OCTOBER 2017

Benefits of Climate Action

Houston: Benefits of the White Oak Bayou Greenway

A report prepared by Arup for C40 Cities Climate Leadership Group

CONTENTS

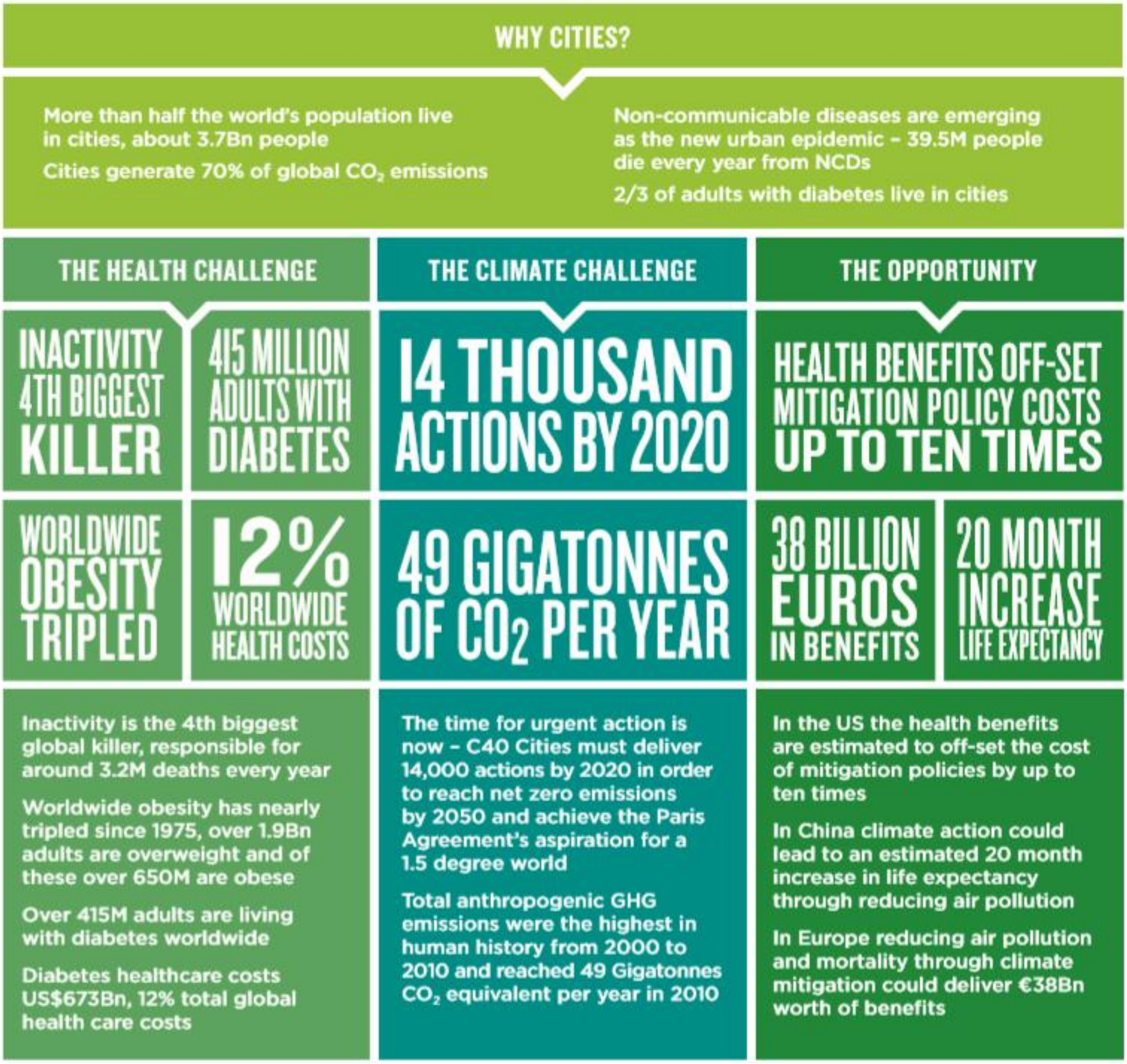
1 EXECUTIVE SUMARY

C40 and Novo Nordisk are working with mayors to support healthier, more liveable cities.

From rising wealth and increasing consumption, to more sedentary lifestyles and inequality of access to healthcare and healthy environments, urban living presents a major challenge to health and climate.

Our work supports cities to not only tackle urban health and climate change challenges, but more importantly realise the vast potential of doing so. The benefits of 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.

This research enables cities to evidence the benefits of climate action as efficiently, effectively and expeditiously as possible. By making a stronger case for climate and health policies and projects, cities can unlock the much greater speed and scale of action that is required.



Only 51.1% of adults in Houston currently get the recommended amount of weekly aerobic physical activity

28.7% adults are obese, 8.5% are diabetic, and 29.8% have high blood pressure

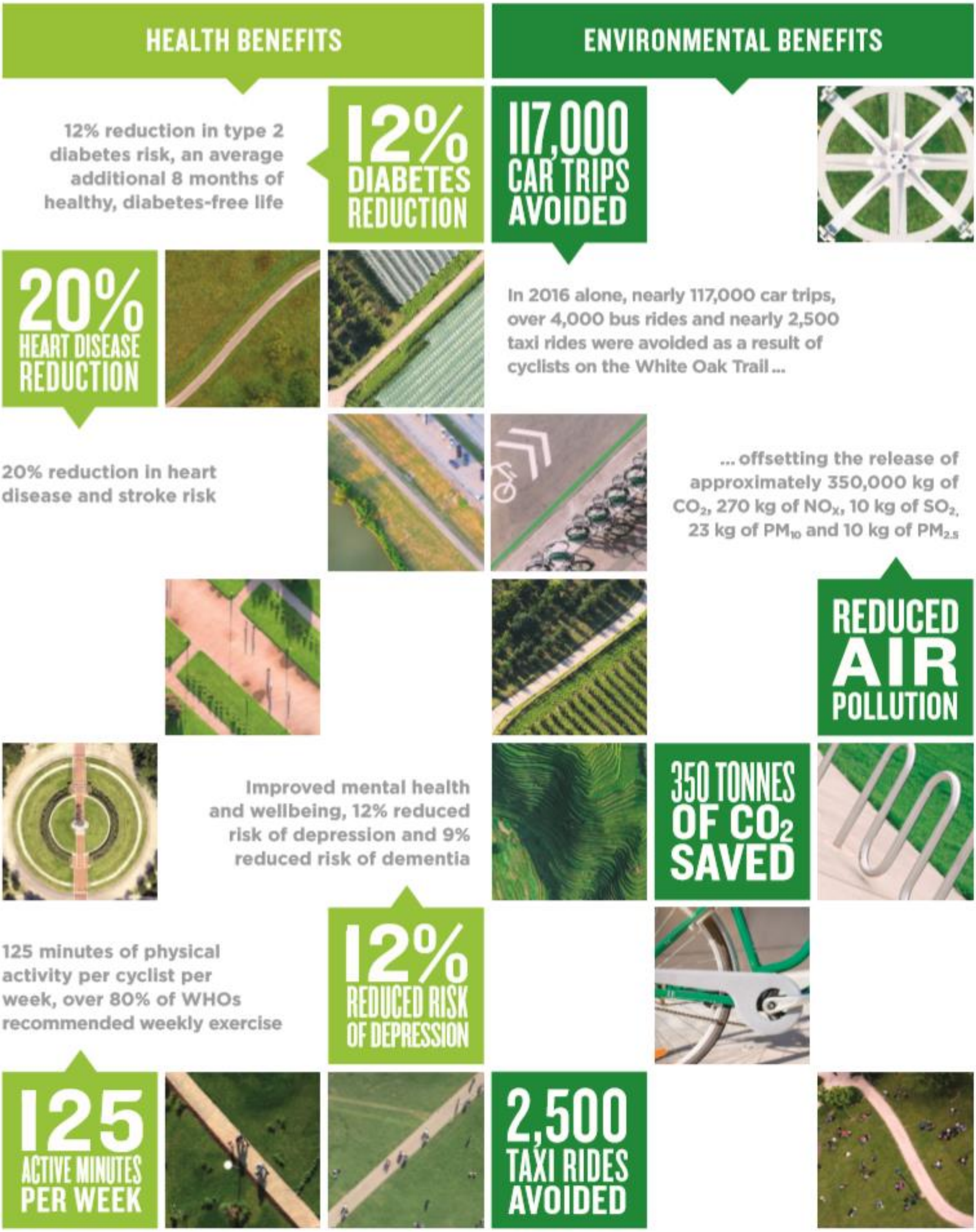
32% of children in Houston are obese, a leading indicator of future health issues

The Houston Bike Plan was launched in 2017 to improve safety, access, ridership and facilities

Plans to increase existing 270 miles of high comfort cycle facilities to 872 miles across the city

Goal to increase cycling from 0.5% to over 1.8% mode share

The White Oak Bayou Greenway is a 17-mile green landscaped and off-street hike and bike trail used for over 250,000 trips by an estimated 1,282 regular riders per year


HEALTH BENEFITS
12% reduction in type 2 diabetes risk, an average additional 8 months of healthy, diabetes-free life
12% DIABETES REDUCTION
20% HEART DISEASE REDUCTION
20% reduction in heart disease and stroke risk
Improved mental health and wellbeing, 12% reduced risk of depression and 9% reduced risk of dementia
12% REDUCED RISK OF DEPRESSION
125 minutes of physical activity per cyclist per week, over 80% of WHOs recommended weekly exercise
125 ACTIVE MINUTES PER WEEK
ENVIRONMENTAL BENEFITS
117,000 CAR TRIPS AVOIDED
In 2016 alone, nearly 117,000 car trips, over 4,000 bus rides and nearly 2,500 taxi rides were avoided as a result of cyclists on the White Oak Trail...
... offsetting the release of approximately 350,000 kg of CO_2, 270 kg of NO_X, 10 kg of SO_2, 23 kg of PM_{10} and 10 kg of $PM_{2.5}$
REDUCED AIR POLLUTION
350 TONNES OF CO_2 SAVED
2,500 TAXI RIDES AVOIDED


ECONOMIC BENEFITS
12 full-time maintenance jobs created each year for 25 years
12 JOBS CREATED EACH YEAR
The value of emissions saved in 2016 was estimated at $24,300
$24,300 OF EMISSIONS SAVED
The benefits of reduced mortality of $2M per year, exceeding the costs of the scheme by 2.38 times
$2 MILLION ANNUAL SAVINGS
328 JOBS CREATED DURING CONSTRUCTION
200 direct jobs and 128 indirect jobs were created during the construction period
SCALING-UP TO CITY-WIDE
TO ILLUSTRATE THE POTENTIAL BENEFITS FROM HOUSTON'S CITY-WIDE BIKE PLAN THE HEALTH IMPACTS FROM ACHIEVING A 2% CYCLING MODE SHARE WERE ESTIMATED
Potential benefits of over $80M per year, representing a 2.64 return on investment
$80+ MILLION ANNUAL BENEFITS
Increased physical activity, over 25,000 new cyclists and over 5M trips per year
5 MILLION TRIPS PER YEAR
12 PREMATURE DEATHS AVOIDED
Over 12 premature deaths avoided per year

2 INTRODUCTION

The C40 Cities Climate Leadership Group (C40) has launched a research programme focused on articulating the Benefits of Climate Action. The aim is to enable cities to effectively and efficiently measure the wider benefits of climate action, unlocking the greater speed and scale of action required to achieve climate safe, liveable cities.

Novo Nordisk and C40, supported by Arup, undertook to measure the benefits of actions to promote cycling and walking in C40 cities. This report presents the latest findings of this ongoing research from the City of Houston.

Houston aims to improve cycling in the city through a number of programmes and initiatives outlined in the Houston Bike Plan, including one of the most ambitious parks projects in the US: Bayou Greenways 2020. Bayou Greenways 2020 is transforming 3,000 underutilized acres of land along the bayous into linear parks and connecting 150 miles of hike-and-bike trails to parks and communities. The focus of this research is to evaluate benefits from one of the first segments of the Bayou Greenways project, the White Oak Bayou Greenway, in order to illustrate the potential gains from the whole project and city-wide bike plan. The White Oak Bayou Greenway is a 17-mile uninterrupted, green landscaped and segregated hike and bike trail within the city limits, connecting parks and neighbourhoods. The first segment of the White Oak Bayou Trail was opened in 2000 and the latest section finished this year. Construction is underway for three segments of trail near to downtown Houston, funded by the Transportation Investment Generating Economic Recovery (TIGER 3) programme.

Based on the data provided by the city and an extensive literature review of proxy data to fill the data gaps, the social, environmental and economic benefits as a result of the White Oak Bayou Greenway were estimated:

2.1 THIS REPORT

This report profiles the findings from the benefits analysis in Houston, whereby the city government provided insights into the benefits of the White Oak Bayou Greenway bike corridor project.

Chapter 3 will describe the context of the White Oak Corridor intervention. Chapter 4 will summarise the aims and objectives of this study and the approach taken during the research, including gap analysis. Chapter 5 presents the analysis and findings, and finally Chapter 6 outlines the conclusions and next steps.

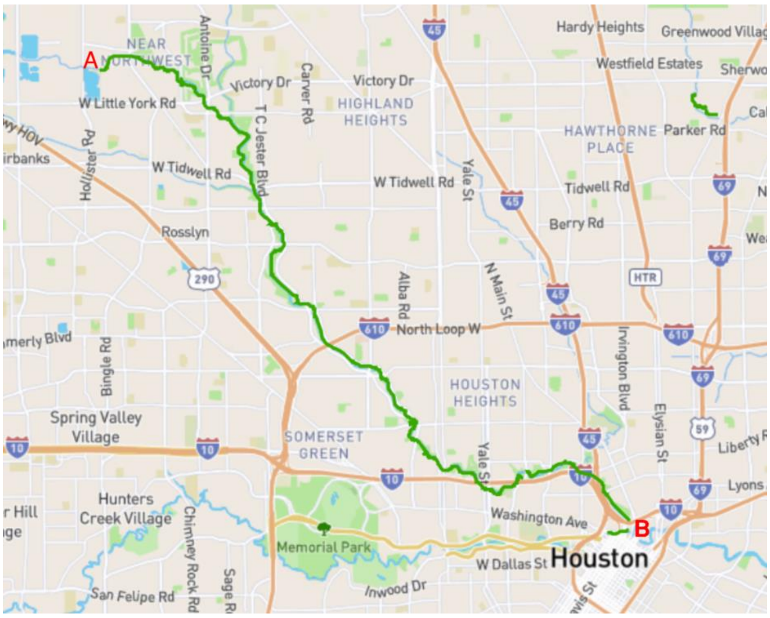
3 HOUSTON’S AGENDA FOR BIKEABILITY

The Houston Bike Plan is the first comprehensive update to the city’s bicycle master plan since 1993. It lays out a vision to be a League of American Bicyclists’ “Gold-level” Bicycle Friendly City by 2027, and is supported by four goals: improve safety, increase access, grow ridership, and develop and maintain facilities. The city of Houston, like many other US cities, is in the early stages of delivering this vision, which will require not only investment in cycling infrastructure, but also a change in culture and travel behaviour. As seen in the now established “bicycle-friendly” cities, such as Amsterdam and Copenhagen, both the introduction of cycling infrastructure and changes in culture can take time to become established. However, by analysing the benefits of existing, relatively small schemes in Houston, the results can indicate what might be expected following the realisation of Houston’s full Bike Plan vision.

The Houston Bike Plan recommends a vision and goals that, if implemented, will provide a safer and more connected bike and pedestrian network, and encourage more people to engage in active transportation, which can potentially reduce the rate of obesity, diabetes, and other health problems and health related costs. Of course, if mode shift can be achieved, the city will also achieve savings in transport-related greenhouse gas emissions.

The White Oak Bayou Greenway is identified in the Houston Bike Plan, and different segments of the greenway have been funded over the years by various entities such as bond fund from the City of Houston, private funding, grants and other partners. This study has focused on the benefits specifically generated by the White Oak Bayou Greenway, one in a number of improved bayou trails.

- **Why this trail?** The White Oak Bayou Greenway has rich data about users. Trip count data, combined with logical assumptions, has enabled the number of users to be estimated. This, combined with estimations of mode shift, help with measuring benefits such as the likely increase in physical activity and air quality.
- **What is it?** A primarily uninterrupted, green landscaped and off-street hike and bike trail within the city limits, connecting parks and neighbourhoods
- **When:** The first 6.5 mile segment of the White Oak Bayou Greenway opened in 2000, a segment at the northern end (from Antoine to Alabonson) was completed in 2015 and the most recent segment at the northern end (from Alabonson to the northern City limits) was completed this year, 2017.
- **Length:** 17 miles
- **Location:** The White Oak Bayou Greenway runs southeast from just west of N Houston Rosslyn Road towards downtown Houston, where it flows into Buffalo Bayou



Source: Google Maps.

- **Capital costs (CAPEX):** $12.1 million
- **Source of funding:** Public funds, bonds, private funding and grants
- **Number of users per year:** 1,282
- **Estimated number of users new to cycling**: 705
- **Future plans:** Construction is underway for three segments of trail near to downtown Houston, funded by the Transportation Investment Generating Economic Recovery (TIGER 3) programme and to be completed in 2017

4 APPROACH

4.1 AIMS AND OBJECTIVES

The City of Houston is participating in this research with C40 for three key reasons:

- To evaluate the health and climate benefits of improved biking facilities and Bayou trails in Houston, to inform the development of similar projects in the future.
- To utilise the methodology and results from this project to build local capacity to assess and analyse the linkages between public health and active transportation.
- To assist Houston Health Department with the assessment of chronic diseases prevention and environmental health.

Based on this, the aim of the analysis was to assess the health, economic and environmental benefits of the White Oak Bayou Greenway. These benefits were selected by analysing the benefits pathway (see methodology) for this type of intervention and agreeing the types of benefits that were most valuable to the City of Houston. Given the trail's segregated location away from main highways and the availability of data at appropriate granularity, health, environmental and economic benefits were selected for the analysis, as listed below:

1) **Health benefits** associated with increased physical activity, with regards to reducing mortality and mitigating the risk of:
    a. Diabetes mellitus
    b. Ischemic heart disease
    c. Ischemic stroke
    d. Alzheimer disease and other dementias
    e. Depression
    f. Breast cancer
    g. Colon cancer

2) **Economic benefits**
    a. Jobs: Impacts on employment, including the creation of direct jobs as well as indirect and induced jobs during the construction phase

3) **Environmental Benefits**
    a. Reduction of greenhouse gas (GHG) emissions
    b. Improvements to air quality, with regard to reductions of the following pollutants: CO2, NOX, SO2, PM10 and PM2.5

4.2 METHODOLOGY

Our methodology for measuring the benefits of the White Oak Bayou Greenway followed the steps outlined below:

4.2.1 BENEFITS PATHWAY

Benefits pathways are a useful way to map out the benefits emerging from walking and biking actions. An action is any intervention on the ground that leads to a change in social, economic and/or environmental conditions, e.g. a new bike lane, a tree planting programme, etc. The output of this intervention is the physical or observable change that it brings about, e.g. an increase in number of people cycling, or an increase in the green area of the city. Finally, the outcome is the benefit of this change to the city or population, e.g. a reduction in risk of obesity, a reduction in average urban temperature. An output can also be a benefit in itself. The diagram below illustrates the possible outputs and outcomes/benefits associated with a new bikeability project.

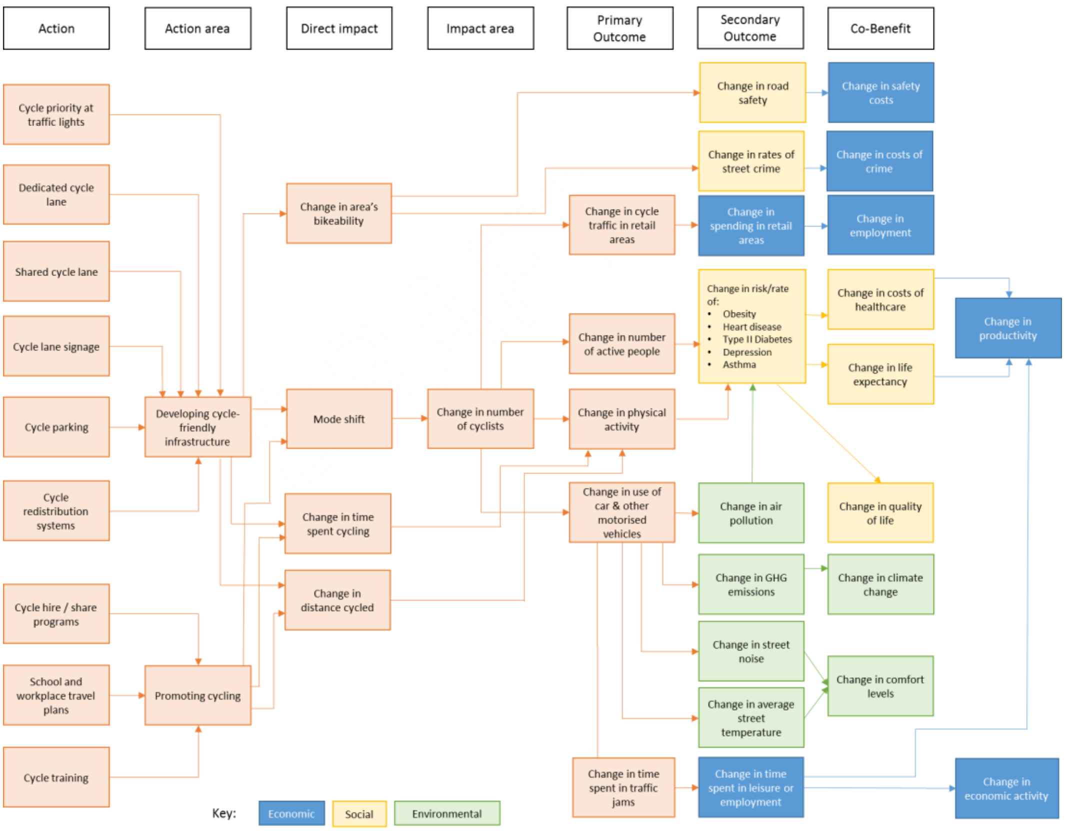


Figure 1 Benefits Pathways for cycling projects in cities.

It is important to understand which benefits are the priority for the city, before commencing data collection. This keeps data collection and analysis targeted on the benefits that are likely to be most valuable or persuasive for city stakeholders.

4.2.2 DATA COLLECTION

Based on the prioritised benefits, the city team completed a data collection template to provide data from before and after the intervention. The data collected covered all elements of the benefits pathway: action, output and outcome. Collecting pre- and post-intervention data is essential for understanding the change over time, and any available continuous time-series data can be particularly useful for this.

The data collected for Houston included:

- Description of the cycling infrastructure, e.g. length of cycle lanes (km), length of cycling journeys before and after the action
- Time and distance that people were cycling before and after the action
- Mode shift, e.g. the increase/decrease in the use of cars or public transport over time
- Direct/indirect jobs from the construction and maintenance of the bike lanes
- Cost of the infrastructure, both capital and operational costs
- Air quality, e.g. the concentration of PM10 / PM2.5 / NOx before and after the action.

4.2.3 DATA GAP ANALYSIS

The data provided by the city team were reviewed and gaps in the data were identified against the essential data required to measure the benefits for this study. Gaps were discussed with the city to understand what further local information might be available, and which gaps should be addressed through a literature review (e.g. using proxy data and benchmarks). See Appendix 1 for a table of the gap analysis findings.

4.2.4 LITERATURE REVIEW

Following the gap analysis, the C40 and Arup project team performed an extensive literature review to identify benchmarks and proxy data from other cities and similar research that could be used to fill data gaps for Houston, to help build a more complete picture of potential benefits.

4.2.5 DATA ANALYSIS

City data was combined with multipliers and proxy data from wider research to estimate the benefits of the White Oak Bayou Greenway. Three types of measurement were used to estimate the benefits:

- Monetisation – economic multipliers were used to convert a social or environmental change, bespoke to Houston, into a monetary value.
    - The Health Economic Assessment Tool (HEAT[1]), developed by the World Health Organisation (WHO), was used to estimate the value of reduced mortality as a result of physical activity on the White Oak Bayou Greenway.

[1] http://www.heatwalkingcycling.org/

- Quantification – utilising data from Houston, in combination with multipliers from wider research, to calculate bespoke action-benefit relationships using a wider set of metrics than dollar values.
- Illustration – based on research about other cities, examples of interventions in other cities were used to provide an indication of what the benefits in Houston might be. Illustration is particularly useful in cases where local city data is not available, but an indication of potential benefits is still needed.

4.3 LIMITATIONS

Some important data was not available for the local area, resulting in the need for assumptions to be made. Most notably, data on the modal shift was not known for this specific scheme. In this instance, guidelines from the HEAT tool were used to reach an informed assumption in combination with local knowledge and understanding of circumstances in other US cities. In some cases however, when data was not available and nor were alternative guidelines, assumptions were made through discussion with the city team. For example, this was the case for the trips per year per user, which was estimated on the basis of cycle counter data combined with logical assumptions about the number of days spent cycling and the number of trips likely per day. For these few examples where no data or guidelines were available, the assumed values were confirmed with the City of Houston. This model can be updated later as more accurate data becomes available.

The quality and consistency of available data varies throughout the model. Ideally, values should be specific to Houston, Harris County or Texas. However, this was not always possible and US values were sometimes used, which somewhat affects the confidence levels for the results. Where national level data was used (e.g. Global Burden of Disease data), it was adjusted to city scale using age and gender proportions to generate more accurate proxy data.

In some cases, such as the values of pollution, data for Houston was available but from a much earlier time period (values from 1989). Throughout the model attempts were made to source the most current and complete data possible for all inputs. Where monetary metrics were used, inflation rates were applied to adjust the results from one year to another.

For the purposes of this study, where data was not available with appropriate granularity to illustrate conditions on the bike lane itself over a significant period of time, these benefits were not prioritised for analysis. For example, crime data along the route did not show a long enough record to demonstrate any clear trends in increased or reduced incidents of crime in the area. In these cases, the City of Houston is encouraged to continue monitoring conditions over time in order to identify significant changes.

5 BENEFITS OF CYCLING IN HOUSTON

5.1 SOCIAL BENEFITS

This section estimates the social value of physical activity in terms of reduced mortality and morbidity, as a result of increased cycling along the White Oak Bayou Greenway. Health benefits relate to the impacts on health risks experienced by the population. By comparing the risk of death and disease before and after the intervention, the health benefits enjoyed by those who choose to use the bike lane regularly were estimated.

Data inputs:

- Average trip time: 32.6 minutes[2]
- Repetition of trip per user: 200 times per year[3]
- National Years of Life Lived with Disability (YLDs) data for the seven considered diseases, split according to age and gender (source: The Global Burden Disease database[4]). To establish baseline risk data, the YLDs were scaled down to the specific group of cyclists benefitting from the additional physical activity using population ratios.
- Average time of physical activity per cyclist on the White Oak Bayou Greenway: 125 minutes per week
- Relative risk reductions[5] [6] (from the ITHIM tool, see below) to estimate the risk reduction achieved through the additional physical activity for each of the seven considered diseases.

YLDs – A measurement of the burden of disease. YLDs are calculated by multiplying the prevalence of a disorder by the short- or long-term loss of health associated with that disability.

ITHIM Tool – Integrated Transport and Health Impact Modelling Tool, refers to a range of related models and tools developed to perform integrated assessment of the health effects of transport scenarios and policies at the urban and national level.

Mortality benefits:

The WHO HEAT calculations show that 0.32 premature deaths in Houston will be postponed each year due to the health benefits of physical activity for the 705 individuals regularly using the White Oak Bayou Greenway.

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[2] https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/811841b.pdf
[3] Based on an assumed average use of 2 trips per day. 5 days per week, 20 weeks a year.
[4] http://www.healthdata.org/gbd
[5] Woodcock, J., Edwards, P., Tonne, C. et al. (2009) Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. Lancet 2009; 374: 1930–43. DOI http://dx.doi.org/10.1016/S0140-6736(09)61714-1
[6] Smith, A.D., Crippa, A., Woodcock, J. et al. Diabetologia (2016) 59: 2527. doi:10.1007/s00125-016-4079-0

Morbidity benefits:

Applying the risk reduction factors to the YLDs prior to the intervention gives the following reduction of YLDs for each disease as a result of increased physical activity from cycling:

Data Type	Scaled risk reduction (125 min/ week)	YLDs before the project (average per person)	YLDs after the project (average per person)	Years saved (average per person)
Heart disease risk reduction	20%	0.55	0.44	0.11
Stroke risk reduction	20%	0.22	0.18	0.04
Dementia risk reduction	9%	0.22	0.20	0.02
Diabetes type 2 risk reduction	12%	5.48	4.80	0.68
Depression (>29 years)	12%	8.34	7.35	0.99
Breast cancer (female)	10%	0.36	0.33	0.03
Colon cancer (male)	7%	0.103	0.096	0.007

Figure 2 Risk reductions and YLDs pre- and post-intervention (see Appendix 2 for full data set)

In all cases, the increased physical activity undertaken by cyclists using the White Oak Bayou Greenway is expected to provide positive improvements in the risk of disease. As the number of users of the trail increases over time, these benefits will accrue to a larger group of the population. If physical activity averages more than 125 minutes per week, the risk reduction will also increase.

Global research

It is estimated that there is a 10% decreased risk of type 2 diabetes pr. 10-mg/m3 fine particulate matter (PM2.5) exposure[7].

[7] Eze IC, et al. Association between ambient air pollution and diabetes mellitus in Europe and North America: systematic review and meta-analysis. Environ Health Perspect 123:381-9 (2015)

5.2 ENVIRONMENTAL BENEFITS

Introducing a bike scheme has positive air quality impacts as it attracts new users, offsetting trips that otherwise would have been made by cars or public transport. This mode shift from automotive modes of transport determines the amount of emissions avoided.

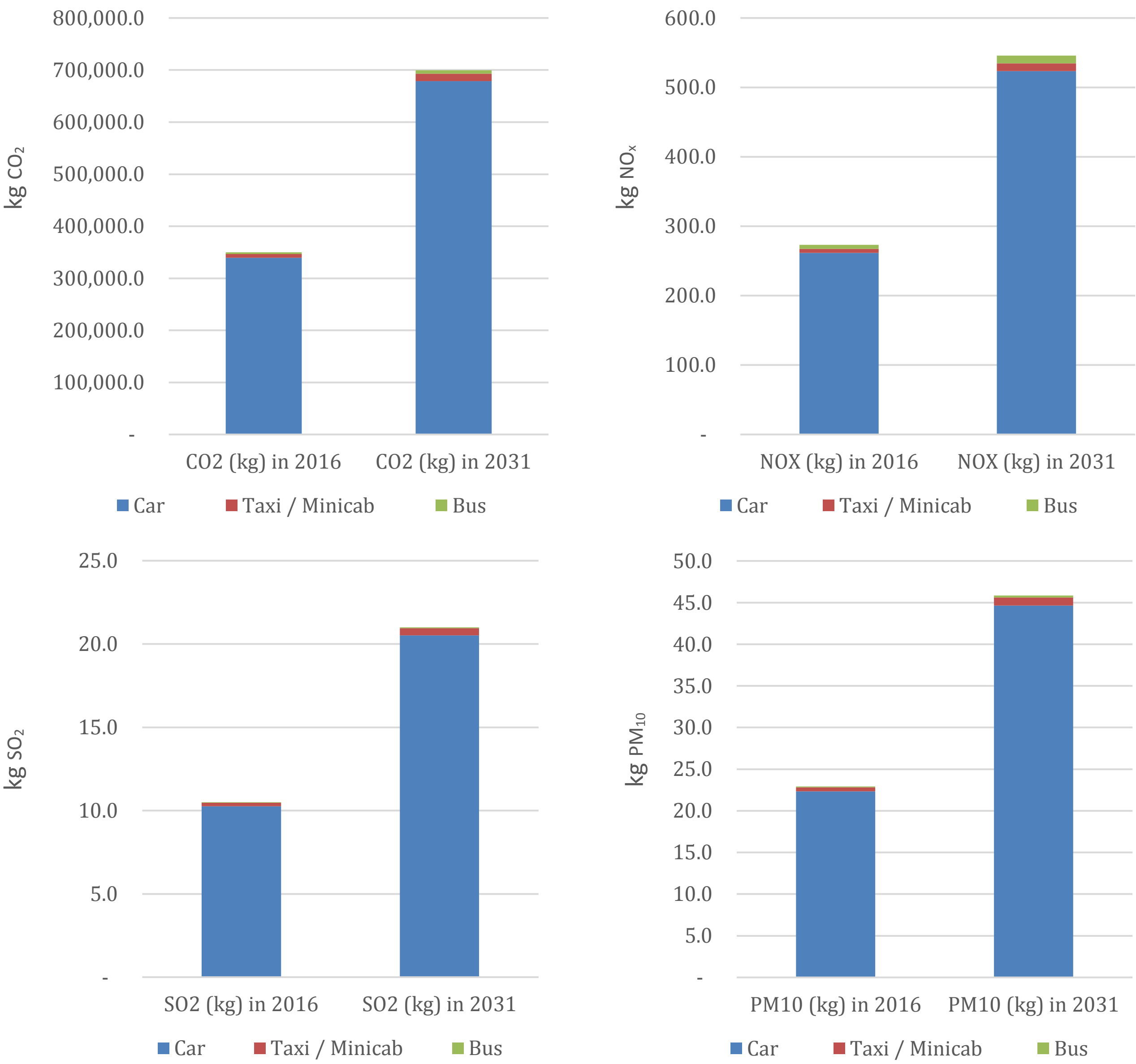
Data inputs:

- Mode shift was estimated to be 55%, which means that of all the trips currently undertaken 55% would have been taken by automotive modes of transports if the bike lane did not exist.
- Number of trips per day: 703 trips/day (based on trip count data from the City of Houston)
- Average length of each trip: 8.2 km (5.1 miles)
- Emissions per km for each type of pollutant for each mode

Benefits:

Based on the inputs above, the avoided emissions for each pollutant and mode of transport was calculated for 2016 and 2031 as follows:

As the data shows, the shift from private car to bicycle has the most significant potential benefit for air quality. This is particularly the case for a city like Houston, where private car travel is high. For all pollutants, there is a significant improvement in air quality associated with mode shift to cycling along the White Oak Bayou Greenway. Assuming that the number of users will double by 2031, this improvement is expected to continue increasing over time. A valuation of these improvements is provided in section 5.3.2.



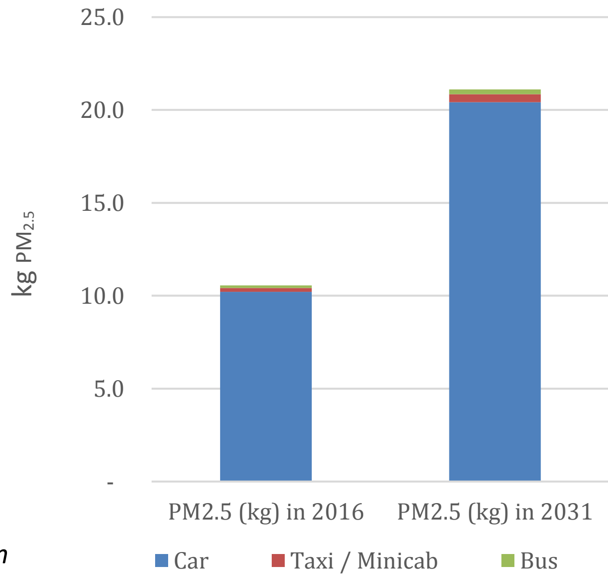


Figure 3 Emissions avoided (kg) of pollutants from different modes

5.3 ECONOMIC BENEFITS

5.3.1 THE ECONOMICS OF HEALTH BENEFITS

As described in Chapter 4, the WHO HEAT tool was used to estimate the reduced mortality as a result of physical activity on the White Oak Bayou Greenway.

Key data inputs:

- WHO HEAT calculations for mortality - 0.32 premature deaths in Houston will be postponed each year due to the health benefits of physical activity
- Value of Statistical Life (VSL[7]) in the US of $8,895,616[8]**Benefits:**

Benefits:

Based on the WHO HEAT calculations and the Value of Statistical Life (VSL) in the US of $8,895,616, this equates to an annual benefit of $2,855,000.

Benefit-cost ratio:

Considering the total discounted costs over the lifetime of the scheme compared with the total discounted benefits, given the number of users in 2016 the scheme achieves a benefit-cost ratio of 2.38:1 (i.e. the benefits exceed the costs by 2.38 times). This ratio becomes more favourable as more users take to the White Oak Bayou Greenway, as there is a positive linear correlation between user numbers and benefits.

By 2031, it is estimated that the number of cyclists using the trail will stabilise, by which time it is estimated that user numbers have doubled compared to 2016 figures. Based on this, 0.64 deaths will be prevented per year, with a benefit-cost ratio of 4.76:1 (benefits exceed costs by nearly 5 times).

	2016	**2020**
Deaths prevented per year	0.32	0.64
Total cost over 25 years	$ 20,907,000	$ 20,907,000
Total savings (benefit) over 25 years	$ 49,715,000	$ 99,430,000
Benefit-cost ratio	2.38:1	4.76:1

Figure 4 The Economics of Health Benefits

[7] VSL is a measure of the value an individual places on changes in their likelihood of death, calculated in terms of the risks that people are voluntarily willing to take and how much they must be paid for taking them. There are different methods of calculating VSL in economics, meaning that the VSL for any country can vary by source.
[8] https://www.ers.usda.gov/webdocs/DataFiles/48464/VSL.xlsx?v=42870

5.3.2 THE ECONOMICS OF ENVIRONMENTAL BENEFITS

The environmental benefits of the scheme include the reduction of harmful gases from transport, which include emissions that are detrimental to climate change and air quality. However, reducing emissions is far further reaching than just the environmental impact. For example, the EPA and other federal agencies use estimates for the social cost of carbon which measure the long term damage per tonne of CO2 released.

The social cost of carbon is a comprehensive estimate of climate change damages and includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning[9]. Based on these impacts, the Environmental Protection Agency (EPA) has estimated the social cost of carbon to be 0.06 \$/kgCO_2[10]. The costs of NO_x, SO_2, PM_{10} and $PM_{2.5}$ have been calculated in a similar way.

Key data inputs:

- Price of Carbon: 0.06 \$/kg[10]
- Price of NOx: 7.13 \$/kg[11]
- Price of SO2: 5.67 \$/kg[11]
- Price of PM10: 11.41 \$/kg[11]
- Price of PM2.5: 79.32 \$/kg[12]

Benefits:

Using the social cost of carbon, and the additional costs for the remaining pollutants, it was estimated that the emissions savings per year as a result of the White Oak Bayou Greenway are equivalent to roughly \$24,300 in 2016. Based on the estimated number of users in 2031, the total annual value doubles to nearly \$49,600.

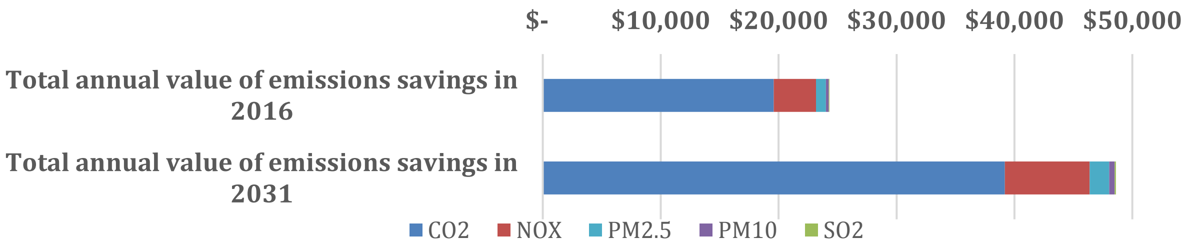


Figure 5 Total value of emissions savings for different pollutants (assuming same cost of carbon in 2031).

[9] https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html
[10] ttps://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf
[11] http://healthpolicy.ucla.edu/Documents/Newsroom%20PDF/tca0510.pdf
[12] http://ec.europa.eu/environment/archives/cafe/activities/pdf/cafe_cba_externalities.pdf

5.4 BENEFITS TO JOBS

Impacts on employment were assessed by looking both at the creation of direct jobs as well as indirect and induced jobs during the construction phase.

Direct jobs refer to employment directly related to the construction of the bike trail, i.e. contractors employed to build the trail. Meanwhile **indirect jobs** are generated as a result of this direct employment, i.e. builder's merchants who supply the necessary goods to the contractors. Finally, when these directly and indirectly generated incomes are spent on a variety of items in the broader economy, i.e. food, clothing and entertainment, it gives rise to **induced jobs**.

Data inputs:

- Multipliers for direct, indirect and induced jobs per $1million invested for road infrastructure with bicycle and pedestrian facilities in Houston[13]
- Scheme capital cost: $12.2m
- 12 full time maintenance jobs

Benefits:

It was estimated that 394.2 job-years would be created over the 25-year lifetime of the scheme, equivalent to 200 direct jobs and 128 indirect jobs during the construction period (2.7 months), 12 full-time maintenance jobs for every year of the 25-year period, and 22 induced jobs over a year. These estimates take into account a number of additionality factors (see below).

The additionality factors include deadweight, leakage, displacement, substitution and an economic multiplier. A deadweight of 20% was assumed, which is typical for interventions related to transport[14]. Leakage is expected to be low as most of the benefits will go to people living within the area, thus 10% was assumed. Both displacement and substitution were considered unlikely to take place due to the relatively isolated location of the trail. Finally, an economic multiplier of 1.38 was utilised, an average linkage value for 'recreation' interventions, based on recommendations from the UK government 'Additionality' guide[14].

Economic multiplier - Further economic activity associated with additional local income and local supplier purchases.

Leakage - The proportion of employment which occurs outside the intervention's target area.

Displacement - When the intervention reduces existing activity from within or outside the area.

Substitution - Where the intervention results in a firm substituting one activity for another.

[13] https://www.peri.umass.edu/publication/item/427-pedestrian-and-bicycle-infrastructure-a-national-study-of-employment-impacts
[14] 'Additionality guide', UK Homes & Communities Agency, Fourth Edition 2014

	Values for Houston (job years/$ million capital investment)[15]	**White Oak Bayou Greenway construction - Adjusted job years**	**White Oak Bayou Greenway maintenance - Adjusted job years**	**Total job years (over 25yrs)**
Direct Jobs	3.7	44.9	298.1	342.9
Indirect Jobs	2.4	29.1	N/A	29.1
Induced Jobs	1.83	22.2	N/A	22.2
Total	7.93	96.1	298.1	394.2

Figure 6 Summary of job years created

Global example

The City of Copenhagen completed an analysis of the social benefits of cycling, including factors such as affordability, security, comfort, tourism, travel times and health. With all of these factors taken into account, the study estimated a net social gain of DKK 1.22 (US $0.18) per kilometre cycled. By comparison, there is an estimated net social loss of DKK 0.69 (US $0.10) per kilometre driven by car.

[15] 'Houston off street multi-use cycle lanes', Heidi Garrett-Peltier, page 13

6 CONCLUSIONS AND NEXT STEPS

The key findings of this research can be summarised as follows:

Category of benefit	Findings	Data sources
Social - Health	Reduced risk of diseases related to increased physical activity (cycling).	Combination of local, state and national level data, with assumed mode shift. Findings could be improved with the development of city-level burden of disease database and city data on mode shift by cyclists using the White Oak Bayou Greenway.
	Reduced risk of mortality due to increased physical activity (cycling).	Combination of local and national data, combined with assumptions of the WHO HEAT tool.
Environmental – Air quality	Significant reduction in all key air pollutants linked to mode shift from motorised transport to cycling. Likely to have a knock-on benefit for the incidence of respiratory disease.	Assumptions about mode shift and typical age/efficiency of motor vehicles in Houston. National benchmarks used to monetise benefits. Findings could be improved with city data on mode shift by cyclists using the White Oak Bayou Greenway, including age/efficiency of vehicles they would otherwise be using.
Economic – jobs	Creation of new direct, indirect and induced jobs as a result of the bike lane, likely to continue for the long term.	Combination of local data about project costs and direct jobs created, with multipliers for indirect and induced jobs.

Figure 7 Key findings

6.1 NEXT STEPS FOR DATA COLLECTION

6.1.1 MODAL SHIFT

Modal shift is the most significant data point for this analysis as this directly impacts on the health and air quality benefits by determining the number of new active users and the number of automotive journeys avoided due to the scheme. Small changes in the mode shift can have large impacts on the benefits experienced. Therefore, gaining a better informed understanding of the mode shift would provide outputs that are more robust and accurate. This should include understanding whether trail use is recreational or commuter/errand, also important in determining the number of automotive journeys avoided.

In addition, the number of new trips (predominantly recreational users) that weren't taking place prior to the introduction of the scheme, is equally important in determining the number of new active users.

6.1.2 NUMBER OF TRIPS

Another important data point is the number of trips per year per user. This, combined with the trip count data along the bike lane, is used to determine the number of users. In turn, combined with the mode shift, this determines the number of new active users benefitting from increased physical activity. As mentioned in the Limitations section, data on the number of trips per year per user was not available resulting in assumptions being made; therefore, gaining an evidence based value would hold considerable value.

The most effective way to understand the mode shift and the number of trips per year per user is to conduct intercept surveys along the length of the bike lane at different times of the day and days of the week. Bicyclists are often keen to engage and contribute to surveys if it is made clear that the findings could result in more cycle lanes being introduced. In the past, Arup has successfully conducted intercept surveys by offering small incentives such as cups of coffee.

6.1.3 CRIME AND SAFETY

Benefits to crime and safety were not included in this report due to the lack of local data or lack of clear trends within the available data. It is recommended that if these benefits were to be assessed in the future, crime rates and cyclist collision rates are collected for the local area, ideally before and after the improvements to cycling infrastructure. The context of the White Oak Bayou Greenway – an off-road route – presents particular challenges with respect to estimating the likely impact of the bike lane itself on cyclist safety along local roads; assumptions would have to be made to isolate the potential effect of the bike lane from other interventions. Likewise, with respect to crime, reductions in street crime rates due to a bike lane project are typically connected to an increased number of “eyes on the street” (natural human observation due to the increased number of cyclists); however, it is difficult to extrapolate findings from on-road bike lanes to a more isolated project such as the White Oak Bayou Greenway. For these reasons, robust local data is essential.

6.2 POLICY NEXT STEPS

As part of the Houston Bike Plan, the White Oak Bayou Greenway is a scalable project that can be connected to other potential capital projects that would link neighbourhood areas into a more comprehensive network of safe cycling and walking infrastructure. In the long term, the Houston Bike Plan is expected to scale over time to create a complete bicycle network. The evidence presented in this report demonstrates the potential value of a wider network for health, environment and the economy.

As the scheme grows, it is recommended that data collection is designed into the network over time to allow ongoing monitoring of user numbers as well as attributes such as air quality, noise levels, heat and other potential benefits. This can be done through simple sensors placed along the route to provide local level data. This data can be monitored and analysed on a regular basis to determine benefits realised over time as the network grows. This would help to better inform city departments, decision makers, and the public on the health and other benefits of increased walkability and bikeability, and in turn help to promote ongoing growth of the cycling and walking agenda in Houston and other cities. To do this often requires the cooperation of a number of different city stakeholders (or data holders) to bring data sets together effectively, from the Police department for crime and safety data, to the Environment department for air quality data.

The long-term vision of the Houston Bike Plan for the full network would “put 97% of the whole population, 97% of population of colour, and 96% of individuals in poverty within ½ mile of a high-comfort bicycle facility”[16]. Therefore, further data needs to be collected to analyse the health and wider benefits of walkability and bikeability and thus assess the effectiveness of hitting these inclusivity targets as the high-comfort bicycle network is built out. In addition to targets on proximity to bicycle facilities it may be worth considering proximity to destinations and provision of effective bike and walk routes to key destinations.

The city of Houston is taking its first steps to delivering a “Gold-level” bicycle friendly city by 2027. The benefits from the White Oak Bayou Greenway therefore represent only a small element of the future benefits that could be realised, once more bike trails are introduced. The more accessible this infrastructure becomes over time, the more the Houston population will take to cycling, as it becomes an increasingly safe, reliable and convenient form of transport. Infrastructure improvements should be supported by education and awareness campaigns to emphasise the personal benefits of cycling, encourage modal shift, and ensure the safety of all road users.

[16] Houston City Application to “Healthy, Liveable Cities - The Benefits of Climate Action” Call for Submissions.

APPENDIX 1: GAP ANALYSIS

Data Type	Local city data points (data received specific to the city)	Proxy data and benchmarks from other research	Data gaps (data required)
Context (data specific to trip)	Length and location of the scheme Trip count data at points along the bike trail (590 trips/day at 5th street, 290 trips/day at 34th street) Capital cost of scheme	Maintenance costs of scheme	No. of users of the scheme and how many hours per week they use the lane.
Output	Length of journey taken Gender split (50:50) Mortality rate (363 per 100,000) Value of statistical life ($ 8895616)	Total number of trips along the bike trail Modal shift to cycling on the bike trail from other modes of transport Morbidity Rate YLDs (years lived with Disability) National Cyclist split Job multipliers Additionality factors Average time taken per trip (32.6 minutes/trip) Average cycle speed (15.5 km/hour)	Number of new active users
Outcome	Links between mortality and introduction of scheme	Links between air quality and introduction of scheme Links between morbidity and introduction of scheme Links between employment and introduction of scheme	Impacts on all outcomes

Figure 81 Gap Analysis

APPENDIX 2: ITHIM RELATIVE RISK REDUCTIONS[17]

Data type	Time physical activity cycling (min/week)	Risk reduction
Heart disease risk reduction	150	23%
Stroke risk reduction	150	23%
Dementia risk reduction	150	11%
Diabetes type 2 risk reduction	133	13%
Depression (>29 years)	150	14%
Breast cancer (female)	71	6%
Colon cancer (male)	413	20%

Figure 92 ITHIM relative risk reductions

APPENDIX 3: DATA COLLECTION SPREADSHEET

See Houston data collection spreadsheet.

APPENDIX 4: DATA ANALYSIS SPREADSHEET

See Houston analysis spreadsheet.

[17] https://link.springer.com/article/10.1007/s00125-016-4079-0#Sec3

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