Development of an integrated GIS-based land use and transport model for studying land-use relocation in Hanoi, Vietnam

Nguyen Ngoc Quang [1], Mark Zuidgeest [2], Mark Brussel [3]

1) Urban Public Works Section, Civil Engineering Department, University of Transport and Communications,Lang Thuong, Dong Da, Hanoi, Vietnam
Tel: (+84-4) 8 584 835   Email: nnquang_gtvt@yahoo.com

2) ITC: International Institute for Geo-information Science and Earth Observation, P.O. Box 6, 7500 AA Enschede, The Netherlands.
Tel: +31 (0)53 4874 444   Email: Zuidgeest@itc.nl

3) ITC: International Institute for Geo-information Science and Earth Observation, P.O. Box 6, 7500 AA Enschede, The Netherlands.
Tel: +31 (0)53 4874 497   Email: brussel@itc.nl

Abstract:

Like many other cities in developing countries, Hanoi-capital city of Vietnam- is suffering severe traffic congestion due to its rapid urbanization and booming of motorization since early 1990s. Many counter-measures have been applied and many discussions have been raised in order to find the solution for Hanoi transportation. Many people think that the situation can be solved if some roads are expanded, some others support for a metro system, only some people suppose that the situation can be relieved if some major land-uses like universities, hospitals and government offices are moved out from the city centre.

In Hanoi, most corridors around or leading to two study areas-Bach Mai area and the urban core (Hoan Kiem district)- have been suffering severe traffic congestion. In this research a GIS-based integrated transport – land use model has been derived to study congestion relief from relocation of some major land uses. The research was carried out to evaluate the contribution of some 'major' land-uses in these areas to traffic congestion on certain corridors and to test how relocation may relieve traffic congestion. To do this a large work-based travel survey was conducted in several major work locations from which travel characteristics and patterns of staffs and visitors were derived. These travel patterns were input to the GIS model, wherein the relocation was simulated.

Traffic volumes on different corridors were used as indicators to evaluate the effects of the relocation. Eight scenarios of integration of land-use and transport at different scales were derived and route choice algorithms used to derive how land-use and transport can best be combined in Hanoi to relieve traffic congestion. It is concluded that the selected land-uses have considerable contribution to traffic congestion and it can be relieved considerably if combined road expansion and relocation activities for some major land-uses is combined appropriately.

Key words: land use and transport, traffic congestion, relocation, Hanoi.

INTRODUCTION

Transport in itself is a fundamental need of people, after food and housing, possibly one of the strongest. Transport of goods and people in a city plays an important role, as its function like the circulation system in a living organism. Urban transport directly affects the economic efficiency of cities and the well-being of their inhabitants (Orn 2003). Rapid urbanization and booming of motorized vehicles in developing countries have put high pressure on urban transport systems. Traffic congestion which is experienced almost every day in many cities of developing countries has been the "headache" problem for the local authorities.

Like many other cities in developing countries, Hanoi-capital city of Vietnam- is also suffering severe traffic congestion due to its rapid urbanization and motorization since early 1990. It is observed during peak hours (from 7:00 to 8:00 and from 17:00 to 18:00) almost every day at bottle necks of all main corridors leading to the city centre, especially some main corridors around or leading to Bach Mai area and the urban core (Hoan Kiem district) like Thai Ha, Chua Boc, Truong Chinh, Kham Thien, Chuong Duong, Cau Giay, Ba Trieu, Nguyen Thai Hoc streets. One can see huge volume of people traveling on the corridors in the direction leading to the city centre in the morning and in the reverse direction, out from the city centre, in the afternoon. The figure 1 below gives you an idea about the current situation of congestion level in Hanoi.

Source: http://vietnamnet.vn/giaoduc/tuyensinh/tintuc-sukien/2007/07/713429/

Figure 1: Traffic congestion in Hanoi

This situation is not only reduces greatly the effectiveness of all social activities, impedes economic development, but also destroys the living quality of inhabitants in the city and creates a polluted environment. This situation might be worse with the current figures of economic and population development. How to improve the situation for Hanoi?

To solve traffic congestion, the traditional approach to urban transport in the United States and many other cities in developing countries like Bangkok (Thailand), Jakarta (Indonesia), etc has always been to "build away" the problems by producing more urban roads and highways with multi-levels or multi-lanes to favor the movement of vehicles or high-cost public transport systems such as rail-based metros. This strategy seems to be logical, but the lesson drawn is that it is not effective way (Petersen 2002). Recently, urban planners have realized that transport and land-use are two key elements for achieving sustainability in an urban context and integration of land-use and transport with aims at reducing the amount of travel can help to alleviate traffic congestion. There are two main streams in the integration of land-use and

transport: that is mixed land-uses and relocation of some major land-uses such as hospitals, offices for example out of the city centre (DUAP 2001, Sim, et al 2001, Petersen 2002, Orn 2003, Whitelegg and Haq 2003, Emberger 2005, Lohani 2005, UITP 2006). Relocation can help to achieve better mixed land-uses and as a consequence traffic congestion can be relieved as emphasized by Jong et al (2003) "Traffic congestion can be relieved or increased with consideration of service/organization location or relocating them".

There are many disputes in literature whether a decentralized patterns of job sites outside the city centre or whether a high concentration of jobs and activities in the inner city will lead to the shortest trip lengths and thus minimize total volume of transport related to journeys to work. Some authors argue, for example that high concentration of activities and jobs in the inner city will reduce number of trips and travel distances. Therefore, relocation of organizations from inner city to suburban area would result in a higher share of number of trips and travel length of employee to work (Naess and Sandberg 1996; Kadesh and Roach 1997; Aarhus 2000; Hanssen 2000; Peuralahti 2003; Marquez, McNamara et al. 2004)

Many cities in the world, especially in the Netherlands, have provided good practice examples, where integration of land-use and transport in planning with consideration of accessibility notion can result in a reduction of car use, improved public transport use, walking and cycling and a better quality of life such as Groningen, Houten, The Netherlands; Manchester (UK) city; Portland, Oregon (USA); Curitiba, Botaga (Colombia) and Copenhagen (Denmark) (Whitelegg and Haq 2003); for example, the decentralization's strategy of commercial activities to regional centers and sub-regional centers to relieve congestion in the CBD of Tampines Regional Centre, Singapore provides a good example of the integration of land use and transport planning that give the opportunity to work closer to home and minimize travel expenses and time(Sim, Malone et al. 2001). Besides, many cases of office relocation land use policy have failed in reducing trip volume and travel distance such as: the suburbanization of offices in the Netherlands in the 1980s resulted in longer travel times by public transport and more congestion on motorways; relocation of the Utrecht Medical Centre (UMC), done by the Geographic Institute of Utrecht University in 1990 reveals that the car use increased from 58% to 72% after the hospital was relocated kilometers away from Utrecht central railway station as compared to the previous location, which was just within walking distance from the railway station (Wee and Maat 2003); firm relocation in Oslo, Norway shows that car use increased (from 25% to 41%), average travel time increased by 7 minutes while the use of public transport was reduced from 61% to 46% despite the new location being well served by public transport(Hanssen 2000).

Recently, there are many disputes on how to relieve traffic congestion and improve mobility for Hanoi people. Many people expected that traffic congestion can be relieved if some roads are expanded; some others think that traffic congestion can not be relieved unless a metro system are built, only some people supposed that traffic congestion can be relieved if some government offices, universities and some hospitals are to be removed out from the city centre (TP 2005). Therefore, the main objectives in this research are to evaluate the contribution of some selected major land-uses to traffic congestion on corridors and to test some scenarios to see if we can relieve traffic congestion by relocating some major land-uses and to what extend can we achieve.

SOME CHARACTERISTICS OF HANOI TRANSPORTATION AND LAND USE

Hanoi-capital city of Vietnam-is an ancient city with almost 1000 years old. It has nine urban districts and five rural districts. Four districts: Ba Dinh, Hoan Kiem, Dong Da and Hai Ba Trung form the city centre. Hoan Kiem district is considered as the urban core since it was ancient city in previous dynasties. An important characteristic of Hanoi is that almost important social activities are happening in the city centre. It can be represented by the number of offices, business enterprises as well as the number of hospitals, universities, colleges and schools in the city centre. According to the survey of General Department of Statistics (G.D.S) in 2002, in the urban core (Hoan Kiem district) there are 464 administration offices with 23,028 staffs in among them 161 offices at national level with 16,218 staffs, and 12,196 business enterprises with total labor of 22,030 people; Ba Dinh district has 1,279 administration offices with 98,976 staffs in total, among them 1,083 offices at national level with number of staff of 93,331 people. That is why Ba Dinh district is always considered as administration district while Hoan Kiem district is considered as business district (G.D.S. 2003).

Table 1: Number of unit and labour in administration offices and business enterprises
Source:(G.D.S 2003)

| No.1 | District name | Administration Offices | | | | | | | | | | Bussiness enterprises | |
| | | Number of offices | | | | | Total number of labour | | | | | No. of enterprise | Total labour |
		Total	Natioal level	City level	District level	Commune level	Total	Natioal level	City level	District level	Commune level		
1	Ba Dinh	1,279	**1,083**	27	94	75	98,976	**93,331**	2,341	2,887	417	5,608	9,840
2	**Hoan Kiem**	464	**161**	78	166	59	23,028	**16,218**	3,432	2,972	406	**12,196**	**22,030**
3	Hai Ba Trung	265	**57**	21	134	53	12,986	**8,101**	1,505	2,841	539	9,583	**15,414**
4	Hoang Mai	133	**29**	11	67	27	6,493	**4,050**	753	1,421	269	**4,792**	**7,707**
5	Dong Da	367	**116**	51	132	68	18,913	**12,095**	2,292	3,900	626	9,567	15,235
6	Thanh Xuan	175	**49**	15	64	47	8,055	**5,388**	803	1,568	296	4,705	7,397
7	Cau Giay	175	**59**	21	54	41	11,717	**8,397**	1,564	1,496	260	4,186	7,994
8	Tay Ho	177	**15**	6	69	87	2,730	**689**	265	1,417	359	3,709	5,949
9	Soc Son	252	**12**	14	148	78	6,268	**406**	398	4,722	742	6,596	10,353
10	Dong Anh	250	**10**	18	118	121	5,465	**259**	767	3,633	806	8,884	**18,132**
11	Gia Lam	115	**8**	6	61	40	3,054	**786**	332	1,557	378	**5,158**	**9,297**
12	Long Bien	229	**15**	12	121	81	6,107	**1,573**	664	3,114	757	**10,317**	**18,594**
13	Tu Liem	312	**52**	15	100	145	8,945	**5,255**	453	2,552	685	6,449	12,472
14	Thanh Tri	386	**15**	11	140	220	6,306	**1,539**	385	3,466	916	5,517	9,289

Besides, according to the Brief Report on Construction Master Plan for Hanoi Region in 2005, Hanoi has more than 30 hospitals at national level, more than 60 universities, colleges and vocational colleges with more than 550,000 students in total which account for about 50% of the number of universities, colleges and hospitals in the whole nation. Most of them are located within the city centre and uneven distributed (M.O.C. 2005).

The characteristics of Hanoi transportation are mixed traffic with high share of motorcycle. It is estimated that motorcycle accounts for 85% of traffic while public transport just meets about 7% of the demand (Hanoibus). Other important characteristics of Hanoi road network are low ratio of road area to Hanoi's total land area (about 1.9%); roads are short and narrow and uneven distribution. It is densely developed in the city centre, especially in the urban core, causing unequal level of accessibility within Hanoi.

As of 2005, Hanoi has a population of 3,183,000, 62% of which resided in urbanized areas. In recent years, many newly-built residential areas with good infrastructure have been built in the urban fringe, especially in the West and the South of the city like Trung Hoa-Nhan Chinh, My Dinh, Nam Trung Yen, Dinh Cong, and Linh Dam. These areas have attracted quite a lot of people out from the city centre for living while most social activities still happen inside

the city centre. The uneven distribution of some major land-uses and population in Hanoi can be seen quite clearly in the figure 2 below.
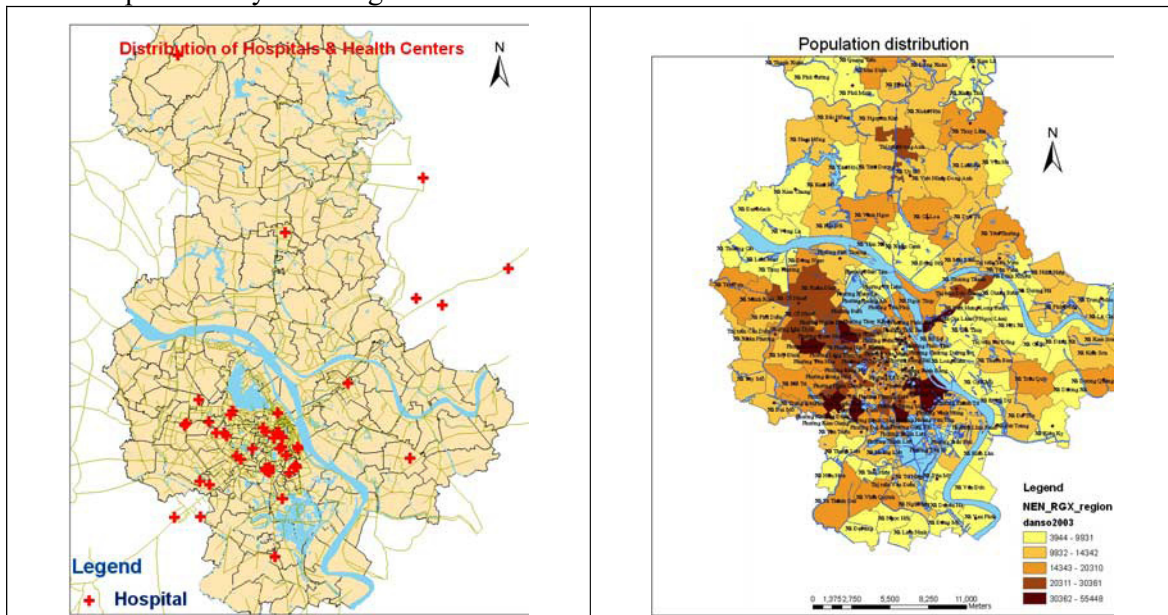

Figure 2: Distribution of population and hospital in Hanoi

That can explain why one can see huge number of people traveling on corridors leading to the city centre in the morning and in the reverse direction, out from the city centre, in the afternoon. Traffic congestion is observed during peak hours almost every day. In recent years, government and local authority have paid much attention on improving Hanoi transportation and relieving traffic congestion. Many countermeasures have been applied, many roads have been built and expanded but the main focus of road development shifted to the completion of ring road no.1, no.2, no.3, and no.2.5 and new roads in urban fringe districts, out site the ring road no.2, since it is very difficult to expand a road within the ring road no.2, especially in the city centre due to high density of residential area and high cost for land acquisition (HAIDEP 2005).

Briefly, since all most social activities in Hanoi are happening in the city centre while many newly-built residential areas with good infrastructure in the urban fringe districts have attracted quite a lot of people for living in combination with high rate of motorcycle as well as short, narrow roads, serious traffic congestion is experienced almost every day. It can be seen very clearly at corridors that traffic congestion is more severe in the direction to the city centre in the morning and in the reverse direction in the afternoon.

METHODOLOGY

Integration of land-use and transport

The movement of people takes place in space and time, from one land-use location to another at a certain time of the day. Most trips are made because people want or have to carry out activities. Land-use is spatial distribution of activities. This distribution generates traffic for people move from one activity to another. Travel demand depends on the utility of the activity, on the one hand, and on the aggregate costs to reach the destination, on the other hand. The aggregate costs measured in time, money, and efforts needed to cover the distance are usually expressed as transport resistance or impedance. Eventually residents tend to move to more accessible locations. Therefore, one of the fundamental axioms of transport planning is that

people do not like traveling, and they only travel because the benefit received at the destination (work, education) more than outweigh the cost (i.e. time and money) of getting there (Blijie and Bok 2002; Wee and Maat 2003; Banister 2002).

The relationship between activity location, travel need and transport resistance is depicted in the well-known scheme of Wee and Maat below.
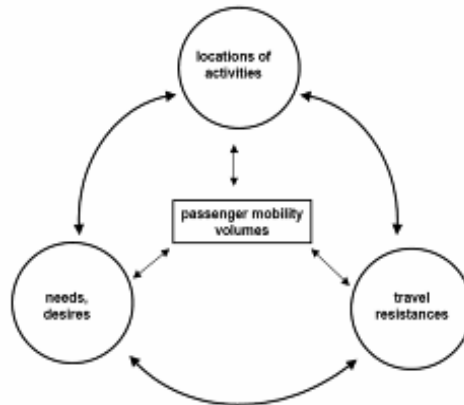

Figure 3: Relationship between activity locations, travel need and transport resistance (Adopted from (Wee and Maat 2003))

These three factors have a strong relation. Any change of one factor among the three might lead to the change of the performance of the whole system. Change in land use patterns might change transport resistance between certain locations and might reduce travel needs also; good planned activity locations might contribute greatly to relief of traffic congestion, reducing travel time/distance as well as improving environment (Wee and Maat 2003).

From literature, there are two main streams in the integration of land-use and transport: that is mixed land-uses and relocation of some major land-uses such as hospitals, offices for example out of the city centre. The main purpose of integrating land-use and transport is to reduce travel demand including numbers of trips, travel time, travel distance and to encourage people shifting from private vehicle ownership to green modes including walking, cycling and bus by improving accessibility to job site and other public services as well as to encourage healthy environment for living (DUAP 2001, Sim, et all 2001, Petersen 2002, Orn 2003, Whitelegg and Haq 2003, Emberger 2005, Lohani 2005, UITP 2006).

Indicators used and model for study of land-use and transport integration in Hanoi

From literature, indicators used for measuring effectiveness of relocation usually are total number of trips, total trip length or fuel consumption, mode share (percentage of people shifting from private vehicle use to "green modes" like walking, cycling or public transport) and change in traffic volume on congested roads compared with before relocation. The main method of relocation studies is comparing the situation before and after the organization is relocated by interview survey or scenarios studies with some transport indicators (DUAP 2001, Sim, et al 2001, Petersen 2002, Orn 2003, Whitelegg and Haq 2003, Emberger 2005, Lohani 2005, UITP 2006). Because neither a transport model, nor a full-pledged transports studies, was available for Hanoi, in this research, a GIS-based integrated transport-land use model has been was developed to study congestion relief from relocation of some major land-uses. Traffic volume during peak hours on different corridors was used as indicator to evaluate the effects of relocation. The shortest path algorithms in GIS was applied in the model to record the routes

one used from a ward to the destination (the selected land –uses) or return with some assumptions as follows:

- People use the shortest path measured in time to go or return from work.
- People go from or return to their ward centre (homes). It means that the ward centre is used as the trip origin/trip destination,
- Travel is considered as single-trip end. It means that people go directly to our study areas from their home and return directly as well.

In order to calibrate the model, a large office-based interview was performed to collect information on travel characteristics and patterns of those working and visiting the selected "major" work locations such as trip origin, travel time, route used, and mode share as well as information of organization for aggregation purpose.

Study areas

Since all corridors near-by or leading to these two areas: Bach Mai area and Hoan Kiem district are suffering severe traffic congestion during peak hours almost every day such as Chua Boc, Thai Ha, Truong Chinh, Kham Thien, etc, these two areas were selected for study. Study area no. 1, Bach Mai area, where three big universities (Polytechnics, Construction, and Economics universities) with almost 70,000 students and a group of hospitals including Bach Mai hospital are located. Study area no.2, Hoan Kiem district, where 16,218 staffs are working in administration offices at national level and 22,030 people working in business enterprises. In total, five hospitals, three universities and two government offices in these two study areas were targeted for office-based interview. Information of travel characteristics and patterns from 5,561 completed questionnaire forms were collected for calibrating the model.

Scenarios for Relocating Some Major Land-uses

In this research, 8 scenarios have been constructed. The scenarios were designed as such to study different combination of levels of relocation as compared to levels of road capacity. All scenarios are related to the current situation levels of relocation vary from the one extreme of removing all activities, no relocation, to particle (50%) and full relocation (100%). The transport road capacity varies from the existing road segments to a situation where selected segments were expanded (in line with current ideas in Hanoi). Six basic scenarios are proposed for evaluation as follows.

Table 2: List of scenarios

	No Relocate	Relocate all to the West	Relocate 50%
No Activity	**Scenario O**		
Existing road	**Current Situation**	**Scenario 2**	**Scenario 3**
Road Expansion	**Scenario 1**	**Scenario 4**	**Scenario 5**

Lastly, two more scenarios 5A, and scenario 5B are developed based on the scenario 5 with assumption that people will move along to live in newly-built residential areas, near the new office base locations.

Congestion level and evaluation

In total, 36 road segments which are suffering severe traffic congestion in the current situation and/or have congestion potential in different scenarios have been selected for evaluation. Based on the comparison between traffic count data by ALMEC in the same peak

hours, road intensity calculation and local knowledge, nine grades of congestion level were proposed for evaluation of congestion in the current situation and scenarios.
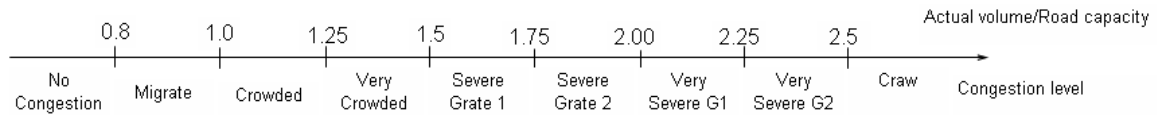

Figure 4: Congestion level

The evaluation was done for both the way-in and way-out and for both morning peak hour (from 7:00-8:00AM) and afternoon peak hour (from 17:00-18:00). For each organization the total number of people who traveled during peak hours and their mode share from a commune will be aggregated for whole population based on the information from completed interview forms with an assumption that the whole population had the same characteristics as the sample population. After that the aggregated number of cars and motorcycles were converted into passenger car unit (pcu). In this calculation, only car and motorcycle are taken into account; walking, cycling and buses are considered as "green modes" and do not contribute to congestion.

Finally, the current situation and scenarios were evaluated based on the number of road segments at each congestion level for both the way-in and way-out in the morning peak hour and afternoon peak hour, and visualization of congestion level in road network map.

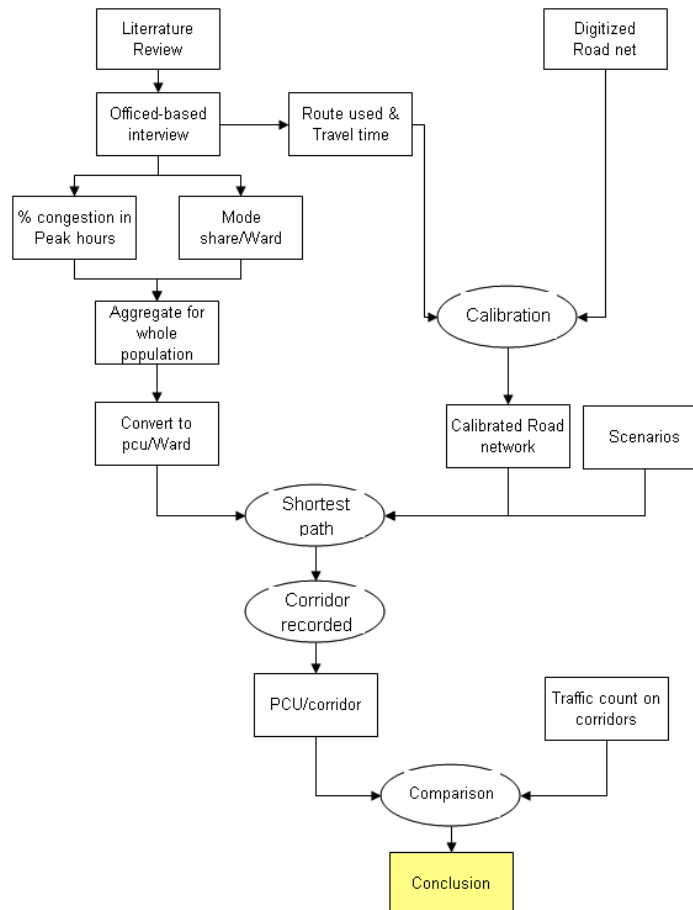The general methodology was summarized in the figure below:

Figure 5: General methodology

RESULTS

Current Situation of Traffic Congestion

In the current situation, the number of road segments and their congestion level is indicated based on the traffic count by ALMEC and road intensity. And then the different segments were colored according to their congestion level.

Table 3: Summarize result of congestion level-Current situation

	Morning Way In	Morning - Way Out	Afternoon- Way In	Afternoon- Way Out
No congestion	2	3	2	1
Migrate	3	5	2	0
Crowded	10	14	10	4
Very crowded	3	9	6	13
Severe G1	15	2	12	11
Severe G2	1	1	2	1
Very severe G1	1	0	1	0
Very severe G2	0	0	0	3
Craw	0	0	0	1

From the summary table and figure below, it can be seen clearly that the way-out in the afternoon was the most severely congested and in the morning the way-in was more severe than the way out.
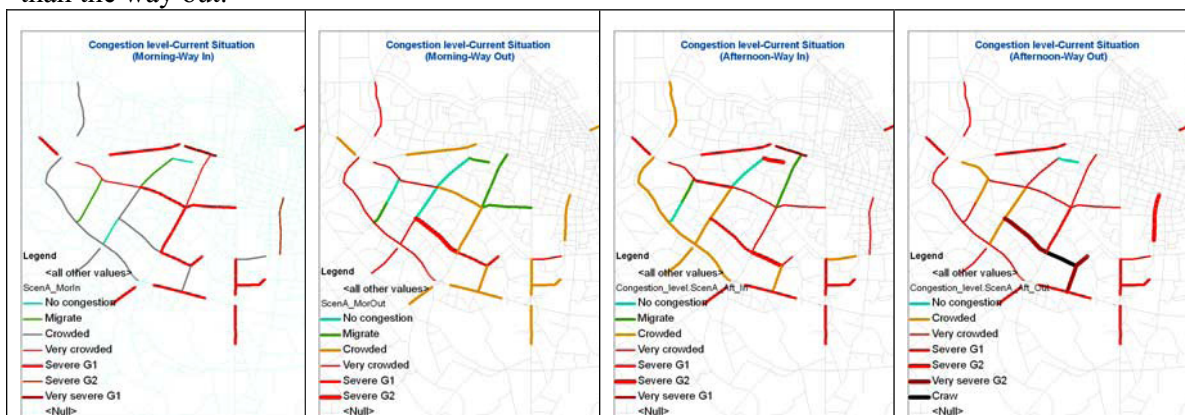

Figure 6: Congestion level-Current situation

Contribution to Congestion of the Selected Major Land-uses

How much do the selected major land-uses contributed to the current congestion situation?

The research result reveals that study area no.1 attracts quite a lot of trips in the morning and even releases more trips in the afternoon to some corridors near-by, since 97.2% of students use these corridors during the afternoon peak hour. For example, in the morning on the way-in of Chua Boc, Pham Ngoc Thach, and Thai Ha streets with considerable contribution of 23%, 27% and 23% respectively, but in the afternoon they contribute to both the way-in and the way-out: 54.7%, 81.3% and 43.9% respectively on the way-in and 43.7%, 56.5% and 27.6% respectively on the way-out; The study area no.2 contributes to some other corridors around like Kham Thien, Nguyen Thai Hoc, and Kim Ma streets with share of 68.7%, 42.5% and 26.2% respectively on the way-in in the morning and 72.8%, 0% and 37.8% on the way-out in the afternoon (Nguyen Thai Hoc is one way road).
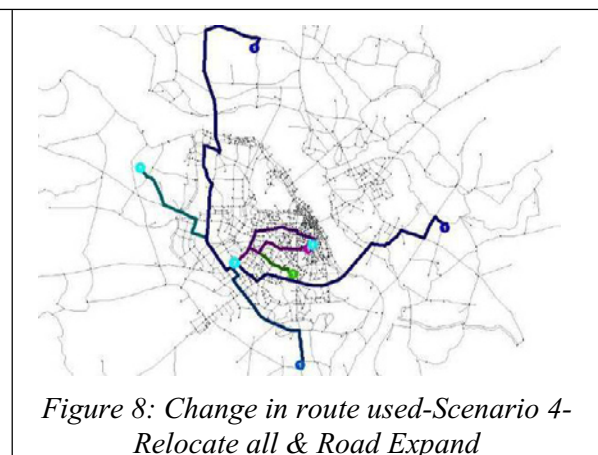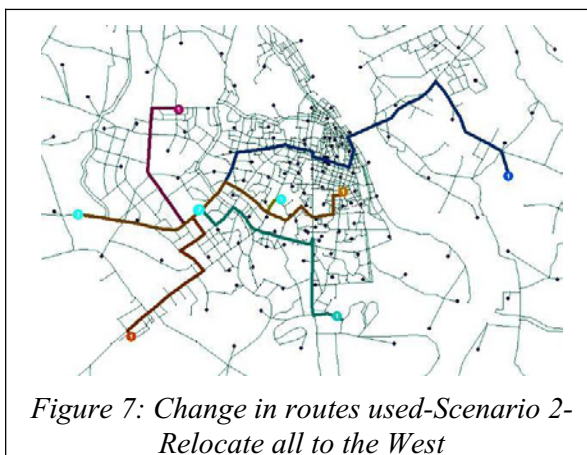
Scenario O: Ideal situation

Scenario O is the base situation with assumption that there is no activity happens at our study areas. It means that all the trips contribute by our selected land-uses will be cut down totally. All the calculation for other scenarios will be calculated based on scenario O.

Scenario 1: Road expansion & No relocation.

Many people think that the congestion situation can be relieved after some roads have been constructed or expanded and some new bridges are built as planned which includes the ring road no.1, no.2, no. 2.5, no.3 and other roads out side the ring road no.2. This situation was tested to see how much can we achieve by doing this. The result shows that congestion levels do not change very much except for the ring road no.1 and no.2 because their capacities have been improved after expanding. Therefore, it can be concluded that congestion can not be relieved if road expansion countermeasure is applied alone. The main reason is that the number of people living in the South and South West were more than from other directions and they used the same routes to the study areas.

Scenario 2&4: Relocate all to the West direction

These scenarios were proposed because the current offices are so narrow and it is quite difficult to expand the office due to some restrictions. Besides, recently government has policy to expand the city to the West direction and in reality this area has favorable conditions compared with others like cheap land, good infrastructure, and less influence of flood and traffic congestion. Therefore, many organizations want to move out from the city centre, for example Ministry of Science and Technology, Ministry of Agriculture and Rural Development, Ministry of Post and Telecommunications, National Institute of Hematology and Blood Transfusion, etc. These scenarios studied what will happen if all of them will move to the West direction. In these scenarios, it is assumed that people's residences in the wards stay the same. In other words, relocation of office doesn't affect trip origins and destination choice (except for the physical location). These assumptions are realistic for Hanoi because of the specific land-uses functions and difficulty in moving houses (In other countries, people can easily rent a house near their office).

Figure 7: Change in routes used-Scenario 2- *Relocate all to the West*	*Figure 8: Change in route used-Scenario 4-* *Relocate all & Road Expand*

An interesting fact is that instead of using the way-in in the morning and the way-out in the afternoon the traffic flow will now move on the reverse directions: they use the way-out in the morning and the way-in in the afternoon. People also use different routes to go to new offices, especially people from the Southern and from the Western direction. In the scenario 2, the congestion level was worse than in scenario 1 because it produces more congestion in the

reverse direction. In the scenario 4, it can be seen that the situation has been improved considerably, for example the number of road segment at severe G1 was cut down from 30 to 11 (please refer to table 4 below). Therefore, it can be seen clearly that relocation alone also does not help to relieve traffic congestion.

Scenario 3 & 5: Relocate 50% to the West direction

These scenarios were constructed because if 50% of the selected land-uses are relocated to the new locations and 50% still stays at the current locations it is possible to make a balance between the way-in and the way-out traffic. And finally, the second reason is that if we just relocate 50% to new locations, while 50% still remains at the existing locations. This means that the land-use will not be changed to other purposes like high-rise commercial, residential buildings with thousands of people, etc. The existing bases will be upgraded and kept as head quarters for government offices, high quality treatment for hospitals, and higher education for universities for example. In scenario 5, it can be seen that situation has significantly been improved, for example the number cases at Very Severe G1, G2, and Craw were cut down; the Severe G1 cases were reduced from 40 to15, etc (Please refer to table 4 below).

Scenario 5A & 5B: Change in trip origin

Two scenarios, scenario 5A and scenario 5B, were constructed with the assumption that some percent of people will also move along to new bases. This assumption is quite realistic since in the Western and the Southern direction of the existing the city centre, especially around the new proposed bases in Trung Hoa ward, many newly-built residential areas have been constructed with good infrastructure. The policy of government is to attract people living out from the city centre with good infrastructure, high quality houses, and good environment.

Figure 9: Newly-built residential areas

Scenario 5A was constructed with assumption that about 18% of people in the city centre (Hoan Kiem, Ba Dinh, Dong Da, and Hai Ba Trung districts) will move out to new residential areas. While in scenario 5B, was constructed with an assumption that government's policy got successes which attract 50% of staffs move along to live in newly build residential areas, near the new office locations. There is one assumption that the person who has moved to new residential areas will work/study at the new locations and not use the selected corridors as before for both morning and afternoon.
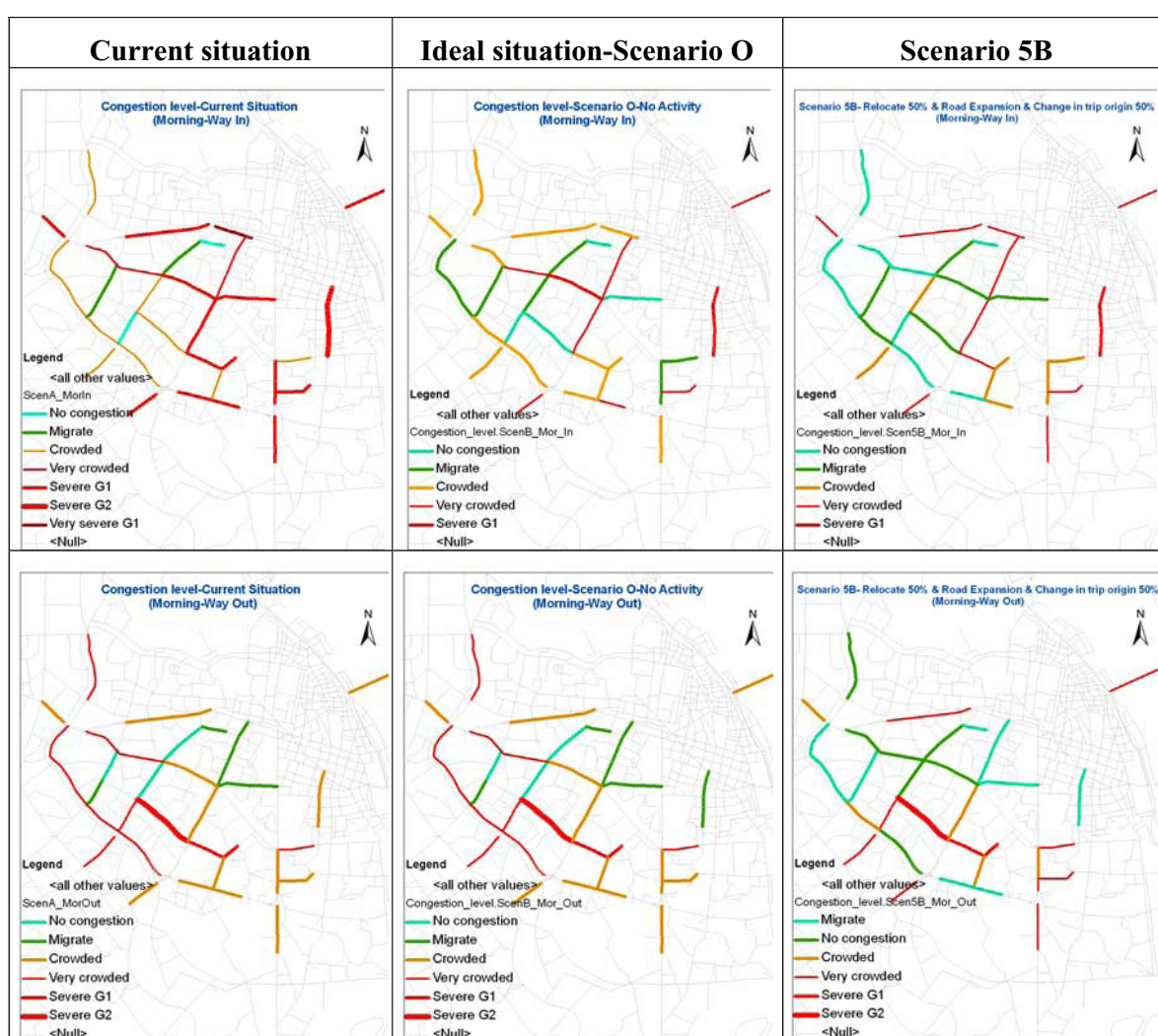
It can be seen that the situation in scenario 5A was not change very much compared with scenario 5, while in the scenario 5B it comes to near the ideal situation in scenario O, which assumed that no activity happens at the study areas. It can be seen that the congestion have been relieved in almost corridors for both morning peak and afternoon peak, except Thai Ha, Kim Ma and Nguyen Thai Hoc streets. A possible reason is that Ba Dinh district where 93,331 government staffs working attracts huge people in the morning and also release huge people in the afternoon.

The result of all scenarios was summarized as follows:

Table 4: Comparison congestion level between scenarios

Congestion grade	Move ability	Sum case								
		Current Situation	Ideal situation	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 5A	Scenario 5B
No congestion	Easy move	8	20	30	16	9	36	28	29	29
Migrate	Easy move	10	26	15	24	13	24	17	16	20
Crowded	Slow move	38	49	31	32	39	28	33	32	35
Very crowded	Slow move	31	31	14	35	45	30	37	39	34
Severe G1	Difficult move	40	7	32	14	22	11	15	15	14
Severe G2	Difficult move	5	4	8	8	5	3	5	5	4
Very severe G1	Hardly move	2	1	4	6	1	6	1		1
Very severe G2	Hardly move	3		1	2	2		1	1	
Craw	Almost None move	1			1					

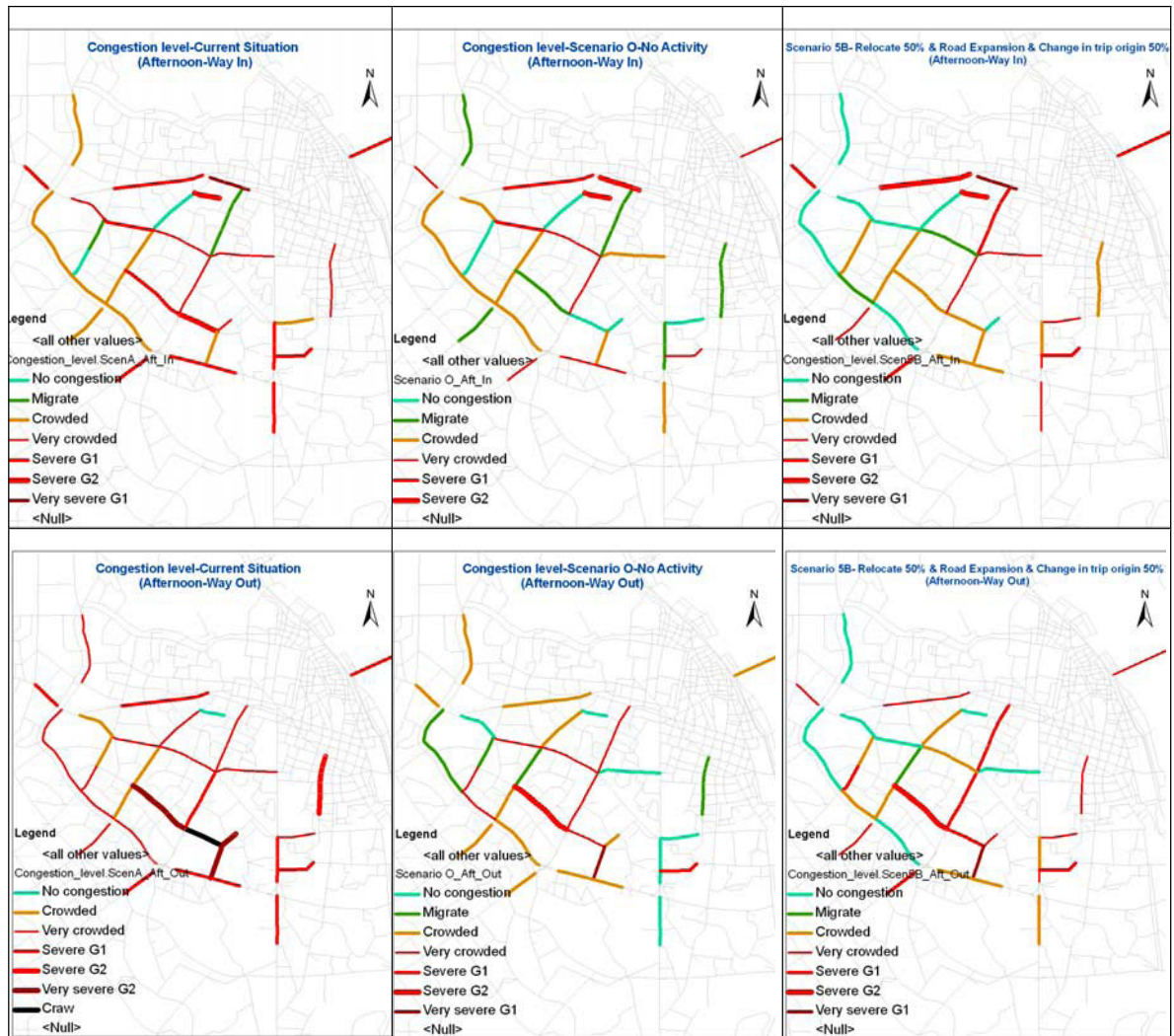| Current situation	Ideal situation-Scenario O	Scenario 5B

Figure 10: Comparison between Current situation, Scenario O and Scenario 5B

CONCLUSIONS

In this research, the contribution of some selected major land uses to the traffic congestion on some corridors is evaluated. Different scenarios of relocating (part) of these land-uses have been formulated and tested in order to see to what extend traffic congestion is relieved and accessibility have been improved for the people of Hanoi, Vietnam. Traffic volume on corridors was used as an indicator to evaluate the benefit of integration between land-use and transport.

Two study areas were selected for evaluation that is Bach Mai area and the urban core (Hoan Kiem district). Some major land-uses like universities, hospitals and government offices in these study areas were targeted for an office-based interview. In total, more than 5.000 responded interview forms were collected to retrieve information on travel pattern such as the trip origins, travel time, travel length, transport mode and routes used. A transport model based on the shortest path algorithm in GIS with an important assumption that people used the shortest path measured in time was applied to estimate the traffic volume contributed by these major land-uses on corridors during peak hours. All main corridors and congested roads leading to these destinations were selected and then divided into 36 road segments for

evaluation of the levels of traffic congestion that can be attributed to these land-uses in both the morning peak and afternoon peak as well as both the way-in and the way-out.

The research reveals that these land-uses contribute considerably to traffic congestion of some corridors nearby. For example, the study area no.1 has considerable contribution to Chua Boc, Pham Ngoc Thach, Truong Chinh and Thai Ha streets while study area no.2 contributes considerably to the other corridors such as Kham Thien, Nguyen Thai Hoc and Kim Ma streets. Eight scenarios of relocation in combination with road expansion at different scales were constructed to see if traffic congestion can be relieved. It was failed in dealing with traffic congestion appropriately in scenarios 1, 2, and 3 where road expansion or relocation alone countermeasure was applied. By combination between road expansion and relocation in scenarios 4 and 5, success was achieved in congestion relief. Scenario 5B shows that both road expansion and relocation plus an active policy of providing new housing by the government of Hanoi is necessary to attract more people for moving out from the city centre to live in newly-built residential areas. It gives us a suggestion that together with combination between road expansion and relocation, government should have good policy on housing to attract more people moving out from the city centre to live in newly-built residential areas.

Beside traffic congestion relief, integration of land-use and transport can have some more benefit such as reduce total travel length, travel time, fuel consumption, and encourage people shifting to using green modes like cycling, walking, and bus instead of using private motorcycle as well as improving a healthy urban environment. Therefore, researches on integration between land-use and transport for Hanoi should be taken more consideration in city planning and transport planning in order to improve accessibility, mobility, social equity as well as to keep a healthy environment for Hanoi people instead of building metro and expanding roads alone which is just to favor travel demand as proposed in the current Transport Master Plan. On the other hand, these major land-uses are suffering overcrowded or narrow conditions. Therefore, relocation can help these organizations have a better chance to build new offices with good infrastructure, modern facilities as well as good environment.

In this research, a simplified transport model was run based on two main assumptions that people use the shortest path measured in travel time and the travel is single-trip end. In reality the travel behavior of people is very complex, for example instead of using the shortest path in time people may choose the shortest in length or cheapest way or the most convenient way (without congestion) to go, etc; and people may visit some other places before reaching the selected destinations. Therefore, the model may have some unexpected error. Anyway, due to large amount of responded questionnaires forms (more than 5.000) as well as sound research procedures it is expected that the research may give the readers, especially decision makers some valuable ideas on the benefit of integration between land-use and transport in Hanoi.

RECOMMENTDATIONS

In order to achieve sustainable transport in Hanoi, some suggestions have been raised based on the findings and conclusions in this research as follows:

- Some major land-uses like government offices, universities, hospitals, schools, etc should be considered to move out from the city centre, especially offices in the urban core (Hoan Kiem district) and Ba Dinh district, in order to lower the density people numbers in these areas and encourage people to use green modes before deciding high-cost investment for metro and expanding roads. Traffic congestion can be relieved as a consequence.
- In combination with relocation policy, government should have good policy to attract more people moving out from the city centre to live in newly-built residential areas such as supply low cost apartments, house renting policy, etc.

- Bachelor students which account for about 50% of total student should be stimulated to move out from the city centre. The existing bases should be kept for higher education and other courses like second-degree course, and in-service course.
- Some restriction policy should be applied for the urban core (Hoan Kiem district) to reduce people and activities and return this area attractive for tourism.

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