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## Urban Transport Dysfunction and Air Pollution in Dakar

### Study Conclusions

This note presents the main conclusions of an on-site study of urban transport dysfunction and air pollution in the Dakar agglomeration carried out from August to November 1998. On December 17 and 18, 1998, the findings were discussed at a national seminar on urban transport and air quality organized jointly by CETUD (The Executive Council for Urban Transport in Dakar) and the World Bank. This formed part of the Sub-Saharan African air-quality initiative that was launched jointly in 1998 by the Urban Transport Component of the Sub-Saharan Africa Transport Policy Program (SSATP) and the World Bank Institute (formerly the Economic Development Institute). The report on this seminar (SSATP Working Paper No.38, February 1999) is available from the SSATP Coordination Unit. This note was originally published as SSATP Technical Note No. 19.

As regards the particular problem of air pollution caused by urban transport, the study and the recommendations formulated at the seminar made it possible to define the principles on which an action plan could be based. The latter is currently being considered for financing as part of the preparation of a project for increasing

urban mobility in the Dakar agglomeration. This project is to be implemented under the auspices of the World Bank.

#### Objectives of the study

The study's goal was to define the main causes of transport dysfunction, quantify them, express them in figures, and recommend a suitable framework for monitoring changes in the parameters. The area studied is the Dakar agglomeration, which has more than 2.2 million inhabitants, 1.2 million of whom live to the east of the city itself, in the Pikine-Guédiawaye Rufisque area.

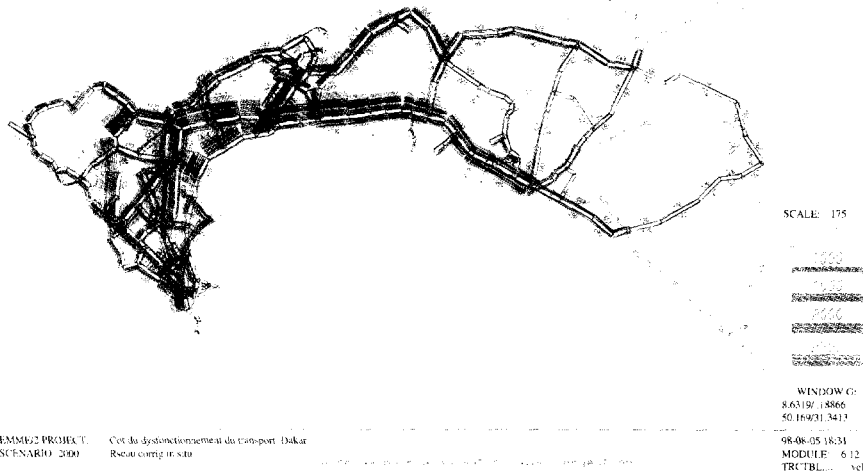
#### Problems

The fundamental problem, as in most large cities, is that the residential location is not coordinated with work place location, and every day this leads to large-scale movements of population. Viewed overall, therefore, the problem is also linked to the question of city planning, and thus to a long-term view of the development of the city and its modes of transport.

The map provides a clear picture of these problems, and shows the heavy flows on Dakar's east-west corridors, especially during rush hours.

# Findings

COMPOSED VOLUMES ON AUTO NETWORK  
CLASS SPECIFIC AUTO VOLUMES



Added to this are the following problems:

- the increase in vehicle ownership
- the inadequacies of the infrastructure in general, and intersections in particular, since they are unable to cope with this increased traffic.

This leads to the following kinds of dysfunction:

- road safety problems, resulting in death, injury, and damage to property
- congestion (and, as a result, time wasted in traffic jams)
- air pollution
- noise pollution.

### Transport demand

According to a 1998 study, daily commutes in the Dakar agglomeration total 4.3 million, 70 percent of which are made by mass transit, which therefore plays a major role, and has been singled out as being responsible for much of the dysfunction.

### Definitions

However, what exactly is “transport dysfunction”?

In reality, it consists of “costs arising from situations in which a transport user does not pay for all the costs generated by the transport service (or else does not receive all the anticipated benefits).

Overall, transport costs are of two types:

- those that appear evident — i.e., the operating costs generated by the activity (fuel, staff, etc.) and its infrastructure (roads), these largely being covered through taxation; and,
- costs generated by dysfunction; these are less evident, but consist of accident-related costs (i.e., health care, the value of lives lost, and losses in productivity), and environmental costs (atmospheric pollution and noise pollution, and costs caused by congestion, represented by the time wasted by passengers when using public transport).

These social costs are borne by the local authority, rather than directly by the individual users (even though it is user demand that causes transport dysfunction).

### The importance of evaluating externalities

It is important to make an accurate evaluation of the costs of dysfunction (or transport externalities), and to decide where the responsibilities lie, so that these costs can be properly allocated; however, this sort of evaluation also plays a major role in providing “decision support” when transport systems are selected. Failing to include all the social costs in the equation means that the real cost of a system will be underestimated, and that a given system may be favored over another that would have generated fewer external costs (by creating less pollution, for example).

Thus, an evaluation comparing a large-capacity bus project and a suburban rail project could lead to a decision in favor of the latter because it was demonstrably safer (resulting in fewer accidents and traffic jams) and created less pollution.

### Ways of measuring dysfunction

The following are the generally accepted methods of calculating external costs:

- the *avoidance cost*, or prevention cost method; this consists of identifying and quantifying the costs of measures for reducing externalities;
- the *damage costs* evaluation method; this consists of quantifying the observable impact (fatalities, health care, and productivity losses);

Estimated costs of the impact of dysfunction in Dakar

Type of dysfunction	Number	Unit cost (CFAF)	Total cost (CFAF)	% of GNP 96
<b>Bodily injury</b>				
Fatalities, per year <sup>1</sup>	179	6,600,000	1,181,400,000	
Serious injuries, per year	1,053	800,000	842,400,000	
<i>Total</i>			<b>2,023,800,000</b>	0.1
<b>Congestion</b>				
Hours wasted, per year	224,400,000	185	41,401,800,000	1.7
<b>Pollution</b>				
Number of inhabitants affected by 2 pollutants (PM10 & Pb) <sup>2</sup>	2,100,000	30,000	63,000,000,000	2.7
<b>Total cost</b>			<b>108,449,400,000</b>	<b>4.6</b>

<sup>1</sup> Estimated by means of the "lost income" method ; it should be noted that the "willingness to pay" method results in figures that are from 25 to 30 times larger.

<sup>2</sup> Estimated on the basis of figures from a study made in Jakarta (Urban Air Quality, World Bank Paper N° 379, 1997.)

- *the hedonic method*; this consists of assessing the difference in value between a good located in a place subject to dysfunction (i.e., pollution and noise) and the same good in an unpolluted place;

- *the stated preference method*, in which interviewees who are victims of transport dysfunction are surveyed to find out how much they would be willing to pay to not be subjected to it, or to receive some form of compensation.

The stated preference method produces results closest to economic values because it reflects market prices; however, it requires more resources than were available for this study.

### Methodology adopted

The damage costs evaluation method was adopted, since it can be applied even when the users in question have little or no appreciation of the extent of the damage caused, or else miscalculate it.

The methods of evaluation, by type of dysfunction, were as follows:

#### *Bodily injury*

- gathering of accident statistics, classified by degree of seriousness;
- calculation of unit costs (by type of accident) and of the cost of human losses, from which the total cost can be deduced;
- definition of indicators for accidents and fatalities caused by public transportation, and establishment of the relationship of these figures to the number of vehicles x the number of km traveled (as ascertained, adjusted, or simulated by means of a traffic model);

#### *Congestion and traffic jams*

- using the EMME2 model, calculation of the *hours wasted* in vehicle trips, measured according to the difference between traveling times on a congested system and on an uncongested system;
- calculation of the *unit cost per wasted hour*, from which the cost of total hours wasted can be deduced;

#### *Air pollution*

- calculation of quantities of pollutants emitted by traffic (CO, VOCs, and NOx), and their concentrations, based on the characteristics of traffic in Dakar as defined by a model (EMME2), and on information on the emission factors for a given vehicle fleet;
- comparison of these levels of pollution with WHO standards; it would be helpful if these data could be calculated on the basis of samples collected by monitoring stations — in Dakar, no such measurements have so far been made;

#### *Noise*

- calculation of the noise level generated by traffic (using data from EMME2 and a computer model prepared by the consultant);

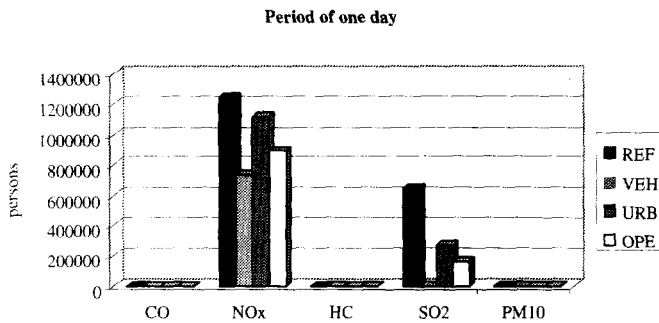
- comparison with European standards; measurements have shown that the noise level during the morning rush hour is always higher than acceptable (65 dBA), on both primary and secondary routes; at other times, however, levels on secondary routes are acceptable.

The models used to evaluate these costs make it possible to monitor trends over time, or to produce simulations based on changes in transport-system parameters.

### Results

The table summarizes the results of the calculations and estimates. It shows that the costs of the main sources of dysfunction are equivalent to about 5 percent of GNP; however, it should be noted that the pollution costs are estimates extrapolated from studies that were made in Asia (in Jakarta) over a number of years, and from which dose-effect curves have been derived through regression analysis. Moreover, the costs as estimated are not entirely due to transport, since there are other sources of pollution in Dakar (e.g. electric power plants, a cement factory, various industries, etc.).

Number of persons > Long-term standard



Key : REF : base scenario ; VEH: measures applicable to vehicles ; URB : planning ; OPE : operational measures.

### A strategy for combating air pollution caused by transport

Air pollution caused by urban transport can be reduced through measures in a number of areas: institutional, technical, or organizational. All of these require forms of investment that differ as to cost, difficulty of implementation, and timing.

So that the effects of the various measures can be compared, they have been divided into the following three main categories, according to their intrinsic features:

- Measures applicable to the vehicles themselves, the aim being to reduce overall pollution by reducing individual emissions; these include:
  - introducing tax and regulatory measures governing vehicle imports, with the aim of reducing the number of older vehicles in operation;
  - providing existing technical monitoring centers with equipment for measuring engine emissions, with special training for staff and new rules defining the standards that vehicles must meet;

cludes:

- reorganization of mass transit in order to achieve optimum integrated operation of the various modes of transport;
- action for easing the flow of vehicular traffic (through a transport plan, street improvements, dissemination of information for users, and staggering of rush hours).
- Finally, measures for reducing demand; these mainly relate to issues of urban planning, such as administrative or educational decentralization.

Traffic levels, the resulting emissions, and the impact on air quality were then calculated using mathematical models reflecting the current situation (the base scenario), together with three other scenarios that would be produced by applying the three categories of measures defined above. For example, the following chart shows how, in the current situation, the NO<sub>x</sub> pollution standard is exceeded.

- improving fuel quality, and introducing tax incentives for the use of cleaner fuels.

• Operational measures for increasing the pollution-abatement efficiency of public transport through changes in the parameters of supply. This category in-

## The Urban Transport Component

The main objective of SSATP's Urban Transport Component is to promote reforms in transport policy. It seeks to achieve this objective by undertaking activities that will improve institutional and regulatory frameworks and road safety, particularly with regard to pedestrian safety, by carrying out studies of microenterprises and launching an air-quality management initiative, and by strengthening local capacity. Currently, the Component has 18 member countries.

This article was first published as SSATP Technical Note No. 19, May 1999. For more information, contact Mr. Patrick Bultynck, Coordinator of the Urban Transport Component. Internet address: [pbultynck@worldbank.org](mailto:pbultynck@worldbank.org)