Greenhouse Gas Emissions Tools and Datasets for Cities

Full Report

November 2022

Contents

Introduction

The IPCC's Sixth Assessment Working Group III Climate Change report shows that climate change is already having a serious impact on ecosystems and communities around the world. This provides ever more evidence that we urgently need to cut greenhouse gas (GHG) emissions to limit global warming to 1.5°C above pre-industrial levels and to avoid catastrophic climate change. Accounting for an estimated 70% of global emissions and home to 55% of the global population, cities[1] have a critical role to play in this transition.

A key part of a city's journey to taking effective climate action is to understand the GHG emissions generated by different activities within their geographic area, sometimes referred to as 'community-wide' or 'city-wide' emissions. To do this, cities develop an emissions inventory. A GHG emissions inventory provides a breakdown of a city's emissions by activity or sector, and scope (where the emissions physically occur, relative to the city's geographic area). It is crucial for informing city climate policy and decision-making, setting meaningful science-based climate targets and monitoring progress towards those targets.

A GHG emissions inventory is critical for effective city climate action planning

Developing a robust and comprehensive GHG emissions inventory:

1) Helps cities establish a base year emissions inventory and set reduction targets;
2) Enables cities to benchmark and compare their emissions with other cities;
3) Helps cities to prioritize city climate actions, through the identification of high emitting sectors and sources, and to attract financing for action implementation;
4) Enables cities to track progress on local climate action and their share of Nationally Determined Contributions (NDC) commitments;
5) Increases the technical capacities of city staff to use and apply methods and tools for emissions accountancy;
6) Helps cities analyze the complexities around emissions, for example, where the city can directly influence emissions reduction and where they have no direct control (eg energy production is usually controlled at regional or national levels); and
7) Demonstrates the important role that cities play in tackling climate change.

Current city GHG accounting practices

Cities typically develop their inventories according to a GHG accounting standard, such as the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC). The GPC provides recommendations on the boundary of the emissions inventory, including the timespan (one year), the geographic area of the inventory, and the GHGs and emissions sources that are covered.

The GPC categorizes emissions by activity sector – stationary energy, transport, waste, agriculture, forestry and land use (AFOLU), and industrial processes and product use (IPPU) – and scope, based on where the emissions physically occur (Figure 1).

[1] The term 'city' is used throughout this document to refer to geographically discernible subnational entities, such as communities, townships, cities, and neighborhoods. In this report, 'city' is also used to indicate all levels of subnational jurisdiction as well as local government as legal entities of public administration. Source: GPC.

Scopes definitions for city inventories and relationship with the Global Covenant of Mayor's Common Reporting Framework (CRF) emissions definitions

GPC Scope	GPC Definition	Related CRF Emissions Type
Scope 1	GHG emissions from sources located within the city boundary	Direct emissions
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary	Indirect emissions from the use of grid-supplied electricity, heat, steam and/or cooling
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary	Emissions occurring outside the jurisdiction boundary as a result of in-jurisdiction activities

Adapted from GPC and CRF Guidance Note.

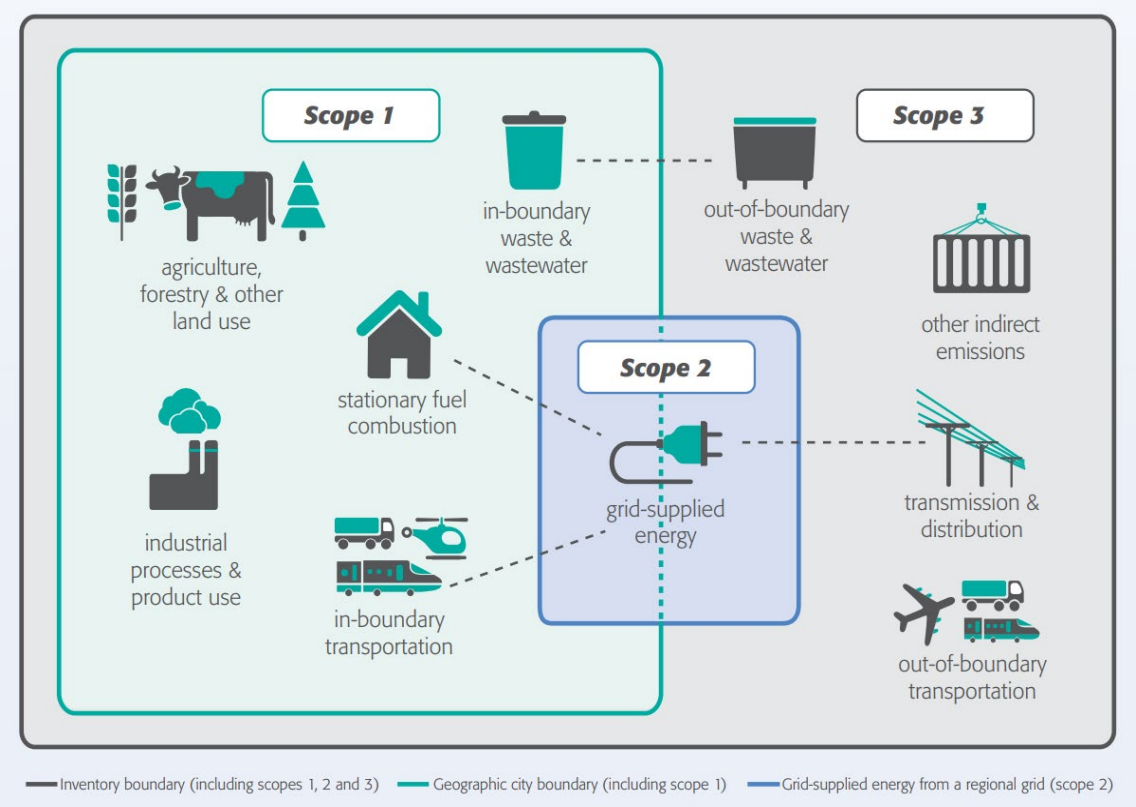


Figure 1: Sources and boundaries of city GHG emissions (taken from the GPC)

Measuring territorial emissions (emissions directly released within a city's boundary) on its own is often not a useful reflection of the city's overall impact on climate. For example, a key proportion of a city's energy may be imported from a power plant outside of the city boundary. The emissions generated by the power plant will not be reflected in the city's territorial emissions because they occur outside of the boundary, even though they are a result of activities taking place within the boundary.

By developing an inventory that focuses on the city's activities, rather than just the emissions released within its boundary, the city can obtain a fuller understanding of what sectors and activities contribute the most to its emissions, and identify emissions sources that are under its direct control and sources that are outside of its direct control. This enables the city to plan the policies and interventions it needs to implement to reduce directly-controlled emissions, and to identify additional political and economic levers it can utilize to encourage the reduction of emissions outside of its direct control.

Consumption-based emissions

As well as the sector-based, or production-based, approach to GHG accounting, some cities are adopting a consumption-based approach to measure their emissions. A consumption-based emissions approach aims to quantify the emissions resulting from the consumption of goods and services by residents within the city and is complementary to the sector-based approach. There is no standardized method to quantify consumption-based emissions to date. However, more information on the broad overlaps and differences between a consumption-based inventory and a sector-based inventory can be found in C40 Cities' Consumption-Based GHG Emissions of C40 Cities report.

According to research by C40 Cities, cities' consumption-based emissions can be 60% higher than their sector-based emissions calculated following standards such as the GPC. However, only a small number of cities have measured their consumption-based emissions. Just 7% (82/1128) of cities reporting through CDP-ICLEI Track in 2021 had a consumption-based emissions inventory[2]. Tools that help cities quantify their consumption-based emissions are outside the scope of this report.

How tools can help local emissions data collection

Cities commonly develop their own community-wide emissions inventories by collecting local activity data on their key sectors (eg energy, transport and waste) and converting it to an emissions value by multiplying it by emission factors. For cities with the capacity to collect high-quality localized activity data and emission factors following a standard such as the GPC and using well-established tools such as CIRIS and ClearPath, this is the recommended approach. This will give the most accurate picture of their emitting activities and sectors, and enable them to see the immediate impact of their policies and interventions as they track changes in this local data over time.

However, this approach is a time- and resource-intensive process that relies on the availability of local data, city technical capacity and/or resources to outsource to consultants; and many local and regional governments are struggling to measure their

[2] Analysis based on city responses to CDP-ICLEI Track in 2021, Question 4.9 (data extract taken on 13 December 2021).

emissions. In some cases, the emissions data exists but it is held by other stakeholders (for example, other tiers of government or utilities providers). Accessing that data requires a lot of networking and communication with different stakeholders, delaying inventories development or sometimes resulting in data gaps.

In 2021, the average GHG emissions inventory reported through CDP-ICLEI Track was three years old (from 2018) and 38% of cities did not report a community-wide emissions inventory[3] This is a barrier to taking further climate action.

Definitions of activity data, emission factors and global warming potential factors

Activity data	A quantitative measure of a level of activity that results in GHG emissions taking place during a given period of time (eg kilometres driven, tonnes of waste sent to landfill, etc).
Emissions factor	A measure of the mass of GHG emissions relative to a unit of activity. For example, estimating CO_2 emissions from the use of electricity involves multiplying data on kilowatt-hours (kWh) of electricity used by the emission factor (kg CO_2/kWh) for electricity, which will depend on the technology and type of fuel used to generate the electricity. IPCC international default emission factors are available but to increase accuracy, it is recommended to prioritize using local emission factors where they exist, followed by regional factors, and to only use national factors where no sub-national data exists.
Global warming potential	A factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given GHG relative to one unit of CO_2. It is used to express other GHGs (eg CH_4 and N_2O) in units of CO_2 equivalent (CO_2e) to enable comparison across GHGs. Emissions values expressed in units of CO_2e include $CO_2$and other GHGs, whereas emissions values expressed in units of CO_2 just include CO_2.

Adapted from source: GPC.

The recent Decision-making and Tools Project White Paper by GCoM, Bloomberg Associates and World Resource Institute (WRI) provided a comprehensive analysis of cities' needs in relation to tools that can support them on their climate action journey – from understanding and planning, to executing and monitoring. It identified that while emissions measurement was one of the stages of climate action best supported by tools, there are gaps and areas for improvement that still need to be addressed to help cities at the early stages of climate action or with capacity and resource constraints to start developing an inventory.

[3] Analysis based on city responses to CDP-ICLEI Track in 2021, Question 4.0 and Question 4.1 (data extract taken on 13 December 2021).

Suggested improvements include:

- Tools that are simpler and easier to use, with better access to proxy data and streamlined methodologies for GHG emissions accounting to reduce the time burden associated with developing an inventory.
- Increased interoperability of data and tools throughout the climate action journey, moving towards common data formatting standards to enable easy data transfer between tools. For example, stronger alignment of tool outputs with reporting platforms such as CDP-ICLEI Track and The European Commission's MyCovenant reporting platform would enable automatic upload of emissions data and reduce the reporting burden for cities. Improved functionality to take data from a GHG emissions accounting tool and input it into a city mitigation and adaptation planning tool could also provide significant benefits for cities in the future.
- More data products that cover different levels of spatial and temporal resolution, with the functionality to aggregate and disaggregate the data according to a range of spatial and temporal scales to enable cities to zoom in and out to different levels of detail when planning climate action.
- Increased accessibility of measurement tools by making them available in a broader range of languages.

In the last five years, there has been a growth in GHG emissions monitoring tools, datasets and approaches[4] that have the potential to support cities to develop their inventories. They provide cities with data where they have data gaps in their inventory or do not currently have the capacity to collect the data themselves. This can enable them to progress more rapidly to the next stage of climate planning and action. From sensors and satellites to scaling down national level emissions, these approaches and tools are diverse. Each comes with strengths and limitations and varying suitability, depending on the city's aim of developing an inventory (eg to establish an emissions baseline or to track change in emissions over time).

[4] Turnbull et al. (in review) IG3IS Urban Greenhouse Gas Emission Observation and Monitoring Best Research Practices, https://ig3is.wmo.int/en/events/towards-international-standard-urban-ghg-monitoring-and-assessment

Aim and scope of report

This technical report aims to provide an overview of GHG emissions monitoring tools, datasets and approaches that can provide cities across the globe with recent, community-wide emissions data they can use to build their inventories. Cities are at different stages on the climate action journey and their emissions data needs change as they progress on this journey: from having no emissions data and needing a starting point, to developing capacity to collect data but requiring data to fill in the gaps and track emissions changes over time.

While high-quality local emissions data is always preferable, as it is more accurate, alternative tools and datasets, such as downscaled or proxy data, can be used to address data gaps as cities transition through the different stages of climate action maturity until they have the capacity to collect this data themselves. This report will provide best practice recommendations on how and when to use the different tools and datasets, including the methodological approaches used to create the data; and the GHGs, boundaries and emissions scopes they cover.

This will equip cities with the knowledge and understanding they need to decide which tools and datasets will meet their requirements, enabling cities that do not have the means to develop a complete GHG emission inventory to get started, removing a key barrier to further climate action.

This report is most useful for cities that are facing barriers to collecting community-wide emissions data and want to establish a starting point from which they can continue to develop and add to their GHG emissions inventory. However, the recommendations in this report will also be valuable for cities that are looking for accessible emissions data that can be used to fill data gaps in their existing inventories, or to provide more detailed data (at higher temporal and spatial resolution) for enhanced climate action planning.

Finally, this report will also identify which tools may be useful for cities that want to track emissions changes and the impact of local policies over time. We recommend that cities that have capacity to collect their own local emissions inventory data continue to do so, as this data is likely to be more accurate than the data provided by the tools in this report.

This report does not cover:

- Well-established tools designed to help cities collect their own activity data to build their inventories (eg CIRIS and ClearPath). These types of tools are comprehensively covered elsewhere.
- Tools that provide cities with local government operations emissions inventories or project-specific emissions inventories.
- Decision-making tools to help cities plan their climate action, project future emissions, or assess the emissions reduction impacts of different climate actions on a local government's inventory.
- Tools that help cities quantify their consumption-based emissions.

For more information on endorsed GHG emissions tools that are not included in this report, visit the GCoM Resource Library.

Choosing the right GHG emissions tool or dataset for your inventory: best practice recommendations

When choosing the most appropriate GHG emissions inventory tool or dataset for your city, there are several things to think about. Below are best practice recommendations for how to develop an emissions inventory and how to decide which GHG inventory tools and datasets are most suitable for your city's needs. These best practice recommendations were the framework used to assess sixteen GHG tools and datasets in this report (p.14).

What stage is your city at on its climate action journey?

A city goes through many phases in its climate action journey, from assessing its impact and setting targets, to planning and taking action, to tracking progress towards its targets and becoming a climate leader. Developing an emissions inventory typically falls into the assessment phase of that journey.

However, even within the assessment phase, cities can be at different levels of maturity, and this will determine which tools and emissions datasets are most useful for you, and how accurate your inventory needs to be for your needs.

Stage 1	**Establishing an emissions baseline**	Your city is just starting on its climate action journey. It has minimal data collection capacity and requires a baseline emissions inventory for initial climate action planning (for example, to identify its most high-emitting sectors). Simplified tools are most useful. Cities looking to establish a baseline emissions inventory to initiate their climate planning will want data that has comprehensive coverage (covering all or most of the city's activity sectors and at least Scope 1 and 2 emissions) and low temporal resolution (annual) and spatial resolution (city boundary).
Stage 2	**Identifying specific sources of emissions**	Your city is in the middle of its climate journey. It has developed some capacity to collect its own data but has data gaps in emissions inventory or it requires more detailed emissions data for advanced climate action planning (for example, to identify the emissions impact of specific sub-sectors and/or at higher spatial and temporal resolution).
Stage 3	**Tracking progress over time**	Your city is advanced in its climate journey. It requires data to track the impact and progress of its climate policies and actions over time. For cities to start meaningfully tracking progress over time, they need to start collecting more detailed local data.

What methodological approach does the dataset or tool take to estimate emissions?

Emissions tools and datasets adopt different approaches to estimating emissions which each come with their strengths and limitations, depending on a city's stage in its climate action journey. Some tools and approaches may be useful for cities at more than one stage. For each tool evaluated in this report, we indicate which stage(s) it is most applicable to.

- Direct atmospheric measurements

This approach derives data from direct atmospheric measurements, including from satellite data, sensors installed on the ground, or continuous monitoring at power stations. The advantage of this approach is that it is based on direct measurements of GHGs and can provide high spatial and temporal resolution data, including tracking emissions changes over time. However, data products and tools derived from this approach typically only cover direct (Scope 1) emissions, and therefore are not helpful on their own for determining city climate action policy, because they do not reflect the activities and consumption in cities driving wider emissions generation (for example, national grid energy consumption). Moreover, the use of ground sensors can be expensive. Therefore, data products tend to be limited to individual cities.

- Local activity data multiplied by emission factors

One of the most common approaches to estimating emissions is collecting local activity data and multiplying it by emission factors. The advantage of this approach, compared with direct emissions measurement, is that a city can build a detailed and comprehensive emissions dataset for all relevant emitting activities within the city boundary, rather than only looking at its direct emissions.

However, collecting local activity data can be a time- and resource-intensive process, and often cities face logistical and financial barriers to collecting the data from the relevant data sources, or the data does not exist.

- Adapting or scaling data from other sources

Wherever possible, cities should prioritize using local, then regional, then national, then international data to estimate their emissions. However, if no local data is available, larger-scale datasets (eg national government emissions data or regional activity data) can be down-scaled using scaling factors such as population or GDP. The strengths of these approaches are that they cover a comprehensive set of community-wide emissions and do not require high data processing power. Many cities starting out with climate action planning do not need higher temporal or spatial data at this stage. However, these types of datasets are not based on direct local measurements but tend to be scaled down from data covering larger geographical scales. This means they may not reflect local city activity accurately and are not appropriate for detailed climate action planning or tracking the impact of local policies or interventions through time because the impact of local actions will not be visible in the data.

- Near-real-time big data approaches

Several new tools and datasets are adopting big data approaches to provide city emissions data at higher spatial or temporal resolution. The characteristics of these datasets vary and they come from a range of different data sources and data processing methodologies, including direct atmospheric measurements, activity data multiplied by emission factors, and other hybrid combinations. They draw on big data – datasets that are too large or complex to be dealt with using traditional data processing software and techniques. The data tends to be spatialized using map data and has high temporal (monthly, daily or hourly) and spatial (sometimes down to street- and building-level) resolution. Some datasets incorporate elements of local data, making them usable for tracking emissions changes over time. Due to their higher temporal and spatial resolution, these tools and datasets have the potential to support cities with more detailed climate action planning by increasing understanding of behavior patterns on hourly, daily or monthly timescales and in specific areas within the city boundary.

A number of these datasets have been developed by academics and their methodologies submitted for scientific peer review, ensuring they adhere to robust scientific principles. However, city GHG accounting is often not the primary purpose of these datasets and the data produced is not always in a useful format for cities to integrate into their inventories, requiring additional data processing. For example, many big data emissions tools have not disaggregated their data into scopes, or only cover direct emissions, and are not aligned with established GHG accounting protocols such as the GPC.

These datasets also tend to be large, requiring high processing power; and accessing and downloading the data is often not user-friendly (sometimes the data can only be downloaded in a bulk excel file for all cities). Moreover, the coverage of these datasets tends to be countries that already have well-established data (for example, the United States, and countries in Europe) while cities in other regions are poorly represented.

Does the tool's data come from reliable and robust sources?

Cities should prioritize using data from publicly available and reputable sources, for example government data or academic peer-reviewed datasets. When choosing an emissions tool or dataset, think about the core data sources that the tool uses – are they publicly available? Is there clear, easy to understand, and publicly available documentation on the methodological approaches used to measure or estimate the data? Does the tool or dataset provide an assessment of data quality? How is data quality calculated?

Does the tool's data align with globally recognized emissions accounting and reporting standards?

Global emissions accounting or reporting standards (eg GPC, CRF and 2006 IPCC Guidelines for National Greenhouse Gas Inventories) provide a robust and transparent framework for developing city emissions inventories. They are internationally recognized, promote the development of high-quality and credible data, and enable direct comparisons between cities' inventories on a global scale.

Where possible, cities should use emissions tools and datasets that align with global city GHG emissions standards. CDP recommends using the GPC standard for cities' emissions data.

Does the tool's data align with your city's inventory boundary?

- It should cover your city's geographic boundary

A city-wide emissions inventory should cover everything within a city's geographic boundary. Check that the tool or dataset covers your city's full geographic boundary and that it is the same geographic boundary your city had used for previous inventories. If the tool or dataset does not match your city's geographic boundary, does it have the flexibility to adjust the boundary to the one your city uses?

Some tools provide data at a higher spatial resolution than the city geographic boundary (for example, providing emissions data for individual streets and buildings). Think about whether you need data at that level of detail for your city's stage in its climate action journey.

Does the tool have flexibility to aggregate and disaggregate between the city boundary and street scale?

- It should cover a relevant inventory accounting period

To be compliant with the GPC and reporting to the CRF, the accounting period for emissions data should be 12 months. Prioritize obtaining recent emissions data (last three to five years) where possible. For cities that are looking to identify specific sources of emissions or track progress towards their target, near-real-time emissions data at higher temporal resolution (eg monthly, daily or hourly) may be useful for getting a better understanding of small-scale activity and behaviors within their city to incorporate in more detailed climate action planning, or to track changes over time at higher granularity.

- Emissions data should cover multiple GHGs

Where possible, cities should use emissions data that covers all seven GHGs in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

At a minimum, emissions datasets should cover CO_2, CH_4 and N_2O. These are often combined in an aggregate total emissions value reported in tonnes CO_2 equivalent (tCO_2e). While CO_2 is the dominant GHG in city emissions, tracking all gases is important for understanding the full impact of cities on climate change. For example, although CH_4 is a short-lived GHG compared with CO_2, only lasting in the atmosphere for about a decade, its warming effect is ~28 times more powerful than CO_2.

In cities and regions that have large agricultural activity, CH_4 can make up a significant proportion of emissions. Cities have been found to be emitting more methane than expected (from landfill sites and from leaking gas infrastructure).[5, 6] So a CO_2-only monitoring tool might not provide a sufficient picture. In addition, many standards and protocols (for example, the GPC and CRF) require multiple GHGs to be reported.

[5] Sargant, M.R. et al. (2021) Majority of US urban natural gas emissions unaccounted for in inventories, PNAS, 118 (44) e2105804118, https://www.pnas.org/doi/10.1073/pnas.2105804118
[6] Dunning, H. (2022) London produces up to a third more methane than estimates suggest, Imperial College London, https://www.imperial.ac.uk/news/233895/london-produces-third-more-methane-than/

- The emissions data should cover core activity sectors

The emissions tools and dataset should cover core activity sectors and other relevant sectors for your city. GPC categorizes emissions by activity sector – stationary energy, transport, waste, agriculture, forestry and land use (AFOLU); and industrial processes and product use (IPPU). Some tools only cover specific sectors. This may still be useful for filling in data gaps in existing inventories or if you are interested in specific sectors for climate action planning.

What are the tool and dataset's other strengths and limitations?

- How often is the data updated?

Some tools update their data regularly (annually). Other tools may not update their data as often. In addition, be aware that some tools may update and improve the methods used to estimate the emissions over time. This may have implications for comparability between different inventory years and may result in changes to your city's emissions. Check to see whether the tool adjusts older emissions years when they update their methods.

- Does the tool include additional climate action planning functionalities?

Many tools provide additional climate decision-making functionalities as well as emissions data. Tools that integrate emissions data and action planning can be beneficial for cities by providing better connections between the different stages of city climate action.

- What is the functionality for downloading or exporting the data?

Think about the format you want the emissions data in to be able to use it and check to see what type of data download or export functionality the tool or dataset has. Some tools enable you to download the emissions data as an excel file or through an Application Programming Interface (API). Other tools only have the functionality to download the data as a PDF report or have no functionality to download the data.

- How easy is it to transfer the data from the tool to other tools and platforms?

Related to how data can be exported from a tool, another thing to consider is the interoperability of tools. Can the data from the tool you are using be directly inputted into another tool (eg a climate action planning tool), or can it be imported to your chosen reporting platform (eg CDP-ICLEI Track)? Choosing an emissions tool that is compatible with other climate action tools will save your city time and reduce the risk of data errors by minimizing the need for manual data processing and transferring.

- Are there any costs to use the tool/dataset?

Be aware that some of the tools included in this report cost money to use or include elements or services that require payment or a subscription. You should take this into consideration when choosing and budgeting for an emissions tool or dataset.

- Does the tool enable you to provide your own local data to improve the results?

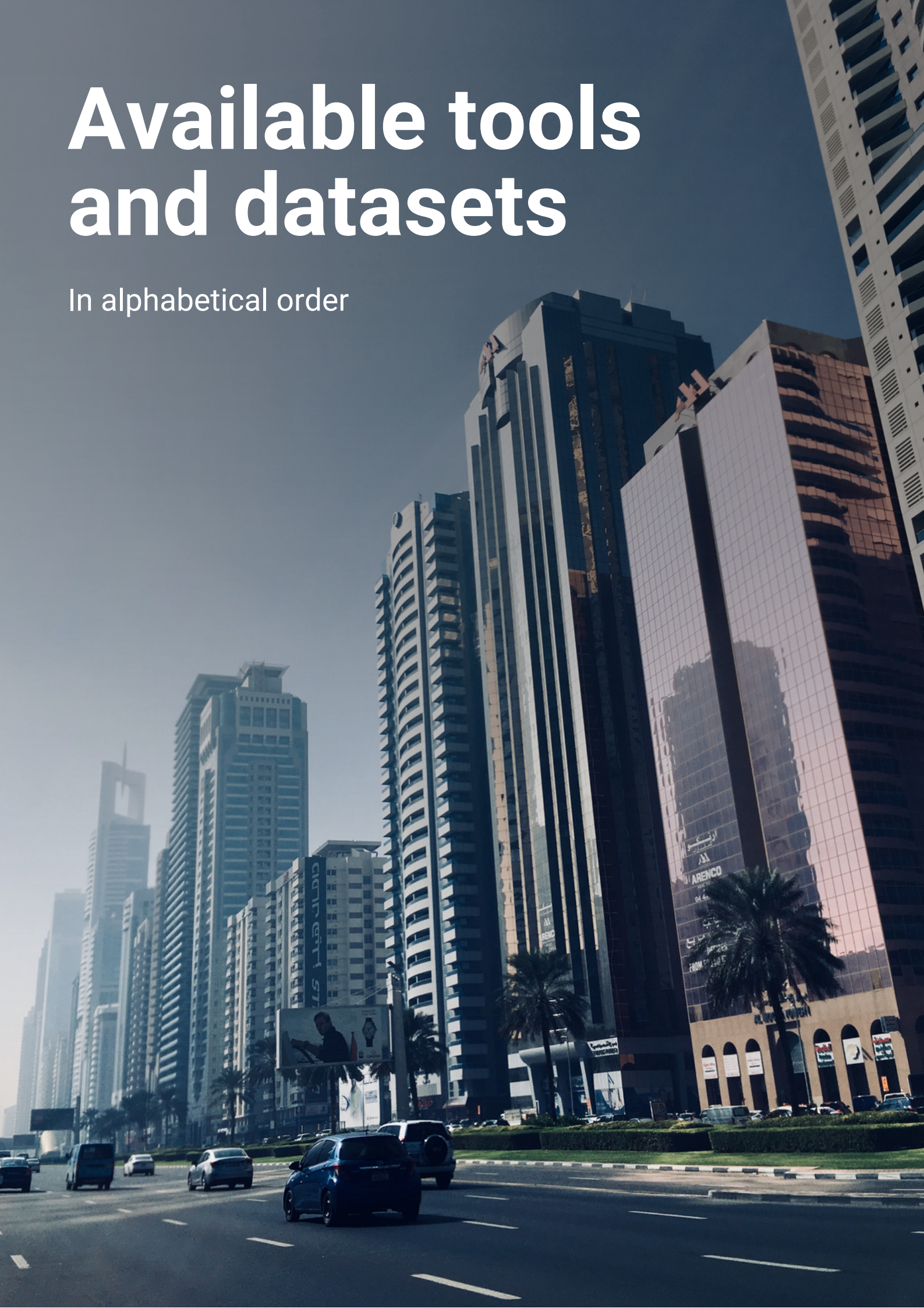
As well as providing cities with emissions data, many tools enable cities to input their own local activity or emissions data to adjust the final emissions dataset. This can be beneficial for improving the accuracy of the data, especially for tools that rely on downscaling national data.

- Does the tool owner provide documentation and support to use the tool?

The ease of use of tools and datasets, and the level of support available to cities to use them, can vary between tool providers. Look for tools and datasets that have clear and easily accessible documentation and/or training and ongoing support.

Available tools and datasets

In alphabetical order



Carbon Monitor Cities

Tool overview	Carbon Monitor Cities is an online CO_2 emissions dataset developed by a group of universities and climate technology firms. It provides near-real-time daily city-level CO_2 emissions data for 1500 cities in 46 countries.
Climate journey stage	Stage 2: Identifying specific sources of emissions Stage 3: Tracking progress over time
Countries	Argentina, Australia, Austria, Bangladesh, Belgium, Brazil, Canada, Chile, China, Colombia, Denmark, Egypt, Finland, France, Germany, Greece, Hungary, India, Indonesia, Iran, Italy, Japan, Republic of Korea, Malaysia, Mexico, Myanmar, the Netherlands, Nigeria, Norway, Pakistan, Peru, Philippines, Poland, Portugal, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, United Arab Emirates, United Kingdom, United States, Vietnam
Language	English
Accessibility	Free to use
Methodology	Carbon Monitor Cities data is downscaled from Carbon Monitor, a near-real-time national level dataset of daily CO_2 emissions that has been monitoring variations of CO_2 emissions from fossil fuel combustion and cement production at a global scale since January 2019, and its global gridded version: GRACED. Carbon Monitor estimates daily CO_2 emissions from a range of activity data, including hourly to daily electrical power generation data, monthly production data and production indices of industry processes, daily mobility data and mobility indices of road transportation. Individual flight location data and monthly data are used for aviation and maritime transportation sectors estimates. Monthly fuel consumption data is used for estimating the emissions from commercial and residential buildings. The data is down-scaled to city-level (10 km resolution) by converting into gridded map data. The gridded daily emissions data is disaggregated into individual cities using city area boundaries. The city-level transport and residential data is corrected using TomTom congestion data and daily heating degree days.
Documentation	https://cities.carbonmonitor.org/ and https://www.nature.com/articles/s41597-022-01657-z
Data quality	The data has been corrected and validated by removing outliers and comparing the results to existing city inventory data. The overall uncertainty of the data is ±21.7%. The data has been scientifically peer-reviewed.
Alignment with standards and protocols	Not aligned with GPC or CRF
Emissions scopes	1

GHGs	CO_2 only
Sectors included	Stationary energy, transport (ground and aviation), IPPU (fossil fuel CO_2 emissions only)
Scopes, GHGs and sectors excluded	GHGs: CH_4, N_2O, HFCs, PFCs, SF_6, NF_3. Sectors: waste, AFOLU emissions (up to 10% of global CO_2 emissions), and non-fossil fuel CO_2 IPPU emissions)
Temporal resolution	Near-real-time, daily
Spatial resolution	10 km, but can be aggregated to city boundary
Tool flexibility	No functionality for cities to input their own local emissions data or to adjust the city boundary.
Latest accounting year	2021
Data updates	Unknown
Units	Metric kilotons (kt CO_2)
Using the tool	The data of 50 selected cities is available to download for free from the Carbon Monitor Cities website and the complete dataset of 1,500 cities can be downloaded for free from Figshare. Links to future updates of the complete dataset will be posted on the Carbon Monitor Cities website. The data output is an excel spreadsheet that contains daily emissions data for every city for every sector. Cities need to add the daily emissions data for each sector for their city to get annual total or sectoral emissions. The sectors are not aligned with the GPC or CRF so would need to be mapped against them in order to report the data against these protocols.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	None
Tool strengths	◥ Recent, near-real time, daily data enables more detailed understanding of temporal changes in emissions. ◥ Publicly available, scientifically peer-reviewed methodology.
Tool limitations	◥ Not aligned with GPC or CRF. ◥ Provides CO_2 data only. ◥ Only provides Scope 1 emissions. ◥ Poor coverage in Africa, Middle East and South-East Asia.

Climate OS

Tool overview	ClimateOS is a climate action decision-making tool for cities developed by climate action technology company ClimateView. Their aim is to provide cities with the data intelligence needed to take effective climate action. As part of this service, ClimateOS provides pre-populated GHG emissions data for cities in selected countries.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Canada, France, Germany, Spain, Sweden, United Kingdom, United States
Language	English, French, German, Spanish, Swedish
Accessibility	All GHG emissions data on the platform is free to use for cities in countries specified above. The full version of ClimateOS, including tailored support, is a paid-for service.
Methodology	ClimateOS emissions data is downscaled from national-averaged activity data (from national statistics and other national data sources) for individual countries. It uses national or global-level emission factors to generate emissions data for cities.
Documentation	Detailed documentation for individual data points is available on the ClimateOS platform.
Data quality	Not verified by a third party.
Alignment with standards and protocols	Aligned with the GPC and CRF
Emissions scopes	1, 2, 3 (for selected cities)
GHGs	CO_2, N_2O and CH_4
Sectors included	Stationary energy, transport, waste
Scopes, GHGs and sectors excluded	GHGs: HFCs, PFCs, SF_6, NF_3. Sectors: AFOLU and IPPU
Temporal resolution	Annual
Spatial resolution	City boundary
Tool flexibility	The tool allows cities to adjust or improve the accuracy of the output by including their own local data where available. It may be possible to redefine boundary – discuss with ClimateView.

Latest accounting year	2019 or 2020, depending on country
Data updates	Data update feature under development with the aim of eventually providing annual updates, depending on data sources.
Units	Metric tons (tCO_2e) and in local units of each country
Using the tool	Register with ClimateView here. The emissions data is provided in an online platform where the user can explore different visualisations of the data from total emissions down to sub-sector level. The data can be exported as an excel file and the output results in a baseline inventory that satisfies GCoM requirements and is aligned with the CRF format.
Import into CDP-ICLEI Track	Outputs of the tool can be imported into CDP-ICLEI Track.
Additional functionalities	ClimateOS is an integrated climate decision-making and action planning platform covering GHG emissions inventory management, simulation and action planning.
Tool strengths	◥ Aligned with the GPC and CRF. ◥ GHG emissions data is integrated into climate action planning tool. ◥ The inventory output from the tool can be imported directly into CDP-ICLEI Track.
Tool limitations	◥ Data available for selected countries only.

Crosswalk Labs

Tool overview	Crosswalk Labs is a collaboration between data scientists and former elected officials that provides estimates of hourly CO_2 emissions from the combustion of fossil fuels and CO_2 emissions from cement production for cities across the United States.
Climate journey stage	Stage 2: Identifying specific sources of emissions Stage 3: Tracking progress over time
Countries	United States
Language	English
Accessibility	Crosswalk Labs offers a free-to-use version. However, cities and other organisations can engage with Crosswalk Labs to develop custom reports and purchase data subscriptions.
Methodology	Crosswalk Labs' data is built on the Vulcan dataset which estimates hourly CO_2 emissions for the entire US, represented in space as points, lines, and polygons. It combines national, state and county-level emissions and activity data for a range of sectors, with power plant emissions data from stack monitoring. The data has recently been updated to near-real time, sector by sector emissions, using sector-specific methodologies. The dataset uses a combination of direct measurements and proxy data, prioritizing direct measurements where available.
Documentation	https://www.crosswalk.io/products
Data quality	To assess the quality of the Vulcan dataset, the developers compared Vulcan to atmospheric measurements of CO_2. Based on this assessment, Vulcan agreed to within 1.4% of direct atmospheric measurements of CO_2. The data has been scientifically peer-reviewed.
Alignment with standards and protocols	Emissions data provided by Crosswalk Labs align with global standards and protocols such as the GPC and GCoM CRF.
Emissions scopes	1
GHGs	Currently CO_2 only but there are plans to expand to additional GHGs in addition to criteria air pollutants.
Sectors included	Stationary energy (residential, commercial, industrial), transport (on-road, non-road, commercial marine vessels, aviation, rail), IPPU (cement production only)
Scopes, GHGs and sectors excluded	Scope 2 (will be available with the release of the next version of the Vulcan dataset), Scope 3. GHGs: CH_4, N_2O, HFCs, PFCs, SF_6, NF_3. Sectors: waste, AFOLU
Temporal resolution	Crosswalk Labs offers GHG emissions data that are near-real time at an hourly temporal resolution that can be aggregated to weekly, monthly, and annual timescales for reporting purposes.

Spatial resolution	Points, lines, and polygons, with size dependent on sector and location. Most urban areas have onroad, residential, commercial, and industrial emissions at <1 km, along with point sources. Emissions in points, lines, and polygons are aggregated into city/county/state boundaries.
Tool flexibility	Cities can choose a custom geographic boundary to output a standard set of emissions. For paid engagements, Crosswalk Labs can work with cities to create GHG inventories that blend Vulcan data with local data to improve the accuracy of the output and increase sectoral coverage.
Latest accounting year	2020
Data updates	Every three months
Units	Metric kilotons (kt CO_2)
Using the tool	Cities can request a demonstration of the data through Crosswalk Lab's website. Data can be exported as maps, spreadsheets, csv files, shapefiles, and custom reports. The Crosswalk Labs team can work with cities to integrate emissions data into common reporting tools such as ICLEI ClearPath. Currently, anyone can preview Crosswalk Labs' calendar year 2015 data for cities with populations larger than 5,000 residents. The data preview is accessible on the Crosswalk Labs website at https://www.crosswalk.io/products. Users can retrieve emissions data ad hoc for one of approximately 6,400 U.S. cities (population > 5,000 residents). The Crosswalk Labs data preview displays emissions totals by sector (Total, Onroad, Commercial, Residential, Non-Road, Airport, Electricity Production, and Other); visualizes a road network of the city; displays a weekly total emissions trend for the city; and list of total emissions for nearby cities.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	Provides detailed maps and spatial analytics to support climate action planning. Future developments will include criteria air pollutant emissions in addition to other GHGs.
Tool strengths	◥ Recent, near-real time, hourly data enables more detailed understanding of temporal changes in emissions. ◥ Publicly available, scientifically peer-reviewed methodology. ◥ Uniform methodology year-to-year and city-by-city direct comparison across cities. ◥ Data has been compared to direct atmospheric CO_2 measurements to assess accuracy. ◥ Prioritizing sourcing data from direct measurements. ◥ Functionality to create hybrid GHG inventories with local city data.
Tool limitations	◥ Currently, provides CO_2 data only. Future developmental milestones will include other GHGs in addition to criteria air pollutants. ◥ Only available for cities in United States.

Data Portal for Cities

Tool overview	Data Portal for Cities is an open data platform, hosted by the Global Covenant of Mayors in collaboration with WRI, that provides activity data and emission factors to enable cities to calculate their GHG inventory. It aims to help cities fill critical information gaps by providing estimates of previously unavailable data drawn from national and regional sources.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Brazil, Canada, Chile, Colombia, Costa Rica, India, Indonesia, Japan, Mexico, Philippines, United States
Language	English, French, Portuguese
Accessibility	Free to use
Methodology	Data Portal for Cities downscales activity data from national and regional data and provides emission factors to convert into emissions data. The local government-scale data is estimated using a combination of existing national and regional statistics, scaling factors, and city-specific data – such as population, building stock data or business patterns. Emission factors used vary from country to country – see country-specific methodologies for more detail. The limitations of the methodology vary from country to country and are well documented. See the Data Methodology & Documentation section on the website (https://dataportalforcities.org/) for more details of country-specific methodologies.
Documentation	Data Methodology & Documentation section on the Data Portal for Cities website: https://dataportalforcities.org/
Data quality	Quality control assessments conducted for individual countries. See methodology for more information.
Alignment with standards and protocols	Aligned with the GPC and CRF
Emissions scopes	1, 2
GHGs	CO_2, CH_4, N_2O
Sectors included	Stationary energy, transport, waste
Scopes, GHGs and sectors excluded	Scope 3, AFOLU and IPPU (these sectors will be available soon)
Temporal resolution	Annual

Spatial resolution	City boundary
Tool flexibility	No functionality within the platform.
Latest accounting year	Varies depending on country – 2015 to 2017. There are plans to integrate GoogleEIE data into future versions of this tool which will result in more recent data becoming available.
Data updates	Unknown
Units	Metric tons (tCO_2e)
Using the tool	Data Portal for Cities is a map-based online data platform. The user can navigate to a city and download the data as an excel file. Activity data and emission factors for the city can be downloaded as a full dataset or in the ClearPath format, or the total and sector-based emissions data can be downloaded in the CRF format. The tool also has an API functionality to download the data in bulk. Data Portal for Cities data can be imported into the latest version of CIRIS (v2.5) to rapidly create an inventory.
Import into CDP-ICLEI Track	The data from the tool can be imported into CDP-ICLEI Track (through CIRIS).
Additional functionalities	Data Portal for Cities allows easy comparisons of emission data with other cities. It can also help users see which sectors should be prioritized when choosing decarbonization actions and for investing in better activity data.
Tool strengths	◥ Aligned with the GPC, CRF and the CIRIS tool. ◥ Publicly available methodology documentation. ◥ Data can be exported via an API.
Tool limitations	◥ The most recent data is from 2017 and for some countries 2015. ◥ Data not currently updated. ◥ Data available for selected countries only and no coverage in Africa or the Middle East.

Ecospeed Region

Tool overview	Ecospeed Region is an online tool developed by energy and climate software solutions provider Ecospeed that provides energy consumption and CO_2 data to cities across Germany, Switzerland, Luxembourg and Italy.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Germany, Switzerland, Luxembourg, Italy
Language	German, English, French, Italian (further languages on demand)
Accessibility	Pay to use
Methodology	The data is downscaled from a range of national statistics (energy and electricity statistics and transport models), national GHG inventories, regional data (energy consumption, traffic counts and production plants) and other forecasting studies. National data is downscaled to key indicators per inhabitant or employee. The energy consumption and CO_2e emissions are then calculated by multiplying the key indicators by the number of inhabitants or employed people in the municipality. The balance can be calculated according to a range of methodologies, including the IPCC.
Documentation	Not publicly available
Data quality	Emissions data is compared with local data provided by cities. In most of the cases, the accuracy of Ecospeed's data is 90%. However, the accuracy of the data varies depending on the size of the municipality or region. The data is not verified by a third party.
Alignment with standards and protocols	Aligned with the German BISKO standard but output can be exported in alignment with GPC and CRF.
Emissions scopes	1, 2 and 3 (using the Life Cycle Assessment - LCA methodology)
GHGs	CO_2, CH_4, N_2O
Sectors included	Household and economy buildings and infrastructure, municipal buildings, vehicles, street lighting and infrastructure; energy production; transport; and non-energy-related emissions, including industrial processes, fugitive emissions, agriculture, LULUCF, and waste
Scopes, GHGs and sectors excluded	GHGs: HFCs, PFCs, SF_6, NF_3.
Temporal resolution	Annual

Spatial resolution	City boundary
Tool flexibility	The tool allows cities to adjust or improve the accuracy of the output by including their own local data.
Latest accounting year	2021
Data updates	Annual
Units	Metric tons (tCO_2e) and other formats
Using the tool	To access the tool, cities need to register with Ecospeed through their website and choose which version of Ecospeed Region they would like to purchase. The tool provides emissions for the sectors mentioned for each city for a given year through an online dashboard. Cities can input this data into their chosen reporting protocol. Data outputs can be aligned with the GPC and CRF if required. All input tables and results can be downloaded as Excel files.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	The tool includes additional climate scenario planning functionalities; excel import and export, unit conversion, plausibility check, various predefined reports, customization; data REST-API
Tool strengths	◥ GHG emissions data is integrated into climate action planning tool
Tool limitations	◥ Data available for selected countries only

Enersis Gaia Platform

Tool overview	Gaia CO_2 balance is an online map-based platform developed by Enersis Climate Intelligence providing data on annual emissions and emissions change to over 1,800 cities in Germany, Switzerland, Portugal and the Netherlands.
Climate journey stage	Stage 1: Establishing an emissions baseline Stage 2: Identifying specific sources of emissions
Countries	Germany, Switzerland, Portugal and the Netherlands
Language	German, English, French
Accessibility	Pay to use
Methodology	Emissions data is partially upscaled from local data (eg data from utilities and satellite data) and partially downscaled from publicly available national German and Swiss data sources, including national statistics for energy, waste and agricultural data and transport emissions models for transport data using population or number of employees.
Documentation	Not publicly available
Data quality	Data quality is assessed on a scale of 1 (low) to 5 (high) based on whether it comes from direct measurements, locally measured data, or is downscaled from national. Some of the nationally-sourced and local datasets are assessed by a third party.
Alignment with standards and protocols	Aligned with the GPC and BISKO (German standard)
Emissions scopes	1, 2 and 3 (partially)
GHGs	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3 considered as CO_2e
Sectors included	Transport, stationary energy, waste, AFOLU and IPPU
Scopes, GHGs and sectors excluded	Scope 3 (partially)
Temporal resolution	Annual
Spatial resolution	City boundary, county, state, country level
Tool flexibility	Cities can choose the geographic boundary they would like to use for their inventory and do a combined emissions inventory with other cities. Cities can also input their own local data to improve the accuracy of the data outputs.

Latest accounting year	2021
Data updates	Annual or depending on client needs
Units	Metric tons (tCO_2e).
Using the tool	Gaia provides total and sector-level annual emissions data for cities. The output can be exported in alignment with the GPC as an excel file and can be directly inputted into a GPC-aligned inventory. The tool allows cities to adjust or improve the accuracy of the output by including their own local data. To access the tool, the city should contact Enersis directly.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	The Gaia module also helps cities with climate action planning by identifying potential areas for climate action across the building, transport and energy sectors.
Tool strengths	◥ Aligned with the GPC. ◥ Data can be exported via an API. ◥ GHG emissions data is integrated into climate action planning tool. ◥ Tool can be integrated into further use cases like municipal heat planning etc.
Tool limitations	◥ Available for cities in Germany, Switzerland, Portugal and the Netherlands but methodology can be transferred to all countries on request.

Everimpact – satellite-based carbon emissions measurements

Tool overview	Everimpact, a company backed by the European Commission and the Asian Development Bank, combines public satellite data and ground sensor data to help cities measure their GHG emissions, track their emissions reduction in real-time and attract financing from the voluntary carbon market to finance further decarbonization investments.
Climate journey stage	Stage 2: Identifying specific sources of emissions Stage 3: Tracking progress over time
Countries	Global
Language	English
Accessibility	Free to use open data/premium data
Methodology	In the free version, this tool uses satellite atmospheric concentrations of CO_2 data measurements (direct emissions) combined with land-use classification satellite images to improve missing data. In the premium version, data can be granular (street level) and certified with sensors and/or other data sources such as traffic, weather, electricity emissions data.
Documentation	Not publicly available.
Data quality	Everimpact's data is based on remote sensing which provides reliable independent and real-time carbon emissions. The data is not currently verified by a third party, but Everimpact is working towards a certification of its data by reputable certification bodies.
Alignment with standards and protocols	Reporting aligned with both GPC and CRF.
Emissions scopes	1. Scope 2 and 3 emissions are possible through partners.
GHGs	CO_2, CH_4 and N_2O
Sectors included	Data broken down by using the activity sectors of GPC and CRF.
Scopes, GHGs and sectors excluded	Scope 3 GHGs: HFCs, PFCs, SF_6, NF_3.
Temporal resolution	Hourly, daily, monthly, quarterly, yearly
Spatial resolution	3 km^2 in free version, hyperlocal/street level in paid for version
Tool flexibility	Cities can compare their own GHG inventories with Everimpact's data and simulate their carbon budget.

Latest accounting year	2022
Data updates	Every 10 minutes
Units	Metric tons (tCO_2e)
Using the tool	Everimpact's tool has a dashboard allowing the visualization of the carbon emissions on a map of the city's territory and graphs of carbon emissions and carbon emissions reductions with the possibility of selecting specific sectors of activity and to compare to the city's historical data. The city can either use Everimpact's dashboard or import the data to its own system using an API. Contact Everimpact for more information.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	Revenue generating functionality: Everimpact's carbon monitoring solution aims to accelerate decarbonization in cities by attracting funding from the voluntary carbon market to help cities finance their climate action. This funding is backed by Everimpact's data and methodology.
Tool strengths	◥ Based on direct emissions measurements ◥ High temporal resolution data (hourly)
Tool limitations	◥ Methodology not publicly available

Futureproofed Cities

Tool overview	Futureproofed Cities is an online city carbon management platform built by climate tech company Futureproofed to measure, reduce and report GHG emissions for cities. Futureproofed Cities supports the creation of GHG emissions inventories, climate goal setting, digital collaboration, monitoring of progress, and stakeholder engagement for over 200 cities worldwide.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Argentina, Belgium, Brazil, Chile, Colombia, Ecuador, France, Guatemala, Honduras, India, Indonesia, Mexico, Peru, Philippines, South Africa, Spain, Sweden, Turkey, United Kingdom, United States
Language	English, Dutch, French, Spanish, Swedish
Accessibility	Pay to use, but some emissions data is free to download through their Open Data API.
Methodology	Futureproofed Cities prioritizes integrating the most local and recent data where it is available. If not, data is downscaled from national and regional data to city level. National and regional activity data and emission factors are used to calculate the final emissions. Where national emission factors are not available, the tool uses default factors provided by the IPCC. Data sources include Eurostat, the European Environmental Agency and national statistical services.
Documentation	Not publicly available but detailed documentation on the methodology is available within the platform.
Data quality	Futureproofed Cities prioritizes data that is public, standardized and endorsed by governmental organizations to ensure the data is good quality. To assess the quality of the data, Futureproofed Cities compares its calculations against data submitted by governments to international initiatives such as the Covenant of Mayors. The data is not currently verified by a third party, but Futureproofed uses bi-weekly data sprints to review, retire and update the data used for the calculation of measures.
Alignment with standards and protocols	Aligned with the GPC and CRF
Emissions scopes	1, 2, some Scope 3
GHGs	CO_2, CH_4, N_2O and CFCs from energy use
Sectors included	Buildings, transport, waste, AFOLU and IPPU

Scopes, GHGs and sectors excluded	Some Scope 3. GHGs: HFCs, PFCs, SF_6, NF_3.
Temporal resolution	Annual
Spatial resolution	City boundary
Tool flexibility	Cities can adjust the geographic boundary in the tool if needed, and create a combined emissions inventory with other cities. The 'Group app' aggregates individual city accounts into a regional, national or global overview of activity and progress. Cities can also input their own local data to improve the accuracy of the data outputs.
Latest accounting year	2020
Data updates	Annual
Units	Metric tons per capita (tCO_2e/per capita) or kilotons (kt CO_2)
Using the tool	Cities can sign up to use Futureproofed Cities through their website. They can then access and download the emissions data in GPC and CRF format as an excel file. Cities do not need to provide their own emissions data. However, the tool does allow cities to adjust or improve the accuracy of the output by including their own local data, such as number of company cars in city, number of buildings, households, newly registered vehicles, passenger vehicle km, population.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	Provides additional target setting and climate planning functionalities, including what actions the city is planning to take and their financial return on investment and co-benefits. Cities can make their profile public to facilitate stakeholder and community engagement. Futureproofed Cities also has a free GHG emissions platform called Launchpad, which provides some city emissions data that can be downloaded for free through an API.
Tool strengths	◥ Aligned with the GPC and CRF. ◥ GHG emissions data is integrated into climate action planning tool. ◥ Public pages for easy communication.
Tool limitations	◥ Methodology not publicly available.

Google Environmental Insights Explorer

Tool overview	Google Environmental Insights Explorer (EIE) is a city emissions data tool developed by Google that uses Google Maps transport and building data to estimate GHG emissions data in these sectors for individual cities.
Climate journey stage	Stage 1: Establishing an emissions baseline Stage 2: Identifying specific sources of emissions Stage 3: Tracking progress over time
Countries	Global
Language	English
Accessibility	Free to use – requires city to sign up
Methodology	Google EIE estimates GHG emissions by modelling estimates of transport activity data and building footprint data based on actual measurements of traffic and buildings (the same underlying information that is made available in Google Maps) and multiplying it by emission factors from the World Bank's Climate Action for Urban Sustainability (CURB) tool. For the transport data, Google EIE estimates annual vehicle trips by mode and vehicle distance travelled for all trips in a city and multiplies this by emission factors from CURB. For the buildings data, Google EIE converts building footprint to energy use data using estimates of building energy performance from CURB. Following this, the data is converted to emissions using emission factors sourced from CURB or national-level values where available.
Documentation	https://insights.sustainability.google/methodology
Data quality	Testing modelled transport data against actual road sensor counts in cities across 10 countries. The data is not verified by a third party.
Alignment with standards and protocols	Aligned with the GPC
Emissions scopes	1, 2, 3
GHGs	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3
Sectors included	Buildings and transport (on-road, water-borne, rail)
Scopes, GHGs and sectors excluded	Sectors: transport (aviation and off-road), waste, AFOLU, IPPU.
Temporal resolution	Annual

Spatial resolution	City boundary
Tool flexibility	Limited functionality to make adjustments. Cities can update population data for 2021 and efficiency and emission factors can be adjusted in the tool. Uses Google Maps to define city boundary. City must contact Google to redefine boundary.
Latest accounting year	2021
Data updates	Annual
Units	Metric tons (tCO_2e)
Using the tool	Cities need to sign up on the website to use the tool. Users can download the data as a csv file. A small amount of data processing is needed to convert the raw transport data into the GPC or CRF format. Pick which year you want the data for. Identify which emissions scope the journeys fall into (for example, 'in-boundary' is Scope 1, whereas 'inbound' or 'outbound' is Scope 3. Following this, you can input the transport data directly into your emissions inventory. The buildings data is provided as a total for residential and a total for non-residential and is not disaggregated by scope (eg Scope 1 and 2). The energy performance data used to estimate emissions from building footprints is sourced from CURB and may vary significantly from local building energy use data. Therefore, most cities will find that local utility-provided data on building energy usage is currently more accurate than that provided by Google EIE.[7] and is recommended where available. Google EIE data only covers the transport and buildings sectors. Therefore, cities would need to combine this data with emissions data for their other sectors to develop a full, comprehensive inventory. Not aligned with GCoM CRF.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	Provides additional data on rooftop solar potential, avoided emissions estimates, co-benefits (job creation estimates)
Tool strengths	◥ Global coverage. ◥ Aligned with GPC. ◥ Provides information on journeys taken by cycling and walking.
Tool limitations	◥ Only covers transport and building sectors. ◥ Low accuracy of building energy use data. ◥ Not aligned with the CRF.

[7] ICLEI (2019) Technical Review of Google Environmental Insights Explorer Data for Local Greenhouse Gas Inventories https://www.gstatic.com/environmental-insights-team/papers/Technical_Review_of_Google_Environmental_Insights_Explorer_Data_for_Local_Greenhouse_Gas_Inventories_ICLEI-USA_August_2019.pdf

Klimaschutz-Planer

Tool overview	Klimaschutz-Planer is an online map-based tool provided by Climate Alliance, one of the world's largest city networks taking local action on climate change. The tool allows municipalities to monitor final energy consumption and GHG emissions. In addition, it incorporates climate action planning functionalities, including benchmark and scenario planning modules. The Klimaschutz-Planer was developed by Climate Alliance e.V., the Institute for Energy and Environmental Research Heidelberg, and Institute for Decentralized Energy Technologies (IdE) in collaboration with dozens of municipalities and monitoring experts. The project was funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Germany
Language	German
Accessibility	Pay to use
Methodology	The tool prioritizes using local activity data where available. Data gaps are filled in with estimates and downscaled national data. Data sources include national statistics, transport data, and census data for building age and heating type. Emissions are calculated in alignment with the BISKO municipal accounting standard for calculating energy and GHG emissions balances for municipalities in Germany.
Documentation	Tool documentation is not publicly available, but documentation of the BISKO methodology is publicly available in German language in long and short formats.
Data quality	Data quality is assessed from high to low based on whether it comes from locally measured sources or is downscaled from national datasets. The data used is not verified by a third party.
Alignment with standards and protocols	Due to missing data on a municipal level, the methodology (BISKO) used cannot be aligned with the GPC and CRF.
Emissions scopes	Not disaggregated by emissions scope.
GHGs	CO_2, CH_4, N_2O
Sectors included	Transport, private households, municipal facilities, business, trade and services, and industry
Scopes, GHGs and sectors excluded	GHGs: HFCs, PFCs, SF_6, NF_3. Sectors: waste, IPPU and AFOLU.

Temporal resolution	Annual
Spatial resolution	City boundary
Tool flexibility	The tool allows cities to adjust or improve the accuracy of the output by including their own local data where available. A minimum of municipal input is needed in order to generate an output.
Latest accounting year	2020
Data updates	Annual
Units	MWh and metric tons (tCO_2e)
Using the tool	Municipalities can access pre-populated data on population, energy consumption for travel, manufacturing and building data (age and type of heating) in the tool. The tool uses this data to estimate total emissions for each municipality. Cities can import and export data as an excel file. The data in the tool is not aligned with the GPC and CRF and not disaggregated by emissions scope, therefore the local government would need to undertake a mapping between the sectors in the tool and the GPC, including identifying the relevant emissions scopes, to be able to input the data into GPC or CRF format. Cities would need to combine this data with additional data on their waste emissions to develop a full, comprehensive inventory.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	The tool includes additional climate action scenario analysis and benchmarking functionalities.
Tool strengths	◥ Designed to provide highly significant local energy consumption and emission inventories (tool prioritizes collection of local activity data vs downscaling from national datasets). ◥ GHG emissions data is integrated into climate action planning tool. ◥ Developed and enhanced with the help and including the needs of municipal users. ◥ Interconnections with other web-based tools of Climate Alliance, eg the https://klimaschutz-praxis.de/ (Climate Alliance's platform for municipal project communication and documentation).
Tool limitations	◥ Not disaggregated by emissions scope. ◥ Not aligned with the GPC and CRF. ◥ Does not cover waste emissions. ◥ Currently only available for cities in Germany and the German-speaking Community, known since 2017 as East Belgium.

Municipal Energy and Emissions Database (MEED)

Tool overview	MEED is an online dashboard, developed by consultancies Sustainability Solutions Group and whatif? Technologies, where Canadian municipalities can view their total and per-sector energy and emissions data. This is a Beta version, and the tool is in the process of being updated.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Canada
Language	English, French
Accessibility	Free to use
Methodology	The tool estimates local municipality emissions by downscaling national and regional energy and GHG emissions data to local governments across Canada, using geospatial analysis and machine learning methods. The national and regional data is downscaled using localized data points, such as population, households, employment, weather and known large emitters. The tool integrates both bottom-up activity-based community GHG inventory data and top-down national and regional data, including waste disposal. To assess the quality of the output, the results are compared to published federal energy and emissions reports. Where there are differences, the MEED calculator assumptions are adjusted. Emissions from large industries have been allocated to the places where their employees are registered. The data sources for MEED come from: Statistics Canada; Census of Population; Business Register; Disposal of waste, by source; Index of Remoteness; Census of Agriculture; Natural Resources Canada; Comprehensive Energy Use Database (CEUD); and National Railway Network.
Documentation	https://meed.info/documents/MEED_Tech_doc_v0-1.pdf
Data quality	To assess the quality of the output, the results are compared to published federal energy and emissions reports. Where there are differences, the MEED calculator assumptions are adjusted. The data is not verified by a third party.
Alignment with standards and protocols	Aligned with GPC
Emissions scopes	1, 2
GHGs	CO_2, CH_4, N_2O

Sectors included	Transport, buildings, stationary energy sources, waste
Scopes, GHGs and sectors excluded	Scope 3. GHGs: HFCs, PFCs, SF_6, NF_3. Sectors: IPPU and AFOLU.
Temporal resolution	Annual
Spatial resolution	City boundary
Tool flexibility	No functionality to adjust the boundaries or for cities to add local data to improve the accuracy of the data. The updated version of the tool coming in 2022 is planned to include the functionality to improve the accuracy of the tool using local utility data.
Latest accounting year	2018 (soon to be updated to 2019)
Data updates	Annual
Units	Metric tons (tCO_2e)
Using the tool	To access the tool, cities need to register on the dashboard. Following this, the user can search for their city using the "Access Data" search bar. Cities can explore the data for total emissions or individual sectors on the dashboard. The tool also automatically converts the data into the GPC format online, therefore the data can be copied and pasted straight into the GPC inventory format. An upcoming update to the tool will enable municipalities to add their own local data as well as export the data to excel.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track
Additional functionalities	None
Tool strengths	◥ Aligned with the GPC format.
Tool limitations	◥ Currently no functionality for municipality to input their own local data to improve the accuracy of the output. The updated version of the tool coming in 2022 is planned to have this functionality. ◥ Currently no functionality to export the GPC report as an excel file. The updated version of the tool coming in 2022 is planned to have this functionality. ◥ Only available for municipalities in Canada.

OpenGHGMap

Tool overview	OpenGHGMap is an online map-based platform built on OpenStreetMap with total GHG emissions values for European municipalities.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Slovenia, Slovakia, Turkey, Ukraine, United Kingdom
Language	English
Accessibility	Free to use
Methodology	The tool downscales national level CO_2 emissions data (from Eurostat) to city-level by spatially disaggregating the data using OpenStreetMap, an open-source global geographical database. The data is disaggregated into nine emissions categories. Vehicle emissions are attributed across fuel stations, train emissions at stations and aviation bunker fuel emissions at airports. Industrial source emissions are located at the registered address where these emissions physically occur or are legally controlled.
Documentation	https://openghgmap.net/data/ and https://essd.copernicus.org/articles/14/845/2022/
Data quality	The dataset was compared against self-reported data from 44 European cities. There was very high agreement between the datasets, despite the different methods and timing of the city inventories. The data has been scientifically peer-reviewed.
Alignment with standards and protocols	Not aligned with GPC or GCoM CRF.
Emissions scopes	1
GHGs	CO_2
Sectors included	Transport (vehicles, airports, harbors, train stations), stationary energy (buildings), industrial facilities, farms and refineries
Scopes, GHGs and sectors excluded	Scopes 2 and 3. GHGs: CH_4, N_2O, HFCs, PFCs, SF_6, NF_3. Sectors: waste and LULUCF.
Temporal resolution	Annual

Spatial resolution	City boundary, county, and state (following the administrative levels used in each country).
Tool flexibility	No functionality for cities to input their own local emissions data. The user can switch between local authority and regional boundaries.
Latest accounting year	2018
Data updates	Unknown
Units	Metric tons (t CO_2) or metric tons per capita (t CO_2/per capita)
Using the tool	Users can access the tool on the OpenGHGMap website and navigate to their city and explore the data visually, including switching between units. To download the data, the user should navigate to the tool's "About" page where they can download an excel file of the full dataset for cities, including total emissions and emissions breakdown by sector. Please note the sectors are not aligned with the GPC or CRF so would need to be mapped against them to report the data against these protocols. The data only provides direct Scope 1 emissions and only includes CO_2. Cities would need to combine this data with other Scope 2 and 3 data and other GHG data to develop a full, comprehensive inventory.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	None
Tool strengths	◥ Publicly available, scientifically peer-reviewed methodology.
Tool limitations	◥ Only covers Scope 1 and CO_2 emissions. ◥ Not aligned with GPC or CRF. ◥ No functionality for cities to input their own local data to improve the accuracy of the output. ◥ Only available for cities in Europe.

Proxy Data Tool

Tool overview	The Proxy Data Tool is an excel-based tool developed by ICLEI Africa and COMSSA as a plug-in for the well-established City Inventory Reporting and Information System (CIRIS) tool, and provides proxy GHG emissions data for cities in Africa.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, D.R. of Congo, Djibouti, Egypt, Eswatini, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Western Sahara, Sao Tome & Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe
Language	English, French
Accessibility	Free to use (for Covenant of Mayors in Sub-Saharan Africa (CoM SSA) signatories only), available upon request from helpdesk@comssa.org or technicalhelpdesk@comssa.org
Methodology	The total emissions are calculated using census and economic data provided by the city, drawing on existing available national, regional and global data and scaling it down (using population and/or GDP depending on data inputs) to provide local-level estimates for the stationary energy, transportation, and waste sectors. Emission factors and Global Warming Potentials are sourced from IPCC data.
Documentation	https://comssa.org/resources/front/pdf/toolbox/en/2.3-CoMSSA-SEACAP-Toolbox-Use-of-Proxy-Data-for-Greenhouse-Gas-Inventories.pdf
Data quality	Data quality not assessed and data is not verified by a third party.
Alignment with standards and protocols	Aligned with GPC and CRF
Emissions scopes	1, 2 and some Scope 3 (GPC BASIC)
GHGs	CO_2, CH_4, N_2O
Sectors included	Stationary energy, transport, waste
Scopes, GHGs and sectors excluded	Scope 3 (Stationary energy and transport). GHGs: HFCs, PFCs, SF_6, NF_3. Sectors: IPPU, AFOLU.

Temporal resolution	Annual
Spatial resolution	City boundary
Tool flexibility	The tool allows cities to adjust or improve the accuracy of the output by including their own local data where available.
Latest accounting year	2019
Data updates	Unknown
Units	Metric tons (tCO_2e)
Using the tool	The Proxy Data Tool is an excel-based tool that has been integrated into C40's CIRIS tool. The tool produces an inventory report that is aligned with the GPC and CRF formats and can be downloaded as an excel file. Users are only required to enter basic census data on population and Gross Domestic Product. However, the tool allows cities to adjust or improve the accuracy of the output by including their own local data where available. Please note, due to the nature of proxy data, the results are an approximation and may not be accurate. Cities are recommended to review and update the default data utilized by the tool wherever possible. For more information on how to use the tool, please see the user guide. The Proxy Data Tool is available on request from helpdesk@comssa.org.
Import into CDP-ICLEI Track	The data from the tool can be imported into CDP-ICLEI Track (through CIRIS)
Additional functionalities	None
Tool strengths	◥ Aligned with GPC and CRF. ◥ Publicly available methodology. ◥ The inventory output from the tool can be imported into CDP-ICLEI Track (through CIRIS). ◥ Useful for providing a starting point for cities that struggle with data collection.
Tool limitations	◥ Due to the nature of proxy data, the results are an approximation and may not be accurate. Cities are recommended to review and update the default data utilized by the tool wherever possible. ◥ Only available for cities in Africa. ◥ The tool requires a certain level of familiarization with how to use it and interpret the results.

SCATTER

Tool overview	SCATTER is an online tool developed by sustainability consultant Anthesis providing GHG emissions data and climate action planning functionalities for United Kingdom local authorities.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	United Kingdom
Language	English
Accessibility	Free to use for United Kingdom local authorities
Methodology	Activity data is downscaled from United Kingdom national government statistics and multiplied together with national emission factors to calculate emissions for all United Kingdom local authorities.
Documentation	https://scatter-staging.anthesis.systems/pages/methodology/
Data quality	The data is not formally verified but SCATTER follows a quality assurance/quality control procedure on the inventory analysis.
Alignment with standards and protocols	Aligned with GPC and CRF
Emissions scopes	1, 2, and some Scope 3 subsectors
GHGs	CO_2, CH_4, N_2O
Sectors included	Stationary energy, transport, waste, AFOLU and IPPU
Scopes, GHGs and sectors excluded	GHGs: HFCs, PFCs, SF_6, NF_3.
Temporal resolution	Annual
Spatial resolution	City boundary
Tool flexibility	No functionality for cities to input their own local emissions data.
Latest accounting year	2019
Data updates	Unknown
Units	Metric tons (tCO_2e)

Using the tool	Cities can register to use the tool on the SCATTER website. From there, the pre-populated data can be exported as an excel spreadsheet in the CRF format. The output results in a baseline inventory that satisfies GCoM and is aligned with the format of the CRF.
Import into CDP-ICLEI Track	The "CDP" tab in the download allows import into CDP-ICLEI Track (Emissions summary table)
Additional functionalities	Provides additional functionalities to model carbon reduction pathways to help local authorities plan their climate action.
Tool strengths	◥ Aligned with GPC and CRF. ◥ Publicly available methodology. ◥ Does not require data input or resource efforts from users. ◥ Provides a comprehensive inventory across most scopes and sectors. ◥ GHG emissions data is integrated into carbon reduction pathways planning tool.
Tool limitations	◥ No functionality for cities to input their own local data to improve the accuracy of the output. ◥ Only available for local authorities in United Kingdom.

SEEG (System for Estimating Greenhouse Gas Emissions)

Tool overview	SEEG is an online platform developed by Brazilian civil society initiative the Climate Observatory that provides GHG emissions data at national, regional and municipal levels in Brazil. The tool provides cities with total emissions for the agriculture, energy, land use change, industrial processes and waste sectors.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Brazil
Language	Portuguese
Accessibility	Free to use.
Methodology	SEEG emissions data is generated by multiplying activity data with emission factors, based on the methodology of the Brazilian Inventories of Anthropogenic Greenhouse Gas Emissions and Removals prepared by the Ministry of Science, Technology and Innovation (MCTI). Data is sourced from government reports, institutes, research centers, sector entities and non-governmental. Emissions data is allocated down to municipal level using municipal activity data where available, and national data where local data is not available.
Documentation	http://seeg.eco.br/notas-metodologicas
Data quality	To assess the quality of the methodology and the data generated by SEEG, the methodology is peer-reviewed by members of the Climate Observatory and other organizations on an annual basis. The data is also compared with the national Brazilian Inventory, published by the Ministry of Science, Technology and Innovation. There is less than 7% difference in total emissions between the two datasets. The data has been scientifically peer-reviewed.
Alignment with standards and protocols	Not aligned with GPC or CRF.
Emissions scopes	Emissions not disaggregated by scope.
GHGs	CO_2, CH_4, N_2O and HFCs
Sectors included	Stationary energy, transport, waste, AFOLU, IPPU.
Scopes, GHGs and sectors excluded	GHGs: PFCs, SF_6, NF_3.
Temporal resolution	Annual

Spatial resolution	City boundary
Tool flexibility	No functionality for cities to input their own local emissions data or to redefine their boundary.
Latest accounting year	2019
Data updates	Annual
Units	Metric tons (tCO_2e)
Using the tool	SEEG's municipality data can be accessed via the tool's digital platform. You can search for your city using the search box or by navigating using the map. Here you can view the data directly or download the complete municipality database as an excel file. The activity data used in the calculations is also available through the platform and it is possible to access infographics about the emissions of each sector, methodological notes that explain in detail how the data collection and production are performed and an evaluation of data quality. The sectors are not aligned with the GPC or CRF so would need to be mapped against them in order to report the data against these protocols.
Import into CDP-ICLEI Track	Currently no functionality to import data into CDP-ICLEI Track.
Additional functionalities	None
Tool strengths	◥ Publicly available, scientifically peer-reviewed methodology. ◥ The tool also provides emissions data for states and regions. ◥ The emissions for individual cities add up to the national level emissions for Brazil, enabling cities to directly compare with neighboring cities and assess their contribution to Brazil's NDC.
Tool limitations	◥ Not aligned with GPC or CRF. ◥ Emissions not disaggregated by scope. ◥ No functionality for cities to input their own local data to improve the accuracy of the output. ◥ Only available for cities in Brazil.

Snapshot

Tool overview	Snapshot is a collaboration between environmental consultancy Ironbark Sustainability and climate think tank Beyond Zero Emissions to develop GHG emission profiles for all municipalities and states in Australia.
Climate journey stage	Stage 1: Establishing an emissions baseline
Countries	Australia
Language	English
Accessibility	Free for summary data, pay for detailed activity and emissions data.
Methodology	Snapshot emissions data is a combination of modelled and local-sourced data. The modelled data is downscaled from global, national and state-level activity data to municipality level using relevant scaling metrics, including population, number of households and number of businesses. Local-sourced data is derived from a range of original data generator sources and converted to emissions using global, national and state-level emission factors. Since 2020, the tool integrates transport activity data from Google Environmental Insights Explorer for some municipalities, combining it with national datasets and converting it to emissions using conversion and emission factors.
Documentation	TBD
Data quality	Data quality is not currently assessed. Snapshot data, methodology, and calculations have been independently verified and endorsed by ICLEI Oceania, Sustainability Victoria, and Renew.
Alignment with standards and protocols	Aligned with the GPC and CRF.
Emissions scopes	1, 2, 3
GHGs	CO_2, CH_4, N_2O
Sectors included	Stationary energy, transport, waste, AFOLU, IPPU
Scopes, GHGs and sectors excluded	GHGs: HFCs, PFCs, SF_6, NF_3. Sectors: some fugitive emissions, water-based transport, other solid waste, some AFOLU sub-sectors
Temporal resolution	Annual
Spatial resolution	City boundary

Tool flexibility	Some local data from individual municipalities has been integrated into the Snapshot emissions profiles. This is assessed on a case-by-case basis. Contact Snapshot for more information.
Latest accounting year	2020-2021
Data updates	Annual
Units	Metric tons (tCO_2e)
Using the tool	Cities can view their local emissions profiles by visiting the Snapshot website. Cities can access a webpage report of their total and sectoral breakdown of emissions free of charge by searching for their municipality or state. To download a PDF version of the report, cities must sign up, free of charge, to Snapshot. Snapshot also provides the data in an excel file in CRF format which can be imported into CDP-ICLEI Track. Cities need to pay to access this excel-based output. The excel output results in a baseline inventory that satisfies GCoM and is aligned with the format of the CRF.
Import into CDP-ICLEI Track	Data from tool can be imported into CDP-ICLEI Track
Additional functionalities	None
Tool strengths	◥ Aligned with GPC and CRF. ◥ Publicly available methodology. ◥ Provides emissions data for states and regions as well as cities. ◥ The emissions for individual cities add up to the national level emissions for Australia enabling cities to directly compare with neighboring cities and assess their contribution to Australia's NDC. ◥ The inventory output from the tool can be imported into CDP-ICLEI Track.
Tool limitations	◥ Only available for local governments in Australia.

Conclusions and future directions

There are many GHG emissions tools and datasets that can help cities that are facing barriers to measuring their emissions get started with developing an inventory or filling in data gaps. These tools have different strengths and limitations and have varying applicability, depending on where the city is on its climate action journey and its geographic location.

Opportunities from these datasets

- The majority of these tools can provide cities with a comprehensive GHG emissions inventory, enabling them to understand their highest emitting sectors, and get started with planning their climate action.
- Many of these tools have a functionality for cities to add their own local data and increase the accuracy of the outputs.
- Several of the tools are aligned with the GPC and CRF global accounting and reporting standards, making it easy for cities to benchmark themselves against other cities and to report their data. Some of the tools enable direct import into CDP-ICLEI Track, reducing the reporting burden for cities.
- Most of the tools provide recent emissions data (since 2018) and are regularly updated.
- The higher spatial and temporal resolution datasets present exciting opportunities for cities to get a better understanding of activities and behavior within their boundaries to help them fine-tune climate action policies.

Limitations and suggestions for future directions

- Many of these tools were not designed for city GHG emissions accounting as the primary purpose (but are now being adapted to be used for this purpose), which is why they are not aligned with the GPC or CRF, or don't include Scope 2.
- Global coverage is still limited, at least for the higher temporal and spatial data, and data gaps disproportionately impact cities in the Global South. Therefore, many of these tools will not be useful for cities in countries that have limited data availability and need it most.
- There remains an issue of some existing emissions data being held by other stakeholders and not easily accessible to cities or these tools and datasets. There is a need for greater data transparency and accountability to advance local climate action.
- Many of the tools and datasets are only available in English. Increased availability of tools in other languages is critical for improving accessibility for many cities.
- Some of the tools are not well documented or the methodologies are hidden behind paywalls, impacting the transparency of the data approaches.
- More work is needed to understand how emissions data from different sources and using different methodologies can be meaningfully combined into a single inventory for city use.
- Some of the more complex academic datasets are not currently in a user-friendly format (for example, the data must be downloaded in bulk and may not be easily converted into a city reporting standard, such as the CRF).
- Tracking emissions change over time is still not something that many tools can do in a comprehensive way. This is because most of the tools do not use local data, which is needed to robustly track progress over time and see the impacts of city policies.

The impacts of local climate action are less, or not, visible in datasets that are scaled down from national-level data.

- Although consumption-based emissions tools were not within the scope of this report, there is a need for better and more standardized approaches to measuring consumption-based emissions for cities. This will enable consumption-heavy cities to obtain a proper understanding of the emissions that they account for.
- However, most of these tools are in continual development, meaning that geographic scope, data availability, and data access is likely to expand and improve over the next few years, enhancing cities' abilities to measure and track their emissions.

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For more information about annual disclosure, please visit the Cities page on our website. If you have any questions, visit the CDP Help Center Home - CDP Help Center.

Declaration of competing interests
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