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From car-free days to pollution-free cities

Reflections on clean urban transport in Rwanda

In brief

- East Africa is home to some of the world's fastest growing cities and levels of traffic congestion, air pollution, and vehicle accidents are rising. Rwanda, with its rapidly growing urbanisation rate, faces a major challenge: to decouple the growth of cities and urban mobility from air pollution.
- Using high-quality data, this policy paper adds to existing research on air pollution in the transport sector by using two natural experiments which reduce urban traffic flows considerably: car-free days and the COVID-19 lockdown.
- We find that the quantity of $PM_{2.5}$, the typical measure of air pollution internationally, was reduced by 15% on car-free days.
- We also find that the full COVID-19 lockdown in 2020 reduced air pollution by around 33%, and the partial lockdown which allowed cars but not motorcycles reduced air pollution by around 21%.
- These results emphasise the high significance of the transport sector for air pollution levels and the need for further action to address air pollution from the sector.
- This paper includes policy reflections on key actions that can support the economy while helping keep the air clean.

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Introduction

East Africa is home to some of the world's fastest growing cities and levels of traffic congestion, air pollution, and vehicle accidents are rising. Rwanda's urban population is growing rapidly and the country aims to increase its urbanisation rate from the current 18% to 70% by 2050.[1] Accelerating population and economic growth have already led to a dramatic increase in demand for urban mobility in Rwanda which not only leading to congestion and increases in costly fuel imports but is driving Green House Gas (GHG) emissions and air pollution. Recent research in Rwanda shows that the transport sector and wood & charcoal-burning for cooking are the major sources of air pollution in Rwanda in roughly equal measure.

Rwanda thus faces a major challenge: to decouple the growth of cities and urban mobility from air pollution. Rwanda has developed a policy interest in air pollution over many years, which continues to strengthen; it also has an increasing focus on environmental policy in both urban planning and the transport sector and is updating its Green Growth and Climate Resilience Strategy which enshrines an aspiration to transition to electric vehicles. Implementing Rwanda's ambitious policy vision for green and clean growth will require continual data and analysis.

Using the highest quality dataset on urban air pollution put together for a city in East Africa, analysis in this policy paper adds to existing research on air pollution in the transport sector by using two natural experiments which reduce urban traffic flows considerably: Car-free days and the COVID-19 lockdown. We measure the quantity of $PM_{2.5}$, the typical measure of air pollution internationally, which represents a mixture of various air pollutants, and which is the measure that is of most importance to health risk.[2][3][4] We find that after controlling for the weather and seasonal variability, $PM_{2.5}$ was reduced by 15% on car-free days (which only target certain major urban roads and not all traffic in Rwanda's cities). This reduction is expected to result in more than 200 disability-adjusted life years being saved in Kigali annually (or approximately 10 for each car-free day), and approximately 150 hospital visits and 600 lost working days being avoided. Importantly, however, levels of particulate matter air pollution ($PM_{2.5}$) even on car-free days remain above the annual WHO Guideline air quality limits value, emphasising the need for further action from policymakers.

1. Government of Rwanda, 2020. Vision 2050. https://www.nirda.gov.rw/uploads/tx_dce/Vision_English_Version_2050_-31_Dec_2020.pdf
2. https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health#:~:text=on%20particle%20size.-,PM2.,tissue%20damage%2C%20and%20lung%20inflammation.
3. https://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
4. https://ehjournal.biomedcentral.com/articles/10.1186/s12940-016-0170-8

We also find that the full COVID-19 lockdown in 2020 – which reduced travel activity by over 80% – reduced air pollution by around 33%, and the partial lockdown which allowed cars but not motorcycles – which reduced travel by 41% - reduced air pollution by around 21%. Post-lockdown traffic levels in which motorcycles were re-introduced, were around 20% lower than the pre-lockdown average. These results emphasise the high significance of the transport sector for air pollution levels, and the need for further action to address air pollution from the sector.

We then present some policy reflections on air pollution and the transport. While air pollution and economic growth have risen in tandem in many fast-developing countries until a threshold of income is reached (the so-called environmental Kuznets Curve), new technologies and well-designed government policies can allow Rwanda to improve its economy without the social, environmental and economic costs of air pollution. Urban design interventions, enforcement of emissions standards and vehicle maintenance, a ban on vehicle idling, and continued support for a nascent e-mobility sector, are key actions that can support the economy while helping to keep the air clean.

Rwanda's transport sector and the looming threat from air pollution

Air pollution can cause cardiovascular and respiratory diseases, lung cancer and strokes.[5] It is thus an obvious public health issue related to urbanisation, and the health hazards can have a considerable economic cost. Air pollution ranks as the fourth highest risk factor for premature mortality worldwide, and the highest among environmental risk factors, leading to more than 4 million premature deaths and more than 100 million Disability-Adjusted Life Years (DALYs) annually worldwide (Global Burden of Disease).[6] In 2013 the World Bank indicated that air pollution led to $5.11 trillion in welfare losses, and $225 billion in lost labour income globally. [7]

Rapid population and economic growth have already led to dramatic increases in demand for mobility in Rwanda, especially urban mobility. As of 1999, just 55,000 vehicles had been registered in Rwanda,[8] but this

5. Schraufnagel DE, Balmes JR, Cowl CT, De Matteis S, Jung SH, Mortimer K, Perez-Padilla R, Rice MB, Riojas-Rodriguez H, Sood A, Thurston GD, To T, Vanker A, Wuebbles DJ. (2019) Air Pollution and Noncommunicable Diseases: A Review by the Forum of International Respiratory Societies' Environmental Committee, Part 2: Air Pollution and Organ Systems. Chest. 2019 Feb;155(2):417-426. doi: 10.1016/j.chest.2018.10.041

6. Institute for Health Metrics and Evaluation, http://www.healthdata.org/gbd/

7. World Bank; Institute for Health Metrics and Evaluation. 2016. The Cost of Air Pollution : Strengthening the Economic Case for Action. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/25013

8. Mott McDonald (2018). "Inventory of Sources of Air Pollution in Rwanda: Determination of Future Trends and Development of a National Air Quality Control Strategy". Consultant report commissioned by Rwanda Environmental Management Authority, p52.

increased four-fold to 221,000 vehicles by 2019.[9] Moreover, Rwanda's urban population is growing rapidly and the country aims to increase its urbanisation rate from the current 18% to 70% by 2050.[10] Without intervention, this will lead to further increases in the number of cars, trucks and motorcycles which will not only lead to congestion and increases in costly fuel imports but is driving GHG emissions and air pollution. Rwanda faces a major challenge: to decouple the growth of urban mobility from air pollution, in the context of very rapid urbanisation.

Research from 2018 identifying the sources of air pollution showed that the transport sector and wood & charcoal burning are the key sources of air pollution in Rwanda,[11] and research from 2021 confirmed this, placing the proportions at approximately 40% each for transport and wood & charcoal burning, with 20% coming from industry. [12] Research on Kigali attributes more than half of GHG emissions to the transport sector,[13] [14] and suggests that the transport sector is a major source of $PM_{2.5}$ and NOx, two key urban air pollutants of particular human health concern. Ambient $PM_{2.5}$ in Kigali is reported to average approximately double the WHO recommended limit of 25μg/m^3, emphasising the need for action and the scale of the potential benefit to be achieved.

Under a business-as-usual scenario, the role of the transport sector in producing air pollution could increase as Rwanda urbanises and develops, as research from other countries has shown that in urban areas as much as three-quarters of air pollution may be attributed to motor vehicle emissions (Arup/C40 2014 [15]; UNEP 2014). In European contexts, where most detailed analysis of urban pollution assesses both levels of emissions and their sources, vehicles account for 9 – 53% of PM10, 9 – 66% of $PM_{2.5}$ and over 80% of NO2 pollutants (Cyrys et. al, 2012).[16]

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9. Byiringiro, Alfred, (2020), "Electric mobility in Rwanda: policy and vision for electric mobility", [PowerPoint presentation] Presented at "Scaling up sustainable transport systems in Rwanda" joint MININFRA-IGC workshop in Kigali on 25th February 2020, Ministry of Infrastructure, Rwanda
10. Government of Rwanda, 2020. Vision 2050. https://www.nirda.gov.rw/uploads/tx_dce/Vision_English_Version_2050_-31_Dec_2020.pdf
11. Egide Kalisa, Edward G. Nagato, Elias Bizuru, Kevin C. Lee, Ning Tang, Stephen B. Pointing, Kazuichi Hayakawa, Stephen D. J. Archer, and Donnabella C. Lacap-Bugler. (2018). Characterization and Risk Assessment of Atmospheric $PM_{2.5}$ and PM10 Particulate-Bound PAHs and NPAHs in Rwanda, Central-East Africa. Environmental Science & Technology 2018 52 (21), 12179-12187. DOI: 10.1021/acs.est.8b03219
12. Bahati, Moise, (2021), Vehicles, firewood contribute 80 percent air pollutants in Rwanda, April 28, 2021, https://www.newtimes.co.rw/news/vehicles-firewood-contribute-80-percent-air-pollutants-rwanda
13. Sudmant, Andrew, Sarah Colenbrander, Andy Gouldson and Natasha Chilundika, (2017) "Private opportunities, public benefits? The scope for private finance to deliver low-carbon transport systems in Kigali, Rwanda" Urban Climate, Volume 20, 2017, Pages 59-74, ISSN 2212-0955, https://doi.org/10.1016/j.uclim.2017.02.011
14. Colenbrander, Sarah & Sudmant, Andrew & Chilundika, Natasha & Gouldson, Andy. (2018). The scope for low-carbon development in Kigali, Rwanda: An economic appraisal. Sustainable Development. 27. 10.1002/sd.1906
15. Arup/C40. (2014). Climate Action in Megacities Version 2.0. Retrieved from http://issuu.com/c40cities/docs/c40_climate_action_in_megacities/11?e=10643095/6541335.
16. Cyrys, J et al, 2012. Variation of NO2 and NOx concentrations between and within 36 European study areas: Results from the ESCAPE study. Atmospheric Environment 62, 374–390. https://doi.org/10.1016/j.atmosenv.2012.07.08

A report published in 2018 by the Rwandan Environmental Management Authority (REMA) indicated that vehicles imported to Rwanda before 1999 contribute 58% of nitrogen oxides (NOx) and 66% of particulate matter (PM10).[17] The report also implicated motorcycle taxis as a large source of emissions, accounting for more than half of all NOx emissions. Importantly, however, the study relied on limited on-the-ground air quality testing and did not include air quality testing of vehicles in Kigali, emphasising the need for further analysis for the development of informed policies for addressing air quality. The study also reviewed the literature on air pollution in Rwanda, and found few studies, using short sampling durations and using limited equipment.

Kalisa et al. (2018) conducted a study in Kigali City and found that traffic restrictions on Sundays during Car-free days appear to reduce $PM_{2.5}$ by 30%.[18] A limitation of this study was that it covered only a three-month period leading to a small sample size and restricting the extent to which weather could be identified as a driving factor in air pollutant reductions. Kalisa is also researching and raising awareness of the air quality effects of cars idling during school pickups in Rwanda; this is common but can increase children's exposure to pollution and exacerbate respiratory diseases.[19]

In order both to inform transport policy and initiatives, and to track progress on air pollution, further data-gathering and analysis are warranted to buttress the limited literature so far. In this policy brief and a subsequent piece, we aim to provide additional air pollution analysis and review it through an economic lens.

Air pollution and the transport sector: Rwanda's policy context

Rwanda's interest in air pollution mitigation goes beyond its much-publicised Car Free Day. In 2016, Rwanda established a "Law governing the preservation of air quality and prevention of air pollution in Rwanda" which covers the transport sector, waste incineration, industry, construction, and other sources[20]. This law led to the development of the Rwanda Air Quality

17. Mott McDonald (2018). Inventory of Sources of Air Pollution in Rwanda: Determination of Future Trends and Development of a National Air Quality Control Strategy. Consultant report commissioned by Rwanda Environmental Management Authority.
18. Kalisa, Egide, Edward G. Nagato, Elias Bizuru, Kevin C. Lee, Ning Tang, Stephen B. Pointing, Kazuichi Hayakawa, Archer, Stephen D. J. and Donnabella C. Lacap-Bugler (2018), "Characterization and Risk Assessment of Atmospheric $PM_{2.5}$ and PM 10 Particulate-Bound PAHs and NPAHs in Rwanda, Central-East Africa" Environmental Science and Technology 2018 52 (21), 12179-12187 DOI: 10.1021/acs.est.8b03219
19. Ashimwe, Edwin, (2020), Students and air pollution: The effects, December 23, 2020, https://www.newtimes.co.rw/lifestyle/students-and-air-pollution-effects
20. Government of Rwanda, (2016) "Law No. 18/2016 of 18/05/2016 Governing The Preservation Of Air Quality And Prevention Of Air Pollution In Rwanda", Official Gazette no 23 of 06/06/2016, Kigali: Government of Rwanda

and Climate Change Monitoring Project, started in 2017.[21] In Kigali the project monitors air quality from a reference station at the Meteo Rwanda headquarters and from low-cost air quality networks in 8 other cities.[22]

The major policy guiding the transport sector has been the Transport Sector Strategic Plan (2013-2018),[23] which has "green economy" as a priority area and deals with public transport and non-motorised transport extensively although does not explicitly mention air pollution, health or carbon emissions. However, a Ministerial Order from 2010 made it mandatory for exhaust fumes of motor vehicles to be included in the annual road worthiness test for vehicles,[24] [25] and traffic police have acquired mobile and handheld emissions inspection equipment for spot checks, although as of 2019 they were not yet in effective use.[26]

Rwanda's Ministry of Infrastructure (MININFRA) prepared a National Transport Policy which was recently ratified by Cabinet in April 2021. MININFRA is also planning to develop a new National Transport Master Plan and the terms of reference for developing this include green mobility, climate change and low carbon growth as a cross-cutting area.[27]

The Government also has ambitious plans to scale up electric motorbike taxis and electric buses, starting in Kigali. In May 2020 the Ministry of Environment released Africa's first updated Nationally Determined Contribution (NDC) to the IPCC, and outlined electric vehicles and vehicle emissions standards as important mitigation measures expected to require investment of 900 million USD and 190 million USD respectively.[28]

21. FONERWA, (2016), "Rwanda Air Quality and Climate Change Monitoring Project", http://www.fonerwa.org/sites/default/files/Final%20PD%20Air%20Quality%20and%20Climate%20Change%20Monitoring%20Project%20%2020th%20August.pdf
22. Environmental Compliance Institute, Ministry of Environment and Rwanda Standards Board, (2018) "Rapid situational assessment: Towards developing/revising air quality (internal combustion engine emission) standards for Rwanda", https://www.eci-africa.org/wp-content/uploads/2018/10/Rwanda-AQ-Stds-Quick-Assessment_Final_ECI-13.07.18.pdf
23. Ministry of Infrastructure, (2018) "Transport Sector Backward Looking Joint Sector Review Report", Kigali: Government of Rwanda, https://www.mininfra.gov.rw/fileadmin/user_upload/Mininfra/Documents/Transport_Docs/Transport_Sector_2017-18_Backward_Looking_Joint_Sector_Review_Report.pdf
24. Environmental Compliance Institute, Ministry of Environment and Rwanda Standards Board, (2018) "Rapid situational assessment: Towards developing/revising air quality (internal combustion engine emission) standards for Rwanda"
25. Government of Rwanda, (2010) "Ministerial Order No. 003/16/01 of 15/07/2010 Preventing Activities that Pollute the Atmosphere, Official Gazette no 35 of 30/08/2010, Kigali: Government of Rwanda
26. Nshizirungu, Fabien, (2019) "Air Emissions Control and Air Quality In Rwanda" Rwanda Standards Board, 2019, http://airqualityandmobility.org/PDFs/ECOWAS2019/Needtolinkwithvehicleemissions.pdf
27. Imvaho Nshya, (2021) "RTDA: Consulting Services for Developing a National Transport Master Plan", Imvaho Nshya, February 8 2021, http://imvahonshya.co.rw/rtda-consulting-services-for-developing-a-national-transport-master-plan/
28. Ministry of Environment, (2020) "Republic of Rwanda: Updated Nationally Determined Contribution", Kigali: Government of Rwanda, 2020

In April 2021 an electric mobility strategy was approved in Cabinet, containing tax incentives for e-mobility inputs, lower electricity tariffs, and other incentives.[29] [30] Rwanda also plans to scale up electric buses.[31]

At the municipal level, City of Kigali has developed the Kigali Master Plan, which was updated in 2020 and includes transport planning, operates on a principle of transit-oriented development and has a Green Economy pillar. This pillar includes the following goals that are relevant to air pollution: i) develop a high-quality mass-transit system; ii) develop a road network that supports mass transit systems; iii) integrate non-motorised Transport Infrastructure including cycle lanes into the road network; iv) establish green transportation network and pedestrian-friendly streets in Kigali; v) provide seamless intermodal transport connectivity. Master plans are also being developed for the six secondary cities that are likely to contain similar principles.

In sum, Rwanda has an ambitious vision to reduce GHG emissions and air pollution from the transport sector, but this will require continual data and analysis.

Findings on the impact of the transport sector in Kigali on air pollution

This study looks at the implementation of car-free days on certain major roads in Kigali every second Sunday, and the lockdown during March-May 2020, in order to understand the role of the transport sector in urban air pollution. In both cases, air quality data is assessed from three sites across the city, and weather data and information on mobility patterns in the city are drawn from Google.[32] These allow for an analysis of the air quality at a level of detail that has previously not been possibly in East Africa.

Air pollution during car-free days in Kigali

Started in 2016, car-free days initially took place once a month in Rwanda, during which major roads were blocked off to provide space for collective exercise sessions objective to promote healthy living. In 2018, Car Free Day was made fortnightly and extended to other secondary cities of Rwanda. In addition to providing opportunities for exercise and socialising, car-free days have also been used as an opportunity to screen for non-communicable diseases in the population, such as cancer, heart disease and diabetes

29. Office of the Prime Minister (2021), "1/2 Statement on Cabinet Resolutions of 14/04/2021", Twitter, https://mobile.twitter.com/PrimatureRwanda/status/1382447988132474886/photo/2
30. Global Green Growth Institute (2021), "Rwanda E-Mobility Technology Showcase", Youtube, https://www.youtube.com/watch?v=gexSg8_W6_k
31. Nkurunziza, Michel, (2021) "Transition to electric motorbikes could save Rwf9 billion annually", New Times, January 26, 2021, https://www.newtimes.co.rw/business/electric-motorbikes-could-save-rwf9-billion-annually
32. Google (2021), "COVID-19 Mobility Reports", https://www.google.com/covid19/mobility/

(Kabakambira et al., 2019[33]; Subramanian et al., 2019[34]).

Figure 1: People exercising during car-free day in Kigali

We compared hourly air pollutant concentrations of $PM_{2.5}$ on Kigali's car-free days with those on normal Sundays. Our results, in Figure 2, show significantly lower levels of $PM_{2.5}$ between 5am and 4pm. While this period extends beyond the time roads are closed it is consistent with the expectation that drivers planning trips that would even partially overlap with the lockdown would cancel or reschedule their trips.

After accounting for weather, car-free days are found to reduce $PM_{2.5}$ by approximately 15%, leading to a 3.7% reduction in total $PM_{2.5}$ pollution in the city annually. Importantly, however, 24-hour mean levels are found to remain above of WHO recommended limits for ambient $PM_{2.5}$ (25μg/m^3). Google mobility data shows that travel activity (by number of vehicles) overall in the city is, on average, 27% lower on car-free days relative to normal Sundays. This does provide evidence that air pollution can be attributed to the transport sector, but the link is somewhat weaker than expected, and implies that even to the extent car-free days can be expanded – to more roads in the city or over a larger of days – they would be unlikely to achieve large reductions in air pollution on their own.

33. Kabakambira, J.D., Bitwayiki, R.N., Mujawamariya, G., Iii, D.E.L.-P., Mucumbitsi, J., (2019). Kigali Car Free Day: An Innovative Model in the Fight against Non-Communicable Disease Pandemics, Rwanda Medical Journal, Vol. 76, No. 3, 2019, pp. 1-5

34. Subramanian, R., Malings, C., Tanzer, R., Presto, A., Robinson, A., Kagabo, A.S., Gasore, J., Jaramillo, P., Feron, A., Formenti, P., Beekmann, M., (2019). "Spatio-temporal variability in urban air quality, source impacts, and pollution controls in Pittsburgh, Kigali, and Paris with well-characterized low-cost sensors". Geophysical Research Abstracts . 2019, Vol. 21.

Figure 2: Impact of limiting vehicular traffic on Sunday mornings in Kigali, Rwanda

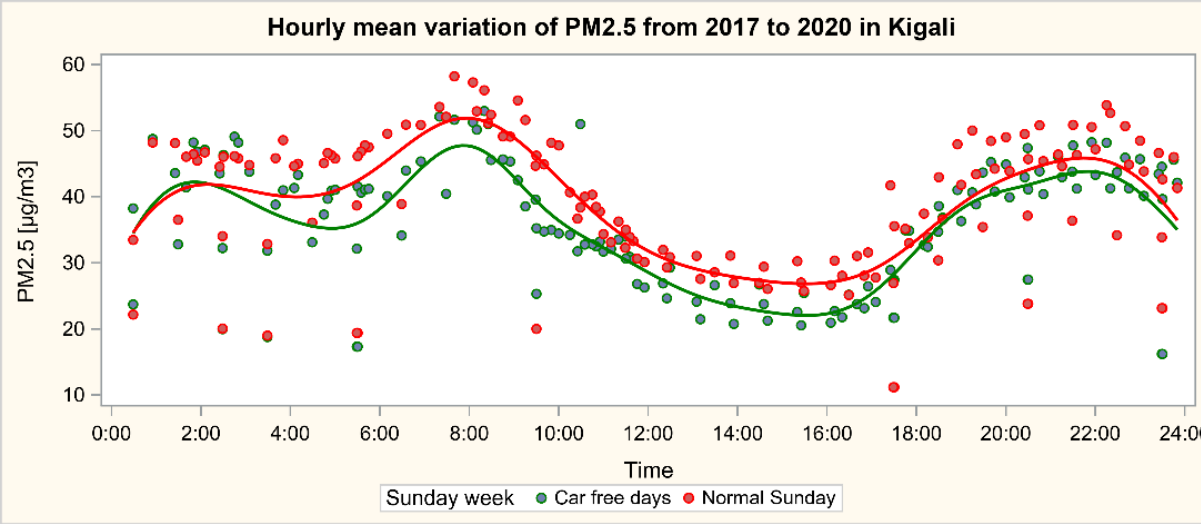


Table 1 summarises the health and economic benefits from this reduction in air pollution. Across the period from 2021-2025, 26 car-free Sundays annually is expected to save almost 1000 disability-adjusted life years, avoid more than 600 hospital admissions and prevent illnesses that otherwise would have resulted in more than 3300 lost working days.[35] Collectively, these benefits are worth 21.4 million USD. In addition to revealing the substantial scale of health and economic benefits attributable to car-free days, these figures provide insight into the scale of potential benefit from future measures to improve air quality: Policies that could achieve a daily reduction of emissions comparable to what has been achieved on Sundays by car-free days could achieve almost $150 million in health and economic benefits for the city, equivalent to approximately 1.5% of national GDP.

35. Key information on all-cause mortality and hospital admissions are drawn from: Dagenais, Gilles R., Darryl P. Leong, Sumathy Rangarajan, Fernando Lanas, Patricio Lopez-Jaramillo, Rajeev Gupta, Rafael Diaz et al. "Variations in common diseases, hospital admissions, and deaths in middle-aged adults in 21 countries from five continents (PURE): a prospective cohort study." The Lancet 395, no. 10226 (2020): 785-794. Dose response functions are drawn from: Gowers AM, Miller BG and Stedman JR, (2014). 'Estimating Local Mortality Burdens associated with Particulate Air Pollution' Report number PHE-CRCE-010, Public Health England Centre for Radiation and Chemicals in the Environment, Didcot, Oxfordshire. The value of a statistical life in Rwanda is drawn from: Robinson, L.A., Hammitt, J.K. and O'Keeffe, L., 2019. Valuing mortality risk reductions in global benefit-cost analysis. Journal of Benefit-Cost Analysis, 10(S1), pp.15-50.

Table 1: Public health and economic impact of car-free days

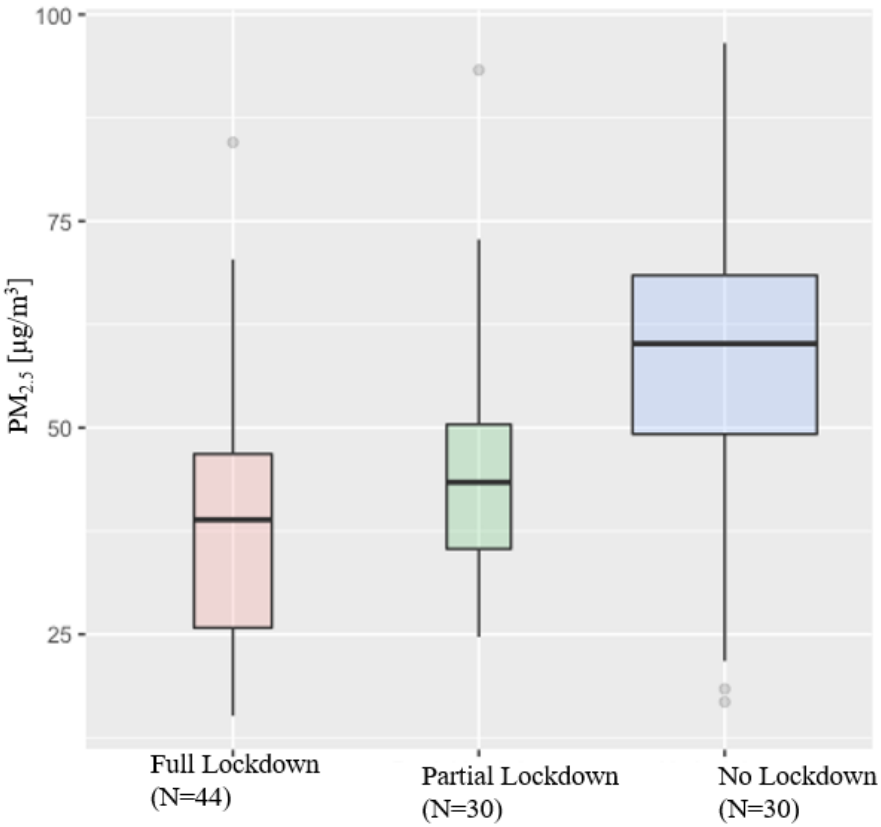
Benefit Type	2021-2025
Disability adjusted life-years saved	1191
Respiratory hospital admissions avoided	726
Cardiovascular-related hospital admissions avoided	179
Additional working days	3979
Economic savings (from avoided hospital visits, additional working days and the value of statistical lives saved, millions)	21.4

Air pollution during the 2020 COVID-19 lockdown

The 2020 COVID-19 lockdown provides a unique opportunity to explore the sources of air pollution in Kigali. We find that $PM_{2.5}$ emissions dropped by 33% with the imposition of the first lockdown (March 22 – May 4th), as shown in Figure 3. During the second, or partial lockdown that followed (May 5- June 3rd), vehicles that deliver food and essential services, and government vehicles, were allowed to return to the roads but private vehicles were not; this reduced air pollution by 21% over baseline levels. In Figure 4 travel activity in Kigali accessed from Google Mobility[36] data is presented. During the full lockdown travel activity was reduced by more than 80% and during the following 'partial lockdown' activity was on average 41% below expected levels. In the months that followed to the end of 2020, travel activity was 10-20% below expected levels.

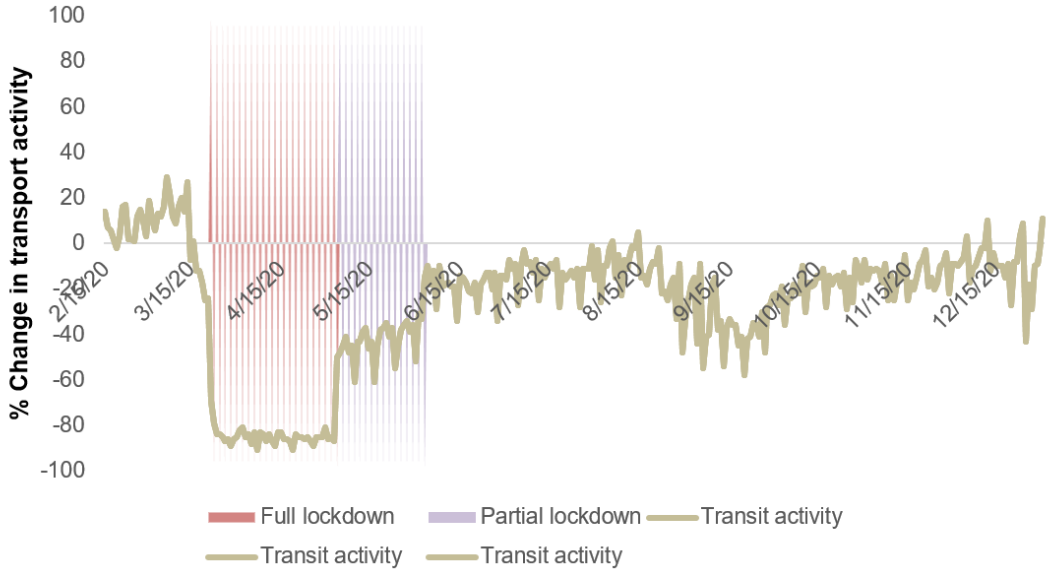
36. Baseline travel activity is defined by Google as "a recent period, before widespread disruption as communities responded to COVID-19" and data collected from Google connected applications and services (https://support.google.com/covid19-mobility/answer/9824897?hl=en). Data is aggregated regionally, preventing identification of specific users but limiting granular analysis of the data that could confirm its validity. Further analysis is therefore required to provide locally sourced information on travel activity

Figure 3: $PM_{2.5}$ during full lockdown, partial lockdown and without lockdown in Kigali



Each box covers 50% of daily recorded values. The middle line represents the median. The lines extending about and below each box are set to 1.5 times the interquartile range.

Figure 4: $PM_{2.5}$ and travel activity before, during and after the 2020 COVID-19 lockdown



The sharp decline in both travel activity and air pollution levels during the lockdown align with evidence from the Rwandan government and wider academic literature that the transport sector is a major contributor to urban air quality. However, the rise in air pollution during the partial lockdown period, and the return of high levels of air pollution in Kigali despite continued reductions in road travel activity suggests that wider sources of air pollution are also important. A multi-sector approach to addressing urban air quality is therefore needed for Kigali to achieve WHO recommended levels of air quality.

Policy reflections

If the 20th century was the "century of the car" (Miller, 2001) the 21st has seen a dramatic turn in the way policymakers and the public are thinking about urban mobility and urban living. Helsinki, Hamburg, Madrid, Vienna and Oslo are among a growing number of cities that have announced plans to become partially car-free. London, New York, Stockholm, Oslo, Singapore and potentially São Paulo are among the cities implementing charges on private cars to access certain areas of the city. "Bicycle Mayors" have been designated in Nairobi, Gaberone, Kampala, and Cape Town, and Paris, Berlin, Bogota and Philadelphia, are among the cities that substantially and permanently increased bike lanes during the COVID-19 pandemic.

This shift is in part a reflection of a growing awareness that air pollution is an economic growth issue and comes with substantial social, economic and environmental costs. Indeed, air pollution ranks as the fourth highest risk factor for premature mortality worldwide, and the highest among environmental risk factors, leading to more than 4 million premature deaths and more than 100 million Disability-Adjusted Life Years (DALYs) annually worldwide (Global Burden of Disease).[37] In 2013 the World Bank indicated that air pollution led to $5.11 trillion in welfare losses, and $225 billion in lost labour income globally.[38]

At the same time, this shift also reflects the opportunity provided by new technologies and businesses who are providing alternatives to private vehicles. In Kigali, Ampersand, Gura, Rwanda Electric Motorcycles, and others, are demonstrating that an e-mobility future can decouple economic growth from rising air pollution and GHG emissions.

Rwandan policy – including city master plans – is ambitious and now aims to shift from a transport network structured around private vehicles to

37. Institute for Health Metrics and Evaluation, http://www.healthdata.org/gbd/
38. World Bank; Institute for Health Metrics and Evaluation. 2016. The Cost of Air Pollution : Strengthening the Economic Case for Action. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/25013

one that relies more on well-functioning public transport, non-motorised transport and shared low carbon mobility options. This requires not just policy intention but also follow-through, planning, investment, institutional capacity and coordination. Thus, simply extending car-free days is clearly not the answer but provides a taste of the benefits of a less car-oriented city with clean mobility options.

Congestion can be managed by optimising road capacity and scaling both public transport and last-mile connectivity

Congestion increases air pollution and poses a health risk for drivers, commuters and individuals living near major roads; it "can change driving patterns, resulting in an increased number of speedups, slowdowns, stops and starts, which increase emissions compared to "cruise" conditions", according to Zhang et al. (2013).[39]

Bajpai wrote in 2014 that to address congestion and increase road capacity, "the priority [for Kigali] should be to first optimise the use of existing road capacity by implementing proper traffic engineering and management measures and in parallel, taking actions to improve the service reliability of buses operated by private firms".[40] As noted, the Government of Rwanda is already working to scale up and improve public transport and implement some bus lanes, and the Kigali Master Plan contains a transport plan that includes a Bus Rapid Transit system. Considerable challenges remain, but Rwanda's policy aspirations are laudable.

Whilst several high- and middle-income countries have implemented congestion charges successfully, and Mumbai[41] and Bangalore[42] in India have done so, they may not be appropriate for Rwanda at this point. First, Bajpai states that congestion charging is a high cost and high- capacity intervention, and notes that there are lower-cost interventions that Rwanda can still optimise such as traffic engineering, reallocation of road space to bus lanes and improvements to public transport. Second, a paper on congestion charging in Bangalore (Kreindler et al., 2018) found that in stark contrast to high income countries, a "peak spreading" congestion charge did not increase welfare because drivers were simply unresponsive to the charge and did not change their travel patterns. The authors' interpretation was that commuters did not value a lower travel duration at an alternative time more than the ability to travel at their chosen time.

39. Zhang K, Batterman S (2013). "Air pollution and health risks due to vehicle traffic". Sci Total Environ.450-451:307-316. doi:10.1016/j.scitotenv.2013.01.074
40. Bajpai, Jit (2014). "The Role of the Government in Sustaining Mobility and Accessibility in Rwanda". Working Paper, International Growth Centre. Unpublished.
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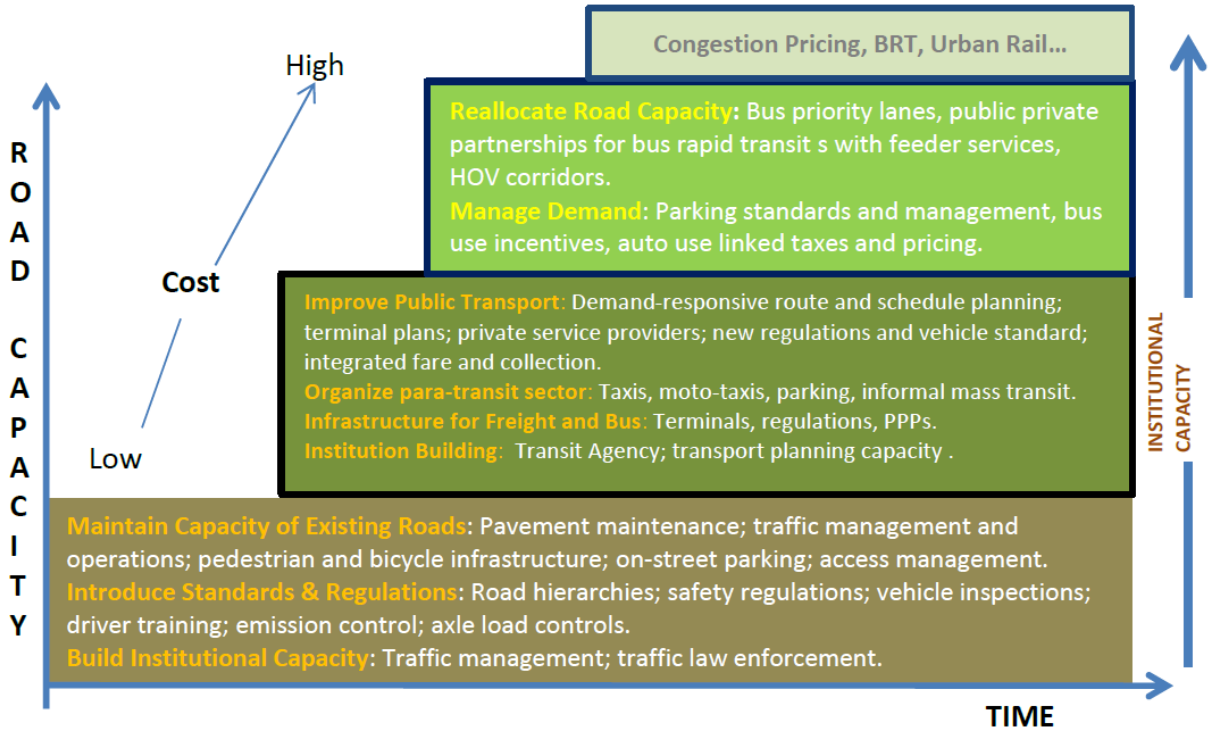
42. Kreindler, Gabriel, Esther Duflo, and Ben Olken (2018), "Benefits and costs of road traffic congestion pricing: Evidence from Bangalore", Policy Brief, International Growth Centre, https://www.theigc.org/wp-content/uploads/2018/08/India-89415.pdf

Third, in a post-COVID world in which Rwandans already baulk at the cost of multiple business taxes[43] and of increased (yet still modest on the continent) property tax[44], an additional charge would probably be politically difficult to implement.

So instead of congestion charging, a "complete streets" approach is needed that provides space for public transport and non-motorised transport. Far in excess of 90% of transport infrastructure in global urban areas is public roads for private vehicles. If applied in Kigali, such an approach which prioritises private cars is likely to lead only to more congestion, reduced air quality, and higher fuel imports. To contribute to the planned transport-oriented development approach in the Kigali Master Plan, e-motos can provide essential 'last-mile' connectivity between bus rapid transit stations and people's homes; this requires that well-placed charging stations and motorbike parking are integrated into city plans.

Figure 5: The complementarities of institutional development, sequenced transport development, and road capacity



Source: Bajpai (2014)[45]

43. Kantengwa, Sharon (2019), "What to know before starting a business", New Times, May 24, 2019, https://www.newtimes.co.rw/lifestyle/what-know-starting-business
44. Ashimwe, Edwin (2021), "Govt makes U-turn on property tax", New Times, March 17, 2021, https://www.newtimes.co.rw/news/govt-makes-u-turn-property-tax
45. Bajpai, Jit (2014) The Role of the Government in Sustaining Mobility and Accessibility in Rwanda. Working Paper, International Growth Centre. Unpublished.

Facilitate transport sector data sharing to use in research and planning

Information generated by the growing number of third-party transport operators in Rwanda can provide valuable insights into travel patterns. Anonymised sharing of this data – with the knowledge and consent of users – could be useful for planning by both public and private actors to maximise road capacity and minimise congestion. For example, new swapping or changing stations can be situated near areas of high demand. Current practice for data gathering, relying on roadside vehicle counts, is costly, time consuming, suffers from consistent biases, and the data generated by this process is not publicly available. National actors are well positioned to review standards around data collection, management, dissemination and sharing. Rwandan policymakers can look to Mexico City, where basic anonymised data from the city's bike-sharing scheme is made available online.[46] Around data regulation, the General Data Protection Regulation in the European Union provides a set of common standards that provide the public with confidence in how their data is gathered, stored and used.[47]

A focus on vehicle maintenance, testing and the enforcement of vehicle standards would be most effective

To clamp down on air pollution in the current vehicle stock, the Government of Rwanda, along with the East African Community, may be considering lowering the maximum age of imported cars to 5 years.[48] [49] However, research from Kenya by Mbandi et al. (2019),[50] shows that vehicle age is not a good proxy for vehicle emissions; other variables such as mileage, engine size, vehicle weight, retention of original emission control technology and crucially, maintenance status, are very important predictors of vehicle emissions, as is the fuel type. The Government's primary objective of reducing emissions and air pollution might be better served through policies that directly target this goal. Imports of passenger vehicles currently comprise just under 10% of the vehicle stock and this will fall if an age restriction is implemented.

An effective policy option in our view would prioritise enforcement of emissions testing and standards both for vehicle imports and for the existing vehicle stock. Rwanda could implement a similar policy not only for imports but for the entire vehicle fleet. Additionally, the policy should target efforts

46. Gobierno de la Ciudad de Mexico, Open Data, https://www.ecobici.cdmx.gob.mx/en/informacion-del-servicio/open-data
47. European Union, General Data Protection Regulation, https://gdpr.eu/
48. MediaMax (2018), "Clock ticks for EAC to enforce vehicle age limit", Trade Mark East Africa https://tinyurl.com/clockticksforeac
49. The East African (2017), "Second-hand cars to get more expensive in new age limit rule", May 26, 2017, https://www.theeastafrican.co.ke/tea/business/second-hand-cars-to-get-more-expensive-in-new-age-limit-rule-1366486
50. Mbandi, Aderiana Mutheu, Jan R. Böhnke, Dietrich Schwela, Harry Vallack,Mike R. Ashmore and Lisa Emberson (2019). Estimating On-Road Vehicle Fuel Economy in Africa: A Case Study Based on an Urban Transport Survey in Nairobi, Kenya. Energies 2019, 12, 1177; doi:10.3390/en12061177

at older, larger diesel vehicles that are not well maintained and that emit a disproportionate amount of air pollution and greenhouse gas emissions.

Engine idling should be banned on public roads and the ban well-communicated

When dropping off and picking up and their children from Rwanda's urban schools, parents often leave their car engines idling. Egide Kalisa, a Rwandan-born air quality researcher and postdoc at the University of Toronto, has begun research on the effects of air pollution on kindergarten and elementary school children in Rwanda. A ban on vehicle engines idling outside schools and hospitals would reduce emissions around children and hospital patients and visitors. This could even be extended to a fine on car idling on public roads; the UK has such a measure but is considering strengthening enforcement after recommendations from Public Health England.[51] [52] For schools, this could be accompanied by other measures – schools might try to locate students away from busy roads where possible, plant trees around the school to absorb some of the pollution, and encourage children to take public transport or walk to school if distance and child maturity allow. This would be most effective if paired with a public communication campaign championed by senior policymakers.[53]

Electric mobility is the future

Whilst reducing reliance on cars and increasing reliance on public transport are vital, it will be very hard to eliminate cars, so another solution that will reduce air pollution will be to eventually electrify all road vehicles. Indeed, the Government of Rwanda aims to rapidly transition to electric motorbikes (e-motos), and eventually to electric vehicles more broadly, and recently passed an Electric Mobility Strategy through Cabinet in April 2021 containing a set of fiscal and non-fiscal incentives that had been developed in close collaboration with the nascent electric vehicle industry.[54] [55]

An eventual shift to electric vehicles is inevitable. Whilst policy is needed at this early stage to speed up the scale-up of e-motos and e-buses, the cost of new electric cars may match and begin to drop below that of new

51. RAC (2020), "Engine idling - why it's so harmful and what's being done", https://www.rac.co.uk/drive/advice/emissions/idling/
52. Busby, Mattha (2019), "Patience exhausted: UK drivers who sit with engines idling could face instant fines", May 14, 2019, https://www.theguardian.com/environment/2019/may/14/patience-exhausted-drivers-who-sit-with-engines-idling-could-face-instant-fines
53. Ramírez, A. S., Ramondt, S., Van Bogart, K., & Perez-Zuniga, R. (2019). "Public Awareness of Air Pollution and Health Threats: Challenges and Opportunities for Communication Strategies To Improve Environmental Health Literacy". Journal of health communication, 24(1), 75–83. https://doi.org/10.1080/10810730.2019.1574320
54. Office of the Prime Minister (2021), "1/2 Statement on Cabinet Resolutions of 14/04/2021", Twitter, https://mobile.twitter.com/PrimatureRwanda/status/1382447988132474886/photo/2
55. Global Green Growth Institute (2021), "Rwanda E-Mobility Technology Showcase", Youtube, https://www.youtube.com/watch?v=gexSg8_W6_k

combustion engine cars by 2025,[56] so eventually economics will dictate that electric cars will dominate. An important caveat is that in 2025, Rwanda is likely to still be largely reliant on imported second-hand vehicles for affordability reasons, so affordable electric cars will take longer to reach the market. However, the Government can – and is already – speeding up the process of EV uptake with proactive policy initiative, and this is to be celebrated from an air pollution perspective. Another key will be to ensure a clean electricity supply; whilst Rwanda is opening significant peat power plant capacity,[57] hydropower also contributes fully half of the country's energy mix.[58]

Coordination between Rwanda's nascent e-moto industry and government transport and land use programs and planning will be critical to optimise coordination and communication. As such, the Government's plan to develop an electric mobility working group is welcome. Ideally wider actors would be welcome at working group events: bus operators, the electricity utility, the regulator, the academic community, and development partners all have a stake in the future of mobility in Rwanda and can bring important insights. This task force will also have an important role to play in establishing standards around battery safety and charging, battery infrastructure, payment methods, and possibly the e-vehicles themselves, in the same participatory manner in which the Electric Mobility Strategy was developed.

Develop a framework for the use of carbon credits to stimulate finance for e-mobility firms without double-counting of emissions

In May 2020 the Rwandan Ministry of Environment released Africa's first updated Nationally Determined Contribution (NDC) to the IPCC, and outlined electric vehicles and investments in public transport infrastructure investments as important "conditional" mitigation measures expected to require investment of 900 million USD and 50 million USD respectively (in addition to 190 million USD of unconditional domestic spending needed on vehicle emission standards).[59] Realising this level of external investment can be supported by developing a framework for the regulation of carbon credits, because a regulation that clarifies which activities are eligible for generation of carbon credits would eliminate the risk of double-counting and in the process would significantly increase the value of carbon credits.

56. Busby, Mattha (2019), "Patience exhausted: UK drivers who sit with engines idling could face instant fines", May 14, 2019, https://www.theguardian.com/environment/2019/may/14/patience-exhausted-drivers-who-sit-with-engines-idling-could-face-instant-fines
57. Mwai, Collins (2019), "Rwanda looks to narrow energy supply-demand gap", June 26, 2019, https://www.newtimes.co.rw/news/rwanda-looks-narrow-energy-supply-demand-gap#.X039uL0Gz60.whatsapp
58. Rwanda Energy Group (n.d.) "Hydro Power in Rwanda", https://www.reg.rw/what-we-do/generation/hydro-power/
59. Ministry of Environment, (2020) "Republic of Rwanda: Updated Nationally Determined Contribution", Kigali: Government of Rwanda, 2020, https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Rwanda%20First/Rwanda_Updated_NDC_May_2020.pdf

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