Chapter Five

Prospects for Decarbonizing Transport in Africa

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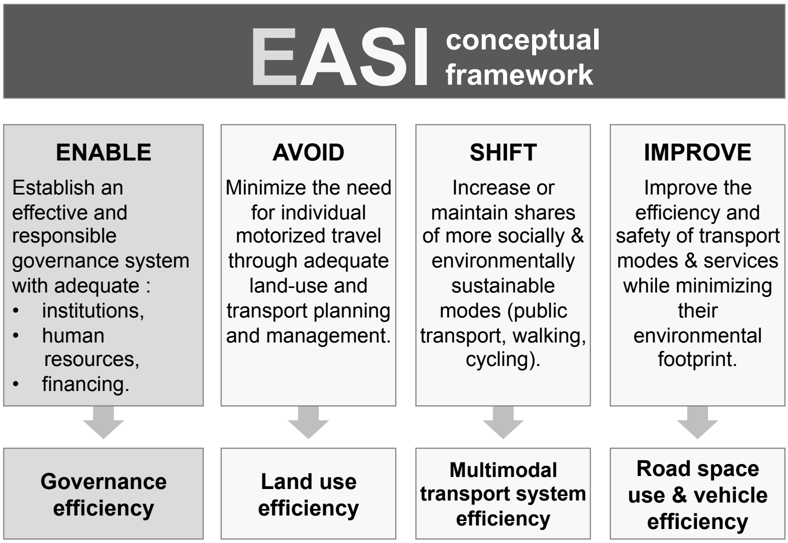
In 2014, Africa was responsible for only 3% of world's total CO_2 emissions, and only 4% of world's *transport-related* CO_2 emissions. CO_2 emissions from transport in Africa are quite low by world standards, but are nonetheless an important cause for concern for those interested in stemming the onset of global warming, for several reasons. First, the intensity of transport-related CO_2 emissions in Africa relative to economic output is high by world standards; as African economies grow, therefore, CO_2 emissions from transport will grow relatively faster in Africa than in other world regions. Second, the proportion of CO_2 emissions that comes from transport is higher in Africa than almost all other regions. On a per-capita basis, transport CO_2 emissions are already growing faster than any other source of energy-related CO_2 emissions across the continent.[1] Third, notwithstanding this already high growth, most of Africa's growth trajectory in transport has yet to occur. Africa is the fastest urbanizing region in the world, and with urbanization comes motorization—that is, the adoption and use of motor vehicles. Exacerbating this situation is that, for the foreseeable future, most of this added vehicle stock, particularly among light-duty vehicles, will come from importation of second-hand vehicles from other world regions, meaning that—all else being equal—other regions will benefit from efficiency and carbon-reducing technologies before Africa.

In this context, then, a key question will be what are the prospects for African transport to decarbonize. This chapter provides a brief, qualitative survey of the prospects for decarbonization of the transport sector in Africa. It relies on the EASI conceptual framework, put forward by the Africa Transport Policy Program to structure the discussion.[2] This framework allows for a policy-based decomposition of the sources of CO_2 growth. The analytical components of the EASI framework are shown in Figure 1.

1. International Energy Agency, "Per capita CO2 emissions by sector," IEA CO2 Emissions from Fuel Combustion Statistics online database (by subscription), (Paris, IEA, 2017).

2. M. Stucki, *Policies for Sustainable Accessibility and Mobility in Urban Areas of Africa* (Washington, DC, Africa Transport Policy Program (SSATP), 2015).

Figure 1. EASI Conceptual Framework



Source: M. Stucki, *Policies for Sustainable Accessibility and Mobility in Urban Areas of Africa* (Washington, DC, Africa Transport Policy Program (SSATP), 2015).

In this framework, each of the elements above can be understood to contribute to potential CO_2 emissions reduction from the sector, when considered against a hypothetical business-as-usual case. *Enable* as a category contributes only indirectly; the ability of governments and governance systems to organize themselves in a manner that can generate CO_2 emissions savings through *Avoid*, *Shift*, or *Improve* methods depends on the governance and institutional aspects of the Enable pillar.

Avoid refers to the minimization of the need for individual motorized travel, generally through adequate land-use and transport planning, consistent implementation of plans, and effective management of land-development processes. *Shift* refers to shifting *over time* the per unit carbon intensity of the modal mix of travel. This generally means reducing the amount of vehicle kilometers of travel by migrating the toward higher numbers of higher-capacity vehicles and improving utilization rates. *Improve* refers to minimizing the per kilometer CO_2 emissions of vehicles by a combination of better vehicles, better drivers, better road conditions, and the decarbonization of fuels and drive-trains themselves.

The remainder of this chapter examines the prospects for each of these approaches in the decarbonization of transportation in the African context.

Avoid: Heading Off the Need for Motorized Transport

Idealized Solution: Urban Context

In most world regions, a conventionally effective way to reduce energy consumption—and with it, GHG-related emissions—on an urban and metropolitan level is to develop and implement mutually supportive land-use and transport plans in a way that avoids the need for motorized transportation demand (current and/or future). The ideal approach would take advantage of highly-populated urban settings which are both compact and dense. Land areas in such an urban space would be developed in a way to facilitate mixed primary uses, and would be easily walkable and cyclable.

African Reality: Urban Context

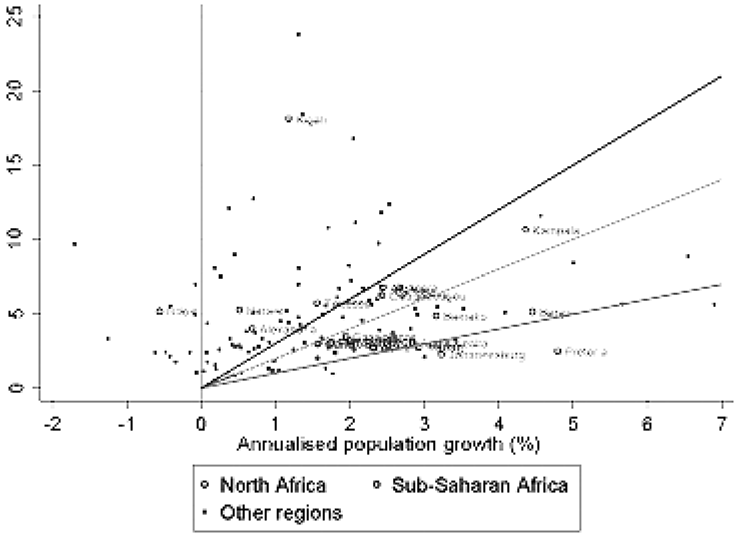
In Africa, however, the notion of avoiding motorized travel through development of compact, dense cities is challenged by two phenomena: developing compact, dense cities in Africa is actually quite difficult, and if it is done well, in the short run, it is likely to—and should—generate *more*, not less, motorized travel.

Several factors make development of compact and dense cities difficult in the African context. The first is time itself. Compact cities require planning and infrastructure investment to nurture their harmonious growth. But the rate of urban growth is so rapid that both planning and infrastructure investment are swamped by it. Cities in Africa are growing so fast that by 2035, the urban population in sub-Saharan Africa (SSA) will be equal to the *total* population of Africa in 2005. In 1990, Africa as a whole had only one urban agglomeration larger than 5 million people; by 2030, it will have 18. By 2050, over 750 million more people will live in sub-Saharan African cities than in 2015.[3]

If Africa's cities are growing at unprecedented rates in terms of population, they are growing even faster in terms of land consumed. A recent compilation of data from 119 cities found that the built-up area of cities in Africa grew at 2.5 times the rate of population growth from 1990 to 2000 (as shown in

3. United Nations, *World Urbanization Prospects: The 2014 Revision* (New York, UN Department of Economic and Social Affairs, Population Division, 2014), CD-ROM Edition.

Figure 2. African Cities' Expansion of Built-up Areas and Population growth, 1990-2000



Source: African Development Bank, OECD Development Centre and United Nations Development Program, *African Economic Outlook 2016: Sustainable Cities and Structural Transformation*. African Economic Outlook. (Abidjan, Paris, New York, 2016).

Figure 2).[4] This means that population densities in African cities are declining over time.

A second key constraint is that land markets do not function as well as they do in other world regions.[5] The traditional focus of development institutions in this respect is on developing those aspects of the land-market that are within the purview of the public sector—cadasters, taxation, business processes, etc. But even private sector roles within land markets, such as titling, insurance, appraisal, and brokerage, are poorly developed in Africa. This is important, because creating compact, dense cities means creating nodes where accessibility value is captured into land transactions. But if the

4. African Development Bank, OECD Development Centre and United Nations Development Program, *African Economic Outlook 2016: Sustainable Cities and Structural Transformation*. African Economic Outlook. (Abidjan, Paris, New York, 2016).

5. Urban LandMark, *Africa's Urban Land Markets: Piecing Together an Economic Puzzle* (Nairobi, UN Habitat, 2013).

services which should work to do that are dysfunctional, then the market response to accessibility value—density—will also be muted.

A third key constraint results from the second. African cities do not aggregate opportunities effectively. Capital investment is not keeping up with population influx. For example, Lall et al. have noted that the share of land devoted to street space is higher in eight representative cities than in comparable cities than in other cities in the world.[6] They also show that during a period of rapid urbanization, African countries have had annual capital investments of about 20 percent of GDP, while those figures were over 40 percent for Asian countries on average during a similar period of urban growth. They show that the value of building stock in four representative cities of Africa (using several different indicators) is markedly lower than for Central American cities, as a benchmark. In short, they conclude, capital influx has not followed population growth in sub-Saharan African cities, which has led to urban sprawl and population density declines.[7]

In the African cities they examine, Lall et al. argue that these factors contribute not only to sprawl and low densities (which are, after all, phenomena observed in many world regions) but, in the case of sub-Saharan Africa, also to spatially fragmented and dysfunctional cities. Using a tripartite index of spatial fragmentation, they conclude that urban Africans have less potential for interaction than urban dwellers in other world regions, and that cities in Africa are becoming more fragmented over time. This means that people in African cities are not as connected to jobs as they are in other regions' cities.

Finally, because of this historical challenge in aggregating opportunities effectively, even if African cities could be transformed magically such that they start creating articulated density with the development of mixed-use, compact, high-intensity urban villages, the economic and development needs of the region are such that avoidance of growth of motorized travel would be neither feasible nor desirable. As Lall et al. argue, the very point of facilitating articulated density in land-development patterns is to enable land-uses to sort themselves in an economically efficient manner, and therefore to draw from a broad labor pool made increasingly viable through improvements in transportation.[8] Indeed, this is the very matchmaker function—of linking labor to jobs—which is the *raison d'être* of cities in the first place.

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6. J. V. Lall, S. Henderson and A. Venables (2017). *Africa's Cities: Opening Doors to the World* (Washington, DC, World Bank, 2017).

7. Ibid.

8. Ibid.

In the context of African cities, then, motorized transport needs to be *facilitated*, not avoided, in order for cities to play their potential roles in leading to economic development.

Shift: Re-Orient Toward High-Capacity Vehicles

Given the need for more motorized travel in African cities for economic development as just discussed above, there is even more need for emphasis on the second of the three broad strategies for de-carbonization of the sector, namely shifting toward high-capacity vehicles that reduce the growth in the total number of vehicle kilometers of travel needed to deliver this higher level of motorized travel.

Shift as a concept—generally reducing the number of vehicle kilometers by better vehicle utilization—has a number of applications in passenger and freight transport. These will be discussed in turn.

Urban Bus Reform

Idealized Solution

The premise of urban bus reform is to facilitate the development of a business model for delivery of urban bus services that improves client orientation of the services, while facilitating professionalization of and capital accumulation for operators. Improvement in client orientation means addressing frequency, comfort and affordability of services, thereby retaining passengers on public transport longer as incomes increase than would be the case in the absence of reform. At the same time, professionalization and capitalization of operators, enables them to invest in larger capacity and higher quality vehicles than they would otherwise be able to afford, thereby increasing vehicle occupancy.

African Reality

In most cities in Africa, public transport services are dominated by small, artisanal operators using small vehicles or mini-buses, referred to here generically as *paratransit* following Behrens, McCormick et al.,[9] though they are often referred to by place-specific colloquial names (e.g., *danfo* in Lagos,

9. R. Behrens, D. McCormick and D. MFinanga, "An Introduction to Paratransit in African Cities" in R. Behrens, D. McCormick and D. MFinanga, *Paratransit in African Cities: Operations, Regulation, and Reform* (New York, Routledge, 2016) pp. 1-25.

matatu in Nairobi, etc.). A 2008 survey of 14 African cities found that, on average, minibuses dominated motorized transport service, with an average of 41 percent mode share. Conventional buses averaged only 10 percent of motorized mode share across the cities. (Kumar and Barrett 2009). A more recent compilation of available data from over 20 African cities found that the share of road-based transport carried by paratransit ranged from 36 to nearly 100 percent, with a median of 86 percent.[10]

Paratransit operations are characterized by a very large number of very small-scale owners and operators (typically one or two vehicles per owner), a range of operating models (e.g., daily rental to drivers, owner-operation, and driver-owner employee models, etc.), and a weak governmental regulatory system.[11] Such characteristics do not necessarily mean that paratransit operations are always unregulated, small in scale, and informal—indeed, there are examples of large-scale and formal mini-bus operations throughout the continent—but on balance, regulation is as likely to occur through bottom-up operator associations as through top-down governmental permitting. The result, however, is competition for passengers on the street, slim operating margins, and poor quality of services reflecting operators' objectives to minimize operating costs, rather than provide responsive service.[12]

Because of these pressures, paratransit-based public transport services tend to be more VKT-intensive (that is, a substantial number of vehicle kilometers of travel are required to deliver a given number of, say, 5-kilometer passenger trips) than would a conventional public transport structure, both because paratransit operators use almost exclusively small vehicles, and because the absence of fare integration means that there is substantial duplication of services. In addition, the operational model provides little opportunity or incentive for investment in vehicle equipment improvements. The survey of 14 cities cited above found that the average age of the paratransit fleet across all the cities was 14 years.[13] Since it is well known that fuel economy deteriorates with vehicle age, it is likely that the vehicles used for public transport in most African cities are relatively fuel intensive. Africa's paratransit-based public transport systems, therefore, have substantial scope

10. Ibid.

11. A. Kumar and F. Barrett (2009). "Stuck in Traffic: Urban Transport in Africa," in V. Foster, *Africa Infrastructure Country Diagnostic*, (Washington, DC, World Bank, 2009); and Behrens and McCormick et al., op. cit.

12. Behrens and McCormick et al., op. cit.

13. Kumar and Barrett, 2009, op. cit.

for CO_2 emissions reductions through paratransit reform, which can both reduce VKT and improve fuel economy.

Mass Transport Development

Idealized Solution

A related strategy to affect a shift in the kinds of public transport movements occurring in African cities is to foster creation of mass transport systems, which channel movements into corridors of peak movements between 25 to 50 thousand passengers per hour per direction, usually through a combination of feeder services and high intensity development at nodes along the service. By structuring a hierarchy of services orientated to these high-capacity corridors, cost-effective operations can be deployed across a range of neighborhood types and densities that further avoids duplication of services and VKT. Depending on the structure of the city, the availability of street space, and the final design flow capacity needed, such corridors could be developed underground, above-ground, or at-grade, and could be either rail or road-based.

African Reality

Surprisingly few sub-Saharan African cities have functioning mass transport services, and even for those that do, they are relatively recent developments. With the exception of commuter rail services in several South African cities, almost all of the region's extant mass transport systems—the Bus Rapid Transit systems (BRTs) in Lagos, Dar es Salaam, Cape Town, and Johannesburg, the light rail in Addis Ababa, and the metropolitan rail system in Gauteng Province of South Africa were all developed within the last 10 years, and are so new that they are comprised of individual lines, rather than being networks.[14] A number of other cities are either planning or constructing mass transit lines, including Dakar, Accra, Nairobi, Abuja, and Durban, but it remains to be seen how rapidly or successfully they will be developed.

One of the key challenges for the development of mass transport has been shortcomings in the decision- and project-management-support structures of municipal, and often even national, governments.[15] Often investment decisions are made in response to politically mandated timelines, without

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14. There are a handful of other commuter rail services operating in sub-Saharan Africa, but the passenger volumes on these services are such that they cannot be classified as 'mass transport' in any meaningful way.

15. Stucki, 2015, op. cit.

adequate consideration to design, cost, or other aspects of the development, in part because the institutions which should be responsible for studies underlying such decisions are inadequately staffed or lack technical capacity. Even in instances where studies are done, they are often sequenced improperly, again because of lack of technical know-how and processes. For example, for a number of the recent African mass transport systems that have opened or are near to opening, civil engineering designs were commissioned and completed even before the operational needs of the system were understood, and in a number of cases, construction proceeded on the basis of these designs. Examples include the Addis Ababa light rail, the Blue line rail system in Lagos, and the Dar es Salaam BRT.

A second challenge in addition to that of planning and decision-support is in the capacity to manage mass transport development generally.[16] The challenge in managing that development is not necessarily related to management of civil works; indeed, civil works project management is often the least problematic aspect of these types of projects. Rather, the challenge is that mass transport development projects are often treated by political decision-makers, transport authorities, and the press, as *purely* civil works projects. Very challenging and complex issues such as who will operate the system (and how will the operator be selected), who will provide operating subsidies, or how will the services be integrated with other urban transport services, are not addressed until very late in the project development process. For example, in Dar es Salaam, the question of who would operate the BRT service was not addressed in earnest until very late in the construction of the BRT infrastructure, necessitating the use of an interim service provider until a more permanent selection process of the service provider could be arranged.[17]

Finally, lack of investment finance capacity in African cities is a substantial constraint to mass transport development. The viable sources of such investment funds vary substantially from country-to-country, and even within a given country, but the finance challenges often relate to lack of local government capacity to adequately source local revenues (such as property taxes, household taxes, and fees), competing priorities for use of whatever local and intergovernmental resources are available, and inability (for various reasons) to access local or international capital markets.[18] Multi-lateral

16. Ibid.

17. World Bank, *Tanzania: Second Central Corridor Improvement Project Implementation Completion Report* (Washington, DC, World Bank, forthcoming, 2017)

18. World Bank, *Planning, Connecting & Financing Cities Now: Priorities for City Leaders* (Washington, DC, 2013).

Development Banks can sometimes be a source for such financing (for example, in Dar es Salaam), but the slow speed of delivery, the need for sovereign guarantees or intermediary lending, and the relative dearth of such finance limit the role that it can play in the long run. Increasingly, MDBs such as the World Bank are looking for ways to use their finance more strategically to 'crowd-in' private capital financing that would not be available otherwise (the so-called 'cascade' approach), but such efforts are just in their infancy.[19]

Last-Mile Connectivity

Idealized Solution

Another key component in effecting a shift in urban transport is to address the challenge of last-mile connectivity. Although the objective of the *avoid* approach is to limit the necessity of as many people as possible to need to use motorized transport for first- or last-segments (indeed, or any other segment of the trip), in practice there will continue to be a large number of people whose origin or destinations will not be within a comfortable walking distance of mass transport. Enticing these people to use mass transport for their trip, therefore, will depend on the attractiveness of the last-mile options. Cities have seen an explosion of options in the last ten years, often enabled by ICT. These include bike-sharing, car-sharing, van-sharing, taxis and shared-taxis, and ICT-enabled paratransit.

African Reality

The elements for good last-mile connectivity are already present and relatively strong in sub-Saharan African cities. Paratransit is omnipresent, including not only mini-bus operations, but also commercial motorized two and three wheelers. Bike-sharing has yet to make a strong penetration in sub-Saharan African cities, but new technologies enabling pod-less bike sharing are likely to bring down the operational costs, such that introduction in the African context may be imminent. Many of these technologies can be facilitated through the use of ICT-enablers, for example, to use smart phones to facilitate access and increase convenience. Smart-phone penetration is already fairly high in sub-Saharan Africa. The industry reports that unique mobile subscribers in SSA are already at about 420 million, of which 27

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19. World Bank Group Development Committee (2017). "Forward Look—A Vision for the World Bank Group in 2030 Progress and Challenges" from the World Bank and International Monetary Fund Spring Meetings (Washington, DC, World Bank, 2017).

percent are smartphone connections. Smartphone penetration rate is growing at 26.6 percent per year, meaning that by 2020, there will be an estimated 54 percent penetration rate of smartphone. This means that in just a few years' time, just under one in three Africans will have a smartphone. Use of mobile money applications in Africa is also among the most advanced in the world; according to the industry, over 40 percent of the adult population in seven SSA countries use mobile money regularly.[20]

The elements are in place for effective last-mile connectivity in African cities. The challenge for the region, however, is to find the way to utilize these pieces to connect the first and last segments of urban trips, rather than use them for the *entire* trip. Used as a means to ensure last-segment connectivity to efficient transport services, ICT-enabled paratransit such as discussed above has the potential to enhance mobility and reduce transport-related emissions in SSA cities.

Truck Shipment Consolidation

Idealized Solution

The discussion about *Shift* approaches in the *Enable-Avoid-Shift-Improve* framework has until now focused uniquely on cities. But a *Shift* strategy can also be applied to the freight sub-sector as well. One key way is to engage in cargo consolidation processes to facilitate trucking shipment consolidation earlier in the logistics chain than might otherwise occur, and to minimize empty backhauling. The objective is to improve vehicle loading factors and to reduce the total amount of truck VKT.

African Reality

The need for improved logistics in SSA is well documented, not only as an explicit means of reducing truck VKT and reducing CO_2 emissions, but also, and more importantly, as a way of bringing down the logistics costs generally, and enhancing access to markets.[21] Africa regularly scores the lowest of any region in the World Bank's Logistics Performance Index (LPI) global rankings, as shown in Figure 3. However, there are some profound structural challenges to improving freight logistics in Africa. First among

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20. GSMA, "The Mobile Economy: Sub-Saharan Africa 2017" (London, GSM Association, 2017) http://www.gsma.com/mobileeconomy (accessed September 27, 2017.)

21. See S. Teravaninthorn and G. Raballand, "Transport Prices and Costs in Africa: A Review of International Corridors" in *Directions in Development*. (Washington, DC, World Bank, 2009); and African Development Bank, *African Development Report 2010: Ports, Logistics and Trade in Africa* (Oxford, African Development Bank, 2010)

Figure 3. World Map of Logistics Performance Index, 2016

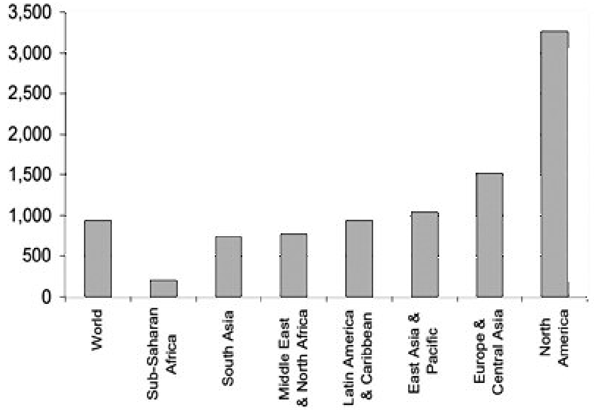
Source: J.F. Arvis, D. Saslavsky, L. Ojala, B. Shepherd, C. Busch and A. Raj (2016). “Connecting to Compete 2016: Trade Logistics in the Global Economy. The Logistics Performance Index and Its Indicators” (Washington, DC, World Bank, 2016).

these are the relatively low rural densities and sparseness of road networks across Africa.

A 2008 survey from the World Bank found that Africa’s road network is the sparsest in the world, when measured both by population and by land area (see Figures 4 and 5.) The sparsity of this network makes the need for logistics consolidation all the more pressing for Africa, but it makes the opportunities to do so quite limited.

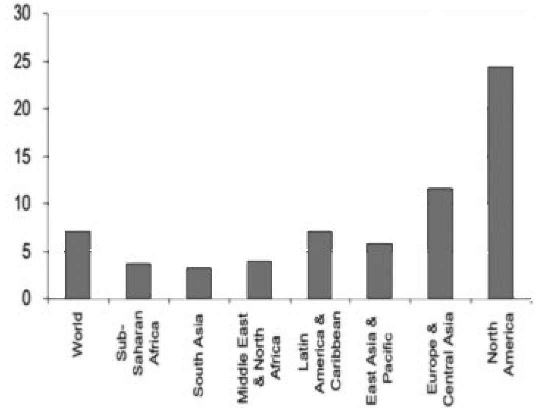
A second structural impediment to improved logistics management of freight enabling lower VKT and GHG emissions in Africa is the imbalance of trade flows prominent throughout the continent. In many parts of the continent, the directionality of the volume of goods being shipped is highly imbalanced. Figure 6 shows the volume of freight shipments to and from Chad through the port of Douala for the period 2002 through 2016. The figure shows that the volume of imports to Chad are orders of magnitude higher than exports, particularly in the early part of the current decade. Clearly, with such an imbalance, there is little opportunity to reduce the number of empty backhauls by truck.

Figure 4. Spatial Density of Road Networks in World Regions



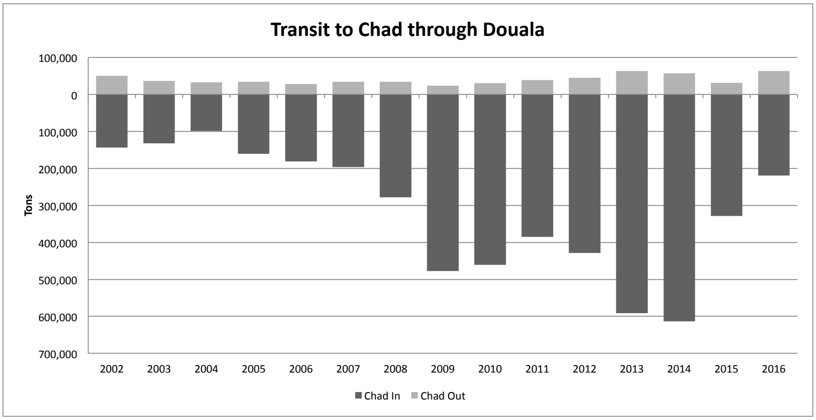
K. Gwilliam, V. Foster, R. Archondo-Callao, C. Briceño-Garmendia, A. Nogales and K. Sethi (2008). "Roads in Sub-Saharan Africa" in V. Foster, *Africa Infrastructure Country Diagnostic* (Washington, DC, World Bank, 2008).

Figure 5. Total Road Network per Capita in World Regions



Source: Gwilliam, Foster et al., 2008.

Figure 6. Trade imbalance in Chad and Cameroun



Source: World Bank.

Freight Mode Shift to Rail

Idealized Solution

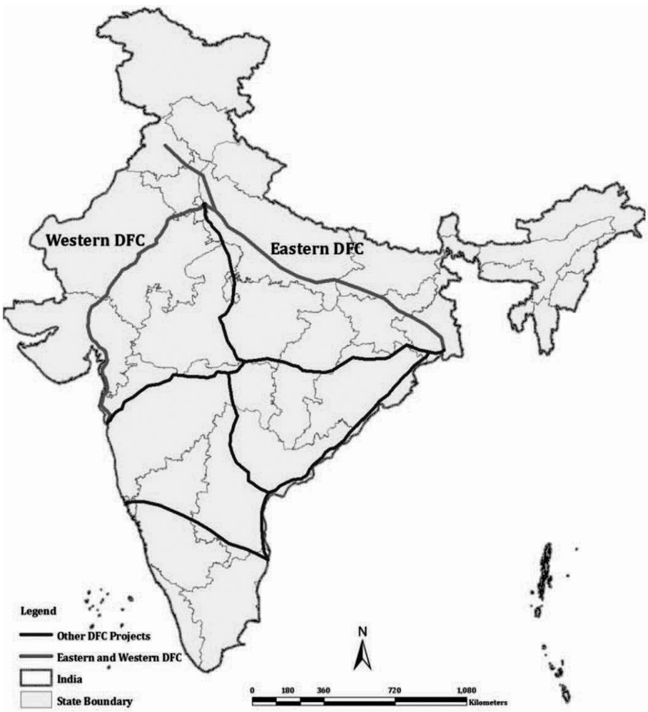
A second way that a *Shift* strategy might be applied to freight logistics would be to try to affect a mode shift toward rail over time. One of the most ambitious examples of undertaking such a strategy is the multi-billion-dollar investment by the Indian government in dedicated freight rail corridors (Figure 7). A study looking at the Western dedicated freight corridor from Delhi to Mumbai estimated that the corridor could result in cumulative savings in CO_2 emissions of 170.5 million tons of CO_2eq, over the 30-year period between 2016 and 2046. 87 percent of this change was assessed to be due to modal shift from road to rail, with the remaining 13 percent resulting from switch to fully electric traction and energy efficiency improvements over time.[22]

African Reality

For Africa, it is unlikely that efforts to shift toward freight rail would be successful in generating substantial CO_2 emissions savings on the order of those calculated for India. First, the extent of the rail network in Africa is

22. P. Pangotra and P. R. Shukla, Promoting Low-Carbon Transport in India: A Case Study of the Delhi-Mumbai Dedicated Freight Corridor (Riso, UNEP Riso Centre, 2012).

Figure 7. Proposed and in-Construction Dedicated Freight Rail Corridors in India

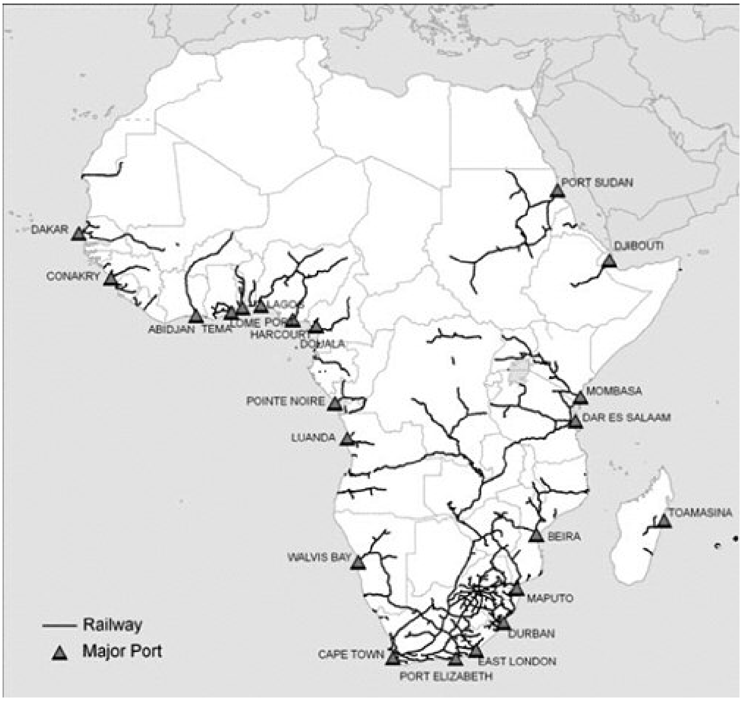


Source: Pangotra and Shukla, 2012.

quite limited. Most existing rail facilities are from the colonial-era, oriented toward moving bulk goods from sites of extraction to ports. The network of rail lines is not only sparse, but it also does not serve many of the key intra-African origin and destination pairs, as shown in Figure 8.

Second, and related, traffic volumes in sub-Saharan Africa are very low by world standards. Even before the dedicated rail corridor project in India, traffic volumes on rail were high—nearly 7 billion tons shipped by rail in 2007-2008 alone. In South Africa, which has the highest levels of rail traffic in sub-Saharan Africa by far, annual volume in 2014 was only about 2 million tons. Relative density can be measured by traffic units (in tons) per kilometer of track. Figure 9 shows that SSA (except for South Africa) has a rail density orders of magnitude lower than the other world regions.

Figure 8. Rail Network in Africa in 2008



Source: Africa Infrastructure Country Diagnostic, World Bank, 2008.[23]

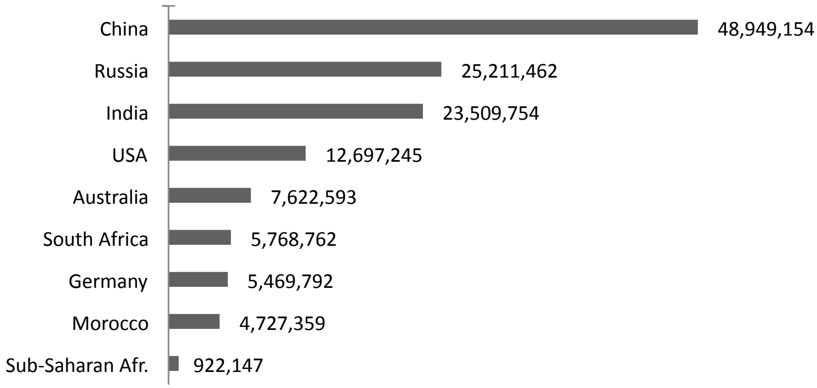
Figure 10 shows how rail traffic density affects costs, with average revenue as a proxy. The five services on the left of the graph are SSA concessions. The figure shows that rail operators' cost structure is uncompetitive with such low volumes of traffic. It should be reiterated that rail operators are also subject to the same traffic flow imbalance pressures as truck operators (discussed in the previous section). For these reasons, prospects to use mode shift to rail as a mechanism to restrain the growth of CO_2 emissions in the transport sector in Africa are limited for the foreseeable future.

Improve: Characteristics of Vehicles and Systems They Operate On

For the most part, the two strategies to reduce transport-sector associated GHG emissions discussed so far in this chapter have focused on reducing the

23. Gwilliam, et al., op. cit.

Figure 9. Rail Traffic Density Comparison of Select Countries, Regions (traffic units/km of track)



Source: V. N. Olievschi, *Framework for improving railway sector performance in Sub-Saharan Africa* (Washington, DC, SSATP, 2013).

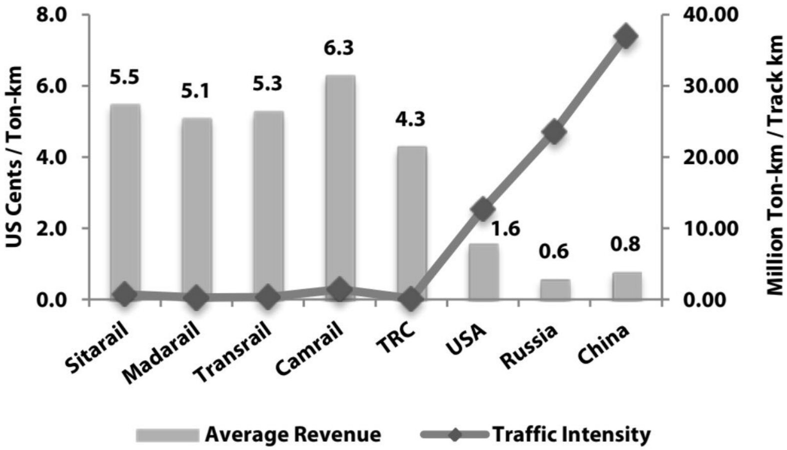
number of vehicle-kilometers traveled (VKT), either by encouraging less motorized travel, or by facilitating the efficiency of the services by which they occur. Reducing transport-related GHGs can also involve a third strategy, namely modifying the characteristics of the vehicles themselves and the networks on which they operate, in an effort to reduce the specific GHG emissions of each VKT. Broadly, there are three sub-strategies that tend to be followed in this respect: (1) efforts to improve the energy efficiency of vehicles; (2) efforts to reduce the carbon content of fuels and drive-trains; and (3) efforts to improve networks and / or behavior of operators so as to minimize the number of and intensity of accelerations per vehicle kilometer. This section discusses the first two of these sub-strategies collectively, in the context of motorization management. The third, improvement of networks and driver behavior, will not be discussed because of space constraints.

Motorization Management: A Neglected Area of African Transport Policy

Africa currently hosts the smallest proportion of the vehicle fleet (only 42.5 million in-use vehicles), and has the lowest vehicle penetration rate (44 vehicles per 1000 population)[24] of any region in the world, but this fleet has

24. Deloitte Consulting, "Navigating the African Automotive Sector: Ethiopia and Nigeria" *Deloitte Africa Automotive Insights*, 2016, pp. 4.

Figure 10. Rail Traffic Density and Costs



Source: Olievschi, 2013.

been forecast to grow by at least 4 percent per year between 2012 and 2040.[25] The current profile of the fleet in many African countries reflects the fact that the continent has, to some degree, served as a dumping ground for old, obsolete vehicles from much of the rest of the world. Most countries on the continent are primarily import-driven in their automotive industries, with only two (South Africa and Nigeria) currently having any vehicle emissions standards. In addition, a high percentage of imported vehicles are second-hand—85 per cent in Ethiopia, 80 per cent in Kenya and 90 per cent in Nigeria in 2015[26]—many of which are more than 10 years old. This is mainly a result of the low capacity of local vehicle assembly and manufacturing, and the limited disposable income to purchase brand new vehicles (burdened with high tariffs and other taxes).

Two aspects of motorization characterize the developing world in general and Africa in particular, and make it distinct from the developed world and perhaps other parts of the Atlantic Basin as well: (1) very high rates of growth in motorized two-wheelers—either primarily for commercial purposes or as a household's *first* vehicle—combined with (2) the predominance

25. International Energy Agency, *Africa Energy Outlook: A Focus on Energy Prospects in Sub-Saharan Africa*. World Energy Outlook Special Report (Paris, 2014), pp. 89.

26. Deloitte Consulting, op. cit.

of imported, second-hand cars as the main source of light-duty, four-wheel vehicle fleet growth.

Worldwide, the volumes and flows of trade in second hand, four-wheeled vehicles are poorly understood. Fuse et al. surveyed the reasons that good quantitative estimates of second-hand vehicle flows are difficult to develop, and proposed a triangulating methodology, based on information partially available from different sources. They estimated a worldwide volume of about 5.65 million units in 2005.[27] Sakai et al., using a methodology based on observed differences between expected and actual scrapping volumes, estimated a volume of about 18.6 million units in 2012.[28] Using Fuse et al.'s 2009 estimate as a base, and applying Kenya's used-car import growth rate of 8 percent per year as a representative low-end benchmark of the worldwide growth in used vehicle flows, Gorham and Qiu have estimated that the current international flows of used cars could be on the order of 14 to 15 million units per year.[29]

Because of the prevalence of two-wheelers and second-hand cars in the growth of the sub-Saharan Africa vehicle fleets, fleet growth management requires a different approach than models available in, for example, OECD countries, and even a different approach than that utilized in many sub-Saharan African countries (based on a perceived need to limit the *age* of vehicles coming into the country). African vehicles, particularly in the light duty fleet, tend to be old. Indeed, average vehicle age in Kenya and Ethiopia in 2016 was 11.7 and 15.6 years, respectively. In 2015, 96 and 73 percent of Kenyan and Ethiopian car imports respectively were older than 5 years at the time of import. Indeed, Kenya would have a substantially older car fleet profile but for the prohibition against importation of cars 8 years or older.

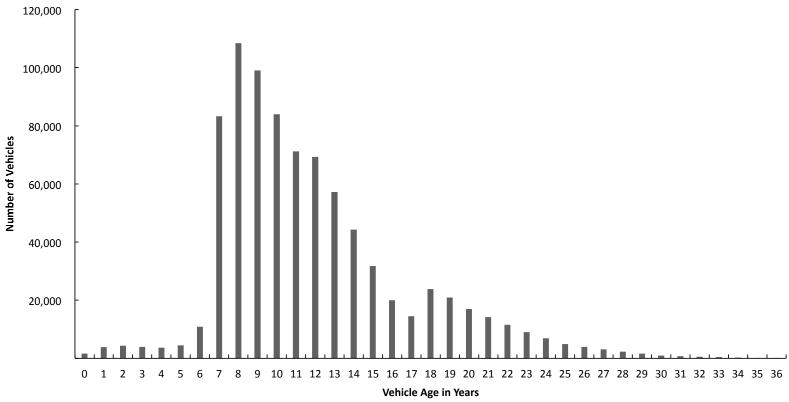
The concern about vehicle age—and the justification for import restrictions based on it—is the presumed link between age and vehicle performance, not only with respect to fuel economy, but also in relation to pollution emis-

27. M. Fuse, H. Kosaka and S. Kashima, "Estimation of world trade for used automobiles" *Journal of Material Cycles and Waste Management* 11(4), 2009, pp. 348-357.

28. S. I. Sakai, H. Yoshida, J. Hiratsuka, C. Vandecasteele, R. Kohlmeyer, V. S. Rotter, F. Passarini, A. Santini, M. Peeler, J. Li, G.-J. Oh, N. K. Chi, L. Bastian, S. Moore, N. Kajiwara, H. Takigami, T. Itai, S. Takahashi, S. Tanabe, K. Tomoda, T. Hirakawa, Y. Hirai, M. Asari and J. Yano, "An international comparative study of end-of-life vehicle (ELV) recycling systems" *Journal of Material Cycles and Waste Management* 16(1), 2014, pp. 1-20.

29. R. Gorham, O. Hartmann, Y. Qiu, D. Bose, H. Kamau, J. Akumu, R. Kaenzig, R. Krishnan, A. Kelly and F. Kamakaté, *Motorization Management in Kenya* (Washington, DC, World Bank, 2017)..

Figure 11. Age Profile of Motor Vehicle Stock in Kenya, 2016

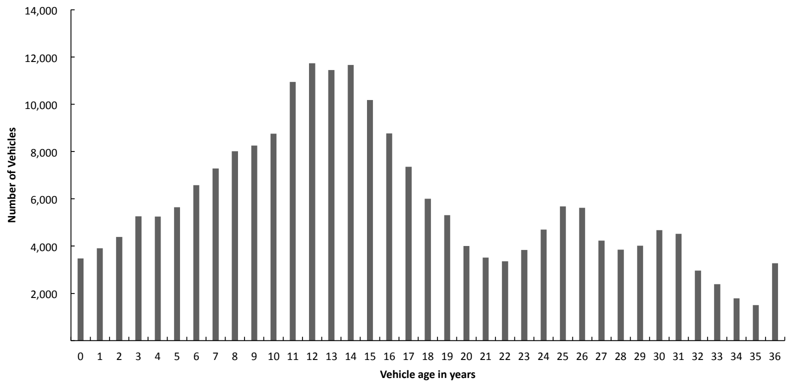


Source: R. Gorham, O. Hartmann, Y. Qiu, D. Bose, H. Kamau, J. Akumu, R. Kaenzig, R. Krishnan, A. Kelly and F. Kamakaté, *Motorization Management in Kenya* (Washington, DC, World Bank, 2017). Based on registration data provided by Kenyan National Transportation Safety Authority.

sions and road-worthiness. Age is a quick and dirty proxy for these other characteristics, one which is relatively easy to monitor in an import regime.

In the African context, however, Gorham and Qiu (2018) argue that for a number of reasons vehicle age may not be a particularly effective lever to improve vehicle fleets at all—at least not as a stand-alone criterion. First, there is enormous variance in the fuel economy of cars across the world. While it may be true that, all else held equal, newer models of a given car may be more fuel efficient than older models (both because of the technology available in the car and because fuel economy deteriorates with age), it would be more effective as a fuel economy policy to influence the specific kinds of vehicles imported rather than their age *per se*. Second, with respect to vehicle emissions, newer vehicles may have more sophisticated emissions control technology, but without an adequate fuel and maintenance 'eco-system,' such technology would be useless anyway. Third, with respect to road-worthiness, age may indeed be associated with dilapidation, but nothing inherently guarantees that newer models will be more road worthy than older models; this is rather a function of maintenance and upkeep, which can only be verified through an inspection regime, rather than through age checks. Further, there is also little correlation between the age of the vehicle and its crash-worthiness; automobile manufacturers regularly market dif-

Figure 12. Age Profile of Motor Vehicle Stock in Ethiopia, 2016



Source: R. Gorham, O. Hartmann, Y. Qiu, D. Bose, H. Kamau, J. Akumu, R. Kaenzig, R. Krishnan, A. Kelly and F. Kamakaté, *Motorization Management in Ethiopia* (Washington, DC, World Bank, 2017). Based on registration data provided by Ethiopian Federal Transport Authority.

ferent brand-new vehicles of the same model to different world regions, with very different empirically tested crash-worthiness characteristics.[30]

For these reasons, a recent World Bank assessment recommended that Ethiopia and Kenya (and governments in Africa more generally) should adopt more comprehensive practices toward management of vehicle fleets than simply age restrictions.[31] These practices (referred to collectively as *motorization management*) are understood as the deliberate process of shaping, through public policies and programs, the profile, quality and quantity of the motor vehicle fleet as motorization occurs. It requires an integrated approach, simultaneously considering different policy objectives that can be addressed by and through the vehicle fleet. In that respect, it is concerned with fuel efficiency, safety (both crash avoidance and crash worthiness), pollution emissions characteristics of the fleet, and potentially even the speed with which the fleet grows.

A fundamental tenet of the motorization management concept is based on the premise that policies alone will not affect an improvement in safety, emissions, or fuel efficiency characteristics of vehicle fleets; what is needed is a more comprehensive set of enabling measures, whose design recognizes

30. Ibid.

31. Ibid.

the fundamental importance of the second-hand vehicle market in fleet growth in these countries. The World Bank team identified 10 such implementation programs plus one or two policy *processes* whose implementation would likely lead to more effective control of the evolution of safety, emissions, and fuel efficiency characteristics of the vehicle fleet itself. These are:

- Motor Vehicle Information Management Systems
- Public engagement to reach citizens at all phases of the vehicle lifecycle
- Import certification process for vehicle imports
- Inspection and maintenance of in-use vehicles
- National protocols for visual and instrumented enforcement
- Mechanics' training and certification
- Quality assurance program for vehicle parts
- Performance standards for vehicle body construction and modification
- Fuel quality testing
- End-of-Life Vehicle management.

In addition, the World Bank team recommended that governments at the national—or even regional—level undertake policy processes to define Dynamic Profiles of Standards for tailpipe emissions, fuel quality, vehicle safety, and fuel economy expected for all vehicles entering the country or region over a foreseeable period.

The World Bank team modeled the potential impacts of these measures on a range of attributes in the motor vehicle fleets in Kenya and Ethiopia. They found that implementing these kinds of measures could lead to a reduction on the order of 4 to 8 percent in overall fuel consumption by 2040, compared to a business-as-usual case for the motor vehicle fleet as a whole, but a 6 to 12 percent reduction for the private car fleet. Such results, while modest, reflect only a portion of the larger benefits that can come from a motorization management approach, which would also include safer vehicles, improved emissions performance, and, potentially, a shift in drivetrain and propulsion technology.[32]

32. Ibid.

Conclusion

This chapter has tried to provide a brief survey of the various mechanisms available to reduce or head off the growth of CO_2 emissions and energy consumption from the transport sector, with a particular focus on such challenges in sub-Saharan Africa. The picture that emerges is a complex one, but several broad observations can be made.

First, the objective of managing energy consumption in the African transport sector is closely tied to the most basic development objectives: increasing access, improving affordability, and making transport and land-markets function. For this reason, efforts to separate energy management objectives in Africa's transport sector from core development objectives are likely to fail. Second, no single strategic approach to managing energy from the sector is likely to be successful; rather, a combination of aggressive Avoid, Shift, and Improve measures will be necessary to keep transportation energy consumption and GHG emissions from growing unsustainably.

Third, as daunting as the challenges are, there are some sources for optimism in the region's potential to manage its transport energy consumption growth. The strong potential in African cities to use ICT to facilitate a shift to more efficient vehicles and modes has already been discussed above. In addition, if motorization management measures are adopted, there is tremendous potential for African countries to leapfrog technologies, particularly since, unlike most other world regions, the large part of motorization in Africa—in terms of vehicle penetration—has yet to occur. There is, therefore, a window of opportunity to orient the profile of the vehicle fleets and affect fairly rapid change. Another potential source of optimism is that growing incomes and the emergence of a vibrant middle class may create opportunities for motor vehicle manufacturers that could drive improvements in the quality of vehicles on offer. Finally, though perhaps too soon to tell, it is also possible that Africa's imminent motorization may be interrupted by disruptive technology in a (positive) way that has not affected other regions. For now, Uber-like services do not seem to be affecting fundamental car ownership decisions in developing countries like Ethiopia or Kenya, but it is possible that niched service delivery models for the growing middle classes will emerge that do.