REVIEW OF TRAFFIC CONGESTION MITIGATION MEASURES: THEIR APPLICABILITY IN AFRICAN CITIES

Eradius Edward Rwakarehe, University of New Brunswick

Introduction

Congestion is a significant issue in urban areas around the world. Increasing demand for travel is expected make the problem even more complex if appropriate solutions are not found and implemented. For developing countries, apart from other several strategies, efficient public transport is considered the major potential solution to the problem of urban road traffic congestion. However, this approach may not help much in solving the same problem in Africa if the root cause of the problem specific for Africa is not well investigated.

According to Edwards et al. (2008), Paris has the lower rate of car ownership than the rest of other cities in Europe. It has 0.5 cars per household while for other cities the situation is: 0.8 for London, 0.9 for Brussels and 1.1 for Madrid. The reason behind this low figure is considered to be the quality of public transport in Central Paris. Their study also found that the shortage of parking space encourages residents to use public transport or walk for short trips. Cars are mainly for trips to suburban shopping centres or during the weekend for moving out of the city. Unlike in New York and London, the Parisian authorities opted to invest in improving public transport instead of increasing parking charges to discourage the residents from driving.

On the other hand, a study by Kitamura (1989) suggests that improving public transport only is not enough to combat traffic congestion. According to him, the increase in car use which is

associated by increase in car ownership may not be suppressed by improving public transit. It is car use that determines transit use, not transit use determines car use. The study concluded that the increase in household car ownership increases car usage. It was also found that, car use may be more effectively suppressed in the long-run by adopting policies to control car ownership instead of car use itself.

In contrast, a study by Goh (2002) that presents the congestion fighting experience in Singapore found that it is car usage and not ownership causes congestion. Therefore, it is a better usage policy that can help fight traffic congestion rather than ownership policy. However, it should be noted that in order to implement Singapore's approach, alternatives for those who cannot afford to pay for congestion price (which is the foundation for car usage policy) should be in place. This limits the applicability of this approach in developing countries that are characterized by inadequate and unattractive public transportation infrastructure; hence, lack of alternatives.

Therefore, it is clear that to combat traffic congestion problem, several mechanisms are needed. This can be done through combining different strategies that integrates engineering expertise, economics and public policies. However, these cited literatures are all talking of cities in developed countries of which almost all the applicable conditions are very different from those of developing countries. For instance, the measures proposed to curb traffic congestion in London can't directly be applied in Dar es Salaam (Tanzania) because the two cities are totally different in terms of transportation related factors especially city plan and existing transportation infrastructure. In order to tackle this problem, this paper discusses the causes of traffic congestion in developing countries especially Africa and the solutions to be adopted.

Congestion

Definition of traffic congestion

According to Grant-Muller et al. (2006), traffic congestion is often understood but not formally defined. However, an engineering definition given by Highway Agencies can be summarized as *'the travel time or delay in excess of that normally incurred under light or free-flow travel condition'*. Traffic congestion is always characterized by slower speeds, longer trip times, and increased vehicular queuing or traffic jam. This situation occurs when a volume of traffic is close or equal to the road capacity; and the situation is termed as saturation.

Source of Traffic congestion

Congestion results from the interaction of many different factors. According to Cambridge Systematics (2004), in general, root causes of congestion can be broken down into two main categories as follows:

Too much traffic for the available physical capacity to handle: A highway like other facilities has its maximum capacity, so, there is a limited number of vehicles that can be moved on a roadway for a given time at a desired safe speed. In transportation engineering, this is referred to as the physical capacity of the highway system. The physical capacity is determined by such things like: how many lanes are available to carry traffic, the curvature of the highway, side clearance, and interchange and intersection design. Physical bottlenecks are locations where the physical capacity is restricted, with flows from upstream sections (with relatively higher capacities) being directed into them. Once traffic flow reaches stop-and-go conditions, the highway capacity is reduced, so fewer cars can get through the bottleneck because of the extra turbulence.

Traffic-influencing events: These include traffic incidents such as crashes and vehicle breakdowns, work zones, bad weather, special events and poorly timed traffic signals. Once these events occur, physical capacity of a roadway is reduced to a great extent. For instance, a closer of one lane reduces the road capacity by 68% on a 2-lane road, 47% on a 3-lane road, 44% on a 4-lane road and 25% on a 5+-lane road (Chin et al., 2004).

Congestion Mitigation Measures

Several strategies/measures can be used to curb traffic congestion. The biggest challenge is how to choose the appropriate one together with the procedure on how to implement it. The choice of a strategy depends on the prevailing circumstance(s) at that particular time. According to Chicago Area Transportation Study (1998), traffic congestion mitigation strategies can be summarised under the following twelve classes: transportation demand management measures, transportation systems management, measures to encourage high occupancy vehicle use, public transit capital improvements, public transit operational improvements, measures to encourage the use of non-motorized modes, congestion pricing, growth management, access management, incident management, intelligent transportation systems, capacity expansion. The detailed explanations for each strategy that includes description, general system benefits and impacts, policies and actions, application principles and analysis guidelines can be found on chapter three of the same document. The problems with the choice(s) of these measures are discussed on page 10.

Passenger Transport Situation in African Cities

This section gives the situation of passenger transport in developing countries especially in Sub-Sahara Africa. Almost all publicly owned and managed public transport companies in Africa ceased to exist in early 1990s as a result of structural adjustment policies that required African countries to comply with aid programmes associated with international agencies, in particular International Monetary Fund (IMF). According to International Association of Public Transport and Africa Association of Public Transport (2010), today throughout Africa, public transport is dominated by the operations of the disorganised informal sector. The dominance of these disorganized services hinders economic development and reduces the quality of life for citizens as the large number of vehicles required to meet demand causes not only congestion but also parking problems, pollution and low levels of road safety.

According to Figure 1, the modal share of informal collective transport (minibus and collective taxis) is 34% while non-motorized transport (walking and cycling) account for about 40% with walking being dominant. From these data, it is clear that up to now, people in Africa have mostly used walking and cycling modes to get around. The reason behind this is that other options, such as private cars, are not affordable for the majority of people. The modal share for private cars accounts for only 12% on average.

Furthermore, although the private car mode is still used relatively little (as compared to developed countries) due to the low purchasing power of the Africans, contrary to the expectation, traffic congestion is worse in the African cities compared to developed countries cities. This implies that the transport problem in Africa is largely attached to limited availability of road infrastructures. As opposed to traffic congestion solutions in most of the cities in developing countries, road expansion is still one of the major solutions towards solving the same problems in developing countries, particularly Africa. However, this does not mean that other problems like poor land use planning, disorganised public transport and the like should not be tackled. Collective solution is inevitable. The issue here is: how many lane-kilometres should be added to reach the optimal level? It is clear that we cannot keep expanding the roads without a limit, otherwise the all land may be allocated to roads; which is not desirable. So far, there is no guideline on this matter. Therefore, it is imperative for transportation engineers and land-use planners to establish the benchmark like *'lane-km per hectare per x persons'*.

The lack of road capacity does not cause only traffic congestion but also contribute largely road traffic accidents in Africa. According to World Health Organization (2009), the number of fatalities per 100,000 people per year in Africa is estimated at 32 compared with only 8 in Europe. If serious measures are not taken, this figure is expected to continue rising due to the increase in motorisation in Africa. As already pointed out, the same problem of inadequate road infrastructure is highly tied to this problem. For instance, in Tanzania, a 100km road section (from Dar es Salaam to Chalinze) that carries all of the traffic from the business city of Dar-es-Salaam to other 23

regions in the country is undivided two-lane road with very limited passing places. The road also connects Dar-es-Salaam port to the neighboring landlocked countries namely Burundi, Democratic Republic of Congo, Malawi, Rwanda and Zambia. According to a 12-hour traffic count that was carried out by TANROADS - Coast Region in 2010 along the section, a total of 9,286 vehicles were counted with morning peak hourly volume of 1,417 vehicles. Due to the lack of passing places and large number of long distance trip vehicles, the driving behaviour on that road section is very unimaginable as it can be seen on Figure 2. According to Kilale et al. (2005), a total of 3,098 road traffic accidents and 768 deaths occurred along Kiluvya - Chalinze - Segera road section in a period of 1995-2000 with an average of 516 accidents per year or 1.4 per day. Most of these accidents are head-on collisions that are caused by evasive overtaking manoeuvres as it can be seen on Figure 2.

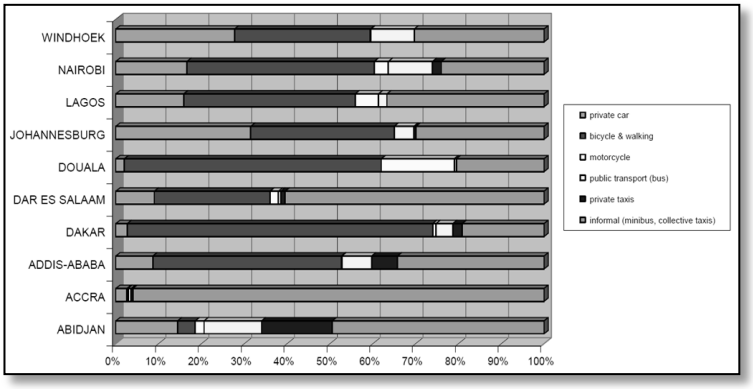

Figure 1: Transport modal share of selected African cities
Source: International Association of Public Transport & Africa Association of Public Transport (2010)

Figure 2: Typical driving behaviour along Morogoro road (Dar es Salaam - Chalinze section)

Singapore's Experience with Traffic Congestion Management

According to Toh et al. (1997), Singapore is believed to be the best country in terms of traffic congestion management; therefore, it qualifies to be considered as the role model. Singapore is a small island city-state of about 714 square kilometers in area, located at the crossroads of commerce and tourism at the southern tip of the Malaysian Peninsula. It has 5.18 million resident population, with a very high population density of 7,257 persons per square kilometer (compared to 34 in the United States). The climatic condition of the country is hot and humid, creating a heavy demand for air-conditioned private transportation. As of 2010, Singapore had 597,746 cars out of 945,829 registered motor vehicles traveling on 3,377 kilometers of roads, which is equivalent to a linear density of about 280 vehicles per kilometer. This is a very high figure compared to: 69 in Japan and 44 in the United States. Despite all of these comparative high figures, the traffic flow in Singapore is relatively good. The secret behind this situation is a better policy regulating transport industry in the country.

It is better to note that Singapore did not arrive at that situation over sudden. There are so many ups-and-downs that it passed through. Table 1 below summarizes the major measures that were introduced to curb road congestion in Singapore. From the Table together with the comparative statistical data in the paragraph above, it can be

noted that an increase in the price of cars did not seriously discourage their purchase. It is a nationwide system of automatic tolls that seriously discouraged their usage. Since it is car usage and not ownership that causes congestion, it can be concluded that '*Electronic Road Pricing*' is the ultimate solution to Singapore's road congestion problem. Because of the system's flexibility, efficiency, non-intrusiveness and effectiveness, Singapore becomes first-best world in terms of traffic congestion management.

Table 1: Major measures introduced to curb road congestion in Singapore

Year	**Measure**	**Description of measures/systems**	**Success rate**
1972	Additional Registration Fee (ARF)	Extra levy imposed on new vehicle, priced at 5% to 140% of the vehicle's open market value depending on the vehicle's capacity and function. The aim was to discourage people from buying new cars.	It initially tried to limit traffic growth by making cars more expensive to own but because of good economic growth, still people could manage to buy new cars. The scheme was revised in 1974 and 1975.
1975	Area Licensing Scheme (ALS)	Restrict access to CBD from 7.30 a.m. to 6.30 p.m. on weekdays & from 7.30 a.m. to 2.00 p.m. on Saturdays through purchase of supplementary licences.	Initial drop in traffic into the CBD was 45%. By 1988, drop was not sustained due to increase in employment in the CBD.
1987	Mass Rapid Transit (MRT)	Serves heavy passenger transit corridors.	Ridership rose from 346 million in 1998 to 360 million in 1999, an increase of 14 million.

Year	Measure	Description of measures/systems	Success rate
1990	Vehicle Quota System (VQS)	Certificate of Entitlement was introduced, i.e., new car population allowed to grow at 3% in tandem with road capacity growth. Motorists now need to bid for the right to own a car.	With VQS, 41,000 fewer vehicles were registered between 1990 and 1993.
1994	Off Peak Car (OPC) scheme	Offer new and existing car owners the option to save on car registration and taxes in return for lower car usage.	It was not very successful as most motorists preferred ready use of car for convenience.
1995	Road Pricing Scheme (RPS)	Manual road pricing scheme introduced for linear passage vehicle flow, i.e., remove bottlenecks at congested expressways or arterials outside CBD.	Initial drop in traffic volume along RPS monitored expressways dropped by 41% from 12,400 to 7,300 vehicles while public transportation travel speed increased by 16%.
1998	Electronic Road Pricing (ERP)	Automated road pricing to reduce the 147 enforcement personnel needed for RPS and replace ALS, OPC and RPS.	Traffic volume on ERP monitored roads dropped by 17%.

Source: Goh (2002)

Problems Associated with Choice and Evaluation of Congestion Mitigation Measures

As a result of studies by Edwards et al. (2008) and Kitamura (1989), it is clear that in order to fight traffic congestion problem, several strategies have to be packaged together. However, it is important to recognize that sometimes strategies can conflict one another; some may have conflicting objectives while others may be competing for the same market. Therefore, determining the potential benefits arising from a combination of these strategies becomes a problem especially at economic evaluation stage. To resolve this problem, Chicago Area Transportation Study (1998) recommends two approaches. First, if the first strategy reduced peak trips by 5% for instance, the impacts of the second strategy would be evaluated based on the remaining 95% of the trips, not the original 100%. Second, consider one strategy as primary and the other one as secondary. The estimated benefits of the primary strategy can then be enhanced or reduced by a marginal factor to reflect the countervailing effects of the secondary strategies.

The choice of traffic congestion mitigation strategy is another challenging issue. Several factors have to be considered so as to choose the appropriate strategy to be adopted. For instance, for short-term measures and treatment of bottlenecks, capacity expansion is considered to be the best option (European Conference of Ministers for Transport, 2007; Litman, 2011). However, this option cannot provide a long-run solution due to the effects of generated traffic. According to Litman (2011), traffic congestion tends to maintain equilibrium. If road capacity increases, the number of peak-period trips also increases until congestion again limits further traffic growth. This is also supported by the study by Noland (2001). According to him, a 10% increase in capacity leads to a 3-6% increase in traffic volume in the short-run and to a 7-10% increase in traffic volume in the long-run.

According to the literatures above, capacity expansion is discouraged when considering long-run traffic congestion mitigation strategies. However, one has to be careful especially when dealing with the situation in developing countries that are characterized by poor and

inadequate transportation infrastructure. It is unfortunate that most of cities in developing countries especially in Africa tend to copy solutions from developed countries without noting that solutions designed for developed countries' cities cannot directly be applied to cities in developing countries. The causes of traffic congestion in developed countries in most cases are different from that of developing countries. For instance, while car ownership per household in London is 0.8 (Edwards et al., 2008), in Dar es Salaam (Tanzania) the rate is 0.1 (JICA, 2008); the traffic congestion problem is worse in Dar es Salaam compared to London. Other things being equal, one would expect a city with higher car ownership rate to face a relatively severe traffic congestion problem. The opposite is true when comparing cities in developed countries with those in developing countries (International Association of Public Transport and Africa Association of Public Transport, 2010). Analysis from the findings of these three literatures above concludes that: apart from relatively poor urban planning, inadequacy of road infrastructure is currently the major cause of traffic congestion in cities of developing countries. Therefore, a proper guidance is needed as to what level capacity expansion becomes no longer a viable option. It is unfortunate that so far no any literature gives such guidance. As already noted earlier, it is imperative for transportation engineers and land-use planners to establish the benchmark like *'lane-km per hectare per x person'*. This will clear the confusion that seems to exist in developing countries by adopting the idea that capacity expansion has never been a solution to traffic congestion as suggested by Litman (2011) while the current major cause of the problem in Africa is the lack of adequate capacity. While taking initiatives to curb traffic congestion, history of transportation industry in developed counties should be well utilized by taking an advantage of learning from the mistakes already made in those countries so that the same shall not repeat.

Availability of fund is another issue dictating the choice of congestion mitigation strategy. The problem is more common in developing countries that are characterized by inadequate public transport infrastructure financing capacity (Briceño-Garmendia, 2004). This complicates the matter to the extent that sometimes an

option that gives high net benefit cannot adopted because of unavailability of enough funds to implement it. Optimization skills are highly needed in such situations. It is an author's 'hypothesis' that developing countries are quickly buying Litman's idea of not opting capacity expansion as the starting point towards solving traffic congestion problems in their cities because of financial problems. However, a study to confirm this hypothesis is important. Capacity expansion is ranked the most expensive among the available options.

Conclusions and Recommendations

Conclusions

This paper summarizes the causes of traffic congestion in developing countries especially Africa; and the solutions to be adopted. According to the review, it has been found that the modal share for private cars, public transport (minibus and taxis); and walking & cycling in Africa are 12%, 34% and 40% on average respectively. From these figures, it can be seen that although private cars are still used relatively little (as compared to developed countries) due to the low purchasing power of Africans, contrary to the expectation, traffic congestion is worse in African cities compared to the cities in developed countries. This implies that the traffic congestion problem in Africa is largely attached to limited availability of road infrastructures. As opposed to traffic congestion solutions to most of the cities in developed countries, road expansion is still one of the major solutions towards solving the same problems in African cities.

Apart from relatively poor urban planning and inadequacy of road infrastructure, disorganized and informal public transport is also one of the major causes of traffic congestion in African cities, as large number of vehicles is required to meet the demand. It has also been shown that most of the traffic congestion solutions applicable to cities of developed countries cannot directly be implemented in developing countries because of heterogeneities in several aspects. Even the causes of traffic congestion in developed countries are different from that of developing countries. It was also found that the choice of

congestion mitigation strategies in developing countries in most cases depend on the available fund instead of formal engineering and economic evaluation techniques. This in turn reduces the financial efficiencies of the adopted projects, and sometimes leading to vicious cycle.

Recommendations

In order to solve traffic congestion in African cities and other similar developing countries, the following should be done:

- Capacity should be added to the existing road infrastructure up to a reasonable level. However, the term 'reasonable level' is too subjective. A study should be done to establish a benchmark like *'lane-km per hectare per x persons'* that will be taken as a limiting indicator.
- The work for road infrastructure expansion should go parallel with improvement of public transport. With the low-income problem existing in African countries, people are likely to own private cars not because of luxury but due to the lack of adequate and attractive public transport. Improvement in this sector is expected to deter the rate of increase in car ownership that does not match with their income.
- By tracing back the history of transportation industry in developing countries, it is clear that no matter how many lane-km are added, as long as economic is growing, congestion will still build-up. To curb that, Singapore's car usage policy is the best option. However, that should be applied after establishing proper public transport that will serve as alternative to private car ownership and/or use. With the current situation, restricting Africans to own and/or use private cars is an insult to them.
- Finally, in carrying out all of these improvements, history of transportation industry in developed counties should be well utilized by taking an advantage of learning from the mistakes already made in those countries so that the same shall not repeat. Moreover, it should be noted that any traffic congestion solution copied from developed countries should incorporate issues of heterogeneities.

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