SYSTEM DYNAMIC APPLIED TO STUDY THE URBAN TRAFFIC CONGESTION OF HANOI

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Abstract: Economic development and urbanization has caused many challenges to transportation system. Hanoi, as other cities in the region, has to face with urban transportation problem such as traffic congestion, environment pollution, traffic safety, limited land use, urban aesthetic, urban layout, etc. The reducing average travel speed, the increasing number of motorcycles and cars, traffic safety, land use for transport, urban environment, etc. are the hot problems today. The paper aims to provide system dynamic approach applied to study the existing urban transportation situation of Hanoi. In the paper, all causes and affects of traffic congestion was investigated and analyzed by the effected method. Long-term policies and measures are proposed and evaluated based on it.

Key word: traffic congestion, transportation policy, system dynamic, urban transportation problem, bus system.

1. INTRODUCTION

Economics of Hanoi has been developed fast after opened-door policy implementation. One of more undesirable effects of this growth is reflected in uncontrolled urbanization, inefficient land use and largely reactive planning and management in urban transport sector. Transportation mode in Hanoi is driven by motorcycle-oriented. Motorcycle ownership has been increasing at an annual growth rate of 15 –- 20% over the last 5 years. Travel demand by motorcycle occupied over 70% and bicycle around 25% among total travel demand of Hanoi while public transport accounted for only 3% in 2000 and increased up to 10% in 2002. Traffic movement in peak hour reduced from an average of 22 km/hour in 1997 to 14 km/hour in 2001. Refer table 1 for detail information.

Traffic congestion is a common one in many roads of Hanoi today. Many papers and studies focused on this problem, however those looked at the part of the whole only, but did not considered causal interactions for traffic congestion patterns over time. The paper aims to apply another method for more integrated view of different factors directly and indirectly affect urban traffic problems.

System dynamics is a methodology for understanding certain kinds of complex problems, focuses on feedback processes. Its approach was developed basing on the principal: everything related and everything changed. It takes the philosophical position that feedback structures are responsible for the changes we experience over time. The premise is that dynamic behavior is a consequence of system structure.

Table 1: Data sheet of Hanoi

Year	Population of city		GDP of city		Motorcycle		Average speed in peak hour	
	Inhabitant	growth rate (%)	No.	growth rate (%)	Number	Growth rate (%)	Week-day (km/h)	Weekend (km/h)
1990	2119100	1.00	2285151	1.00	195451	1.00	32	33
1991	2181000	1.03	4982925	2.18	280142	1.13	30	32
1992	2243500	1.03	6200000	1.24	322164	1.15	28	30
1993	2306800	1.03	8200000	1.32	370488	1.15	27	28
1994	2369700	1.03	10773200	1.31	433471	1.17	26	27
1995	2431000	1.03	14499425	1.35	498492	1.15	25	26
1996	2492900	1.03	17292271	1.19	571233	1.15	23	24
1997	2556000	1.03	20306275	1.17	627953	1.14	22	25
1998	2621500	1.03	24082620	1.19	728425	1.16	20	22
1999	2685000	1.02	26655031	1.11	874111	1.20	18	21
2000	2739200	1.02	29053984	1.09	1040192	1.19	16	20
2001	2841700	1.04	31378302	1.08	1206622	1.16	14	19

2. ANALYSIS OF URBAN TRAFFIC PROBLEM BASED ON SYSTEM DYNAMIC APPROACH

The feedback loop that analyze urban motorcycle-oriented societies and its traffic problems are presented in figure 1.

Loop (1) is a negative feedback loop that presents the relationship between road construction and traffic congestion. Economic development cause increasing number of private vehicles, especially motorcycles. Every family in Hanoi usually has 1 -– 2 motorcycles. On the supply side, traffic congestion due to increasing number of motorcycle leads to the demand of road expansion and road construction. In short term, when new roads began to use, traffic congestion was reduce immediately. For some years (from 1995 -– 1999), traffic congestion in Hanoi was significantly reduced due to the rehabilitation of road network.

Considers loop (2) for traffic condition in construction period. Some road space have to be used for construction work, such as materials and equipment storage, work site, etc. Therefore during construction time, traffic congestion of the road or area for some cases, is appeared more heavily and frequently due to the limitation of road space. Traffic jam at Nga

Tu Vong intersection during construction of the over flying bridge at the road is one of example.

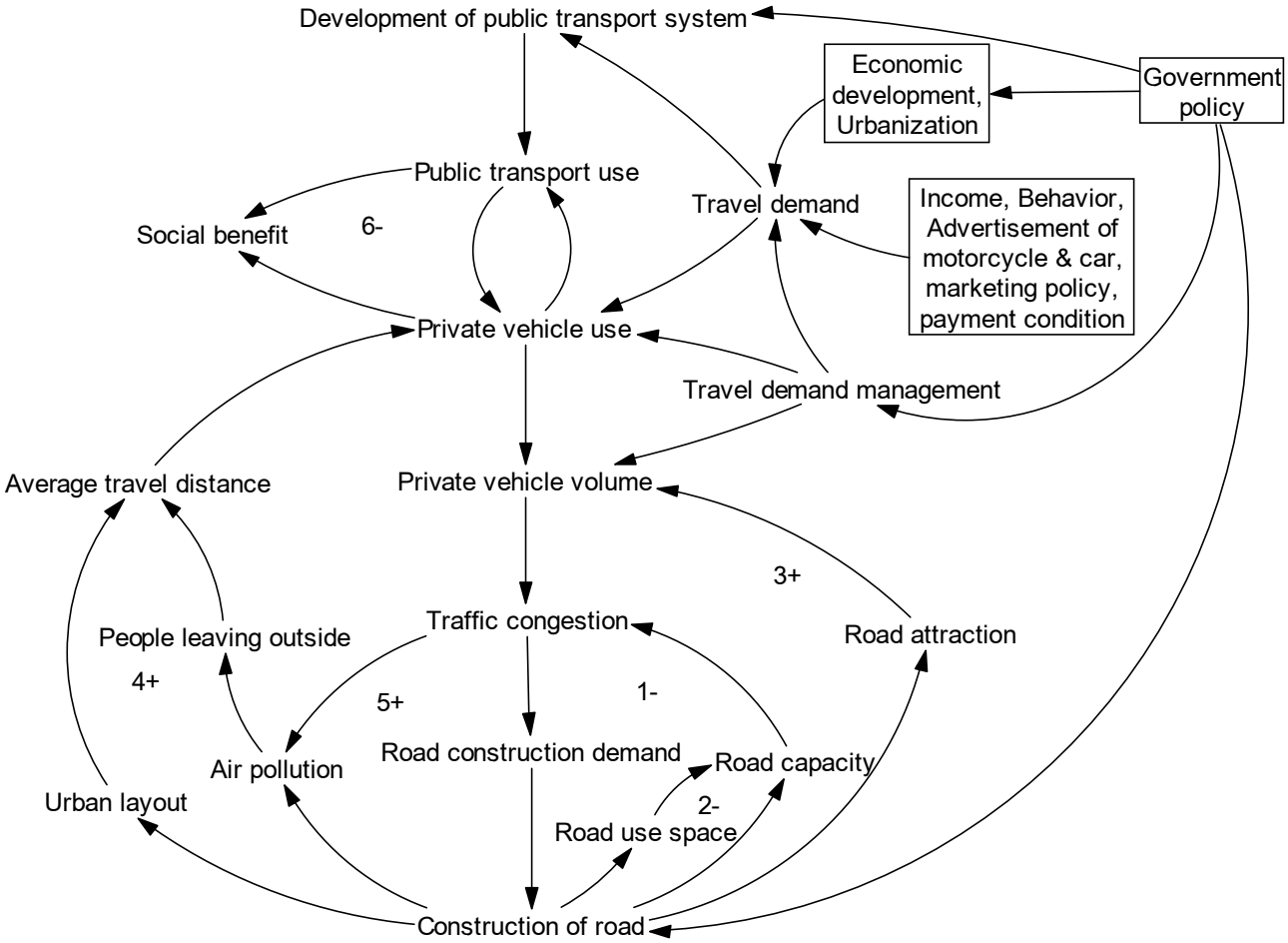

Figure 1: Urban traffic problems based on system dynamic approach

However, in long term, road network improved leads to maximizing land use around the road constructed after a delay time, such as development of resident, shops, industrial parks, markets, etc. At that time, travel demand increase as a result, the road is narrowed down to the development of new area, traffic flow is mix on the road, etc. The adverse principle was revealed: situation worsening after the road be effected. Loop (3) reveals the worsening transport situation due to the increasing of traffic volume.

Loop (4) shows the urbanization trend today: the more construction of road, the more vehicle use. About more than ten major roads were built in the past few years leads to urban expansion, the average travel distance of people in Hanoi increasing from 4 km in 1999 to 7 km in 2001. Radius of the city go up two times from 6 km in 1995 to 12 km in 2001. People likely use motorcycles and cars for their trips. As a result, despite many efforts made, the severity of the problems still exists. Without appropriate master plan from the government, yesterday's solution turn out to be today's problems.

Loop (5) shows environmental impacts due to transport worsening, air quality is threatening people's health. Referring a result of a general air quality survey of Hanoi, level of SO_x, NO_x, CO, HC is 9 to 10 times compared to the standard level allowed at major intersection such as Nga Tu So, Nga Tu Vong, Kham Thien, etc.

Loop (6) considers the important of using public transport system for Hanoi. The more public transport usage, the less private vehicle use, and then social benefit would be increased. In order to narrow down traffic congestion and air pollution in Hanoi, private vehicles, especially motorcycles and cars in the near future should be reduced. Development of public transport system would be one of major alternatives. Bus system of Hanoi started to be developed from 2001, proportion of bus share increases from 3% in 2000 and before, up to 10% in 2002. However, number of motorcycle has been increased at something between 15% - 20% per year. It would be a long delay time for declining motorcycle growth rate.

Economic development as well as urbanization has increase travel demand much. Travel demand management would be considered as the second major alternative to reduce private vehicle usage.

3. POLICIES PROPOSED TO SOLVE PROBLEM OF URBAN TRAFFIC CONGESTION IN HANOI

Policies were proposed base on the theory of system dynamic approach applied to study traffic problem of Hanoi. In order to avoid the positive loop (3), government policy and planning would be considered as a main factor to affect transport situation of Hanoi. There are three partial approaches to reduce traffic congestion:

(1) Development of public transportation system is the first priority. Mass and rapid transit such as metro, light railway system with significant investment and certain operation charge would be not easy to set up in developing metropolitan like Hanoi. Such a system was set up during urbanization and motorization in developed cities while it was established after urban development in developing cities. Therefore, its operation is not so effective and causes many negative impacts to social such as polluted environment, urban aesthetic and land use, etc. For Hanoi, bus service is the most appropriate public transport mean at this time. Recent years, bus system was improved but there is a gap to be the desired service. The light railway transit system would be an appropriate alternative in the future. Improving traffic condition and environment for pedestrians would be the first priority to increase public rider ship.

(2) On the supply side: capacity of transportation system in general and road network in specific is needed to expand. Transportation land use in Hanoi was limited (occupied 8% among the total land use of city). There is a big efforts to meet an international standard. Transportation planning would be a key answer of the development process. The master plan of transportation system development of Hanoi was approved by the government in 2001, however, it is a big capital investment that over the ability of the government themselves. Participation of multi-economic sector in road network construction would be encourage much. Recent years, transportation system in Asia cities is developed by the trend of more private participation as well as more foreign investment on transport project. Private and foreign capital is important source to develop transportation system of Hanoi today.

(3) On the demand side: travel demand management is needed for reducing the potential increasing number of motorcycles and cars (15% - 20% increasing per year). Many alternatives to control the number of private vehicles were proposed, for example, import tax, motorcycle and car registration fee, vehicle owner fee, different prices of petrol for public and private vehicle, policy allows every family has one vehicle only. Other alternatives to limit road use for private vehicle such as toll fee, high parking fee, parking prohibition, time staggering of offices, etc. However, policy to reduce motorcycle and car ownership would be unsuccessful method due to Vietnam is on the integration process with other countries in the region. Road fee is considered as common alternative to many big cities in the world but inappropriate in Hanoi due to under-standard road network of Hanoi is unfeasible to apply.

The main aim of urban development are the development of economic zones and the improvement of people's life. The policy to support development of sub-centers and integrated land use and transport planning are urgently required. For urban transportation sustainable development, "hard" policies from the government should be supported by a whole community participation because the whole social concerns could not be solved by the technical solution.

4. CONCLUSION

Economic and urbanization development has caused many negative impacts on people's life such as under-standard and over-used infrastructure, traffic problem, environment pollution, etc. To face with traffic congestion, many solutions were proposed in many previous studies. However traffic congestion as well as traffic problem were not considered in the relationship with other factors of the whole system. In the paper, an effective method was applied to identify related causes and effects of traffic problem in Hanoi. By system dynamic, alternatives would be proposed in order to limit the effectiveness of negative loops. The most promising trend is presented in loop 6. The aim is to increase public usage while decreasing motorcycle usage and car usage for near future. Base on the analysis, policy were proposed to reduce traffic congestion of the city. Three main measures of policy makers would be public transport system development, road network expanding and enhancing, travel demand management alternatives.

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