ACCELERATING CITY CLIMATE ACTION
THROUGH GEOSPATIAL DATA

GLOBAL COVENANT of MAYORS for CLIMATE & ENERGY

World Geospatial Industry Council

Developed with contributions from members of the GCoM Research and Innovation Technical Working Group (R+I-TWG) - Tools Subcommittee

The Joint Research Centre –
the European Commission's
science and knowledge service

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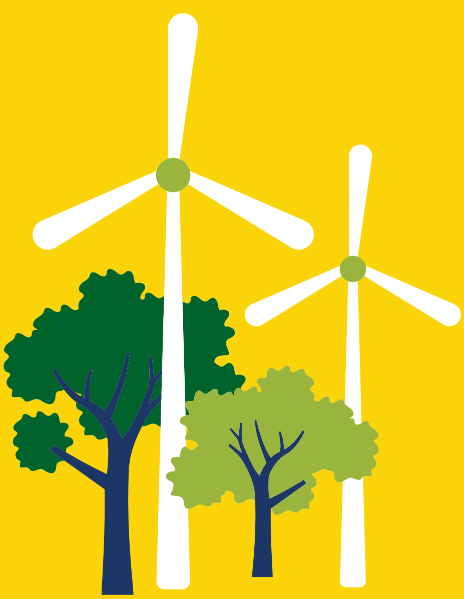
Executive Summary

Data and tools play an enabling role in climate action for cities, as they provide the evidence base that cities need to build up resilience, reduce their greenhouse gas (GHG) emissions and support the identification, delivery and tracking of priority actions and progress over time. The geospatial industry encompasses a range of technologies, including data, software, hardware, analysis and services that can be utilized to support cities in their climate action journey.



The collection of geospatial industry capabilities and brief analysis of city needs highlights three areas of action moving forward, to be pursued with the integration of regional perspectives:

(1) prioritize the application of geospatial data at the city scale for Climate Risk and Vulnerability Assessments (CRVAs) and Greenhouse Gas Emissions Inventories (GHGIs);

(2) explore the application of geospatial solutions to urban demonstrations; and

(3) advance the implementation of city climate action monitoring and evaluation processes and leverage geospatial data and solutions.

The Global Covenant of Mayors for Climate & Energy (GCoM) and World Geospatial Industry Council (WGIC) aim to collectively highlight the potential for applied geospatial technology in cities today and the scale at which emissions reduction, resilience, mitigation and energy action can be achieved through data-driven collaboration.

Data for City Climate Action: A Persistent Challenge

Climate-related risks, hazards, and disasters are intensifying and becoming more frequent, and the window for a 1.5°C future is rapidly closing. At the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28), UN Secretary-General Antonio Guterres highlighted that "we are living through climate collapse in real-time - and the impact is devastating."[1]

Demographic shifts, technological transformations, and budgetary constraints already have cities and local governments under mounting strain, breeding uncertainty and placing ever-greater pressure on city administrations to answer increasingly complex challenges and make short- and long-term decisions.

Achieving drastic emissions reduction and resilience measures needed to avoid the devastating impacts of climate change requires efficient planning and meticulous action from all levels of the government and sections of society. This requires leveraging the role of cities as agile implementers who can be supported and resourced with data, tools, and partnerships to achieve national mitigation and adaptation goals at scale.

Delivering fit-for-purpose data and tools at city scale, especially for those with limited capacity and resources to progress through their climate action journeys, continues to be challenging. Select examples of national and regional collaboration with local governments have emerged[2].

1 United Nations Regional Information Centre for Western Europe (2024), Climate: Highlights of COP28. Accessed 05/02/2024. [https://unric.org/en/climate-highlights-of-cop28/]

2 GCOM (2021), The multilevel climate action playbook for local & regional governments. https://www.globalcovenantofmayors.org/press/the-multilevel-climate-action-playbook-for-local-and-regional-governments/

Still, several gaps in understanding emission footprints and risk and hazard profiles remain, hampering climate action progress. COP28 sent a strong signal for intragovernmental collaboration through the launch of the Coalition for High Ambition Multilevel Partnerships (CHAMP) - now amassing more than 70 national government endorsements - which is expected to develop and foster channels for cooperation in the coming years.

Data and tools have proven to be of significant value in enabling local and regional governments to take climate action[3]. In a 2020 global survey of nearly 300 cities, respondents who used data and information in their climate action journey were 2.5 times more likely to be in the implementation stages – suggesting that data plays a crucial role in enabling city progress towards climate action implementation.

This is especially true in providing data to build a greenhouse gas (GHG) emissions inventory: a critical need that remains incomplete today for many cities globally but can be met by applying data and tools[4]. Unlocking proxy emissions data equitably, especially for cities and local governments who face severe capacity constraints and barriers to accessing data and tools, can activate a tide of city climate action momentum.

Making tools easier to use and data more accessible can provide necessary and scalable support to cities with different capacities and/or at various stages of their climate action journey, in part by taking into account regional differences and specific needs.

While there is no one-size-fits-all approach to climate policy, the steps needed to take evidence-based and impactful action can be represented through a city climate action journey **(Figure 1)**[5].

This journey aligns the steps cities take in their climate action planning and implementation process with available data, tools and resources - while remaining open to additional priorities and policy domains in which local governments remain engaged. The journey begins with the initial stage of committing to implementation from the perspective of each of the three GCoM pillars of GHG reduction, adaptation to climate change, and increasing access to clean and affordable energy.

Figure 1: City climate action journey. *Source: GCoM*

3 *ICLEI, C40 (2018), Data speak louder than words: Findings from an initial stocktake of climate change adaptation and urban resilience efforts.* https://shorturl.at/lyHIS

4 *GCOM, Bloomberg Associates and WRI (2021), Understanding data and tools to accelerate city climate action. A Decision-making and Tools Project White Paper* https://shorturl.at/byET4

5 https://www.globalcovenantofmayors.org/journey/

A landscape assessment conducted by GCoM and the World Resources Institute (WRI) highlighted key deliverables at each stage of the climate action journey needed to progress towards mitigation action implementation[6]. These deliverables, part of a broader set of 75 identified city needs[7], are enumerated in **Table 1.**

City Climate Action Journey Step	Assess	Set Goals & Targets	Develop Action Plan	Implement	Monitor & Report
Deliverables	— GHG emissions inventory — Climate risk and vulnerability assessment — Climate action capacity assessment	— Expected policy and project benefits - including non-climate and equity — Scenario outputs — Cost-benefit analysis	— Climate action plan — Priority actions list	— Engaged community and local businesses — Multilevel governance mobilization and coordination — Dedicated funding streams — Policy frameworks for accountability — Regulations, policies, and ordinances to advance climate action	— Realized policy and project impacts - including non-climate and equity — Policy refinements

Table 1: Key deliverables at each stage of the climate action journey needed to progress towards mitigation action implementation.
Source: GCoM and WRI

These findings unlocked a shared language between cities, local governments, and data and tools providers, opening opportunities for collaboration grounded in the use of diverse datasets and tools that can accelerate progress across the city climate action journey.

Crucially, this work delivered three compelling insights from the perspective of city-scale data:

✔ Proxy data[8] is (still) required to help cities and local governments accelerate their climate action planning without expending excessive time and resources on data gathering

✔ Cities and local governments stand to benefit significantly from more robust interoperability among tools that support collaboration across departments, functional domains, and sectors

✔ There is both appetite and room for improvement in the communication of city-scale data, both within government departments and across communities

Meeting these local needs will be crucial to enabling the 13,000+ cities and local governments globally to take meaningful climate and energy action and, equipped with the right support, help realize the increasingly ambitious commitments of their respective national governments.

6 *The white paper focused solely on mitigation, further analysis needed to identify parallel needs for adaptation and resilience.*
7 *Annexure I: Cities Need - Decision-making and Tools White Paper.*
8 *https://www.eea.europa.eu/help/glossary/eea-glossary/proxy-indicator*

Geospatial Data: A Key Piece of the Puzzle

One significant answer to this challenge lies in geospatial data and technology, which are crucial in understanding and addressing climate change. Geospatial data is data about objects, events, or phenomena that have a location on the surface of the Earth. The location may be static in the short-term (e.g., the location of a road, an earthquake event, children living in poverty) or dynamic (e.g., a moving vehicle or pedestrian, the spread of an infectious disease).

Geospatial data combines location information (usually coordinates on the Earth), attribute information (the characteristics of the object, event, or phenomena concerned), and often also temporal information (the time or life span at which the location and attributes exist)[9].

The geospatial industry is engaged in the collection and visualization of data related to Earth's features, such as land, water, and atmospheric conditions, as well as man-made features, obtained through underground, land-based, airborne and space-based sensors.

This data is foundational for geospatial technology. Massive volumes of legacy and current data, raw and processed data, underpin a multitude of value-added data products, software services, AI-powered analytics and modelling developed by the geospatial industry. Further, the sector provides solutions that can be utilized to support cities in numerous ways, including their climate action journeys.

With the proliferation of sensor technologies, new data providers and data sources have emerged, and the amount of data collected worldwide has multiplied exponentially.

Remotely sensed data in a broad range of spatial, spectral, radiometric and temporal resolutions are available today, collected using a variety of sensors, including electro-optical, thermal, or infrared, LiDAR (Light Detection and Ranging), SAR (Synthetic Aperture Radar) and HSI (hyper-spectral imagery) sensors.

Satellites (spanning a wide range of sizes, individual or constellation), crewed and uncrewed aerial vehicles, marine vessels, and even land-based vehicles are used to house these sensors and collect data, useful for a wide variety of applications and advantages contingent on the resolution of the data.

Types of data are also wide-ranging: from multispectral high-resolution imagery of the Earth to point cloud data that is neither cloud nor weather dependent. Innovative commercial systems that can detect heat emissions, small plumes of greenhouse gasses, or the health of seafloor grasses are emerging in the market. As the lifecycle of technology and innovation becomes ever shorter and new data products, services, and solutions become available, city governments can avail themselves of a rapidly evolving list of options to meet their unique needs.

9 https://www.sciencedirect.com/topics/computer-science/geospatial-data

Below is a sample of currently available geospatial technologies that can address climate-related challenges:

GHGSat specializes in detecting greenhouse gas emissions. Established in 2011, GHGSat operates a constellation of satellites as well as aircraft-based sensors that routinely perform facility-level methane monitoring across the world, providing data needed to empower better environmental decisions by governments, industries and communities.

The company pioneered the measurements of greenhouse gasses directly from individual industrial facilities using satellites. GHGSat currently has 12 satellites in orbit, one of which detects CO2, and they expect to launch another four in the coming year.

Figure 2: GHGSat-C10 'Vanguard', the world's first commercial high-resolution CO2 satellite. *Source: GHGSat*

Each GHGSat satellite has an advanced methane sensor with a spatial resolution of less than 30 meters and a 100 kg/hr detection threshold. GHGSat partners with and integrates data from public entities such as the European Space Agency (ESA) to complement its data. Overlaying GHGSat's high-resolution imagery with the broad-coverage, coarser resolution data from ESA helps guide researchers in identifying methane hotspots. GHGSat satellites routinely measure emissions from oil and gas facilities, waste management sites, coal mines, and agricultural activities.

Thermal Infrared (IR) imagery is a recognized tool for assessing the impacts caused by higher energy consumption due to the rapid growth of the built environment and urban infrastructure. According to the International Energy Agency, 28% of the world's CO2 emissions in 2019 were due to the energy consumed in buildings.

While IR imagery is an excellent source for detecting urban heat islands and evaluating the thermal performance of buildings (or detecting their defects), the collection of high-resolution IR imagery has traditionally been limited to aerial or drone surveys. But a new start-up, SatVu, recently launched the world's first commercially available high-resolution infrared imaging satellite, HotSat-1.

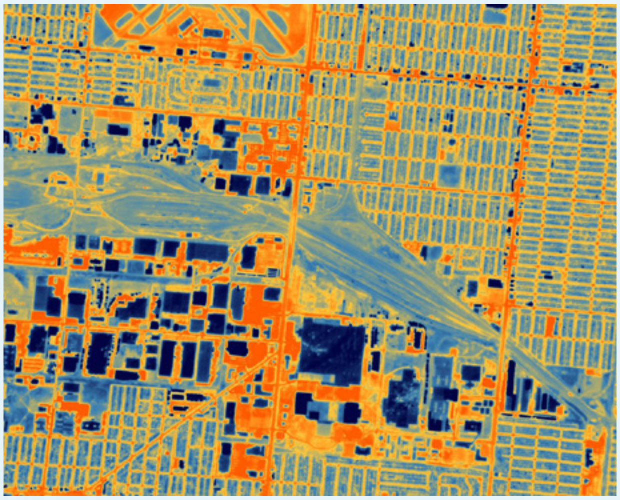


Figure 3: *High-resolution infrared imagery of Chicago captured to monitor rail logistics.*

This space-based solution, which will eventually grow to an eight-satellite constellation, now allows governments to more cost-effectively and routinely map and measure temperatures at very high resolution (3.5m), day or night, over any place on the globe.

Commercially available satellite earth observation imagery has become increasingly sophisticated in the last two decades, with increasingly higher resolution, multispectral imagery that can detect items as small as 15 centimeters from space. Two example companies include Maxar and Planet.

Maxar updates 6,000 cities annually-to-every two years at resolutions of 30-50 cm and has collected 1.8 billion square kilometers of imagery at 50 cm. Planet is building out the largest constellation of commercial Earth observation satellites in history, a small-sat constellation with roughly 200 satellites with three-meter resolution and 21 satellites with 0.5m resolution.

It is currently finalizing work on a constellation of hyperspectral satellites that can detect methane and other gasses from space and a very high resolution 0.3m fleet. Planet has one of the highest frequencies of satellite data commercially available, and their data set powers decision-making in sectors such as agriculture, forestry, mapping, and government.

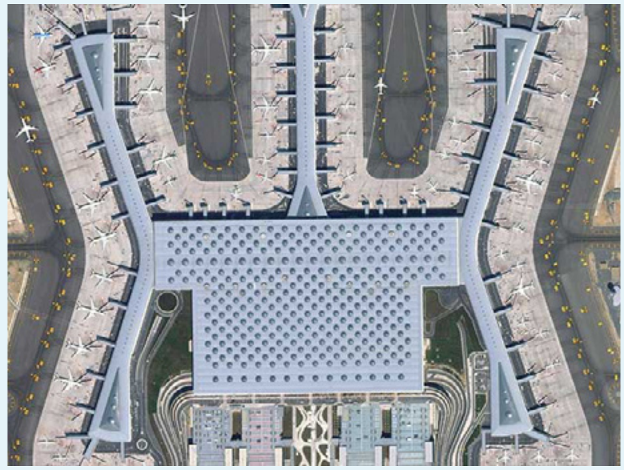


Figure 4: Satellite imagery provides foundational context and visualization of ground conditions. *Source: Maxar*

Acquiring geospatial data is the first step: A foundation of information that can be layered over pre-existing data or added to new information. However, standalone data is only part of the equation. Extracting deeper insights requires analytical models and applications to identify patterns, create predictive modeling, and formulate adaptive responses. Part of the challenge cities confront today, in addition to acquiring the most pertinent available geospatial information, is how to most effectively and quickly analyze and interpret the mountain of data at its fingertips.

The geospatial industry provides many customer-focused solutions, including an evolving range of software and analysis tools that use human expertise and artificial intelligence (AI)/machine learning (ML). Cities need the tools to support, organize and distribute incoming data; they need data and solutions that can be easily shared across multiple platforms, stakeholders and users.

Data infrastructure is often shared between city architects, engineers and planners to maximize the success and efficiency of a project; with citizens to create transparency, buy-in and support; with policymakers, government officials, nonprofits and financial institutions to demonstrate budgetary needs, and to make complex data understandable to audiences ranging from climate experts to non-experts. Specialized software applications help users access, visualize, manipulate and engage in spatial analysis and maximize data-driven decisions.

Monitoring air and greenspace quality in Riga

People living in cities are increasingly exposed to environmental stresses, such as air pollution and heat stress. Nature-based Solutions (NbS) in urban environments can provide cooling effects, decrease air pollution, and improve mental health, amongst other essential ecosystem services and health-related benefits.

However, public authorities still face considerable data gaps and lack circular open data ecosystems to implement NbS, support climate adaptation measures, and drive urban transitions. In this context, the Urban ReLeaf project delivers change by bringing public authorities and local communities together to shape green infrastructure actions in their cities.

Six pilot cities co-create citizen-centric innovations to democratize urban greenspace monitoring and the broader policy-making process in pursuit of urban climate resilience. One pilot city, Riga, engages diverse audiences to address air pollution and green space usage concerns to ensure better-informed policies.

The Riga Planning Region, the city of Riga's digital agency, and local communities are joining forces to deploy low-cost air quality monitors to collect temporal, hyperlocal, and geospatial data on pollutants such as Particulate Matterw (PM2.5).

This network of affordable monitors, which covers both high-traffic areas and urban greenspaces, offers an efficient means of acquiring real-time data on PM2.5 to identify pollution hotspots and implement targeted interventions.

Additionally, Riga plans to engage its citizens through mobile applications to assess its greenspaces better and stimulate dialogues between communities and policymakers.

These various data streams contribute to a data ecosystem that will be openly accessible via GeoRiga, the city's geospatial information system, for the implementation of key policies such as the Riga Sustainable Development Strategy for 2030 and the Riga City Energy and Climate Action Plan 2022-2030.

The Data Geospatial Industry Wields Today

By integrating geospatial data with climate data, cities can gain valuable insights into climate change and develop effective strategies to mitigate its impacts.

Geospatial technology is used for climate change via:

Digital Twins and Modeling:

A digital twin is a virtual representation or 'mirror' of a real-world, or proposed, physical feature or process, where the digital counterpart may replicate and/or mimic characteristics of the actual physical item. It can be used for simulation, integration, testing, monitoring or maintenance, saving time and energy, and improving product or process quality. The digital twin may even exist before there is a physical entity, allowing the intended entity's entire lifecycle to be modeled and simulated.

As described in WGIC's 2022 policy report, Spatial Digital Twins: Global Status, Opportunities, and the Way Forward, these twins "include a specific spatial context and provide a holistic dimensional and location-based representation of assets, infrastructure and systems... Spatial Digital Twins can cover buildings, clusters of buildings or other infrastructure, entire networks, cities, countries and even the globe."

Figure 5: Geographical Information Systems (GIS) is the foundation for digital twins. *Source: Esri*

By understanding and predicting the physical counterpart's performance or process, digital twins can provide feedback about the condition and performance of real-life objects. Using geospatial tools, we can overlay multiple information layers onto maps or databases to create a richer understanding of climate change in urban and rural areas. We may determine the density of buildings or the materials used in their construction, pollution levels, traffic flow and congestion, greenhouse gas emissions, tree inventory, energy consumption and others. AI and ML can be used as predictive simulation tools to predict the probable impacts of storm surge or sea-level rise on flooding, erosion, or run-off from construction or impervious material into waterways. Geospatial data, climate sensors and topographic information can be combined to create climate models that simulate future scenarios. These models help researchers understand the complex interactions between the atmosphere, oceans, land, and ice and predict changes in temperature, precipitation patterns, sea level rise, and other climate variables.

Geographic Information Systems (GIS)

GIS, or a geographic information system, is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there). This provides a foundation for mapping and analysis used in every industry. GIS helps understand patterns, relationships, and geographic context.[10]

A city GIS can be highly potent to track and analyze the plethora of data and information with which cities work. The software and analytic tools are integral to project management, keeping stakeholders connected and improving communication, information sharing and efficiency. GIS is an effective decision-making and management system to improve transparency and productivity.

Renewable Energy Sources

Research from the Coalition for Urban Transitions highlights that today's technically feasible low-carbon measures could reduce emissions by nearly 90% by 2050 - a substantial portion of that featuring decentralized renewable energy[11]. Diversifying non-carbon energy sources is critical to achieving these goals, and governments will need to combine multiple renewable sources to generate enough low-carbon energy, including solar, wind, geothermal, hydropower, and hydrogen, to power the world.

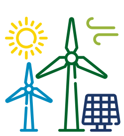
Geospatial analysis assists in identifying suitable locations for renewable energy projects, such as wind farms, solar installations, and hydroelectric plants. By considering factors like solar radiation, wind speed, topography, and land use, geospatial tools optimize the placement of these projects, enhancing energy generation capacity and reducing reliance on fossil fuels.

Risks and Vulnerabilities, Resource Management

Geospatial analysis helps identify regions and communities most vulnerable to climate change impacts, such as coastal areas prone to sea-level rise or drought-prone regions. It aids in mapping critical infrastructure, population distribution, and natural resources to assess their exposure and vulnerability. This information supports the development of adaptation plans, including land-use planning, water resource management, and disaster risk reduction strategies.

Geospatial technology also enables continuous monitoring and assessment of these climate-related parameters. It provides real-time data on land cover changes, deforestation, glacier melting, sea ice extent, and carbon dioxide emissions. This information helps track the extent and rate of climate change and assess its impacts on ecosystems, biodiversity, and vulnerable communities.

Natural resource management may include using geospatial technology to monitor and manage forests, wetlands, coastal zones, and water resources, ensuring their conservation and sustainability. Additionally, it supports activities such as forest carbon monitoring, biodiversity mapping, water resource planning, and ecosystem restoration.



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10 https://www.esri.com/en-us/what-is-gis/overview

11 Coalition for Urban Transitions. 2019. Climate Emergency, Urban Opportunity. World Resources Institute (WRI) Ross Center for Sustainable Cities and C40 Cities Climate Leadership Group. London and Washington, DC. Available from: https://urbantransitions.global/urban-opportunity/

Greenhouse Gas Emissions

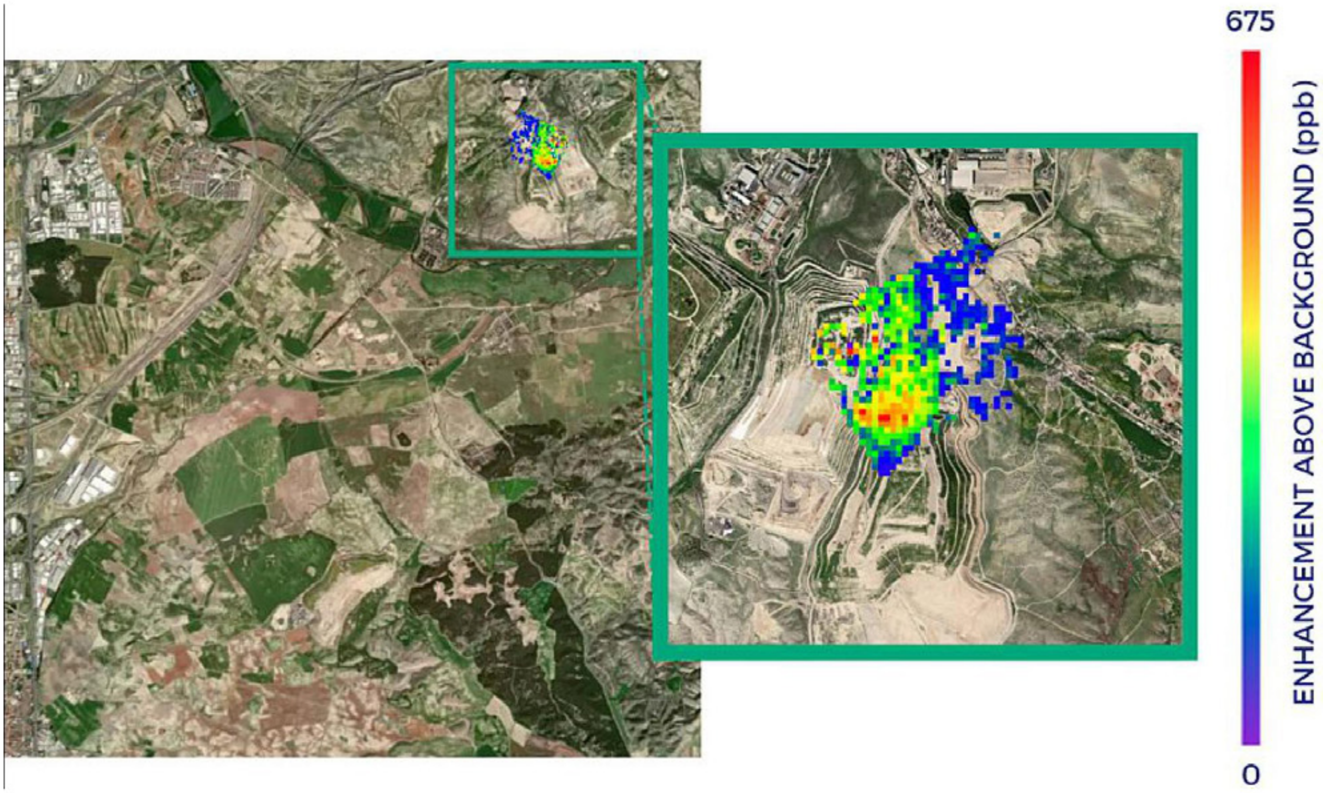

Figure 6: Methane emissions detected from Madrid landfill in August 2021. *Source: GHGSat*

Geospatial tools contribute to monitoring greenhouse gas emissions from various sources. Combining data from satellites, aerial surveys, and ground-based sensors makes it possible to estimate emissions from industrial facilities, landfills, power plants, transportation networks, and deforestation activities. Geospatial technology helps create emission inventories, track emission trends, and evaluate the effectiveness of mitigation efforts.

Researchers increasingly depend on satellite data that detect leaks to quantify and address methane emissions, a potent greenhouse gas and vital component of climate change. Methane is the second largest contributor to climate warming after carbon dioxide. Methane is 80 times more powerful than carbon dioxide in its planet-warming potential in a 20-year span, and curbing methane emissions is one of the most effective ways to slow climate change. On a local scale, mitigating methane emissions can help safeguard public health and address environmental justice goals by reducing the formation of smog and air pollution.

Transportation and Mobility

Effective and precise traffic monitoring can help cities manage the number of vehicles on their roadways as well as estimate and manage CO_2 emissions. Understanding current congestion patterns, timing, and location of traffic can assist cities in their emission mitigation programs and future infrastructure planning. Acquiring detailed data and analytic tools allows cities to develop more sustainable transportation options, including mass transit bike and pedestrian-friendly alternatives that reduce a city's carbon footprint.

These geospatial solution types were created for the matrix analysis of this paper and are by no means an exhaustive catalog of geospatial solutions. This is a sample compilation of the advanced solutions within WGIC membership.

The Data and Tools Cities Need Today

Data and tools provide the evidence base cities need to develop a climate action plan[12] to build resilience, reduce their greenhouse gas (GHG) emissions and support the identification, delivery and tracking of priority actions and progress over time.

There are four critical deliverables in a city's climate action journey, where data becomes an enabler to moving faster and further: At the "assess impacts and risks" stage, (1) developing a GHG Inventory and (2) developing Climate Risk and Vulnerability Assessment; at the "set goals and targets" step, (3) modeling information to build scenarios and support the decision-making process; and at the "monitor and report" step, (4) supporting the monitoring of the impact of the actions that were selected as part of the climate action plan.

A **Greenhouse Gas Emissions Inventory (GHGI)** takes stock of all the GHG emissions induced by a city, intending to mitigate these emissions and enable tracking changes in emissions over time. GHGIs help inform decision-making in the city, highlighting priority areas for action, monitoring progress and providing the information to allow communication on progress towards reducing GHG emissions. A GHGI is an important evidence base across all the climate action journeys. GHGIs are the most established element of climate action planning and are most frequently reported by cities.

According to the Global Covenant of Mayors' Common Reporting Framework, signatories are required to report GHG emissions from at least three main sectors - namely stationary energy, transportation, and waste and may also report GHG emissions from Industrial Processes and Product Use (IPPU) and Agriculture, Forestry and Other Land Use (AFOLU) sectors - where the emissions are significant. Additionally, they may report GHG emissions from upstream activities, such as material extraction or other out-of-boundary sources.

A **Climate Risk and Vulnerability Assessment (CRVA)** is the framework by which the probability, frequency, intensity, timescale and spatial distribution of significant climate hazards affecting a city both currently and in the future are assessed. Additionally, the CRVA provides a framework to understand the current and potential impacts, and the consequences thereof, of identified climate hazards on city sectors, systems, and population groups, as well as their capacity to adapt.

Building on the evidence base, cities need to **model** scenarios for climate action with budget estimates, expected policy and project benefits, non-climate benefits, cost-benefit analysis, and pre-feasibility studies to identify actions and prioritize those that will have the most significant impact.

A **Climate Action Plan (CAP)** is a strategic roadmap developed by local governments to guide their response to address the challenges presented by climate change. CAPs are designed to aid decision-making, guide policy formulation and implementation, engage stakeholders, allocate resources effectively, and establish a long-term vision for mitigating emissions and adapting to the effects of climate change. In doing so, CAPs should enable cities to proactively address both local sources of GHG emissions and prominent climate hazards. By adopting CAPs, cities can demonstrate global leadership in combatting climate change while considering local contexts and priorities.

12 GCOM (2023), Common Reporting Framework. https://www.globalcovenantofmayors.org/wp-content/uploads/2023/11/CRF7-0-2023-09-14-final.pdf

Prioritizing Actionable Geospatial Data for Local Climate Planning

Understanding the data needs of cities in the context of their climate action journeys alongside the datasets, tools, and solutions being developed across the geospatial community suggests a pressing demand that can be met through impactful public and private partnerships.

Crucially - and against a backdrop of limited resources and time - it is vital to identify which needs and solutions can be realized today and those which may require additional research and development before being deployed at the local level. GCoM and WGIC have begun to prioritize actionable geospatial data for use in the city climate action journey[13], as enumerated in **Table 2**. These insights highlight which city climate deliverables can be supported by ready geospatial data and tools today, while also pointing towards gaps in the action journey that can potentially be addressed through further local capacity and/or geospatial data readiness.

Complemented by a rich tapestry of case studies, WGIC and GCoM aim to collectively highlight the potential for applied geospatial technology in cities today, the opportunity for public-private partnerships (PPPs), and the scale at which emissions reduction, resilience, and energy action can be achieved through data-driven collaboration.

13 Deliverables for each step taken from the Decision-making and Tools White Paper

Table 2: City climate action journey steps. *Source: GCoM and WGIC*

City Climate Action Journey Steps										
		Assess Impacts and Risks			Set Goals and Targets	Implement	Develop Actions and Adaptation Strategy			Monitor and Report
		GHG Inventory	Risk Studies	Capacity Assessment	Modeling Information	Funding, Regulation, and Engagement	Expected Benefits	Cost-benefit Analysis	Priority Actions	Project Impacts
Geospatial Solution Types	Digital Twins and Modeling	Not yet applicable	Can be applied today	Not relevant	Can be applied today	Can be applied today	Can be applied today	Can be applied today	Can be applied today	Not yet applicable
	Geographic Information System	Not relevant	Can be applied today	Can be applied today	Can be applied today	Can be applied today	Not relevant	Can be applied today	Can be applied today	Can be applied today
	Risks and Vulnerabilities, Resource Management	Not relevant	Can be applied today	Not relevant	Not relevant	Can be applied today	Not relevant	Can be applied today	Can be applied today	Can be applied today
	Renewable Energy Sources	Can be applied today	Can be applied today	Not relevant	Not yet applicable	Not relevant	Not relevant	Can be applied today	Can be applied today	Not yet applicable
	Greenhouse Gas Emissions	Can be applied today	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Can be applied today	Not yet applicable	Not yet applicable
	Transportation and Mobility	Can be applied today	Not relevant	Not relevant	Can be applied today	Can be applied today	Can be applied today	Can be applied today	Can be applied today	Can be applied today

LEGEND

- Can be applied today
- Not yet applicable, needs further local capacity/technological investments
- Not relevant

Conclusion

The city climate action journey depends upon data and tools that enable well-informed decision-making and feed action implementation, significantly reduce the data collection and technical capacity burden on local governments, and provide a foundation for climate risk and energy coordination across levels of government. These data and solution-driven advances should also align with recommendations from the High-Level Expert Group on Net-Zero Commitments, whose Integrity Matters report highlights that accountability, transparency, and integrity in the data cities use across their climate pledges are critical to ensure science- and evidence-based action.

Previous research has highlighted how proxy data can help advance evidence-based climate action in cities - especially in capacity- and resource-constrained contexts. In particular, geospatial technologies offer valuable insights into climate change processes, with the potential to support the development of mitigation and adaptation plans that aid local government decision-making. Using geospatial data and tools enables cities to assess their vulnerability to climate risks, enhance monitoring capabilities and assist in planning and implementing climate change adaptation and mitigation measures.

In recent times, the geospatial industry landscape has changed drastically. The proliferation of new companies, data and technologies, such as AI and ML, has disrupted the old way of mapping cities and collecting data. The number of data sensors — satellites, drones, ships, cars, handhelds — and the software, tools and analytics that utilize data has grown exponentially. This evolution of technology, combined with the rapidly increasing needs of cities to address their climate issues, makes it imperative that we connect data users to data providers, and the city needs to technology solutions in as many ways possible.

It augurs well for geospatial companies to better understand city and regional needs to address the multitude of climate change-related issues. They can then direct their capabilities and expertise towards providing customized solutions to the end-users' needs. Cities, on the other hand, should have a complete picture of public and private resources available to them to optimize their decision-making, planning and implementation.

The matrix analysis of the geospatial solution types and the deliverables that cities need to advance through their climate action journeys highlights three areas of action moving forward:

- ✔ **Prioritize the application of geospatial data and solutions at city-scale for Climate Risk and Vulnerability Assessments (CRVAs), Greenhouse Gas Inventories (GHGIs) - especially methane and transport - and scenario planning.** The advances in making data available and streamlining its usage, particularly on these deliverables, are crucial to unlocking climate action, especially in cities and local governments that face severe capacity constraints.
- ✔ **Explore the application of geospatial solutions for renewable energy site selection and natural resource management and develop pilots to test its use in urban contexts**
- ✔ **Advance the implementation of city climate action monitoring and evaluation processes and leverage geospatial data and solutions.**

Annexure – I

"City Needs" across each step of the climate action journey[14]

Step	Category	City needs
Assess Impacts and Risks	INPUT	Best practice guides and methods for producing GHG inventory
Assess Impacts and Risks	INPUT	Demographic trends and projections (e.g. population, economic, etc.)
Assess Impacts and Risks	INPUT	Outcome data (e.g. air quality, public health, congestion, etc.)
Assess Impacts and Risks	INPUT	Sectoral activity data (e.g. buildings, transport, waste, land use, etc.)
Assess Impacts and Risks	INPUT	Consumption data
Assess Impacts and Risks	INPUT	Informal sector data
Assess Impacts and Risks	INPUT	Equity / city-wide inequities data
Assess Impacts and Risks	INPUT	Geospatial data (e.g. GIS)
Assess Impacts and Risks	SUPPORT	Priorities for climate action (e.g. community priorities and concerns)
Assess Impacts and Risks	SUPPORT	Proxy data
Assess Impacts and Risks	DELIVERABLES	GHG emissions inventory - city operations, community-wide, consumption emissions
Assess Impacts and Risks	DELIVERABLES	Climate risk studies
Assess Impacts and Risks	DELIVERABLES	Climate action capacity assessment (e.g. political landscape & context, community assets & resources, city powers)
Develop Actions and Adaptation Strategy	INPUT	Best practice guides, methods, and RFPs for climate action plan development
Develop Actions and Adaptation Strategy	INPUT	Interconnectivity of projects and policies with planned initiatives (city, other actors)
Develop Actions and Adaptation Strategy	INPUT	Community input, participation, empowerment, and coalition
Develop Actions and Adaptation Strategy	SUPPORT	Mandate for climate action
Develop Actions and Adaptation Strategy	SUPPORT	Buy-in and relationships with climate-related systems controllers (e.g. city departments, other levels of government, private sector)
Develop Actions and Adaptation Strategy	SUPPORT	Budget estimates for projects and policies
Develop Actions and Adaptation Strategy	DELIVERABLES	Expected policy & project benefits
Develop Actions and Adaptation Strategy	DELIVERABLES	Non-climate benefits (e.g. public health, economic, etc.)
Develop Actions and Adaptation Strategy	DELIVERABLES	GHG emissions benefits
Develop Actions and Adaptation Strategy	DELIVERABLES	Equity benefits

14 *ICLEI, C40 (2018), Data speak louder than words: Findings from an initial stocktake of climate change adaptation and urban resilience efforts.* https://shorturl.at/cln35

Step	Category	City needs
Develop Actions and Adaptation Strategy	DELIVERABLES	Scenario outputs
Develop Actions and Adaptation Strategy	DELIVERABLES	Cost-benefit analysis - projects & policies
Develop Actions and Adaptation Strategy	DELIVERABLES	Prioritized list of actions
Develop Actions and Adaptation Strategy	DELIVERABLES	CAP implementation plan
Develop Actions and Adaptation Strategy	DELIVERABLES	Climate program proposal (e.g. CAP)
Implement	INPUT	Pre-feasibility studies
Implement	INPUT	Prior project or policy results
Implement	INPUT	Capital structures / financial models
Implement	INPUT	Assessment of financing options (e.g. municipal budget, external, governmental)
Implement	INPUT	Project-level cost-benefit analysis
Implement	INPUT	Policy/program impact analysis or pilot studies to build buy-in and approval
Implement	INPUT	Project and policy proposals (e.g. Mayoral, legislative, investment, or budget-related)
Implement	INPUT	Community engagement and collective influence campaigns
Implement	SUPPORT	Sustained political will
Implement	SUPPORT	Sector-specific technical expertise for project development
Implement	SUPPORT	Local expertise and partners to craft policy and run programs
Implement	SUPPORT	Legal frameworks, regulations, and standards
Implement	SUPPORT	Accountability and assigned governance/leadership responsibilities
Implement	SUPPORT	Access to and prioritization of capital for climate action
Implement	SUPPORT	Procurement models and contracting procedures
Implement	SUPPORT	Deal-brokers / facilitators for financial transactions
Implement	DELIVERABLES	Engaged community & local businesses
Implement	DELIVERABLES	Mobilization of other governmental actors (e.g. regional and national)
Implement	DELIVERABLES	Dedicated funding streams
Implement	DELIVERABLES	Adopted policy frameworks to hold city departments accountable
Implement	DELIVERABLES	Adopted policy frameworks to hold other actors accountable
Implement	DELIVERABLES	Adopted new regulations, policies, and ordinances to advance climate work
Monitor and Report	INPUT	Methodology/framework for monitoring and evaluating impact
Monitor and Report	INPUT	Demographic data (recollection)
Monitor and Report	INPUT	Outcome data (recollection)
Monitor and Report	INPUT	Sectoral activity data (recollection)
Monitor and Report	INPUT	Informal sector data (recollection)
Monitor and Report	INPUT	Equity / city-wide inequities data
Monitor and Report	INPUT	GHG emissions inventory (recalculated - city operations, community-wide, and consumption)
Monitor and Report	SUPPORT	Community partners to gather information needed for results

Step	Category	City needs
Monitor and Report	DELIVERABLES	Realized impacts of projects and policies
Monitor and Report	DELIVERABLES	Non-climate impacts
Monitor and Report	DELIVERABLES	GHG emissions impacts
Monitor and Report	DELIVERABLES	Equity impacts
Monitor and Report	DELIVERABLES	Policy refinements based on realized impact
Communicating	INPUT	Realized non-climate, GHG, and equity impacts of projects and policies within the city and across the community
Communicating	INPUT	Result of action taken by city departments, community, businesses/private sector, and other levels of government
Communicating	SUPPORT	Relationships with media
Communicating	SUPPORT	Best practices for different communication vehicles to reach elected officials, city departments, community, business, & other government levels
Communicating	DELIVERABLES	Marketing and communications materials
Communicating	DELIVERABLES	Tailored communications strategies to elected officials, city departments, community, businesses, and other government levels
Communicating	DELIVERABLES	Resident impact/stories
Communicating	DELIVERABLES	Community engagement
Communicating	DELIVERABLES	Outputs aligned with external frameworks (e.g. CDP)

Annexure – II

Acronyms and Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
AI	Artificial Intelligence
CAP	Climate Action Plan
CHAMP	Coalition for High Ambition Multilevel Partnerships
COP28	28th Conference of the Parties to the United Nations Framework Convention on Climate Change
CRF	Common Reporting Framework
CRVA	Climate Risk and Vulnerability Assessment
GCoM	Global Covenant of Mayors for Climate & Energy
GHG	Greenhouse gas (usually referring to 'greenhouse gas emissions')
GHGI	Greenhouse gas emissions inventory
GPS	Global Positioning System
HSI	Hyperspectral imagery
IPPU	Industrial Processes and Product Use
IR	Infrared
LIDaR	Light Identification Detection and Ranging
NbS	Nature-based Solutions
SAR	Synthetic Aperture Radar
WGIC	World Geospatial Industry Council
WRI	World Resources Institute

GLOBAL COVENANT of MAYORS for CLIMATE & ENERGY

https://www.globalcovenantofmayors.org/

World Geospatial Industry Council

https://wgicouncil.org/