personal mobility in the city. Socioeconomic and structural factors play a significant role in vehicle ownership and dependency in urban areas,[24] and the density of automobiles in a city correlates with several negative environmental outcomes, including air pollution, greenhouse gas emissions, noise, risks to pedestrians and cyclists, and unproductive land use for parking and road infrastructure. The registered vehicles included in this indicator are automobiles and light trucks and do not include the scooters, motorcycles, and other two- and three-wheeled vehicles that are predominant in many middle-income countries.

8. Road infrastructure efficiency

Road infrastructure efficiency is defined as the road density – the length of road per square kilometre of the city's area – and is intended to reflect the efficiency with which the population is served by the roadway network. All else being equal, cities with inefficient and ultimately unsustainable transportation systems are characterized by higher road densities that go along with sprawling land use and settlement patterns. Studies have shown that a larger road capacity leads to increased use of roads for personal transportation.[25]

9. Sustainable transport

The third transportation-related indicator in the Sustainable Cities Index captures the share of total trips made by public transit, walking, or cycling. The distinction between the number of trips and the amount of mobility (person-kilometres of travel, or PKT) is important in this regard. Most trips are short and amenable to active transportation modes, but most PKT happens in longer trips where automobiles predominate. This indicator considers the total number of trips made by sustainable modes and not the PKT of their mobility. The reduction of transportation-sector emissions requires changes in behaviours and substantial investment in sustainable transport modes, such as public transport, walking, and cycling. It also requires that cities be planned and built so that amenities are available to residents within walking and cycling distance, such as the "15-minute city" approach, which allows everyone in the neighbourhood to meet most of their daily needs within a short walk or bike ride of their home.

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(23) Romero-Lankao, P. & Gnatz, D. M. (2016). "Conceptualizing urban water security in an urbanizing world." *Current Opinion in Environmental Sustainability*, 21, 45–51. doi:10.1016/j.cosust.2016.11.002.

(24) Heinonen, J., Czepkiewicz, M., Árnadóttir, A., & Ottelin, J. (2021). "Drivers of car ownership in a car-oriented city: A mixed-method study." *Sustainability* 13(619), 1–26. doi: 10.3390/su13020619.

(25) Kenworthy, J. R. (2020). "Passenger transport energy use in ten Swedish cities: Understanding the differences through a comparative review." *Energies* 13(14), 3719. doi: 10.3390/en13143719.

10. Solid waste generated

There are many possible indicators related to the generation, management, and disposal of waste in cities, and many different types of waste. Urbanization and rapid population growth are expected to result in a 70% increase in annual waste from 2016 levels by 2050. In addition, operating and maintaining effective waste management systems in urban areas is costly – up to 50% of a municipal budget – but they provide an essential service.[26] There is no more effective way to reduce the environmental impact of waste than to reduce its generation in the first place, and the metric of choice for the waste sector in the Sustainable Cities Index is daily solid waste generated per capita.

11. Climate change resilience

The poorest and most marginalized populations are disproportionately vulnerable to climate risks and do not have the financial resources to mitigate their risk to climate disasters.[27] The Notre Dame Global Adaptation Initiative (ND-GAIN) produces a Country Index of national indicators of vulnerability to climate change and readiness to improve resilience to climate impacts. The ND-GAIN Country Index Technical Report provides targets and reference points for each indicator that contributes to the calculations of the national vulnerability and readiness scores. In the absence of a global database of urban vulnerability and readiness scores, we use the ND-GAIN national scores in the Sustainable Cities Index. The ND-GAIN vulnerability score assesses the propensity for negative impacts due to climate change on food, water, health, ecosystem services, human habitat, and infrastructure. The ND-GAIN readiness score assesses countries' economic, governance, and social readiness to make effective use of investments for adaptation actions.[28] The Sustainable Cities Index climate change resilience indicator is the ratio of the ND-GAIN readiness score to the vulnerability score, so the indicator is higher for cities with both high readiness and low vulnerability scores (e.g., Norway), and lower for cities with both low readiness and high vulnerability scores (e.g., Nigeria).

12. Sustainable policies

The 12th and final indicator in the Sustainable Cities Index reflects the extent to which the city has enacted policies to support renewable energy, reduced greenhouse gas emissions, and clean transportation. While all our indicator inputs are subject to review and suggested revision by the cities themselves, our starting point for this indicator is the CDP Cities data set, for which cities voluntarily respond under the "targets" section, where adaptation goals, sector targets, and mitigation targets are described. In the Sustainable Cities Index, cities are given credit for having enacted each of five key policies: (i) renewable energy target, (ii) electric vehicle target, (iii) emission reduction target, (iv) net-zero GHG target, and (v) renewable energy enabling policy.

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(26) World Bank (2022). "Solid waste management." Retrieved from worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management#:~:text=With%20rapid%20population%20growth%20and,impacted%20by%20unsustainably%20managed%20waste.

(27) Kacyira, A. K. (2022) "Addressing the sustainable urbanization challenge." Retrieved from un.org/en/chronicle/article/addressing-sustainable-urbanization-challenge.

(28) Notre Dame Global Adaptation Initiative (2015). *Country Index Technical Report*. Retrieved from gain.nd.edu/assets/254377/nd_gain_technical_document_2015.pdf.

APPENDIX B: CORPORATE KNIGHTS SOCIO-ECONOMIC ADJUSTMENT FACTOR (CKSEAF)

Understanding and comparing environmental performance indicators requires consideration of the underlying social and economic dimensions of sustainability. For example, indicators such as per capita greenhouse gas emissions or per capita water consumption will be low in rich countries and cities if water conservation and efficiency are priorities, but they will also be low in poor countries and cities because of poverty and low access to fuels, electricity, and potable water. The Corporate Knights Socio-Economic Adjustment Factor (CKSEAF) described below has been developed and incorporated in the Sustainable Cities Index to discount environmental KPI scores to the extent they coincide with unsustainable social and economic conditions.

The CKSEAF is based on the product of three separate indices and is defined as:

$$\text{CKEAF} = \left(\frac{\text{Log}(10a * 10b * 10c)}{3} \right)$$

where:

a is the UNDP Human Development Index, a statistical composite of life expectancy, education, and per capita income indicators.
b is one minus the GINI coefficient for income distribution. The GINI index coefficients are scaled where 0 represents perfect equality and 1 represents perfect inequality of income distribution. To be consistent with the other two indices where 0 indicates low performance and 1 indicates high performance, the index is based on (1-GINI coefficient). For example, very high degree of income equality in Slovak Republic results in a GINI index coefficient of 0.232, which is subtracted from 1 to result in a value of 0.768. In the opposite example, a GINI index coefficient of 0.630 for South Africa (indicating highly unequal income distribution) translates to a score of 0.370.
c is an index of per capita GDP, expressed as a fraction of US$48,480 purchasing power parity (PPP), equal to the GDP PPP for the EU, up to a maximum of 1.

The three indices are scaled from 0 to 10 in the application of the CKSEAF formula above.

The CKSEAF is based on the product of the component indices rather than on a simple average so that, for a given average of the three indices, a higher CKSEAF will result when the values of the three indices are more evenly distributed. For example, a set of values of 7, 7, and 7 will yield a higher CKSEAF than a set of values of 9, 9 and 3, even though the average of the two sets are equal.

The formula yields a CKSEAF that is a decimal fraction of 1 and can be used to discount KPI scores that are also expressed as decimal fractions of 1.

Table C. Corporate Knights Socio-Economic Adjustment Factor (CKSEAF).

	CKSEAF
Norway	0.99
Denmark	0.98
Finland	0.98
United Arab Emirates	0.98
Sweden	0.98
Netherlands	0.98
Germany	0.98
Australia	0.97
Canada	0.97
Korea	0.97
France	0.97
United Kingdom	0.97
New Zealand	0.96
Japan	0.95
United States of America	0.95
Hong Kong	0.94
Spain	0.94
Singapore	0.88
Turkey	0.87
Chile	0.85
Argentina	0.83
Costa Rica	0.80
China & Taiwan	0.77
Mexico	0.76
Brazil	0.71
Peru	0.71
Colombia	0.70
South Africa	0.63
Philippines	0.62
Bangladesh	0.58
India	0.57
Ghana	0.53
Pakistan	0.49
Cote d'Ivoire	0.48
Kenya	0.47
Nigeria	0.46
Cameroon	0.42
Senegal	0.38
Tanzania	0.37