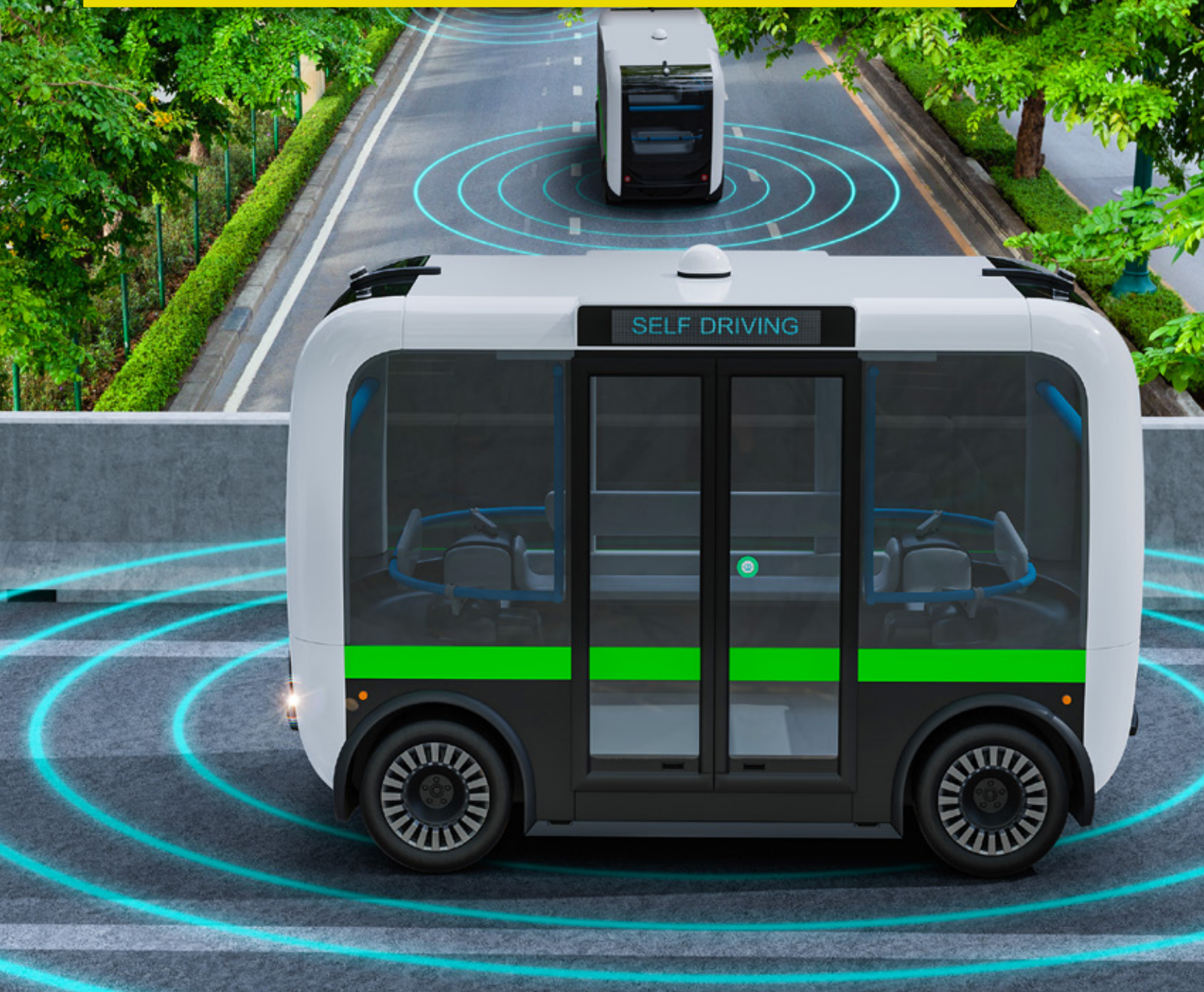


# Mobility AND Development

INNOVATIONS, POLICIES AND PRACTICES



**WORLD BANK GROUP**  
Transport

FALL 2021 EDITION

©2021 The International Bank for Reconstruction and Development / The World Bank  
1818 H Street NW  
Washington, DC 20433  
Telephone 202-473-1000  
Internet: [www.worldbank.org](http://www.worldbank.org)

This volume is a product of the staff of The World Bank. The findings, interpretations, and conclusions expressed in this volume do not necessarily reflect the views of the Executive Directors of The World Bank or the governments they represent.

The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

#### **Rights and Permissions**

The material in this publication is copyrighted. Copying and/or transmitting portions or all of this work without permission may be a violation of applicable law. The International Bank for Reconstruction and Development / The World Bank encourages dissemination of its work and will normally grant permission to reproduce portions of the work promptly.

For permission to photocopy or reprint any part of this work, please send a request with complete information to the Copyright Clearance Center Inc., 222 Rosewood Drive, Danvers, MA 01923, USA: telephone: 978-750-8400; fax: 978-750-4470; Internet: [www.copyright.com](http://www.copyright.com). All other queries on rights and licenses, including subsidiary rights, should be addressed to the Office of the Publisher, The World Bank, 1818 H Street NW, Washington, DC 20433, USA: fax: 202-522-2422; e-mail: [pubrights@worldbank.org](mailto:pubrights@worldbank.org).

Transport publications are available on-line at <http://www.worldbank.org/transport/>



# Contents

---

A message from the World Bank's Vice President for Infrastructure

**4**

---

A Note from the Editor-in-Chief

**6**

---

Mobility on Demand (MOD) and Mobility as a Service (MaaS): Similarities, Differences, and Potential Implications for Transportation in the Developing World

**10**

---

Toward Greening Transport in India

**22**

---

Using Geospatial Analysis to Calculate Flooding Impacts on Urban Accessibility in Matola, Mozambique

**30**

---

Quantifying the Health Co-Benefits of Active Mobility: Developing Tools for Health Impact Assessments of Transport Choices in Five Latin American Cities

**42**

---

Changing Transport in Pakistan

**58**

---

Response to COVID-19 Employment Creation through Infrastructure Investment

**72**



---

**Riccardo Puliti**  
Vice President for  
Infrastructure,  
The World Bank

# A message from the World Bank's Vice President for Infrastructure

**I**t is my pleasure to introduce this first edition of *Mobility and Development: Innovations, Policies, and Practices*, a new periodical produced by the World Bank's Transport Global Practice.

We are experiencing an era of exceptional change that has highlighted the critical role mobility and connectivity will have to play in building a more sustainable, more resilient world.

But even though the current context has made transport development more relevant than ever, it is also pushing us to be more flexible and innovative.

To answer the call, it has become increasingly important for experts across the transport sector to share their knowledge and develop cutting-edge solutions together.



That is precisely the motivation behind the Mobility and Development periodical. By fostering knowledge exchange and collaboration between clients, partners, educational institutions, and many others, we hope this new series will help strengthen our infrastructure knowledge and solutions even further.

Many thanks to the authors and contributors of this inaugural edition and to the Transport Global Knowledge Unit for initiating this medium to further the dialogue with our stakeholders around the globe.



**Riccardo Puliti** is the Vice President for Infrastructure at the World Bank. In this position he leads the institution's global efforts to build effective infrastructure in developing and emerging markets and supports the World Bank Group's strategic business priorities, such as the climate change action plan. He oversees the Bank's critical work across energy and transport sectors, digital development, and efforts to provide access to renewable energy and low-carbon transportation and quality infrastructure services to communities through public-private partnerships. Infrastructure represents around USD 75 billion of the Bank's portfolio. Click [here](#) to read more.

*Riccardo Puliti*





We are only now beginning to adapt, analyze, and sort out ways in which the transport sector can move forward and thrive in this new reality.

Accordingly, our writers delve into topics relevant to the transport sector in a post-pandemic world where climate change presents an increasingly complex challenge. Our first guest article, contributed by **Susan Shaheen** and **Adam Cohen** of the University of California, Berkeley, looks at how the evolution of two new, and complementary, approaches to mobility is shaping the future of transportation, especially in emerging economies. In addition to explaining the similarities and differences between the two approaches (Mobility on Demand and Mobility as a Service), Shaheen and Cohen discuss the role of

various stakeholders and the potential for partnerships to address spatial, temporal, and other service gaps — particularly in response to pandemic-related changes in travel behavior and public transit service.

Then, attention shifts to creating and overseeing a greener, more integrated and energy-efficient transport sector in India, thanks to a multipronged strategy proposed by **O.P. Agarwal** and **Chirag Gajjar** of World Resources Institute India. Working toward its renewable energy commitments under the nationally determined contributions (NDCs), Agarwal and Gajjar note that India must include decarbonizing transport in the effort to meet these commitments. They propose that an integrated approach to sector policy led by a multi-ministry mission could hold the key to creating a more sustainable transport in India.

Our World Bank staff articles navigate the state of transport in several global regions. First up is Africa, where **Xavier Espinet Alegre** and **Fatima Arroyo Arroyo** discuss how geospatial analysis is helping researchers gauge and mitigate the impact of flooding on urban transport in Mozambique. Their analysis provides a better understanding of transport disruptions in and around Maputo, the capital of Mozambique, and the resulting losses in the public's accessibility to reach places of work or seek employment opportunities (EOs). In turn, the data is helping city planners make essential transport systems more resilient to the increasingly frequent urban flooding in the Greater Maputo



**Binyam Reja** serves as the Global Practice Manager for the Transport in the Infrastructure Vice Presidency of the World Bank. Dr. Reja oversees the World Bank's Transport Global Unit's knowledge program, analytical studies, technical support to operational units, partnerships, and corporate mandates. He directs an extensive technical assistance program and analytical studies and leads a team of technical professionals and experts in the delivery of the program. Prior to being selected to this position in November 2020, Dr. Reja was the Regional Practice Manager for China, Mongolia, and Central Asia where he oversaw a lending program totaling US\$8 billion for China, Mongolia, and Central Asia covering all subsectors, including urban transport, BRT, metros, highways, railways, intermodal freight transportation, and logistics. He holds a Ph.D. in Economics from the University of California, Irvine, and attended the Executive Education program at Harvard's Kennedy School of Government.

Area — and more resilient transport systems will lead to more reliable access to jobs and EOs, despite the ever-present challenge of climate-induced flooding.

Moving to Latin America, **Felipe Targa**, **Juan Pablo Orjuela**, and **Daniel Gil Sánchez** explore how to better evaluate the health benefits of nonmotorized transport policies. While case studies in five bustling Latin American cities indicate increased use of nonmotorized transport modes could help reduce traffic-related injuries, the renewed interest in two-wheeled motorized vehicles — especially during the COVID-19 pandemic — could lead to higher road fatalities. New tools, being developed by the World Bank based on joint research conducted with the University of Cambridge and the University of Oxford, are set to help policy makers better estimate the health impacts of their cities' urban mobility plans, use the resulting data in cost-benefit analyses, and garner political support for greater active mobility.

Next, **Said Dahdah**, **Hasan Afzal Zaidi**, and **John H. Winner** take us to South Asia for a discussion on how the integration and strengthening of vital transport systems is connecting far-flung urban centers in Pakistan. As Pakistan's largest city, Karachi serves as a major industrial hub and home to two major seaports,



which handle almost all of Pakistan's overseas trade by volume. Continued economic growth in Pakistan depends upon increased freight movements to and from these ports, improvements to the surface transport infrastructure, and the policy objective of significantly increasing the volume of port traffic moving by rail. With this in mind, the World Bank study analyzes the capacity of the existing network and considers which of the various proposed solutions would be most effective, including greater involvement of the private sector.

Finally, **James Markland, Muneeza Alam, Mridula Singh, and Sudhashree Chandrashekar** widen the scope, looking at how targeted infrastructure investment could help shape employment creation worldwide in the aftermath of COVID-19. As countries and organizations plan their routes to economic recovery, many have adopted Building Back Better (BBB) as a mantra. A key element of BBB is the commitment to ensure a low-carbon, resilient infrastructure moving forward. However, economic stabilization will only be achieved if BBB also addresses poverty

and unemployment. BBB offers a renewed opportunity to use infrastructure investments to create employment. Using experiences and data from a number of countries, this article outlines a process for and describes elements essential to the design of programs to maximize employment. With multiple options available, no one single solution fits all situations, and requires careful consideration and planning by industries, services, construction, and agriculture.

We thank our contributors for sharing their research with us in what we hope is an inviting and accessible format. We trust that you, our readers — whether as sector experts or members of a broader, though equally interested, audience — will in turn engage with, gain insights into, and be inspired by how transport is adapting to the post-COVID-19 world.

Have a transport-related topic you would like us to explore in future issues? Reach out to the editorial team with your suggestions at [WBGTransport@worldbank.org](mailto:WBGTransport@worldbank.org).

*Binyam Reja*

---



---

**Authors:** Susan  
Shaheen and Adam  
Cohen, **University of  
California, Berkeley**

# Mobility on Demand (MOD) and Mobility as a Service (MaaS): Similarities, Differences, and Potential Implications for Transportation in the Developing World



In Europe and North America, two complementary approaches to integrated mobility and multimodal access to public and private transportation services are evolving in parallel. In the United States and Canada, consumers are assigning economic values to transportation services and making mobility decisions (including the decision not to travel and instead have goods delivered) based on cost, travel and wait time, number of connections, convenience, and other attributes — a concept commonly referred to as Mobility on Demand (MOD). In Europe, services that allow travelers to sign up for mobility services in one bundle are gaining popularity — a concept known as Mobility as a Service (MaaS). In addition to explaining the similarities and differences between MOD and

MaaS, this paper discusses the role of various stakeholders and the potential for partnerships to address spatial, temporal, and other service gaps particularly in response to pandemic changes in travel behavior and public transit service.

Discussion includes developments from the developing world, such as for-hire services, jitneys; informal ride services; and international global benchmarking data from carsharing and bikesharing. This article features lessons learned and best practices for support mobility innovations, such as considerations to encourage physical, information, and fare payment integration, and concludes with a discussion of emerging innovations in shared automated vehicles (SAVs), last-mile delivery, and advanced air mobility (AAM).

In cities around the world, innovative and emerging mobility strategies offer consumers more options than ever before to access mobility, goods, and services. As these services grow in many regions of the world, consumers are engaging in more complex multimodal decision-making processes. Rather than making decisions between modes, travelers are linking modes together to optimize route, travel time, and cost. Fare and digital information are being integrated in an effort to enhance consumer convenience, increase transparency, and reduce costs.

Two approaches to the multimodal integration of public and private transportation services are evolving with

---

#### About the Authors



*[Dr. Susan Shaheen](#)* is a professor in the department of civil engineering and codirector of the Transportation Sustainability Research Center (TSRC) at the University of California, Berkeley.



*[Adam Cohen](#)* is a senior research manager at the Transportation Sustainability Research Center (TSRC) at the University of California, Berkeley.

particular speed, one more popular in North America and the other more popular across Europe. In North America, consumers are assigning economic values to transportation services and making mobility decisions (including the decision not to travel and choosing instead having a good or service delivered) based on cost, travel and wait time, number of connections, convenience, and other attributes — a concept commonly referred to as mobility on demand (MOD).

In Europe, services allowing travelers to access bundled mobility services are becoming more popular — a concept known as mobility as a service (MaaS). This article discusses the similarities, differences, and relationship between these two concepts; it also explores potential applications and implications for the developing world.

**Table 1** provides a list of existing and emerging shared mobility modes found within MOD and MaaS.

**Table 1.** Existing and Emerging Shared Mobility Modes

<p><b>Advanced air mobility</b></p> <p>A broad concept focusing on emerging aviation markets and use cases passenger mobility, goods delivery, and emergency services for urban, suburban, and rural operations. Advanced air mobility includes local use cases within a 50-mile (80 kilometers) radius in rural or urban areas, and intraregional use cases within the range of a few hundred miles.</p>	<p><b>Auto rickshaw</b></p> <p>A motorized version of the pulled rickshaw or cycle rickshaw sometimes used as a taxi. Typically, auto rickshaws have three wheels and an open frame. Frequently referred to as “baby taxis” in Bangladesh; “bajaj” in Tanzania and Ethiopia; “toktok” in Egypt; “tuk-tuk” in Cambodia, Madagascar, South Africa, Sri Lanka, and Uganda; “keke-marwa” in Nigeria; “Raksha” in Sudan; and “kekeh” in Liberia.</p>	<p><b>Bikesharing</b></p> <p>A service that provides travelers on-demand, short-term access to a shared fleet of bicycles, usually for a fee. Bikesharing service providers may own, maintain, and provide charging (if applicable) for the bicycle fleet.</p>	<p><b>Carsharing</b></p> <p>A service that provides the traveler with on-demand, short-term access to a shared fleet of motor vehicles typically through a membership; the traveler pays a fee for use. Carsharing service providers typically own and maintain the vehicle fleet and provide insurance, fuel or charging, and parking.</p>
<p><b>Courier network services (CNS)</b></p> <p>A commercial for-hire delivery service for monetary compensation using an online application or platform (such as a website or smartphone app) to connect freight (packages, food, and so on) with couriers using their personal, rented, or leased vehicles, bicycles, or scooters.</p>	<p><b>e-hail</b></p> <p>Smartphone apps that supplement street hails by allowing on-demand hailing of taxis. The e-hail service option also provides travelers with prearranged and/or on-demand access to a ride for a fee using a digitally enabled application or platform (for example, smartphone apps) to connect travelers with drivers using their personal, rented, or leased motor vehicles. The latter is commonly referred to as “transportation network companies” (or TNCs) and “ride-hailing” in the United States and Commonwealth countries and “voiture de transport avec chauffeur”(or VTC) in francophone countries.</p>	<p><b>Jitney</b></p> <p>Typically an informal, unlicensed, or illegal for-hire private transit or taxicab operation.</p>	<p><b>Microtransit</b></p> <p>A technology-enabled transit service that typically uses shuttles or vans to provide pooled on-demand transportation with dynamic routing.</p>
<p><b>Motorcycle and moped sharing</b></p> <p>A service that provides the traveler on-demand, short-term access to a shared fleet of motorcycles and/or mopeds for a fee. Service providers typically own and maintain the vehicle fleet and provide insurance, fuel or charging, and parking.</p>		<p><b>Pedicab</b></p> <p>A for-hire ride service in which a cyclist transports traveler(s) on a tricycle with a passenger compartment.</p>	<p><b>Pooling</b></p> <p>The formal or informal sharing of rides between drivers and travelers with similar origin-destination pairings using mopeds, motorcycles, or motor vehicles. Riders may share some costs of the trip (fuel, for example).</p>
<p><b>Scooter sharing</b></p> <p>A service that provides the traveler on-demand, short-term access to a shared fleet of scooters for a fee. Scooter sharing service providers typically own, maintain, and provide fuel or charging (if applicable) for the scooter fleet. Service providers may also provide insurance.</p>	<p><b>Shared automated vehicle (SAV)</b></p> <p>A service allowing automated vehicles to be shared among multiple users. SAVs can be summoned on-demand or operated via a fixed-route service.</p>	<p><b>Taxi</b></p> <p>A service that provides the traveler on-demand, short-term access to a shared fleet of scooters for a fee. Scooter sharing service providers typically own, maintain, and provide fuel or charging (if applicable) for the scooter fleet. Service providers may also provide insurance.</p>	

**Source:** Original table produced for this publication.

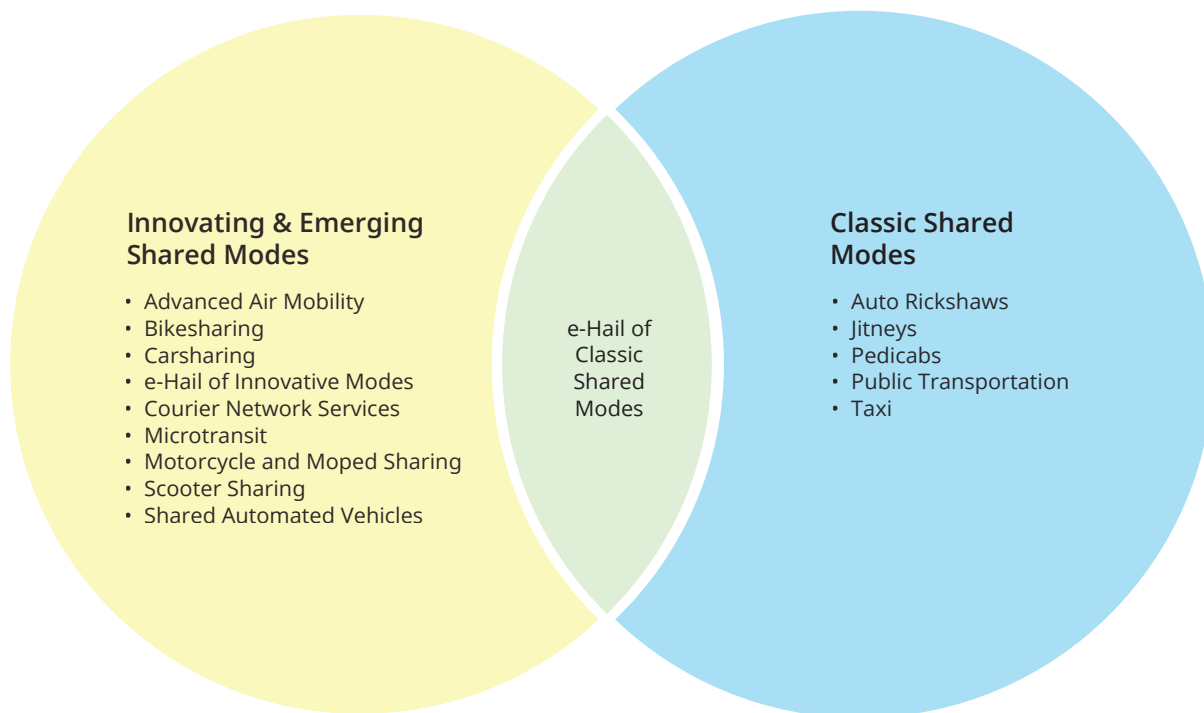
## Mobility on Demand (MOD)

MOD is based on the principle that transportation is a commodity where modes have economic values distinguishable in terms of cost, journey time, wait time, number of connections, convenience as well as other attributes. MOD offers users access to mobility, goods, and services on demand by dispatching or using informal shared transportation services (for example, autorickshaws and jitneys), shared mobility, delivery services, and public transportation strategies through an integrated

and connected multimodal network.

Passenger modes facilitated through MOD providers include: carsharing; bikesharing; ridesharing (carpooling and vanpooling); for-hire and e-hail services such as taxis, motorcycle taxis, auto rickshaws, and so on; motorcycle, moped, and scooter sharing; microtransit; public transportation; and other emerging transportation strategies such as shared automated vehicles, advanced air mobility, and so forth (see **figure 1**).

**Figure 1.** Examples of Classic, Innovative, and Emerging Shared Modes in the Developing World



**Source:** Original table produced for this publication.

## The most innovative passenger services typically incorporate trip planning and booking, real-time information, and fare payment into a single user interface.

Shared mobility in the developing world is not new. The use of human-powered rickshaws or two-wheeled carts has a long history. Today, auto rickshaws — motorized versions of the pulled rickshaw or cycle rickshaw — are beginning to employ e-hail apps in a number of regions around the world. Known in Tanzania and Ethiopia as “bajaj,” in Egypt as “toktok,” in Nigeria as “keke-marwa” and in Sudan as “Raksha,” and in Liberia as “kekeh,” drivers can purchase the vehicles for US\$3,500 (€3,100). Drivers can be hired at a daily rate of around US\$25 in many parts of Africa. Both the sharing and electrification of these mobility options could help the developing world reduce greenhouse gas emissions (GHG) and work toward achieving climate action goals.

The most innovative passenger services typically incorporate trip planning and booking, real-time information, and fare payment into a single user interface. The most advanced courier services incorporate robotic delivery, app-based courier network services (CNS), and unmanned aircraft systems such as delivery drones. In addition

to the supply side of the MOD ecosystem, the MOD concept also emphasizes transportation systems management to optimize operations of the transportation network, or managing demand. Whereas the supply side of the marketplace includes transportation services for mobility or goods and service delivery, the demand side of the marketplace is comprised of travelers and goods, including their choices and preferences. At its core, the MOD concept envisions multimodal operations management in which a public agency: (1) receives data from all aspects of the system, (2) aggregates the data into an overall picture of current and predicted conditions, and (3) identifies challenges considering a range of operational objectives (see **figure 2**). In the future, the concept of using MOD to manage the supply and demand sides of the network could be pivotal in helping guide consumers to more environmentally sustainable choices.

Public agencies can in turn use this information and pair it with policy interventions to more effectively manage the transportation network. Pricing schemes are the most common ways public agencies influence demand of the transportation network. For example, an agency might use congestion pricing (a system of charging roadway users for excess use during peak periods) to help manage demand. In the 1970s, Singapore was one of the first developing nations to employ a combination of policies, such as road pricing and public transit improvements, which has contributed to that country's low motorization rates and congestion management.

Figure 2. USDOT's Architecture for MOD and Multimodal Management



Source: Shaheen et al. 2017. <https://rosap.ntl.bts.gov/view/dot/34258>.

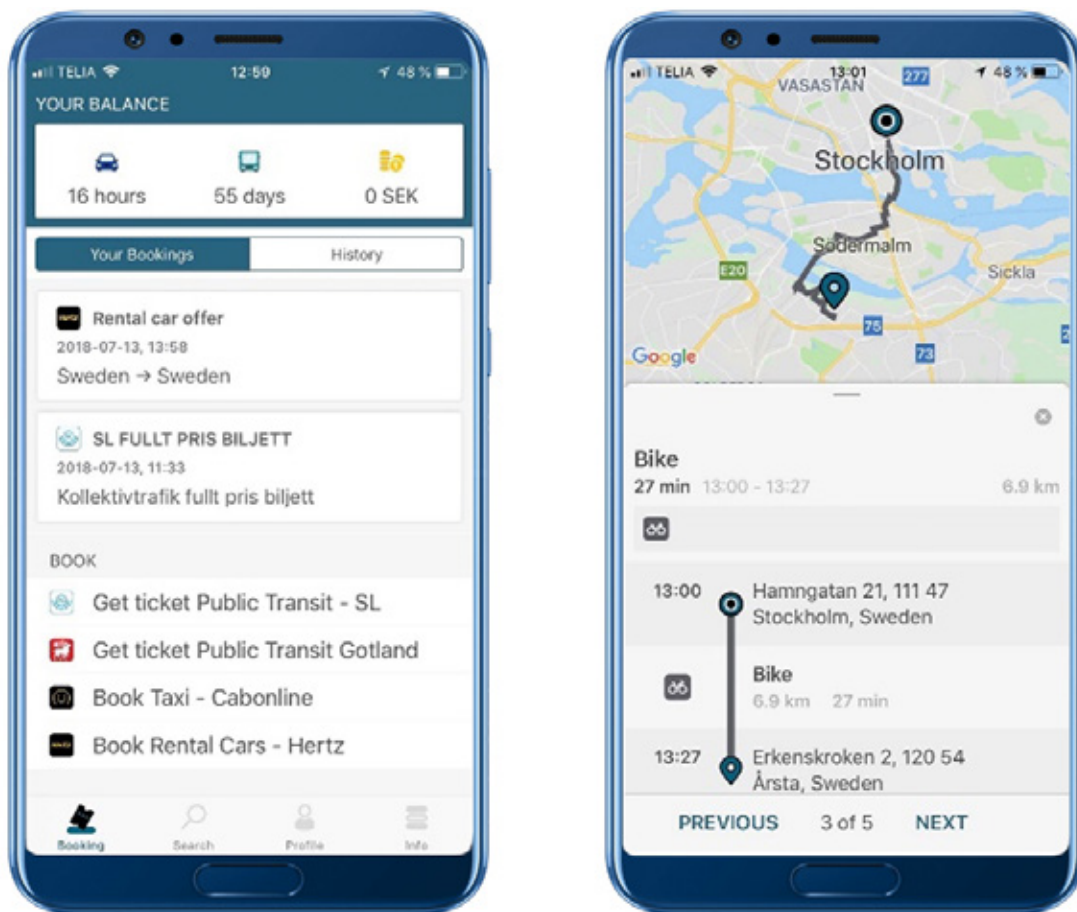
Note: This figure illustrates the U. S. Department of Transportation's (USDOT) vision of a multimodal operations management approach that can interact and/or influence the supply and demand of the transportation network as well as the key enablers and stakeholders of this ecosystem.

## Mobility as a Service (MaaS)

Another multimodal concept, known as MaaS, is emerging in Europe, Asia, and Australia. MaaS is an integrated mobility marketplace where travelers can access multiple transportation services over a single digital interface. Brokering travel with suppliers, repackaging, and reselling it as a bundled package is a distinguishing characteristic of MaaS. For example, [UbiGo](#),

an app-based service in Sweden, offers households a mobility subscription in place of vehicle ownership. The subscription allows households to prepurchase mobility access in a variety of increments on multiple modes, operating like a multimodal “digital punch card” for a number of transportation services, such as public transportation, carsharing, rental cars, and taxis (**figure 3**).

Figure 3. UbiGo Mobility App as a Service Interface



Source: UbiGo (<https://www.ubigo.me/en/home>).



## Similarities and Differences of MOD and MaaS

While MOD and MaaS are similar in a number of ways, the primary emphasis of MaaS is passenger mobility, such as allowing travelers to seamlessly plan, book, and pay for a multimodal trip on a pay-as-you-go and/or subscription basis. In contrast, MOD emphasizes the commodification of passenger mobility, goods delivery, and transportation systems management. [Key similarities between MOD and MaaS include their mutual emphasis on physical, fare, and digital multimodal integration.](#)

Recently, MOD and MaaS have been converging even more, as the public and private sectors increasingly emphasize concepts of integrated mobility. A growing number of digital services are offering connected travelers with real-time information and integrated payment services that can simplify trip planning and payment for multiple transportation modes. As a result, these conveniences have encouraged travelers to: (1) search routes, schedules, near-term arrival predictions, and connections; (2) compare travel times, connection information, distance, and costs across multiple routes and transportation modes; and (3) access to real-time travel information for a journey — all typically from a smartphone application. Particularly in environments where transportation services can be infrequent or unreliable, these services have the potential to help bridge information gaps and enhance traveler decision making with real-time and actionable information throughout an entire journey.

However, the growing reliance of MOD and MaaS on digital platforms and banking relationships can raise a number of social equity concerns. The requirements for users to have smartphones with high-speed data packages could be a barrier to low-income and rural households who might not be able to afford or lack data coverage needed to access app-based mobility platforms. Similarly, many of these app-based services could require debit or credit cards for payment and, in some cases, collateral for vehicles or equipment. This could be a barrier for underbanked or unbanked consumers. Alternatives such as cash payment options, digital kiosks, telephone services, and non-technology-based access (such as street hailing) could help overcome some of these challenges.

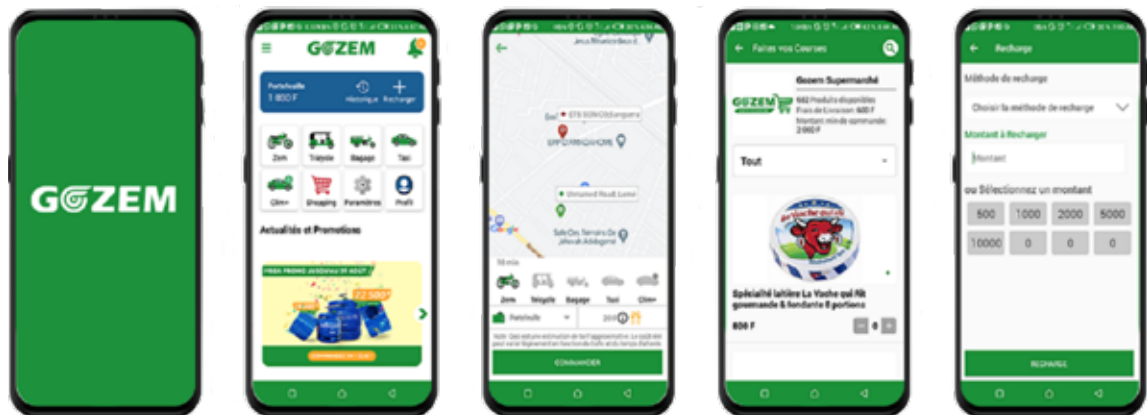
**Growing reliance of MOD and MaaS on digital platforms and banking relationships can raise a number of social equity concerns.**

## MOD and MaaS in the Developing World

In some cases, the developing world is “leap frogging,” or bypassing prior evolutionary states, the developed world in the features and level of sophistication of its app-based mobility services. For example, [Gozem](#), a smartphone app and transportation service in the francophone Western and Central Africa, blends MOD and MaaS modalities. What makes Gozem particularly unique is that the app integrates a number of mobility, delivery, e-commerce, and payment services. Gozem users can use the

app to: (1) dispatch a variety of mobility services (such as motorcycles, mopeds, auto rickshaws, and taxis); (2) deliver cargo; (3) order groceries, household items, and durable goods; and (4) pay for goods and services using a digital wallet (see [figure 4](#)). As of March 2021, the Gozem app is active in Benin, Burkina Faso, Cameroon, Côte d’Ivoire, Gabon, Mali, Senegal, and Togo. During the first quarter of 2020, [the service completed 500,000 rides](#), as noted in a news article published online by Techpoint.Africa.

Figure 4. Screenshots of the Gozem App



Source: Gozem (<https://website.gozem.co/en/>).

**Gojek claims 190 million downloads since 2015, more than 2 million drivers, and 900,000 merchant partners.**

Sometimes referred to as “super” apps, these multifunctional so-called “lifestyle” apps are expanding in other regions of the developing world. Gojek — which primarily operates in Indonesia, the Philippines, Singapore, Thailand, and Vietnam — integrates shared mobility, parcel and food delivery, moving services, telemedicine, streaming video, mobile payment, and business services into a single platform. The service claims 190 million downloads

since 2015, more than 2 million drivers, and 900,000 merchant partners. Grab, which operates in Cambodia, Indonesia, Malaysia, Myanmar, Singapore, Thailand, and Vietnam, also integrates a variety of shared mobility services (such as e-hail, pooling, auto rickshaws, bikesharing, and shuttles); food, parcel, and grocery delivery; and a mobile wallet. Other similar “super” apps include Paytm in India, Careem in the Middle East, and WeChat in China.

## Common MOD and MaaS Partnerships

The public sector can play an important role supporting MOD and MaaS, typically through a variety of partnership modes. A few common and emerging partnership approaches include the following:

- **First- and last-mile partnerships** target use cases that help bridge spatial gaps and increase access to fixed-route public transportation;
- **Low-density service partnerships** focus on providing supplemental transportation services in built environments that may have less frequent public transit service and lower ridership. A primary goal of this type of partnership is to provide gap filling services, increase ridership, and reduce operational costs of providing services in suburban, exurban, and rural communities;
- **Off-peak service partnerships** emphasize offering alternative late-night and weekend transportation services to provide additional mobility options during periods of low ridership;
- **Paratransit partnerships** are typically employed to supplement fixed-route public transit service to provide flexible and personalized mobility services for people with disabilities;
- **Trip planning partnerships** focus on developing and/or integrating multimodal trip planning into a single platform. Common goals of trip planning partnerships include: (1) increasing consumer trip planning convenience, (2) encouraging multimodal transportation, and (3) reducing barriers to public and active transportation use;
- **Fare integration partnerships** allow riders to easily pay for trips that span across public and private transportation modes and allow riders to either pay for: (1) each trip leg using the same fare medium, or (2) trip legs employing a single fare (apportioned to each mobility provider that serves each trip leg on the backend);
- **Data sharing partnerships** include partnering with the private sector to share a variety of data types to enhance local transportation planning, operations, trip planning, and fare integration; and
- **Infrastructure partnerships** leverage public and private sector resources to support the development of enabling infrastructure — such as curbs, bicycle lanes, and other enhancements — to encourage active transportation and improve safety.

## Conclusion

Innovative and emerging transportation services, such as shared mobility, MOD, and MaaS, are expanding across the developing world. MOD emphasizes the commodification of passenger mobility and goods delivery and transportation systems management, whereas MaaS primarily focuses on passenger mobility aggregation and subscription services. The public sector can support and leverage MOD and MaaS through a variety of service, information, fare integration, and data sharing partnerships. In particular, the growth of “super” apps in Africa and Asia are offering consumers all-in-one mobile platforms for a variety of transportation and shopping options, mobile wallets, and other services that, in some cases, offer deeper levels of integration and are more advanced than comparable platforms in Europe and North America. While research on “super” apps is limited, anecdotal evidence suggests that by bundling a variety of consumer services together, these apps have the potential to enhance traveler convenience, multimodal trip planning, and access to goods and services.



## Acknowledgments

The authors would like to thank the World Bank, the American Planning Association, the California Department of Transportation, the Mineta Transportation Institute, and the U.S. Department of Transportation for supporting this research. The authors would also like to acknowledge the numerous service providers, public agencies, and other experts and practitioners that provided valuable data and support MOD and MaaS research.



References



Additional Resources





---

**Authors:** O.P. Agarwal  
and Chirag Gajjar,  
**World Resources  
Institute India**

# Toward Greening Transport in India

**W**orking towards its renewable energy commitments under the nationally determined contributions (NDCs), India is well on its way to installing 175 gigawatts (GW) of generation capacity by 2022 and has scaled up its targets to 450 GW by 2030. India must now look at decarbonizing transport to further its NDC commitments. While transport contributes about 15 percent of the greenhouse gas emissions globally, current estimates for India stand closer to 9.7 percent. However, transport sector emissions are set to grow rapidly given the pace of

urbanization and the economic growth projections, and attending to them at an early stage will save the country from locking itself into high emission, and high cost, pathways that will be difficult to move out of later.

This article argues for a four-pronged strategy to help reduce emissions from transport, even as the demand of transport grows strongly to support economic growth. An approach that aims at greater use of cleaner fuels, adopting a preference for sustainable transport modes, integrating transport



systems, and optimizing the use of vehicles to minimize idle capacity appears to be the best way forward. However, with transport sector policies fragmented across five ministries in the government of India, successful implementation requires an integrated approach, ideally led by a multi-ministry mission.

As part of its nationally determined contributions (NDCs), under the Paris Agreement, India committed to increasing its share of nonfossil fuel sources in installed capacity for electricity generation to 40 percent. Additionally, India also adopted a domestic goal of installing 175 gigawatts (GWs) of renewable energy (RE) capacity by 2022. It has since raised the bar and plans to install 450 GWs of RE capacity by 2030.

After five years of the Paris Agreement, India has made significant progress — by August 2021, India had achieved 39.6 percent nonfossil fuel installed capacity and 100 GWs of RE capacity.

Having put itself firmly on a sustainable track in the energy sector, India would be prudent to turn its attention to the transport sector. In 2016, India's transport sector contributed to **13 percent** of emissions from the energy sector, compared to the global average of **22 percent**, with transport projected to be among the country's fastest growing sectors. In terms of modes of transportation, 90 percent of India's emissions come from road vehicles, compared to 72 percent globally. The anticipated growth in transport sector emissions is primarily due to the following reasons:

- The country is rapidly urbanizing. Despite having 377 million urban residents according to the 2011 census, this number represented only about one-third of India's total population. India's urban population falls well below the world average, where the urban population now stands at more than 50 percent. United Nations (UN) urban population projections indicate India's urban population will reach 850 million by 2050.
- Urbanization means higher incomes and a higher affordability of personal motor vehicles. Given that India's per capita ownership of cars is barely 18 per 1,000 — compared to 800 per 1,000 in the United States and 600 per 1,000 in Europe — the likelihood

#### About the Authors



**O.P. Agarwal** is currently the chief executive officer of World Resources Institute India.



**Chirag Gajjar** serves as head of subnational climate action in WRI India's climate program.

*Views expressed in this article are personal*

of rapid motorization as the country urbanizes can only increase.

- Urbanization also means longer travel distances and thus an increased demand for travel. This in turn means more fuel use and higher emissions.

The impact of urbanization on motor vehicles is quite staggering. Within seven years the number of motor vehicles has doubled, resulting in more urban congestion, air pollution, and health impacts as well as increasing greenhouse gas (GHG) emissions from the transport sector. In fact, the growth in transport emissions is outpacing the growth in energy emissions. Between 2009 and 2016 the number of motor vehicles has doubled in India. States like Delhi, Gujarat, Maharashtra, Karnataka, Tamil Nadu, and Uttar Pradesh have maintained the high share of motor vehicles.

**The impact of urbanization on motor vehicles is quite staggering. Within seven years the number of motor vehicles has doubled, resulting in more urban congestion, air pollution, and health impacts as well as increasing greenhouse gas (GHG) emissions from the transport sector.**

According to the [India Energy Outlook 2021](#), published by the International Energy Agency (IEA), stated policy scenario (STEPS) energy demand for road transport will double by 2040. The scenario assesses current policy settings and constraints in which India's energy sector will grow. The transport sector will function as a key driver for energy demand with a fivefold increase expected in per capita car ownership. More importantly, robust physical connectivity will be crucial for India to achieve its goal of becoming a US\$5 trillion economy.

Consequently, the transportation sector will see huge growth in infrastructure, including highways, railways, metros, ports, and airports. However, to adopt a sustainable pathway, India should act fast by pushing for electrification, efficiency standards, and switching to clean fuels. Therefore, greater attention to the transport sector will be important if India is to reduce the emissions intensity of its gross domestic product (GDP) by 35 percent, as committed. This needs to be done urgently to avoid becoming locked into high energy transport patterns as urban land use gets locked into unending sprawl.

A firm foundation for a transition toward clean transport can be laid through the following four-step action plan.



## 1. Adoption of Cleaner Fuels

Moving away from fossil fuels and toward clean electricity and green hydrogen must be mainstreamed in any plan toward clean transport, specifically in two areas:

- Transport electrification must be backed by low-carbon electricity**

In 2013, India announced a National Electric Mobility Mission Plan (NEMMP) to promote hybrid and electric vehicles (EVs) over the conventional internal combustion engine (ICE) vehicles. To further support the NEMMP, India announced two rounds of the Faster Adoption and Manufacture of EVs (FAME) program in 2015 and 2019, both of which offered financial incentives for purchase of vehicles and installation of charging facilities. These incentives have given a strong fillip to EVs, especially buses and shared mobility options, such as taxis. Several states have announced local level policies to promote the use of and manufacture of EVs and their components.
- Costs will play a key role in transitioning to hydrogen**

Several teething problems, such as creating frameworks for lending and setting up charging facilities across a city, have already created challenges in the transition toward cleaner fuels. In the meantime, a decision has been taken to set up a hydrogen mission tasked with developing a comprehensive approach to the adoption of hydrogen, especially looking at its use in long distance trucking. Developing

incentives for production and use will be key for developing a roadmap. Also, transport and storage costs will play a significant role in the competitiveness of the hydrogen. If hydrogen must travel before it can be used, the costs of transmission and distribution could incur significant costs. These are early days in the move toward hydrogen, but once it has attracted attention the transition is bound to move ahead.

However, the transition to cleaner fuels is not an easy one to envision and achieve, and requires a significant network of supporting infrastructure to facilitate large-scale adoption. Among them are primary requirements such as battery charging facilities. High battery costs, high charging time, and the convenience of the existing technology make the transition difficult, especially when people's behavior patterns are aligned with the convenience of the ICE vehicle. These will also need changing, accompanied by compelling justifications for why people should change their driving-related behavior patterns from ICE to EV or hybrid vehicles — not an easy task anywhere.

And yet, declining battery price, increasing energy density of batteries, and research on improved battery chemistries is creating hope for the future. While India has been slow to start, the pace is picking up with several cities looking at a higher share of electric buses and electric autorickshaws as part of their public transport and para-transit fleets.

An important question has been the viability of EVs for long-distance freight and passenger movements, considering the limitation in its “range” (currently available batteries need to be charged for a minimum of four hours at an interval of 200 to 300 kilometers). Hydrogen-based fuel could hold the answer to this hurdle, but its technology is still evolving, and costs are high, having not yet benefited from scale economies. The recent announcement of a National Hydrogen Energy Mission in the budget for 2021–22 signals the government of India’s recognition of hydrogen as a fuel for the future and could catalyze stronger action in toward this fuel.

## 2. A Shift to Energy-Efficient Modes

Two dimensions factor into the modal shift in India: first, to persuade the people to shift from personal motor-vehicles to public and nonmotorized transport (buses, bicycles, and so on) and second, to encourage long-distance transport — especially freight — to shift from road-based systems to rail or marine.

- **Modal shift in passenger transport**  
According to the Ministry of Road Transport and Highways, the passenger transport activity for 2016–17 totaled

17,832 billion passenger-kilometers. The growth in motorization for mobility is largely driven by two or three wheelers, with passenger cars representing the third fastest growing vehicle category in India. Population growth coupled with affordability and shortage of reliable public transport will ensure continued growth in private motorization.

India is responding to the challenges associated with private motorization through policy interventions aimed at improving fuel quality and efficiency. In 2017, corporate average fuel efficiency (CAFE) consumption norms for cars were introduced with an upper limit of 5.49 liters per 100 kilometers. This standard will become more stringent beginning in 2022.

The National Urban Transport Policy (NUTP) 2006 strongly recommended the shift from personal motor vehicles to public transport and nonmotorized modes. Based on these recommendations, several Indian states and cities have invested massively in public transport in the past few years. Review of comprehensive mobility plans of 27 Indian cities revealed that passenger modal shift is second to nonmotorized transport in strategy. Today, India’s large cities all have operating metro rail systems, while they are under construction in many smaller and growing cities. Further, the national budget has allocated over US\$2.5 billion for public bus systems. In addition, the calls to deploy low-cost metros in smaller cities have provided the needed shot in the arm to boost mass transit.

Several Indian states and cities have invested massively on public transport in the past few years.

- **Modal shift in freight transport**

Modal choice in freight is mainly dictated by travel time and cost for most commodities. Time sensitive commodities such as perishables and high value goods always choose the fastest mode, while heavy commodities such as coal, stone, and others opt for rail transport as the more cost effective option. Industries use travel time and distance data to decide the mode of travel for their goods. Consideration of the emissions impact is largely missing when choosing freight transport modes. With the current modal mix for freight transport skewed toward road transport (60–65 percent), a modal shift would require greater use of rail or marine transport. Unfortunately, neither of these transport systems offer door-to-door services on their own. Doing so would require both rail and marine transport to integrate with other modes, particularly short-distance road transport. Clearly, the cost of transshipments is more taxing than the higher cost of road transport itself.

As stated above, the 2017 World Resource Institute (WRI) India internal study showed consideration of

emissions data associated with the mode of freight transport is largely missing from the decision making. Further, in WRI India's analysis of petroleum oil and lubricants (POL), one of the 50 commodities included in the study, 100 percent of POL to Tamil Nadu and 27 percent to Delhi are transported by road from Gujarat. Transporting POL products from Gujarat to Tamil Nadu and Delhi by rail instead of road could reduce emissions by three-fourths and one-half respectively. Ongoing projects such as the [Dedicated Freight Corridor](#) (DFC) could accelerate the modal shift (see **table 1**). The eastern and western dedicated freight corridors will be commissioned by June 2022, and 100 percent electrification of broad-gauge routes will be completed by December 2023. These dedicated freight rail corridors could lower India's cumulative railways emissions significantly. Setting up a comprehensive logistics division in the Ministry of Commerce and Industries is also a step in the right direction for integrating transport for export cargo. However, a fundamental change requires greater integration at the institutional level.

**Table 1.** Dedicated Freight Corridors in India

No	Dedicated freight corridor	Start point	Termination point
1	Western dedicated freight corridor	Dadri	JNPT, Nava Sheva
2	Eastern dedicated freight corridor	Ludhiana	Dankuni
3	East–West dedicated freight corridor	Dankuni	Bhusalwal
4	North–South dedicated sub-corridor	Vijaywada	Itarsi
5	East coast dedicated freight corridor	Kharagpur	Vijaywada
6	Southern dedicated freight corridor	Madgaon	Chennai

### 3. Integrating Transport Systems

Integrating transport systems is important to ensure the lack of door-to-door service does not compel use of unsustainable modes. Rail and marine systems must coordinate with road transport to offer a complete end-to-end service. This will require integrating fare policies, data, schedules, standards, branding, and even governance. However, this has been a challenge in India, largely due to the fragmented oversight of transport across five national ministries, as mentioned earlier. Models such as those in the United States, United Kingdom, China, the Republic of Korea, and Brazil, each with a single department for transport sector policy making that

should be replicated in India. The recent merger of the railway budget with the general budget is a step in the right direction, though we have to see if that moves forward to its next steps. Promising efforts that could enable multimodal transport systems include innovating the container size to suit domestic transportation and exploring the use of stacked containers in railways, which could help contain the costs and tariffs for commodities or developing feeder routes and multimodal logistics parks for DFCs to ensure full utilization.

Even at the city level, the problem of fragmentation presents a challenge. Though the national Ministry of Housing and Urban Affairs is the sole ministry responsible for urban transport policies, the rail and road-based systems in cities operate in competition with one another with no integration. Similarly, road construction planning is done separately and land-use planning is also managed as an independent exercise. As a result, the benefits of door-to-door service are not realized, thus forcing urban commuters to prefer their personal motor vehicles over public transport. While the 2006 NUTP recommended the establishment of unified metropolitan transport authorities in cities to help bring about the needed integration, only a few cities have complied so far. The recently set up Kochi Metropolitan Transport Authority, in Kerala, promises to set an example for others to follow.

**Integrating transport systems is important to ensure the lack of door-to-door service does not compel use of unsustainable modes. Rail and marine systems must coordinate with road transport to offer a complete end-to-end service.**

## 4. Optimization of Available Capacity

The concept of transport infrastructure “optimization” is based on the premise that an empty seat in a moving vehicle is a wasted resource and should be minimized. So far overlooked by transport operators and policy makers alike, this concept is gaining greater attention within India’s existing transport systems.

In fact, world over, a variety of shared mobility options are drawing on this premise and maximizing the available capacity of public transport. On-demand taxis are

today offering pooled services to multiple riders on the same routes. The concept of mobility as a service (MaaS) has also been gaining ground. Such digitally advanced integration can help improve utilization of the available transport assets and reduce waste of scarce resources. The hassles of driving on congested roads, the challenges of finding parking, and the love of the smart phone are collectively changing the behavior of young Indians, many of whom show a preference for app-based taxis over their personal motor bikes or cars.

## Conclusion

Few countries in the world oversee transport systems in as fragmented a manner as India. Even at the national level, five different ministries are responsible for transport sector policy making — the Ministry of Road Transport and Highways, the Ministry of Railways, the Ministry of Shipping, the Ministry of Civil Aviation and the Ministry of Housing and Urban Affairs. In most other countries, national-level policy making for transport is housed in a single ministry or department that oversees policy making, with implementation handled through various technical agencies. India needs to do this as well. Could a single Ministry of Transport for policy making, with separate agencies responsible only for implementation, strengthen and streamline India’s transport sector? We propose this as a promising solution.





---

**Authors:** Xavier  
Espinet Alegre and  
Fatima Arroyo-Arroyo,  
The World Bank

# Using Geospatial Analysis to Calculate Flooding Impacts on Urban Accessibility in Matola, Mozambique



Climate change is having a direct impact on accessibility to employment opportunities (EOs) by disrupting transport services during the intense rainy season. In the area surrounding Maputo, the capital of Mozambique, frequent flood events prevent residents from accessing public transportation, lower traveling speeds, and create disruptions on the network — substantially reducing the ability of people to reach their places of work or seek EOs. Unpaved roads, poor drainage infrastructure and management as well as the city’s overall lack of urban planning worsens the effects of flood events. Floods have become more frequent in recent years and are expected to follow this trend due to climate change effects, thus posing a threat to the city’s road network, and

## Climate change is having a direct impact on accessibility to employment opportunities (EOs) by disrupting transport services during the intense rainy season.

ultimately the Greater Maputo Area (GMA). Additionally, the World Bank projects urbanization will continue growing in the Maputo exacerbating the risk of urban flooding events.

Under this context, the proposed study uses geospatial analysis to gain understanding on accessibility losses due to flooding disruption, with the aim to ensure climate resilience investments in urban transport Maputo are based in both evidence and data. Our analysis reveals that in Matola, for example — the largest agglomeration in the Maputo metropolitan area — due to flooding disruptions on the transport network, around 10 percent of people lose more than 50 percent of EOs due to flooding and inaccessible job location. The poorest resident would experience even deeper reductions in their ability to use public transport, with reliance on walking increasing from 10 to 15 percent of all trips. The higher incomes, while representing 11 percent of the population, see the least impact of flooding, accounting for only 3 percent of accessibility losses due to flooding-related disruptions.

### About the Authors



*Xavier Espinet* is a transport economist at the World Bank working in the Latin American and The Caribbean region.



*Fatima Arroyo-Arroyo* works in the Transport Global Practice, supporting the transportation agenda in Africa.

## Climate Impacts and Urban Mobility in Greater Maputo

Located on the southeastern coast of Africa, Mozambique borders with Tanzania to the north; Zambia, Malawi and Zimbabwe to the west; and with South Africa and Swaziland to the south. Endowed with ample arable land, water, energy as well as mineral resources and newly discovered natural gas offshore, Mozambique has three deep seaports, along with a relatively large potential pool of labor. With four of its six border countries landlocked, and hence dependent on Mozambique as a conduit to global markets, Mozambique is also strategically located. The country's strong ties to South Africa underscore the importance of its economic, political, and social development to the stability and growth of southern Africa as a whole.

**Social and economic growth continues to be hindered by recurrent climate impacts.** Most recently, due to the impact of cyclones Idai and Kenneth, the country faced an economic slowdown in 2019, with GDP growth dropping from 3.4 percent to 2.2 percent. Floods, triggered by cyclones and intense rain events, have become more frequent in recent years and are expected to follow this trend due to climate change effects, posing a threat to the city's road network, and ultimately the Greater Maputo Area (GMA). Rainfall projections based on 35 available global circulation models (GCMs) used by the 5th Assessment Report, published by the Intergovernmental Panel on Climate Change (IPCC), estimate the number of heavy rainfall events — defined as a daily rainfall total greater than the

threshold exceeded on 5 percent of rainy days in the current climate of that region or season — will increase by 2060, particularly during the dry season (January to June), [according to the World Bank's climate data projections for Mozambique](#).

**Maputo serves as the country's main financial, business, and commercial center.** With a population of 1.2 million (2019) and land area of 347 square kilometers, the capital city is geographically the smallest and most densely populated province in Mozambique, and has been administered as a self-contained separate province since 1998. In recent years, residential and industrial development has spread to the surrounding districts of Matola, Boane, Matutine, and Marracuene, creating the Maputo Metropolitan Area (AMM), also called Greater Maputo Area (GMA). The population of GMA is expected to increase from 2.8 million in 2018 to almost 4.0 million by 2035. Currently, jobs are mainly concentrated in the city and province of Maputo with housing growing on the outskirts of the cities of Maputo, Matola, and Marracuene. This urban and economic development can be associated with a greater need for the mobility of people and goods, and a number of urban infrastructure works have already been carried out in the recent years (for example, the Katembe bridge and *Circular de Maputo* ring road projects); however, traffic congestion is worsening, which in turn increases pollution and declining road safety. The expansion has also overstretched the city's



health, education, and transport systems, posing enormous challenges to the local governments in their efforts to deliver basic services, provide food, and improve the city's infrastructure.

**The district of Matola is growing at an exponential pace, doubling its population over a decade, from 671,000 in 2007 to 1.7 million in 2017,** and increasing the density from 2,807/km<sup>2</sup> to 4,400/km<sup>2</sup> (see **figure 1**) The rapid growth has overwhelmed the urban infrastructure services, such as transport, not designed to accommodate such a rapid population growth. Residents in Matola are highly dependent on public transportation to commute to places of employment; however, they suffered from low levels of accessibility to public transport, especially the poorest areas (**figure 1**), which hampers social and economic development. One of the main causes of low accessibility, frequent flooding impacts, become particularly disruptive during the rainy season (December to March).

**Public transport is dominated by the unregulated/informal transport services provided by the private sector (chapas, myloves, two and three wheelers).**

Chapas, minibus services operated on a fixed route by associations of private operators, are particularly popular, especially for the poor people living in suburban areas who depend on informal modes to reach work and conduct other daily activities. Myloves or unregulated open-backed trucks, have grown exponentially and remain an important mode of transport for the poor, although they have been banned in different parts of the AMM due to safety and

## Public transport is dominated by the unregulated/informal transport services provided by the private sector.

security concerns. These informal modes coexist with other regulated modes, such as the municipal-owned bus enterprise (Transporte Public Metropolitana or TPM) and the commuter rail (MetroBus) (**figure 1**).

**By disrupting transport services during the intense rainy season, climate change has a direct impact on accessibility.**

Current flood events prevent residents from accessing public transportation, lowering traveling speeds and creating disruptions on the network, reducing substantially the ability of people to reach their employment opportunities (EOs). In Matola, for example, due to flooding disruptions on the transport network, about 10 percent of people in Matola lose more than 50 percent of EOs due to flooding and job location (**figure 1**).

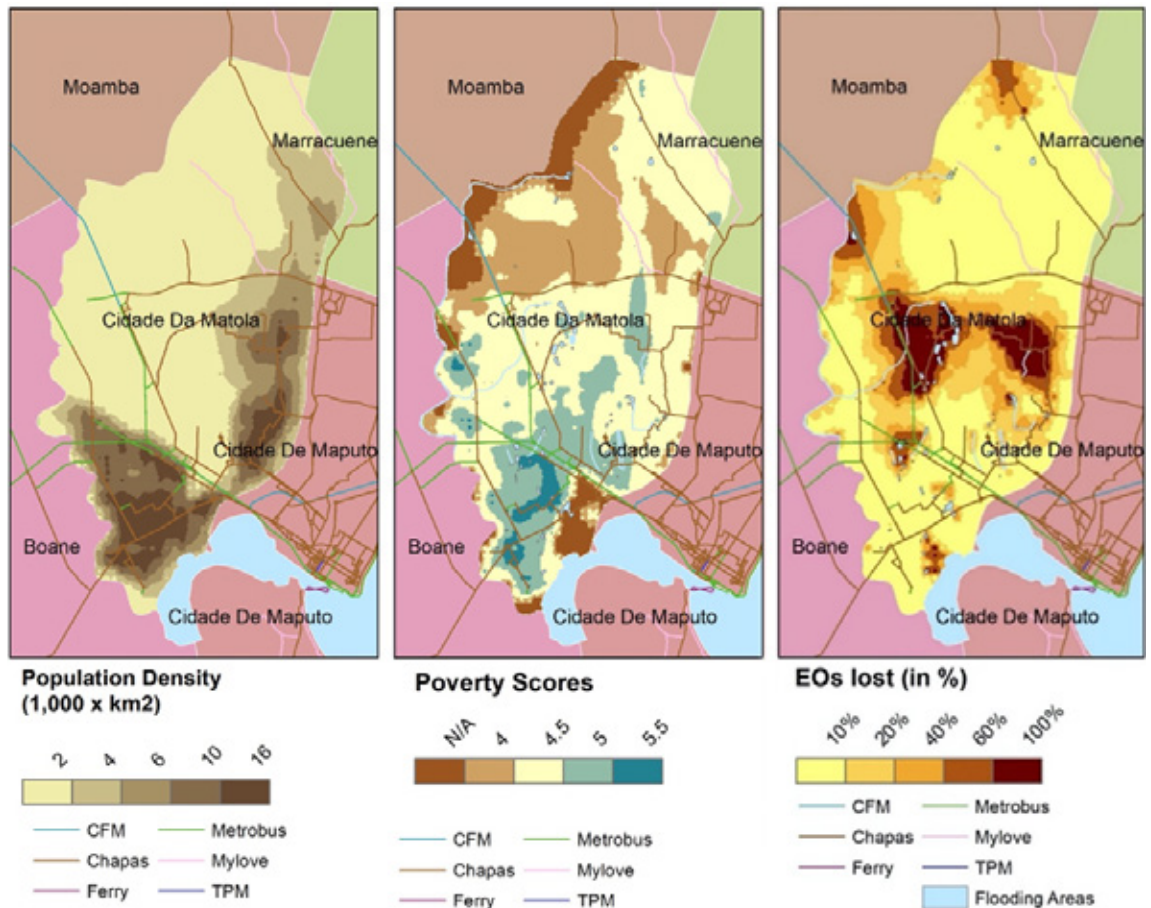
Floods have become more frequent in recent years and are expected to follow this trend due to climate change effects, posing a threat the city's road network, and ultimately the GMA. Unpaved roads, poor drainage infrastructure and management as well as the city's overall lack of urban planning worsen the effects of flood events. Additionally, the "[Mozambique Urbanization Review](#)," a World Bank working paper published in 2017, projects urbanization growth will continue increasing in the Maputo and Matola areas, exacerbating the risk of urban flooding events.

Under this context, the GMA and the World Bank Group (WBG), under the Greater Maputo Multimodal Mass Transit Development Project (P175322), are discussing intervention to increase accessibility to jobs and other critical services in the GMA, especially benefiting some areas in Matola. The preparation of this lending operation in Maputo is supported by an ongoing technical assistance (TA) — Private Sector Participation — financed by the Public-Private Infrastructure Advisory Facility (PPIAF). This TA aims to: (1) provide options for strengthen governance and planning framework, (2) identify integrated packages of investment, (3) develop service and operations plans, and (4)

identify opportunities for private sector participations.

This note fits onto the [Climate Resilience & Environmental Sustainability Technical Advisory \(CREST\) Trust Fund](#) grant supporting the ongoing PPIAF TA to evaluate urban transport flood risk with current and future likely climate change projections. The CREST support aims at improving the private sector investment environment for bus rapid transit (BRT) projects contributing to climate change adaptation (CCA). The outputs of the proposed additional grant would fit into the results of the ongoing TA and would support the preparation of the lending operation (P175322).

Figure 1. Matola: Population Density, Poverty Distribution, and Accessibility to Employment Loss Due to Floods



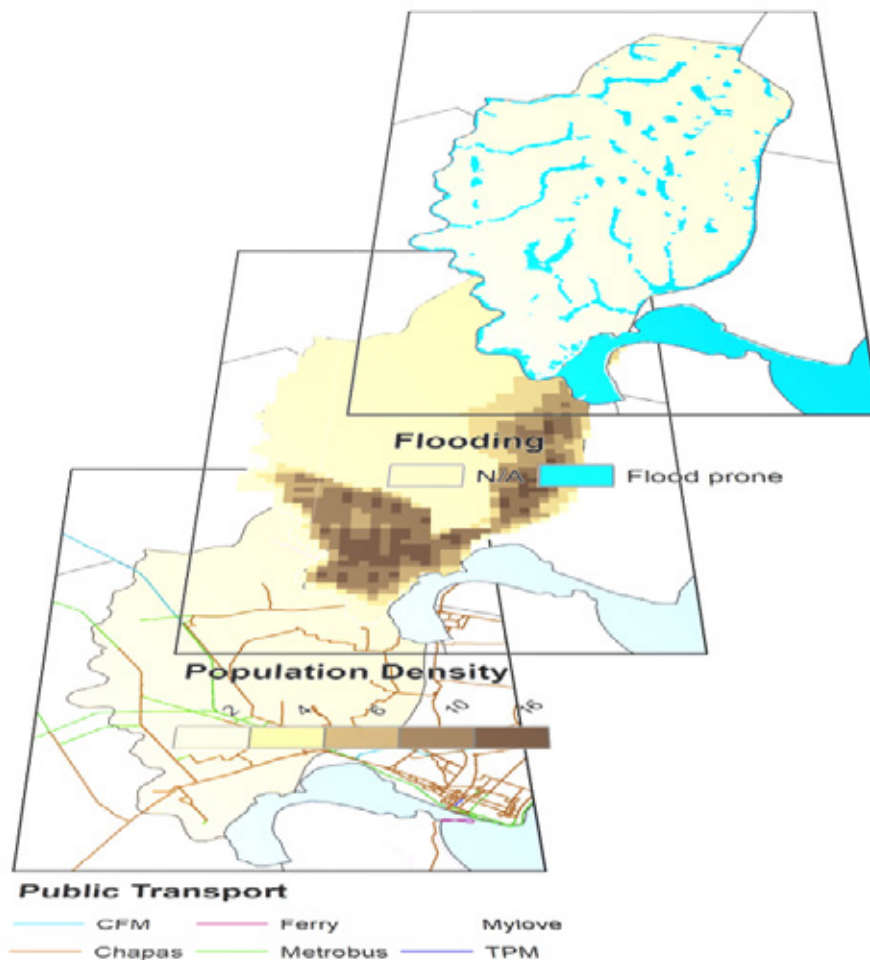
Source: Original figure produced for this publication.

## Geospatial Analysis to Support Evidence-Based Decisions

The overall objective of this study is to identify areas in the transport network for investments to ensure climate resilience in Matola. In particular, this study aims to answer the following questions: “How does flooding impact urban mobility and accessibility in Matola?” and “Who is impacted the most?” In order to achieve this goal,

this study utilized a geospatial network analysis based on the location of EOs, public transport network, and flooding (**figure 2**). The method is rooted in geospatial analysis, the concept of accessibility and the use of a networkwide approach to evaluate accessibility to EOs, their impacts of flooding, and poverty reduction.

Figure 2. Geospatial Analysis Diagram of Matola



Source: Original figure produced for this publication.

### ACCESSIBILITY TO JOBS

The study analysis uses data on EOs generated through a methodology developed by the World Bank Group's Urban team that combines open source and other inputs. The accessibility analysis calculates the travel time to each of the EOs in the GMA. Accessibility is then measured as the ability to reach the EOs in 60 minutes travel time.

### CLIMATE RESILIENCE

The analysis views the access to EOs through a climate resilience lens and uses flood maps and problematic areas identified throughout Matola to assess the impact of floods on access to employment. In addition, the analysis determines which roads

would be impassable during flood events and calculates the losses in accessibility, by estimating how many EOs would become inaccessible to the residents of Matola due to flooding.

### POVERTY REDUCTION

The study analysis uses data on poverty to assess the level of poverty of areas most affected by flooding, and identifies interventions that would directly benefit the poorest and most vulnerable communities in Matola. Poverty is measured by a poverty score dataset and defined as a value ranging from 3 to 5, with 3 ranked as the poorest (see **table 1**).

**Table 1.** Data Inputs and Sources for Assessing Poverty Levels in Flood-Affected Areas in Matola

Data inputs	Source
Population	WorldPop United Nations estimates (2015) at 100 meter resolution ( <a href="https://www.worldpop.org">https://www.worldpop.org</a> )
Employment Opportunities	Avner et al. (forthcoming) <sup>a</sup>
Poverty	Poverty score <sup>b</sup>
Transport Network	OpenStreetMaps ( <a href="https://www.openstreetmap.org">https://www.openstreetmap.org</a> ) and General Transit Feed Specification (GTFS) for public transport ( <a href="https://gtfs.org/">https://gtfs.org/</a> )
Floods	Problematic areas collected under World Bank's Matola Climate Resilience Technical Assistance (2015) <sup>c</sup>

**Source:** Various, as noted.

Note: a. Avner, Paolo, Tatiana Peralta Quirós, Bharat Singh, and Chiara Ghiringhelli. Forthcoming. "Rapid Appraisal Methodology to Determine Employment Opportunity Areas in African Cities — Case Study: Kampala, Dakar & Nairobi." Policy Research Working Paper, The World Bank, Washington, DC. b. Poverty score taken from: Gallego-Ayala, Jordi Jose, Michele Davide Zini, Mohamed Ihsan Ajwad, Eric L. Zapatero, Fnu Zainab, and Peter Beck. 2017. "[Urban Safety Nets and Activation in Mozambique](#)." Working Paper, The World Bank, Washington, DC. c. TA prepared under the Drainage Master Plan of Maputo Metropolitan Area, financed by the [Mozambique Cities and Climate Change Project](#) (P123201).

## ACCESSIBILITY TO EMPLOYMENT OPPORTUNITIES

Matola is highly disconnected from EOs in the larger urban area. Only 19 percent of Matola's population can reach more than 50 percent of the EOs in the GMA. Some areas in Matola are isolated; approximately 26 percent of the population can access only 10 percent of the EOs within a one-hour commute via public transport (see **table 2**).

Public transport plays a critical role in bringing people in Matola to EOs. In the absence of public transport, only 9 percent of Matola could reach at least 10 percent of EOs in Greater Maputo.

However, as shown in **table 3** and **figure 3**, many people still need to walk long distances even when using public transport options to reach EOs. Approximately two-thirds of the Matola population walks an average of more than 20 minutes to reach EOs.

**Table 2.** Percent of Matola Population and Employment Opportunities Access within a One-Hour Commute

EOs accessible within 1 hour (%)	Total population	Matola population (%)
0 to 10	332,557	25.4
10 to 30	353,923	27.0
30 to 50	372,853	28.4
50 to 70	246,091	18.8
More than 70	6,251	0.5

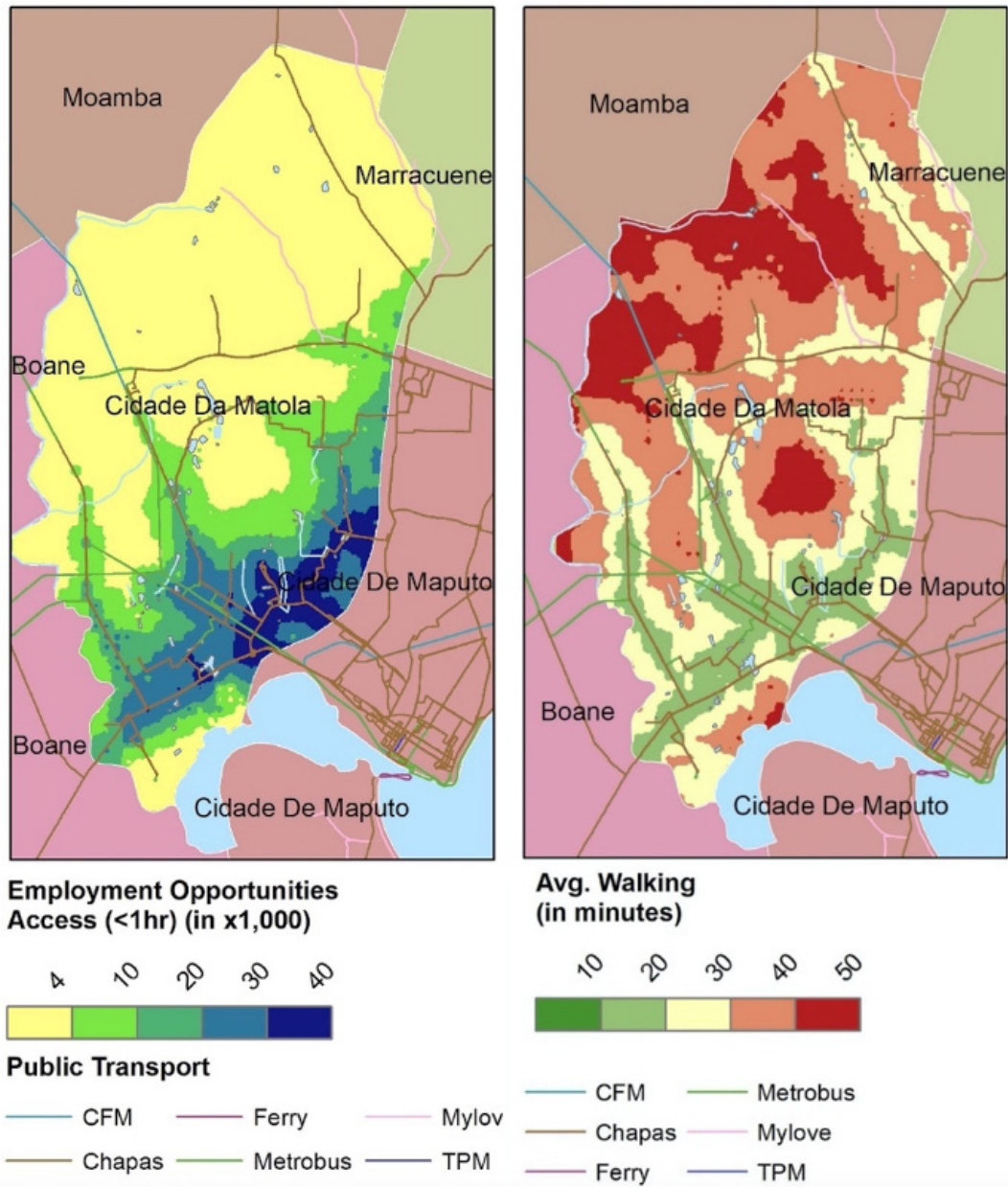
Source: Original calculations produced for this publication.

**Table 3.** Walking Time Needed to Reach Employment Opportunities in Matola

Walking time (minutes)	Total population	Matola population (%)
0 to 10	8,547	0.7
10 to 20	455,162	34.7
20 to 30	527,440	40.2
30 to 40	265,349	20.2
More than 40	55,177	4.2

Source: Original calculations produced for this publication.

Figure 3. Access to Employment Opportunities in Matola by Public Transport and Average Walking Time



Source: Original figure produced for this publication.

In Matola, poverty is highly correlated with accessibility to employment (table 4). More than 40 percent of the poorest can access less than 10 percent of EOs, while 75 percent of higher income people can reach at least 30 percent of EOs. Poverty is defined through the poverty score: 3.7 to 4.4 (higher poverty), 4.4 to 5 (medium poverty)

and 5 to 5.7 (lower poverty). While overall dependence on public transport exists across all poverty levels, poverty is slightly correlated with dependence on walking to access opportunity. The study defines high dependence on walking as the ability to access 50 percent of the EOs by walking only. About 12 percent of the poorest

depend on walking only to access most of their EOs, 7 percent for middle income, and less than 1 percent of high income.

### IMPACTS OF FLOODING ON ACCESSIBILITY

As shown in **table 5**, during the severe rainy season, employment opportunity access (EOA) is significantly challenged in Matola due to disruption of roads. The disruption is caused by degraded surface road conditions

and poorly engineered drainage systems resulting in localized urban flooding that challenges driving speeds and, in some cases, renders some roads impassable. The study analysis reveals most of the population will experience some reduction in accessibility to EOs. Impacts due to flooding are often localized; in some areas, approximately 10 percent of the population lose nearly all access to EOs, with a drop of 50 percent or more.

**Table 4.** Links between Poverty Level and Access to Employment Opportunities in Matola

Poverty	Pop. with EOs <10%	Income group (%)	Pop. with EOs >50%	Income group (%)	Pop. with high dependence on walking	Income group (%)
Higher	190,186	43	60,266	14	51,501	12
Medium	134,227	18	160,461	22	48,402	7
Lower	8,142	6	31,614	23	—	<1

Source: Original figure produced for this publication.

**Table 5.** Reduction of Employment Opportunity Access in Matola Due to Flooding Disruptions

Reduction in EOA (%)	Total population	Matola population (%)
0 to 10	866,292	66.0
10 to 20	110,986	8.5
20 to 50	160,383	12.2
50 to 70	43,161	3.3
More than 70	80,094	6.1

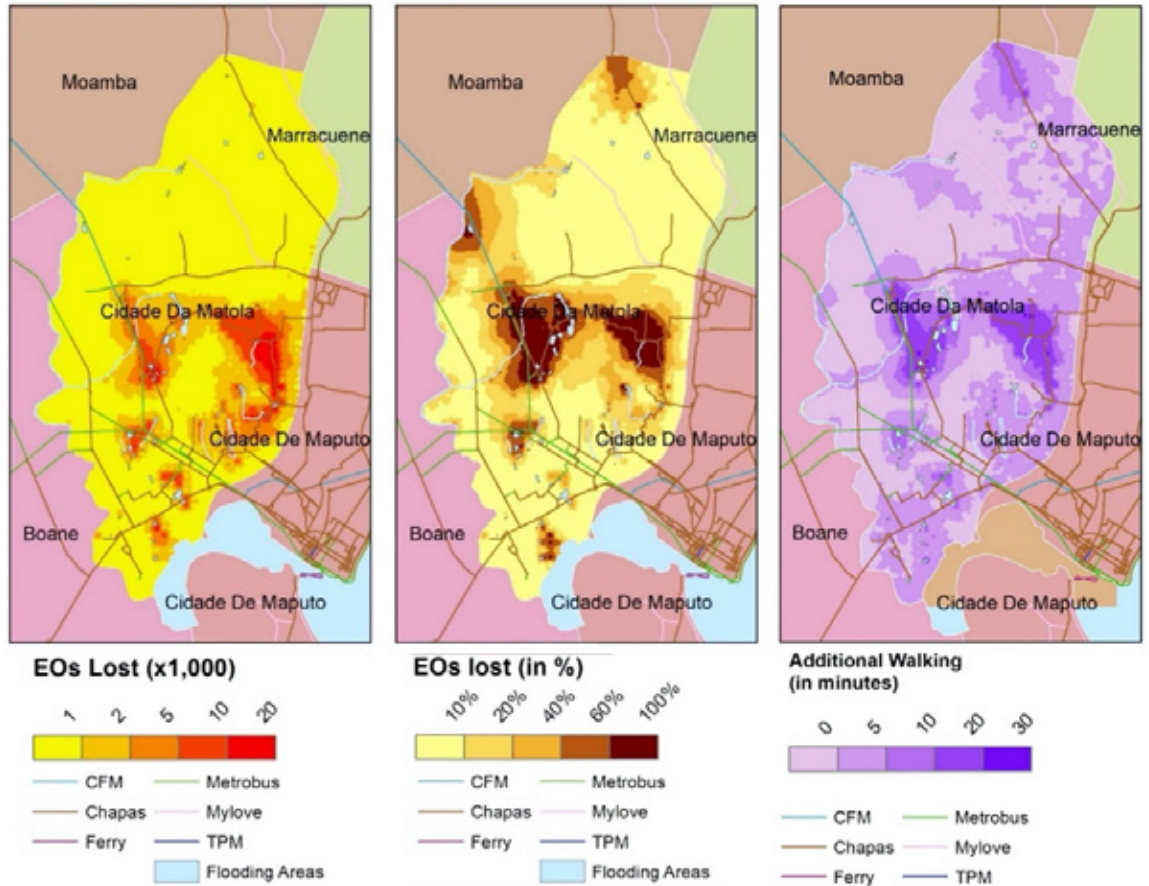
Source: Original figure produced for this publication.

**Table 6.** Flooding Impacts on Employment Opportunity Access, by Poverty Level

Poverty	Total of EOs lost	Total EOs lost (%)	People with high dependence on walking	Income group (%)
Higher	613,986	35	80508.15	18
Medium	1,079,768	62	133186.7	18
Lower	50,251	3	0	<1

Source: Original figure produced for this publication.

**Figure 4.** Loss of Employment Opportunities Access and Additional Walking Time Due to Flooding in Matola



Source: Original figure produced for this publication.

As illustrated in **figure 4**, while Matola residents largely depend on the EOs available in Maputo (with 60 percent of accessible EOs located in Maputo proper), when the GMA floods, this reliance is inverted, with 50 percent of the EOs accessible in Matola itself, which indicates flooding mainly disrupts trips to places of employment outside of Matola. Additionally, flooding causes a slight increase in walking, with about 15 percent of people in Matola walking an additional 10 minutes to reach their accessible EOs.

Interestingly, flood impacts on accessibility affect mainly the mid-poverty level residents in Matola (**table 6**), who experience more than 60 percent of all flooding-related EOs losses. In contrast, the higher income residents experience the lowest impact of flooding, with only 3 percent of all lost EOs. Flooding forces the poorest to rely even more on walking to access EOs; for the poorest residents, flooding increases walking from 12 percent, as shown in **table 4**, to 18 percent in **table 6**. Conversely, flooding does not affect the reliance on walking — which is already close to zero — for the higher income levels.



## Discussion Points

### **Accessibility to employment is low for Matola residents relying on public transport and long walking distances.**

On average, a person in Matola can reach only 1 out of 3 EOs within a one-hour travel time in the GMA. A person's ability to access employment relies heavily on public transport (mainly "poda-podas," or informal minibuses) and requires walking long distances, on average 25 minutes of walking out of the one-hour trip. In fact, without the presence of public transport, accessibility drops significantly, with only 1 out of 25 EOs accessible in that same one-hour trip.

### **Accessibility is lowest for the area's poorest, who also benefit less from the supply of public transport.**

Poverty in Matola appears to correlate with accessibility to employment. Nearly 60 percent (57 percent) of low-access communities, defined as people able to reach less than 10 percent of EOs in a one-hour trip, have a high poverty score, while only 2.5 percent of the lowest poverty level are in that category. While dependence on public transport exists across all poverty levels, poverty is closely linked with walking to access opportunity. Approximately 12 percent of the poorest communities reach most EOs by walking only, while this number drops to 3 percent for middle income, and less than 1 percent of lower poverty communities.

### **Flooding has significant impacts on accessibility to employment, affecting the poorest and the mid-income**

**residents the most.** During the severe rainy season, accessibility to employment in Matola is significantly challenged due to the poor road surface conditions and poorly engineered drainage systems, which cause localized urban flooding that reduce driving speeds and, in some cases, make roads completely impassable. The study analysis reveals most of the population will experience some reduction in accessibility to EOs, with an individual Matola resident losing, on average, 13 percent of EOs due to flooding. Localized impacts in some areas can result in about 10 percent of the population losing most of its access to EOs, with a loss of more than 50 percent. Additionally, flooding forces people to walk slightly more, with about 15 percent of people in Matola walking an additional 10 minutes to reach their accessible EOs.

### **Flooding accentuates the dependence on walking for the poorest in Matola.**

Interestingly, flood impacts on accessibility affects mainly the medium-poverty level residents in Matola, with almost 62 percent of all EOs losses, while representing 56 percent of the population. The higher income residents would experience the lower impact of flooding, experiencing only 3 percent of all lost EOs. Flooding also forces the poorest communities to rely on walking even more to access EOs, increasing the EOs accessible by walking only from 12 to 18 percent. In contrast, flooding does not affect the already insignificant dependence on walking for those with higher incomes.



---

**Authors:** Felipe Targa,  
Juan Pablo Orjuela and  
Daniel Gil Sánchez,  
**The World Bank**

# Quantifying the Health Co-Benefits of Active Mobility: Developing Tools for Health Impact Assessments of Transport Choices in Five Latin American Cities



## COVID-19 has inspired renewed interest in promoting nonmotorized transport around the world, and Latin America is no exception.

As part of a recent research collaboration with the University of Cambridge and the University of Oxford in the United Kingdom, the World Bank is developing tools to evaluate health impacts of nonmotorized transport policies in Latin American cities. Using a prototype of the tool, the World Bank team evaluated the impacts of promoting different transport modes in five different cities and calculated the expected change in premature deaths through the combination of three main variables: air pollution exposure, traffic injuries, and health benefits from physical activity. The results show how the case-study cities could avoid around 10 premature deaths per 100,000 inhabitants every year by increasing walking and cycling

mode shares to 30 percent and 6 percent respectively.

Worryingly, however, the increase in use of motorized transport, particularly motorcycles, could lead to an increase of 10 premature deaths per 100,000 inhabitants every year in Bogota, and more than 50 in Mexico City and Santiago. COVID-19 has inspired renewed interest in promoting nonmotorized transport around the world, and Latin America is no exception. With this tool, policy makers will be able to estimate the health impacts of their urban mobility plans and use the resulting data in cost-benefit analyses and to garner political support for greater active mobility.

---

### About the Authors



*Felipe Targa* is a Senior Urban Transport Specialist working at the World Bank.



*Juan Pablo Orjuela* is an Urban Transport Consultant for the World Bank.



*Daniel Gil Sánchez* is a Transport Consultant for the World Bank.

## Introduction

Urban transport can play a key role in promoting healthier cities. Both obesity and sedentarism are on the rise around the world, and switching to active modes of transport could be part of the solution to this global health crisis. Yet promoting healthier transport alternatives in urban environments will require more than simply advertising the benefits of walking and cycling. Solutions must derive from interdisciplinary and holistic planning that considers the connectivity of the entire urban transport system, and acknowledges significant aspects such as employment locations, behavior change drivers, and environmental stressors (for example, air pollution).

Encouraging physical activity through transport is probably one of the most cost-effective tools transport authorities and planners have available to promote health. Evidence of the health benefits of physical activity is clear and abundant: increased physical activity levels among the general population can bring substantial improvements in cardiovascular and mental health, among other benefits.

Yet promoting active transport in today's cities is not without its challenges. Air pollution, for example, could be seen as a threat to cyclists' health. Studies focused on emission reductions tend to ignore how a modal shift from motorized transport to active transport not only implies less emissions per trip, but quite probably a decrease in personal exposure to air pollution.

Instead, most studies claim that cyclists and pedestrians have higher inhaled doses of air pollutants than vehicle users. Traffic injuries are also cited as an important threat, as cyclist and pedestrians are particularly vulnerable actors when adequate infrastructure is not provided.



This article summarizes the literature on some of these issues and presents the results of recent research done by the World Bank in collaboration with the University of Cambridge and the University of Oxford. As part of this collaboration, the World Bank team is currently developing tools to

evaluate the health impacts of nonmotorized transport policies in Latin American cities. The team evaluated the impacts of promoting different transport modes in five case study cities, namely Bogota, Cali, Medellin, Santiago de Chile, and Mexico City. With the tools being developed, the team calculated the expected change in premature deaths through the combination of three main variables: air pollution exposure, traffic injuries, and health benefits from physical activity. In Bogota the team performed an in-depth study to further understanding of how these tools can be used in future policy analysis. Using both the literature review and the city analysis, the team provides some recommendations for the promotion of healthy transport alternatives in Latin American cities moving forward. This article aims to guide Bank staff and client decision makers by presenting an overview of the literature available on this topic, the main challenges to creating healthier cities through transport alternatives, and some key points to keep in mind when developing projects with the aim of improving urban livelihoods.

The COVID-19 pandemic has inspired renewed interest in promoting nonmotorized transport around the world, and Latin America is no exception. With this tool, policy makers will be able to estimate the health impacts of their plans and use the resulting data in cost-benefit analyses and to garner political support for greater active mobility.



## Synthesis of Key Literature

### THE HEALTH BENEFITS OF PHYSICAL ACTIVITY

The health benefits of promoting physical activity are difficult to overstate. [A systematic review of the literature, as presented by Reiner and others in 2013](#), shows a positive influence of physical activity on weight gain, obesity, coronary heart disease, type 2 diabetes, Alzheimer's, and dementia. By summarizing 15 longitudinal studies with at least a five-year follow up, the study team can conclude an increase in physical activity has a positive long-term effect on all selected diseases. This list of diseases is particularly important when seen in a global context. Among the [top 10 global causes of death listed by the World Health Organization \(WHO\) for 2016](#), coronary heart disease occupied first place, with

more than 9 million people dying prematurely that year. Alzheimer's and dementia occupied fifth place, and type 2 diabetes seventh place. Together, these diseases accounted for 13 million deaths, or more than 1 in 5 deaths worldwide. However, not all these deaths are preventable by promoting physical activity. A healthy diet, lower air pollution levels, higher exposure to green spaces, and other factors are also necessary. Yet getting people to be more physically active will help tackle these health challenges.

A common misconception is that in order to achieve the greater health benefits of physical activity, people must follow a vigorous or moderate-intensity routine for long periods of time, and this has downplayed the role active transport can have in the promotion of healthier cities. Meanwhile, WHO's recommended levels of physical activity can easily be achieved by daily commuters. For adults ages 18 to 64, for example, the WHO suggests at least 150 minutes of moderate-intensity (or 75 minutes of vigorous-intensity) aerobic physical activity throughout the week in bouts of at least 10 minutes' duration. These 150 minutes could be achieved, for example, by 15-minute active commutes twice a day, five days a week. Moreover, incorporating active mobility into commuting routines does not require extra time or money to go to a gym or sports facility.

**A common misconception is that in order to achieve the greater health benefits of physical activity, people must follow a vigorous or moderate-intensity routine for long periods of time, and this has downplayed the role active transport can have in the promotion of healthier cities.**

## HEALTH IMPACTS OF AIR POLLUTION EXPOSURE

According to a 2018 WHO fact sheet, [ambient air pollution causes 4.2 million deaths every year](#). The use of fossil fuels in the transport sector has been ubiquitous for half a century now, contributing significantly and consistently through the years to overall emissions in cities around the globe. These energy sources have brought with them exhaust emissions, including toxic substances, which then mix in the atmosphere and contribute to the overall poor air quality that has been affecting citizens for years. While the proportion and nature of these substances have changed, without serious disruptions in the way mobility in cities works transport emissions will continue to play a key role in the poor air quality of urban settlements.

Today, particulate matter (PM) is one of the most widely studied and discussed air pollutants. A mix of solid and liquid-state substances combine to form different sorts of particulates with varying compositions depending on sources and meteorological conditions, among other factors. PM has been traditionally categorized by size, with most environmental authorities reporting on the concentration (mass per unit volume) of PM of 10 microns or less in diameter (PM<sub>10</sub>) and of 2.5 microns or less (PM<sub>2.5</sub>).

Some of the most relevant reviews of long-term exposure to air pollution have been made by the Committee on the Medical Effects of Air Pollutants of the United Kingdom (COMEAP). [In a 2009 report, the committee presents compelling evidence](#) associating an increase in 10 micrograms per cubic meter (µg/m<sup>3</sup>) of long-term

## According to a 2018 WHO fact sheet, ambient air pollution causes 4.2 million deaths every year.

exposure to PM<sub>2.5</sub> with all-cause, cardio-pulmonary, and lung cancer mortality. Similarly, in later reports, the committee also shows [evidence associating morbidity cases of chronic bronchitis](#) (2016) and [cardiovascular diseases](#) (2018) with long-term exposure to PM<sub>2.5</sub>. Poor health associations with short-term exposure to PM<sub>2.5</sub> are typically lower, as shown in a [2015 systematic review done by Shah and others](#) on the short-term impacts of air pollution on strokes. In addition, transport emissions play an important role in the adverse health effects of air pollution. A [2019 study done by Achakulwisut and others](#) estimated approximately 4 million new pediatric asthma cases each year could be linked to long-term exposure to transport-related air pollutants, with Latin America as a region and its capitals (particularly Lima and Bogota) showing the greatest impact in a city-by-city analysis.

Emissions have received a lot of attention from transport experts and policy makers, but air pollution exposure while in transport has taken longer to become part of the policy and technical debate. Despite exposure being widely discussed in environmental and epidemiological forums, this has not transformed into actual policies and actions intended to reduce exposure or intake of air pollutants. When *emissions* from different sources mix in the atmosphere,

ambient air pollutant concentrations can be measured with air quality measurement systems. Such measurements form the basis for most epidemiological studies and air quality national standards. However, people are rarely exposed to consistent *concentrations*. People move around — they can be indoors, outdoors, travelling, close or far from air pollution sources — and thus, even within less than 100 meters, concentrations could vary greatly. Personal *exposure* refers to the air quality in an individual's personal cloud of air. Depending on things such as physical activity, people's breathing rates will change, as will the amount of pollutants people are actually breathing in. The amount of pollutants breathed in is normally referred in the literature as *inhaled doses*.

Transport plays an important part in people's exposure and inhaled doses of air pollutants. One of the variables to have in mind, then, is the transport mode being used. As shown in a [2017 systematic quantitative review done by de Nazelle, Bode, and Orjuela](#), measurements in Europe show important differences between transport modes. For example, pedestrians have lower PM<sub>2.5</sub> exposure than cyclists, while both have greater exposure than people not in transport. This means that while important exposure differences between transport modes exist, exposure in transport tends to be higher than when not in transport, regardless of the mode.

### WHAT HAPPENS WHEN WE COMBINE AIR POLLUTION AND PHYSICAL ACTIVITY?

Promoting active transport can increase levels of physical activity and therefore promote healthier populations. It will also reduce air pollution emissions from motorized transport, helping reduce ambient air concentrations, which will, in turn benefit all citizens. However, considering personal exposure to air pollutants adds negative effects to the equation. Should cities still promote active transport when ambient concentrations are upsettingly high? In one word: yes. Even in cities with relatively high background concentrations, promoting active transport seems to bring health benefits.

In 2015, Tainio and others published a paper trying to determine the strength of these forces (benefits of physical activity vs. negative impacts of air pollution) in urban settings around the world. The paper, provocatively titled, "[Can Air Pollution Negate the Health Benefits of Cycling and Walking?](#)" shows, for most considered scenarios, physical activity would have to extend across very long periods of time in order for air pollution to counteract its benefits. The authors present an example of a city with a background concentration set at a medium level of 50µg/m<sup>3</sup> of PM<sub>2.5</sub>. Here, citizens would continue to benefit from physical activity way beyond an hour. In fact, a cyclist would have to cycle for more than 300 minutes a day to see higher health risks than benefits. In the same year, Mueller and others conducted a [systematic review of the health effects of active transport](#) that confirmed these trends.



## Methods

In order to explore the health impacts of transport choice in Latin America, the study team used the methodological framework of the TIGTHAT (Towards an Integrated Global Transport and Health Assessment Tool) project proposed by a team of researchers at the MRC Epidemiology Unit at the University of Cambridge. In a nutshell, TIGTHAT uses the Integrated Transport and Health Impact Modelling Tool (ITHIM) to perform a [health impact assessment combining three variables linking transport and health](#): air pollution inhalation, physical activity, and traffic-related injuries, according to a 2009 study by Woodcock and others. This section briefly presents the TIGTHAT methodological framework, and then presents the methods followed in the study.

ITHIM is a tool developed to do a comparative risk assessment to estimate the health benefits of various transport modes. Although updated through the years, the main methods to estimate health impacts remain essentially the same. TIGTHAT is a project that aims to create a methodology for applying the ITHIM model in low- and middle-income countries, considering data availability restrictions.

Using data from origin-destination (OD) surveys, in combination with physical activity data, traffic injury data, and air quality data for both emissions and concentrations, the model sets a baseline for the three main variables to consider

in the analysis. When the modal split is altered by creating various scenarios (as detailed below), it is possible to estimate the relative changes. For physical activity, distances are first calculated using time of trip and average mode speed, and then a change in physical activity is obtained by using metabolic equivalents of task (METs) differentiated by mode, age group, and sex. For air quality data, changes in mode will imply changes in three main variables: (1) a change in mode results in a change of the emission factor from which total emissions can be calculated using trip distance; (2) ambient air pollution will be slightly affected depending on the contribution of various sources, which is estimated from local air quality network data and existing estimates of citywide emission inventories; and, (3) mode changes will imply changes in inhaled doses of pollutants due to changes in exposure and inhalation rates. Finally, using local data from traffic injuries, a stochastic model estimates the probability of a traffic injury as a function of the transport mode used. For example, when a 20-minute car trip of a 26-year-old female is changed to a cycling trip, we see an increase in the woman's physical activity levels that depends on the length of her trip, her age, and sex. Given that she is not using her car for that trip, those emissions are subtracted from emission inventories and their impact on ambient air can be calculated, as well as her new exposure to air pollution and increased inhaled doses. The probability of being in

a traffic injury will now change from one associated to women in her age group using a car, to one associated to women in her age group using a bicycle. This entire process can then be repeated for all trips in the OD survey.

Premature deaths from air pollution and physical activity are estimated using the [Institute for Health Metrics and Evaluation \(IHME\) global burden of disease database](#) for 2017 and local data for both current physical activity and air quality levels.

**Table 1.** Trip Proportions Defined for Each Scenario in the Cross-Sectional Study According to Trip Distance Categories

Scenarios	Distance category		
	Less than 2 km	2 ≤ x < 6 km	6 km or more
Walking	94.2%	20.6%	1.8%
Cycling	4.9%	12.2%	2.2%
Car	5.6%	47.1%	30.5%
Motorcycle	4.6%	27.7%	20.7%
Public transport	1.6%	39.9%	58.3%

**Source:** Original calculations produced for this publication.

## Scenario Development

As mentioned in the introduction, the study team’s work is divided into a cross-sectional study of five cities in Latin America and an in-depth study in Bogota to illustrate the use of our methods.

Rather than basing the cross-sectional study scenarios on hypothetical constructions of changes in modal split, the study uses a comparative approach in which new modal splits are created based on trip proportions in other cities. This allows the team to generate a total of five somewhat more realistic scenarios better aligned with regional trends. Each scenario prioritized a different transport mode: (1) walking, (2) cycling, (3) private car, (4) motorcycle, and

(5) public transport. First, all trips in the OD surveys were broken into three categories based on their estimated distances: 0–2 km, 2–6 km, and 6 or more km. Then, a modal split for these three categories was calculated for all cities. The “walking” scenario was then created by finding the city with the greatest proportion of walking trips in each distance category and assigning these to all the cities. The remaining trips were distributed between the rest of the modes in proportion to current city levels. This process was then repeated for all other modes. **Table 1** presents the resulting trip proportions in each distance category for the five scenarios.

For Bogota, the team created six different scenarios of modal split, as agreed with the local mobility authority. These scenarios were defined as follows:

1. **Gender parity in cycling (gender).** Current levels of cycling in Bogota show that men are more likely to use a cycle than women. The team created a scenario in which a higher number of women would cycle in order to reach a 50 percent of cycling trips without altering the number of cycling trips done by men.
2. **Equal socioeconomic distribution in cycling trips (SES).** Current levels of cycling in Bogota show people who live in areas classified as the second-lowest socioeconomic stratum, or SES, are more likely to cycle than any other of the six levels defined in the city urban planning strata. Thus, this scenario indicates people living in all other strata would cycle as much as current stratum 2 levels.
3. **Double cycling trips from car users (cycling X2, car).** Here, the team doubled cycling trips, with all new trips involving people who were previously using a private car.
4. **Double cycling trips from car and motorcycle users (cycling X2, car and m.cycle).** In this scenario, the team doubled cycling trips, with all new trips involving people who were previously using a private car or private motorcycle.
5. **Double cycling trips from public transport (cycling X2, PubTransport).** For this scenario, the team doubled cycling trips, with all new trips involving people who were previously using public transport.
6. **Double cycling trips from all modes (cycling X2, all).** The team doubled cycling trips in this scenario, with new trips coming from a combination of all other modes.



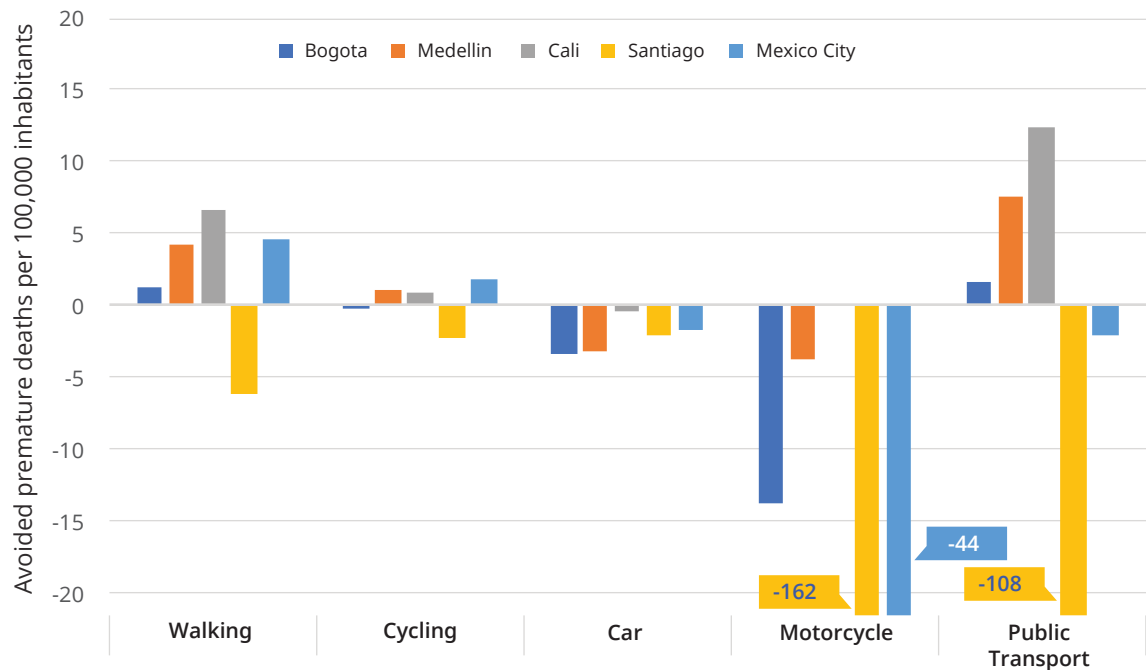
## Results

**Figure 1** presents results from the cross-sectional study. Note the y-axis is the number of premature deaths avoided per 100,000 inhabitants, as cities vary greatly in size. Also note that in the motorcycle and public transport scenarios, the results from Santiago and Mexico City extend way beyond the y-axis scale. The scale has been shortened to show the details of the other scenarios, but it is important to observe the disproportionate number of premature deaths, mainly due to very large number of injuries associated with motorcycle trips in these two cities. In addition, the figure does not show any avoided deaths in Bogota for

the cycling scenario since this city currently claims the largest proportion of cycling trips and thus this scenario represents no change from the baseline.

Avoided premature deaths are only achieved in the scenarios prioritizing walking, cycling, and public transport. In contrast, the prioritization of private cars and motorcycles results in additional premature deaths in all cities. According to the study results, traffic injuries in Santiago present a significant threat to sustainable transport as no premature deaths were avoided in any of the created scenarios.

**Figure 1.** Avoided Premature Deaths per Year per 100,000 Inhabitants for Different Transport Mode Scenarios in the Cross-Sectional Study

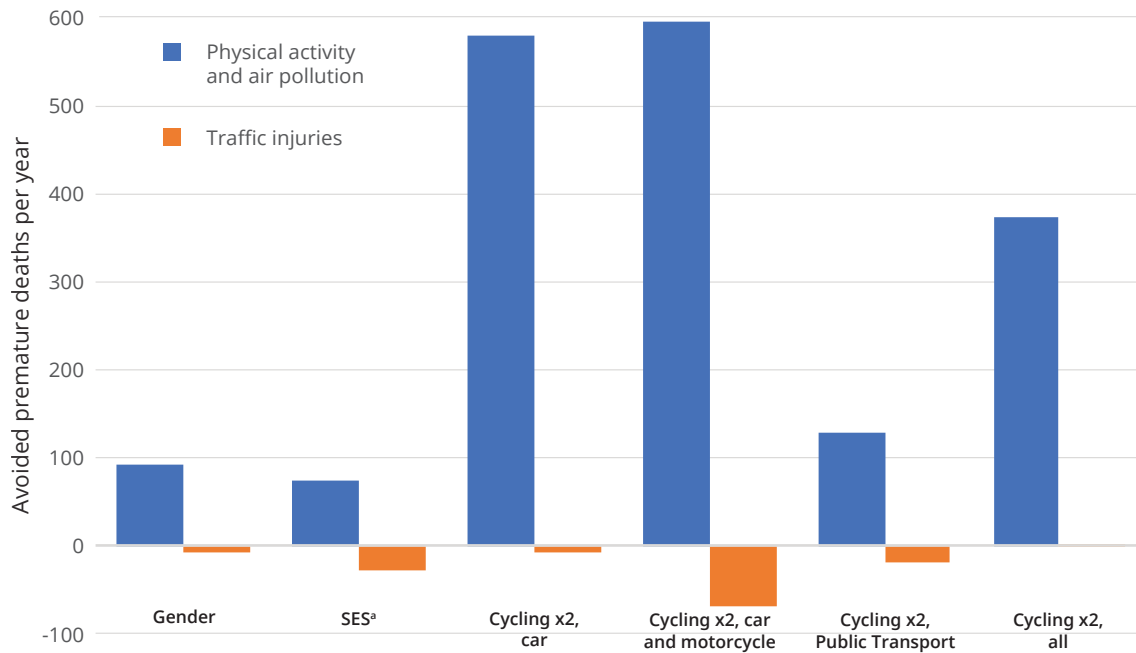


Source: Original figure produced for this publication.

**Figure 2** shows the total changes in premature deaths from all six scenarios in the in-depth study of Bogota. The blue bars represent avoided premature deaths due to changes in air pollution and physical activity, and the orange bars represent additional deaths from increased traffic-related

fatalities. In all cases more premature deaths are avoided from air pollution and physical activity than the additional traffic incident fatalities. This is not to say that road safety is not an issue, as every fatality in traffic has immeasurable social and economic implications.

**Figure 2.** Avoided Premature Deaths per Year for Different Scenarios in Bogota



**Source:** Original figure produced for this publication.

**Note:** a. SES = socioeconomic stratum

## Discussion for Policy Makers

The results of the cross-sectional study indicate how the case-study cities could avoid around 5 premature deaths per 100,000 inhabitants every year by increasing walking and cycling trip shares to 30 percent and 6 percent respectively. Worryingly, however, the increase in use of motorized transport, particularly motorcycles, could lead to an increase of 10 premature deaths per 100,000 inhabitants every year in Bogota, and more than 50 in Mexico City and Santiago. Promoting public transport could also lead to avoided premature deaths, mainly because it incentivizes some physical activity, in the walk to and from public transport stations among age groups with lower baseline levels of physical activity. However, road safety is a main threat to sustainable transport in all case-study cities and in particular in Santiago de Chile, where no premature deaths were avoided in any of the modeled scenarios.

The in-depth study of Bogota illustrates how doubling cycle trips in that city could result in avoiding between 130 (if all new trips come from public transport) and 600 (if all new

trips come from motorized private vehicles) premature deaths every year. Given that the COVID-19 pandemic has renewed interest in promoting nonmotorized transport around the world, including in Latin America, these goals do not seem unreachable and would constitute a great step forward in decarbonizing transport systems in the region. A challenge identified for city officials consists of how to maximize these results by inducing a shift of trips away from private vehicles or and public transport only.

This article has outlined an in-depth study of Bogota to demonstrate how these tools could be used to estimate avoided premature deaths due to the promotion of active transport. With these tools, policy makers will be able to estimate the health impacts of their plans. Although the cross-sectional study is limited in terms of scenario ambitions, it helps to illustrate how the current trend of private motorized transport in the region would lead to additional annual deaths that could be avoided by promoting cycling and walking to levels already present in other cities in the region.

## Policy Recommendations

1. **Promote health impact assessments in low- and middle-income countries (LMICs).** As mentioned before, most of the research comparing air pollution exposures, injuries, and health benefits of physical activity has been done in high-income countries that have access to more detailed data. The tools presented here should help LMICs to

incorporate health impact assessments into cost-benefit analyses that offer a more complete picture of the benefits of active travel. However, many cities in the LMICs will need to make greater efforts to collect reliable data on their travel patterns and traffic injuries, as even the level of data used for this project may represent a burden.

2. **Facilitate the development of health impact assessments in LMICs.**

Considering most of the research on health benefits, air pollution, and active mobility is happening in high-income countries, efforts to support nonmotorized transport in LMICs should focus on building local capacities to develop health impact assessments, with a special consideration for local challenges related to data recollection, processing, and analysis. The tools presented in this article could be used by Bank staff and client policy makers and planners in the preparation of cost-benefit analyses to monetize the health benefits of active mobility. For instance, in 2020, health benefits calculated in the [Social Cost-Benefit Analysis for the World Bank–developed Bicycle Infrastructure Plan in Lima, Peru](#), made up a large portion of the savings related to the implementation of the plan, which featured a staggering benefit-cost ratio of 19.

3. **Promote active travel.** The available research confirms the health benefits of active travel outweigh the potential negative effects. Thus, policy makers and planners should promote active mobility in order to make the benefits of physical activity available to most of the population and to support healthier urban livelihoods. Active mobility should be a key element of the Bank agenda for decarbonizing transport systems, with stakeholders engaging national and subnational governments to support audacious and impactful measures that effectively increase walking and cycling among the population.

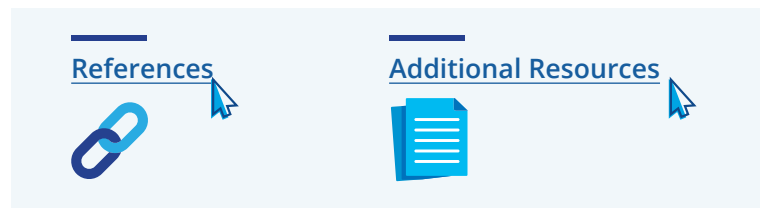
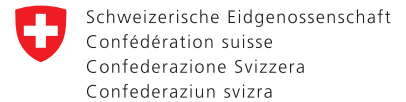
## The available research confirms the health benefits of active travel outweigh the potential negative effects.

4. **Support building infrastructure to make active travel safe, accessible, and attractive.** The fact that the benefits of physical activity are greater than its potential risks does not mean in any way additional measures to protect pedestrians and cyclists should not be taken. As shown here, cyclists have higher daily inhaled doses of pollutants than all other modes, despite cycling itself being zero emission. In order for societies and individuals to reap the health benefits of active travel, policy makers should focus on investing in quality infrastructure for safe walking and cycling. For example, planning tools such as the Level of Traffic Stress could indicate changes in infrastructure that need to be included at the street level in order to attract users interested in cycling more, but who are not concerned about road safety. In addition to road safety, active mobility networks should feature other elements such as greenery, lighting, and shade, which make active travel more attractive and increase the place function of streets. Furthermore, policy makers should consider rebalancing public space by reducing the area devoted to private motorized transport (responsible for numerous negative externalities) and reclaiming it for the most sustainable, healthy, and equitable, yet vulnerable, transport modes.

## Acknowledgments

The authors would like to thank all the people in the case-study cities who by sharing their most up-to-date data made this study possible. These include people at mobility and environmental authorities, universities, and the World Bank staff in the analyzed countries. We would also like to thank Dr. James Woodcock and his team at the University of Cambridge for their help in the execution of the tools used in TIGTHAT and for making us feel part of the team. This project was funded under the Mobility and Logistics (MOLO) Trust Fund. The MOLO is funded by the Austrian Ministry of Finance, German Ministry for Development Cooperation (BMZ), and Swiss Ministry of Economic Affairs (SECO).

This report has been cofunded by the Mobility and Logistics Multidonor Trust Fund (MOLO), managed by the World Bank Group and supported by the Governments of Switzerland (SECO), Germany (BMZ), Austria (BMF), and Poland (Ministry of Climate).









---

**Authors:** Said Dahdah,  
Hasan Afzal Zaidi, and  
John H. Winner,  
**The World Bank**

# Changing Transport in Pakistan

**A**s Pakistan's largest city, Karachi serves as a major industrial hub and home to two major seaports, Karachi Port (KPT) and Port Qasim (PQA), which together handle almost all of Pakistan's overseas trade by volume. Accordingly, continued economic growth in Pakistan depends upon increased freight movements to and from these ports along with improvements to the surface transport infrastructure.

Against this background, and the policy objective of significantly increasing the volume of port traffic moving by rail, this World Bank study analyzes the capacity of the existing network, including arrangements at port terminal

facilities for receiving and dispatching services and the capacity of the line itself, over the short, medium, and longer term. The study then considers which of the various proposed solutions would be most effective, including greater private sector involvement of the private sector.

The study concludes Karachi Port will need new rail terminal facilities that ensure faster turnaround, while Port Qasim will need high-standard rail access facilities to its key terminals, especially Pakistan International Bulk Terminal (PIBT). The study proposes Pipri as a logistics hub for train load movements to and from both Karachi Port and Port Qasim.

## Pakistan's total population stands at more than 220 million

The world's fifth most populous country, Pakistan is a developing country with growing imports and export. Over the last decade to 2019, Pakistan averaged real gross domestic product (GDP) growth of about 4 percent, while goods imports and exports grew at an average annual rate of about 6.1 percent through to the start of the pandemic in late 2020 (see **figure 1**).

### About the Authors



*Said Dahdah* is a Senior Urban Transport Specialist for the World Bank.

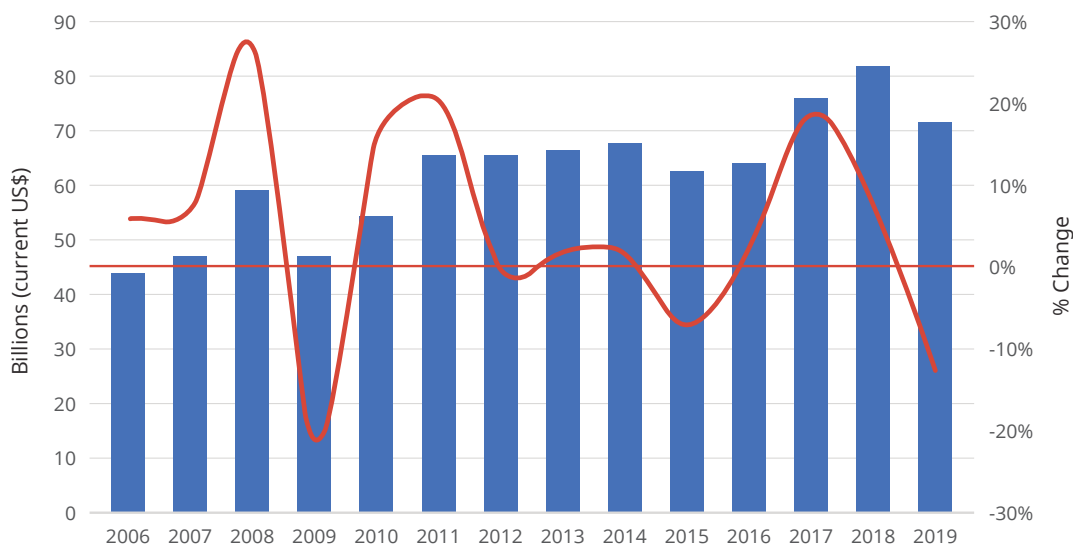


*Hasan Afzal Zaidi* is a Senior Urban Transport Specialist for the World Bank.



*John H. Winner* is a Senior Railway Expert/Consultant for the World Bank.

**Figure 1.** Value of Goods Imports and Exports in Pakistan, 2006–19

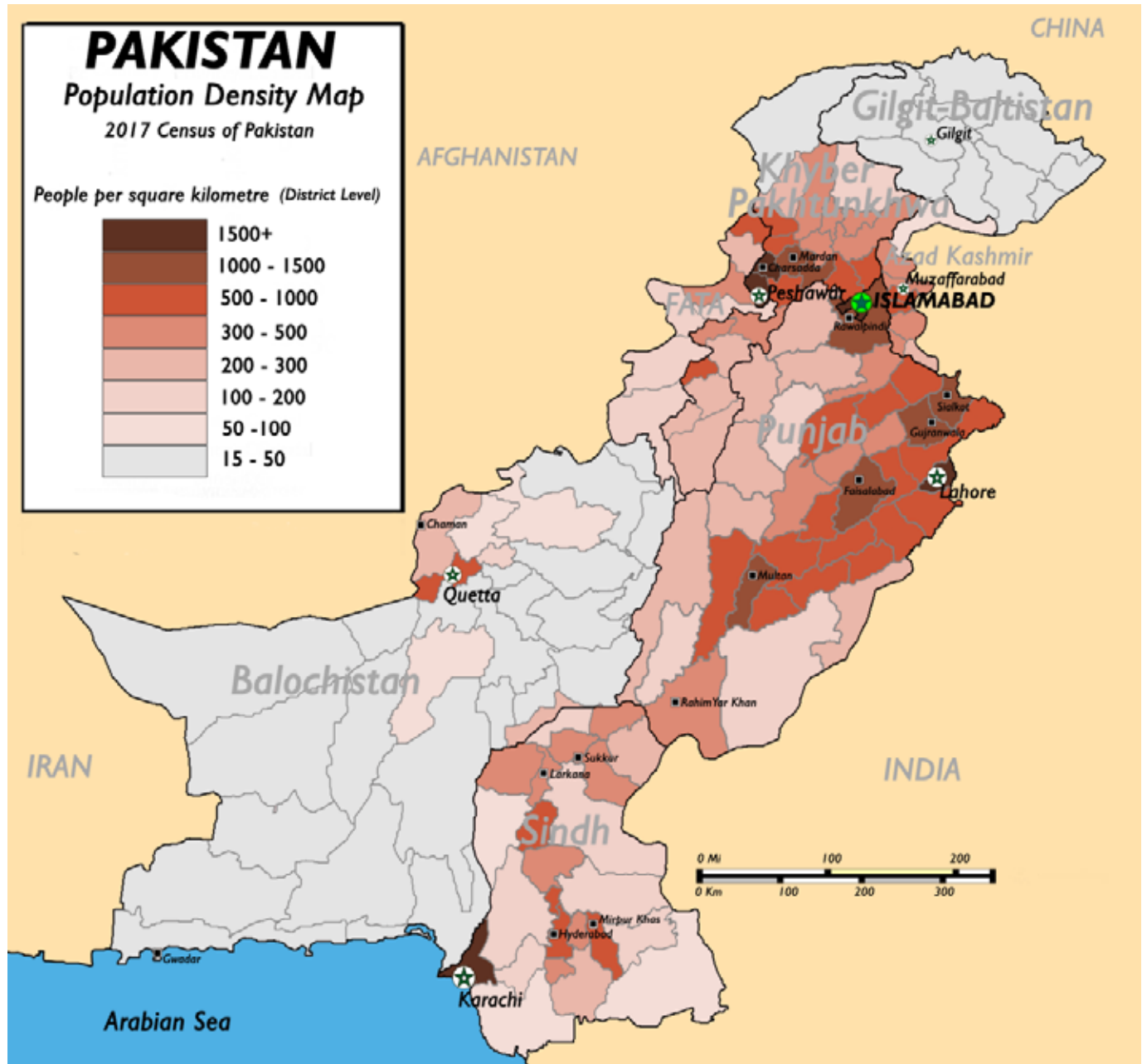


Source: World Bank, [World Development Indicators](#).

Pakistan's total population stands at more than 220 million; the population of Karachi, the country's largest city, located in southern Pakistan on the Arabian Sea — hovers around 14 million. However, most Pakistanis live in the northern part

of the country, some 1,000 kilometers from the Arabian Sea coast. The map in figure 2 shows the population distribution in Pakistan based on the 2017 census.

Figure 2. Pakistan Population Density Map, 2017



Source: Wikimedia ([https://commons.wikimedia.org/wiki/File:Pakistan\\_population\\_density.png](https://commons.wikimedia.org/wiki/File:Pakistan_population_density.png))

Nearly all imported and exported goods flow through the major ports in Karachi. In 2019/20 (the fiscal year used in reporting), Karachi's major ports handled about 92 million tons (**table 1**).

Since imports and exports for Pakistan were lower in 2019/20 than in prior years, 100 million tons serves as a good estimate for

import and export traffic moving through Karachi's ports. Most of the bulk liquids are moved via pipeline and some fuels, including coal and liquefied natural gas (LNG), are consumed near the port. Total import and export volume moving through the ports via Pakistan's surface transportation systems is likely around 75 million tons per year.

**Table 1.** Karachi's Two Major Ports, Fiscal Year 2019/20

Commodity	Quantity
Container (TEU)	3,073,000 million tons
Containers	43,758
Coal	14,311
Bulk liquids	26,272
Iron and steel products	1,754
Fertilizers	1,545
Cement exports	900
Others	4,317
<b>Total</b>	<b>92,857</b>

Source: [Karachi Port Trust](#); [Port Qasim Authority](#).

## The Ports of Karachi

To handle this volume, the city of Karachi operates two ports. Karachi Port (figure 3), embedded in but just west of Karachi, is managed by Karachi Port Trust (KPT) under the administrative control of the Federal Maritime Secretary. Formed in 1887, the Port of Karachi is one of the largest and

busiest deep-water seaports in South Asia. It handles about 50 percent of Pakistan's cargo. KPT has three container terminals, including one for ultra-large container ships, and multiple berths for handling general, bulk, and liquids traffic. In addition, the port services military and navy operations.

Figure 3. Illustrated Map of Karachi Port



Source: [Karachi Port Trust](#); World Bank (unpublished study on Karachi–Hyderabad medium-term rail capacity).

The second port (see **figure 4**), Port **Muhammad Bin Qasim**, lies approximately 40 kilometers due west of Karachi. Port Qasim (PQ), a relatively new and still developing port, opened in 1980 and is managed by the Qasim Port Authority, which also operates under the administrative control of the Federal Maritime Secretary. The

port has a single container terminal and berths for bulk, LNG, liquids, and coal. A number of “subports” also operate with Port Qasim, including the new privately built Pakistan International Bulk Terminal (PIBT), LNG terminals, a couple of nearby power plant coal terminals, and other specialized terminal facilities.

**Figure 4.** Illustrated Map of Port Qasim



**Source:** Port Qasim Authority; World Bank (unpublished study on Karachi–Hyderabad medium-term rail capacity).

Since it opened, Port Qasim has been the smaller of the two ports in the Karachi area; however, in recent years a shift in coal traffic has increased the port’s share to where it now handles slightly more total

tonnage than KPT. Even so, with its three container terminals, KPT handles about 65 percent of the container traffic, while PQ handles 35 percent.

Pakistan's port traffic has generally increased at a higher pace than its GDP. Forecasts for Pakistan's economic growth suggest the economy will continue to grow at 4 percent to 4.5 percent per year, resulting in the likely substantial growth of import and export traffic at Karachi's ports over the next decade — by at least 50 percent in the next 10 years; some forecasts have port traffic increasing by nearly 100 percent as Pakistan's economy evolves.

## Transport Networks

In most countries around the world, both road and rail modes provide transport of goods to and from the ports, with the available transport modes and price structures shaping and constraining a country's freight transport patterns. In Pakistan, an evolving freight transport network focusing on roads has shaped and developed Pakistan's logistics capabilities; movement of goods between Karachi's ports and its commercial centers done nearly all by road. Indeed, over the past decade, road transport has been the *only* mode readily available in Pakistan.

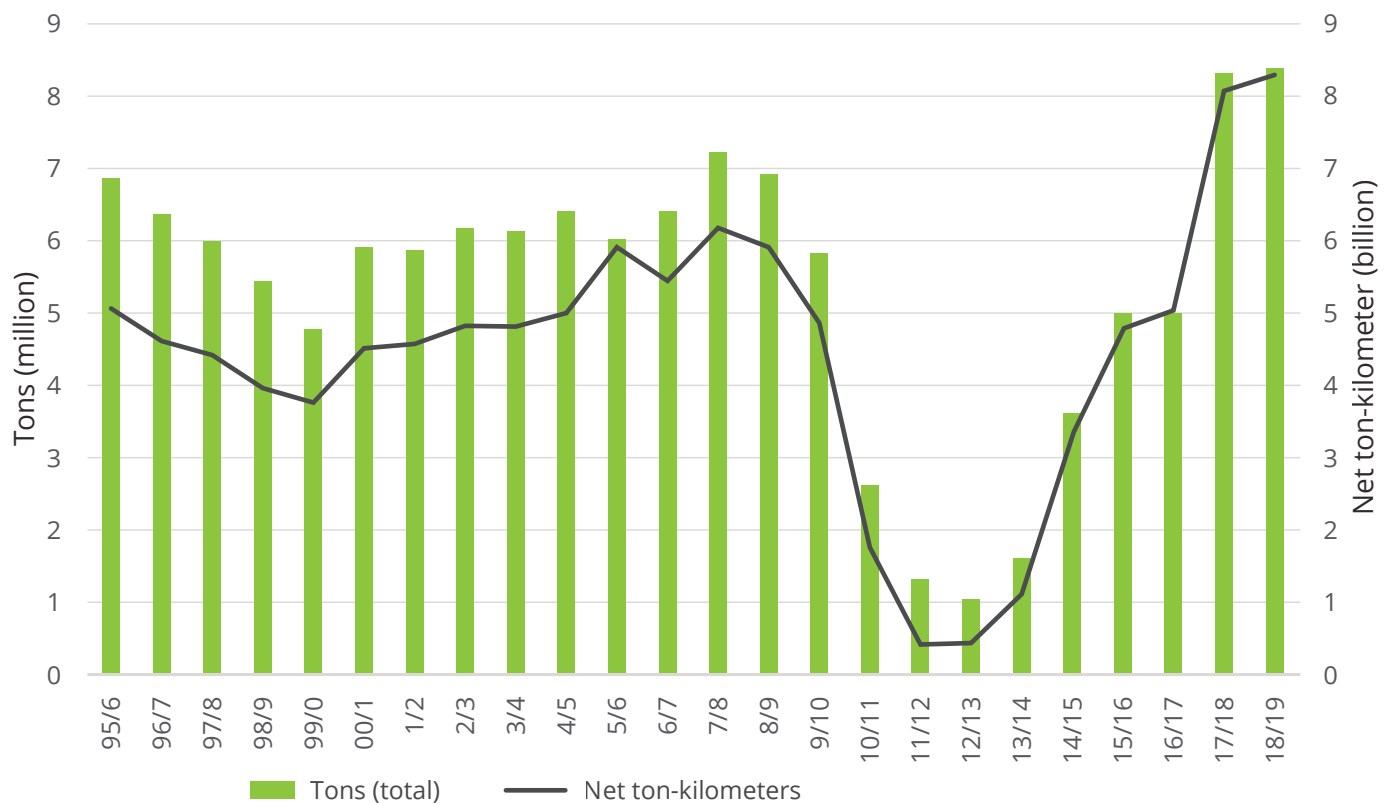
Having invested heavily in motorways and upgrading its national highway system over recent decades, Pakistan's road network includes a 10,000 kilometer national highway and motorway network, which carries 80 percent of Pakistan's total transport traffic. Small private operators dominate the road transport industry, which is thriving with intense competition and low road transport costs. In fact, transporting containers from Karachi to Lahore and other upcountry destinations is currently cheaper and faster by road than by rail.

Much of the projected increase stems from energy-related imports, including oil, coal, and LNG for power systems. Some of this increase will be handled with dedicated berthing facilities serving a power plant or a terminal for a pipeline distribution networks. Nonetheless, rapid growth of goods imports and exports is projected over the next decade. However, Pakistan faces the problem of how to transport these goods to and from Karachi's ports.

Pakistan's focus on developing the road network has resulted in a logistics system with a high concentration of consolidation and distribution terminals near Karachi and long road transport services direct to upcountry and Central Asian customers. As new transport alternatives are introduced, the sector will need time to reshape these structural elements.

In contrast, over the past decade rail network capacity has been hindered by a lack of investment and aging infrastructure, with underinvestment sapping the railway's ability to participate in economic growth. Locomotive and rollingstock available for service declined for lack of investment in parts and new equipment; the condition of many railway lines deteriorated, trains slowed, and services reduced. The sector prioritized continuing passenger services, curtailing [Pakistan Railways](#) (PR) freight services. As a result, the amount of freight carried by the railway declined precipitously, especially between 2010 and 2017 (**figure 5**).



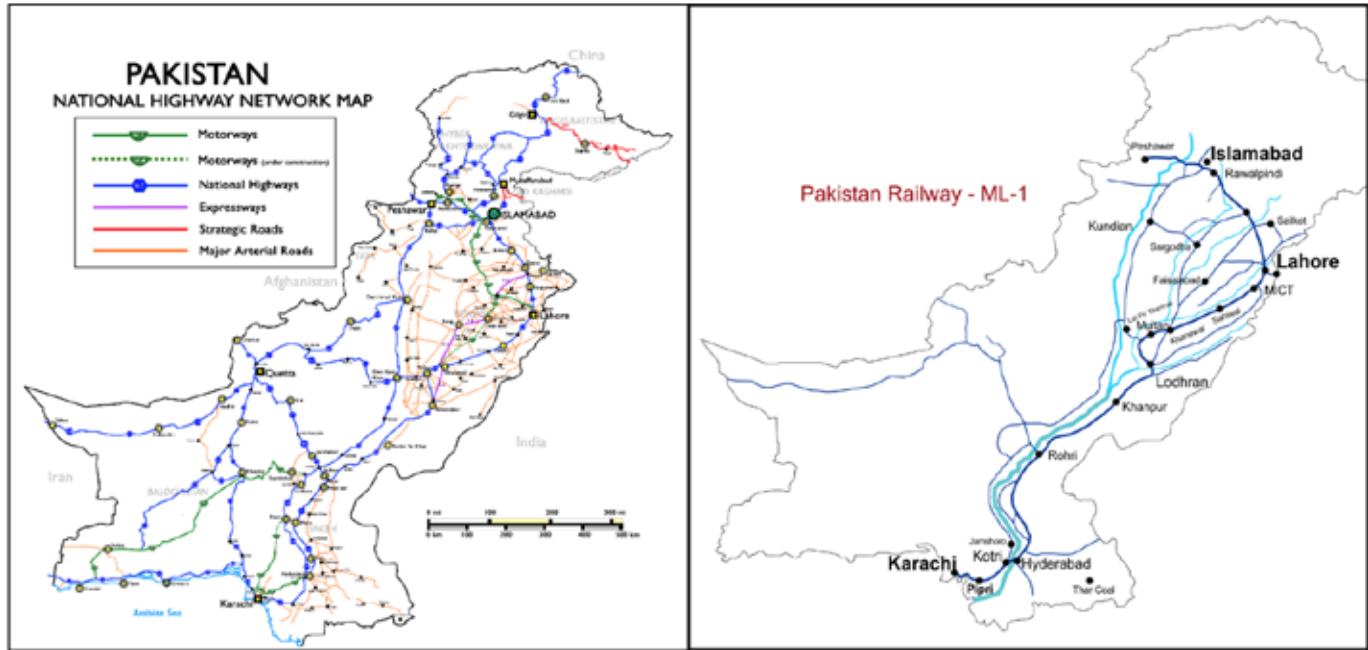
**Figure 5.** Pakistan Railways Freight Traffic, 1995 to 2019

Source: [Pakistan Railways](#); World Bank (unpublished study on Karachi-Hyderabad medium-term rail capacity).

While PR's main line from Karachi to Lahore is double track and generally in good condition, its technology (including track, signaling, communications, and road crossings) is dated. As a result, capacity on the line is less than it would be with modern technology. Pakistan's highway and railway networks are shown in **figure 6**. Because of

the country's different investment priorities, nearly all import and export traffic from Karachi's ports moves by road. This presents several problems for both Pakistan and Karachi, including higher transport costs, greater greenhouse gas (GHG) emissions, more road crashes, and increased traffic congestion, especially in Karachi.

Figure 6. Pakistan National Highway Network and Pakistan Railway Maps



Source: [Pakistan National Highways Authority](#); World Bank (unpublished study on Karachi–Hyderabad medium-term rail capacity).

Surrounded by the city of Karachi, Karachi Port's railway facilities are designed for the single box wagon market, which no longer exists, and for much lower volumes of traffic. In the past, outbound goods were handled in warehouses on or near the port and moved dockside for loading onto ships; imports were moved from dockside to many smaller warehouses to be deconsolidated for movement to commercial centers. In modern times, most imported bulk goods are bagged dockside and loaded directly onto trucks for outbound movement. Arranging rail movement is more complicated and difficult. Container traffic mostly moves to and from local warehouses by road transport because rail facilities at the port are limited and awkward, and the railway is not very sensitive to changing market conditions.

Because most traffic through Karachi port moves by road, some 10,000 truck movements per day within Karachi create a great deal of congestion around the port as trucks stage in city streets for access. The city has responded to this increased traffic and congestion by restricting access to many streets and roads to certain times of day. Unless the city makes significant changes in both highway and rail facilities, Karachi streets could see as many as 25,000 movements per day seeking access to the port in the near future. Proposals to construct an overhead highway at Karachi Port will redirect more truck traffic from city streets. At the same time, Pakistan is starting a railway investment program worth more than US\$8 billion to upgrade its main line (ML-1; Karachi to Peshawar) as a part of its [China–Pakistan Economic Corridor \(CPEC\) program](#). The railway investment seeks

to increase passenger train speeds on the corridor to 160 kilometers per hour (kph) and to increase the train capacity of the main line. Higher speed passenger services should attract new passenger traffic with additional passenger trains, many of them operating at 160 kph into Karachi City passenger station near the port.

Given the planned increases in high-speed passenger trains on ML-1, KCR is expected to have its own dedicated double-track corridor, separate from ML-1. Even so, given the preponderance of current and projected passenger services on the ML-1, the physical capacity of ML-1 should be increased before operating additional freight services.

At the same time, PR is rehabilitating the [Karachi Circular Railway](#) (KCR), an urban rail line circling downtown Karachi (**figure 7**), and plans to start high-frequency train services over the line with some suburban services extending some 50 kilometers to the west, past Port Qasim. KCR services operate along the north side of Karachi Port and along the ML-1 railway to the west.

With the objective of significantly increasing the volume of port freight traffic moving by rail, a recent series of unpublished World Bank studies analyzed the capacity of the existing network and rail facilities at both Karachi area ports to determine the most effective investments and their expected timing, given potential traffic demand.

Figure 7. Karachi Circular Railway Map



Source: Pakistan Railways; World Bank (unpublished study on Karachi-Hyderabad medium-term rail capacity).

## A Shift to Rail

The Bank studies determined rail capacity at both Karachi-area ports is determined by three specific constraints: (1) the ability to load and unload full trains, particularly for container services; (2) the capacity of ML-1 to accommodate freight trains; and (3) the

ability to run freight services on ML-1 to a strict timetable. The Bank studies concluded a major shift to rail would require significant investment in modern rail terminal facilities within the ports, especially within Karachi Port (see the satellite map in **figure 8**).

**Figure 8.** Google Earth Image of Karachi Port



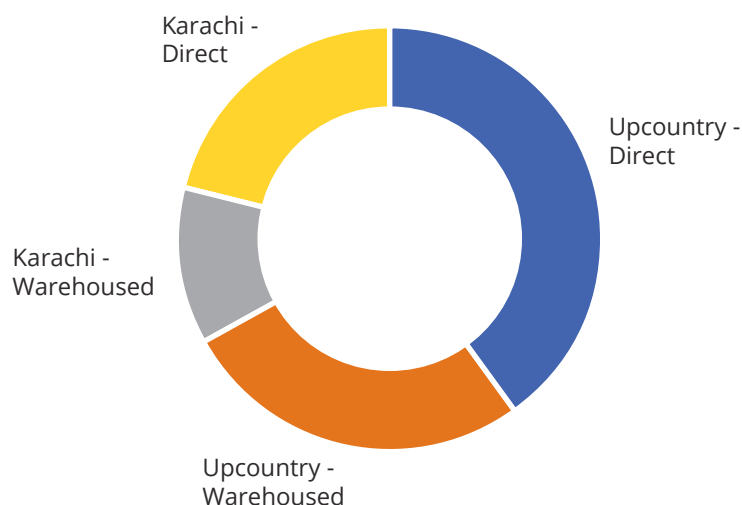
**Source:** Karachi Port Trust; World Bank (unpublished study on Karachi–Hyderabad medium-term rail capacity).

**Note:** PICT = Pakistan International Container Terminal; KICT = Karachi International Container Terminal; SAPT = South Asia Pakistan Terminals; A = Railway tracks at West Wharf Karachi Port; B = Pakistan Railways Yard, Karachi City; C = East Wharf Karachi Port; D = South Asia Pakistan Terminals; E = Area of railway land located outside the port, midway between Karachi City and Karachi Cantonment Stations, proposed for loading and unloading or staging facilities; F = Loading Facility at Wazir Mansion; TPX = Thule Produce Yard, an area south of Karachi City currently used as overflow storage for containers.

These investments would provide modern rail facilities for each of the major container terminals and permit fluid rail movements. Some of the potential investment locations are shown in **figure 9**. They include longer loading tracks so that full trains can be moved into the port, loaded, and then depart with little interference with trains operating on the main line. Other potential investments include new connections to permit quicker movement into and out of KPT. Investments at Port Qasim will also facilitate rail movements, including a direct

rail connection to PIBT and additional loading and staging tracks on the port. The investments should be associated with and accompanied by much greater involvement of the private sector, who would operate the specialized terminals and facilities. If traffic through the ports continues to grow, and if rail is successful in capturing a greater share, then additional investment in railway line capacity (track triplication or quadruplication) would be required sometime around 2035.

**Figure 9.** Karachi Port: Inland Distribution



**Source:** World Bank analysis, based on the following sources: EA Consulting. 2015. "Consultancy Services for Alignment, Detailed Design and Development of Road/Rail Network for Pakistan Deep Water Container Port.;" ISO Partners. 2016. "Development of National Trade Corridor Highway Business Plans.;" and interviews with port users.

Most road traffic from Karachi Port is destined to upcountry population centers. Some cargo is loaded onto trucks in container terminals or port loading facilities and moved directly upcountry (roughly 40 percent), while roughly 20 percent of cargo is warehoused in and around Karachi city, then moved upcountry. The remaining cargo (roughly 40 percent) moves to

customers in or near Karachi or to warehouses used by these local customers. It is likely that some of this "Karachi" traffic finds its way to or from upcountry population centers as well. Because all port traffic must traverse the city of Karachi; finding ways to shift this traffic to railways becomes an important consideration.

Since the opening of Port Qasim, the area around Bin Qasim has developed as a new industrial and logistics center for Karachi. In the longer term, this area is expected to continue to grow quickly. An option to reduce truck traffic in Karachi is to develop an unused railway yard in the town of Pipri — located northeast of Port Qasim — as a major logistics hub. In any event, a facility will be needed in this area to service and stage container trains moving to and from both Karachi Port and Port Qasim. The staging facility is needed to ensure freight

trains move quickly through the busy ML-1 corridor, mixing with highspeed passenger trains, normal passenger trains, and sub-urban services to and from Karachi.

A dedicated freight corridor could allow staging container services as well as serve freight shuttling between Karachi Port and Port Qasim to and from the new logistics center. **Figure 10** shows the suggested corridor route (blue line) stretching from Karachi Port, past Port Qasim, and ending at the logistics hub in Pipri.

**Figure 10.** Suggested Freight Corridor to Connect Karachi Area Ports with the Pipri Logistics Hub



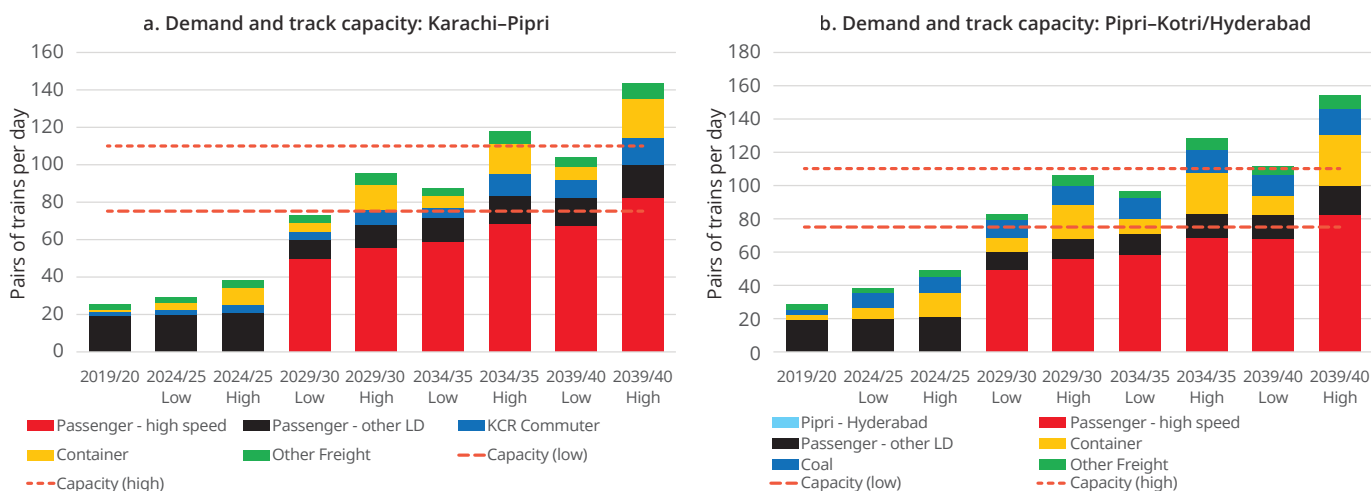
Source: [Karachi Port Trust](#); World Bank (unpublished study on Karachi–Hyderabad medium-term rail capacity).

A new freight corridor and Pipri area staging and logistics center could reduce rail transport costs since trains will be able to move directly between the ports and the logistics hub with minimal interference to passenger services, especially if the corridor is designed to permit double stack container trains.

Under most freight traffic projections, capacity analysis shows additional track

capacity might be needed by 2030. A high-capacity train load facility at Pipri could provide space for inspections, wagon, and locomotive servicing, container storage and shifting, and for staging to meet timetabled freight slots (**figure 11, panel a**). The World Bank analysis shows that additional capacity may be required between Pipri & Hyderabad by 2035 or so (**figure 11, panel b**).

**Figure 11.** Demand and Track Capacity for Karachi–Pipri and Pipri–Hyderabad Rail Lines



Source: [Karachi Port Trust](#); World Bank (unpublished study on Karachi–Hyderabad medium-term rail capacity).

In summary, continued economic growth in Pakistan depends upon increased freight movements to and from Karachi’s two major ports. However, surface transport access at Karachi Port is poor, technically outdated, and creates traffic congestion in the city of Karachi. To allow growth at Karachi Port, improvements must be made to on-port rail facilities in the short term, and different operating practices used in the medium and long term. Karachi Port will need new rail terminal facilities that ensure faster turnaround. Port Qasim will need high-standard rail access facilities to its key terminals, especially PIBT. Pipri could serve as an excellent holding and staging facility for train load movements to and from both Karachi Port and Port Qasim. The proposed

Pipri logistics facilities would need to be redesigned to service and inspect whole trains and provide high-capacity modern locomotive and wagon servicing facilities.

The logistics hub should also have modern container terminal capacity with the ability to store, load and unload, and swap containers between trains. Shuttle trains with no brake vans should move cargo between Pipri and both ports, which would require no locomotive turning; all servicing, brake tests, and inspections would be handled at Pipri. In the longer term, Pipri has the potential to become a major road and rail freight and warehousing hub for Pakistan, eliminating a great deal of heavy truck traffic from Karachi’s city streets.



---

**Authors:** James Markland, Muneza Alam, Mridula Singh, and Sudhashree Chandrashekar, The World Bank

# Response to COVID-19 Employment Creation through Infrastructure Investment

**T**he COVID-19 pandemic has caused an unprecedented worldwide crisis, with devastating economic impacts felt across the spectrum, from multinational companies through small and microenterprises to daily-paid, migrant, and informal workers and their families. Lockdowns have led to the disappearance of disposable income and customers as well as the

closure of all but the most essential services. A very few sectors have benefited from the situation or continued to operate largely unchanged. Services that continued to operate have had to adapt procedures to the new situation.

The impacts of the crisis have disproportionately affected low-paid workers, many of whom have been laid





## The impacts of the crisis have disproportionately affected low-paid workers, many of whom have been laid off

off, as employers have not been able to continue paying salaries given the widespread disappearance of income, despite their obligations or government support programs. Migrant workers, a large proportion of the labor force in South Asia, have not only lost their sources of income, but have had to travel hundreds of kilometers without support to reach their homes, forced to contemplate rebuilding their lives. The informal sector has been hit hard by the drop in numbers of customers.

As governments struggle to balance the twin priorities of controlling the waves of COVID-19 and minimizing the economic impact of the shutdowns, lockdowns are being introduced and eased and planning is advancing for the recovery phase. How can meaningful

employment be generated to provide income for those who have lost their jobs? A clear understanding of the available approaches to “Build Back Better” and their associated rollout strategies is critical in view of the uncertainties surrounding the start and pace of the recovery phase, the period over which COVID-19 will continue to be a challenge, and the employment creation needs.

This article presents options for the creation of infrastructure-related employment, and gives guidance on the selection of the most appropriate option(s). To be effective and sustainable, programs must match needs with opportunities. Factors that influence solution choice include the attitudes of stakeholders, availability of skills, local infrastructure needs, and the existence of ongoing activities that can be scaled up or adjusted. Cross-sectoral programs are more flexible in adapting to diverse opportunities, and bring other advantages. Although the discussion and examples that follow focus on the road sector, opportunities in other sectors should be considered.

### About the Authors



*James Markland* is a Senior Transport Specialist for the World Bank.



*Muneeza Alam* is a Senior Economist for the World Bank.



*Sudhashree Chandrashekar* is a Senior Consultant for the World Bank.

## What Labor-Intensive Methods Can Offer

### THE CONCEPT

The well-considered inclusion of labor-intensive principles in the construction and maintenance of infrastructure and service provision can generate significant levels of meaningful employment when compared with conventional approaches. Labor-intensive construction methods have been widely used to create employment to assist recovery from disasters or wars; they have proved to be effective and much experience of their use exists. In many developing

countries, labor-intensive methods have been mainstreamed through infrastructure or social programs by governments and development agencies in recognition of their impact on increasing incomes of vulnerable people, while at the same time providing necessary infrastructure. The [International Labour Organisation \(ILO\)](#) [has been instrumental in developing this approach](#). **Box 1** provides some examples of employment creation during times of economic shock.

### Box 1. Use of Employment Creation Programs during Times of Economic Shock

Employment creation programs, including labor-intensive public works, are an important tool for governments in developing countries. Such programs have historically been used in countries where unemployment and/or underemployment is high and at times of macroeconomic or climate shocks. For example:

- Infrastructure investment in the *United States* during the Great Depression ([Leduc and Wilson 2012](#));
- In *Indonesia*, the government launched a social safety net program in 1998/99 in response to the financial crisis ([Anant and Siregar 1999](#));
- In *India*, the State of Maharashtra launched an employment guarantee scheme in the face of an acute drought in 1972/73 and in 2005 the government enacted the National Rural Employment Guarantee Act (NREGA) which provides guaranteed employment for works relating to rural development ([Patel 2006](#)); and
- In *South Africa*, where the causes of unemployment are structural and historic, the government launched the Expanded Public Works Programme in 2004, aimed at developing the skills of the unemployed, and providing essential social services and physical infrastructure to disadvantaged communities ([SACN 2017](#)).

Any infrastructure more than 150 years old was built using labor-intensive methods. Roads and other infrastructure built by hand are often more resilient than those constructed by machines due to the greater attention to detail possible during the construction process.

An economic “trickle down” effect from construction work will benefit local businesses and informal vendors supplying raw materials, transport, accommodation, food, and other goods and services to large projects.

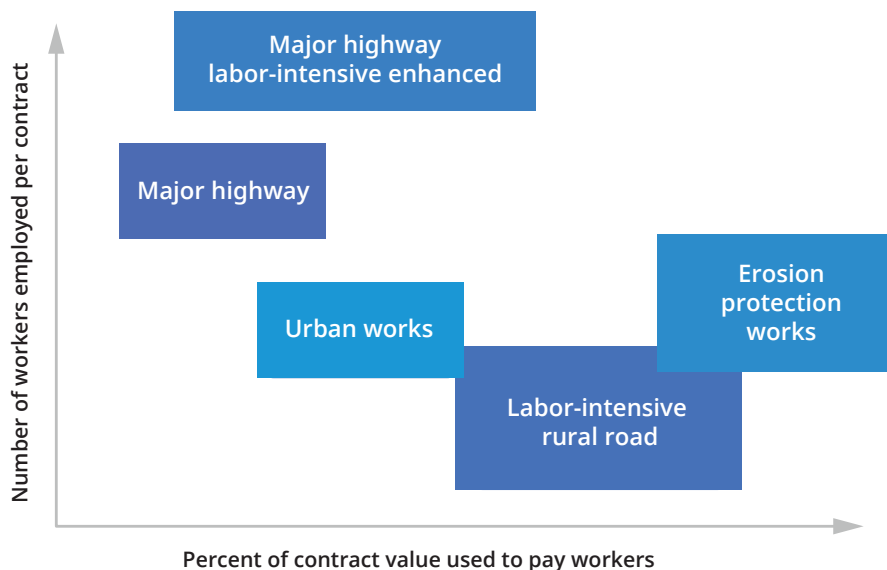
**THE IMPACT**

As construction techniques have evolved, many of the tasks once performed by manual labor have been taken over by machines, which reduces the number of workers required on a construction site, and the proportion of a contract’s value used to pay wages. This change has not been uniform, and substantial numbers of workers continue to be used in some types

of construction. While most roads, from major highways to minor access roads, are now constructed using a high level of machinery, in some situations simple paved or unpaved rural access roads could be constructed using methods that require a substantial proportion of labor.

In considering employment creation programs, it is important to appreciate the difference between the number of workers employed on a specific contract or activity, and the proportion of that contract value used to employ workers. This distinction is illustrated indicatively in **figure 1**. For example, although labor-intensive erosion protection works convert a high proportion of the contract cost into jobs, a larger number of workers could be employed on a major highway contract, although a smaller proportion of that investment is spent on wages. The key indicator for assessing the effectiveness of an activity in converting investment value into employment is the number of jobs created per unit of cost.

**Figure 1.** Indicative Employment Creation for Different Types of Work



Source: Original figure produced for this publication.

The adoption of labor-intensive construction methods requires a conscious decision to identify and prioritize those types of activity that can be undertaken with a high proportion of manual labor. The key to success is to maximize the amount of employment for a given level of investment while retaining a reasonable degree of efficiency and ensuring quality of the end products. Whatever the level of employment created, the need will always exist for some level of other inputs such as transport, construction materials, machinery, or hand tools.

The levels of direct employment expected for the construction of unpaved rural roads range between 1,000 to 1,500 days of employment per kilometer. As noted in the 2018 report copublished by the World Bank and the ILO, "[Assessment of Infrastructure Investments in Transport and Job Creation: Examples from Road Sector Investments in Lebanon and Jordan](#)," for a range of mechanized contracts in the Lebanon and Jordan approximately 4,200 person-days of employment per kilometer could be created for rural roads and significantly more, 8,000 person-days per kilometer, for urban roads, or 18 percent to 33 percent of the contract value. Road maintenance work shows a significantly higher conversion of cost into salaries at approximately 50 percent than for mechanized road construction works where the proportion is unlikely to exceed 25 percent. Other work indicates in India 13,500 person-days of employment are created per US\$1 million of investment.

Mechanized construction work will convert a small proportion of the investment into employment opportunities. Together,

maintenance and labor-intensive construction generate a high level of employment in relation to the investment; these areas should therefore be the focus for maximizing long-term job creation.

Employment opportunities can be targeted to benefit specific groups in the community such as migrant workers, or female-headed or low-income households who have been particularly disadvantaged as a result of the pandemic. For targeting to be effective, data on (un)employment levels, vulnerability, and migrant labor distribution will be required, although quality and availability could be limited. Different approaches to targeting are needed depending upon the type of activity: for local-level community-based initiatives, targeting criteria can be built into the recruitment process managed by the local authority responsible for implementation. Targeting can be more difficult in the case of large construction contracts, where labor selection criteria need to be agreed and implemented by contractors; this topic is discussed in more detail in the following section.

Employment creation programs can lead to major distortionary impacts on local labor markets by affecting the demand and supply of labor, and by influencing local wages. It is important that the possibility of these impacts is considered in the design of the program. The use of tailored selection processes can assist in mitigating such distortions. [Devereux and Solomon \(2006\)](#) found that short-term programs (lasting two to three years) designed to provide livelihood opportunities in times of crisis have limited distortionary impact on the labor force.

## Potential Areas of Work for Labor-Intensive Programs

If a labor-intensive program is to be implemented successfully, the design must take into account: (1) the type of work to be carried out; (2) the ease and speed of establishment of the program, and (3) the social and political acceptability of labor-intensive work to beneficiaries and the authorities.

The following principal options could be considered for programs dedicated to employment generation under the present circumstances:

- Conventional labor-intensive programs
- Existing community infrastructure programs
- Scale-up of employment opportunities in major construction contracts
- Cash transfer or food for-work programs
- Maintenance works
- COVID-19 related activities

**Whichever option is adopted, each requires a systematic capacity building program for all stakeholders.** Labor-intensive methods require high levels of labor management skills in addition to program management, planning, engineering design, labor management and supervision, and reporting to attain the desired levels of productivity, quality, and efficiency.

### Conventional labor-intensive programs:

- Rural infrastructure works — typically unpaved road construction, but a broad range of activities, including landscaping, land conservation, erosion protection, water conservation infrastructure, irrigation schemes, urban infrastructure works, and building construction are suitable for labor-intensive techniques.
- Programs could be implemented using government departments, community groups or micro, small and medium enterprises (MSMEs). The choice should be influenced by what is already available or working. The establishment of private sector contractors (if they do not already exist) will be time consuming and produce only a moderate success rate.

### Existing community infrastructure programs:

- Explore programs based on an existing community development initiative to take advantage of existing frameworks, staff, and experience.
- Scale up existing programs by using available institutional, operational and capacity-building models as a quick route to the creation of sustainable employment. In some cases, compromises might need to be made in the wider objectives of such programs.

Other components could be added as implementation progresses to address any missing elements.

- Assess the capacity and effectiveness of an existing program before a final decision is taken. Interventions to increase capacity might be required as part of the scale-up.
- While these programs provide meaningful employment, they risk being transient, usually as a result of seasonal, cultural or program design factors. Perhaps the most significant challenge to sustainability is the lack of the required resources or organizational framework for asset maintenance.

**Scale-up of employment opportunities in major construction contracts:**

- Major works contracts using largely mechanized techniques can create significant levels of employment, although at lower levels of jobs per investment unit than labor-intensive works. Opportunities to substitute equipment with labor need to be identified; the necessary technical oversight and labor-management techniques must be introduced. Examples of tasks most suitable for implementation by labor include masonry, drainage activities, bush clearance, placing fill in confined spaces, erosion protection, and building construction activities.
- This approach has the advantage of producing results quickly. Scale-ups depend upon receptive attitudes on the part of contractors, achieved through negotiation and perhaps the use of incentives to reach agreed targets.
- For contracts, employment scale-up can be achieved by customizing the design and procurement process to incentivize the substitution of equipment by labor. Target values could be given for the proportion of expenditure spent on labor, or the proportion of jobs allocated to vulnerable groups. Such provisions can be abused by contractors; although they might meet the targets, the jobs created might not be meaningful and are absorbed by the contractor as a cost of doing business. Contracting models to create jobs in construction include the following: (1) force account, where a government agency hires and manages labor directly; (2) conventional contracting, where the selected contractor employer hires labor; (3) subcontracting, where the main contractor subcontracts parts of the main contract that are labor intensive to smaller firms; and (4) an agency model, where a nonprofit organization or project manager hires and manages the labor. Preferably, employment creation initiatives would be assumed by a contractor as part of their corporate social responsibility agenda.

**Box 2** illustrates a plausible scenario of identifying employment opportunities for a large-scale rail construction project.

**Box 2.** Scenario: Identifying Opportunities to Increase Employment

Imagine a new rail line is being constructed through arid terrain, crossing sandy and alluvial soils. The contractor decides to construct the low embankment for the track-bed by using laborers to excavate the alluvial material occurring within 10 meters of the alignment to form the embankment. Five hundred laborers are able to construct 1 kilometer of embankment each day.

The contractor finds this to be more cost effective and easier to implement than using equipment to build the embankment.

Thus, the combination of easily excavated soils, very short haul distance, and the availability of labor produced the opportunity to substitute equipment with labor.

**Source:** Original content produced for this publication.

**Maintenance works:**

- Rural and urban infrastructure maintenance activities offer important sources of sustainable employment, provided the financing is secured through recurrent expenditure budgets.
- Routine maintenance of rural roads is often carried out using self-help groups, community maintenance or length-person systems. In many such arrangements, women occupy a high proportion of the jobs.
- The level of employment created is relatively low, up to one or two persons per kilometer of rural road; however, the jobs created are long-lasting. Routine maintenance activities may also be structured to allow private sector management through performance contracts.

**COVID-19-related activities:**

- Within the context of the coronavirus pandemic, transport service providers are required to adopt new protocols in order to resume operations safely and retain the trust of the traveling public. The pandemic has created new areas of work: sanitization of public transport facilities, streets, and public places; cleaning and sanitization of rolling stock and buses for public transport; cleaning and sanitization of workplaces; supervision of social distancing; contact tracing; management of quarantine procedures; and the manufacture of protective equipment.
- Some activities would be suitable for small or medium businesses, which could either be created or repurposed for the work.

## Program Identification and the Design Process

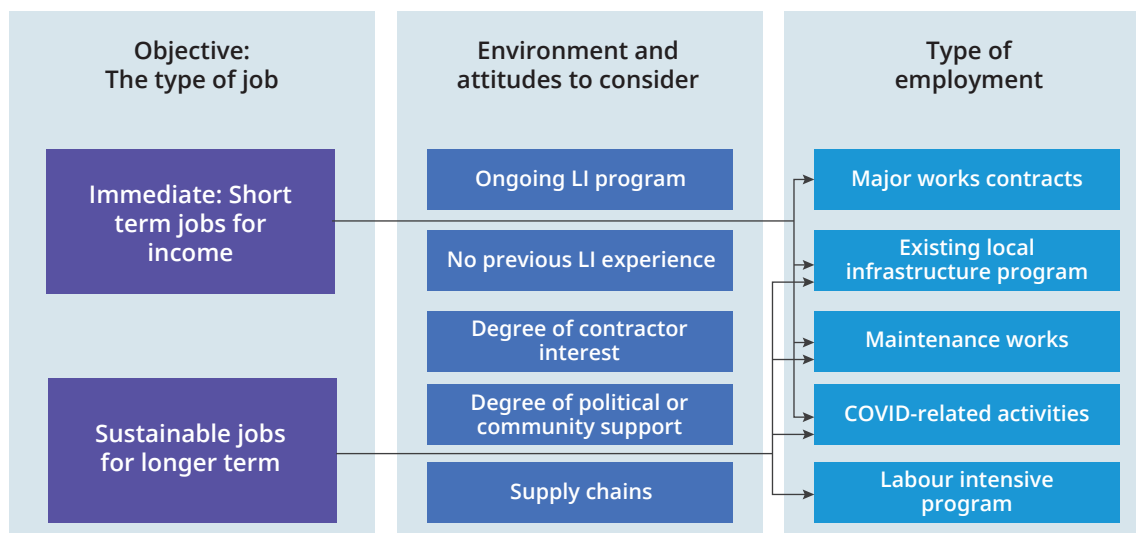
Important steps in identifying and designing a labor-intensive employment creation program are as follows:

- **Define the program objectives:** Clarity in what the program is to achieve is essential. Is the goal to provide short-term jobs and income, or more sustainable long-term employment? Who will benefit, and how can women and vulnerable community members be included? Is it part of a wider strategy to address the jobs market or migrant labor? What type of jobs are needed?
- **Map the levels of employment and underemployment:** It is essential to identify the areas of need in terms of gender, vulnerability, and migrant labor across the country for a targeted approach to job creation to be effective. The situation will change rapidly with time or season. Data collection processes need to be responsive to reflect changes over time.
- **Program identification:** For each target area, establish those sectors in need of infrastructure or services, and the activities required. Match the types of activity to the acceptability level of labor-intensive methods; extensive consultation will be necessary. As the target areas become clearer, the mapping process should expand to consider the wider labor market and potential impacts on program design. This stage lies at the heart of the process, and is represented in **figure 2**.
- **Opportunities to maximize benefits:** Once the main scope of a program has been identified, complementary investments that would enhance the benefits of primary investments under the program should also be considered. For example, a rural roads maintenance program could also consider maintaining rural market structures, warehouses, cold storage, water, and sanitation infrastructure. Such an integrated approach would not only enhance the benefits of the program to the local community through better infrastructure, but also create an ecosystem in which a larger proportion of the local population can participate. If small contractors are part of the program, this diversification will strengthen their future sustainability.
- **Social and community considerations:** Employment creation initiatives present unique challenges that should be factored into program designs. These challenges include the interests and cultural practices of communities as well as wage levels. Programs must be designed not to interfere with other essential community livelihood activities, such as agriculture.
- **Build capacity:** Establish the basic institutional capacity to enable public agencies to prepare, package, and manage the programs, rolling out later to program implementers and communities.



- **Operational details:** Establish the program financing schemes and the procedures for planning, activity design, procurement, and implementation.
  - **Monitoring, reporting and evaluation:** Frameworks will be needed for managers to supervise implementation, regular reporting of progress, and program impacts to be assessed.
- Labor-intensive programs could include either programs established specifically in response to COVID-19, or existing programs that can be scaled up to provide additional employment opportunities. The best overall solution that most closely matches the above requirements should be adopted.

Figure 2. Activity Selection Guide

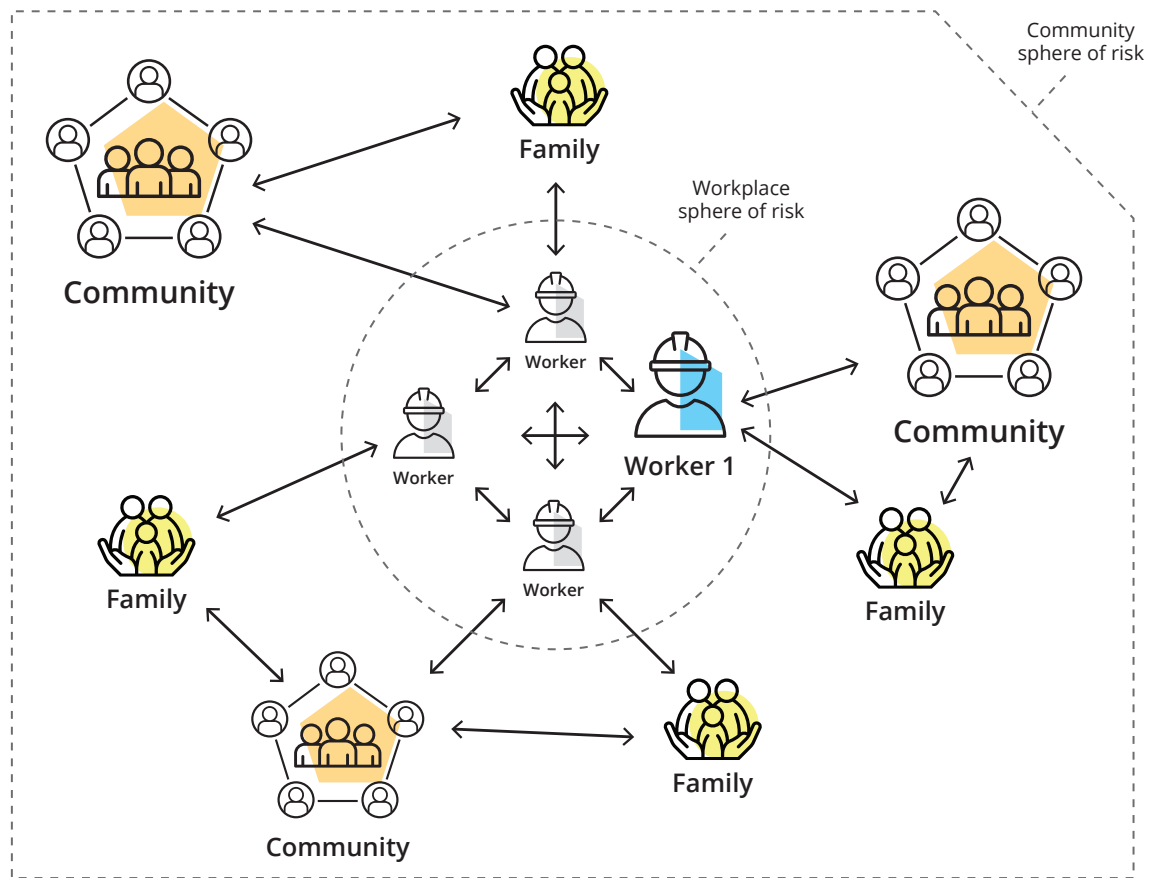


Source: Original figure produced for this publication.

### IMPLICATIONS OF COVID-19 FOR PROGRAM DESIGN

Recruitment and organization of labor: The conventional guidance on labor recruitment for construction activities is to hire workers from the communities around the areas where the work will take place so that the workers can live at home, traveling to work each day. Does COVID-19 mean this needs to change? The widespread movement and mingling of people resulting from this

live-at-home approach significantly increases the risk of propagation of infection. Even if social-distancing protocols are followed, the risk of transmission remains. The options are examined more closely from the perspective of “worker 1” through **figures 3 and 4**. Although they are presented as two distinct options, in practice a site may need to adopt a combination due to their specific labor requirements.

**Figure 3.** Spheres of Risk with Workers Living in the Community

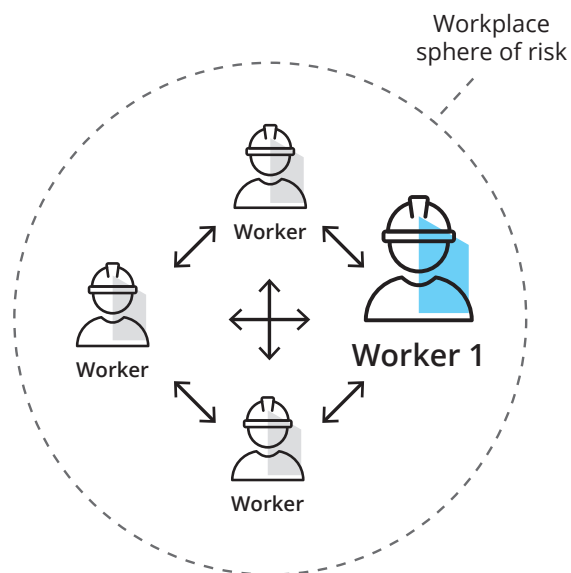
Source: Original figure produced for this publication.

Living-at-home/in the community (**figure 3**) means that worker 1 will be in contact and interact with (1) family members, who will also be in contact others in the community; (2) others in their community; (3) fellow workers, along with their families and communities, while at work or traveling to and from the site, whether on foot or on vehicles provided by the workplace. Each type of possible contact provides opportunities for wider transmission. The sphere of

risk extends to worker 1's community, and the families and communities of their fellow workers.

Living onsite (figure 4) means that worker 1's interaction outside the workplace is much more limited, although they do spend more time in "managed" contact with fellow workers. Opportunities for transmission are restricted to the worksite environment and sphere of risk.

**Figure 4.** Sphere of Risk when Workers Live Onsite



Source: Original figure produced for this publication.

The immediate reaction to the above figures is that workers should live onsite due to the greatly reduced sphere of risk. However, an assessment from a public health perspective is needed of the potential work-type options to balance the risks and arrive at the correct decision. Naturally, the risk of transmission between workers living and working together will be higher, but the conditions for transmission can be controlled and monitored, and any outbreak would be contained. Although a much

wider pool of potential transmission routes exists when workers live with their families, the risk of any one of those probably brief contacts with an infected person resulting in transmission could be reduced. The downside of the live-at-home scenario is the risk infection transmits from one family or community to another through worker-to-worker contact at the workplace. Therefore, the potential for wider propagation of the disease is greater.

## Employment: The Longer-Term Perspective

This note has been prepared in the context of responding to the COVID-19 pandemic, or similar crisis, and the role labor-intensive programs can play in mitigating the resulting shocks. However, employment creation has a much wider relevance given the trends for accelerating automation

and efficiency in economies throughout the world. Increasingly, people rely on the informal sector or the gig economy for their livelihoods. Increased attention needs to be given to the evolution of the employment environment to ensure social sustainability for future generations.

[References](#)



Article

## Mobility on Demand (MOD) and Mobility as a Service (MaaS): Similarities, Differences, and Potential Implications for Transportation in the Developing World



### References

Shaheen, Susan, and Adam Cohen. 2020. "Chapter 3 — Mobility on Demand (MOD) and Mobility as a Service (MaaS): Early Understanding of Shared Mobility Impacts and Public Transit Partnerships." In *Demand for Emerging Transportation Systems: Modeling Adoption, Satisfaction, and Mobility Patterns*, edited by Constantinos Antoniou, Dimitrios Efthymiou, and Emmanouil Chaniotakis, 37-59. UC Berkeley, Transportation Sustainability Research Center: Elsevier.

<https://doi.org/10.1016/B978-0-12-815018-4.00003-6>.

Shaheen, Susan, Adam Cohen, Balaji Yelchuru, and Sara Sarkhili. 2017. "Mobility on Demand Operational Concept Report." U. S. Department of Transportation. Report # FHWA-JPO-18-611. <https://rosap.ntl.bts.gov/view/dot/34258>.

### Additional Resources

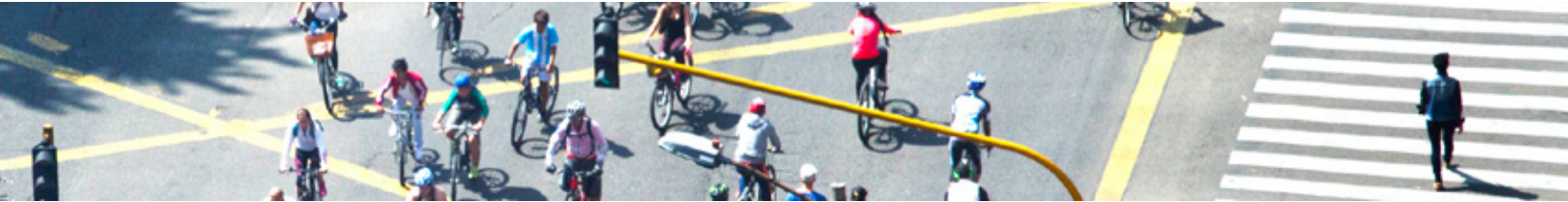
For more information on mobility on demand, see the following publications, also coauthored by Susan Shaheen and Adam Cohen, for the U.S. Department of Transportation: "[Mobility on Demand Operational Concept](#)" and "[Mobility on Demand Planning and Implementation: Current Practices, Innovations, and Emerging Mobility Futures](#)." Stay tuned for a new report by the World Bank, "Adapting Mobility-as-a-Service for Developing Cities: A Context-Relevant Approach" to be launched this Fall.

See also:

- Cohen, Adam and Susan Shaheen. 2016. "Planning for Shared Mobility." Planning Advisory Service (PAS) 583, American Planning Association, Washington, D.C. <https://planning.org/publications/report/9107556/>.
- Shaheen, Susan, Adam Cohen, Michael Randolph, Emily Farrar, Richard Davis, and Aqshems Nichols. 2019. "[Shared Mobility Policy Playbook](#)." UC Berkeley Transportation Sustainability Research Center, Berkeley, CA. <https://escholarship.org/uc/item/9678b4xs>.

## Quantifying the Health Co-Benefits of Active Mobility: Developing Tools for Health Impact Assessments of Transport Choices in Five Latin American Cities

Article



### References

- Achakulwisut, P., M. Brauer, P. Hystad, and S. C. Anenberg. 2019. "Global, National, and Urban Burdens of Paediatric Asthma Incidence Attributable to Ambient NO<sub>2</sub> Pollution: Estimates from Global Datasets." *The Lancet Planetary Health* 3 (4): e166–78. [https://doi.org/10.1016/S2542-5196\(19\)30046-4](https://doi.org/10.1016/S2542-5196(19)30046-4).
- COMEAP (Committee on the Medical Effects of Air Pollutants). 2009. *Long-Term Exposure to Air Pollution: Effect on Mortality: A Report by the Committee on the Medical Effects of Air Pollutants*. Oxfordshire, UK: COMEAP Secretariat. [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/304667/COMEAP\\_long\\_term\\_exposure\\_to\\_air\\_pollution.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/304667/COMEAP_long_term_exposure_to_air_pollution.pdf).
- COMEAP. 2016. *Long-Term Exposure to Air Pollution and Chronic Bronchitis: A Report by the Committee on the Medical Effects of Air Pollutants*. Oxfordshire, UK: COMEAP Secretariat. [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/541745/COMEAP\\_chronic\\_bronchitis\\_report\\_2016\\_rev\\_07-16\\_.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/541745/COMEAP_chronic_bronchitis_report_2016_rev_07-16_.pdf).
- COMEAP. 2018. *The Effects of Long-Term Exposure to Ambient Air Pollution on Cardiovascular Morbidity: Mechanistic Evidence*. Oxfordshire, UK: COMEAP Secretariat. [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/749657/COMEAP\\_CV\\_Mechanisms\\_Report.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/749657/COMEAP_CV_Mechanisms_Report.pdf).
- de Nazelle, A., O. Bode, and J. P. Orjuela. 2017. "Comparison of Air Pollution Exposures in Active vs. Passive Travel Modes in European Cities: A Quantitative Review." *Environment International* 99 (February): 151–60. <https://doi.org/10.1016/j.envint.2016.12.023>.
- IHME (Institute for Health Metrics and Evaluation). 2017. "Global Burden of Disease." <http://ghdx.healthdata.org/gbd-2017>.

- Mueller, N., D. Rojas-Rueda, T. Cole-Hunter, A. de Nazelle, E. Dons, R. Gerike, T. Götschi, L. Int Panis, S. Kahlmeier, and M. Nieuwenhuijsen. 2015. "Health Impact Assessment of Active Transportation: A Systematic Review." *Preventive Medicine* 76 (July): 103–14. <https://doi.org/10.1016/j.ypmed.2015.04.010>.
- Reiner, M., C. Niermann, D. Jekauc, and A. Woll. 2013. "Long-Term Health Benefits of Physical Activity: A Systematic Review of Longitudinal Studies." *BMC Public Health* 13 (1): 1–9. <https://doi.org/10.1186/1471-2458-13-813>.
- Shah, A. S. V., K. K. Lee, D. A. McAllister, A. Hunter, H. Nair, W. Whiteley, J. P. Langrish, D. E. Newby, and N. L. Mills. 2015. "Short Term Exposure to Air Pollution and Stroke: Systematic Review and Meta-Analysis." *BMJ Online* 350 (March): h1295. <https://doi.org/10.1136/BMJ.h1295>.
- Tainio, M., A. J. de Nazelle, T. Götschi, S. Kahlmeier, D. Rojas-Rueda, M. J. Nieuwenhuijsen, T. Hérick de Sá, P. Kelly, and J. Woodcock. 2015. "Can Air Pollution Negate the Health Benefits of Cycling and Walking?" *Preventive Medicine* 87 (June): 233–36. <https://doi.org/10.1016/j.ypmed.2016.02.002>.
- WHO (World Health Organization). 2018a. "Ambient (Outdoor) Air Quality and Health." [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health).
- WHO. 2018b. "The Top 10 Causes of Death." <https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death>.
- Woodcock J., P. Edwards, C. Tonne, B. G. Armstrong, O. Ashiru, D. Banister, S. Beevers, Z. Chalabi, Z. Chowdhury, A. Cohen, O. H. Franco, A. Haines, R. Hickman, G. Lindsay, I. Mittal, D. Mohan, G. Tiwari, A. Woodward, and I. Roberts. 2009. "Public Health Benefits of Strategies to Reduce Greenhouse-Gas Emissions: Urban Land Transport." *Lancet* 374 (9705): 1930–43. [https://doi.org/10.1016/S0140-6736\(09\)61714-1](https://doi.org/10.1016/S0140-6736(09)61714-1).
- World Bank. 2020. *Propuesta de actualización del Plan de Infraestructura Ciclovía para Lima y Callao*. Washington, DC: World Bank. <http://documents.worldbank.org/curated/en/294041589874919754/pdf/Propuesta-de-actualizacion-del-Plan-de-Infraestructura-Ciclovía-para-Lima-y-Callao.pdf>.



## Additional Resources

- Atkinson, R. W., B. K. Butland, H. R. Anderson, and R. L. Maynard. 2018. "Long-Term Concentrations of Nitrogen Dioxide and Mortality." *Epidemiology* 29 (4): 460–72. <https://doi.org/10.1097/EDE.0000000000000847>.
- Bigazzi, A. Y., and M. A. Figliozzi. 2012. "Impacts of Freeway Traffic Conditions on In-Vehicle Exposure to Ultrafine Particulate Matter." *Atmospheric Environment* 60 (December): 495–503. <https://doi.org/10.1016/j.atmosenv.2012.07.020>.
- de Nazelle, A., E. Seto, D. Donaire-Gonzalez, M. Mendez, J. Matamala, M. J. Nieuwenhuijsen, and M. Jerrett. 2013. "Improving Estimates of Air Pollution Exposure through Ubiquitous Sensing Technologies." *Environmental Pollution* 176 (May): 92–99. <https://doi.org/10.1016/j.envpol.2012.12.032>.
- Di, Q., L. Dai, Y. Wang, A. Zanobetti, C. Choirat, J. D. Schwartz, and F. Dominici. 2017. "Association of Short-Term Exposure to Air Pollution with Mortality in Older Adults." *JAMA—Journal of the American Medical Association* 318 (24): 2446–56. <https://doi.org/10.1001/jama.2017.17923>.
- Dons, E., L. Int Panis, M. van Poppel, J. Theunis, and G. Wets. 2012. "Personal Exposure to Black Carbon in Transport Microenvironments." *Atmospheric Environment* 55 (August): 392–98. <https://doi.org/10.1016/j.atmosenv.2012.03.020>.
- Dons, E., M. Laeremans, J. P. Orjuela, I. Avila-Palencia, A. de Nazelle, M. Nieuwenhuijsen, M. van Poppel, G. Carrasco-Turigas, A. Standaert, P. de Boever, T. Nawrot, and L. Int Panis. 2019. "Transport Most Likely to Cause Air Pollution Peak Exposures in Everyday Life: Evidence from Over 2000 Days of Personal Monitoring." *Atmospheric Environment* 213 (September): 424–32. <https://doi.org/10.1016/j.atmosenv.2019.06.035>.
- Dons, E., D. Rojas-Rueda, E. Anaya-Boig, I. Avila-Palencia, C. Brand, T. Cole-Hunter, A. de Nazelle, U. Eriksson, M. Gaupp-Berghausen, R. Gerike, S. Kahlmeier, M. Laeremans, N. Mueller, T. Nawrot, M. J. Nieuwenhuijsen, J. P. Orjuela, F. Racioppi, E. Raser, A. Standaert, L. Int Panis, and T. Götschi. 2018. "Transport Mode Choice and Body Mass Index: Cross-Sectional and Longitudinal Evidence from a European-Wide Study." *Environment International* 119 (October): 109–16. <https://doi.org/10.1016/j.envint.2018.06.023>.



- Fuller, G. 2018. *The Invisible Killer*. London: Melville House UK. <https://www.mhp-books.com/books/melville-house-uk-the-invisible-killer/>.
- Gerike, R., A. de Nazelle, M. Nieuwenhuijsen, L. I. Panis, E. Anaya, I. Avila-Palencia, F. Boschetti, C. Brand, T. Cole-Hunter, E. Dons, U. Eriksson, M. Gaupp-Berghausen, S. Kahlmeier, M. Laeremans, N. Mueller, J. P. Orjuela, F. Racioppi, E. Raser, D. Rojas-Rueda, C. Schweizer, A. Standaert, T. Uhlmann, T. Götschi, and S. Wegener. 2016. "Physical Activity through Sustainable Transport Approaches (PASTA): A Study Protocol for a Multicentre Project." *BMJ Open* 6 (1): e009924. <https://doi.org/10.1136/bmjopen-2015-009924>.
- Giles, L. V., S. J. Tebbutt, C. Carlsten, and M. S. Koehle. 2018. "The Effect of Low and High-Intensity Cycling in Diesel Exhaust on Flow-Mediated Dilation, Circulating NOx endothelin-1 and Blood Pressure." *PLoS ONE* 13 (2): 1–16. <https://doi.org/10.1371/journal.pone.0192419>.
- Int Panis, L., B. de Geus, G. Vandenbulcke, H. Willems, B. Degraeuwe, N. Bleux, V. Mishra, I. Thomas, and R. Meeusen. 2010. "Exposure to Particulate Matter in Traffic: A Comparison of Cyclists and Car Passengers." *Atmospheric Environment* 44 (19): 2263–70. <https://doi.org/10.1016/j.atmosenv.2010.04.028>.
- Jansen, K. L., T. V. Larson, J. Q. Koenig, T. F. Mar, C. Fields, J. Stewart, and M. Lippmann. 2005. "Associations between Health Effects and Particulate Matter and Black Carbon in Subjects with Respiratory Disease." *Environmental Health Perspectives* 113 (12): 1741–46. <https://doi.org/10.1289/ehp.8153>.
- Janssen, N. A., M. E. Gerlofs-Nijland, T. Lanki, R. O. Salonen, F. Cassee, G. Hoek, P. Fischer, B. Brunekreef, and M. Krzyzanowski. 2012. *Health Effects of Black Carbon*. Bonn: World Health Organization (WHO). <http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/2012/health-effects-of-black-carbon>.
- Janssen, N. A. H., G. Hoek, M. Simic-Lawson, P. Fischer, L. van Bree, H. ten Brink, M. Keuken, R. W. Atkinson, H. R. Anderson, B. Brunekreef, and F. R. Cassee. 2011. "Black Carbon as an Additional Indicator of the Adverse Health Effects of Airborne Particles Compared with PM10 and PM2.5." *Environmental Health Perspectives* 119 (12): 1691–99. <https://doi.org/10.1289/ehp.1003369>.





- Kahlmeier, S., T. Götschi, N. Cavill, A. Castro Fernandez, C. Brand, D. Rojas Rueda, J. Woodcock, P. Kelly, C. Lieb, P. Oja, C. Foster, H. Rutter, and F. Racioppi. 2017. *Health Economic Assessment Tool (HEAT) for Walking and for Cycling. Methods and User Guide on Physical Activity, Air Pollution, Injuries and Carbon Impact Assessments*. Copenhagen, Denmark: WHO.
- Lemoine, P. D., O. L. Sarmiento, J. D. Pinzón, J. D. Meisel, F. Montes, D. Hidalgo, M. Pratt, J. M. Zambrano, J. M. Cordovez, and R. Zarama. 2016. "TransMilenio, a Scalable Bus Rapid Transit System for Promoting Physical Activity." *Journal of Urban Health* 93 (2): 256–70. <https://doi.org/10.1007/s11524-015-0019-4>.
- Morales Betancourt, R., B. Galvis, J. M. Rincón-Riveros, M. A. Rincón-Caro, A. Rodriguez-Valencia, and O. L. Sarmiento. 2019. "Personal Exposure to Air Pollutants in a Bus Rapid Transit System: Impact of Fleet Age and Emission Standard." *Atmospheric Environment* 202 (January): 117–27. <https://doi.org/10.1016/j.atmosenv.2019.01.026>.
- Orjuela, J. P. 2018. "Exploring Methods of Air Pollution Exposure and Intake in Active Populations."
- Smith, K. 1993. "Fuel Combustion, Air Pollution Exposure, and Health: The Situation in Developing Countries." *Annual Review of Energy and the Environment* 18 (1): 529–66. <https://doi.org/10.1146/annurev.energy.18.1.529>.
- Tingvall, C., and N. Haworth. 1999. "Vision Zero: An Ethical Approach to Safety and Mobility." Paper presented at the 6th ITE International Conference "Road Safety & Traffic Enforcement: Beyond 2000," Melbourne, September 6–7.
- Warburton, D. E. R., and S. S. D. Bredin. 2017. "Health Benefits of Physical Activity: A Systematic Review of Current Systematic Reviews." *Current Opinion in Cardiology* 32 (5): 541–56. <https://doi.org/10.1097/HCO.0000000000000437>.



Article

## Response to COVID-19 Employment Creation through Infrastructure Investment



### References

- Ananta, A., and R. Siregar. R. 1999. "Social Safety Net Policies in Indonesia: Objectives and Shortcomings." *ASEAN Economic Bulletin* 16 (3): 344–59. <https://www.jstor.org/stable/25773597>.
- Devereux, S., and C. Solomon. 2006. "Employment Creation Programmes: The International Experience." Discussion Paper. International Labour Office, Geneva. [https://www.ilo.org/wcmsp5/groups/public/---ed\\_emp/documents/publication/wcms\\_120673.pdf](https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_120673.pdf).
- Leduc, S., and D. Wilson. 2012. "Roads to Prosperity or Bridges to Nowhere? Theory and Evidence on the Impact of Public Infrastructure Investment." *NBER Macroeconomics Annual* 27: 89–142. <https://www.nber.org/papers/w18042>.
- Patel, S. 2006. "Empowerment, Co-Option and Domination: Politics of Maharashtra's Employment Guarantee Scheme." *Economic and Political Weekly* 41 (50): 5126–132. <https://doi.org/10.1177/0262728018816404>.
- SACN (South African Cities Network). 2017. "The State of the Expanded Public Works Programme in South African Cities 2016/17." Report of the Expanded Public Works Programme Reference Group, SACN, Johannesburg. <https://www.sacities.net/wp-content/uploads/2020/06/FINAL-South-African-Cities-Network-Annual-Report-2018-2019.pdf>.

## Image credits



Cover Page: Suwin/Shutterstock

Page 4-5: Franz Mahr/World Bank

Page 6-7: Hendri Lombard/World Bank

Page 10, 11, 20: Chan2545/Shutterstock

Page 22, 23, 29: Gaurav Shrishrimal/Shutterstock

Page 30-31: Sarah Farhat/World Bank

Page 42-43: Marmolejos/Shutterstock

Page 44, 45, 51: Dominic Chavez/World Bank

Page 57: Vitpho/Shutterstock

Page 58-59: Salmanlp/Shutterstock

Page 72-73: Gerardo Pesantez/World Bank

