Urban traffic management strategy for sustainable development in motorcycle dependent cities: Case study of Hanoi

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***Abstract*— The urban transportation system always faces with big issues in densely populated cities with the limitation of land resources. The problems is especially increasing in developing countries with rapid increase in the mobility demand to serve social-economics activities. The existing imbalance between supply and demand, which continues to increase rapidly, has put great pressure on urban people's lives, posing great risks such as traffic jams, environmental pollution, and accidents. traffic. To reduce traffic pressure, the current top solutions are such kinds of developing high-quality public transport services, encouraging city residents to use public transport, especially for basic trips such as going to work or school. The problem is that if urban traffic planning and management solutions are not user oriented, they may meet many problems in practical implementation with a lot of difficulties, and negative impacts as well. The article conducts research on (i) literature review on road users' behavior of transportation mode selection; (ii) conducting the field survey on Hanoi case study of 04 scenarios of transportation management solutions; (iii) proposing policy recommendation for sustainable development.**

Keywords - emission, urban transport, sustainable development

I. INTRODUCTION

The term of "sustainable development" was firstly launched in 1987 in the report "Our Common Future" published by the World Commission on Environment and Development (WCED). The classic definition of sustainable development is "Development to meet the present demand without compromising the ability of future generations to meet their own demand" [20]. In 1992, world leaders proposed the principles of sustainable development at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil.

Sustainable development is often understood as the convergence among three pillars: economic development, social justice, and environmental protection. Sustainable development is a visionary development concept and over the past three decades, governments, businesses and societies have accepted sustainable development as a guiding principle to achieve progress in sustainable development indicators, while improving the participation of enterprises and society in the sustainable development process. However, practical implementation has been proven to be very difficult. Unsustainable trends continue despite the commitments of government. The reality shows that sustainable development has not really found its way into political mechanism to achieve real progress. Although the Sustainable Development Goals mention three pillars, over the past two decades they have often focused only on environmental issues.

From the general definition of sustainable development, it can be understood that a sustainable city is an urban area designed to reduce negative impacts on the environment through reducing the use of non-renewable resources as well as reducing pollutants into the environment. Reducing the use of fossil fuels is the biggest challenge for sustainable urbanism because they are non-renewable resources and also emit CO_2, which is the main cause of global warming. and climate change. Therefore, switching to using renewable fuels and efficient energy is an essential strategy for sustainable urban development. Environmental efforts must always be associated with economic, cultural and social factors such as hunger eradication and poverty reduction, economic integration and fair distribution.

It can be said that in recent years, transportation vehicles have been rapidly motorized in developing countries, especially with the explosion in the use of motorbikes and other individual motor vehicles, in conditions of limited facilities. Infrastructure, along with limitations in driver awareness and traffic management capacity are main causes leading to urban traffic problems, such as pollution, congestion, traffic accidents.

Enhancing public transport and reducing individual vehicles are important solutions in mitigating transportation negative effects to the urban living environment. Transportation mode choice can be identified as a basic,

sustainable factor and the final destination of managing and controlling solutions, concentrating into traffic participants.

Public transportation systems not only provide faster and safer transportation options but also limit the use of individual vehicles, thereby actively contributing to the reduction of greenhouse gas emissions, noise, use of non-renewable energy. Public transport vehicles also operate on fixed routes, thereby minimizing conflicts among groups of traffic participants.

Currently, many countries are still making efforts to develop public transportation infrastructure such as UMRT, subways, public bus, bus rapid transit (BRT) systems and prioritizing infrastructure floor reserved for buses. However, if the system lacks appropriate connection between public and individual transport, the design of stops and transition has many risky factors, potentially causing danger for traffic participants. Therefore, it may discourage people from using public transport.

In Vietnam, with the economics development, mobility demand is increasing rapidly in recent decades. Due to the fact that the public transportation is not highly prioritized in road users' awareness, individual vehicle ownership increased very quickly in Hanoi in particular and other Vietnam cities in general.

In 2010-2021, the car growth reached at the rate of 16,77%/year, motorcycles growth at 8,48%/year. In 2022, motorcycles are dominant in the traffic flow with the rate of 77,98%; next is car at the rate of 4,99%; and public transportation (including buses and UMRT) is 8,69% [15]. The consequence is the seriously increasing traffic congestion, environmental pollution and traffic accidents. This situation causes direct loss to economic development, seriously reducing the quality of life residents' lives.

Recently in Hanoi, in particularly, the traffic management based on the concept of prioritizing the supply side has shown a lot of limitation. Public transportation services aiming at *expanding the service area, increasing vehicle fleets, increasing quality* seems to be insufficient as they are not very attractive to people. One reason can be that buses are difficult to compete with motorcycles in its characteristics of flexibility and maneuverability. In Hanoi, there are still areas, which are called "two-wheeler blocks", with many long and narrow streets and alleys. In such areas, it is rather difficult for mass transit to have the accessibility to potential users. Of course, when the life is improving, convenient, comfortable and safe mobility will also be at the high rank of priority among road users.

It is now required the new approach of traffic demand management and control, among which *exploring characteristics of traffic demand* can be considered as essential factor.

Understanding the behavior of transportation mode choice may help in applying policies and mechanism flexibly in the more suitable manner with the demand of traffic users. Traffic users are people to propose the final decision of developing the most suitable mode of transportation in the urban area.

II. BEHAVIOURAL THEORY IN TRANSPORT MODE CHOICE

The importance of human factors in transport policy discussion is growing. There is a realization that policy options that appear beneficial in principle have to be checked for implementation feasibility.

There are some qualitative models to describe driver behavior including (applying in order to proceedpredicts and ultimately changes the behavior that leads to crashes): HBM (the health belief model),TRA (Theory of reasoned action), TPB (Theory of planned behavior), TAM (Technology Acceptance Model). These theories draw mainly on the disciplines of sociology and psychology; print particular, social psychology.

There are several researches has been conducted on the behavior of selecting public transportation. [16] found that the probability of shifting to public transportation is higher in female. Similarly, [3] concluded that men have the hobby of driving and lower probability of shifting to public transportation. [1] established the positive relationship between age and the ability of using public transport. The research shows that elders are more willing to shift to public transportation if the quality is enhanced.

Besides, other elements are mentioned in previous researches, such as education, income, household, driving license, accessibility to vehicles and parking [1]. Car ownership and public transport accessibility are important in transport mode choice as highlighted in [19]. [9] and [18] argued that awareness over vehicles' characteristics is an important factor in determining the ability to shift from individual vehicles to public transportation. [7] proves that preference of comfortable and convenience will increase the capacity to choose UMRT than bus service.

In MDC (motorcycle dependent cities), researches focus on shifting from motorcycles to public transportation. In [11], though enhancing quality of public transport can help in reducing motorized vehicles' usage, long habits are difficult to change in MDCs. Therefore, motorcycle use in such areas will continue raising, despite different "push/pull" strategies. Based on [6], in MDCs, cars and public transport will be replacement for motorcycles. Without good public transport, motorcycle users may shift to cars due to convenience and comfortability. Enhancing public transport system, therefore, should be considered as the main strategy to reduce motorcycle usage. At the same time, efficient "push" and "pull" strategies should be carefully designed and implemented.

Typically, indicators for evaluating strategies can be classified into two groups: effectiveness and application level. These indices are widely used for quantitative and strategic evaluation [14].

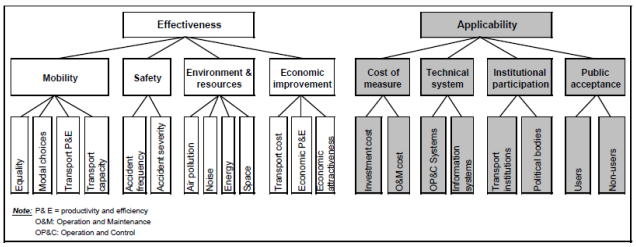


Fig. 1. Criteria for evaluating transport policies

III. RESEARCH METHODOLOGY

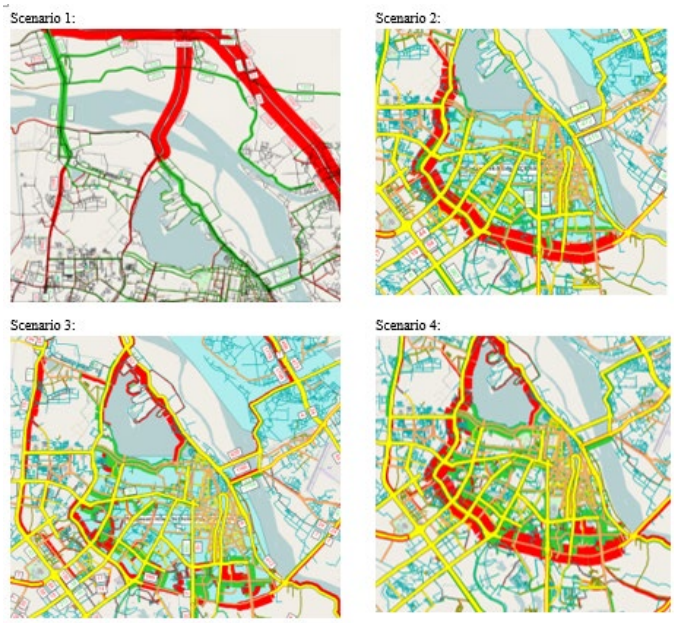
To study the feasibility and effectiveness of different solutions of urban traffic management in Hanoi, in May 2022, the research team conducted a sampling survey of traffic participants, to evaluate:

- What are the factors vehicle selection factors?
- How people react to policy scenarios?
- Suggestions for model building & policy proposals

There are total 2000 samples, covering (i) 1.000 motor cyclers; (ii) 400 bus riders; (iii) 200 bicyclers; and (iv) 400 car users.

Proposed policy scenarios for Hanoi traffic development from now to 2030 include:

- Scenario 1: Developing the city to the East, connecting the two banks of the Red River
- Scenario 2: Developing the ring road infrastructure.
- Scenario 3: Collecting fees of entering the inner city
- Scenario 4: Combining scenario 2 and 3



Note: *red = roads covered by management policies, green = roads with potential impacts*

Fig. 2. Different scenarios in the network model

Among four scenarios mentioned above, the model was simulated based on the current status and new routing with other identical parameters. Long-term effects are changes in residential areas due to changes in transport links or some changes not considered here.

Calculation model for transportation mode choice is based on the Logit function:

$$P_{ijm} = \frac{e^{U_{ijm}}}{\sum_{m=1}^{n} e^{U_{ijm}}}$$

Whereas:

i, j: zone i, j

P_{ijm} is the probability of choosing method m from i to j

The utility of mode m (U_{ijm}) is calculated as follows:

$$U_{ijm} = -(\propto_m C_{ijm} + \beta_m)$$

Whereas:

C_{ijm}: Overall travel cost by mode m between i and j

α_m, β_m: Parameters in the model of each method m

General travel costs by each type of mode are different between individual and public transport, as follows:

For individual vehicles:

$$C_{ijm} = T_{ijm} \times VOT_m + \frac{VOC_m \times d_{ij} + PC_m}{OP_m}$$

For public transport:

$$C_{ijm} = PJT_{ijm} \times VOT_m + Fare_m$$

Whereas:

C_{ijm}: The overall cost of traveling by mode m from i to j

T_{ijm}: Actual travel time by vehicle m between zone i and j

For public transport modes, the travel time is weighted for each segment of the trip to determine the travel time included in (PJT) to calculate the overall cost of this mode.

(*PJT = time on the bus + 2*Accessing time + 2*Walk time to stop + 2*Waiting time + 2*Time transfer + 2 minutes*number of transfers*)

VOT_m: Time value of method m

VOC_m: Unit operating cost of mode m (bus ticket)

PC_m: Parking cost at the destination of mode m

OP_m: Average capacity utilization coefficient of mode m

IV. RESULTS

The survey results show that the likelihood of shifting transportation modes is different for different groups of road users (Fig. 3).

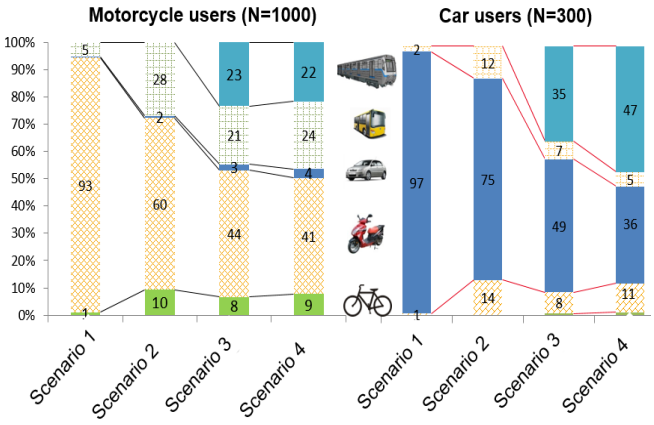


Fig. 3. Percentage of shifting transportation modes

In terms of the rate to change from individual motorized vehicles (cars/motorcycles) to public transportation (including buses and UMRT), scenario 4 may have the most positive results. Car users have more potential to shift to UMRT, whereas motorcycle users are likely to shift to buses. Scenario 3 may have some similar effects with scenario in the group of motorcycle users. The results also imply that combining

structural and non-structural measurements of transportation management and control may have more sufficient and long-term effects.

From the survey results, using a four-step traffic simulation algorithm, it is possible to see the traffic flow results in different scenarios and the relationship of the current traffic situation with the urban air pollution. Typical scenario has significant effects on traffic conditions in the study area, thereby reducing local penetration of air pollutants. On the other hand, reducing carbon dioxide emissions requires more comprehensive measures.

Along with measures to reduce traffic flow, leading to environmental pollution reduction, it is also easier for authority to choose advanced environmentally friendly means of transport.

Calculating forecasts of vehicle emission reductions to 2030 in Hanoi is described in the figure below.

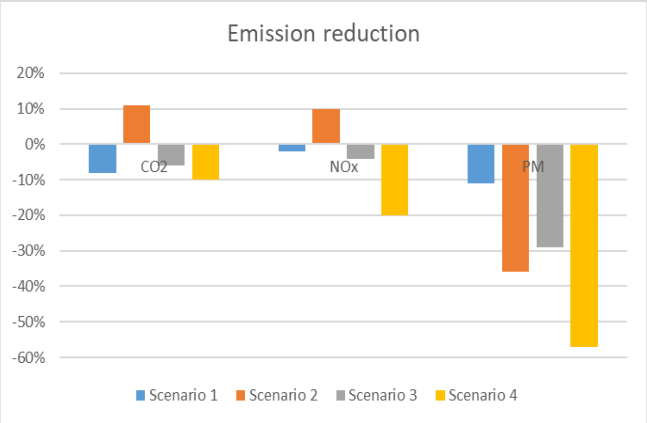


Fig. 4. Forecasting rate of emission reduction until 2030

The main emission reduction targets calculated are CO2, NOx and PM. It can be seen that choosing different modes of transport in different policy scenarios will lead to emission reductions with relative differences between emission targets. Depending on the emission reduction goal in each period, different policies may be selected.

In Hanoi, the number of individual vehicles is large and the road infrastructure in many places is overloaded already. The situation will be much more seriously in the future. Therefore, adding more buses may not bring about environmental improvements as expected. However, it can be said that changing citizens' mind and habit of mobility should be considered as a better and more sustainable solution, so that Hanoi can become a city with environmentally friendly urban transport.

For urban areas with mixed traffic flow and slow traffic speeds like Hanoi, the use of micro mobility vehicles, such as electronics bikes, scooters, etc. can be encouraged. Electric bicycles with the support of electric motors, reduces the physical stress of cyclists and allows traveling longer distances, especially in a hot and humid environment like Hanoi. Due to its compactness and light weight, parking can be solved in many ways, such as using wall brackets in living areas to underground parking lots in business centers.

The paradigm shift in urban transport needs to be supported by policies and community. The awareness can have long-tem influence in order to encourage people to use environmentally friendly vehicles such as electric bicycles, micro mobility vehicles, etc.

Experience drawn from the study shows that Hanoi has very high potential to develop an environmentally friendly urban transportation system. However, applying lessons learned from developed cities may not be easy and sufficient. Hanoi needs to find its own way to develop a suitable smart mobility manner.

Policies need to be improved step by step, firstly by establishing an effective urban individual transport standard. The following strategies may be suggested such as enhancing better and safer traffic organization and management; providing fuel-efficient vehicles; concentrating resources on developing effective public transportation systems, especially along main corridors; developing the suitable concept of TOD (transit oriented development) in the city.

V. CONCLUSIONS

Vietnam's urbanization process, along with the process of industrialization, modernization and globalization, has had a great influence on the socio-economic characteristics as well as the shape of urban areas and people's life-style. Most likely, Vietnam in general and Hanoi in particular will develop following the model of countries that have become industrialized countries such as Japan, Korea, Malaysia and China.

In the coming time, Hanoi, as well as Vietnam big cities, still strongly depends on motorcycles in fulfilling mobility demands. The motorcycle dependent traffic flow with the serious (and increasing) unbalance between transport demand and supply is causing serious problems of urban transport environment.

To limit negative impacts on the transportation system from the urbanization process, state management agencies have oriented the development of public transportation (especially urban railways) as an effective solution. However, world experience shows to achieve optimal efficiency in converting from an urban area dependent on individual transport to an urban area dependent on public passenger transport, only building transport infrastructure may not be enough.

Lessons learned and best practice show that effective regional construction planning in integration with the public passenger transport system is needed to ensure the solution of traffic problems.

Urban traffic management is increasingly important as infrastructure development projects cannot keep up with the increase in travel demand in developing countries. Changing community's perception and awareness of smart vehicle usage will always be an essential and efficient measurements with long-term effects. Unstructured solutions bring new opportunities in urban development, attracting resources to limit the use of individual vehicles, develop public passenger transport systems, and improve the quality of life towards sustainable development goals.

This study summarizes the findings of emission reduction rate in different scenarios of the transport management policies in Hanoi until 2030. The field survey has been conducted in order to explore the ability of shifting from individual to public transport of Hanoi citizen.

So far, the study just applied the field survey result to examine one target of emission reduction in different scenarios of urban transport policies in Hanoi. The results of using the transport mode selection model in evaluating the effectiveness of urban traffic management policies can be extended to other sustainable development goals such as smooth traffic, environment, socio-economic efficiency, and traffic safety as well. Other criteria can be applied to evaluate effectiveness and application level of different policies, strategies and measurements in next steps.

ACKNOWLEDGEMENT

This study is based on research supported by Vietnam Ministry of Science and Technology and German Federal Ministry of Education and Research (Project No. NDT/DE/21/30).

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