BENEFITS OF CLIMATE ACTION

Piloting A Global Approach To Measurement

Final Report

PARTNERS AND COLLABORATORS

C40 Cities Climate Leadership Group

The C40 Cities Climate Leadership Group (C40), now in its 12th year, connects more than 90 of the world's greatest cities, representing over 650 million people and one quarter of the global economy. Created and led by cities, C40 is focused on tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks, while increasing the health, wellbeing and economic opportunities of urban citizens.

Novo Nordisk

Novo Nordisk is a global healthcare company with more than 90 years of innovation and leadership in diabetes care. Nordisk initiated the Cities Changing Diabetes partnership programme in response to the urgent challenge caused by the dramatic rise of diabetes in cities. In late 2015, Novo Nordisk and C40 formed a research-based partnership aimed at ensuring that urban climate action is beneficial to both the environment and the health of urban citizens. This collaboration aims to generate new insights into a range of benefits of climate action – in particular the health of city populations. At the heart of the partnership lies the pivotal role of cities in the fight against climate change and poor health.

Pilot Cities

Mexico City, New York City, Johannesburg, Santiago, and Melbourne were the pilot cities for this benefits research. They have been instrumental in helping us build the evidence base for the benefits of taking climate action.

Arup

C40 commissioned Arup to support this research. Arup is the creative force at the heart of many of the world's most prominent projects in the built environment and across industry. They offer a broad range of professional services that combine to make a real difference to their clients and the communities in which they work.
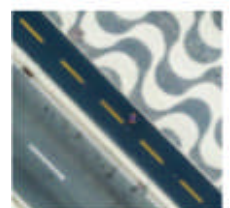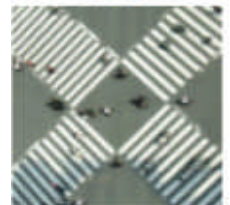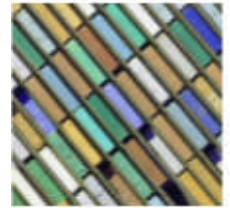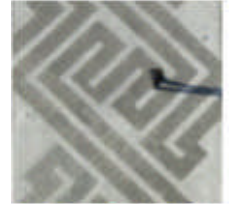
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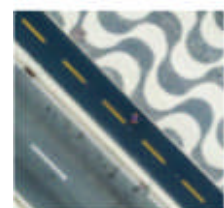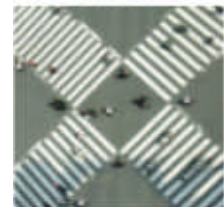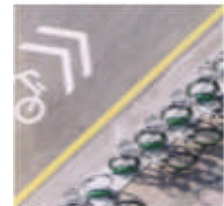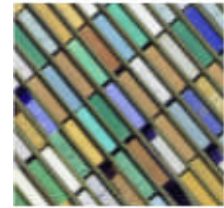
FOREWORD

The Paris Agreement has set a clear target – limit global temperature rise to 1.5 degrees Celsius in order to prevent catastrophic climate change.

Now we need to deliver.

This research on measuring the benefits of climate action is critical to enabling the much needed step change in the speed and scale of climate action taken by cities in order to deliver the Paris Agreement.

We know that truly transformational and urgent action is needed on climate change – our research shows that C40 cities must take approximately 14,000 new climate actions by 2020. That means doing things faster and more efficiently, thankfully C40 is perfectly placed to support this.

We also know that making the case for climate action is one of the biggest barriers preventing city leaders from taking action. That is why I welcome this new report and the work that will flow from it.

This benefits research aims to equip C40 mayors with the evidence and tools to make the case for faster, broader climate action. By demonstrating the full range of benefits of climate action, C40 can help cities unlock action and avoid false trade-offs.

The pilot work highlighted in this report shows that climate action has a wide range of economic, social and environmental benefits. We provide evidence which demonstrates that climate action can not only reduce the impacts of climate change but also provide employment and support economic growth, as well as improving the health and wellbeing of citizens.

This pilot is the critical first step to measuring benefits - enabling C40 cities to make a stronger case for climate action and supporting the development of the healthy, liveable, low carbon cities of the future.

Mark Watts

Executive Director

C40
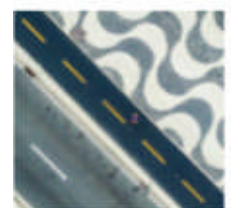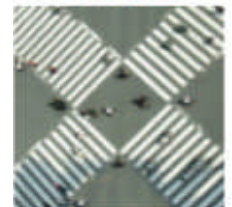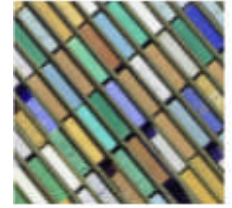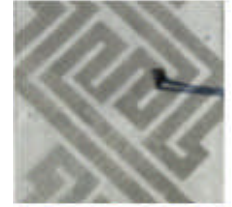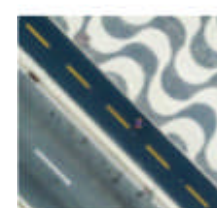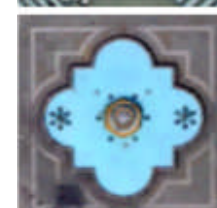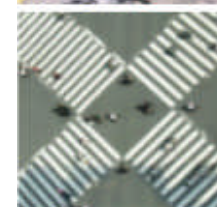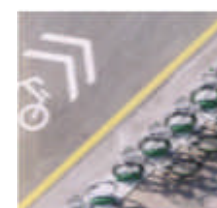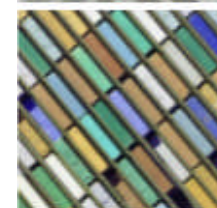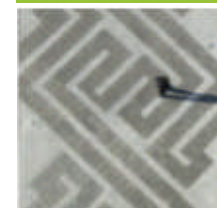
1   The Benefits of Urban Climate Action

This pilot research aims to enable cities to measure the wider benefits of climate action, empowering them to make a much stronger case for a much greater scale of action. The purpose of the research is to evidence the benefits of climate action, but more than this to understand how cities can evidence these benefits as efficiently, effectively and expeditiously as possible.

This report shares the methodology developed for understanding the benefits of climate action. It also includes the detailed findings from the climate actions looked at in each of the five pilot cities.

Climate action has a range of wider benefits for the health and prosperity of cities and their citizens. The benefits of urban climate action – from green jobs and growth, to active, happier lives and cleaner air and water – have an immediate, tangible impact on people's lives.

Making the case for climate action is one of the leading challenges cities face to undertaking ambitious urban climate action. The ability to demonstrate these benefits is a critical first step to unlocking climate action. Cities need the evidence and tools to make a stronger case, enabling the staggering increase in the scale and pace of action required.

Inclusive climate actions present opportunities to forge a more equal, happy and prosperous society as well as a climate positive one. Inclusive climate actions tackle multiple mayoral priorities simultaneously, deliver multiple benefits to all segments of the population, and ultimately result in more transformational climate solutions

2   Enabling Action Through Research

The Paris Agreement represents a historic step in tackling climate change. It recognises that transformational and urgent action is needed and creates an unprecedented mandate and momentum for this. The global task now is to identify and deliver action at the tremendous pace and scale needed to achieve it.

Cities are central to achieving this ambition. They are responsible for 70% of global greenhouse gas emissions and home to more than 50% of the world's population. C40 and Arup's research on delivering the Paris Agreement indicates that C40 cities must reach zero net emissions by 2050 if they are to achieve the aspiration to keep the world below 1.5 degrees Celsius of global warming. Achieving this target requires an explosion in action; cities need to take approximately 14,000 new climate actions by 2020 (around 170 actions per city). Each one of these actions will need political and financial support.

Yet one of the main barriers hindering cities from delivering climate action is effectively making the case for it. Climate change is often seen as competing with a range of more immediate and tangible issues, such as lack of affordable housing, poverty, unemployment, and poor health. Without a holistic and persuasive case that articulates how climate action contributes to these priorities, it is challenging to attract the support required.

2.1   Accelerating impact: Benefits research to unlock inclusive action

In response to this critical barrier, C40 has launched an enabling research programme on the benefits of inclusive climate action. This programme recognises the enormity of the challenge but also the scale of the opportunity; climate action has a wide range of benefits for health and prosperity and offers the potential to create not only low carbon cities but more liveable cities where everybody has an opportunity for a better quality of life.

The focus on inclusive action recognises that cities face a range of competing priorities, and that in order to enable climate action cities need to address these short-term and local priorities as well. Similarly, the use of the term 'benefits' instead of co-benefits reflects the fact that climate change is often seen as competing with a range of more immediate and tangible issues. This focus on inclusive action and overall benefits not only better reflects the reality of cities but furthermore encourages integrated decision-making and encompasses all citizens – vital to enabling the scale and scope of action.

The research programme will focus on enabling the priority, high impact actions. By providing evidence of the full range of benefits from climate action, cities can avoid making false trade-offs and can drive urban development that reduces greenhouse gas emissions and climate risks, while increasing the health, wellbeing and economic opportunities of urban citizens.

2.2   Proof of concept: Piloting a practical approach to benefits measurement

As part of the wider research programme, C40, in partnership with Novo Nordisk, launched this pilot project. This work sets out to break new ground on benefits measurement, paving the way for an ongoing global effort.

The aim is not only to add to the growing body of evidence confirming (at a city and project level) that climate action has wider benefits, but also to understand the art of the possible in measuring the benefits of urban climate action. How can cities evidence the benefits of climate action as efficiently, effectively and expeditiously as possible? And how can C40 and the wider research community best support this effort?

Given the urgency, it is vital to make the case for action now using the best available existing data. In parallel C40 will also work to improve the data cities have and strengthen the case in the future. And throughout it all it is important to develop a process that cities can practically and readily deploy.

Through this pilot C40 developed and tested a standard and practical approach to measuring the benefits of five climate actions in five cities: bikeability and walkability in Mexico City; energy efficiency retrofits in New York City; solar water heaters in Johannesburg; Bus Rapid Transit in Santiago; and urban forestry in Melbourne. This on the ground research provides valuable insights into how best to evidence the case for climate action.
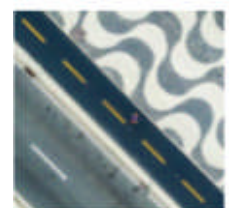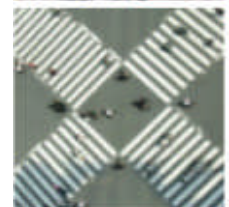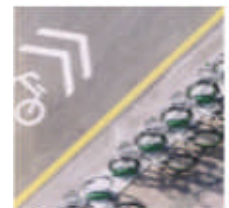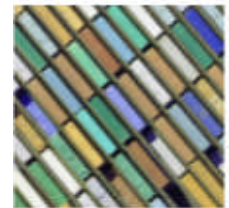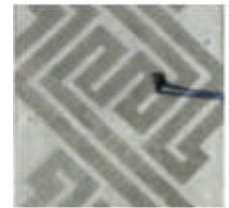
3 Headline Findings

This section presents the headline findings, a detailed description of the results is available in the appendices.

3.1 Bikeability and walkability in Mexico City

Benefits of EcoBici bike share scheme in Mexico City

The EcoBici bike share scheme was launched in Mexico City in 2010. Today it counts more than 6,000 bikes, 444 docks and over 100,000 users and is expected to replace around 24,000 car kilometres per year

- Increased physical activity - an average Ecobici user spends 47-82 minutes per week biking
- Improved quality of life - 82% of EcoBici users experienced improved quality of life
- Better climate – nearly 1,190 tonnes greenhouse gas emission per year saved
- Financial benefit - the monetised health benefits gained by shift from cars to EcoBici are estimated at $26 million
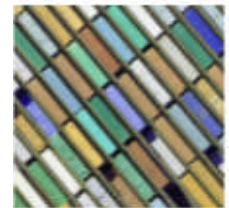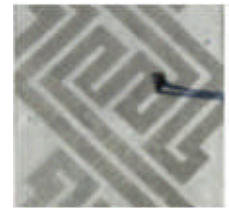
Benefits of bike lanes in Mexico City

The first cycle route was launched in 2007. Today Mexico City has 40km recreational cycle ways and over 60km segregated road based lanes
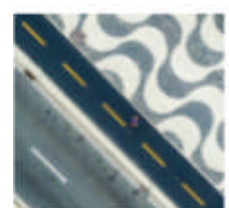
- Reduced mortality - prevents on average 10 deaths per year
- Financial benefit - the potential net present benefits totals more than US $65 million, almost 6 times more than the costs.
- The value of physical fitness - the estimated benefits exceed $44.6 million
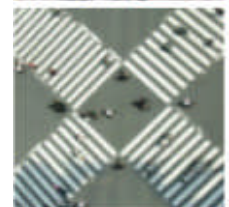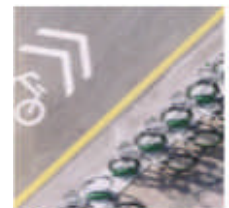
Benefits of pedestrianisation of Madero Street

Madero Street in Mexico City was pedestrianized in 2010, it is over 11,000 m^2, almost 1km long and is used by 200,000 pedestrians per day.

- Increased physical activity – Madero street is used for around 117 million 1-kilometre walking trips per year.
- Increased safety - reported crimes along Madero Street have decreased by around 96%
- Reduced heat stress – potential reduction in summer temperatures by up to 0.5ºC
- Better mental health – walking 1.1km, just over the length of Madero Street, reduces the risk of dementia by 33%
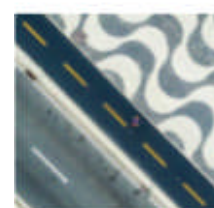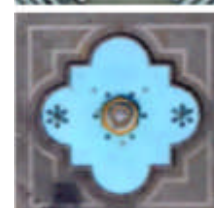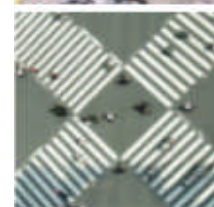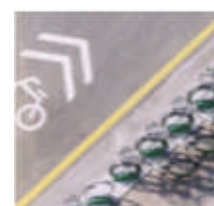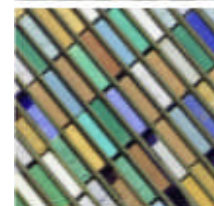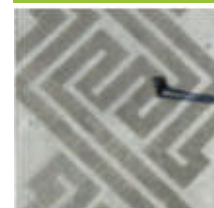
3.2   Energy efficiency retrofits in New York City

The NYC Retrofit Accelerator is part of New York City's commitment to reduce citywide greenhouse gas (GHG) emissions by 80 percent from 2005 levels by 2050 (80x50). As part of this process, New York City have identified 100 energy conservation measures for their technical energy and greenhouse gas (GHG) reduction potential. The ECMs include improving building envelope, heating distribution system, water heating, lighting, plug loads, and ventilation, and vary in application to the city's typologies. The pilot research focused on the impact that energy efficiency investments could have on employment, including:

- The energy conservation measures (ECMS) with the highest job multiplier (jobs created per million USD investment) for New York City are those that are aimed at improving the efficiency of building operations and improving the building envelope (through capital upgrades).
- Studies showed that investments in the energy efficiency sector in NYC can create on average between 10 and 20 job-years per million USD invested.

Here is a selection of potential jobs created per ECM in NYC. Please refer to the full data in Appendix B for more detail.

ECM description	Multifamily direct job years	Multifamily indirect job years	Multifamily induced job years
Air seal and insulate roof	7,700	4,500	4,900
Decrease window u-value (punched openings)	2,700	1,600	1,700
Enhanced Process & Plug Load Management	1,600	900	1,000
Optimization of Steam boilers	1,800	1,600	1,400
One Pipe Steam Distribution - Comprehensive Upgrade	5,700	5,000	4,300
Two Pipe Steam Distribution (excluding PTAC) - Comprehensive Upgrade	2,700	2,400	2,000

3.3   Solar Water Heaters In Johannesburg

The City of Johannesburg launched a solar water-heating programme in 2012 to provide residents with more affordable energy, to create job opportunities and to help reduce the city's carbon emissions. The programme resulted in the installation of 76,713 solar water heaters in Johannesburg. The scheme is part of the City's 2040 Vision to use low carbon infrastructure to save energy and create employment.

- The avoided health costs associated with reduced particulate matter and other pollutants in households in Johannesburg where solar water heaters have been installed, are between 58 and 15 Rand per household per year, which is

equivalent to between 440,800 R and 114,000 R ($34,000 - $88,000 USD) across the 76,713 homes where the scheme was implemented.

- The household air pollution intervention tool showed that the solar water heater installations could prevent between 10 and 22 deaths in Johannesburg due to reduced exposure to emissions.
- Between 364,300 and 91,100 tonnes of particulate matter pollutant per year could be avoided due to installation of household Solar Water Heaters in Johannesburg's low-income neighbourhoods.

3.4   Bus Rapid Transit in Santiago

In the beginning of 2007 a bus reform was implemented in Santiago, Chile and the first BRT corridor started operating in 2008. Today it is estimated that the total demand of the bus priority-system is above 600,000 daily. A new BRT route is planned for 2020 to serve the most important public transportation axis in the city, the Nueva Alemeda Providencia (NAP). It has been estimated that the proposed NAP corridor will increase the daily passenger numbers by 150,000 due to the additional 12km of BRT service.

- It has been estimated that between 108,000 and 412,500 minutes of additional walking could be achieved thanks to the implementation of the NAP in Santiago.
- This level of walking could prevent between 3 and 10 deaths for the NAP BRT users in Santiago each year due to the health benefits of physical activity.
- Associated health benefits are valued at US$ 17.5 – 67M.

3.5   Urban forestry in Melbourne

Melbourne's urban forest has 66,000 council trees, representing 22% canopy cover and an amenity value of AU$650M. The urban forest strategy aims to increase canopy cover to 40% whilst improving tree health and biodiversity.

- Research into the value of Melbourne's urban forest showed that the financial value of carbon dioxide per metric tonne ranges from AUS $14 to AUS $1179 (US $11 to $897), depending on the methodology used. The mean value from the research was AUS $153 per metric tonne (US $116).
- Research into the value of Melbourne's urban forest showed that the financial value of air pollutants per metric tonne varies enormously depending on the pollutant and the methodology used. The mean value of one metric tonne of NOx is AUS $10,065 (US $7,655), SOx is AUS $4053 (US $3,082) and PM10 is AUS $9163 (US $6,969).
- Research into the value of Melbourne's urban forest showed that the financial value of stormwater management can range from AUS $0.70 per m3 (US $0.53) to AUS $14 per m3 (US $11) depending on the methodology used. The mean value is AUS $4.40 per m3 (US $3.35).
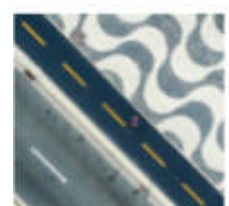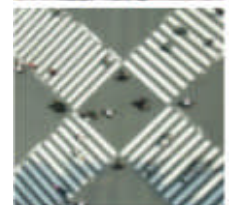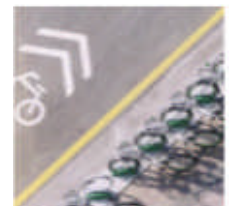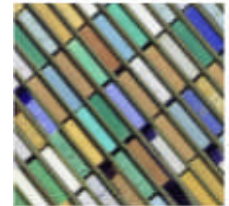
4   Approach

The Benefits of Climate Action is pilot study is an in-depth exploration of approaches to measuring the benefits of climate action across multiple domains – including social, economic, financial and environmental. The pilot builds on earlier work by C40 and the London School of Economics' Cities centre (LSE Cities), which developed a high-level framework to categorise benefits.

From the preliminary scoping research and consultation with cities, the following drivers for further study were identified:

- There is a significant gap in data, at both the city level and the action level, which can be used to measure benefits.
- There is potential that this data exists at the city level but is not being effectively utilised.
- There is demand from cities for a standard approach to measuring the benefits of climate action in order to support a stronger business case for action.

Given these drivers, the pilot study is framed around two key questions:

1. What benefits can be measured now, based on the data currently available in cities and feasible methods of analysis?
2. How can gaps in data and research be filled and what methods can be employed to improve the measurement of benefits in the future?

Based on these questions, the approach includes two principal components: data collection and data analysis. Raw data from each city is being collected and analysed, and combined with evidence from existing literature and tools to identify replicable methods for measuring benefits.

The pilot explores the benefits of five climate actions in five cities:

- Bikeability and walkability in Mexico City
- Clean energy retrofits in New York City (employment benefits)
- Installation of solar water heaters in Johannesburg
- Bus Rapid Transit in Santiago (health benefits of increased walking)
- Urban forestry in Melbourne (monetising carbon dioxide, air quality and stormwater management benefits)

This scope allows an in-depth exploration of the approach, acknowledging that the small number of actions represent only part of the whole benefits framework, and that the cities involved in this study are only a small sample among all cities in the world, or even among all C40 cities. The findings will be shared and reviewed by a wider group of cities through C40's network programmes, enabling enhanced testing of the approach.
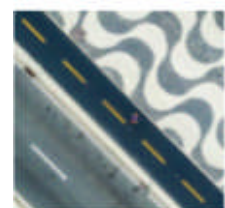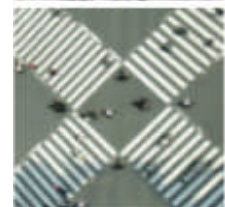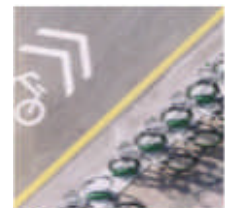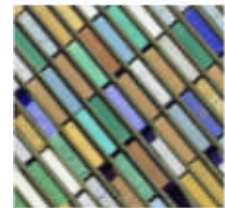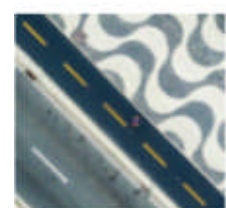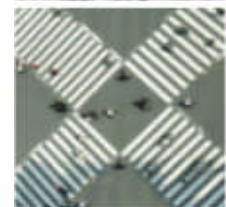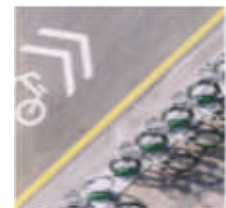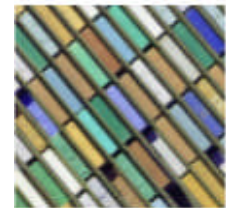
4.1 Data Collection

Building on the high-level benefits framework created by C40 and LSE Cities, a detailed data collection template was developed for each pilot action to enable cities to collect data across economic, social and environmental indicators. These templates highlight specific metrics and data points that illustrate the policy, institutional and physical context in which climate actions took place, as well as the change and impact brought about by those actions. The templates call for data recorded pre- and post-implementation of the action wherever possible. By developing a template for the ideal benefits data, it was possible to understand the availability of relevant data from city institutions – both directly available city data and proxy data points.

An initial round of data collection was undertaken working with the lead city government team. This was followed by a data gap analysis to determine whether alternative data sources would be needed to estimate the full range of potential benefits in the city. Further data collection was undertaken via:

- targeted interviews with a wider range stakeholders, both from city departments and external organisations to identify existing but currently 'unused' data
- an extensive literature review to identify benchmarks from other cities and similar research that could be used to fill data gaps. The appendices include each city report, which detail the search terms used for the literature review and the full list of references.

4.1.1 Types of city data

Data collection focuses on three main types of data that illustrate the benefits of an action:

Action data: Data about the attributes of the action itself, including the policy context, related actions, cost and scale, among other points.

Output data: Data about the change that emerged as a result of the action, for example the increase in numbers of cyclist and pedestrian trips in Mexico City, or the energy saved from the building retrofit scheme in New York City.

Outcome data: Data about the impact of the action in the city itself, which is a direct indicator of benefits. For example, in Mexico City the government team provided data showing that reported crimes along Madero Street have decreased by around 96% since the street was pedestrianised.

4.2   Data Analysis

After compiling the available data, analysis was undertaken combining city data with existing research following three main lines of enquiry to explore effective methods of benefits measurement:

1. To use existing tools from the literature review to the city's data, to convert action and output data into outcomes (benefits) based on peer-reviewed evidence, providing quantification and monetisation of benefits (see appendices for further details).
2. To apply benchmarks from the literature review to the city's data, to convert action and output data into outcomes (benefits) based on evidence from elsewhere, providing quantification, and where possible/appropriate monetisation, of benefits.
3. To use examples from the literature review together with the city's own data to corroborate direct outcome (benefit) measurement, providing support for city quantification of benefits.

Combining the three lines of enquiry, as listed above, enabled observations for the stated research questions.
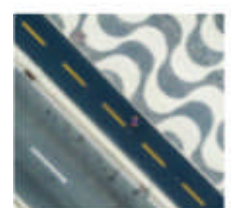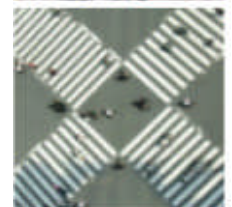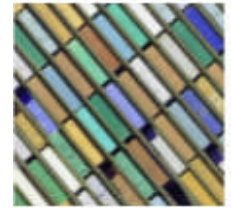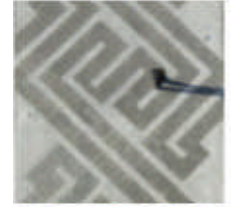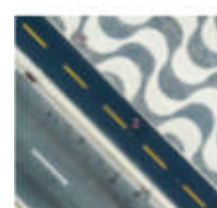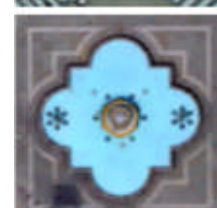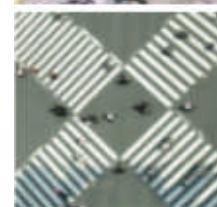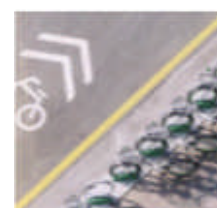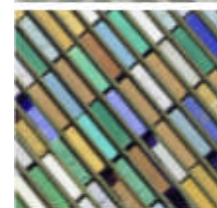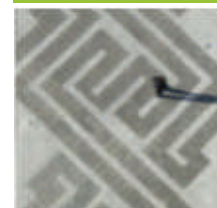
5   Limitations and learnings for future research

Understanding critical data gaps

As well as identifying what data exists, it is important to understand the data gaps. Key gaps identified in this pilot are:

- the availability of pre- and post-action data
- the availability of data at the granularity that corresponds to a climate action, i.e. is the area of data collection the same as the area of the climate action
- a lack of context specific research from a similar city setting, especially for Low and Middle Income Countries (LMIC)
- insufficient data to enable a good understanding of how equitably the benefits are distributed.

Furthermore, some data will have a much greater impact on results. Identifying the most critical data gaps and focusing data collection and research efforts on this will help cities and researchers make the most of the limited resources for monitoring and evaluation.

### Integrating data sources to fill gaps

Analysis applied from non-city specific research to fill data gaps should ensure its contextual prevalence is considered in advance. For example, if using data from other cities to estimate the increase in biking following the introduction of bike lanes, geographic factors such as distance and 'hilliness' and cultural factors such as base activity levels should be accounted and adjusted for. Another example is using national level socio-demographic data to fill city data gaps, differences between e.g. age or health data should be accounted and adjusted for. This has not been done within the scope of this pilot but is an important area for future research.

The importance of inclusive action

The lack of data, and therefore understanding, about the distribution of benefits is a particular issue. Understanding the equity of the distribution of benefits from climate action is of major importance given the striking inequities that exist in cities, and given the need for climate action to reach the whole population in order to achieve the scale and scope required. Further research to enable this is urgently required, as estimates can be strongly biased if these hidden patterns of inequality are ignored.

Assumptions and confidence

The findings in this report are based on a number of assumptions throughout the analyses to help arrive at feasible conclusions, and these are explained in the appendices. The findings are also based on a variable quantity and quality of data sources. It is important to present results with varying degrees of confidence according to the sources of data, strength of correlations and potential confounding factors. This pilot starts to build an evidence base of assumptions and data sources that can be built on to provide a consistent and robust approach to analysis.
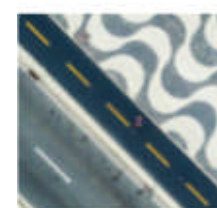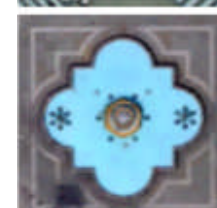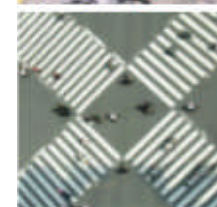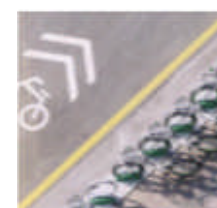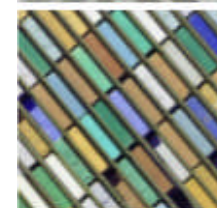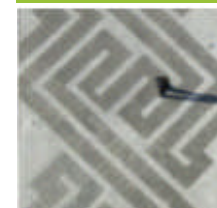
Causation vs correlation

It is important to note that the findings presented here should be interpreted as potential correlations rather than clear causal relationships between actions and outcomes. Demonstrating causality is particularly challenging and resource intensive. Therefore, it is especially important to focus and coordinate research efforts on causation on the most critical data gaps and across the key city contexts. Furthermore, where this research does exist it should be made available to cities to use as widely as possible.

Benefits and net impact

It should also be noted that this work has focused on measuring the benefits of climate actions. Only limited consideration of potential negative impacts ('disbenefits') has been undertaken. This is an important area for future work as it enables better evaluation of 'net' benefits and reduces the risk of potential negative side-effects of climate action.

Measuring health benefits

Measuring health benefits is extremely complex. For example, in relation to bikeability and walkability most of the health benefits come from increased physical activity. The benefits from physical activity will depend on a number of factors, e.g. intensity of exercise, age and gender, and wider lifestyle and behaviours. This level of data is unlikely to be available and therefore limits measurement of health benefits. Future research should focus on building an evidence base across a range of city contexts that can then be drawn upon to enable better measurement of health benefits globally.

Distinguishing between individuals and the general population

It is important to distinguish between the benefits experienced by an individual affected by the action, compared with the benefits spread across the city population. This impacts decision making and facilitates communication for different audiences. For instance, per capita health gains for bike share users are expected to be much larger, and therefore much more convincing, than population per capita gains, particularly for interventions at smaller scale. At the same time, local stakeholders are more willing to engage with absolute population benefits, as this is more closely related to the planning and decision-making at the local level.

Confounding factors, disaggregating actions/benefits

It can be challenging to completely disaggregate actions and the benefits being associated with a given action. A city will generally be delivering numerous actions, which could have overlapping benefits. For example, a city may roll out cycle lanes and start taxing polluting vehicles. In this instance, it can be difficult to determine how much each of those actions have contributed to an improvement in air quality.

6   Recommendations & next steps

This pilot research confirms the wealth of wider benefits resulting from climate action, and it helps demonstrate practical approaches for measuring these benefits. The initial findings point to a number of conclusions for the development of this research agenda, and for how best to support and empower mayors to make the case for liveable, low carbon cities.

Demonstrating the wider economic, social and environmental impacts makes a much stronger case for climate action.

This report shows the wider benefits of climate action and illustrates the positive impacts on the health and well-being of citizens, on the economic development of the city and demonstrates the cross-departmental benefits of investment in climate action.

By combining data sources, benefits can be estimated across economic, social and environmental indicators – from reduced crime rates along pedestrianised city streets, to jobs created by cycling infrastructure.

The findings demonstrate viable approaches to data collection and analysis for measuring the wide-ranging benefits of climate action based on data available today. This pilot study illustrates what is possible in terms of benefits measurement, using the data that cities typically have access to today, together with existing tools and the benchmarks available from wider research. This is a strong starting position for cities to begin quantifying benefits now, to make the case for urgent climate action.

There are numerous opportunities for further research that will help to improve the process of benefits data collection, analysis and interpretation, and the robustness of results.

These include: improving data availability targeting data that is most critical to benefits evaluation; expanding the range of context-specific benchmarks; and exploring new methods for combining and interpreting data.

Collaboration across city departments is important to understand how actions led by one department may yield benefits for another.

The study has helped to illustrate that the benefits of climate action are not limited to one sector or institution. By working together, city departments can make a more persuasive case for city-wide climate action, leveraging greater political and financial support while also improving the efficient use of departmental budgets.

By working together across the government, business and nongovernment sectors to develop the robustness of benefits measurement, we can accelerate climate action.

C40 is committed to building the evidence base on the benefits of climate action and enabling cities to improve their approach to measuring benefits. The best way to achieve this is for more partners to join in this effort. C40 calls upon the private sector, community groups, citizens and the research community to support this effort, and for cities to partner with us in developing and testing a globally relevant and replicable approach to benefits measurement.