Cycling Cities | ITDP | FIA FOUNDATION

Protected Bicycle Lanes Protect the Climate

Measuring How Networks of Protected Bicycle Lanes Reduce Carbon Emissions, Transport Costs, and Premature Death

About ITDP and Cycling Cities

The Institute for Transportation and Development Policy (ITDP) is a global nonprofit that works with cities worldwide to design and implement high-quality transport systems and policy solutions that make cities more livable, equitable, and sustainable. ITDP's Cycling Cities campaign was launched in 2021 to provide governments, planners, advocates, and others with the tools to make cycling a safe and affordable transportation option in cities.

https://www.itdp.org/
https://cyclingcities.itdp.org/

About FIA Foundation

This report was supported by the generous funding of The FIA Foundation.

The FIA Foundation is an independent UK-registered charity, working closely with grant partners to shape projects and advocate to secure change in policy and practice. Our objective is safe and healthy journeys for all. Through partners with global reach, we are supporting safer vehicles and highways, clean air and electric cars and greater mobility access & inclusivity.

https://www.fiafoundation.org/

Authors and Acknowledgments

Lead Author

D. Taylor Reich
Institute for Transportation and Development Policy (Global)

Contributing Authors

Gashaw Aberra
Institute for Transportation and Development Policy (Africa)

Angie Ángel
Fundación Despacio

Miguel Ángel Cuéllar
Fundación Despacio

Kanghao He
Institute for Transportation and Development Policy (China)

Qianqian Hu
Institute for Transportation and Development Policy (China)

María Fernanda Ramírez
Fundación Despacio

Li Wei
Institute for Transportation and Development Policy (China)

Weilong Yu
Institute for Transportation and Development Policy (China)

Reviewers

Saba Akber
Institute for Transportation and Development Policy (Global)

Sebastian Castellanos
World Resources Institute

Chris Dekki
SLOCAT Partnership on Sustainable, Low Carbon Transport

Jacob Mason
Institute for Transportation and Development Policy (Global)

Pepe Monroy
C40 Cities

Daniel Moser
World Bank

Honorine van den Broek d'Obrenan
C40 Cities

John Symons
Institute for Sustainable Industries and Livable Cities – Victoria University

Alphonse Tam
Institute for Transportation and Development Policy (Global)

Catalina Vanoli
CAF – Development Bank of Latin America

Sheila Watson
FIA Foundation

Dana Yanocha
Institute for Transportation and Development Policy (Global)

Publication Date: October 19th, 2022

Cover Photo: Protected bicyle lane in Toyu Road in Guangzhou, China. **Source:** ITDP China

Support

This research was made possible with support from the FIA Foundation. Any flaws or errors remain the responsibility of the authors alone.

Contents

Contents 4

1. Summary and Introduction 6

2. Context 8

- **2.1. Climate Change and Protected Bicycle Lanes** 8
- **2.2. Literature Review** 11

3. Measuring Impacts 13

- **3.1. City Background** 14
  - 3.1.1. Bogotá 15
  - 3.1.2. Guangzhou 18
- **3.2. Method** 20
  - 3.2.1. Counts 21
  - 3.2.2. Surveys 24
  - 3.2.3. Carbon Emissions 24
  - 3.2.4. Time and Cost Savings 25
  - 3.2.5. Public Health 26
  - 3.2.6. Limitations 26
- **3.3. Results and Discussion** 27
  - 3.3.1. Cycling Activity 27
  - 3.3.2. Modal Shift 28
  - 3.3.3. Carbon Emissions 32
  - 3.3.4. Cost–Benefit Comparison for Carbon Emissions 33
  - 3.3.5. Time and Cost Savings 38
  - 3.3.6. Public Health 39

4. Predicting Impacts 41

- **4.1. City Background: Addis Ababa** 43
- **4.2. Method** 45
  - 4.2.1. Predicting Cycling Activity 45
  - 4.2.2. Predicting Modal Shift 47
  - 4.2.3. Predicting Greenhouse Gas Impacts 49
- **4.3. Results** 49
  - 4.3.1. Predicting Cycling Activity in Addis Ababa 49
  - 4.3.2. Predicting Modal Shift in Addis Ababa 50
  - 4.3.3. Predicting Greenhouse Gas Impacts in Addis Ababa 50
- **4.4. Predicting Impacts in Other Cities** 51

1. Summary and Introduction

Source: Despacio

1. Summary and Introduction

To avoid the worst effects of climate change, the world's cities need to both electrify their vehicle fleets and shift most automobile travel to walking, cycling, and public transit.[1,2,3,4] Research has broadly shown the positive climate impacts of more cycling, but there has been little research that directly links cycling infrastructure to reductions in greenhouse gas (GHG) emissions, with a particular lack of studies in low- and middle-income countries. As a result, decision-makers may understand that cycling is associated with environmental benefits, but have not focused on cycling as a climate solution.

Connected networks of physically protected bicycle lanes, rather than individual or unprotected lanes or other policy measures, are generally regarded as the most important factor in promoting cycling.[5,6,7] What has remained unstudied is the quantitative specifics of how much of a reduction in driving, and therefore in emissions, is caused by protected bicycle lane networks. This study takes a new step, providing what may be the first-ever empirical measure of GHG reductions from networks of protected bicycle lanes in low- and middle-income countries. We did this by examining two cities in middle-income countries that have built extensive networks of protected bicycle lanes. We used cyclist counts to measure the increase in cycling attributable to those networks and carried out intercept surveys to identify the portion of that increase shifting from cars and motorcycles to cycling.

We found that a citywide network of protected bicycle lanes in a middle-income city can prevent the emission of tens of thousands of metric tonnes of CO_2eq GHG every year.

In our case study cities, Bogotá and Guangzhou, we estimated impacts of 22,000 and 16,000 tonnes GHG prevented per year respectively. Given the low cost of building protected bicycle lanes, this equates to roughly 10 times as much GHG reduction per dollar spent on infrastructure than with metro rail systems, and slightly more than bus rapid transit. In other cities, the impacts of bicycle lanes will scale with the size of the city and the coverage of the network.

Based on these findings, we developed a publicly available modeling tool to predict the GHG reductions that can be expected from planned bicycle lane networks. This tool takes only a few minutes to produce context-sensitive projections of the climate impacts of proposed or planned bicycle lane networks in any city.

Huadi Avenue North in Guangzhou, China is a complete street that incorporates protected bicycle lanes. Source: ITDP China

1. International Transport Forum (2021), ITF Transport Outlook 2021.
2. Teske, S., Niklas, S., Langdon, R. (2021), TUMI Transport Outlook 1.5°C – A Global Scenario to Decarbonise Transport, Transformative Urban Mobility Initiative.
3. Fulton, L., et al. (2021), The Compact City Scenario – Electrified, ITDP & University of California, Davis.
4. International Council on Clean Transportation (2020), VISION 2050: A Strategy to Decarbonize the Global Transport Sector by Mid-Century.
5. People for Bikes (2017), Protected Bikes Lanes 101.
6. Global Designing Cities Initiative (2016), Global Street Design Guide.
7. Javaid, A., et al. (2020), "Determinants of low-carbon transport mode adoption: systematic review of reviews," Environmental Research Letters, 15: 103002.

Beyond reducing GHGs, a citywide network of protected bicycle lanes has other measurable benefits. In fact, once the network is complete, these co-benefits create a greater economic value in a single year than the cost of building the entire network. For example, in Bogotá, people who cycle instead of drive or ride transit save time and money on every trip, for an estimated total economic benefit of 80 million USD/year. Cycling is also a form of physical exercise, so bicycle lane networks also have benefits for public health: we estimate that they prevent about 300 premature deaths every year in Bogotá, with an economic benefit of 230 million USD. Bogotá's bicycle lane network cost only an estimated 130 million USD to build. As with GHG reductions, these values will scale with the size of the city and the bicycle lane network. Economic value estimates for Guangzhou are included in the table below.

Networks of protected bicycle lanes are highly effective investments in carbon reduction, transportation efficiency, and public health. They are relatively inexpensive and can be built rapidly, but when these networks are implemented at a citywide scale their impacts are huge. Development banks and climate funders, as well as city and national governments, should take note: The benefits of protected bicycle lane networks are clear. It is time to build them.

Estimated Impacts of Protected Bicycle Lane Networks in Bogotá and Guangzhou

	Bogotá	**Guangzhou**
Length of protected bicycle lane network (km)	592	288
Cost to build network (USD)	132 million	69 million
Amount of cycling activity on protected bicycle lanes (person-kilometers traveled per year)	1.6 billion	1.5 billion
Percent of cycling activity that would have been traveled by car or taxi if the bicycle lanes did not exist	6.3	5.7
Percent of cycling activity that would have been traveled by motorcycle if the bicycle lanes did not exist	9.9	-
Reduction in greenhouse gas emissions caused by protected bicycle lanes (tonnes CO_2eq per year)	22,000	16,000
Travel time savings per trip (min per trip)	14	0.12
Total travel time savings (hours per year)	27,000,000	550,000
Travel cost savings per trip (USD per trip)	0.62	0.10
Total travel cost savings (USD per year)	80 million	30 million
Premature deaths prevented due to protected bicycle lanes (deaths per year)	300	50
Premature deaths prevented due to protected bicycle lanes (deaths per year)	230 million	55 million

2. Context

SOURCE: ITDP México

2.1. Climate Change and Protected Bicycle Lanes

The crisis of climate change has become clearer. We are witnessing unprecedented wildfires, droughts, heatwaves, floods, and storms, but these disasters are small in comparison to the catastrophes that will follow if global warming is not limited to the Paris Agreement goal of 1.5°C by the end of the century.

While many have focused on vehicle electrification as a means for reducing emissions, electrification alone is not a complete solution. Several recent studies have shown that to limit emissions from the transportation sector in line with the Paris Agreement, cities will require rapid and significant increases in walking, cycling, and public transit as well as electrification of motor vehicle fleets.[8, 9, 10, 11] The Intergovernmental Panel on Climate Change states that "Cities can reduce their transport-related fuel consumption by around 25% through combinations of more compact land use and the provision of less car-dependent transport infrastructure. Appropriate infrastructure, including protected pedestrian and bike pathways, can also support much greater localised active travel."[12]

Cycling is not the only solution. It stands alongside electrification, public transit, walking, and land-use reform as a key pillar of the decarbonization of urban passenger transportation.

Experts agree that many policies and interventions are important in promoting cycling, including:

- Bikeshare systems[13]
- Safe and convenient bicycle parking facilities
- Promotion of e-bikes and scooters, including financial incentives for purchase[14]
- Legal protection for people riding bicycles
- Laws requiring motor vehicles to pass people riding bicycles in a safe way
- Reduction of import tariffs on bicycles and e-bikes
- Reduction of vehicle speeds on shared streets
- Cycling education
- Cultural shifts to promote cycling, especially among women

Although these policies expand safety and access to cycling, consensus is that the most crucial action a city can take to promote cycling is the construction of a network of protected bicycle lanes.[15, 16, 17] Throughout this study, when we use the phrase "network of protected bicycle lanes," we mean an **extensive, well-connected network of physically protected lanes for bicycles and other forms of micromobility.**

8. International Transport Forum (2021), ITF Transport Outlook 2021.
9. Teske, S., Niklas, S., Langdon, R. (2021), TUMI Transport Outlook 1.5°C – A Global Scenario to Decarbonise Transport, Transformative Urban Mobility Initiative.
10. Fulton, L., et al. (2021), The Compact City Scenario – Electrified, ITDP & UC Davis.
11. International Council on Clean Transportation (2020), VISION 2050: A Strategy to Decarbonize the Global Transport Sector by Mid-Century.
12. IPCC AR6 WGIII (2022), "Chapter 10: Transport," Executive Summary, in Climate Change 2022: Mitigation of Climate Change, p. 10-4.
13. Yanocha, D., et al. (2018), The Bikeshare Planning Guide (2018 Edition), ITDP.
14. Yanocha, D., Allan, M. (2019), The Electric Assist: Leveraging E-Bikes and E-Scooters for More Livable Cities, ITDP.
15. People for Bikes (2017), Protected Bikes Lanes 101.
16. Global Designing Cities Initiative (2016), Global Street Design Guide.
17. Javaid, A., et al. (2020), "Determinants of low-carbon transport mode adoption: systematic review of reviews," Environmental Research Letters, 15: 103002.

Extensive: For cycling to be a reasonable transportation option, a network of protected bicycle lanes must connect many places throughout the entire city. If a city only has a few kilometers of protected bicycle lanes, no matter how high the quality of those lanes may be, they will be useless for the vast majority of trips as these will either start or end at locations not served by the lanes.

Well-connected network: For most people to be able to ride a bicycle from one place to another, the two places must be connected by protected lanes that enable a reasonably direct trip from one to the other, without any need for riding a bicycle in mixed traffic. That means that protected bicycle lanes are not only necessary, they also must fit together into a connected network. Connection requires not only large-scale geographical design of a network (rather than unrelated separate lanes) but also small-scale urban design of safe street crossings between different bicycle lanes, especially at major intersections.

Physically protected lanes: The majority of people are unwilling to ride a bicycle for transportation unless there is some kind of physical separation that protects them from motor vehicle traffic. In the United States, for example, only about 10% of people are confident cyclists, while about 50% are interested in cycling but unwilling to cycle on facilities that are not physically protected from fast-moving cars. This protection can take the form of concrete barriers, metal bollards, planter boxes, a grass verge, railings, curbs, landscaping, or barriers of other forms. Cycle pathways through parks or other car-free areas are also considered physically protected. Bicycle lanes must be physically separated not only from cars but also from pedestrians to prevent unsafe conflicts.

Bicycles and other forms of micromobility: Throughout this paper, we refer almost exclusively to bicycles, both for simplicity and because they are the most common form of micromobility. These protected bicycle lane networks, however, can serve many other kinds of small slower-moving vehicles, including e-bikes, cargo bikes, skateboards, standing scooters/kick-scooters, and wheelchairs and other adaptive mobility devices.

Beyond reducing carbon emissions, networks of protected bicycle lanes confer many benefits for public health and the economy. This study includes an estimate of the physical health benefits of increased cycling in Bogotá and Guangzhou. It also includes an estimate of the direct savings of time and money experienced by people riding bicycles. Owing to limitations of data collection, however, this study does not include the benefits of protected bicycle lane networks for air quality, mental health[19], or road safety,[20, 21] nor does it include the indirect economic contributions of increased cycling.[22]

With the climate crisis looming, it is urgent that we decarbonize our societies in a way that is rapid and economically efficient. Bicycle lane networks can be built much more quickly than rapid transit systems: implementation takes years rather than decades. They are also relatively inexpensive to implement compared with other transport infrastructure and bring many economic co-benefits.[23] Bicycle lanes have often not been treated as major infrastructure in the same way as rapid transit and highways – they may be considered streetscape improvements, neighborhood benefits, or side-benefits of a larger project. We hope this report will encourage development banks and governments to see citywide protected bicycle lane networks as large-scale infrastructure projects, worthy of large-scale funding and planning.

2.2. Literature Review

There is clear evidence that GHG emissions are growing most rapidly in low- and middle-income countries, and there is a general recognition that cycling is essential to carbon reduction. There is also a consensus that networks of protected bicycle lanes are essential for promoting cycling. However, there remains little empirical evidence tracing the causal link between protected bicycle lane networks and carbon emission reductions in the Global South.

There is some research on the carbon impacts of investment in other modes of sustainable transportation in middle-income countries, including bus rapid transit (BRT) and metro rail.[24,25,26,27] But the current literature on cycling disproportionately considers Europe and North America. One recent study shows a clear relationship between increased cycling and reduced carbon emissions in Europe.[28] Others provide evidence that pop-up bicycle lanes and networks of protected bicycle lanes substantially increase cycling rates in the same region. Another shows a strong and direct relationship between bicycle lanes and GHG reduction in a North American city.[29,30,31]

18. The remaining 40% are uninterested in cycling at all. Dill, J., McNeil, N. (2016), "Revisiting the four types of cyclists: findings from a national survey," Transportation Research Record, 2587: 90-99. See also https://jenniferdill.net/types-of-cyclists.
19. Ma, L., Ye, R., Wang, H. (2021), "Exploring the causal effects of bicycling for transportation on mental health," Transportation Research Part D: Transport and Environment, 93: 102773.
20. Castro, A., Kahlmeier, S., Gotschi, T. (2018), Exposure-Adjusted Road Fatality Rates for Cycling and Walking in European Countries, International Transport Forum.
21. Marshall, W.E., Ferenchak, N.N. (2019), "Why cities with high bicycling rates are safer for all road users," Journal of Transport & Health, 13: 100539.
22. Yanocha, D., Mawdsley, S. (2022), Making the Economic Case for Cycling, ITDP.
23. Yanocha, D., Mawdsley, S. (2022), Making the Economic Case for Cycling, ITDP.
24. Clean Development Mechanism (2012), Monitoring Report: BRT Bogotá, Colombia: TransMilenio Phase II to IV, 7th Monitoring Period 01/01/2012-31/12/2012.
25. Hughes, C., Zhu, X. (2011), Guangzhou, China Bus Rapid Transit: Emissions Impact Analysis, ITDP.
26. Chen, F., et al. (2017), "An evaluation of the low-carbon effects of urban rail based on mode shifts," Sustainability, 9(3): 401.
27. de Andrade, C.E.S., D'Agosto, M.D.A. (2016), "The role of rail transit systems in reducing energy and carbon dioxide emissions: the case of the city of Rio de Janeiro," Sustainability, 8(2): 1–16.
28. Brand, C., et al. (2021), "The climate change mitigation effects of daily active travel in cities," Transportation Research Part D: Transport and Environment, 93: 102764.
29. Kraus, S., Kock, N. (2021), "Provisional COVID-19 infrastructure induces large, rapid increases in cycling," Proceedings of the National Academy of Sciences, 118(15).
30. Marques, R., et al. (2015), "How infrastructure can promote cycling in cities: Lessons from Seville," Research in Transportation Economics, 53: 31–44.
31. Zahabi, S.A.H., et al. (2016), "Exploring the link between the neighborhood typologies, bicycle infrastructure and commuting cycling over time and the potential impact on commuter GHG emissions," Transportation Research Part D: Transport and Environment, 47: 89–103.

Few comparable studies have been published on carbon emission reductions in low- and middle-income countries. Perhaps the only such study is that of Massink et al., 2011, which measures the impacts of cycling on carbon reduction in Bogotá, one of the two case studies in this report.[32] It finds a reduction of 55,000 tonnes CO_2eq per year, of which about half is from modal shift from cars or motorcycles.[33] However, Massink et al. are concerned with all cycling in Bogotá, not only cycling attributable to protected bicycle lanes. Their contribution to the literature is valuable, and we hope that it will be taken alongside the present study to confirm the important role bicycle infrastructure plays in GHG reduction.

Citywide networks of protected bicycle lanes are major infrastructure, comparable to mass rapid transit or highway investments. Source: Carlos Felipe Pardo via Flickr

32. Massink, R., et al. (2011), "The climate value of cycling," Natural Resources Forum, 35(2).
33. The other half is attributed to modal shift away from motorized public transit (buses), which we have excluded from the present study.

3. Measuring Impacts

Source: ITDP China

3.1. Climate Change and Protected Bicycle Lanes

By studying Bogotá and Guangzhou together, we intend to provide a broader perspective of the impacts of protected bicycle lane networks in middle-income countries.

Bogotá and Guangzhou are different in many ways. Guangzhou is much larger in population and area, but Bogotá has a larger bicycle lane network. Incomes are higher, and rising more rapidly, in Guangzhou than Bogotá. Guangzhou has an extensive metro rail network and a single BRT line, while Bogotá has no metro but one of the world's largest BRT systems. Guangzhou has a longer history of urban cycling, which has decreased overall since the mid-1990s, while Bogotá has only begun to have high rates of cycling within the past decade.

Our study area in Bogotá includes the entire city, while in Guangzhou our analysis is limited to the central area, where most bicycle lanes are found.

Citywide Modal Splits in Bogotá and Guangzhou (%)

	Bogotá[a]	Guangzhou (citywide)[b]	Guangzhou (central study area)[b]
Walking	23.9	26.5	28.6
Pedal bike	6.6	7.7	8.4
E-bike	0	8.9	5.7
Bus	43.2	14.1	18.6
Rail	0.0	10.7	14.5
Other	1.0	1.6	1.2
Motorcycle	5.5	4.8	1.4
Private car	14.9	21.8	16.9
Ridehail/taxi	4.9	3.9	4.8

[a] Secretaría Distrital de Movilidad de Bogotá (2019), Encuesta de Movilidad 2019.
[b] Direct communication from Guangzhou Transportation Bureau.

3.1.1. Bogotá

Protected Bicycle Lanes and Study Locations in Bogotá

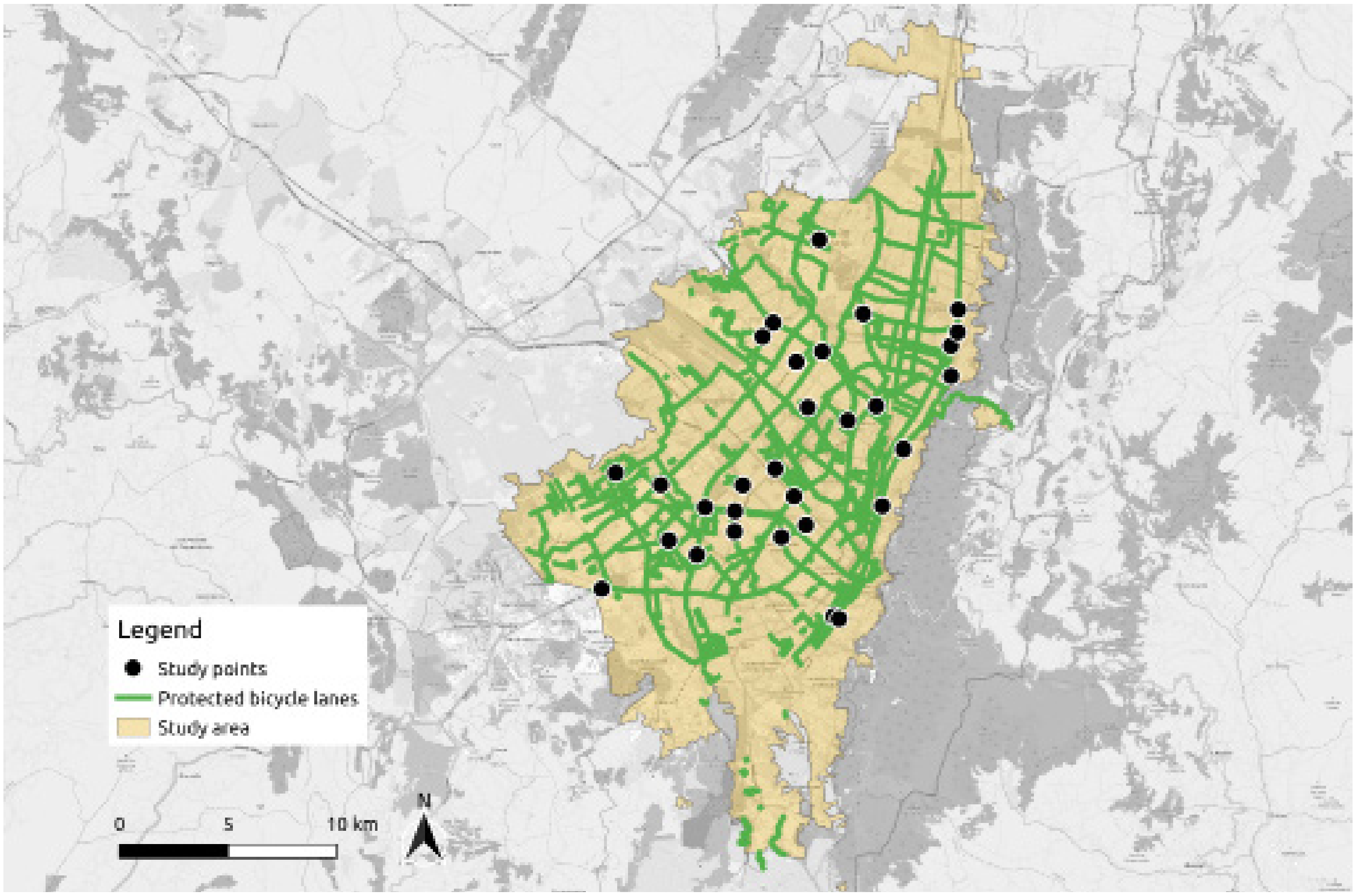


Image by authors, data from authors, Secretaría Distrital de Movilidad de Bogotá, and OpenStreetMap contributors.

The modern history of cycling in Bogotá began in 1974, when the first ciclovía took place. One Sunday, a section of streets, less than 20 km, was closed to motor vehicles to promote recreational cycling. Every Sunday and holiday of the year since then, many roads of the city are closed to motorized vehicles, and people can tour the city by bicycle, skates, skateboard, and walking. The length of the ciclovía road closures has grown over the decades, reaching 128 km today.[34]

The ciclovía was seen as a recreational program, but in 1998 the city government began to promote the bicycle as a practical means of urban transport. This promotion took the form of a network of protected bicycle lanes, which grew very rapidly from only 8 km in 1998 to 240 km just two years later. The growth of the network has continued at a steady pace since then, and by 2020 it reached 550 km.[35]

34. Instituto Distrital de Recreación y Deporte (n.d.), Historia Ciclovía Bogotána.
35. Pardo, C. (2013), "Bogotá's non-motorised transport policy 1998-2012: the challenge of being an example," in Aspects of Active Travel: How to Encourage People to Walk or Cycle in Urban Areas (edited by W. Gronau, W. Fischer, R. Pressl, 49-65), Verlag MetaGISInfosysteme.

Protected bicycle infrastructure in Bogotá, Colombia, has been an important factor to promote cycling. Source: Despacio

The first bicycle lanes were built on sidewalks, but pedestrians complained about their moving space being taken over by fast bicycles. Over time, this problem was addressed, and today most bicycle lanes are separated from both cars and pedestrians.[36]

When the COVID-19 health emergency paused the entire world, Bogotá was one of the first cities to implement emergency bicycle lanes on key roads, as a measure to avoid crowds and contagion in the public transit system. Eighty-four kilometers of emergency cycling infrastructure was implemented, for a citywide total of 592 km.

In 2019, according to the Household Travel Survey, Bogotá achieved a record level of cycling activity: about 1.2 million daily trips, 6% of the city's mode split.[37] The COVID-19 health emergency raised this number to an estimated 8%, or about 1.5 million daily trips (although this data is awaiting confirmation in the next mobility survey in 2023).

According to Bogotá's quality of life report (2021), 13% of trips in the city were made by bicycle.[38] Of these, only 24.8% were made by women. Although this represents an increase relative to past years, many problems must still be overcome so that women can safely travel by bike. These problems include personal security, harassment, a lack of bicycle parking and shower facilities at workplaces, and a lack of knowledge about how to ride and maintain bicycles.[39] Forty-nine percent of cyclists in Bogotá are between 20 and 35 years old, the average travel time by bike is 39 minutes, and the average cycling trip speed is 13.7 km/h, very close to a motor vehicle's at rush hour.

Of the noncycling population, 79% do not use a bicycle because they do not have one, and 21% do not use one for reasons including long distances traveled, not knowing how to ride a bicycle, road insecurity, and fear of theft.[40]

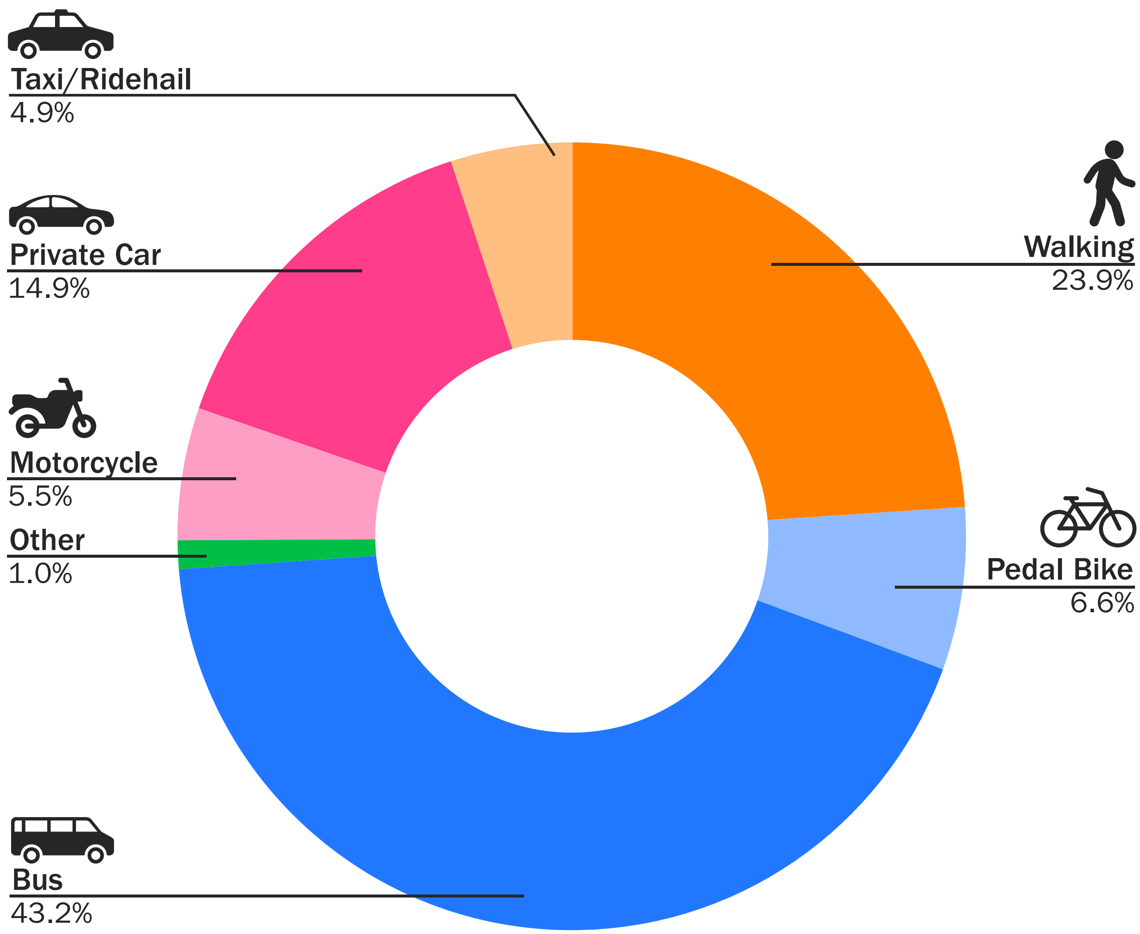
A two way bicycle lane in Colombia separated by temporary barriers. Source: Despacio

36. Rosas-Satizábal, D., Rodriguez-Valencia, A. (2019), "Factors and policies explaining the emergence of the bicycle commuter in Bogotá," Case Studies on Transport Policy, 7(1): 138–149.
37. Secretaría Distrital de Movilidad de Bogotá (2019), Encuesta de Movilidad 2019.
38. Bogotá Cómo Vamos (2021), Informe de Calidad de Vida en Bogotá, 2021.
39. Majcher, K. (2020), "Bogotá wants to get more women on bikes," City Monitor.
40. Secretaría Distrital de Movilidad de Bogotá (2019), Encuesta de Movilidad 2019.

A docked bikeshare system is currently being implemented, to include 3,300 bicycles.[41] The city plans to continue expanding the bicycle lane network, which still has some gaps in connectivity and coverage. The city has recently piloted a road pricing scheme,[42] which could help reduce car travel, making streets safer for cyclists.

In many aspects, Bogotá is a successful example of urban cycling, with the most extensive protected bicycle lane network and highest rates of cycling in Latin America. Even so, much remains to be done so that more people can ride bicycles comfortably and safely.

Citywide Modal Split in Bogotá



Source: Secretaría Distrital de Movilidad de Bogotá (2019), Encuesta de Movilidad 2019.

41. Rivera, Y. (2022), "Con 3.300 bicis, Bogotá le da la bienvenida al Sistema de Bicicletas Compartidas," Bogotá.gov.co.
42. Carey, C. (2022), "Bogotá pilots road congestion pricing app," Cities Today.

3.1.2. Guangzhou[43]

Protected Bicycle Lanes and Study Locations in Guangzhou

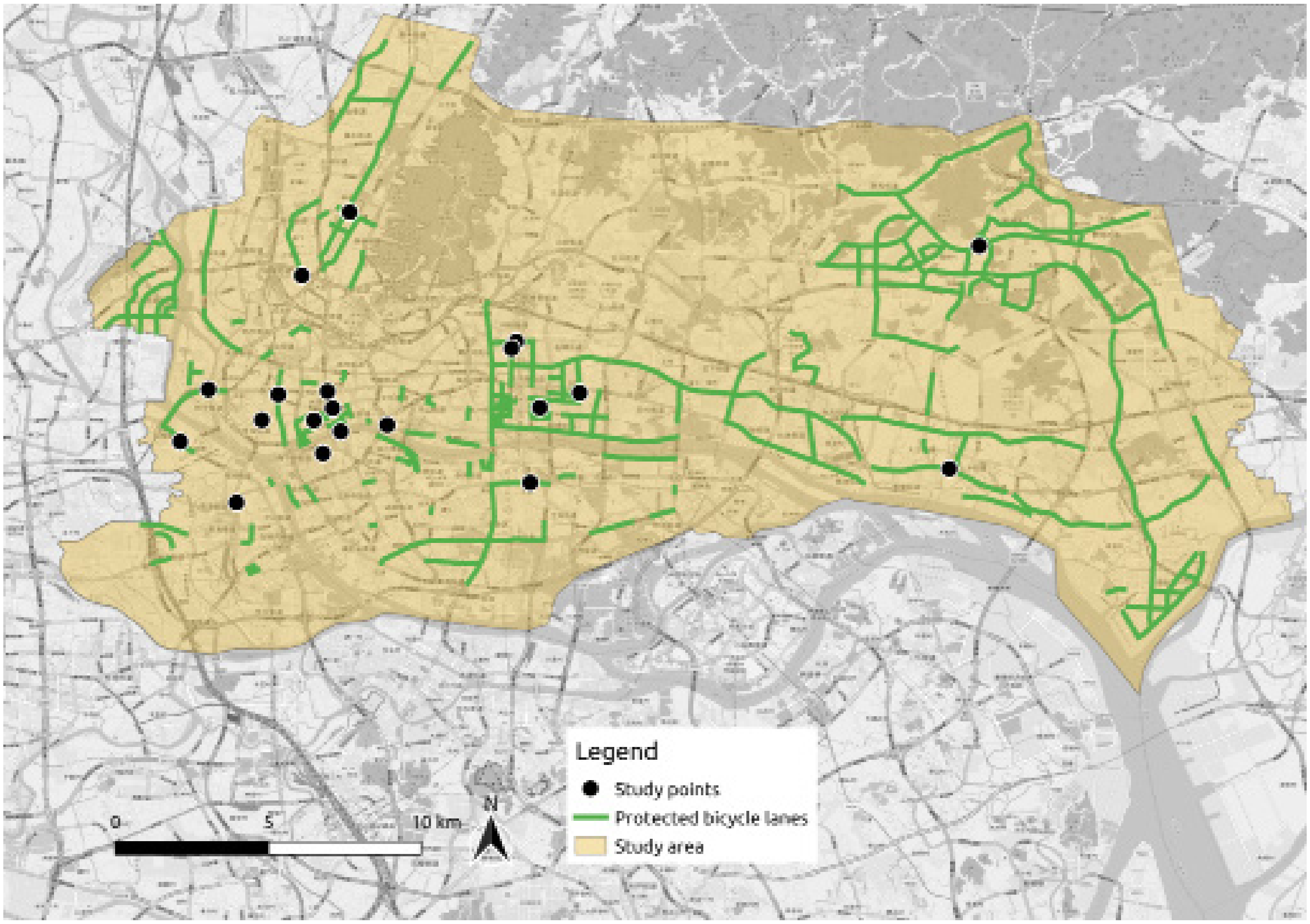


Image by authors, data from authors, Guangzhou Transportation Bureau, and OpenStreetMap contributors.

As an international trade center and a hub of the Pearl River Delta in southern China, Guangzhou has experienced rapid development of motorized transportation since the late 20th century, along with a great improvement in public transit and road infrastructure. Cycling – a very common mode in the 1980s – was neglected or even restricted. After reaching a low point around 2010, increased investment has begun a resurgence in urban cycling.

During the 1980s and 1990s, bicycles became popular in the city. Owing to the increasing distance between work and home, people rode to work instead of walking. In 1983, the bicycle share of trips in Guangzhou reached 35%.

After the mid-1990s, economic development allowed more families to own private cars; therefore, cycling began to shrink, and urban transportation motorized rapidly.

43. Much of the information in this section was provided by Guangzhou-based staff of the ITDP-China office and public references for data are not available.

The Guangzhou Urban Master Plan (1991–2010) indicated that Guangzhou needed to gradually restrict bicycle development and separate bicycles from arterials to improve public transit services. Since then, in an attempt to alleviate growing traffic congestion, Guangzhou has converted many existing bicycle lanes into motor lanes (mainly motorcycle lanes, slow lanes, or public transit lanes), forcing bicycles to use lower-grade parallel roads or to mix with pedestrians on sidewalks. As a result, the bicycle share of trips in the original eight districts of Guangzhou dropped from 35% in 1983 to 8.2% in 2005.

In 2010, Guangzhou started to promote a "bicycle + public transit" strategy, positioning bicycles as both public transit feeders and short-distance travel modes. At the same time, public bikeshare systems were established. With the implementation of the initiative "Trial measures for the operation and management of public bicycle transportation system in Guangzhou," there were 110 public docks and 5,000 bicycles in operation.

In 2014, the Guangzhou Slow Transportation System Plan proposed that bicycles should be positioned for short and medium-distance trips, and especially for connection to public transit. During the same year, Mobike emerged as the first dockless bikeshare system. In 2015, Guangzhou proposed to vigorously develop a public bicycle system and successively put public bicycles in areas such as the Higher Education Mega Center University City and the huge residential island Jinshazhou. Since the end of 2016, bicycle sharing has expanded rapidly.

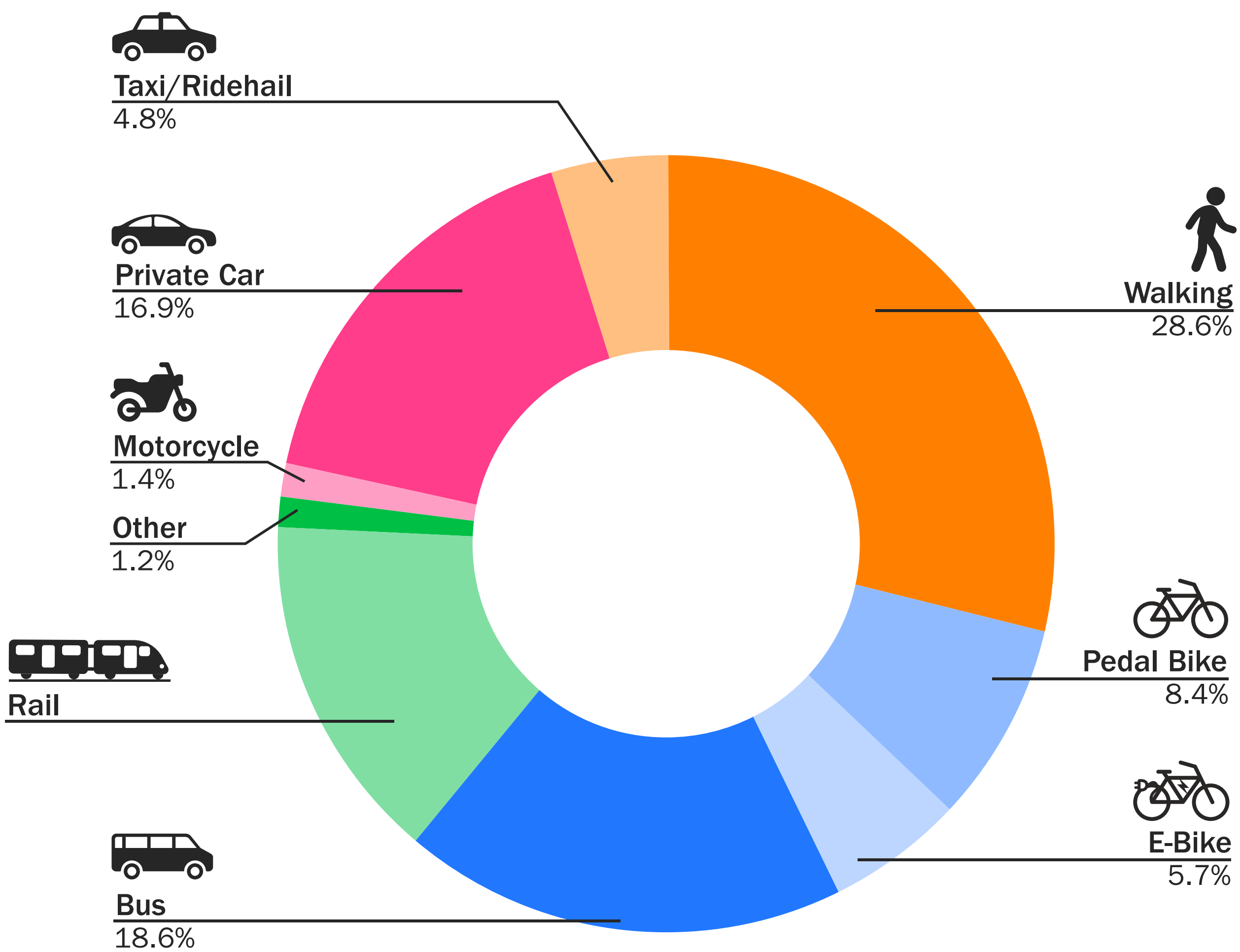
By 2020, Guangzhou held approximately 400,000 shared bikes in the central urban area, with an average daily travel volume of up to 1.3 million. There has been particular growth in the use of e-bikes for small deliveries, such as courier service and food delivery.

After the outbreak of COVID-19, people traveled less on public transit due to the infection risk and gradually turned to individual transport trips, with which came an increase in the number of e-bike trips. By mid-2021, the number of e-bike owners in Guangzhou had reached 4 million, while the number of private cars was 2.66 million. However, owing to the car-oriented planning in past years, the development of the bicycle lane network is lagging. Problems include poor connectivity and discontinuity of lanes, insufficient width, lack of right-of-way protection, poor cycling environment, and a lack of parking facilities.

Cycling infrastructure has been improving in the past two years. Guangzhou has boosted the construction and renovation of protected bicycle lanes in the city. According to the Guangzhou Municipal Transportation Bureau, 99.3 km of cycling network has been retrofitted and 87.3 km of bicycle lanes protected by a barrier have been newly constructed. Many hope that a more continuous and safer bicycle lane network and a more comfortable cycling environment will serve Guangzhou citizens in the near future.

Trees as barriers to separate bicycles from other traffic can create a more comfortable cycling environment. Guangzhou, China. Source: ITDP China

Citywide Modal Split in Guangzhou



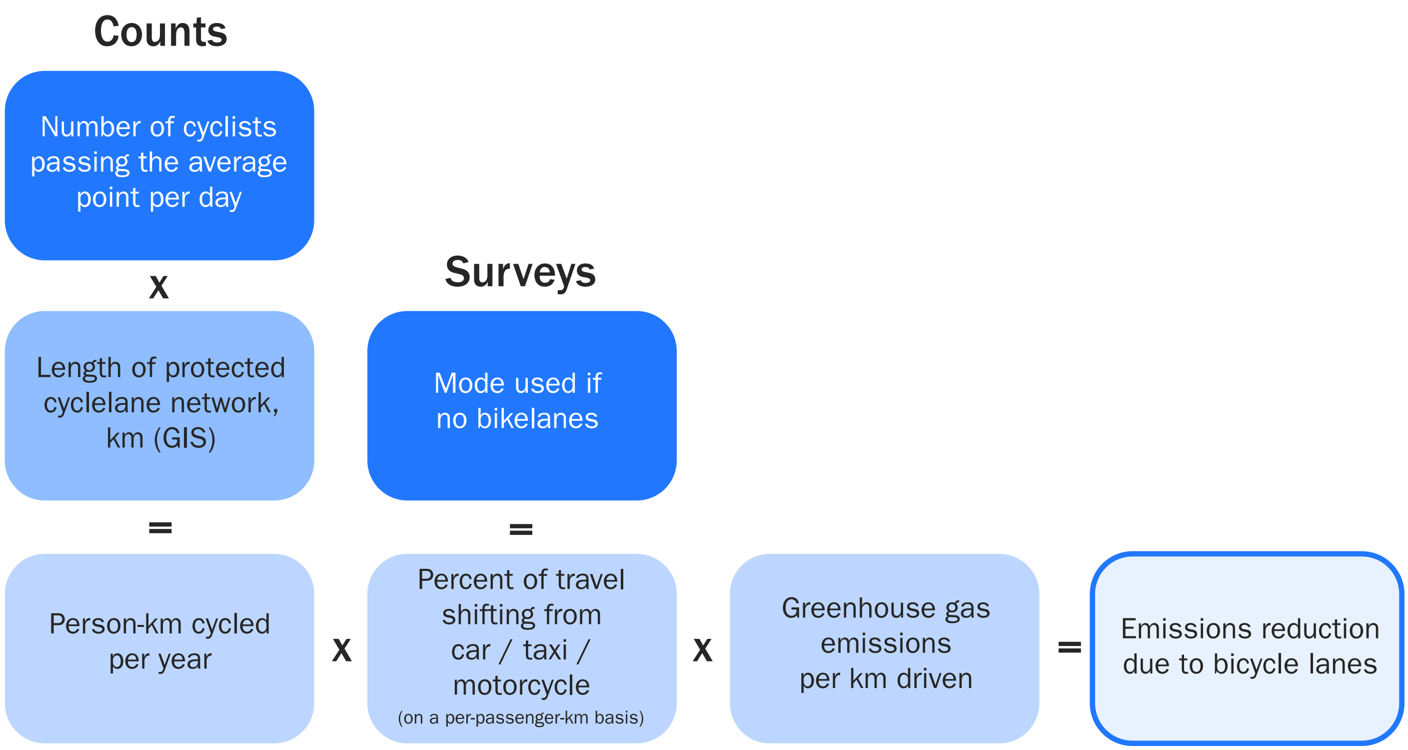
Source: Direct communication from Guangzhou Transportation Bureau.

3.2. Method

We used the following method to estimate the reduction in GHG emissions attributable to modal shift from cars and motorcycles to bicycles due to the protected bicycle lane networks in Bogotá and Guangzhou.

Our study maintains an exclusive focus on the first-order impacts of networks of protected bicycle lanes on GHG emission reductions in low- and middle-income cities attributable to the shift from travel by car or motorcycle. We chose this specific focus for two reasons: First, it enabled us to design a method for estimating impacts that is based not on assumptions but on observed data of cycling activity and modal shift rates. Second, it means that we connect carbon reductions directly to networks of protected bicycle lanes, a category of infrastructure that is relatively inexpensive to construct but generally underfunded by development banks and governments.

Method for Estimation of Emissions Reduction



3.2.1. Counts

Our first goal was to estimate the total person-kilometers traveled per year on protected bicycle lanes (which may be significantly less than the total person-kilometers traveled per year by bicycle). We first took count samples at locations with protected bicycle lanes across Bogotá and Guangzhou to estimate the average number of cyclists passing the average point on the bicycle lane network per day. We then multiplied that figure by the length of the network, assuming that each point on the network of the same facility class has roughly the same level of cycling activity. This provided an estimate of the average amount of cycling on protected bicycle lanes in each of our cities, measured in person-kilometers traveled per day or per year.

Section 3.1.2 for a map of protected bicycle lanes and study locations in Guangzhou.

In Guangzhou, the ITDP team carried out one peak-hour count at each of 20 locations along the protected bicycle lane network, at a sample of morning and evening peak hours in April–July 2022. Locations were selected to ensure coverage of the entire network of protected bicycle lanes, with an equal spatial distribution across the network, at places where counting was feasible. These counts included all cyclists using a road (bicycle lane, mixed traffic, and sidewalk) in both directions. A more detailed count of a subset of these locations provided the estimate that about two-thirds of this traffic was in the protected bicycle lanes on those roads, with the remaining third taking place on sidewalks or in mixed traffic. To ensure that we did not count cycling activity on sidewalks or in mixed traffic, we multiplied the peak-hour counts by two-thirds to estimate the amount of cycling taking place in the protected lanes. We also carried out two full-day counts (one 15-hour and one 18-hour), which we used to establish curves representing the change in cycling activity over the course of the day. By comparing the peak-hour counts with those curves, we were able to estimate the average daily traffic at each of the 20 sample locations. For example, consider a peak-hour count of 100 cyclists at a particular point between 8 am and 9 am. If the full-day counts indicated that an average of 10% of daily cyclist traffic was between 8 am and 9 am, we would conclude that about 1,000 cyclists pass by that point every day. Based on these calculations, we estimated the average daily traffic on roads of three classes: arterials, collectors, and local roads.

Protected bicycle lane in Tlyu West Road, Guangzhou, China. Source: ITDP China

Bike taxis are a practical means of urban transport in the bicycle network of Bogotá. Source: Despacio

For each of those classes, we then multiplied the average daily traffic by the total length of that class in the protected bicycle lane network, and we took the sum of those values to estimate the overall number of person-kilometers cycled on protected bicycle lanes every day in Guangzhou.

See Section 3.1.1 for a map of protected bicycle lanes and study locations in Bogotá.

In Bogotá, new collection of cyclist counts was not necessary because such samples were available from the municipal Secretariat of Mobility. The Secretariat monitored 20–28 locations over a period from January 2021 to March 2022, collecting between one and three dates each month, seven hours per day, for a total of 4,431 hours of observation. In Bogotá, unlike in Guangzhou, the count data clearly differentiated between cyclists on protected bicycle lanes and those riding in mixed traffic or on sidewalks, and so our estimates will reflect only cyclists on protected bicycle lanes.

Because the Secretariat of Mobility did not record full-day counts, we used the full-day cycling activity curves from the Guangzhou counts to project full-day estimates in the same fashion.

This may lead to inaccuracy because of differences in activity curves between the two cities, but we preferred to use cycling activity curves from Guangzhou than from Europe or North America because of their similarity as cities in middle-income countries. Unlike in Guangzhou, in Bogotá the count locations were already well distributed across different classes of roads in the protected bicycle lane network and did not require adjustment to different road classes.

In both cities, we multiplied the full-day estimates by 252, the number of weekdays per year, to estimate the amount of cycling activity on protected bicycle lanes every year. We used the factor of 252 because we measured cycling on a weekday that was not a holiday, and we assume that the results will be similar for all nonholiday workdays. This may underestimate the total amount of cycling because it assumes no cycling on weekends or holidays, but it may overestimate the total on days with inclement weather or other unusual conditions. Overall, we believe that this is a reasonable estimate.

The count data collected by ITDP in Guangzhou is available in this Google Drive folder. The counts of cyclists in Bogotá are data that is the property of the city's Secretariat of Mobility and cannot be shared publicly.

Bicycle lane in Tianhe North Road in Guangzhou, China. Source: ITDP China

3.2.2. Surveys

We used intercept surveys to estimate the modal shift resulting from the presence of the protected bicycle lane networks in Bogotá and Guangzhou. In Bogotá, we surveyed a total of 748 respondents at six locations; in Guangzhou, we surveyed a total of 508 respondents at six locations. The locations were selected by our field teams to be representative of the city as a whole while also having sufficiently high levels of cycling activity to make surveys feasible. The surveys were designed in English before being translated into local languages, and they were carried out by local consultant teams. Respondents were incentivized in Bogotá through entry into a raffle to win bicycle safety–related prizes, such as bicycle lights, and in Guangzhou through the offer of free face masks.

In each survey, we asked for a description of the actual trip the respondent was currently taking and how they would have taken that trip if the protected bicycle lanes did not exist. These descriptions included breakdowns of the amount of time and money spent in each mode.

Method for Estimation of Emissions Reduction

Actual trip (on protected bicycle lanes)			**Hypothetical trip (if no protected bicycle lanes)**		
Mode used	Time (min)	Cost (COP)	Mode used	Time (min)	Cost (COP)
Walking	5	0	Walking	5	0
Bicycle	60	0	Feeder bus	25	0 (incl. in BRT)
			BRT	35	2,650
Total	**65**	**0**	**Total**	**55**	**2,650**

BRT = bus rapid transit.

The survey also provided demographic information that was useful in understanding the impacts of the protected bicycle lane networks on equity across age, gender, and socioeconomic status.
The results of all surveys are available for download in this Google Drive folder.

3.2.3. Carbon Emissions

Using the data from the surveys, we were able to measure the average change in person-kilometers traveled by the other modes of travel per person-kilometer cycled on protected bicycle lanes. We could express those findings as modal shift rates – that is, the percentage of travel on protected bicycle lanes that would have been traveled by each different mode if the protected bicycle lanes did not exist.

After conducting the counts and the surveys, we multiplied the total amount of cycling on protected bicycle lanes (person-kilometers traveled) by the percentage of travel shifting from private motorized modes: private car, ridehail/taxi, and motorcycle. This resulted in estimates of the number of person-kilometers that would have been traveled by each of these modes if the protected bicycle lane networks had not been built. We then multiplied those estimates by factors of emissions per person-kilometer for each of those modes and summed the results to estimate the reductions in GHG emissions directly attributable to protected bicycle lane networks in Bogotá and Guangzhou (see Section 3.2.)

We used regionally specific lifecycle emission factors for cars, motorcycles, and bicycles. These numbers include the emissions not only from fuel but also from building and maintaining roadways and from manufacturing vehicles. They are derived from joint research by ITDP and the University of California, Davis,[44] based in turn on research by the International Transport Forum[45] and the International Council on Clean Transportation.[46] In Guangzhou, we applied the lifecycle emissions factor for e-bikes; in Bogotá, we used the factor for pedal bicycles. For ridehail/taxi, we included a "deadheading" factor of 1.4, representing the distance that these vehicles travel without a passenger, for example cruising between dropping off one passenger and picking up another. Research has found this value to range from 1.3 to 1.8 (that is, between 3 and 8 km empty for every 10 km traveled with a passenger).[47]

3.2.4. Time and Cost Savings

In addition to carbon emission reductions, we quantified the direct economic benefits of the protected bicycle lane networks in terms of the cost and time savings experienced by people traveling in Bogotá and Guangzhou.

The survey data enabled us to estimate the average change in travel time and cost attributable to the networks of protected bicycle lanes. Those indicators may be computed on a per-trip basis or on a per-person-kilometer-traveled basis, but the latter is more useful because it can be multiplied against overall cycling travel activity. Using the surveys, we were able to calculate:

- The average change in travel time per person-kilometer cycled on protected bicycle lanes
- The average change in travel cost per person-kilometer cycled on protected bicycle lanes
- Modal shift (described in Section 3.2.2)

Cyclelanes expand urban mobility and connect to other transport modes. Source: Carlos Felipe Pardo, Flickr

44. Fulton, L., et al. (2021), [The Compact City Scenario – Electrified,](#) ITDP & University of California, Davis.
45. International Transport Forum (2020), [Good to Go? Assessing the Environmental Performance of New Mobility.](#)
46. Bieker, G. (2021), [A Global Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars,](#) International Council on Clean Transportation.
47. International Transport Forum (2020), [Good to Go? Assessing the Environmental Performance of New Mobility.](#)

Using these results, we were able to estimate the average amount of time and money saved per person-kilometer traveled by bicycle on protected bicycle lanes. We could then multiply those factors by the estimated total amounts of cycling on protected bicycle lanes in these cities to estimate the total contribution of this infrastructure to the local economy.

3.2.5. Public Health

Cycling is a form of physical activity and is known to bring health benefits. We quantified those benefits by using the World Health Organization's Health Economic Assessment Tool (HEAT) v.5.0.6.[48]

The HEAT model is prepopulated with many city-specific factors, especially mortality rates, enabling it to estimate the reduction in premature mortality that would be caused by any given increase in cycling or walking. To use the HEAT model, we first multiplied our estimate of cycling on the protected bicycle lanes (Section 3.2.1) by the percentage of travel shifting from motorized modes (Section 3.2.2) to estimate the overall increase in cycling due to the protected bicycle lanes. We then divided that value by an average cycling per day of 8.7 km[49] to estimate the population size of the group of beneficiaries.[50] We used HEAT city-specific defaults for all other factors involved in the calculation.

In addition to estimating the number of premature deaths avoided, the HEAT model uses a method based on the concept of "value of statistical life" to estimate the economic benefit attributable to the lives saved. As the HEAT user page explains, "Despite its somewhat misleading name, [the value of statistical life] does not quantify the value of preventing the loss of 'an entire individual's life' but rather the sum of extending many lives through small reductions in risk of death. It is commonly used in transport appraisals."[51] Human life is, of course, priceless. But the benefits of protected bicycle lane networks for public health are quantifiable and deserve attention.

3.2.6. Limitations

This study maintains a narrow focus on the contribution of protected bicycle lanes to GHG emission reductions in low- and middle-income cities through the mechanism of shift from travel by car or motorcycle. There are other mechanisms by which cycling or protected bicycle lanes may reduce GHG emissions that we could not include in this report. Examples include:

- Cycling on painted (unprotected) bicycle lanes or in mixed traffic may cause modal shift from driving.
- The presence of protected bicycle lanes may enable individuals to live without owning a car, meaning that they also ride transit, walk, and cycle on other facilities more often than they would if the bicycle lanes had not been built.
- Modal shift from public transit to cycling may free up space in crowded transit vehicles, causing a second-order modal shift from car to transit.
- Modal shift from public transit to cycling may result in a need to run fewer transit vehicles, reducing emissions from transit.
- Reallocating street space from car lanes to bicycle lanes may decrease traffic capacities, resulting in a decrease in emissions from cars.

48. Kahlmeier, S., et al. (2021), Health Economic Assessment Tool (HEAT) for Walking and for Cycling: Methods and User Guide on Physical Activity, Air Pollution, Injuries and Carbon Impact Assessments, WHO Regional Office for Europe.
49. The value comes from the average trip length in Bogotá; see Section 3.3.1.
50. The rate of cycling per day has no bearing on the results of the HEAT model but is necessary because we must determine a population size. A larger value would have resulted in a smaller population but more cycling (greater impacts) within that population, to no net effect.
51. See https://www.heatwalkingcycling.org/#vsl

By focusing narrowly on the direct impacts of protected bicycle lane networks on modal shift, we hope that our estimates of impact are conservative, evidence based, and applicable in other contexts.

3.3. Results and Discussion

3.3.1. Cycling Activity

Following the method described in Section 3.2.1, we collected counts of cycling activity in Bogotá and Guangzhou, adjusted peak-hour counts to full-day estimates based on a daily activity curve, and estimated yearly person-kilometers traveled on protected bicycle lanes in each city. In Guangzhou, we divided the protected bicycle lane network into three facility types, conducting this analysis for each facility type before taking the sum for the entire city.

Estimation of Cycle Activity on Protected Bicycle Lanes in Guangzhou

Road class	Number of count locations	Estimated daily bidirectional bicycle traffic on protected bicycle lanes	Estimated daily bidirectional traffic on protected bicycle lanes	Total length of road class in network (km)	Estimated total cycling activity per day (pkt)
Arterial	12	37,000	25,000	173	4,000,000
Collector	5	24,000	16,000	71	1,000,000
Local	3	16,000	11,000	44	500,000
Total	20			288	5,500,000
Total per year[a]					**1,500,000,000**

[a] 252 working days.

Estimation of Cycle Activity on Protected Bicycle Lanes in Bogotá

Road class	Number of count location-days	Average bidirectional number of cyclists on protected bicycle lanes in 7 hours	Estimated daily bidirectional traffic on protected bicycle lanes	Total length of road class in network (km)	Estimated total cycling activity per day (pkt)
Protected bicycle lane	633	4,500	11,000	592	6,500,000
Total per year[a]					**1,600,000,000**

pkt = person-kilometers traveled.

We estimate a total of about 1.5 billion person-kilometers traveled on protected bicycle lanes in Guangzhou each year and 1.6 billion person-kilometers traveled on protected bicycle lanes in Bogotá each year.

Based on comparisons with official data, we conclude that these estimates are reasonable. In Bogotá, the Secretariat of Mobility estimated in 2019 that there were 880,000 trips by bike per day, a figure that has almost certainly risen since then due to the COVID-19 pandemic. An average trip length of 8.7 km[52] means that about 1.9 billion passenger-kilometers are traveled by bicycle every year in Bogotá – about one and a half times the total travel bicycle activity we found on the protected bicycle lane network, indicating that our estimates of cycling activity are reasonable. Unfortunately, similar official data is not available to validate our findings in Guangzhou.

3.3.2. Modal Shift

Following the method in Section 3.2.2, we used intercept surveys to estimate the modal shift caused by the protected bicycle lane networks in Bogotá and Guangzhou. Specifically, we estimated the number of person-kilometers not traveled by other modes of transport per person-kilometer traveled on protected bicycle lanes.

[a] 252 working days.

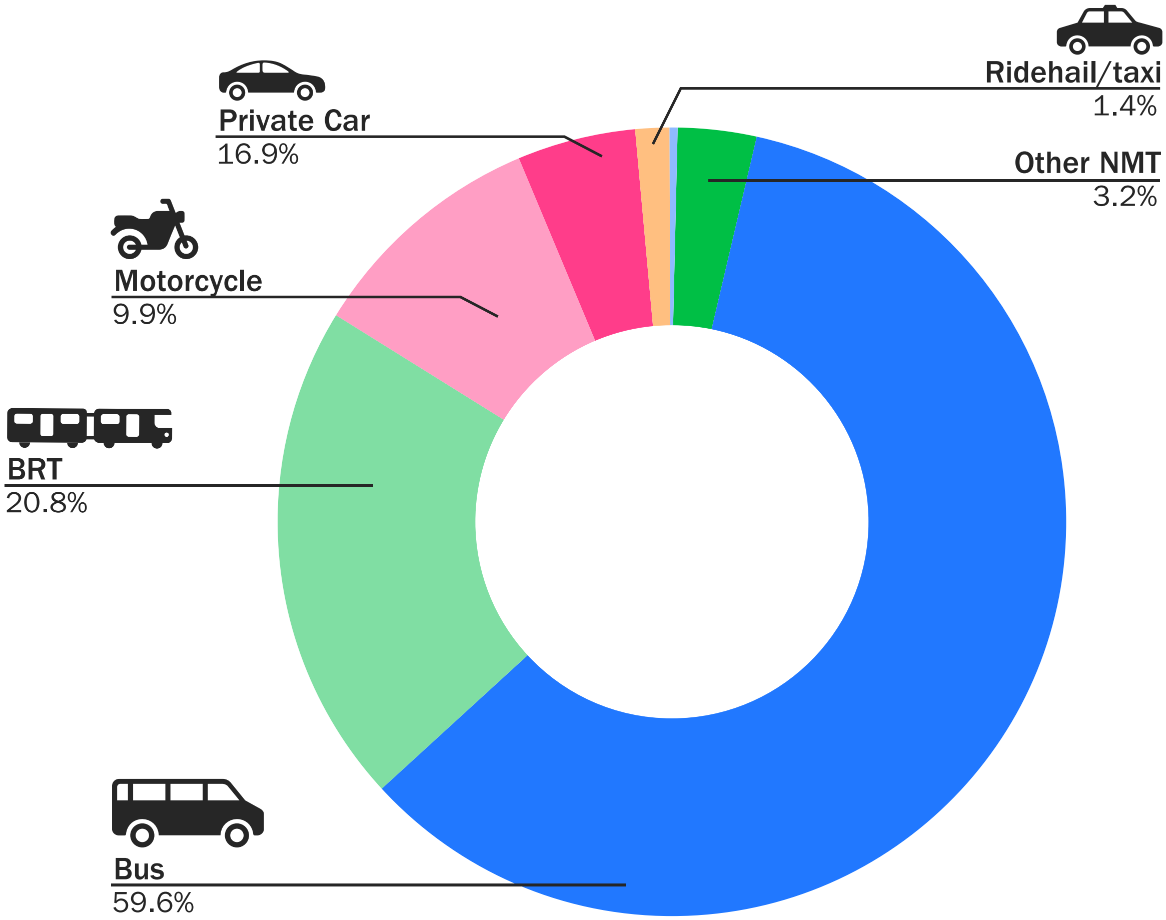
52. According to the Observatorio de Movilidad de Bogotá, the average time duration of a bicycle trip is 38 minutes. Given an average cycling speed of 13.7 km/h, this means that the average trip length is 8.7 km. See https://observatorio.movilidadBogotá.gov.co/encuestas_de_movilidad and https://www.movilidadBogotá.gov.co/web/sites/default/files/Paginas/20-12-2019/resultados_preliminares_encuestamovilidad_2019-20191220.pdf

Rates of Modal Shift Caused by Protected Bicycle Lanes

Mode (shifted from)		Bogotá % shift (by pkt)	Guangzhou % shift (by pkt)
Nonmotorized	Bici Taxi	3.0	-
	Skateboard	0.2	-
	Walking	0.3	1.6
	Would have biked anyway	0	84.0
Transit	BRT feeder bus	1.7	-
	Standard bus	53.8	6.5
	Long-distance bus	4.1	-
	BRT	20.8	0
	Metro	-	2.1
Motorized private	Motorcycle	9.9	-
	Private car	**4.9**	**1.6**
	Ridehail/taxi	**1.4**	**4.1**

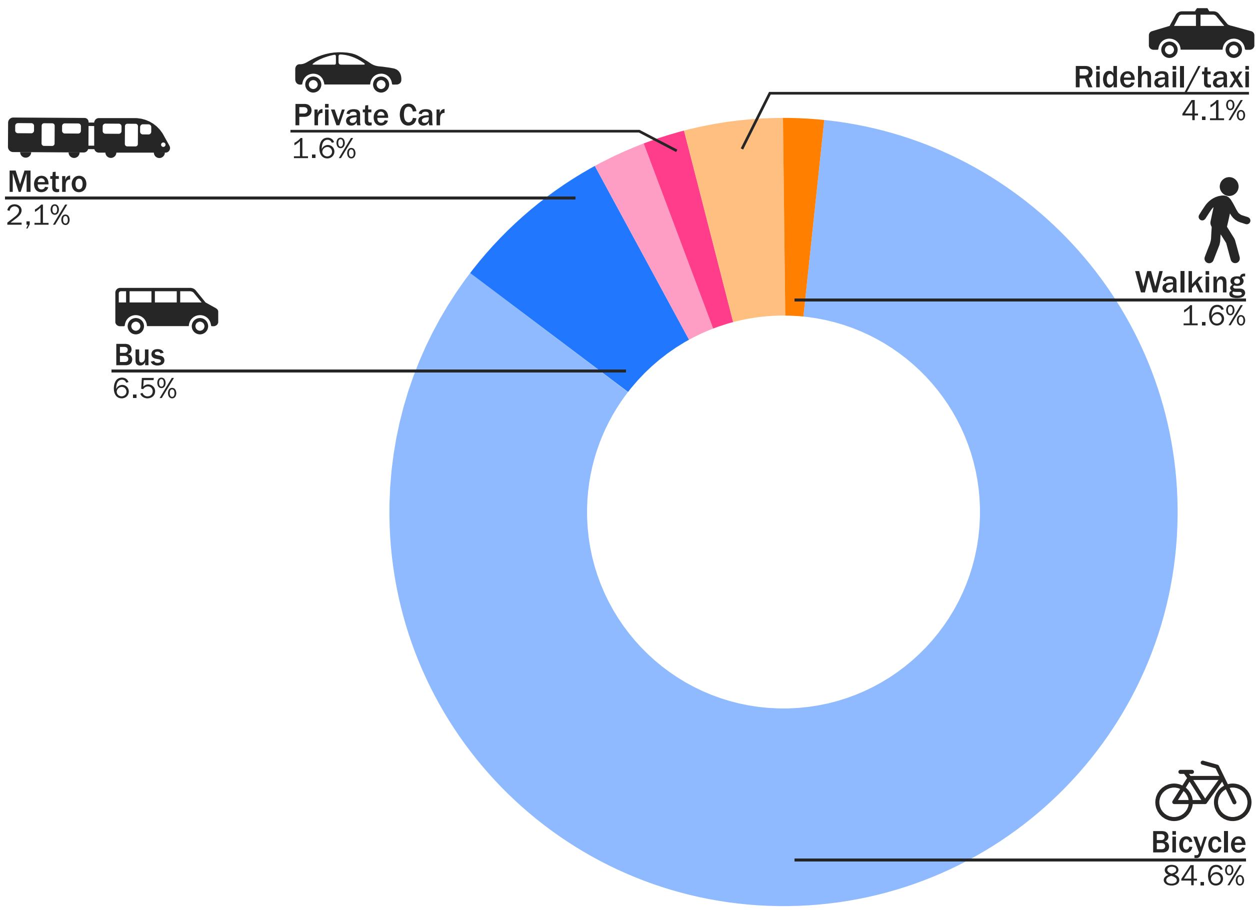
BRT = bus rapid transit; pkt = person-kilometers traveled.

Modal Shift to Cycling on Protected Bicycle Lanes in Bogotá



BRT = bus rapid transit; NMT = nonmotorized transport.

Modal Shift to Cycling on Protected Bicycle Lanes in Guangzhou



We found some variation in the types of bicycles being ridden on protected bicycle lanes: In Bogotá, almost all cyclists rode private pedal bikes. In Guangzhou, most cyclists rode private e-bikes – a category that in China includes many throttle-based rather than pedal-assist vehicles, often with higher top speeds than pedal-assist e-bikes. Even in Guangzhou, however, there were also some shared and private pedal bikes.

Despite the many differences between Bogotá and Guangzhou, in both cities roughly 6% of cycling travel represents a shift from cars, which includes ridehail vehicles and taxis. We do not interpret this as a universal pattern, but rather a result of the similar levels of driving in the two cities (about 20% of all travel).

Perhaps the most surprising finding is that more than 80% of Guangzhou's cyclists would cycle even if the protected bicycle lanes did not exist, while none of Bogotá's would. There are at least two possible explanations for this large difference.

Culturally, Guangzhou has a much longer history of mass urban cycling, and cycling in mixed traffic is more common. It is likely that more people in Guangzhou are comfortable with cycling in mixed traffic and treat protected bicycle lanes as only an assistance to their travel, rather than a necessity. The widespread availability and affordability of shared bicycles and e-bikes may also contribute. In Bogotá, however, the recent growth in cycling has been closely tied to the expansion of protected bicycle lanes, and it is likely that many cyclists using the lanes would not be willing to cycle without them.

Methodologically, it is possible that survey respondents in Bogotá did not understand the intent of the question "How would you have made this trip if the protected bicycle lanes did not exist?" They may have understood the question as, "How would you have made this trip if cycling was not possible?"

Despite this potential issue, we have two reasons for believing that the approximately 6% modal shift figure in Bogotá is at least roughly accurate. First, the riders shifting from private cars are the riders with the greatest freedom of choice in their mode, and therefore the most sensitive to cycling infrastructure quality; it is unlikely they would have cycled in mixed traffic. Second, another study[53] using intercept surveys to measure modal shift to cycling (though not necessarily on protected bicycle lanes) in Bogotá found a much higher rate of shift from driving to cycling – 11.7% – and so we conclude that the 6% figure is realistic or even conservative.

3.3.3. Carbon Emissions

To estimate the impacts of the protected bicycle lane networks on carbon emissions, we combined the annual estimates of person-kilometers traveled, the estimated modal shift from private, polluting modes, and mode-specific per-person-kilometer emissions factors, as described in Section 3.2.3.

Estimate of Overall Carbon Emissions Reduction from Mode Shift due to Protected Bicycle Lane Networks in BogotáNetworks in Bogotá

Mode	Total pkt cycled on protected bicycle lanes per year	Percent shifting from this mode	Deadheading factor	Emissions per pkt from this mode (fuel, infrastructure, and manufacture) (gCO_2eq/pkt)	Emissions per pkt from cycling (fuel, infrastructure, and manufacture) (gCO_2eq/pkt)	Total emissions reduction per year (tonnes CO_2eq)
Private Car	1,600 million	4.90	N/A	157	8	11,682
Ridehail/taxi	1,600 million	1.40	1.4	157	8	4,673
Motorcycle	1,600 million	9.90	N/A	44	8	5,702
					Total (tonnes CO_2eq/year)	**22,000**

pkt = person-kilometers traveled. N/A = not applicable.

53. Massink, R., et al. (2011), "The climate value of cycling," Natural Resources Forum, 35(2): 100–101.

Estimate of Overall Carbon Emissions Reduction from Mode Shift due to Protected Bicycle Lane Networks in Guangzhou

Mode	Total pkt cycled on protected bicycle lanes per year	Percent shifting from this mode	Deadheading factor	Emissions per pkt from this mode (fuel, infrastructure, and manufacture) (gCO_2eq/pkt)	Emissions per pkt from cycling (fuel, infrastructure, and manufacture) (gCO_2eq/pkt)	Total emissions reduction per year (tonnes CO_2eq)
Private Car	1,500 million	1.60	N/A	157	10	3,528
Ridehail/taxi	1,500 million	4.10	1.4	157	10	12,657
Motorcycle	1,500 million	0.00	N/A	44	10	0
					Total (tonnes CO_2eq/year)	**16,000**

pkt = person-kilometers traveled. N/A = not applicable.

In Guangzhou and Bogotá, the extensive networks of safe, protected bicycle lanes prevent the emission of 16,000 and 22,000 tonnes CO_2eq of GHGs per year. In each city, this is equivalent to the amount of carbon that would be sequestered by planting 300,000 to 400,000 new trees every year.[54]

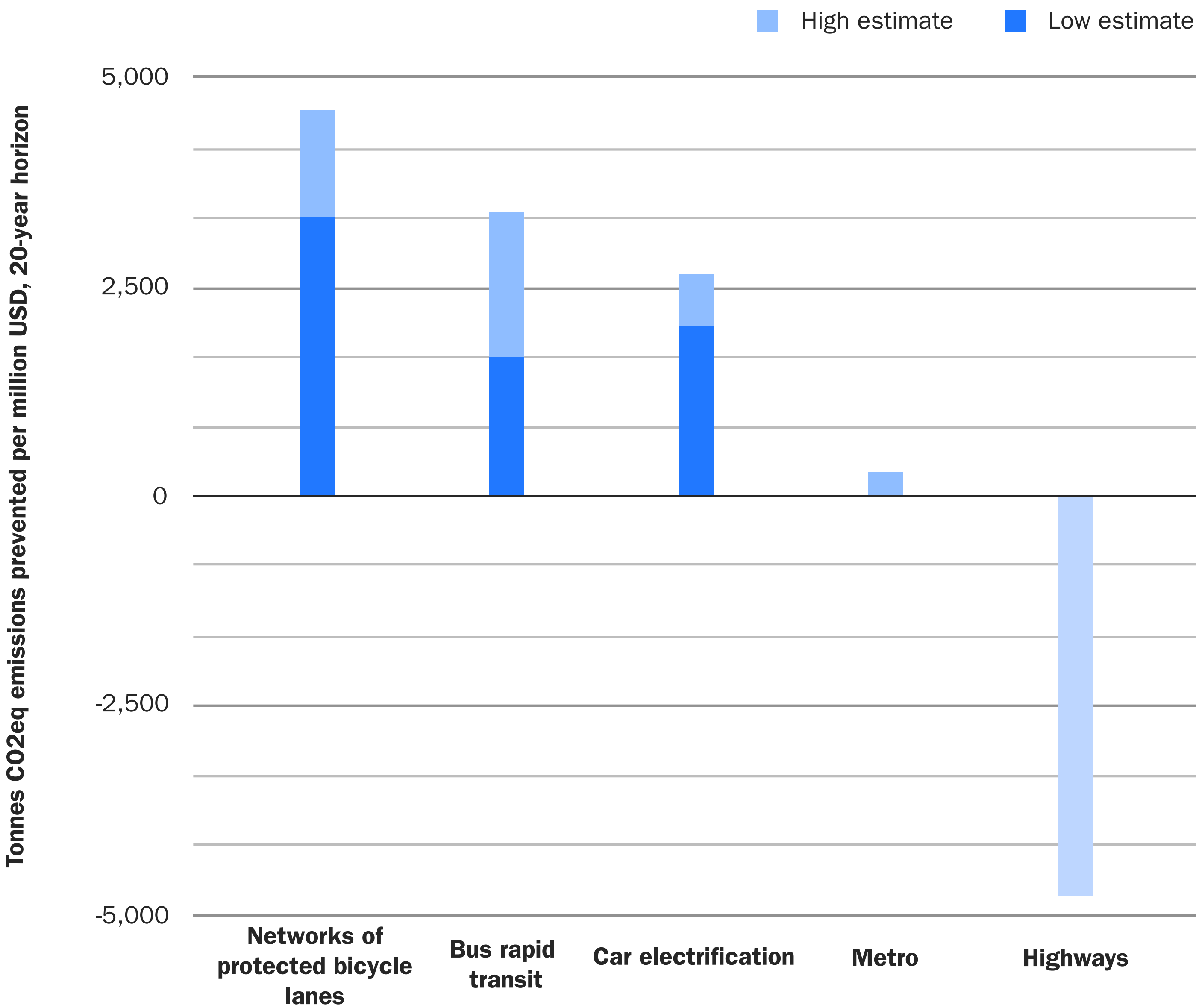
3.3.4. Cost–Benefit Comparison for Carbon Emissions

To estimate the impacts of the protected bicycle lane networks on carbon emissions, we combined the annual estimates of person-kilometers traveled, the estimated modal shift from private, polluting modes, and mode-specific per-person-kilometer emissions factors, as described in Section 3.2.3.

To put these GHG reductions into context, we can estimate the climate cost–benefit ratio of building protected bicycle lane networks in Bogotá and Guangzhou in terms of tonnes of CO2-equivalent GHG emissions prevented per dollar spent on infrastructure. We can then compare those values to other kinds of interventions in the urban transport sector, including BRT, metro rail, electric buses, highway expansions, and electric car subsidies and charging technologies. This comparison is only made on the basis of infrastructure costs and CO2 prevention benefits. It does not take into account operational or maintenance costs nor the other direct or indirect benefits that transportation provides. See here for more detail on the calculations.

54. Calculated using the Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator.

Carbon Reduction Cost-Effectiveness



Highways cause 1 tonne of emissions for every ~$200 spent.

Protected bicycle lane networks are among the most cost-effective ways to reduce GHG emissions while also improving urban transportation. They are up to twice as cost-effective as BRT, even without maintenance or operating costs. Both protected bicycle lanes and BRT are an order of magnitude more cost-effective than metro rail in terms of emissions prevented per dollar spent.

Protected bicycle lane networks in middle-income countries are also more cost-effective than private electric vehicle subsidies in higher-income countries in terms of GHG reduction. The only intervention that is more cost-effective than protected bicycle lane networks is the electrification of public buses, because in many cities new electric buses have a lower lifetime total cost of ownership than diesel buses.

Protected bicycle lane networks also provide a benefit to mobility and equity, whereas replacing internal combustion vehicles with electric ones does not.

Of the interventions we examined, the only ones that increased emissions were highway expansions, which cause increased travel by car through the phenomenon of induced demand.

Another advantage of protected bicycle lane networks in comparison to these other forms of infrastructure is that they are usually quicker to implement. BRT can take several years, even a decade or more, to plan and build. Metro takes even longer. A full network of protected bicycle lanes can be planned and built in only a few years: Bogotá built 230 km in only two years, from 1998 to 2000.

Although this comparison was done in only two cities and is not necessarily a universal pattern, the consistency of these results in Colombia and China is a clear indication that protected bicycle lane networks are a highly efficient investment for a government or funding organization seeking to reduce emissions in low- or middle-income countries.

By comparing protected bicycle lanes networks, BRT, metro, and electrification, we do not mean to suggest that governments should seek to only invest in the most cost-efficient option. All four of these, along with pedestrian infrastructure and compact land use, are necessary for sustainable and efficient urban transportation. These different modes also support one another. Integrated BRT and metro transit work together to improve transit overall; electrification makes buses healthier and more comfortable to ride; protected bicycle lane networks help people ride to metro or BRT stations.

Protected bicycle lane networks in Chinese Cities provide a benefit to mobility and equity. Source: Lu Zhenguang

Cost–Benefit Comparison of Emissions Reductions for Transport Interventions

City/country	Project	GHG reduction (tonnes/year)	Total cost (million USD, 2022)	Cost-effectiveness: GHG emissions (tonnes) per million USD (2-year horizon)
Bogotá	Protected bicycle lane network	22,000	132[a]	3,333
	BRT (phase II, 2012)[b]	80,000[c]	989[d]	1,618
	Highway expansion (hypothetical)[a]	-91,688	390	-4,695 (highways cause emissions)
Guangzhou	Protected bicycle lane network	16,000	69	4,630
	BRT	40,000[f]	234	3,423
Beijing	Metro Lines 6, 9,10, and 15 (sum)	529,000[g]	39,802[h]	266

[a] Costs for bicycle lanes in both Bogotá and Guangzhou estimated based on Yanocha, D., Mawdsley, S. (2022), Making the Economic Case for Cycling, ITDP. Since no China-specific numbers are available, we use the same value as in Latin America. However, this may be an overestimate, since Guangzhou's bicycle lanes are often simpler to construct than Bogotá's. Cost is for bidirectional bicycle lanes.
[b] This measures the impact only of TransMilenio Phase II as of 2012, when only 23.6 km of that phase had been completed.
[c] Clean Development Mechanism (2012), Monitoring Report: BRT Bogotá, Colombia: TransMilenio Phase II to IV, 7th Monitoring Period 01/01/2012-31/12/2012.
[d] All BRT cost values are taken from ITDP (2017), "Capital costs" in BRT Planning Guide. Adjusted for inflation since 2013.
[e] See this Google Sheet for more detail on the estimation of emissions from hypothetical highway expansion in Bogotá, based on Mangones, S.C., et al. (2020), "Air pollution emission effects of changes in transport supply: the case of Bogotá, Colombia," Environmental Science and Pollution Research, 27: 35971–35978.
[f] Hughes, C., Zhu, X. (2011), Guangzhou, China Bus Rapid Transit: Emissions Impact Analysis, ITDP. We only use the estimate of impact in 2010 caused by modal shift, bus speed increase, and reduction in bus vehicle-kilometers traveled. The impact from increases in mixed traffic speed are outside the scope of analysis because (a) those impacts are not considered in either the bicycle lane analysis or the CDM analysis of TransMilenio, and (b) due to induced demand, there is no clear evidence that traffic speeds substantially improve. We also do not include the projections of increased reductions for 2011–2019, because these projections were based on optimistic increases of ridership that have not actually been observed in the past decade. Daily boardings on Guangzhou BRT in 2022 are in fact lower than in 2010.
[g] Chen, F., et al. (2017), "An evaluation of the low-carbon effects of urban rail based on mode shifts," Sustainability, 9(3): 401.
[h] Costs for metro systems taken from Goldwyn, E., et al. (n.d.), Transit Costs Project. Data was available for Rio de Janeiro Line 4; data for Beijing uses an average per kilometer for all Beijing metro.

Cost–Benefit Comparison of Emissions Reductions for Transport Interventions

City/country	Project	GHG reduction (tonnes/year)	Total cost (million USD, 2022)	Cost-effectiveness: GHG emissions (tonnes) per million USD (2-year horizon)
Rio de Janerio	Metro Lines 4	55,000[i]	7,722	142
	Trans Carioca BRT	65,000[j]	743	1,750
Mexico City	Metrobus BRT (Insurgentes corridor)	26,000[k]	152	3,412
USA	Highway expansion	-246,000[l]	370[m]	-13,333 (highways cause emissions)
	Dynamic wireless power Transfer (for electric vehicle charging)[n]			1,799
	Electric vehicle subsidy[o]			2,020
Canada	Electric vehicle subsidy[p]			2,667

[i] de Andrade, C.E.S., D'Agosto, M.D.A. (2016), "The role of rail transit systems in reducing energy and carbon dioxide emissions: the case of the city of Rio de Janeiro," Sustainability, 8(2): 1–16.

[j] Moura, I., de Oliveira, G. (2015), Análise de impacto do BRT transcarioca na mobilidade urbana do Rio de Janeiro, ITDP.

[k] Hook, W., et al. (2010), "Carbon dioxide reduction benefits of bus rapid transit systems: Learning from Bogotá, Colombia; Mexico City, Mexico; and Jakarta, Indonesia," Transportation Research Record, 2193: 9–16.

[l] Based on 100 lane-miles of highway built in Washington, DC. Emissions estimated with Rocky Mountain Institute's State Highway Induced Frequency of Travel calculator.

[m] Cost estimates based on research for Fulton, L., et al. (2021), The Compact City Scenario – Electrified, ITDP & University of California, Davis.

[n] Bi, Z., et al. (2019), "Life cycle assessment and tempo-spatial optimization of deploying dynamic wireless charging technology for electric cars," Transportation Research Part C: Emerging Technologies, 100: 53–67.

[o] Gillingham, K., Stock, J.H. (2018), "The cost of reducing greenhouse gas emissions," Journal of Economic Perspectives, 32(4): 53–72. Mid-cost estimate adjusted to 2022 dollars.

[p] Azarafshar, R., Vermeulen, W.N. (2020), "Electric vehicle incentive policies in Canadian provinces," Energy Economics, 91: 104902. Converted to USD at 2022 rates.

3.3.5. Time and Cost Savings

Time and Cost Savings Attributable to Protected Bicycle Lanes

	Bogotá			Guangzhou		
	Per trip	Per person-kilometer	Total per year	Per trip	Per person-kilometer	Total per year
Cost savings (local currency)	3,100 COP	234 COP	518 billion COP	0.7 RMB	0.09 RMB	200 million RMB
Cost savings (USD)	0.62	0.05	80 million	0.10	0.014	30 million
Time savings	14 min	1.03 min	27 million hours	0.12 min	0.015 min	550,000 hours

Based on the intercept surveys of cyclists on protected bicycle lanes in Bogotá and Guangzhou, we find that this infrastructure can have substantial benefits to city residents in terms of time and cost savings during travel. In fact, the annual cost savings to people using the protected bicycle lane networks are comparable to the estimated total cost of infrastructure construction (130 million USD in Bogotá and 70 million USD in Guangzhou): The cost of building the protected cycling infrastructure went back to the people using it in only two years.

On a per-trip basis, the time and money savings are also noteworthy, especially in Bogotá, where the average person riding a bicycle saves 14 minutes and 3,100 COP on their trip relative to the mode of travel they would have used otherwise.

Time and money savings are much greater in Bogotá than in Guangzhou because far more cyclists in Bogotá shift from public transit, with its costly fares and sometimes slow vehicles, while the vast majority of people using protected bicycle lane networks in Guangzhou would have cycled even if those lanes did not exist.

Bicycle lane networks are among the most cost-effective ways to reduce GHG emissions. Machang Road, Guangzhou, China Source: ITDP China

3.3.6. Public Health

To estimate the impacts of the protected bicycle lane networks on carbon emissions, we combined the annual estimates of person-kilometers traveled, the estimated modal shift from private, polluting modes, and mode-specific per-person-kilometer emissions factors, as described in Section 3.2.3.

Calculation of Premature Deaths Avoided due to Increased Physical Activity

	Bogotá	Guangzhou
Annual cycling on protected lanes (person-kilometers cycled)	1,600,000,000	1,500,000,000
Percent shifting from motorized modes	96.5	14.4
New person-kilometers of physical activity per day	4,231,923	593,182
Assumed daily cycling per person (km)	8.7	8.7
New people cycling	486,428	68,182
All-cause mortality rate for cycling in the reference case (HEAT default)	232	285
Premature deaths avoided per year	286	49
Economic value of lives saved per year (USD)	227,000,000	55,000,000

The protected bicycle lane network in Bogotá prevents about 286 premature deaths per year through increased physical activity, while the network in Guangzhou prevents about 49. The impact is somewhat smaller in Guangzhou because many more people would have ridden bicycles even if the protected lanes did not exist.

In addition to reducing carbon emissions, protected bicycle lane networks are a remarkably effective investment in public health.

The prevention of these premature deaths has a very high economic value – even greater than the value of the transportation costs saved by people riding bicycles. In the case of Bogotá, the yearly value of those lives saved is several times higher than the full infrastructure cost of the protected bicycle lane network.

Protected bicycle lane networks are an investment in public health by preventing premature deaths. Source: Despacio

4. Predicting Impacts

Source: ITDP Indonesia

The results of the study in Bogotá and Guangzhou may be used to predict the impacts of other planned networks of protected bicycle lanes in low- and middle-income countries. In this section, we propose a method, develop an interactive model, and make a prediction of the impacts of the proposed bicycle lane network in Addis Ababa, Ethiopia.

As with the estimation of impacts in Bogotá and Guangzhou, our method for predicting impacts in other cities follows three steps:

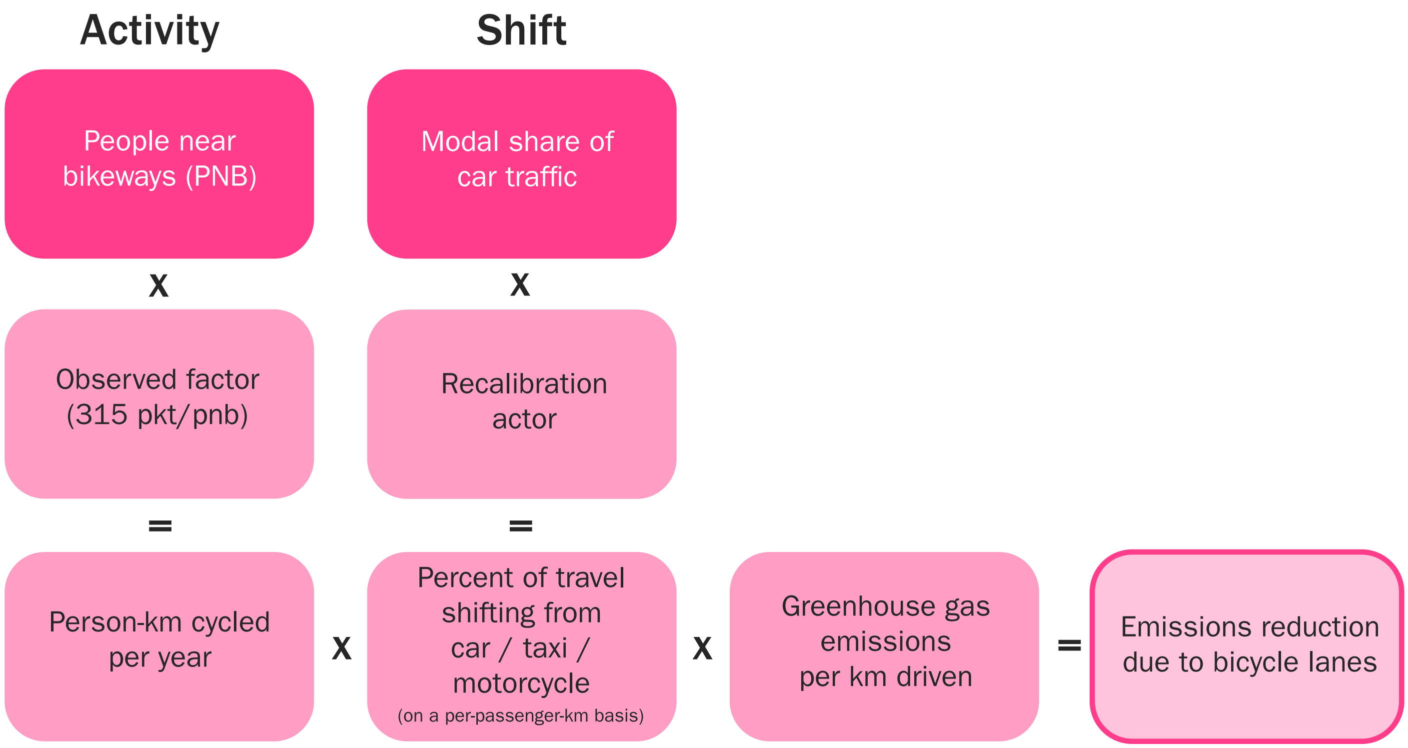
1. Predict total cycling activity on protected lanes.
2. Predict modal shift rates from other modes of transport to cycling.
3. Estimate carbon emissions from reduced use of private motorized modes.

As with the results in Section 3, this only includes the first-order impacts of the protected bicycle lane network, not indirect impacts from cycling outside of protected lanes, from reduced car ownership, from changes in public transit, or from decreased traffic capacities on roads.

You may view the model on Google Sheets at this link and see a version prepopulated with data for Addis Ababa. You may also make a copy of that file (select ‘File’ in the upper left, then ‘Make a copy’), or download it as a Microsoft Excel file; this will enable you to interactively model a possible protected cycle lane network in another city.

A protected bicycle lane in Zhongshan 5th Road in Guangzhou, China. Source: ITDP China

Method for Prediction of Emissions Reduction



GHG = greenhouse gas; pkt = person-kilometer traveled; PNB = people near bikeways.

4.1. City Background: Addis Ababa

Walking and public transit are the dominant forms of mobility in Addis Ababa, making up an estimated 85% of trips. The 31% of the population using public transit depend on minibus taxis, midi-bus taxis, Sheger buses, Anbessa buses, and light rail transit. Addis Ababa has a diverse range of public transit options, but there are significant limitations in the provision of transport services.

Modal Split in Addis Ababa Compared with Bogotá and Guangzhou (%)

	Bogotá[a]	Guangzhou (citywide)[b]	Guangzhou (central study area)[b]	Addis Ababa[c]
Walking	23.9	26.5	28.6	50
Pedal bike	6.6	7.7	8.4	4
E-bike	0	8.9	5.7	0
Bus	43.2	14.1	18.6	31
Rail	0.0	10.7	14.5	31
Other	1.0	1.6	1.2	0
Motorcycle	5.5	4.8	1.4	0
Private car	14.9	21.8	16.9	15
Ridehail/taxi	4.9	3.9	4.8	15

The number of private vehicles in Addis Ababa has been rapidly increasing, contributing to worsening congestion, loss of the public realm, air pollution, and traffic fatalities. To tackle these challenges, Addis Ababa has begun to invest in efficient, sustainable mobility, including high-quality public transit systems and streets that are safe for active mobility.

After the launch of the Addis Ababa Non-Motorised Transport Strategy in 2019, the city has taken up several initiatives to improve the walking and cycling environment and promote active mobility. The city has already implemented 10.3 km of protected bicycle lanes. The Addis Ababa Transport Bureau, with technical support from ITDP, has planned a cycle network that aims to cover key urban corridors, especially arterial streets with a right-of-way of at least 30 m and two or more lanes of mixed traffic per direction. Per the Addis Ababa Master Plan, 60% of the street sections in the city center must be allocated for walking and cycling infrastructure. The implementation plan includes short-term projects that can be implemented within two years, medium-term projects to be implemented over three to five years, and long-term corridors that will be implemented over six to 10 years.
If the planned network is built, it will total about 750 km of protected bicycle lanes – by far the largest such network in Africa, and one of the largest in the world. It will be paired with a bikeshare system[55] to promote travel by bicycle in Ethiopia's capital. This network would certainly cause an increase in cycling – the question is how large of an increase, and with what impacts for the climate?

[a] Secretaría Distrital de Movilidad de Bogotá (2019), Encuesta de Movilidad 2019.
[b] Direct communication from Guangzhou Transportation Bureau.
[c] World Bank (2015), Addis Ababa, Ethiopia: Enhancing Urban Resilience.
55. https://biskletmegarat.net/about-bikeshare

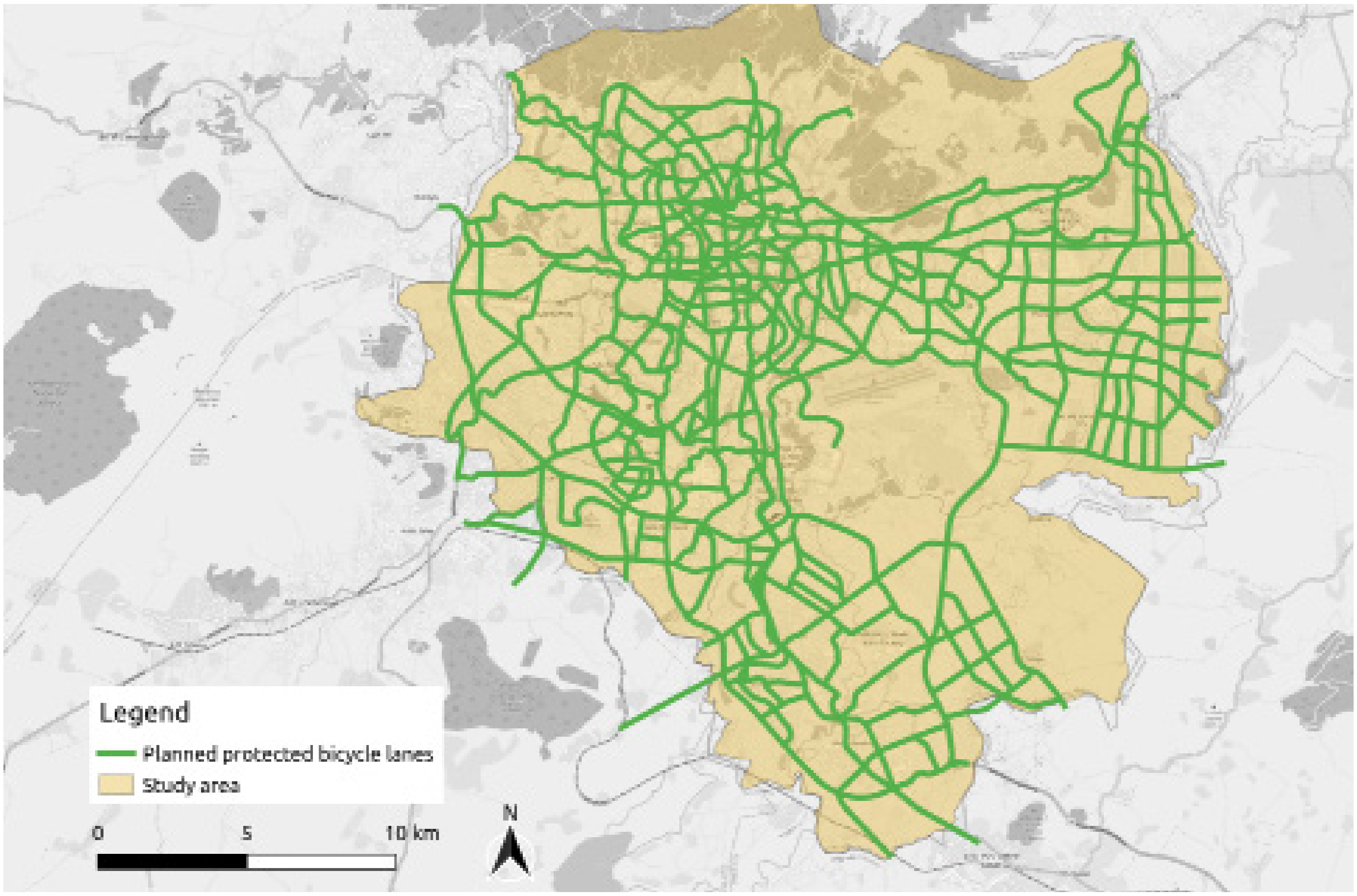


Image by authors, data from authors and OpenStreetMap contributors.

4.2. Method

4.2.1. Predicting Cycling Activity

To predict the amount of cycling activity that will be caused by a planned network of protected bicycle lanes, we must choose a measure of bicycle lane networks that correlates with rates of cycling activity in various cities. After examining several indicators, we identified a measurement of "people near bikeways," or PNB, as having the strongest correlation with person-kilometers traveled by bicycle. PNB measures the number of people living within a short (300 m) walking distance (along walkable streets or paths, rather than a simple buffer) of a protected bicycle lane.

In a sample of eight Latin American[56] cities for which data is available, we investigated the relationship between PNB and cycling activity on protected lanes. We measured PNB in these cities using a web database, Ciclomapa,[57] which is based on OpenStreetMap, as well as some original calculations also based on OpenStreetMap data. In these cities, data about overall cycling activity (person-kilometers traveled per year) is available from Google's Environmental Insights Explorer.[58] The Explorer figures include cycling on protected bicycle lanes as well as cycling on sidewalks or in

56. We excluded Guangzhou from this analysis for the sake of conservatism. Guangzhou's very high rates of cycling activity are driven at least partly by its history of cycling and by the prevalence of e-bikes, factors which might not apply in Addis Ababa or other cities.

57. These factors for Porto Alegre, Curitiba, São Paulo, and Belo Horizonte are taken from ITDP-Brazil and University of California, Berkeley's Ciclomapa. They are estimates, because Ciclomapa does not disaggregate between people near protected bicycle lanes (our concern here) and people near unprotected lanes.

58. https://insights.sustainability.google

mixed traffic, and so to estimate the amount of cycling on protected lanes in particular, we adjusted those numbers by a factor of 62%, the estimated percentage of cycling in Bogotá that takes place on protected lanes.[59]

We found a clear linear relationship ($R^2 = 0.88$) between PNB and cycling activity on protected lanes: for every person living within 300 m of a protected bicycle lane, roughly 315 km are cycled on protected lanes every year.

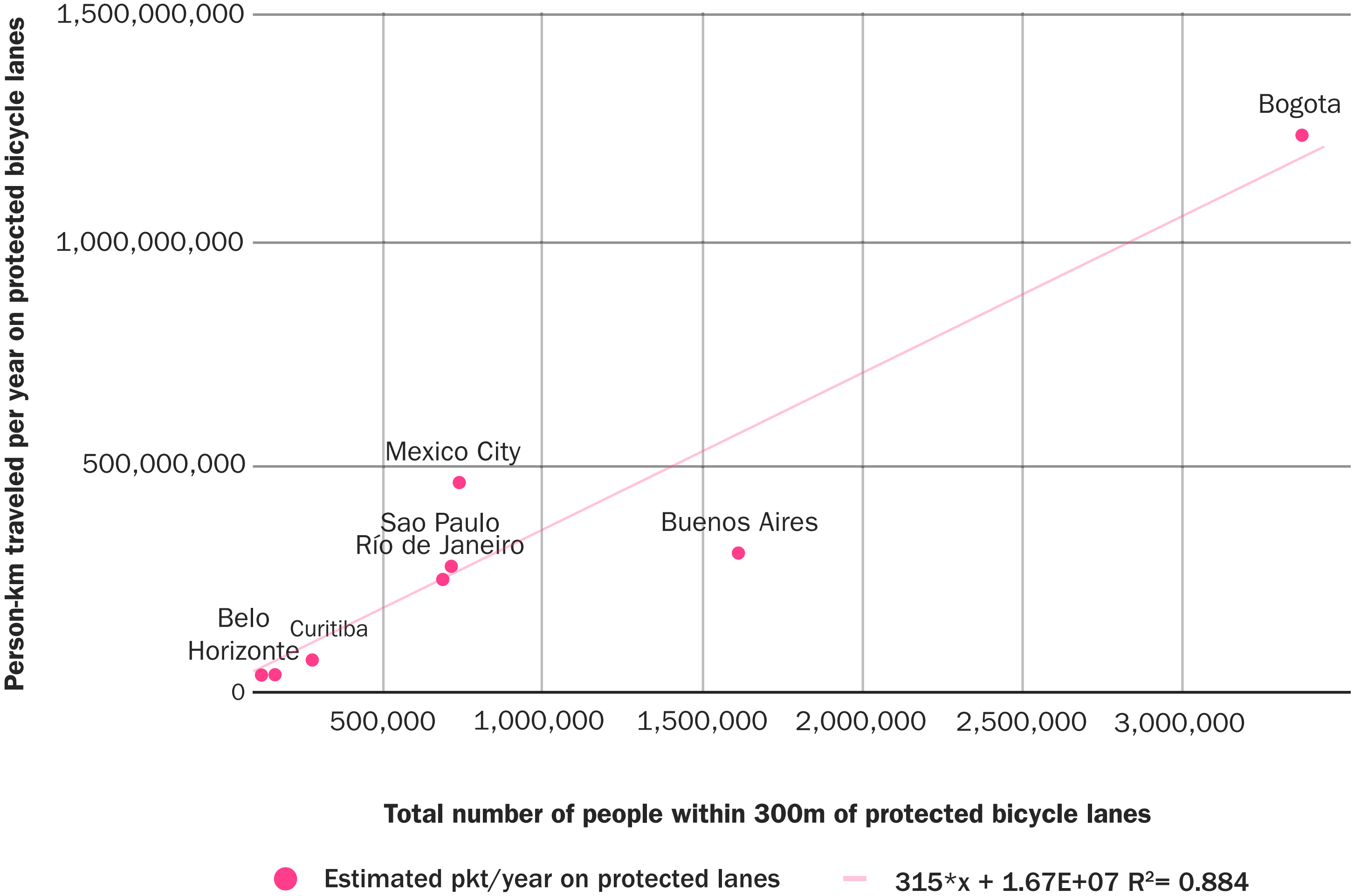
Correlation between PNB and Cycling Activity

	Kilometers of protected bicycle lane	PNB (% of population within 300 m of protected bicycle lanes)	City Population	PNB (no. of people within 300 m of protected bicycle lanes)	Total pkt/year[b]	Estimated pkt/year on protected lanes	Predicted pkt/year on protected lanes (~315 × PNB)[c]
Bogotá	500	45	7,705,472	3,467,462	1,929,312,000	1,200,000,000	1,092,250,641
Mexico City	273	8	9,229,844	738,388	700,000,000	435,388,366	232,592,064
Buenos Aires	256	59	3,016,010	1,779,446	500,000,000	310,991,690	560,525,518
Porto Alegre	36	8	1,500,000	118,983	65,000,000	40,428,920	37,479,661
Curitiba	153	14	2,000,000	275,238	117,000,000	72,772,056	86,700,000
Sao Paulo	232	7	10,700,000	712,164	450,000,000	279,892,521	224,331,639
Belo Horizonte	68	8.7	1,700,000	147,127	68,000,000	42,294,870	46,345,091
Rio de Janeiro	261	10.1	6,798,000	686,598	404,000,000	251,281,286	216,278,270

pkt = person-kilometers traveled; PNB = people near bikeways.

[a] Only including the cities, not the full metropolitan areas.
[b] For Bogotá, this is based on the Secretariat of Mobility's estimate of 880,000 trips by bike per day, with an assumed average trip length of 8 km. For other cities, this is taken from Google Environmental Insights Explorer.
[c] Technically, the line of best fit followed: pkt = 315 × PNB + 16,700,000.
59. The estimate of 62% follows the ratio between the estimates of total cycling in Bogotá and cycling on protected lanes in Bogotá. This is a conservative estimate, because it means we do not claim that the bicycle lanes have any second-order impact on promoting cycling on other roads.

Correlation between People near Protected Bicycle Lanes and Amount of Cycling on Protected Lanes



pkt = person-kilometers traveled.

As described in Section 4.3.1, we can use this correlation to predict the amount of cycling activity that will be seen on planned or proposed networks of protected bicycle lanes in low- or middle-income countries.

4.2.2. Predicting Modal Shift

In both Bogotá and Guangzhou, about 6% of person-kilometers traveled on protected bicycle lanes would otherwise have been traveled by car. This statistical similarity is probably attributable to the similarity in the citywide modal share of driving between them: in both cases that share is about 20%. Although this represents a sample of only two cities, it seems reasonable to conclude that the modal shift from driving to cycling has some relationship to the modal share of driving.

The Spanish city of Seville provides a third example, from a city with a higher share of driving. The construction of a protected bicycle lane network resulted in an increase in the modal share of cycling, coinciding with a similar increase in the share of public transit and a decrease in driving from 57% to 48% over only four years.[60]

60. Marques, R., et al., (2015), "How infrastructure can promote cycling in cities: Lessons from Seville," Research in Transport Economics, 53: 31–44. This study did not include any direct measurement of modal shift, only a measurement of overall changes in modal splits.

More research is needed to solidify an empirical model relating these variables. Until this data can be collected, we propose the method in the "Modal shift adjustment" tab of the [Protected Bicycle Lane Network Impact Model]:

1. For both Bogotá and Guangzhou, we compare known modal splits[61] with observed modal shifts to cycling to establish a ratio. Essentially, for each percentage point of the modal share of driving, we expect X percentage points of cyclists to have shifted from driving.

2. For each of four mode categories (car, ridehail/taxi, motorcycle, and other), we take the average of those ratios between Bogotá and Guangzhou.

3. We multiply the modal split of the city being modeled by those average factors to estimate the modal shift rates.

4. We normalize those modal shift rates so that they sum to 100% for the city being modeled.

Protected bicycle lanes improve the cycling experience in Belem, Brazil. Source: Lorenço Uira

Finding Mode-Shift-to-Mode-Split Proportions in Bogotá and Guangzhou

Bogtá			Guangzhou			
Citywide modal split (%)	**Observed shift to cycling on protected lanes (%)**	**proportion of shift to citywide split**	**Citywide modal split (%)**	**Observed shift to cycling on protected lanes (%)**	**Proportion of shift to citywide split**	**Average shift-to-split proportion (Bogotá and Guangzhou)**
14.9	4.9	0.33	16.9	1.6	0.09	0.21
4.9	1.4	0.29	4.8	4.1	0.85	0.57
5.5	9.9	1.80	1.4	0.0	0.00	0.90
74.7	80.3	1.07	75.8	94.2	1.24	1.16

61. The sources of these modal splits are as follows:
Bogotá: Secretaría Distrital de Movilidad de Bogotá (2019), Encuesta de Movilidad 2019.
Guangzhou: Direct communication from Guangzhou Transportation Bureau.
Addis Ababa: World Bank (2015), Addis Ababa, Ethiopia: Enhancing Urban Resilience.

4.2.3. Predicting Greenhouse Gas Impacts

For a planned network of protected bicycle lanes, once we have estimated both the total amount of cycling activity on those lanes and the rate of modal shift from private motorized modes, we can follow the methods outlined in Section 3.2.3 to predict the reduction in GHG emissions due to protected bicycle lanes.

4.3. Results

4.3.1. Predicting Cycling Activity in Addis Ababa
In Section 4.2.1, we identified a strong correlation between PNB and cycling activity, with a factor of 315 person-kilometers traveled per year per PNB. We can compare this factor with a measurement of the number of people living within 300 m of the proposed bicycle lane network in Addis Ababa. When the full bicycle lane network is completed, about 2.7 million people will be living within 300 m of protected bicycle lanes there. Following the established relationship, we predict that about 850 million person-kilometers will be bicycled every year on the protected bicycle lane network in Addis Ababa.

People near Bikeways for the Planned Network in Addis Ababa

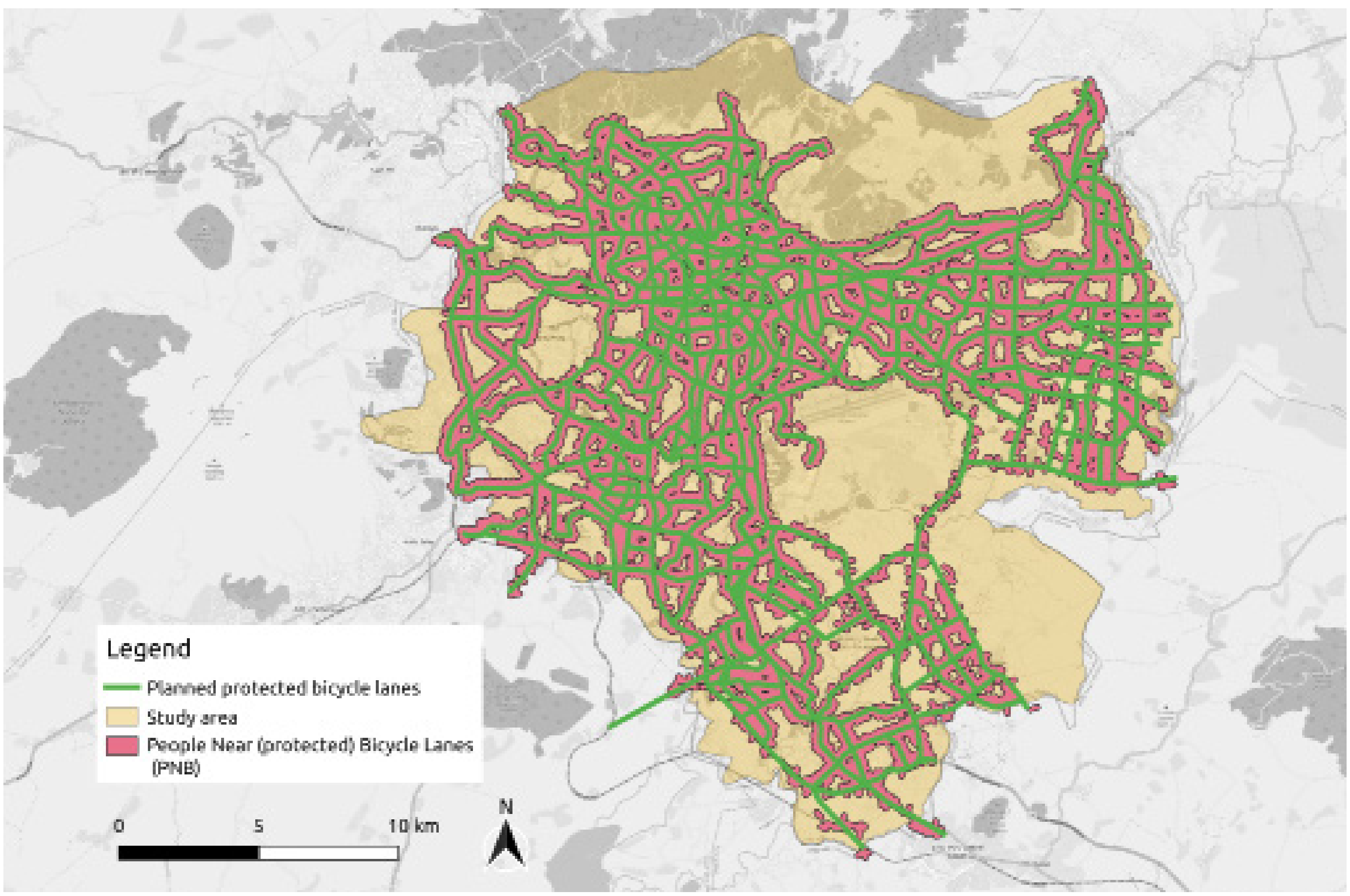


Image by authors, data from authors and OpenStreetMap contributors.

4.3.2. Predicting Modal Shift in Addis Ababa

By following the method in Section 4.2.2, we can compare the citywide modal split in Addis Ababa with the average mode shift to mode split proportions from Bogotá and Guangzhou, then normalize modal shift in Addis Ababa to 100% to predict the rates of modal shift from private motorized modes to cycling.

We estimate that about 4.2% of person-kilometers traveled on the Addis Ababa protected bicycle lane network will represent a shift from private motorized vehicles (cars, taxis, ridehail vehicles, and motorcycles).

Predicting Modal Shifts in Addis Ababa

Addis Ababa – existing citywide modal split (%)	Average shift-to-split proportion (Bogotá and Guangzhou)	Addis Ababa – adjusted proportions of modal shift	Addis Ababa – adjusted modal shift normalized to sum to 100% (%)
12.0	0.21	0.03	2.5
3.0	0.57	0.02	1.7
0.0	0.90	0.00	0.0
85.0	1.16	0.99	95.9

4.3.3. Predicting Greenhouse Gas Impacts in Addis Ababa

By multiplying the total increase in cycling by the percentage shifting from private motorized modes and the emissions factors of those modes, we predict that the protected bicycle lane network in Addis Ababa will reduce GHG emissions by between 4,000 and 7,000 tonnes CO2eq per year. This is lower than the impacts of the networks in Bogotá and Guangzhou, but Addis Ababa is a considerably smaller city (about 3 million inhabitants, to Bogotá's 8 million and Guangzhou's 13 million). Addis Ababa also has lower levels of car ownership and thus likely has a lower overall carbon footprint from passenger transportation.

Even more than in Bogotá and Guangzhou, we consider this a conservative estimate. In many cities across the low- and middle-income world, car ownership is growing rapidly. By 2028 – the planned completion of Addis Ababa's bicycle lane network – it is likely that car ownership will increase substantially, especially if the bicycle lanes are not built. That trend is not included in our calculations.

4.4. Predicting Impacts in Other Cities

In the process of making these predictions for Addis Ababa, we have developed a model that can be used to predict the impacts of protected bicycle lane networks in any other city, especially any city in a low- or middle-income country. The model is available here. It is meant for use by planners, advocates, and researchers to predict the impacts of any possible bicycle lane network.

The model is detailed enough to provide a well-informed estimate, but not so detailed that it requires extensive specialized expertise. Our predictions, like any attempt to forecast the future, are imprecise, but we hope that they are accurate enough to be useful for planning purposes. The design of this method is based on data from middle-income countries. It will be most accurate in cities similar to Bogotá and Guangzhou in terms of population, size, and modal split, but it may be applied elsewhere.

This proposed model is only a first attempt at a tool to predict the impacts of protected bicycle lane networks. It paves the way for more sophisticated modeling that takes into account second-order impacts. But until such a tool is developed, this one provides a way for governments, development banks, and other funders to understand the costs and the climate benefits of investing in networks of protected bicycle lanes. The costs are small, and the benefits are great.

Much remains to be done so that more people can ride bicycles comfortably and safely. Siem Reap, Cambodia. Source: Gail Palethorpe

October 2022