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Transport and urban environment in developing countries: the situation is known, pragmatic policies and understanding of related elements are needed

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TRANSPORT AND URBAN ENVIRONMENT IN DEVELOPING COUNTRIES; THE SITUATION IS KNOWN, PRAGMATIC POLICIES AND UNDERSTANDING OF RELATED ELEMENTS ARE NEEDED

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Abstract

Environmental impacts of urban transport in developing countries are well known as indicated through many examples from Africa, Asia and Latin America. Policies and countermeasures are classified and listed as well as the numerous involved actors, variables and effects. A pragmatic approach is needed to ensure success and sustainability of the solutions. The paper discusses main barriers impeding applicability, success and sustainability of mitigation policies and countermeasures. It also outlines the complexity of handling and modelling such multivariate problem of policies, actors, variables and effects. A simplified approach is suggested, which can ensure applicability, implement-ability, success and sustainability of policies and countermeasures. The paper addresses the need to achieve balance between facing the problem with "immediate vision" and the importance of looking to "future needs", between "simplifying the analysis" and "comprehensiveness" and between the ambition of setting out "ideal objectives and policies" and the importance of being "pragmatic" in view of the prevailing city constraints. Recommended practical directions on designing achievable objectives and policies are given.

Keywords: Environment; Sustainable environmental policies; Environmental analysis; Environment and transport in developing countries; Multi dimension environmental problem
Topic Area: G08 SIG7 Urban transport in developing countries

1. Introduction

The paper tries to go into the practical aspects of the problem of the adverse impacts of urban transport on the urban environment. Many reports, studies and papers state that the situation in many major cities of developing countries is unhappy. This deteriorated situation is well known and we in many developing countries have had enough related criticism. Also, many policies and measures are recommended for many cities by international aid and financing agencies and national and local governments. It is also believed that although some of the recommended policies gave encouraging results and reasonable success, yet we still need to know why others are unsuccessful and to know if the successful ones are sustainable. We need to be more practical in defining objectives that can be achievable. We need to find the right and realistic ways and requirements that lead to setting out sustainable policies in view of the realities and the prevailing constraints. This is the core of argument researched in the current paper. The paper aim is to study how realistic and sustainable policies and countermeasures can be formulated and successfully applied. It starts with a review of recent

observations of air pollution and noise levels in some cities in Asia, Africa and Latin America. Many examples of recommended and/or tried policies and countermeasures are given based on recent references. The paper analyzes and classifies these policies and countermeasures as they relate to six main drivers. These are “transport mode”, “fuels and power”, “promoting sustainability”, “traffic management and control”, “encouraging walk and non-motorized travel” and “restricting traffic congestion”. In addition, examples of reported complementary actions for success of some of those policies and countermeasures are presented. The degrees of success of application of policies and countermeasures to reduce the adverse effects of transport on the environment are briefly outlined with example cases of success from many cities that are still, however, constrained by other forces. The constraints of implementation, success and/or sustainability of the policies and countermeasures are then discussed, pointing out eight main barriers, and the difficulty to shift interests of authorities and residents to the future as they are usually interested in the immediate solutions.

Next, applicability, implement-ability, success and sustainability of policies and countermeasures are discussed explaining the difference between a policy being applicable and implement-able, a policy being implement-able but unsuccessful and a policy being successful but unsustainable. The numerous involved "policies", “actors” and “variables” are identified and classified into several groups and subgroups. The "effects" of transport on the environment are also briefly outlined. The complexity of handling this “4-Dimensional” Problem that includes the “policies and countermeasures”, the “actors”, the “variables” and the “effects” (Huzayyin, 2003) is, then, explained. The paper points out guidelines for simplification which is particularly required for developing countries and how the defined policy objectives should be realistically achievable in practice and sets some guidelines for formulation of practical policies.

2. Review of recent observations

Deterioration of environmental quality particularly in congested urban areas of many developing countries is known. Many measurements have been conducted and many reports have been published, particularly on air quality and noise levels (Huzayyin, 2001). In Delhi for example it is reported that 55% of noise is due to vehicular traffic and that existing levels are as high as 80 dB(A), (Sarkar and Rohatgi, 2000). It was also found that the passenger car noise equivalents (PCNEs) for bus and three wheelers (3Ws) is 7.08 for each. while it is only 2 for trucks (Sundaram and Verma, 2000). With the noticeable presence of buses and 3Ws in the streets of Delhi, it is clear that these two modes participate actively in the increased noise levels.

The conditions of air quality are serious in some cities due to deteriorated vehicle maintenance and the high average age of the fleet. For instance, in Pune and Bangalore, India, a random check of 1092 new vehicles indicated that 44% and 42% of the vehicles failed the emission test, respectively (Khan and Udayakumar, 2000). The average age of a sample of 100 taxi cabs in Cairo was as high as 16 years (Huzayyin and Osman, 2000). In Sao Paulo the contribution of all transport modes to all pollutants in the CO content is 98%. Contribution of the private car alone compared to all transport modes in the city is 86% (Madar, et al, 2000). In Delhi although it is reported that CO levels are acceptable, yet those of SO_2 are more than WHO standards in some cities in India. Furthermore, the suspended particulate matter SPM is 9-10 times more than WHO standards, but lead levels are very low as unleaded fuels are used (Badami, 2000). The same reference reported that ozone exceeds the 8-hr and 1-hr limits in several cities particularly in winter. The motorized 2 wheelers (M2Ws) are blamed for

pollution. In contrast to buses they reach 67% of veh.km and only 16% of pass.km, while the same percentages for bus are 10% and 70%, respectively. The shares of M2Ws in air pollution reaches 30% of CO, 51% of HC and 30% of SPM produced by all modes. It is indicated (Akinyemi, and Medani, 2000) that for 10% increase in the number of 2-stroke motor cycles in congested areas there will be an increase of 20-55% in CO, 32-38% of SPM and 73-160% of HC. Compared to 4-stroke motor cycles these percentages are 11-47%, 2-10% and 15-60 for CO, SPM and HC, respectively. Recent observations in some sites in Cairo showed that CO concentration ranged between 5.7 and 30.4 mg/m^3 (EL Hakim, et al, 1999). The current law allows a high of 30 mg/m^3 for 1-hr exposure and 10 mg/m^3 for 8-hr exposure. However, at one highly congested intersection CO concentration, reached about 50 mg/m^3.

In Santiago de Chile (O'Ryan et al, 2001) the transport system is the primary source of air pollution. Mobile sources are responsible for 92% of CO emission, 71% of NOX and 46% of volatile organic compounds (VOCs) and directly responsible for only 7% of SPM. Consequently, over 80% of emissions are the responsibility of transport. Vehicles are also the principle source of the smallest and most health threatening fine particles. As buses operate in densely populated areas, they directly expose many people to air pollution. They are found to be the major source of NOX, while cars are a major source of COX and NOX and VOCs. In Mexico City according to the 1998 emission inventory, mobile sources are responsible for 98% of CO, 81% of NOX, 41% of HC, 36% of PM10 and 25% of SO_2. Automobiles produce the biggest shares of these pollutants except for PM10 whose main generator is the diesel fleet. (Rabindran, 2001)

About 40% of the 3.8 million vehicles of the Philippines in 2001 are in Metro Manila. Almost a third of the total registered vehicles are diesel powered. Present levels of air pollution come from mobile sources with estimates of 116000 tons of PM10, 39000 tons of SOX, 140 tons of lead, as well as undetermined amounts of CO, HC, NOX and VOC.(Asian Development Bank (ADB), 1998). In 1999, estimated emissions in Jakarta showed that mobile sources contribute to 8% of the total particulate matter, 80% of total SOX, 36% of total NOX, 80% of total HC and 87% of total CO (Aboeprajitno, 2001).

It is estimated that in a developing countries 0.5 to 1.0 million people die prematurely because of exposure to urban air pollution in addition to millions of cases of respiratory illness in large cities of these countries due to the same cause (Kojima and Lovei, 2000). The same reference mentions an economic damage of air pollution between $1 and $4 billions annually in cities of Asia. This represents 10% of urban income in Bangkok, Kuala Lumpur and Jakarta.

As for visual intrusion, many flyovers and elevated roads were constructed in many cities during the last two decades to relief traffic congestion. These superstructures even if care is taken to give them good architectural look, yet they still obstruct the view. Residents instead of seeing free skies, they see steel and concrete structures carrying vehicles of all types intruding the view (Huzayyin, 1995). Also, fleets of buses and paratransit modes not only congest the network but also badly affect the street view and the environmental image of the city at large.

Another environmental impact of urban transport that can be easily observed in developing countries, and unfortunately always ignored, is the "pedestrian/vehicle" conflict. In densely populated cities, severe conflicts occur between the walking travelers and vehicles in the traffic stream. This is due to the high percentages of walk and the lack, in many cities, of enough widths of sidewalks, lack (or non-use) of recognized safe pedestrian routes and pedestrian crossing facilities accompanied by lack of enforcement. Insufficient knowledge of

traffic rules by both the walking traveler and the vehicle driver also contribute. So, it is often to observe people walking on the traffic lanes and pedestrians crossing the street at random locations. Many adverse results occur, such as high accidents rates and accident potential as well as delay to both the pedestrian and vehicle users. This means more energy consumption and increased air and noise pollution. Unfortunately, however, there seems to be lack of research in this direction.

Although some communities in different cities can have similar perception of some of the adverse impacts of transport on the environment, yet some others can differ in opinion. Such difference, however, is possibly attributed to the unawareness of the serious long term impact of some of those effects. In all cases there seems to be full understanding and consensus in almost all communities and governments on traffic safety and air pollution as the most serious impacts of transport that affect human life. This applies not only to local governments but also to the more influential central governments that in many developing countries are trying to do something positive to enhance the quality of the urban environment. Also, many NGOs are showing increasing interest as well as international aid agencies of the industrialized world.

In summary, it is clear that environment deterioration in many of the major urban areas of many developing countries is well known. It is believed that no further evidence, observation or data gathering is needed for proving a well-known situation. Observation should concentrate on monitoring the impact of applied remedies.

3. Policies, countermeasures and complementary actions

3.1. Examples of policies and countermeasures

Many policies and countermeasures for reducing the impacts of urban transport on the environment have been implemented with varying degrees of success. The literature is very rich on this topic. Some of these policies/countermeasures are classified and listed below as given and referenced (e.g., those caught in section 2) and in an earlier paper by the author, (Huzayyin, 2001), otherwise the additional references are (Alvares, 2002), (Wangwongwatana and Warapetcharayut, 2000), (O'Ryan, et al, 2001) and (Aboeprajitno, 2001).

<u>Policies and countermeasures related to transport modes</u>

- Replace the 2 stroke 2 wheelers by 4 stroke engine.
- Enhance public transport to replace 2 wheelers.
- Ban imports of old vehicles to reduce age of fleet.
- National fleet renewal programs.
- Controlling the use of used engines in newly built vehicles to meet new vehicle emission standards.
- Ban imports of unsuitable vehicles for public transport and apply intensive inspection and maintenance programs for public buses.
- Improve vehicle technology and enhance vehicle maintenance.
- Roadside inspection.
- Tighten vehicle emission standards and introduce vehicle emission tests.

<u>Policies and countermeasures related to fuels and power</u>

- Increase utilization of CNG and LPG.
- Encourage taxis to convert to CNG operation via appropriate schemes.
- Use solar power for LR.
- Encourage conversion of 2 wheelers to electric battery powered engines.
- Encourage environment friendly electric driven transit modes (e.g. LR and metro).
- Improve fuel quality.

- Tax penalties and incentives to promote cleaner vehicles and fuels.

Policies and countermeasures related to traffic management and control

- Increase average operating speed on the street network via traffic management.
- Expand and improve public transport, including bus lanes and improved bus terminals and transfer facilities.
- Introduce efficient traffic management including new communication technology.
- Improve parking supply management.
- Strict enforcement on traffic regulation and control of 2 wheelers.
- Ban heavy vehicles from entering CBD and improve cargo terminals.

Policies and countermeasures to encourage walk

- Take necessary measures to encourage walk such as: widening sidewalks, ban sidewalk occupancy, safe street crossings, etc.
- Demonstrate walking benefits through appropriate campaigns.
- Improve cycling facilities.

Policies and countermeasures related to demand management

- Flexible working hours.
- Introduction of appropriate traffic demand management measures.
- Impose charge on polluting vehicles.
- Charge low occupancy vehicles entering CBD to encourage shift to buses.
- Encourage increasing car occupancy.
- Restrain use of taxis, including higher taxi license fees.
- Restrain use of cars, through for example, promoting the use of public transport, introduction of road user fees and higher parking fees.

Policies and countermeasures related to sustainability

- Integration of environmental, economic and equity impact assessment in decision making.
- Integrated initiatives for heavily polluted areas.
- Encourage sustainable self-enforcing transport.
- “Polluters must pay” policies. This should lead to justice and equity among road users and people living along congested corridors.

3.2. Examples of complementary actions to support policies

- Establish database, action plans, regulations and mobilization of public support.
- Enhance environmental evaluation techniques to demonstrate benefits of environment friendly modes in a quantifiable objective manner.
- Complement the “polluter must pay” policy by an effort to understand how and why people pollute.
- Campaigns to increase awareness.
- Training of technicians working in vehicle repair garages.
- Development of programs for self-monitoring, training, orientation and awareness of fleet owners.
- Introduction of efficient regulatory directives.
- Public/private partnership to support successful implementation of policies.

3.3. A brief on the degrees of success of policies and countermeasures

Success of application of policies and countermeasures to reduce the adverse effects of transport on the environment is varying according to the city under consideration and the type of policy or measure in question. A brief discussion is given below on example cases of

success that are still constrained by other forces. For instance, because of the economic crisis in Indonesia, not all the vehicles in Jakarta undergo the compulsory emission test. The institution responsible for vehicle emission testing needs several actions such as strengthening the capabilities and facilities for roadworthiness and implementing and enforcing the law, (Aboeprajitno, 2001). Furthermore, introduction of natural gas by converting certain vehicles like taxis and buses into CNG has been happening with continuous success, particularly for taxis in Jakarta and Cairo; both countries enjoying a wealth of natural gas. For instance, in GC the number of converted taxis to CNG operation has increased from only 200 to 27000 between 1996 and 2001 and the number of CNG fueling stations increased from 37 in 1999 to 47 in 2001. A very effective policy and financing scheme and strong government commitment have contributed to this sustainable achievement (Huzayyin and Omar, 2000). Irrespective of this remarkable success, the constraint is always the high initial cost of the gas network construction and expansion.

The quality of automotive fuels, which directly affects emissions, has shown great success in Brazil as one of the first countries to use a gasoline additive that is lead-free nationwide. The State of Sao Paulo made considerable progress in the field of controlling automobile pollutants with the consolidation of PROCONVE, The National Automotive Vehicular Air Pollution Control Programme, which is applied since the early 1990s. Fleet emissions were effectively controlled for all production of the new heavy duty vehicles in 2002, and limits were set for the controlled pollutants. However, due to a natural delay in implementing national regulations on environmental certification for this category of vehicles, only less than 20% of this fleet (post-1996) meets limits similar to EURO I and EURO II. An upgrade of the PROCONVE is already planned, aiming to bring it into line with limits set in Europe, the U.S. and Japan. More details are given in reference (Alvares, 2002).

In Santiago de Chile, the Regional Environmental Commission (CONAMA RM) launched the Greater Santiago Air Pollution Prevention and Decontamination Plan back in 1998 with a goal to meet air quality standards by 2011. Under this “umbrella” plan, 54 specific measures were developed at an overall cost of US$1 billion. The planning process involved many government agencies and more than 300 NGOs, business and academia. An implementation schedule was designed for each measure, and compliance and enforcement responsibilities were assigned. After two years, only half of the measures that should have started in the planned period have advanced according to the schedule. It is stressed (O’Ryan et al, 2001) that advances in reducing air pollution depend strongly on the relationship between CONAMA and the government agencies that oversee transportation activities, as well as support from businesses and voters. Improved air quality, and reduced traffic congestion and greenhouse gases, will often require behavioural adaptation, impose some extra costs, and adversely affect some interests. Considerable political and educational effort is necessary to accomplish change (O’Ryan et al, 2001).

4. Forces constraining cities

In the following paragraphs constraints and barriers of: implementation, success and/or sustainability of the above mentioned policies and countermeasures (Huzayyin, 2001) are briefly discussed. This is not an attempt to give an exhaustive list of constraints, the discussion rather points out how some of the constraints and barriers can be grouped under eight main headings. It should be noted however, that not all constraints exist in one city at the same time, but rather many are prevailing. First, lack of political will among some of the concerned decision making bodies prevents right decisions from being taken at the right time. It is not

enough to be aware of the problem and to indicate the desire of an improved environment, but "will" and "determination" should be expressed clearly. This can then be translated into actions at the top level including mobilization of resources, making budget available and removing implementation obstacles, etc., and without "will" those actions would not be in force.

Second, another barrier which impedes sustainability of policies and countermeasures is the difficulty to shift interests to the future, as authorities and residents are usually "immediate-term-solution-minded". People and authorities want to see immediate improvement (not only environmental) regardless of what can later happen in the future. Of course it can be argued quite logically that the same prevails for authorities and residents of the developed world cities, yet in those cities authorities are under continuous pressure to practically adapt to emerging ideas and concepts (sustainability, for example) in more practical ways.

Third, lack of locally generated "dedicated" fund to be assigned for environment improvement programmes and enforcement of regulations and standards is another barrier for implementation. Often when international aid is made available to provide fund and technical assistance for the environment, there would be a problem of "un-sustainability". Simply, and usually, when the foreign aid terminates, the local authorities find it difficult to continue alone in running the improvement schemes. Coupled with the lack of "political will", this constraint hinders continuity of the adopted policies and countermeasures. As environmental impacts of transport are continuous for as long as transport modes are moving and transport projects are built, discontinuing the progress of improving the urban environment is very damaging. Institutional deficiency is a fourth constraint that is imposed on city authorities in many developing countries. In some cities there is no special agency for environmental affairs and so its duties are done by the central government and/or by local government, sometimes employing non-specialized, staff. In cases where environmental agencies exist, sometimes they are not well staffed and equipped to carry out their professional duties up to the acceptable standards. So, big effort is needed either to introduce new institutional structure within the city technical section or to bring about institutional development in the already existing environmental agencies. This is to be coupled with human resource capacity building schemes so as to increase competence of the environmental inspection and monitoring staff. In addition, it can be understood (Badami, 2000) that there is cross sectional interference at the institutional level between different bodies involved. It is also hinted indirectly that overlap exists between the regional and national levels dealing with environmental matters that can add to the complexity of the issue at the local government level.

Another obstacle is the huge number of players involved as listed in section 6.1. This makes it extremely difficult to coordinate activities, to avoid overlapping work and harmonize environmental improvement programmes that minimize the relevant adverse effects of urban transport. A sixth barrier is the lack of information that limits the capability of city authorities to convince legislative councils to approve funding of environmental improvement policies and measures. This needs technical capability, human recourses and cost for collection and continuous updating and processing. Furthermore, data sources are not always in hand and many external bodies may be involved. Finally, in some cities behavioural manners of drivers coupled with difficulties of enforcement may impose a serious constraint on achieving acceptable levels of air and noise pollution and thus delays implementation of air quality improvements. Furthermore, in some cases the behaviour of some stake holders when improvement policies conflict with their own interests is a direct cause of delaying decisions

and budget approvals. So, it is not only the behaviour of drivers that matters but also institutional behaviour can be unacceptable in some situations.

5. Applicability and sustainability of policies and measures

In spite of the awareness and serious effort of governments and the international and bilateral initiatives and projects (see Huzayyin, 2001 for elaborate discussion), the above mentioned constraints impede important elements of success of the implemented policies and measures and do not bring about the expected results, which match the cost of implementation.

Bearing in mind the above mentioned examples on the policies and countermeasures (section 3.1) and the discussion on the degrees of their success (section 3.3) as well as the constraints and barriers (section 4), one can easily detect that it is not easy to implement the devised measures and policies as it is for naming them! The same is for continuing to implement the policies and/or the measures that have been implemented. For instance, it is easy to say "replace the 2 stroke 2 wheelers by 4 stroke engine", but is it easy to implement this policy? Would users of the former mode agree to convert? If they agree, what would be the cost? And who would pay for it? If the policy is to "encourage walk" and the measures to promote this policy include (a) widening sidewalks and (b) banning sidewalk occupancy by street venders and parking, it is interesting to note the following. If many of the streets in the considered city are narrow and do not facilitate widening, then the former measure is applicable but non-implement-able. Whereas, if the city authority is serious and includes the right staff for enforcement, then the latter measure is applicable and implement-able. Another example is if we adopt a measure that is calling for the "use of solar power for LR", would it be easy to technically do so? Is it easy to convert existing electrically powered LR systems to solar? What would be the cost involved? Would the city be prepared to find financing? An additional example is if a policy is calling for "encouraging bus operators to convert to CNG operation" depending on foreign aid for financing, that otherwise neither the city nor the operators could afford to finance, then sustainability of such policy would be questioned. Although success is foreseeable and of course a number of buses would actually be converted, yet after termination of foreign support it is doubtful that the city and/or the operators would continue to be capable of converting buses. Several other examples can be set out to affirm the above points of view.

So, we must distinguish between "applicability", "implement-ability", "success" and "sustainability" of the adopted policies and measures to mitigate the adverse effects of transport on the environment by trying to answer a set of related questions (Huzayyin, 2003). To what extent are the formulated policies and the adopted measures ***applicable***? If some of the policies are inapplicable, what are the reasons behind this loosing situation? And how can we make the "inapplicable" applicable? Is it only by overcoming the obstacles (reasons) behind inapplicability? Are all the applicable policies and countermeasures ***implement-able***? And if not, why and how can we make the "applicable" implement-able? Furthermore, why are some of the implement-able (already implemented) policies ***successful***, while others are not? Also, are all the successfully implemented policies and countermeasures ***sustainable***? And how can the "successful" unsustainable ones be made sustainable? It is far more important to try to answer these questions, in view of the prevailing constraints, than to formulate many policies and countermeasures or to continue talking about the deteriorated situation. We need to be more positive and more practical and to move via appropriate research from one step to the other as in Figure 1.

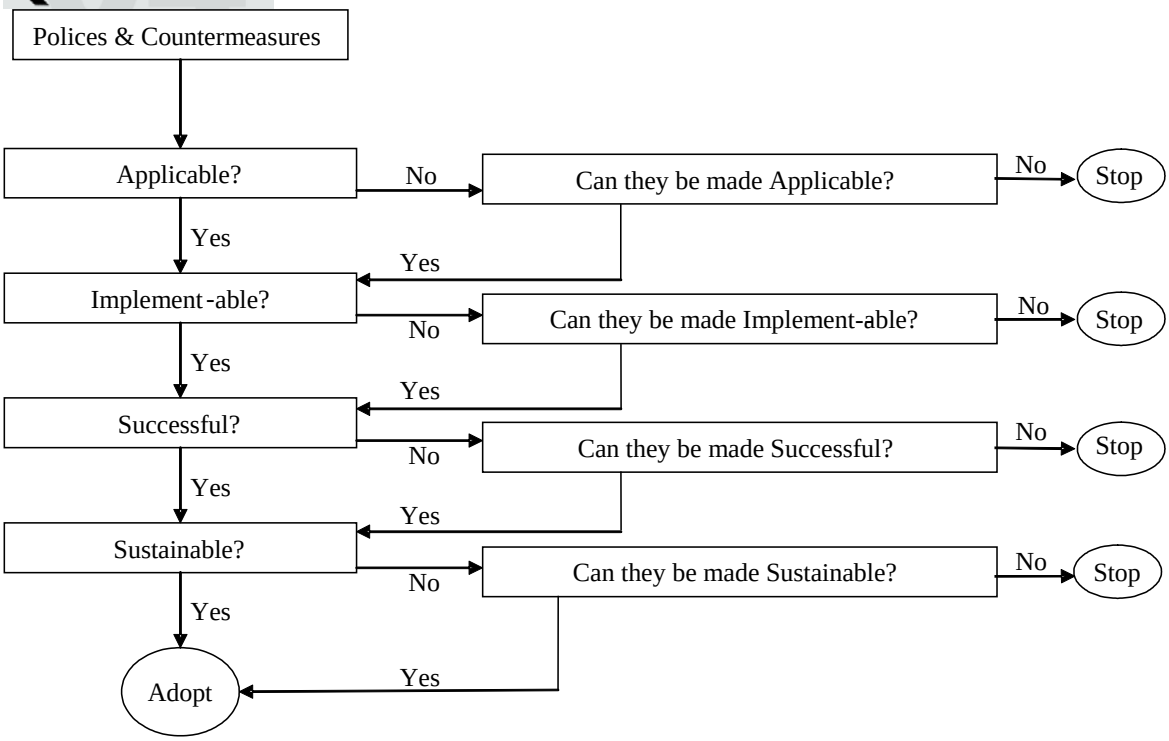


Figure 1: The philosophy of moving from a stage to another in search for applicable, implement-able, successful and sustainable polices and countermeasures of mitigation of transport impact on the environment.

An interesting example can be found in reference (World Bank, 2000), which sets out air quality measures (policies) based on realistic considerations to make them applicable. Examples of the given measures are: modal shift to more efficient and less polluting modes, non-motorized transport and fuel cell or battery-operated 2 and 3 wheelers and public transport vehicles. Examples of the given considerations as prerequisites for successful implementation of the above measures are: extent of the development of R&D in the country, extent to which the primary market exists, cost of current technology and multiple domestic benefits from the technology (e.g. safety, air quality, reducing congestion, etc.). The reference gives more details and discussions of relevance.

More research effort is needed to reveal the write answers to the above questions and to investigate similarities and dissimilarities between cities and situations. This is in addition to grouping the reasons of success and failures under, for example, technical/technological, financial, institutional and behavioral reasons. This leads to thorough understanding of the realities of the local context and to arriving at the important considerations that should be borne in mind before getting involved into formulating policies that stay on paper.

6. Actors and variables

6.1. Examples of the involved actors

Many actors are involved in the formulation of policies, design of countermeasures, setting out environmental standards, monitoring and follow up of environmental quality and of the

applied mitigation policies and countermeasures. These add up to the complexity and the constraints that delay or prevent successful implementation of the policies and/or measures.

The involved actors can be classified under seven groups as listed below with examples of the actors given under each group (Huzayyin, 2001).

Group I: Central government
- Ministries, or Departments, of: transport, the environment, industry, power and energy, public works, health, petroleum.
- Legislative elected councils: parliament, people assembly, etc.

Group II: Local government
- City Governor.
- City Council.
- City Engineer (technical office).
- Transport and traffic section of the City Engineer.
- Other City Engineer Sections (e.g., physical planning, architect, housing, vegetation, cleaning, electricity, water & sewer, etc.).
- Elected Council of the city.
- City Traffic Police Department, etc.

Group III: Operation side
- Bus companies.
- Light Rail operators.
- Metro (underground) operators.
- Rapid commuter rail operators.
- Car parks operator.
- Transit terminals operators, etc.

Group IV: Industry side
- Vehicle manufacturers.
- Vehicle maintenance workshops.
- Vehicle spare parts suppliers.
- Companies of converting vehicle engines to CNG operation.
- Companies of manufacturing electric power driven vehicles (particularly 2 wheelers), etc.

Group V: Non-government side
- NGOs (e.g. environment societies, women guilds, public health societies).
- Shared taxi (paratransit) drivers union.
- Taxi cabs drivers union.
- General Syndicate of Transport Workers, etc.

Group VI: Education, training and research institutions
- Schools.
- Universities.
- Research institutions.
- Training institutions.
- Driving Schools, etc.

Group VII: Aid agencies
- National aid agencies.
- National development banks.
- International aid agencies from different industrial world countries.
- International Banks, etc.

6.2. Examples of the involved variables

Many variables are involved in causing the adverse impacts of urban transport on the environment. As explained later, the existence of so many variables add to the complexity of arriving at successful solutions. Examples of those variables are listed below classified under five groups (Huzayyin, 2001).

Group I: Mode related

- Types of mode operating in the city: cars, buses, 2 and 3 wheelers, electric rail (LR, metro, rapid transit), shared taxi (paratransit), river bus, ferries, etc.
- Vehicle characteristics: age, size, maintenance and engine type (2- stroke, 4-stroke, diesel, etc.).
- Type of fuel: gasoline (leaded / unleaded), diesel, natural gas (compressed / liquid), and electric (main, or battery), etc.

Group II: Traveler style and behaviour

- Driving Style (mode): acceleration, deceleration, cruise and idle.
- Driver behaviour: speed, stop / start, changing lanes, use of horn, sudden break for no reason, raising the volume of audio sets, understanding of traffic rules, degree of obeying traffic rules, etc.
- Pedestrian behaviour: walk speed, walk style, crossing behaviour, degree of obeying traffic rules, etc.

Group III: Transport infrastructure

- Network: design, characteristics (e.g. intersections, links and lengths), etc.
- Terminals: parking lots and garages designs, bus terminals designs, etc.
- Street features: no. of lanes, lane widths, horizontal curves, vertical curves, gradients, surface condition, sidewalks widths, sidewalks surface conditions, etc.
- Bridges, flyovers and elevated roads: location, entrances and exits designs, surface conditions, etc.

Group IV: Traffic characteristics, management and regulations

- Traffic characteristics: speed, delay, headway, queue length, composition, etc.
- Traffic management: signals, signs, intersections design, one-way systems, pedestrian facilities, etc.
- Traffic regulations: on vehicle mechanical check, on traffic flow rules, on vehicle licensing (e.g. age, make and type of fuel), etc.
- Traffic designs: for parking places, intersections, bus stops and bus terminals, etc.

Group V: Nature conditions

- Meteorological: temperature, wind direction, wind speed, humidity, rain, fog, snow, sand storms, etc.
- Topographical: gradient (up/down), hills, valleys, etc.
- Rivers and canals: water stream speed, aquatic life, water used for irrigation, etc.

The above variables are involved in many impacts of transport on the urban environment. Some have their effects on air pollution while others affect noise, water pollution, visual intrusion and city image. Also, some of the factors lead to increased pedestrian/vehicle conflict. And also one variable may have more than one impact (e.g. traffic delay affects air pollution and city image). However, it is out of the scope of the current paper to reclassify the above variables according to the type of impact they cause or to undertake related comprehensive analysis of them. The variables are listed to demonstrate the complexity of the problem.

7. The "4-D" problem "PAVE" and the complexity of analysis

In section 3 examples of many ***Policies*** (and countermeasures) for mitigation of the adverse effects of transport on the urban environment that are suggested and/or applied in cities of the developing world are grouped. In section 6.1 examples of the many ***Actors*** involved in devising the above policies and measures, responsible of reducing the impacts of transport on the environment, setting out environmental standards, monitoring of environmental impacts, running/operating the transport modes and systems that can pollute the environment, etc. are grouped. In section 6.2 examples of the ***Variables*** causing the adverse impacts of urban transport on the environment are grouped. Whereas in section 2 some of the many observations of the ***Effects*** of transport on the environment in may African, Asian and Latin American developing countries are presented. The main effects of transport on the urban environment can be classified in 8 Groups (air pollution, noise, visual intrusion, pedestrian vehicle conflicts, traffic safety, stress and frustration of road users, water pollution in cities operating river ferries and vibration). Some of these groups have more than one component related to it such as, for example, air pollution having 7 major components that threaten human health (lead, COX, NOX, SOX, SPM, airborne toxics, ozone and smoke) and even some of those components include more than one element (e.g., COX has CO_1 or CO_2) and the same for NOX, SOX and SPM. It is clear, therefore, that we are facing a four tier situation or in other words a 4-Dimensional or "**4-D Problem**" that we shall denote hereinafter as "**PAVE**"**-Problem**. The "**PAVE**" **Problem** refers to the problem of having to deal with **P**olicies needed to be applied by **A**ctors to control the involved **V**ariables in order to finally reduce (or control) the **E**ffects of transport on the environment (Huzayyin, 2003).

Starting by the policies (and countermeasures) it is clear from the examples given in section 3.1 that at least we are dealing with 6 groups of policies which are subdivided into 37 examples of polices and/or countermeasures. From the examples of actors given in section 6.1 the concerned actors are classified into 7 groups which are further subdivided into 33 subgroups of actors. Section 6.2 gives examples of 5 groups of variables with 17 subgroups of different variables that are involved in causing the environmental impacts of urban transport. The previous paragraph indicates that the effects of transport on the environment are classified into at least 8 groups which certainly have more than 19 components that threaten human life and the natural environment.

Table (1) gives the numbers of the above mentioned groups and sub-groups of policies, actors, variables and effects involved in the "**PAVE**" problem. The last column of the table gives also the minimum number of the elements of the said sub-groups based on the example listing of policies, actors, variables and effects given earlier in Sections 3, 6.1, 6.2 and 7, respectively. Based on this table and the discussion given above, it is clear that the number of related elements is numerous. Consequently, trying to construct the 4- dimensional interaction between the "**PAVE**" elements is extremely complex. This is true irrespective of the fact that not all elements are exhaustively interacting with each other. Complexity is further magnified when realizing the following points.

Many of the individual variables can have more than one effect. For example, any of the vehicle characteristics (age, size, engine type or maintenance) can lead to air, noise and pedestrian/vehicle conflict. Driver behaviour may also lead to noise, stress and frustration of other road users, threatens traffic safety in addition to adverse effect on city image.

Many of the individual policies/countermeasures can have more than one impact on reducing/controlling some of the effects. For example, a policy to enforce using pedestrian crossing facilities certainly reduces pedestrian/vehicle conflict, which in turn reduces air

pollution as a result of reducing traffic delays and also reduces stress and frustration of the road user and improves traffic safety. Another example is a policy to encourage increased car occupancy, which reduces air pollution, noise and improves city image.

Many of the individual effects can be controlled by more than one policy/countermeasure. For example, "air pollution" can be controlled by many policies some of which are related to transport modes (e.g., replacing the 2-stroke M2W by 4-stroke engine, banning imports of old vehicles, improving vehicle technology and enhancing vehicle maintenance and roadside inspection, etc.). Others are related to fuels and power such as alternative fuel vehicles, encouraging environment friendly electric transit modes, improving the fuel quality, etc.

Many of the individual actors can have more than one role to play. For example, the city authority can be responsible of the formulation of policies, design of countermeasures, monitoring the effects and enforcing related regulations. Training institutions play different roles in creation of awareness, improving driver behaviour, capacity building of policy makers for developing policies and countermeasures, and raising the capability of environmental inspectors, etc.

Table 1: Examples of the main groups and subgroups/components of the 4-Dimensional ("**PAVE**") Problem involved in the environmental impacts of urban transport.

		No. of Example Groups	**No. of Example Subgroups/Components**	**Min. No. of Possible Elements**
P*olicies*	(See section 3)	6	37	>> 50 policies & countermeasures
A*ctors*	(See section 6.1)	7	33	>>> 100 actors
V*ariables*	(See section 6.2)	5	17	> 100 variables
E*ffects*	(See section 7)	8	19	>> 30 effects

Consequently, this is clearly not a "one-to-one" type of problem and, hence, adds another component to the complexity of reaching applicable policies/countermeasures that are implement-able, successful and sustainable. Previous research effort provides mathematical modelling of the effects of transport on the environment (e.g. Miamoto and Sathyaprasad, 1995) stemming from the fact that land use generates trips that can be modelled and trips generate traffic delay which also can be modelled and traffic delay consumes fuel of the used modes which in turn generates exhausts causing air pollution that can also be modelled. However, the level of accuracy of calibration and application of this type of modelling in cities of the developing countries is not as high as it can be for those in the developed world. The level of accuracy of input data is not always guaranteed, calibration conditions are mixed and the conditions for application and model use for prediction of effects do not guarantee stability and, hence, accuracy of models shall remain in doubt for many cities.

8. The need for simplification without loosing practicality of policy formulation

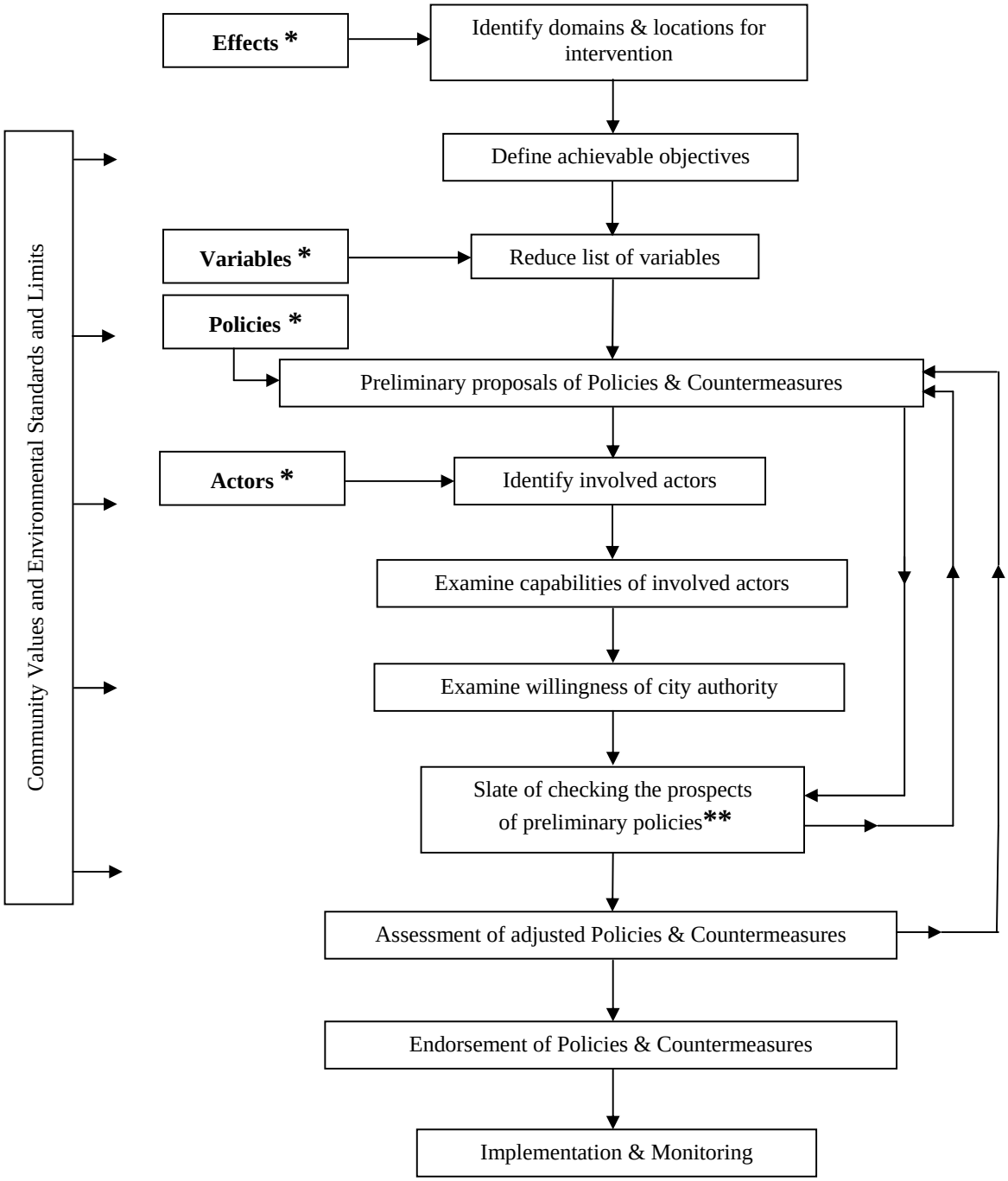
Based on the above discussion, it is clear that we need to simplify the analysis and to take care of arriving at a practical way for the formulation of applicable pragmatic policies/countermeasures that can be implement-able, successful and sustainable. However,

while it is important to find out how to handle the faced complexity, it is equally essential to investigate practical ways to overcome the barriers and constraints mentioned earlier in section 4. The challenge is to achieve balance between "*immediate vision*" and "*future needs*", between "*simplifying the analysis*" and "*comprehensiveness*" and between the ambition of setting out "*ideal objectives* and *policies*" and the importance of being "*pragmatic*" in view of the prevailing city constrains.

8.1. Concepts of a simplified approach

Realizing the extreme difficulty to arrive at reasonably accurate results through sophisticated mathematical modelling approach of the complex 4-D "PAVE" Problem mentioned earlier, it is important to go for simplification without loosing practicality of policies. The suggested simplified approach is shown in Figure 2. Obviously community values and environmental goals should serve as a basic background input. Then we start by identifying the domains, locations and/or corridors that need intervention depending on recent or newly collected observations of the effects of transport on the environment. Then, objectives that are possible to achieve are to be defined. This is more pragmatic than defining objectives calling for ideal environmental standards that cannot be practically achieved. Next we need to reduce the list of variables to be handled by elimination of the variables that are irrelevant to the location/corridor under consideration and to the defined objectives out of the comprehensive list as in section 6.2. A preliminary proposal of policies and countermeasures is to be set out (after reviewing previous ones, e.g. as those listed in section 3.1) and based on which the different actors involved are to be identified out of an exhaustive list as that in section 6.1. The list is to cover all possible actors who would be involved in the preliminary policies/countermeasures as those related to implementation decisions, setting appropriate standards, budget approval, on the ground implementation, monitoring as well as the actors on which the policies/countermeasures may be applied, e.g., bus operators. The technical, human, regulation enforcing and financing capabilities of the identified actors are to be examined. This is to investigate their potential of successful implementation of the proposed polices and countermeasures. Next it is necessary to examine the willingness of the city authority to continue supporting the proposed policies/countermeasures in the future and to make sure of their relevant futuristic vision. This is necessary in order to investigate the potential of making the proposals sustainable. In view of this type of investigation, the preliminary proposals should be revised so as to overcome any obstacles that can affect, in a way or another, the four important aspects explained in section 5, and presented in Figure 1, namely the proposals should be *applicable*, *implement-able*, *successful* and *sustainable*. Next, the adjusted proposals of policies and countermeasures are to be assessed against their anticipated effects. Here, it would be necessary to use simple mathematical models as an analytical tool at the disposal of the transport engineer for evaluation.

Furthermore, it is necessary to approach the additional complexities mentioned in the end of section 7 starting with the fact that many of the individual variables can have more than one effect. This means that full understanding of the variables and the effects of urban transport on the environment should be achieved allowing for "in-depth" analysis in order to formulate/design appropriate policies/countermeasures. Another component of complexity is that many of the individual policies/countermeasures can have more than one impact on reducing/controlling some of the effects. This necessitates the need to rationalize decisions on



* See sections 7, 6.2, 3, and 6.1 for effects, variables, actors and policies, respectively.

** Check prospects of applicability, implement-ability success and sustainability of the proposed policies as in Figure 1.

Figure 2: A conceptual frame for simplification of the "PAVE" problem

implemented policies so as to avoid unnecessary duplication and, hence, waste of cost and resources that makes the applied policies/countermeasures unsustainable.

Rationalizing decisions needs powerful institutional mechanism at the concerned circles of the national/local government with the right technical staff that can give decision makers the needed support. The third component of additional complexity is that many of the individual effects can be controlled by one policy/countermeasure. This calls for the same powerful institutional body that can arrive at harmonizing the different policies/countermeasures so as to eliminate duplication and waste of resources in order to ensure sustainability of those solutions. Finally, as many of the individual actors can have more than one role to play, this call for clear authorized institutional coordination and an overall powerful (mother) body to observe this supervisory role in a sharp and sustainable manner, is needed in order to take care of any delicacies and to create the right work environment for the different actors.

8.2. Recognition of reality facts and recommended practical directions

Bearing in mind the above discussion, the following six basic facts (Huzayyin, 2001) should be clearly recorded before giving guidelines for policy formulation:

a) The situation of deteriorated environmental quality in many of the major urban areas in developing countries is known. The practiced effects of transport on the environment are many and common between these urban areas; they are similar in nature and even also sometimes in magnitude.
b) Many people are aware, but also some groups are not enough aware, of the adverse impact of transport on the urban environment.
c) The number of involved variables and actors are many.
d) There is a host of policies either tried or suggested to minimize transport impacts on the urban environment. Their impacts have varied between full success and success under certain, sometimes unavoidable, constraints.
e) No one policy (or solution) seems to have a big impact alone; implementing a group of carefully designed policies should have sound impact.
f) Policies cannot stand alone, they rather need complementary supportive requirements to be successfully implemented.

Resulting from these six facts, a set of five complementary realistic practical requirements that can support successful implementation of sustainable short and long-term policies are derived as follows, (Huzayyin, 2001).

a) Lessons and experience should be transferred and exchanged between cities as problems are usually of common nature. Bilateral and multilateral communication channels and cooperation agreements can help so much in that respect coupled with coordination with international agencies.
b) Coordination between the efforts, plans, programmes and actions of the very big number of actors involved in urban transport and their impact on the environment is needed. This is not easy, however. These actors belong to many bodies, central government, local government, operators, vehicle industry, unions, etc. and each has its own policy directions, capabilities and obligations. A good step towards achieving the coordinated effort is to set up a “coordinating council” gathering representatives of concerned bodies. Full confidence and powers should be given to this council so as to let its coordinating directives be fulfilled and respected by all bodies involved.

c) As many policies for reducing the adverse impacts of transport on the environment have been already tried and many others are only suggested, we should concentrate effort on two directions. One, to study carefully the results of implemented policies and to learn from this experience. Two, to investigate why some policies are not implemented and how to make them become a reality. Again exchange of information and transfer of experience between cities of the developing countries on implemented and suggested policies is very important for drawing lessons to be learned, avoiding mistakes and capitalizing on merits.

d) It is necessary to realize that it is the collective impact of a group of policies (or countermeasures) that counts. Such compound effect can have sound impact on improving the quality of the urban environment. The difficulty lies in selecting a group of complementary rather than contradictory policies and countermeasures.

e) Each policy needs a set of complementary measures that can first support successful implementation of the policy and second maximize the benefits of the policy. To realize the complementary measures of any policy three points should be considered. First, decision-makers should be fully aware of the need for these measures and to give full support and guarantees to implement them. Second, the complementary measures should be designed very carefully taking into consideration maximizing the benefits of the original policy. Third, as time grows, the complementary measures should be monitored and enhanced, if necessary, so as to ensure continuity of achieving their original objective and hence sustainability of the original policies. For practical reasons, the agency that adopts a policy and its complementary measures should set up permanent staff and budget to take charge of these measures.

8.3. A note on policy objectives and formulation

In order to arrive at applicable policies it is important to be as practical and realistic as possible. This is to be achieved in two directions related to the policy objectives and requirements of policy formulation.

Admitting the extreme difficulty to eliminate the adverse impacts of transport on the urban environment in a few years time, the objectives of short term policies should be in harmony with this reality. For example, a realistic objective would be to control vehicle emission rather than to totally prevent it (Badami, 2000). Another example of an achievable policy objective is to reduce pedestrian/vehicle conflict along congested corridors, rather than to aim at eliminating these conflicts on all links of the city street network and along the whole day. It is far more appropriate to declare a humble objective that can be achieved than to adopt a super objective that cannot be realized. Certainly we should take our hopes and expectations further steps foreword but never to let ourselves dream too much forgetting the constraints that our cities are likely to face in the future. For instance, long term objective can be conditioned by required aims of the community other than only those related to the environment. A good example that illustrates this view is given in reference (Badami, 2000), which suggests a long term objective as follows: “to minimize pollution effect on health and welfare”. This is subject to: (a) low cost on users, the government and the industry and (b) minimum compromise on accessibility and mobility of the public whose majority is poor.

As for policy formulation and the directions to make them as realistic and practical as possible, the main concern is summarized in five points as follows (Huzayyin, 2001).

a) The formulation of each policy is to consider achieving the declared realistic objective(s) of the policy.

b) The policies should take care of the realities of the existing condition and constraints. Many examples of the conditions and constraints can be given as shown below and supported also by reference (Badami, 2000).
   - User related (e.g. pedestrian behaviour, driver behaviour, etc.).
   - Vehicle related (e.g. type, age, capacity, used fuels, industry, import policies, etc).
   - Enforcement and control related (e.g. traffic regulations, vehicle engine inspection regulations, pedestrian movement discipline, etc.).
   - Institutional related (e.g. technical capabilities, human recourses, given powers, allowable budget, current barriers, future development possibilities, etc.).
   - Possibilities of raising awareness of urban travelers, operators, local authorities, etc.

c) Each policy is to be set out in a way that avoids duplication and/or contradiction with sister policies that are adopted to combat the different adverse impacts of urban transport on the environment. These include, for example, policies related to reduction of: vehicle emissions, noise levels, pedestrian/vehicle conflict, visual intrusion, etc.

d) The formulated policies should be in harmony with the urban transport policies adopted mainly to achieve transport objectives in the city under consideration. Examples of the latter policies are those related to transit performance, traffic demand management, future transportation, etc. Again reference (Badami, 2000), stressed the importance of the policies to consider the interaction between: (a) transport impacts on safety, cost, energy and accessibility and (b) policies addressing these impacts.

e) The policies should also be in harmony with other policies related to environment protection and improvements that are adopted in the city (and country) under consideration. These include, for example, policies related to control emissions from industrial plants, control of industrial waste disposals, vegetation of urban vacant lands, and control of unplanned urban development and reservation of city image, etc.

9. Closure

It is hoped that the paper has drawn the attention of concerned agencies and researchers to the importance of getting into action with respect to policies and solutions of reducing the adverse impact of urban transport on the urban environment. Many efforts have been made over the last two decades to describe the urban environment situation in developing countries and how it is seriously deteriorated mainly because of mobile sources. This effort has already raised awareness, stimulated governments and encouraged international support to do something before it is too late. However, it is time now to give more attention to action. We need to set out realistic objectives that can be realized. We need to investigate previous policies and why they succeeded or failed. We need to take care of formulating applicable sustainable policies. We need to work together and to learn from each other. We need to pay more attention to actions that can make us and our future generations live in a better and a more manageable urban environment.

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