Integration of transport and land use in Hanoi: Can we relieve traffic congestion by relocating some major land-uses?

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February, 2007

Integration of land-use and transport in Hanoi: Can we relieve traffic congestion by relocating some major land-uses?

by

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Thesis Report submitted to the International Institute for Geo-information Science and Earth Observation in partial fulfilment of the requirements for the degree of the Degree of **Master of Science in Urban Planning and Land Administration (UPLA).**

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Abstract

Transport in itself is a very fundamental need of people, after food and housing, possibly one of the strongest. Urban transport directly affects the economic efficiency of cities and the well-being of their inhabitants. Rapid urbanization and booming of motorized vehicles in developing countries have put high pressure on urban transport systems. Traffic congestion is experienced almost every day. *"Improved mobility = Improved prosperity*" But the question for many developing cities is how to relieve traffic congestion and improve mobility?

The traditional approach to urban transport was to *"build away"* the problems by producing more urban roads and highways to favour the movement of vehicles. This strategy seems to be logical, but the lesson drawn is that it is not effective way. Recently, urban planners have realized that infrastructure alone will not solve traffic problems; only through the integration of land-use and transport in combination with promotion of good public transport and restriction of private vehicle use sustainable transport can be achieved. From literature, there are two main directions in the integration of land-use and transport: that is mixed land-uses and relocation of some major land uses such as offices, hospitals, etc. for example out of the city centre. The purpose of integrating land-use and transport is to move local and regional spatial structures in the direction of:

- Reducing the demand for transport (including number of trip and travel time/distance),
- Increasing the choice of available transport and reducing dependence on motorized mode,
- Improving accessibility to job, public services
- Supporting the efficient and viable operation of public transport services, walking and cycling
- Enhancing healthy conditions for living.

Hanoi is the capital and biggest centre of politics, culture, education, technology and the second centre of economics in Vietnam. Like other Asian cities, traffic congestion is experienced during peak hours every morning on some corridors leading into the city centre and in the afternoon in the reverse direction.

Recently, the government has adopted a policy to expand the city to the West. As a result, many organizations want to move out from the city centre.

Against this background, the main aim of this research is to evaluate the contribution of some selected major land uses to the traffic congestion of some corridors and test some scenarios of relocating selected some major land uses to see if it can relieve traffic congestion and improve accessibility for the people of Hanoi. Five hospitals, three universities and two government offices were targeted for office-based interview to retrieve the trip origins, travel time, travel length, transport mode and routes used. The research has revealed that there is an imbalance in the distribution of some major land-uses like hospitals, universities and government offices within the Hanoi region as well as a high separation between these major land-uses and residential areas. Most of the government offices are located in the core centre (Hoan Kiem district) and Ba Dinh district with number of staff at national level are 16,218 and 93,331 respectively. With a total of almost 70,000 students, these three universities are very attractive for not only bachelor students but also for students of second-degree, in-service and higher education courses. Bachelor students already account for 50% of total students and among them student from Hanoi is account for 23.7%. In the morning, only 2% of students commute during peak

hour since they start the lesson very early but in the afternoon more than 90% of the students commute during peak hour. It also means that 89% of the students contribute to congestion on some corridors. Over 80% of government officers, hospital staffs and teaching staffs own private motorcycle and more than 80% of them commute during congestion in both morning and afternoon peak hours. That is why one can see huge number of people travelling on main corridors leading to the city centre and in the reverse direction in the afternoon with very low speed of 1.5 to 2.5 m/s (about from 5km/h to 9km/h).

It turns out 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, and Thai Ha streets with shares of about 54.7%, 81.3% and 43.9% respectively on the way-in in the afternoon peak hour. Study area no.2 contributes considerably to the other corridors such as Kham Thien, Nguyen Thai Hoc and Kim Ma with a contribution of about 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.

A set of scenarios for relocation have been constructed. The comparison of traffic volume with road capacity of all main corridors is applied to evaluate the contribution of the selected land-uses to traffic congestion in both morning peak hour and afternoon peak hour as well as after relocation. This is done by applying advanced spatial and network capabilities of GIS. It appears that congestion can be relieved considerably by integration of land-use and transport in combination with good land-use policy of government.

Acknowledgements

First of all, I am grateful to my supervisors, Dr. Ir. M.H.P. Zuidgeest (First Supervisor) and Ir. M.J.G. Brussel (Second Supervisor) for their advice, encouragement and support during my research. Their advice and constructive criticism lead me on the right track. I always recover full energy after receiving their encouragement which helps me to overcome many difficulties during the analyse process.

Secondly, I would like to express my sincere thanks to the management boards and all staff of Vietnam Railways, Ministry of Science and Technology, Bach Mai hospital, Viet-Duc, C, K hospitals as well as all teachers and students of Polytechnics University, University of Construction and University of Economics for their support and information. Without their support I can not complete my research.

Thirdly, I would like to express my gratitude to my assistants: Ms. Dao Thi Anh Chuc, Ms. Chu Thi Nguyet Nga, Ms. Do Thi Dieu Thuy, Ms. Dang Thi Phuong Quynh, Ms. Ta Thi Huyen, Ms. Duong Thi Ha, Ms. Ngo Thi Hong, Mr. Nguyen Anh Phong and Mr. Vu Dinh Quang who work shoulder to shoulder with me during my fieldwork. Every day, they worked from 6:00 AM till late afternoon for delivering questionnaires and collecting them as well as inputting all information into database.

Next, I would also like to thank Mr. Tran Nguyen Toan from Government Office of Vietnam, Mr. Bui Dinh Nghi, Mr. Nguyen Duc Duc from Vietnam Railways, Ms. Nguyen Thi Thanh Hoa, Mr. Vo Anh Tuan, Mr. Khuat Viet Hung, Mr. Le Dai Ngoc and Mr. Vu Anh Tuan for their help and providing materials.

I am indebted to Prof. Tran Tuan Hiep-Vice Rector, Prof. Nguyen Quang Toan and Prof. Nguyen Huy Thap from the University of Communications and Transport for supporting me.

Lastly, I want to give my best gratitude to my family and my friends, especially Ms. Chu Thi Chi, Ms. Vu Mai Trang and Mr. Tran Hong Kien who encourage me and give me confidence in difficult moments.

Nguyen Ngoc Quang

Enschede, February 18th, 2007.

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1. Introduction

1.1. Background

Transport in itself is a very 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 it functions like the circulation system in a living organism. Urban transport directly affects the economic efficiency of cities and the well-being of their inhabitants. When urban transport is inefficient, it can be a major source of problems for cities and their inhabitants(Orn 2003).

Rapid urbanization and an increase in motorization in developing countries have put high pressure on transport as reported by World Bank *"Most of the cities in the developing countries face severe transport problems. Road congestion is spreading; the movement of people and goods is slowing to a crawl"*(World Bank 1986; Orn 2003).

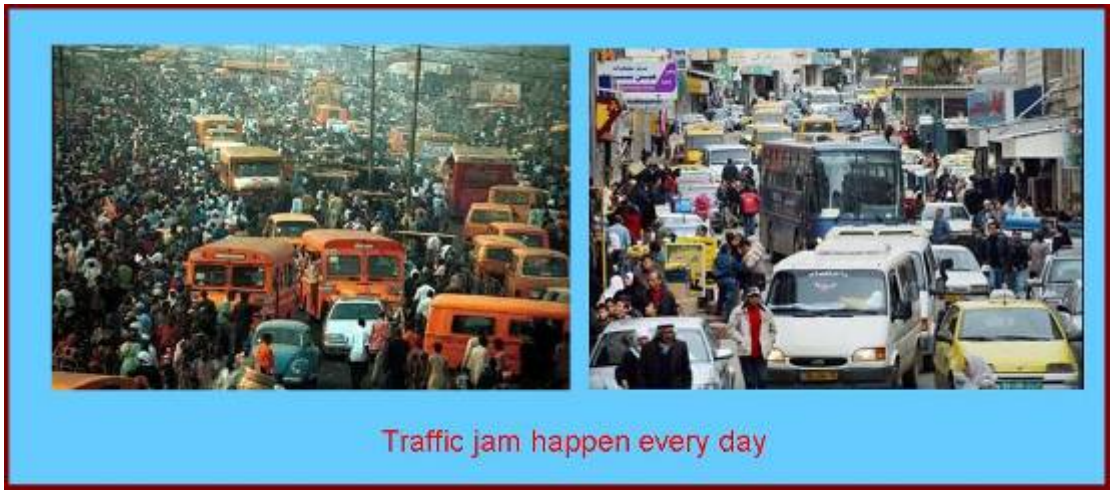


Figure 1.1: Traffic congestion in developing countries (Source:(Square 2003))

"Improved mobility = Improved prosperity"(UITP 2006). But the question for many developing cities is how to relief traffic congestion and improve mobility? The traditional approach to urban transport in the United States and many other cities like Bangkok (Thailand), Jakarta (Indonesia), etc has been always been to *"build away"* the problems by producing more urban roads and highways with multi-lanes and elevated expressways to favour 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. Recently, urban planners have realized that infrastructure alone will not solve traffic problems, only through the integration of land-use and transport in combination with promotion of good public transport and restriction of private vehicle use can achieve sustainable transport(DUAP 2001; Sim, Malone et al. 2001; Petersen 2002; Orn 2003; Whitelegg and Haq 2003; Emberger 2005; Lohani 2005; UITP 2006).

Intelligent land use planning plays an important role in coping with traffic congestion and ensuring sustainable transport because spatial distribution of housing, working, shopping, leisure and other activities determines trip frequency, trip distance and modal share. Therefore, by influencing the

spatial structure of activity locations in the urban environment, land use planning can contribute to reduce number of trips, trip lengths and support a high share of "green modes"(public transport, cycling and walking). Petersen (2002) emphasizes that *"Without acknowledgement of the interactions between land use planning, urban growth and transport development, no sustainable transport system will emerge, neither with respect to economic nor to social and environmental criteria. Setting priority on road network capacity extensions without a clear vision of spatial development has failed to mitigate congestion everywhere in the world"*. Therefore, the integration of land use and transport is one of the most important tasks in transport planning in order to achieve sustainable transport. It aims to improve mobility and accessibility for people, services and resources for achieving economic effectiveness and social equity and should be considered carefully in the planning.

The travel of people with a transport mode (bus, walking, cycling) from one place to another through road network involves costs measured in travel time, travel distance or travel fee. These costs cause an impedance or resistance for travel and are used as accessibility indicators. By putting some impedance constraints such as maximum travel time by bus within 30 minutes or walking time less than 15 minutes, we can evaluate how good the spatial distribution of land-uses in combination with transport and indirectly measure the congestion level. A good spatial distribution of land-uses and transport will reduce the number of trips, total trip length or increase the number of people using *"green modes"* (bus, walking, cycling) and congestion level will be reduced relatively as a consequence. If a service location is not good in term of accessibility, it should be relocated. Recently, this notion has been applied to evaluate the integration of land-use and transport in several researches(Cervero 1988; Aarhus 2000; Hanssen 2000; Sim, Malone et al. 2001; Jong, Geertman et al. 2003; Jong, Geertman et al. 2003; Wee and Maat 2003; Marquez, McNamara et al. 2004; Belal 2006; Geurs 2006)

1.2. Transport issues in Hanoi

Hanoi is the capital of Vietnam, where more than 30 hospitals at national level, more than 2000 government offices with more than 300,000 staff, 112 institutes and more than 60 universities and colleges, 41 vocational schools and 34 technical schools with more than 553,000 students in total are located. Most of them are located in the city centre (M.O.T 2004; M.O.C 2005). With poor and uneven road distribution, just about 1.9% of road area to Hanoi's total land area, in combination with poor public transport and a high share of motorcycle traffic congestion is experienced during peak hours every morning and afternoon.

To cope with traffic congestion, many counter-measures have been applied such as: expanding the existing roads, building new roads, flyovers, enforcing traffic laws, applying traffic signal, improving operation of public transport, etc but the situation has not been improved very much. This situation might be worse with the current figures of economic and population development. Recently, there are many disputes on how to improve mobility for Hanoi people, some ideas are that traffic congestion can not be relieved unless metro lines are built, while others say 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). A targeted task of the transport sector is to relieve traffic congestion and improve public transport to meet 30% of the demand by 2010 with the support of a rail-based system (MOT 2004). The main question in this research is whether we can relieve congestion and improve accessibility by relocating some major land-uses?

1.3. Research problem

Traffic congestion in Hanoi, particularly in the city centre, is serious. Several discussed on how to solve the co-exist. One of the ideas is to relocate some major land-uses to the Western part of the city. The effect of this relocation on traffic congestion is however unknown.

Therefore, the main hypothesis in this research is relocation of some major land uses such as government offices, hospitals and universities can relieve the congestion situation and as such improve accessibility.

In this research this hypothesis will be investigated by testing some alternatives of integration of land uses and transport in Hanoi in order to have better mobility for Hanoi people.

1.4. Research objectives

The main objective is to investigate the hypothesis by testing some alternatives of integration of land uses and transport in Hanoi in order to have better mobility for Hanoi people will be tested.

The sub-objectives are:

- To evaluate the current situation of some selected major land-uses in term of how they contribute to the current levels of traffic congestion in Hanoi.
- To test some scenarios of relocation for some selected major land-uses to see if and to what extent they can relieve traffic congestion in Hanoi.

1.5. Key research questions

Some key research questions are addressed as follows:

- How much do the selected land-uses contribute to congestion on corridors and congested roads?
- Can traffic congestion situation be relieved by expanding roads only?
- Can we relieve congestion by relocating the selected major land-uses? And how much can we achieve?

1.6. Study area

The main study area is in the city centre of Hanoi-Vietnam, particularly the part within the ring road no. 2, where most government offices, universities, and hospitals are located and where congestion is very serious. The main study area is indicated within bold line in figure 1.2 below. Two specific study areas are proposed.

Study area no.1 is Bach Mai area where three big universities (Polytechnics, Construction, and Economics universities) and a group of hospitals including Bach Mai hospital. Some corridors near-by this area are suffering severe traffic congestion during peak hours every day such as Chua Boc, Truong Chinh, and Thai Ha streets.

Study area no. 2 is the urban core (Hoan Kiem district) where many government offices are located. Huge of people is observed on some corridors leading to this area every morning on the way-in and on the reverse direction in the afternoon such as Kham Thien, Kim Ma, Nguyen Thai Hoc, Ba Trieu, Pho Hue, Chuong Duong.

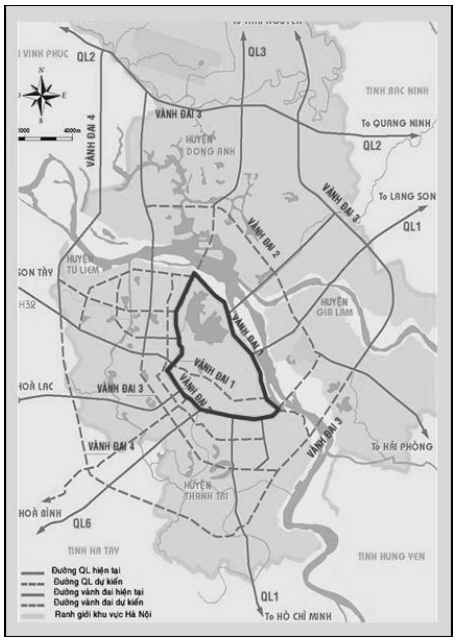


Figure 1.2: Study area

1.7. Conceptual framework

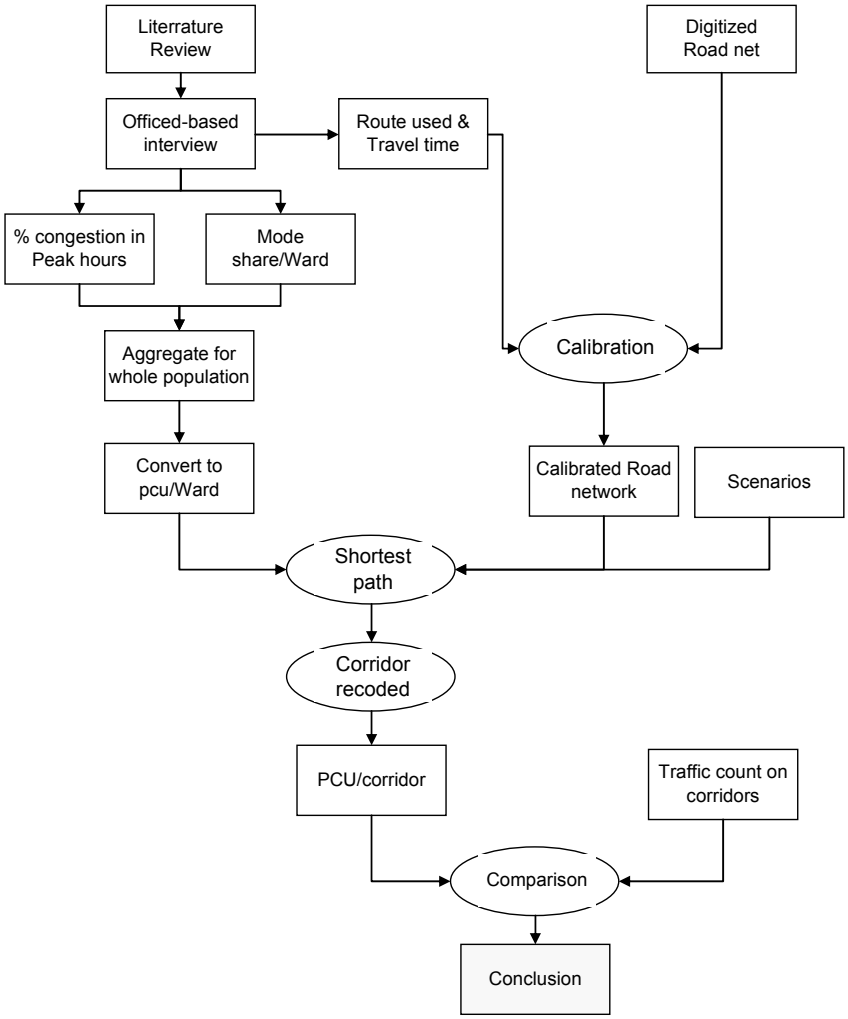


Figure 1.3: Conceptual framework

Based on literature, an office-based interview method was selected to get information on trip origins, transport mode, travel time, route used and some other important information on social-economic characteristic of trip.

Based on the information extracted from the survey, the road network is calibrated before conducting analyses.

From interview responses, the percentage of people who travel during peak hours as well as the mode share per commune are calculated and then converted into pcu (passenger car unit) for comparison purpose. A shortest path algorithm is then applied to record corridors used when a person is going from one commune to the destination. And finally, the comparison is made between the existing situation and scenarios based on the traffic count on corridors, congestion level and congestion mark.

Because a transport model, nor a full-fledged transport study, is available for Hanoi, this research focuses on information on travel patterns of those working or visiting the selected land-uses. Their travel patterns reveal important information on the contribution of the land-uses to the congestion situation in Hanoi.

Note: In this research, all green modes like walking, cycling and going by bus are considered not contribute to traffic congestion. Only motorcycle and car is taken into account.

1.8. Structure of the research

Chapter 1: Introduction

This chapter contains the background of the research, research problem, research objectives, research questions, and research methodology.

Chapter 2: Interaction between land-use and transport

This chapter will give some ideas of the interaction between land use and transport, accessibility indicators.

Chapter 3: Hanoi: An introduction

This chapter will give some background information about Hanoi, including population, distribution of some major land-uses, the existing road network, the existing public transport system, the congestion situation, the modal share, and reviews some recent studies for Hanoi transport and their short comings.

Chapter 4: Data collection and data preparation

This chapter will discuss the data requirements, data collection, fieldwork, and data preparation.

Chapter 5: Contribution to congestion of the selected land-uses

This chapter will evaluate the selected major land-uses in term of their contribution to congestion on the different main corridors and congested roads.

Chapter 6: Scenarios of relocating some major land uses

In this chapter, some selected alternatives of land use and transport will be tested.

Chapter 7: Conclusions and Recommendations

This chapter gives some conclusions and recommendations for further research.

1.9. Discussion on newspapers on the relocation of some major land-uses

Relocation of land-uses is an important discussion currently held in Hanoi. Here is a brief summary of an article from the electronic newspaper Hanoinet from late 2005 (http://hinet.net.vn/news), indicating the importance of this research.

What is the solution for transport in Hanoi: build new road or just expand the existing roads?

Summary:

- Inner districts of Hanoi have an area of about 110km2 with total road network of about 400km long (6 km2) equivalent to 6% of urban land. The road network is uneven distributed: the road density of the old squared streets is about 12%, while the other area is just about 5%.
- According to some transport experts, in order to deal with traffic congestion, Hanoi needs to increase the road density up to 20% of urban land. But due to very densely population, Hanoi needs at least US$14 billion just for land clearance and the total investment for road construction is about US$17 billion. And the investment will be much higher if metro lines are built.
- What is the best solution for transport in Hanoi? There are some different ideas as follows:
  - ✓ The first idea is to build good infrastructure together with other social services and low-price houses in outer districts (surrounding the city centre) to attract people to live outside the city centre, while keeping the same conditions of the city centre (within ring road no.2). The advantage of this solution is it reduces the population density inside the city centre and as a result it will reduce traffic congestion. But the disadvantage is that we need long construction time and during this time the traffic congestion situation in Hanoi is the unchanged.
  - ✓ The second solution is to expand and build new roads in Hanoi and at the same time to build new urban areas with good infrastructure as in solution 1. This solution has the disadvantage that it is an expensive investment and that actually people do not want to live far from the city centre if the transport is already improved.

The weakness of both solutions is the government's offices and other organizations like hospitals, universities are still located inside the city centre. Therefore the traffic congestion will not be solved or even become worst because the travel distance is longer. That will be the main reason why people do not want to live far from the city centre. The solution is to relocate government's offices and other organizations outside the city centre.

  - ✓ The third idea is to remove (relocate) government's offices out of Hanoi centre. According to economic experts, with US$15 billion, Hanoi can build new urban centre for education, politics, and finance, etc activities with very good infrastructure outside ring road no.3. And if organizations like Polytechnics University, Construction University, and Economics University and some hospital like Bach Mai hospital, Viet_Duc hospital, K hospital, and C hospital are removed from Hanoi, the transport situation might be better. And on the other side we can have a chance to build better and up-to-date infrastructure for these organizations.

- Finally, to reduce traffic congestion in Hanoi both solutions have the same idea as to reduce population density inside the city centre. But in order to reduce population density and attract people to live outside Hanoi, beside good infrastructure, low-price houses and other social services for people we need to relocate government's offices and other organizations outside the city centre. But how to relocate, government should have good and clear policy. (TP)

(Note: For the original article in Vietnamese version, please refer to Appendix A)

2. Interaction between land use and transport

2.1. Urban transport in developing countries

Transport is an activity that people have engaged in since the beginning of humanity. Transport helps people to reach different places, where they can perform their activities and enable the movement of goods inside cities. Generally urban transport can be defined as the movement of people and goods in urban areas. This movement takes place in space and time. In "space" as activities are located in different land uses of the city and people have to move from one land-use location to another; in "time" as activities are often constrained by time, which means that people should travel to these activities at a certain time of the day. Besides these spatial and temporal characteristics, the movements are also determined by socio-economic, demographic and cultural characteristics of the city. These characteristics create the demand for travel and define where people travel and what modes of transport they use for travelling. This demand can be satisfied if an adequate transport system is provided (Belal 2006). Traffic congestion will happen when the travel demand is far beyond the capacity of the transport system at a certain time of the day.

Rapid urbanization and booming of motorized vehicles in developing countries have put high pressure on the urban transport systems. Over the last two decades, Asian cities have been suffering severe traffic congestion due to dramatic increases in motor vehicle growth rates. And traffic congestion is experienced almost every day. The average speed of motor vehicles during peak hours in many cities is just between 5-10km/h(World Bank 1986; Orn 2003; Whitelegg and Haq 2003; Belal 2006). This situation not only reduces greatly the effectiveness of all social activities, impede economic development in the city, but also destroys the living quality of inhabitants in the city and creates a polluted environment(Whitelegg and Haq 2003).

One of the challenges for urban planners in developing countries is to make cities sustainable and equitable with good accessibility through an efficient transport system without congestion. The variety of measures that have been used to alleviate traffic congestion in cities can generally be classified into the integration of land use and transport planning on the one hand, and demand management instruments on the other. The first group of measures, based on the premise that there is a close link between land use activities and the number of trips generated, is aimed at reducing the amount of travel (trip lengths and trip generation). The second group of measures, however, aims to reduce reliance on the car, and for example promote the use of public transport. (Sim, Malone et al. 2001).

Various measures have been tried such as expanding existing roads, building new roads, improving public transport including metros, traffic restriction, improving traffic signals and traffic control, congestion price, parking fee, road pricing, etc. but with little success. Recently, urban planners have realized that infrastructure alone will not solve traffic problems, and only through integration of land-use and transport in combination with promotion of good public transport and restriction of private vehicle use can achieve the targeted task (Sim, Malone et al. 2001; Orn 2003; Whitelegg and Haq 2003; Emberger 2005; UITP 2006). Transport and land-use are two key elements for achieving sustainability in an urban context. In the past, land-use and transport were treated separately-their

interdependence was not realized in full. Recently, it is recognized that sustainable development can only be achieved when transport and land-use are treated simultaneously (Emberger 2005).

2.2. Interaction between land use and transport

Integrated land-use and transport planning are essential for environmentally, socially and economically sustainable urban development as observed in Peterson (2002).

In transport analysis, a city is usually modeled as a collection of separate homogenous islands (zones) that are most commonly called Traffic Analysis Zones (TAZ). These zones are areas where travel originates (origins) and terminates (destination). The transport network is the "bridge" that links these zones(Belal 2006).

As mentioned above, the movement 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(Blijie and Bok 2002; Wee and Maat 2003).

According to Bert van Wee and Kees Maat with a given population size and demographic characteristics, the total volume of passenger transport and the split transport modes depend on the locations of human activities (such as education, working, shopping, etc), the needs and desires of people and the transport resistances. The travel needs and desires of people (usually expressed as total travel distance or number of trips) relates to socio-economic and cultural characteristics, while transport resistances relate to financial factors, travel time, comfort and reliability of transport mode. The aggregate costs needed to cover the distance are not only determined by the quality of the transport system but also by the characteristics of the spatial structure surrounding the sites where the activities take place. The spatial structure determines the generalized costs between the activities, as well as the ease of access to the various traffic modes(Wee and Maat 2003).

The relationship between activity location, travel need and transport resistance is depicted below.

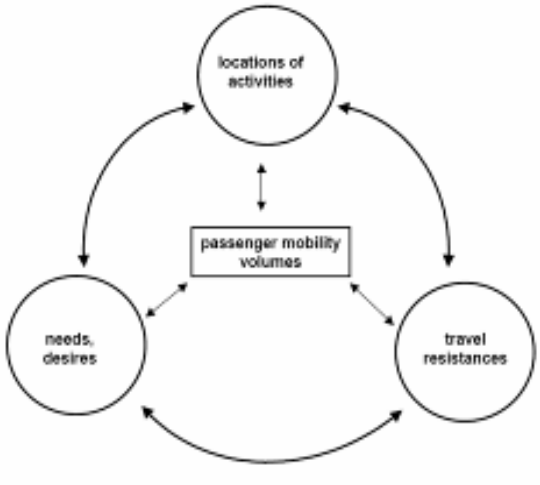


Figure 2.1: Relationship between activity locations, travel need and transport resistance (Adopted from (Wee and Maat 2003))

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 directions in the integration of land-use and transport: that is mixed land-uses and relocation some major land uses such as office, hospital, etc. for example out of the city centre. The purpose of integrating land-use and transport is to move local and regional spatial structures in the direction of:

- Reducing the demand for transport (including number of trip and travel time/distance),
- Increasing the choice of available transport and reducing dependence on motorized mode,
- Improving accessibility to jobs, and public services
- Supporting the efficient and viable operation of public transport services, walking and cycling
- Enhancing healthy conditions for living.

In general, the integration of land-uses and transport contributes greatly to relief traffic congestion, reduction private automobile dependence and improvement of the urban environment (DUAP 2001; Sim, Malone et al. 2001; Petersen 2002; Wee and Maat 2003; Whitelegg and Haq 2003; Geurs 2006).

2.2.1. Mixed land-uses

Many authors agree that higher densities, and mixed land-uses that are associated with them, shorten the length of trips by all modes, for example making walking and cycling attractive for more trips and create sufficient concentrations of activities for an effective, frequent public transport service(Cervero 1988; Sim, Malone et al. 2001; Petersen 2002; Whitelegg and Haq 2003)

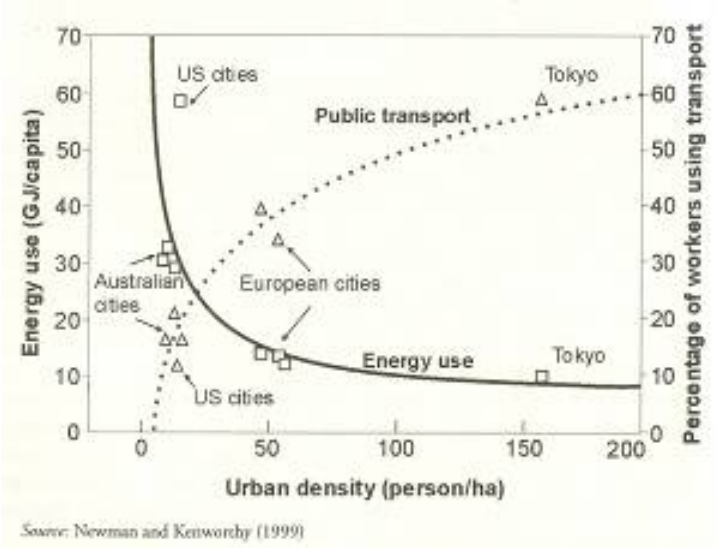


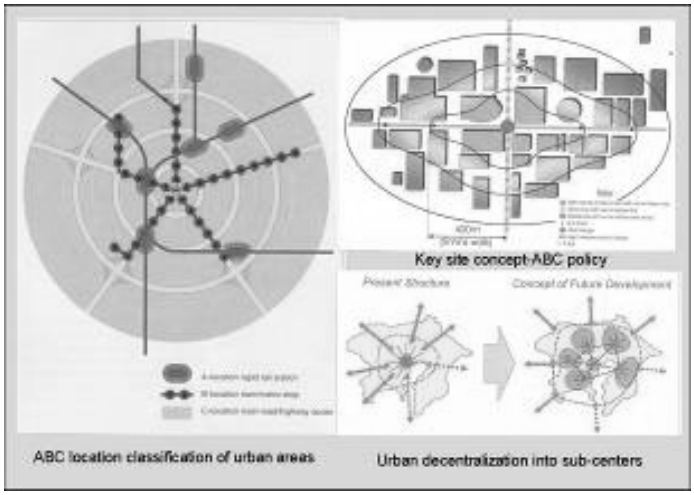
Figure 2.2: Energy used and urban density(Petersen 2002)

Anyway, there is no fixed number for good urban density. It depends very much on how well the spatial structure is organized, relative separation in location between residential area and activity locations like schools, hospitals, business area, and highly depends on culture as well as other factors. Therefore, it can explain for example why in Hong Kong, with its very high urban density

(300 persons/ha), there is hardly congestion ; but can not explain why Bangkok with its higher urban density (162 persons/ha) than Singapore (88 person/ha) has a much worse traffic situation(Whitelegg and Haq 2003). We can only know that mixed land-uses with well structured high density urban areas can reduce total trip length, consumed energy used for transport, and increase effectiveness of public transport as well as encourage walking and cycling within urban area.

In Hanoi, almost all government offices, business centres and many large hospitals are located in the city centre (within ring road no.1); some other hospitals and universities are located within ring road no.1 and no.2 while main labour forces are living outside ring road no.2 (in between ring road no.2 and no.3). This is because the centralized ideal is *"Thu Nhat Kinh Ky, thu nhi pho Hien"* which means all the best and highest quality services are located within centre area of the capital city was predominant in previous urban planning. That is why the number of universities, colleges, institutes as well as hospitals in Hanoi account for 50% of the whole country. It makes a big gap in both service quality and quantity between Hanoi and other areas surround. Therefore, a great amount of labour force, students and patients from half of the country flock into Hanoi for working, study and treatment. That is why we have experienced a huge flow of people coming in the city centre every morning and return in reverse direction in the afternoon; And together with high rate of motorcycles (1.9 millions of motorcycles account for 74% of trip demand) and poor public transport running on quite low density of road network (6% of urban land) congestion happens during peak hours almost every morning and afternoon(MOT 2004; HAIDEP 2005).

But how to evaluate the quality of mixed land-uses, what are appropriate criteria/indicators for evaluation of mixed land-uses? Eventually residents tend to move to more accessible locations (Blijie and Bok 2002). Therefore, a good indicator recently used for assessment of mixed land-uses is accessibility. As indicated by Banister(2002), "Underlying much of the debate on sustainable development is the importance of accessibility or the ability to reach a range of services and facilities easily. This simple concept is at the heart of much planning and transport thinking as its intention is to keep travel distance as short as possible. One of the fundamental axioms of transport planning is that people do not like travelling, 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. An important corollary of the axiom is that if journey distances are short, then people are more likely to use "green modes" of transport (walk, cycle) or public transport". Therefore, based on this notion we can somewhat know how well the spatial distribution and transport system are organized. For example, according to recommendation of Department of Urban Affair and Planning of Sydney, Australia every household should be substantially within 800m total walking distance from an existing or programmed rail station (or equivalent mass transit mode), served at least every 15 minutes or within 400m walking distance of a bus route at least every 30 minutes(DUAP 2001). Or the relation between quality of location and transport demand is studied comprehensively in the well-known Dutch ABC-Planning, in which cities with more than 100,000 inhabitants are required to prepare land use plans allocating the area into three different categories A, B and C with all the classes A,B,C explained in figure 2.3.



A: suitable for population-based activities
B: Suitable for mixed activities
C: Suitable for freight-based activities

A: Locations that are easily accessible to local, regional and national public transport (area around public transport junction); share of commuting by car should be under 10-20%. These locations are typically suitable for offices with a large number of employees and many visitors. The sites have to be within 600m of a national or regional railway interchange or within 400m of a high quality tram or bus stop; not more than 10 minutes ride bicycle from a national railway station and a good connection to park & ride facilities.

B: These locations are characteristically chosen for offices and institutions with a large number of employees, which depend partly on car journeys for professional reasons. Such sites are within 400m of a high quality tram or bus stop and no more than 5 minutes ride from a regional railway station. In addition, they have to be within 400m of a main road connected to a national highway; share of commuting by car is under 35%.

C: These locations are suitable for car-dependent companies like factories, industries. These sites are within 1000m of a direct connection to a national highway and normally situated in the outskirts of metropolitan areas.

Figure 2.3: Dutch ABC planning (Source: (Petersen 2002)

According to this planning concept, the best location (in green area) attracting large numbers of travellers is within walking distance around a rail station also served by major bus routes. Increasing distances from that spot will be less attractive for transit passengers, and travellers will increasingly tend to use private cars and taxis. This ABC scheme and key site concept should be combined with general urban development paradigm to avoid traffic problems such as congestion, emission hot spots in high concentrated centre area, especially when housing spreads in the outskirts of the cities, and workplaces as well as shopping facilities located in the city centre. In this situation, sub-centres within the city boundaries should be formed to reduce traffic pressure on the roads leading to the main centre and average trip distances as well as number of trips by homogenous distribution of activities in the whole city(Petersen 2002). It means that some major services/organizations should be relocated as called *"decentralization"* in many other literatures or newly set up outside the city centre (Naess and Sandberg 1996; Sim, Malone et al. 2001; Whitelegg and Haq 2003).

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 in Groningen city, The Netherlands, where since 1990 already, got success with 48% of all trips within the city were by bicycle, 17% by foot, 5% by public transport and just 30% by car; Houten in the Netherlands has developed a comprehensive bicycle/pedestrian network and cut car trips per household by 25%; Manchester (UK) the Metrolink tram has taken up to 50% of car journey off roads in the area it serves. It has replaced over 1 million car journeys into the city centre each year; Portland, Oregon (USA) 40% of commuters using public transport; Curitiba, Botaga (Colombia) and Copenhagen (Denmark) (Whitelegg and Haq 2003); or

Singapore with the most reliable and efficient transport system in the world *"The key to Singapore's success lies in its comprehensive and highly coordinated land transport policy, which combines the integration of land use and transport planning with demand management measures"*.(Sim, Malone et al. 2001)

2.2.2. Relocating major land uses

Service location relates to organization/ service effectiveness it self and relates to effectiveness of society through the effect to accessibility of its staffs and customers, affect to traffic on road network. Traffic congestion can be relieved or increased with consideration of service/organization location or relocating them(Jong, Geertman et al. 2003). Therefore, locations of activities that lead to traffic congestion or reducing accessibility of attendants (staffs, customers), or that increase private vehicle use dependence or reduce effectiveness of activities themselves and effectiveness of society, should be relocated. The 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(Cervero 1988; Naess and Sandberg 1996; Aarhus 2000; Wee 2000; Peuralahti 2003; Whitelegg and Haq 2003).

Anyway, 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 ague 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).

Traffic is not only affected by land use but also by public transport, parking policy, etc. Changes in land-use patterns might change in transport resistance between certain locations. 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. It also increased car ownership because of the poor public transport accessibility of the new office locations; relocation of the Utrecht Medical Centre (UMC), for example, 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 kilometres 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); a case study of 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). Besides these failures, many success cases have been recorded such as: a survey carried out in 1979 on occasion of relocation of a department of the Province of South Holland with the moved distance of just a couple of hundred meters to a location very close to the Central Station in The Hague revealed that the car use was found to be halves: from 37% to 19%, while public transport use doubled: from 34% to 70%; the relocation of the Ministry of Housing, Spatial Planning and the Environment of Netherlands in 1992 to new location with highly accessible by public transport, just beside the

Central Station in The Hague, got achievement in reducing the car use from 41 to 4% with shorter total travel distance(Wee and Maat 2003); the decentralization's strategy of commercial activities to regional centres and sub-regional centres 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).

These examples reveal that the main reasons of these failures are firms relocated from locations with respectively good accessibility to locations with relatively poor public transport access and the provision of ample free car parking in the new locations.

The main method of relocation studies is in comparing the situation before and after the organization was relocated by interview for example, surveys or making scenarios with some indicators (Naess and Sandberg 1996; Aarhus 2000; Hanssen 2000; Peuralahti 2003; Kirca and Tabalu 2004; Marquez, McNamara et al. 2004).

The suitable indicators selected for Hanoi case study should be total trip length and change in traffic volume on congested roads and the suitable method would be to compare scenarios of before and after relocation, as the real relocation has not been done yet.

2.3. Conclusions

Recently, urban planners have recognized 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. The main purpose of integrating land-use and transport is to reduce the travel demand including reduced 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.

The 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

In this research, some scenarios will be constructed to compare the current situation and possible future scenarios with an indicator for traffic volume on some corridors and congested roads.

3. Hanoi city: An introduction

This chapter will give you an overview of Hanoi city, distribution of population and some major land uses; Hanoi transport and current situation of traffic congestion as well as some missing in the recent studies for Hanoi transport.

3.1. Brief introduction on Hanoi city

Hanoi, capital city of Vietnam, is located in the North of Vietnam. Hanoi is not only the capital of the nation but is also its political and cultural hub, as well as the science, education, and economic centre. It plays a leading role in the region being the gateway to national and international markets. In addition, it is an attractive city both to tourist and residents due to the preservation of its beautiful and cultural surroundings and the stable political situation and low crime figures. (JICA August, 2006).

Figure 3.1: Hanoi-Capital city of Vietnam

3.2. Hanoi population distribution

Since the Doi Moi policy was introduced in 1986, Vietnam's economy has grown rapidly and Hanoi has experienced notable urbanization. During the last decade, Hanoi has grown rapidly in many aspects. Its population has increase at a rate of nearly 2.9% per year. As of 2005, Hanoi has a population of 3,183,000, 62.6% of which resided in urbanized areas. Although such rapid population growth can be seen in the entire city, it is particularly significant in the city's urban

fringe districts like Thanh Xuan, Cau Giay, Hoang Mai and Tu Liem districts(JICA August, 2006) (see table 3.1)

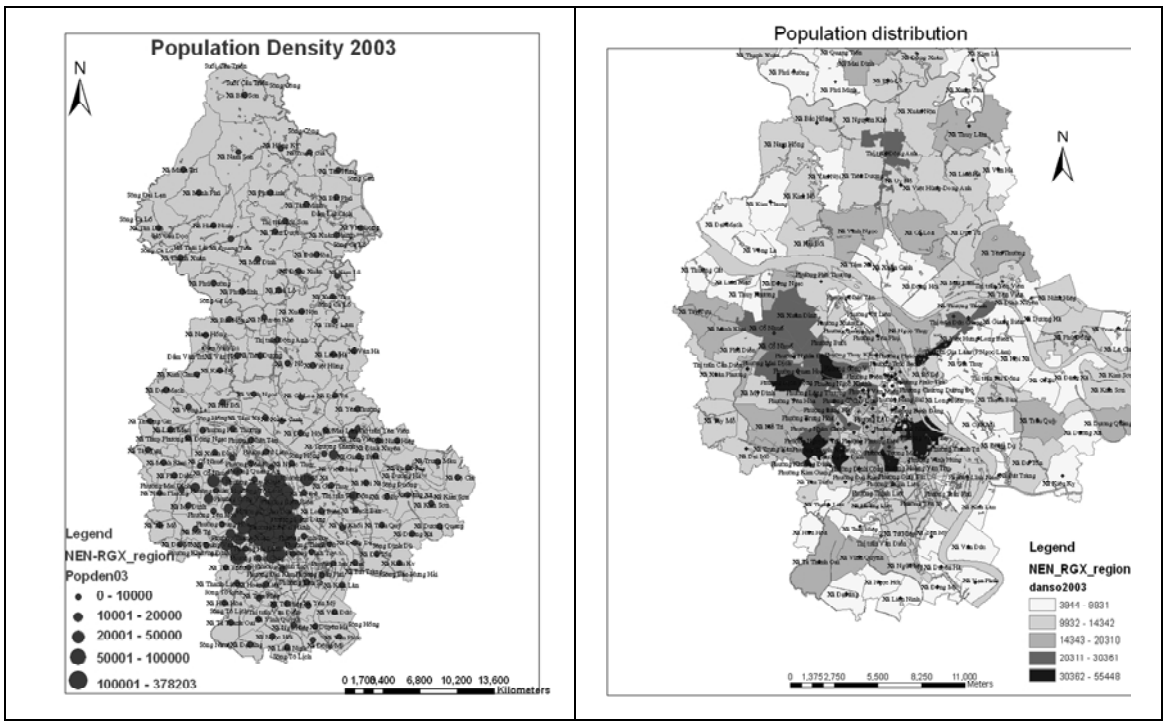


Figure 3.2: Distribution of population in Hanoi

Hanoi's population by District

			Population (1000 people)					Annual Pop. Growth (%/year)	Population Density, 2005 (no.ha)		
				1,999		2,005					
			Area (km2)	no.	%	no.	%		Total	Net	Residential area
Hanoi City			921	2,675	100.0	3,183	100.0	2.9	35	38	52
	Urban Core		35	963	36.0	1,094	34.4	2.1	316	353	399
		Ba Dinh	9	198	7.4	231	7.3	2.6	249	272	369
		Hoan Kiem	5	165	6.2	179	5.6	1.3	338	407	361
		Hai Ba Trung	10	272	10.2	312	9.8	2.3	310	362	393
		Dong Da	10	328	12.3	372	11.7	2.1	374	392	455
	Urban Fringe		144	673	25.2	896	28.1	5.1	62	75	111
		Tay Ho	24	91	3.4	108	3.4	2.9	45	75	64
		Thanh Xuan	9	149	5.6	196	6.2	**4.9**	215	226	353
		Cau Giay	12	122	4.6	171	5.4	**6.2**	142	146	281
		Hoang Mai	40	161	6.0	236	7.4	**7.2**	60	72	129
		Long Bien	60	151	5.6	186	5.8	3.6	31	36	46
	Suburban		139	343	12.8	427	13.4	3.8	3	34	61
		Tu Liem	75	193	7.2	262	8.2	**5.5**	35	38	83
		Thanh Tri	63	150	5.6	165	5.2	1.5	26	28	34
	Rural		604	696	26.0	766	24.1	1.5	13	14	16
		Soc Son	307	246	9.2	266	8.4	1.3	9	9	11
		Dong Anh	182	261	9.8	288	9.0	1.6	16	18	20
		Gia Lam	115	188	7.0	212	6.7	2.0	18	21	24

Table 3.1: Population by district in Hanoi

Hanoi's distinguishing characteristic is the compactness of its urban area with a high population density. While its urban core which comprises four districts only occupies 35km2, it has a population density of 316 persons/ha. In residential areas, the density increases to 399 persons/ha.

In the urban fringe, population density is moderate at 62 persons/ha, except in Thanh Xuan, which has 215 persons/ha and Cau Giay which has 142 persons/ha. However, the density in residential areas sharply increases to 111 persons/ha in the urban fringe. A similar pattern is also seen in suburban areas (JICA August, 2006).

The changes in the urban environment in Hanoi have occurred rapidly and drastically. Inflow of population from rural areas and other cities has been more than expected, probably due to the wider employment opportunities and higher education, among other things, offered in the capital city (JICA August, 2006)

Recently, some newly-built residential areas with good infrastructure in the West and the South of the city like Trung Hoa-Nhan Chinh, My Dinh, Nam Trung Yen, Dinh Cong and Linh Dam as shown in the figure below have attracted quite a lot of people out from the city centre for living.

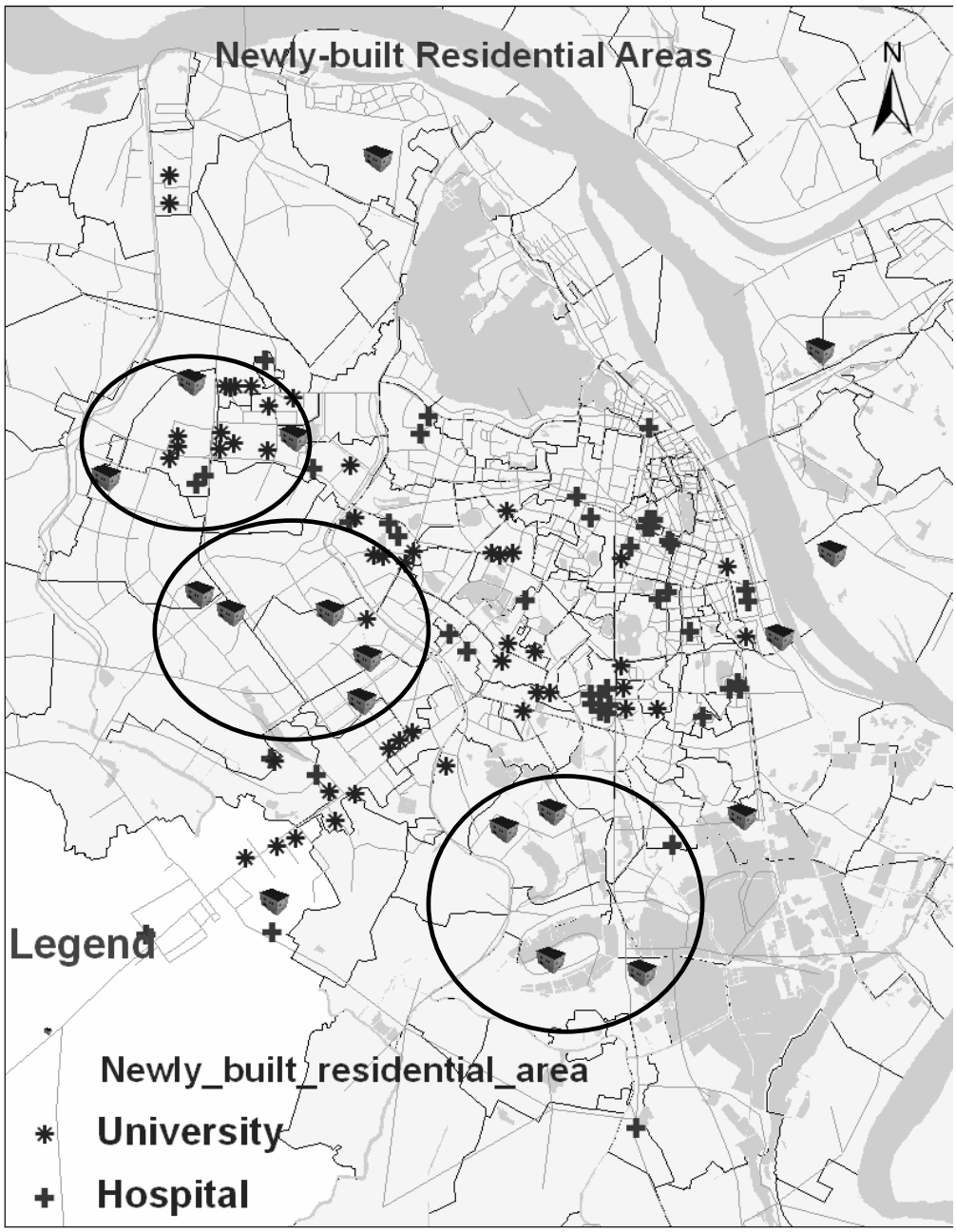


Figure 3.3: Newly-built residential areas

3.3. Distribution of some major land uses

According to the survey of administration offices and business enterprises of Hanoi in 2002, in urban core (Hoan Kiem district) there are 464 administration offices with 23,028 staff in among them 161 offices at national level with 16,218 staffs, and 12,196 business enterprises with total labour 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 and Hoan Kiem district is considered as business district (G.D.S 2003; pp33,48,51).

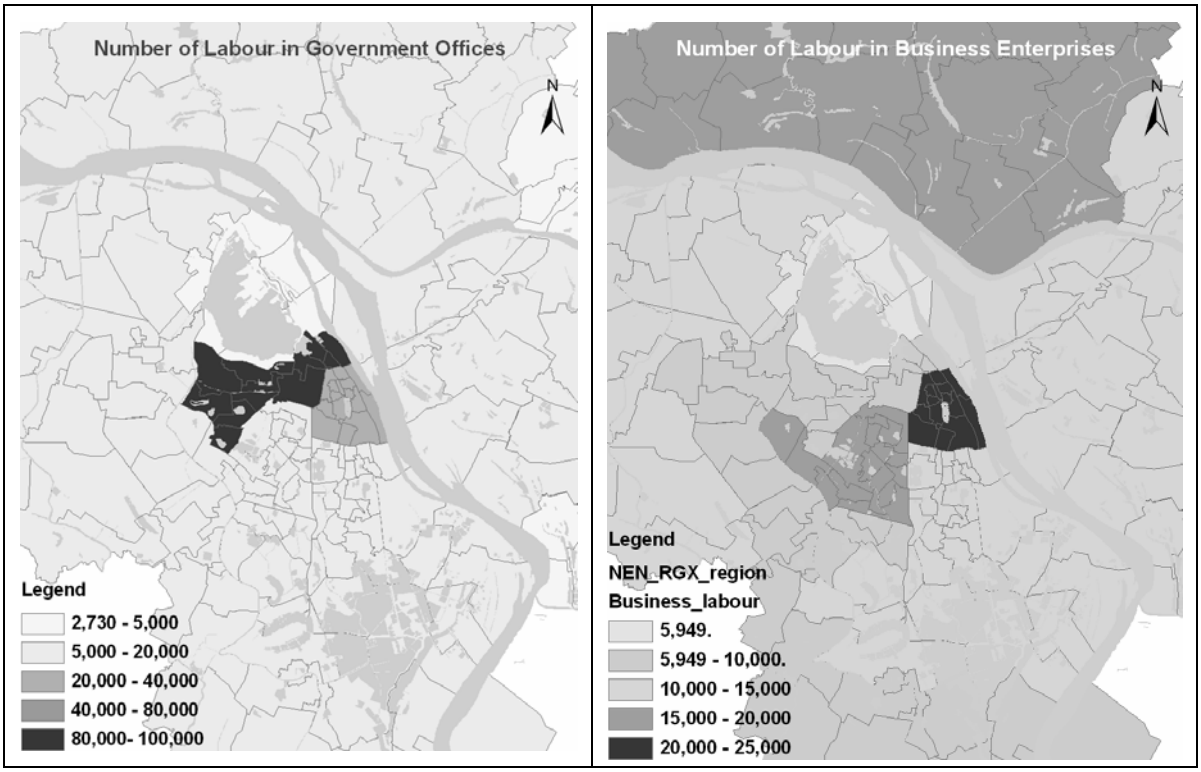


Figure 3.4: Number of labour in administration offices and business enterprises

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

Table 3.2: Number of unit and labour in administration offices and business enterprises
Source:(G.D.S 2003)

Besides that according to the Brief Report on Construction Master Plan for Hanoi Region in 2005, Hanoi has 31 hospitals at national level, more than 63 universities, colleges and vocational colleges with more than 553,000 students in total. Most of them are located within the city centre(M.O.C 2005). It can be seen clearly the uneven distribution of these basic facilities in the figure 3.3 and 3.5 below.

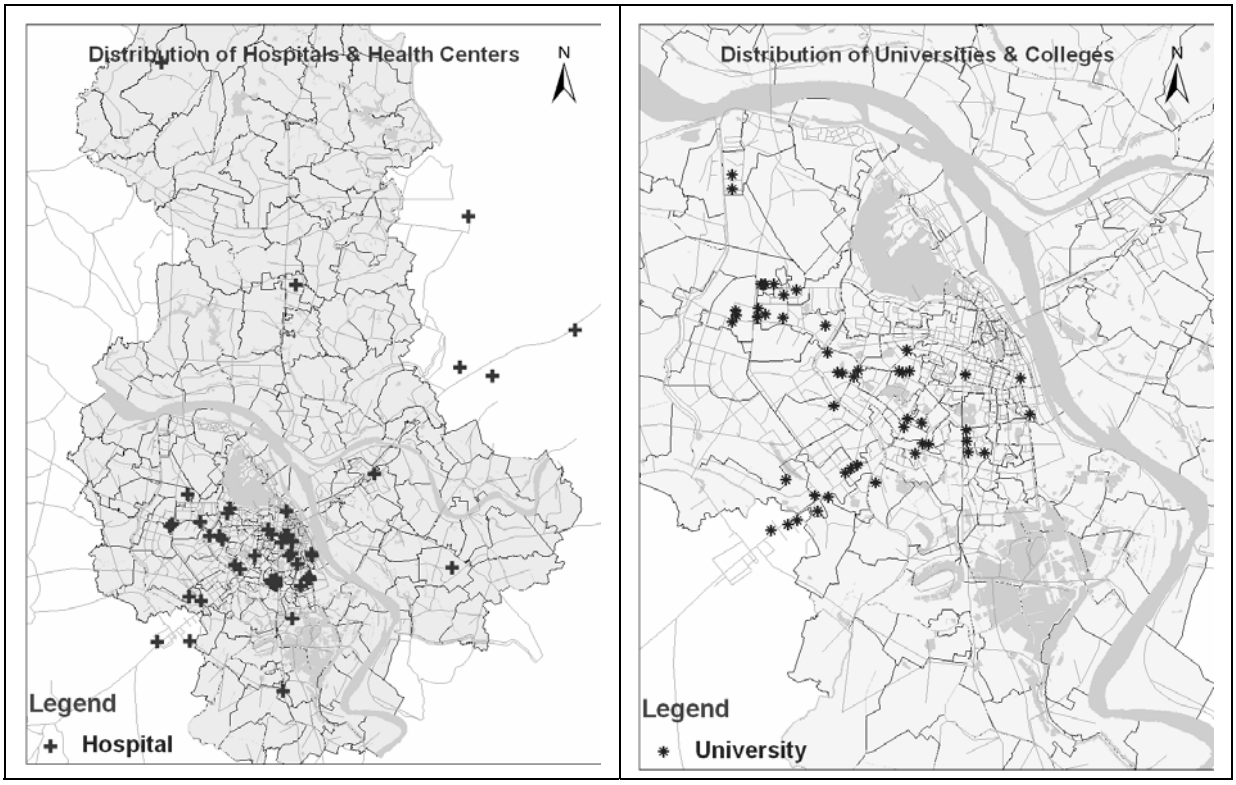


Figure 3.5: Distribution of hospitals

Land-use patterns highlight the fact that the main economic and social functions are highly concentrated in the urban core districts even through their actual land size is very small (JICA August, 2006).

This uneven distribution has put high pressure on urban infrastructure and other urban services.

3.4. Hanoi transport

3.4.1. Characteristics of Hanoi road network

Hanoi has a road length of 624km. The ratio of road area to Hanoi's total land area is 1.9% which is absolutely low compared to major cities in other countries. It is road system is densely developed in urban areas, and it is less dense in rural areas, causing unequal level of accessibility within Hanoi. The city's road network basically consists of radial and ring roads. The radial road network is connected directly to the regional primary road network. It has been observed that the road design standard is often inconsistent with the road function, which, among others, causes "missing links" in the road network, e.g. arterial roads suddenly becoming narrow or interrupted at many places (JICA August, 2006).

Before 2003 when SEA Games were held in Vietnam, a number of road projects were completed in Hanoi, particularly in the west side of central Hanoi where the main stadium was located. After

2003, however, the main focus of road development shifted to the completion of Ring Road (RR) no.2, no.3, and no. 2.5 (HAIDEP 2005). In the city centre, it is very difficult to expand a road due to high density of residential area and high cost for land acquisition. It can be seen in the figure below.

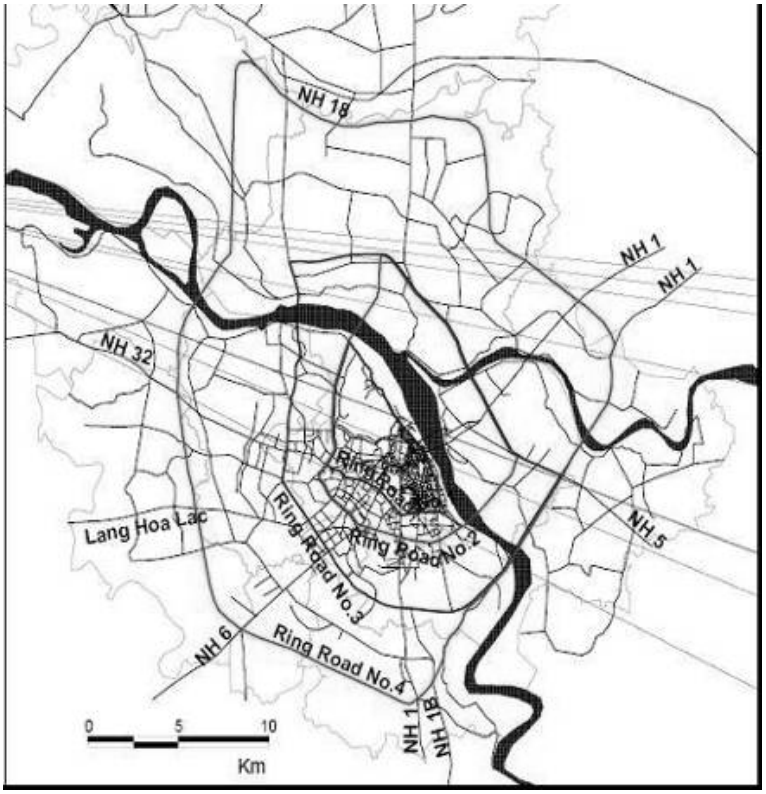


Figure 3.6: Road distribution in Hanoi. Source: (HAIDEP 2005)

Table 5.9.1 Road Development Indicators in Hanoi's Urban and Rural Areas

District	Area (km^2)	Population (2003)	Urban Road Length (km)	Urban Road Area (km^2)	Road Service Level[1)]	Road Density[2)]	Road Ratio[3)]
Hoan Kiem	5.29	177.4	68.2	0.68	0.38	12.9	0.13
Ba Dinh	9.25	224.1	53.9	0.54	0.24	5.83	0.06
Dong Da	9.96	363.3	51.1	0.55	0.14	5.13	0.06
Hai Ba Trung	14.65	398.2	61.7	0.70	0.15	4.21	0.05
Cau Giay	12.04	160.1	40.1	0.44	0.25	3.33	0.04
Tay Ho	24.00	104.0	17.3	0.15	0.17	0.73	0.01
Thanh Xuan	9.11	188.3	38.2	0.24	0.20	4.19	0.03
Subtotal	84.30	1,615.4	330.	3.31	0.20	3.92	0.04
Tu Liem	75.32	242.4	114.5	-	0.47	1.54	-
Thanh Tri	98.22	275.8	105.3	-	0.38	1.07	-
Gia Lam	174.32	378.9	152.0	-	0.40	0.87	-
Dong Anh	182.30	280.1	171.0	-	0.61	0.94	-
Soc Son	306.51	262.7	227.0	-	0.86	0.74	-
Subtotal	836.67	1,439.9	769.8	-	0.53	0.92	-
Grand Total	920.97	3,055.3	1,100.2	-	0.36	1.19	-
Ho Chi Minh	2,095	5,554.8	1,245.0	-	0.22	0.59	-
Metro Manila	636	10,000	2996	-	0.30	4.66	-

1) Road Service Level: RSL=L/'000 population
2) Road Density: RD(km/km^2) =L/A
3) Road Ratio: RR=RA/A

Table 3.3: Road Development Indicators in Hanoi. Source: (HAIDEP 2005)

3.4.2. Transport in Hanoi

Motorization: Along with its population growth, vehicle ownership has sharply increased particularly that of motorcycle. As of 2005, there are 164 thousand cars and 1.566 thousand motorcycles in Hanoi City, increasing at an annual growth rate of 11.1% and 14.8% respectively. Of the total household, 84% own a motorcycle, of which 40% have more than two. Although car ownership is still low at 1.6% of the total population in Hanoi, this figure has increased rapidly, posing a threat to smooth traffic flow in some locations. Rapid economic growth, at a rate of 11% per year, is expected to further accelerate ownership of private vehicles such as motorcycles and cars (JICA August, 2006).

Public transport: Hanoi achieved an initial success in the revitalization of bus services through modernization, with the share of bus in terms of person trips increasing to about 7% of the total in 2005 from a very dismal 1-2% in the previous 5 years. Anyway, the share in total urban transport demand is still insignificant(JICA August, 2006).

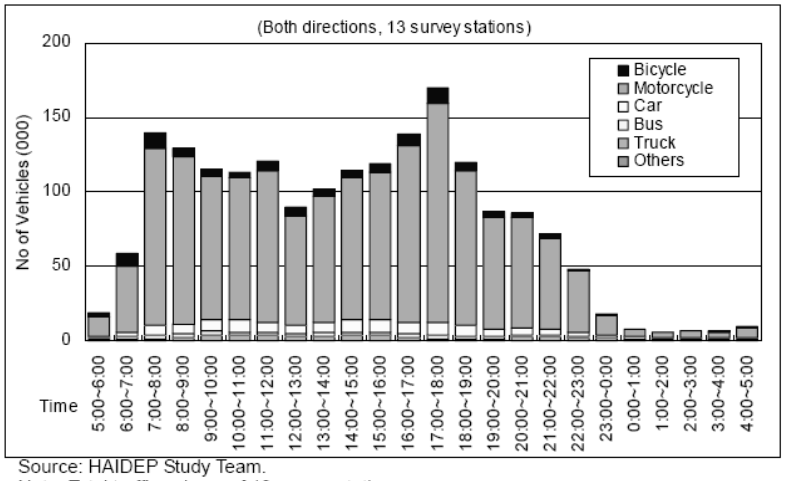
Other transports: "Railway services only operate on long-distance routes, with limited efficiency, poor infrastructure facilities and connectivity. River transport is also limited despite the high density of rivers and water channels"(JICA August, 2006)

One important characteristics of Hanoi transport is mixed traffic with very high share of motorcycle. The collapse of public transport in 1989 in combination with a mushrooming motorcycle ownership, led to the strange situation where "Hanoi found itself with the lowest public transport usage and the highest percentage of private transport of all Asian capitals"(HAIDEP 2005)

3.4.3. Traffic congestion in Hanoi

Due to the poor road infrastructure while almost all social activities happens in the city centre in combination with poor public transport services and high share of motorcycle, traffic congestion is experience almost every morning and afternoon peak hours. The morning peak is from 7:00AM to 8:00 AM, the afternoon peak is from 17:00 PM to 18:00 PM

Figure 4.2.16 Hourly Trip Fluctuation in Urban Areas



Source: HAIDEP Study Team.
Note: Total traffic volume of 13 survey stations.

Figure 3.7: Trip Fluctuation in Urban Areas (HAIDEP 2005)

Figure 3.8: Traffic congestion in Hanoi

3.5. Recent studies on Hanoi transport & their shortcomings

Recently, there are two important studies relating to Hanoi transport. The first one is Hanoi Transport Development Master Plan for 2020 prepared by Transport Engineering and Design Incorporation (TEDI) in 2004. The second one is the Hanoi Integrated Development and Environmental Program (HAIDEP) under JICA project in 2006. Both proposals are under review for approval of the Prime Minister.

3.5.1. Transport master plan

According to the Master Plan prepared by TEDI, the development targets are set for public transport projects including satisfying 30% of Hanoi‘s passenger transport demand by 2010 and 50% by 2020 with the mode share as in the table below.

	Bicycle	Motorcycle	Car	Bus	Rail-based	Other
2010	13-14%	34%	11-12%	20-22%	8-10%	10%
2020	10%	20-24%	16-19%	25-30%	20-25%	12%

Table 3.4:Proposed mode share by TEDI (M.O.T 2004; table 8.6, pp8-19)

The followings objectives are highlighted:

- Provide a transport linkage for new development areas
- Develop the public transport system including an urban rail transit system either at-grade, elevated, or underground.

- Alleviate local congestion and enforce traffic laws
- Construct transport nodes at the intersection of radial and circumferential roads.

The report recommends the use of rail-based transit systems with eight new rail routes either at-grade, elevated, or underground and about 200 km long in total. (M.O.T 2004; HAIDEP 2005).

One major shortcoming in this proposal is that it discourages walking and cycling and mainly support for a rail-based system. In the whole document there is no mention about the abnormal distribution of the major land-uses like hospital, universities and government offices as well as there is no solution to re-distribute these major land-uses and encourage people using green modes like walking and cycling.

3.5.2. HAIDEP study

Next to the study by TEDI, in 2004, the Government of Vietnam requested the Government of Japan to conduct a study on comprehensive urban development to ensure that Vietnam follows an appropriate and a sustainable urban development under the name Hanoi Integrated Development and Environmental Program (HAIDEP).

In the HAIDEP study, they also mentioned integration of land-use but the meaning is on-site improvement of land-use.

They also mentioned about relocation but just "...Relocate polluting industries…" (JICA August, 2006). There is no mentioned about the distribution of other land-uses like university, hospital and government office.

Besides that they also mentioned that transport infrastructure needs to be improved but in direction of favour mass transit "For large urban areas, such as Hanoi, the only way to effectively meet the transport demand is to provide the city with a high-quality public transport system that is integrated with urban development. The core network will be composed of urban rail metro, and bus rapid transit (BRT)"(JICA August, 2006). There is no mentioned about how to favour and encourage people using other green modes like walking, cycling and bus. However, "building a good public transport system is not an easy task; it requires large amounts of funds as well as operation and management capacities" (JICA August, 2006)

In general, in HAIDEP study, there is no mention about redistribution or relocation of the existing major land-uses like hospital, universities and government offices to relief traffic congestion, reduce number of trip; reduce trip length as well as improve accessibility to encourage number of people shifting to green modes.

3.6. Government policy

Recently, government has a policy to expand the city to the West direction (Ha Tay, Xuan Mai, Hoa Lac, Ba Vi, Son Tay and to the West-North direction (Soc Son, Xuan Hoa, Phuc Yen) (M.O.T 2004; pp6-1). In early 2007, information appeared on newspaper that Hanoi's People Committee has decided to move 50% of polluting hospitals and industries out from the city centre and residential areas before 2010.

(http://www.qdnd.vn/qdnd/baongay.kinhte.10142.qdnd, accessed date Feb,09.2007)

Hanoi: 50% of polluting hospitals, factories will be moved out.

"Hanoi's People Committee together with Ministry of Natural Resources and Environment has issued a document mentioned: ***From now up to 2010 50% of polluting hospitals and industries will be moved out from the city centre and residential areas…."***

(http://www.qdnd.vn/qdnd/baongay.kinhte.10142.qdnd , accessed date Feb,09.2007)

3.7. Hanoi's vision

The vision and goals for Hanoi are interlinked with the fact that it is the nation's capital and as such, it should be in the forefront of Vietnam's march toward future growth and the anchor for its identity as a proud and robust nation. This is rightly stated in the vision for Hanoi in Order no. 1/2001/L-CTN which reads: "Hanoi must be built as a modern and thriving capital city, symbolizing the whole country, and functioning as a national and regional centre for policy, culture, science, technology, education, economy, and international trade"*(JICA August, 2006)*.

And one of the objectives is to provide efficient infrastructure to make it possible for people to commune safely without traffic congestion(JICA August, 2006)

3.8. Conclusions

Poor road infrastructure, poor public transport and uneven distribution of some major land-uses like hospitals, universities and government offices leading to high separation between the trip origin and trip destination in combination with high rate of motorcycle have caused severe traffic congestion in Hanoi.

Both recent studies for Hanoi transport support rail-based system. And there is no mention about how the major land-uses like hospitals, universities and government offices should be re-distributed and how much can we achieve by relocating them in terms of relief traffic congestion.

4. Data collection and data preparation

This chapter describes the data collection at field, and data preparation with focus on road network preparation.

4.1. Data requirements

From the conceptual framework in chapter 1 and indicators used as discussed in chapter 2, the following information is necessary to be obtained from the field:

- Transport mode people used,
- Travel time people go from home and return home from work,
- Living address (ward) where people go to/return from our study areas (trip origin),
- Corridors people used,
- General information of organization for aggregate purpose,
- Their intention of relocation and new location, if any.
- Road network data and its information such as road type, road width, number of lane, traffic volume, etc.

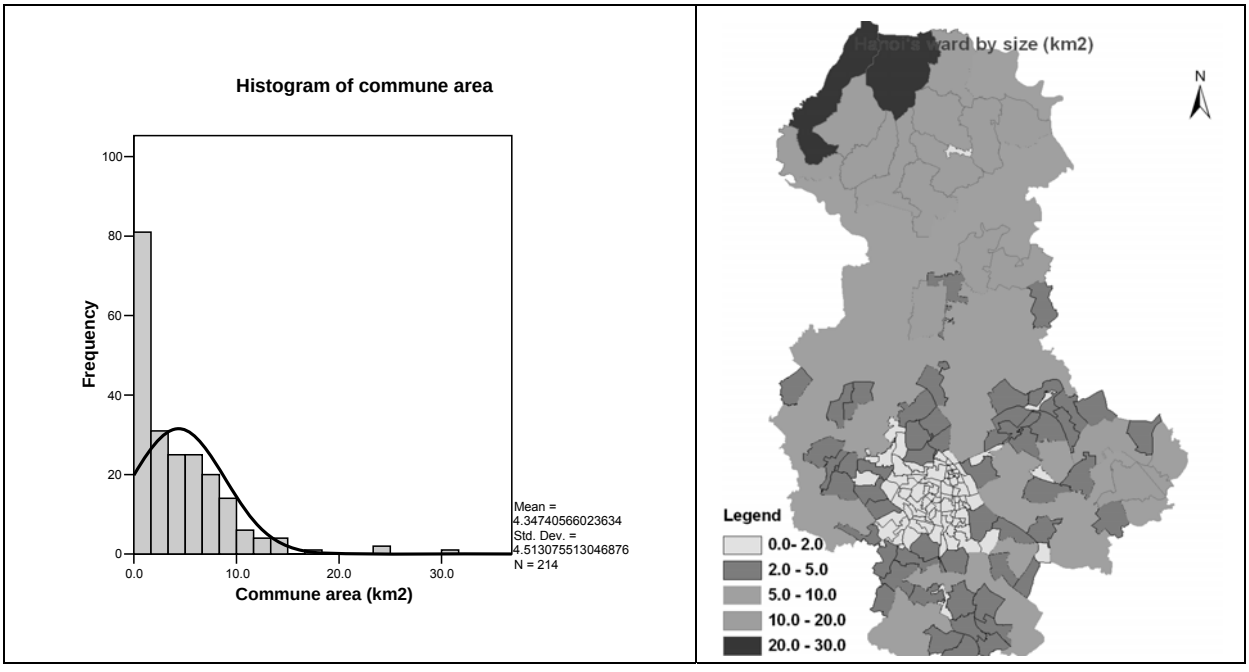


Figure 4.1: Hanoi's ward by size (km2)

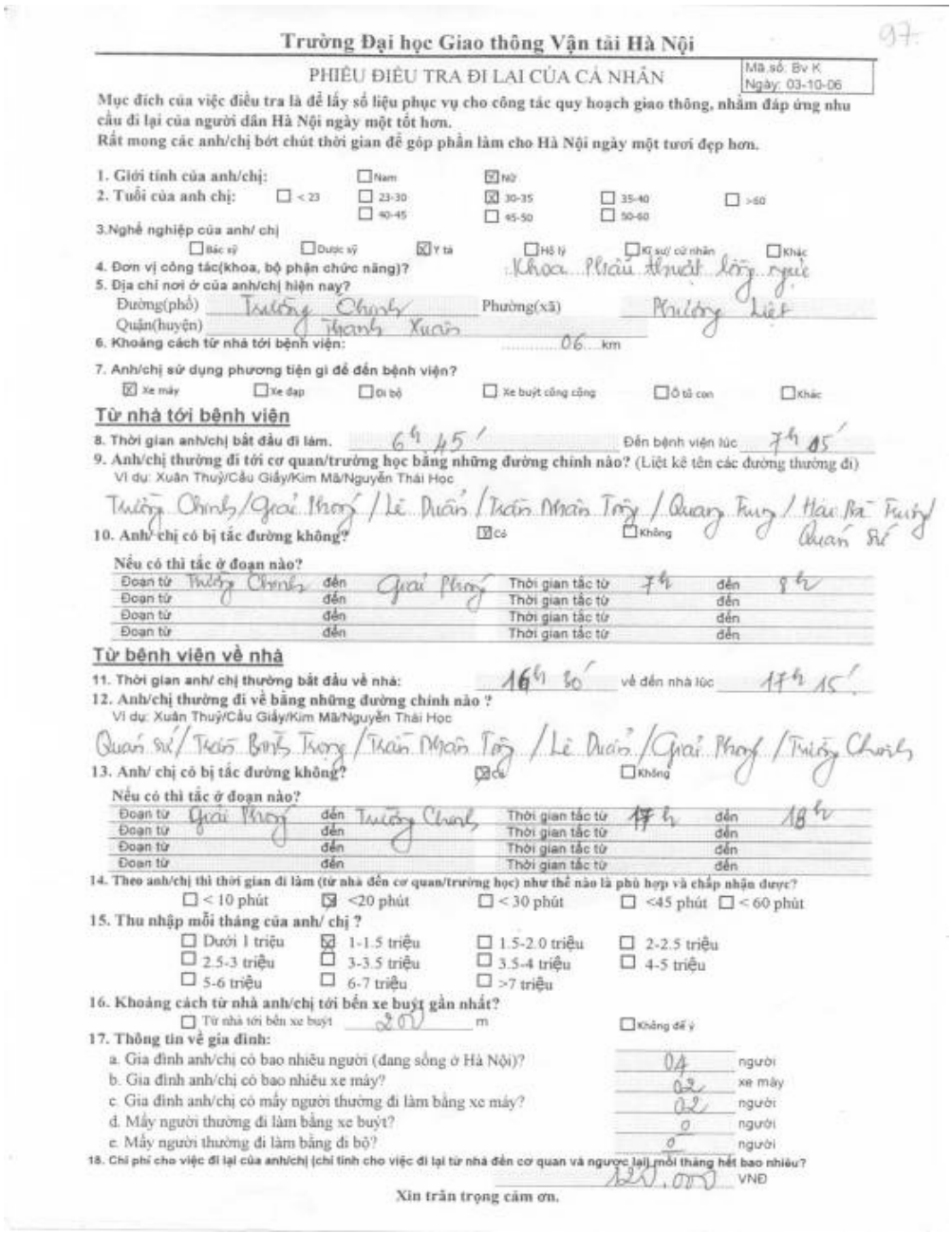
One characteristics of Hanoi is that all wards in the city centre have smaller size than the outskirts. In Hanoi, the smallest ward is Tran Hung Dao with an area of 0.059 km2 (or average distance is 136.0 m from ward centre) and largest ward is Bac Son in the outskirt of Hanoi with area of 30,05km2 (or average distance from ward centre is 3.09km), and on average the ward's area is

4.34km2 or average distance from ward centre is 1.17km. Most of Hanoi people are living in the city centre or in fringe wards where the average area is small enough as average area to consider people going from ward centre. Therefore, in this research, the smallest unit used as trip origin is the ward.

4.2. Data collection

4.2.1. Interview form/questionnaires

Since the trip destinations were already decided as mentioned in chapter 1. Therefore, the office-based interview method is selected to get the information on trip origin, transport mode, travel time and corridors used. All these information can be filled very quickly in the short interview forms/questionnaires designed as depicted in a sample below.



Trường Đại học Giao thông Vận tải Hà Nội 97

PHIẾU ĐIỀU TRA ĐI LẠI CỦA CÁ NHÂN

Mã số: Bv K
Ngày: 03-10-06

Mục đích của việc điều tra là để lấy số liệu phục vụ cho công tác quy hoạch giao thông, nhằm đáp ứng nhu cầu đi lại của người dân Hà Nội ngày một tốt hơn.
Rất mong các anh/chị bớt chút thời gian để góp phần làm cho Hà Nội ngày một tươi đẹp hơn.

1. Giới tính của anh/chị: ☐ Nam ☒ Nữ
2. Tuổi của anh chị: ☐ < 23 ☐ 23-30 ☒ 30-35 ☐ 35-40 ☐ >60 ☐ 40-45 ☐ 45-50 ☐ 50-60
3. Nghề nghiệp của anh/ chị: ☐ Bác sỹ ☐ Dược sỹ ☒ Y tá ☐ Hộ lý ☐ Kỹ sư/ cử nhân ☐ Khác
4. Đơn vị công tác(khoa, bộ phận chức năng)? Khoa Phẫu thuật lồng ngực
5. Địa chỉ nơi ở của anh/chị hiện nay?
   Đường(phố) Trường Chinh Phường(xã) Phương Liệt
   Quận(huyện) Thanh Xuân
6. Khoảng cách từ nhà tới bệnh viện: 06 km
7. Anh/chị sử dụng phương tiện gì để đến bệnh viện? ☒ Xe máy ☐ Xe đạp ☐ Đi bộ ☐ Xe buýt công cộng ☐ Ô tô con ☐ Khác

Từ nhà tới bệnh viện

8. Thời gian anh/chị bắt đầu đi làm. 6h45' Đến bệnh viện lúc 7h05'
9. Anh/chị thường đi tới cơ quan/trường học bằng những đường chính nào? (Liệt kê tên các đường thường đi)
   Ví dụ: Xuân Thuỷ/Cầu Giấy/Kim Mã/Nguyễn Thái Học
   Trường Chinh/Giải Phóng / Lê Duẩn / Trần Nhân Tông / Quang Trung / Hai Bà Trưng / Quán Sứ
10. Anh/ chị có bị tắc đường không? ☒ Có ☐ Không
    Nếu có thì tắc ở đoạn nào?

Đoạn từ	Trường Chinh	đến	Giải Phóng	Thời gian tắc từ	7h	đến 8h
Đoạn từ		đến		Thời gian tắc từ		đến
Đoạn từ		đến		Thời gian tắc từ		đến
Đoạn từ		đến		Thời gian tắc từ		đến

Từ bệnh viện về nhà

11. Thời gian anh/ chị thường bắt đầu về nhà: 16h30 về đến nhà lúc 17h15'
12. Anh/chị thường đi về bằng những đường chính nào ?
    Ví dụ: Xuân Thuỷ/Cầu Giấy/Kim Mã/Nguyễn Thái Học
    Quán Sứ/Trần Bình Trọng/Trần Nhân Tông / Lê Duẩn/Giải Phóng / Trường Chinh
13. Anh/ chị có bị tắc đường không? ☒ Có ☐ Không
    Nếu có thì tắc ở đoạn nào?

Đoạn từ	Giải Phóng	đến	Trường Chinh	Thời gian tắc từ	17h	đến 18h
Đoạn từ		đến		Thời gian tắc từ		đến
Đoạn từ		đến		Thời gian tắc từ		đến
Đoạn từ		đến		Thời gian tắc từ		đến

14. Theo anh/chị thì thời gian đi làm (từ nhà đến cơ quan/trường học) như thế nào là phù hợp và chấp nhận được?
    ☐ < 10 phút ☒ <20 phút ☐ < 30 phút ☐ <45 phút ☐ < 60 phút
15. Thu nhập mỗi tháng của anh/ chị ?
    ☐ Dưới 1 triệu ☒ 1-1.5 triệu ☐ 1.5-2.0 triệu ☐ 2-2.5 triệu
    ☐ 2.5-3 triệu ☐ 3-3.5 triệu ☐ 3.5-4 triệu ☐ 4-5 triệu
    ☐ 5-6 triệu ☐ 6-7 triệu ☐ >7 triệu
16. Khoảng cách từ nhà anh/chị tới bến xe buýt gần nhất?
    ☐ Từ nhà tới bến xe buýt 200 m ☐ Không để ý
17. Thông tin về gia đình:
    a. Gia đình anh/chị có bao nhiêu người (đang sống ở Hà Nội)? 04 người
    b. Gia đình anh/chị có bao nhiêu xe máy? 02 xe máy
    c. Gia đình anh/chị có mấy người thường đi làm bằng xe máy? 02 người
    d. Mấy người thường đi làm bằng xe buýt? 0 người
    e. Mấy người thường đi làm bằng đi bộ? 0 người
18. Chi phí cho việc đi lại của anh/chị (chỉ tính cho việc đi lại từ nhà đến cơ quan và ngược lại) mỗi tháng hết bao nhiêu? 120.000 VNĐ

Xin trân trọng cảm ơn.

Figure 4.2: A sample of questionnaire form

Usually it took less than 5 minutes to fill a form. This strategy is suitable since people are very busy.

4.2.2. Deliver Interview forms and questionnaires

Now the critical matter is how to get information, especially from government staff, doctors, and lecturers since they are very busy. The problem was solved by delivering questionnaires through the administration system of these organizations with the support from management boards. The completed forms were collected one week after delivering. For students, the questionnaires were delivered at classes and collected immediately after 30 minutes from class representatives. The classes were randomly selected and the questionnaires were delivered for all morning class, afternoon classes and night classes. For patients, there is no other way than interview directly with the help of 8 assistants. Finally, 5,561 completed questionnaire forms were collected. The result is summarized in table 4.1, 4.2, 4.3.

Figure 4.3: Interview at hospitals

After collecting the completed forms, all information from questionnaires was input in database immediately by assistant staff. All completed forms were coded and numbered as seen in figure 4.1 above before inputting in database.

4.2.3. Interview management boards

The management boards were interviewed to get general information of these organizations for aggregate purpose and to get information on their intention of relocation, location of new base and solution of relocation, if any. The interview reveals that all the existing bases are overloaded and so narrow that some of them already have the intention to relocate to new bases; some others also have intention to move but still have no idea where to move. And most of the new locations are planned in the west side of the city, except K hospital to the South. The result is summarized in the table 4.1, 4.2, 4.3 below. Later this information will be used to calculate the contribution to congestion on corridors of the whole population of these land-uses in chapter 5 and used to construct scenarios in chapter 6.

Result of survey at hospitals

No.	Hospital name	No. of patient bed	Staff			Patient			Relocation intention	New address	Type of relocation	Year of relocation
			Number of staff	No. of completed form	%	Average number of patient daily	No. of completed form	%				
1	**Bach Mai hospital consortium**	1700	2875	684	23.79	2651	637	24.03				
a	Bach Mai Hospital	1150	1925			1516 (33362/22			Not yet	Waiting for permission		
b	National Institute of Infectuous and Tropical Diseases (Vien Lay)	120	200			80			Yes	Not clear now		
c	National Institute of Hematology and Blood Transfusion (Vien Huyet hoc)	200	300			35			Yes	Nhan Hoa-Trung Kinh-Hanoi	Move all	2010
d	National Institute of Dermato-Venereology (Vien Da lieu)	100	200			400-700			Yes	Not clear now		
e	Vietnam National Institute of Gerontology (Vien Lao khoa)	30	50			20			Yes	Not clear now		
f	Vietnam-French Hospital	100	200			300			No			
2	**Viet-Duc hospital**	500	982	256	26.07	400	150	37.50	No			
3	**K hospital**	470	557	218	39.14	800	166	20.75	Yes	Tan Trieu-Thanh Tri-Ha Noi	Move all	Before 2010
4	**C hospital (Phu San)**	400	600	208	34.67	250	109	43.60	Not yet			
5	**Saint Paul hospital**	500	670	196	29.25	1970 (43349/22	145	7.36	Yes	Not clear (Waiting for permission)		

Table 4.1: Result of survey at hospitals

Result of survey at universities

No.	University name	Teacher and Staff			Total number of student	No. of students study at Hanoi base	No. of completed form of student				Relocation intention	New address	Type of relocation	Year of relocation
		Number of staff	No. of completed form	%			Morning class	Afternoon class	Night class	%				
1	**Construction University**	832	72	8.65	20,754	23,000	572	502	229	5.67	Not yet			
2	**Polytechnics University**	1950	99	5.08	30,000	30,000	159	257	112	1.76	Yes	Tay Mo commune	a part	Before 2020
3	**Economics University**	1130	48	4.25	27,996	18,700	0	294	283	3.09	Not yet			

Table 4.2: Result of survey at universities

Result of survey at government offices

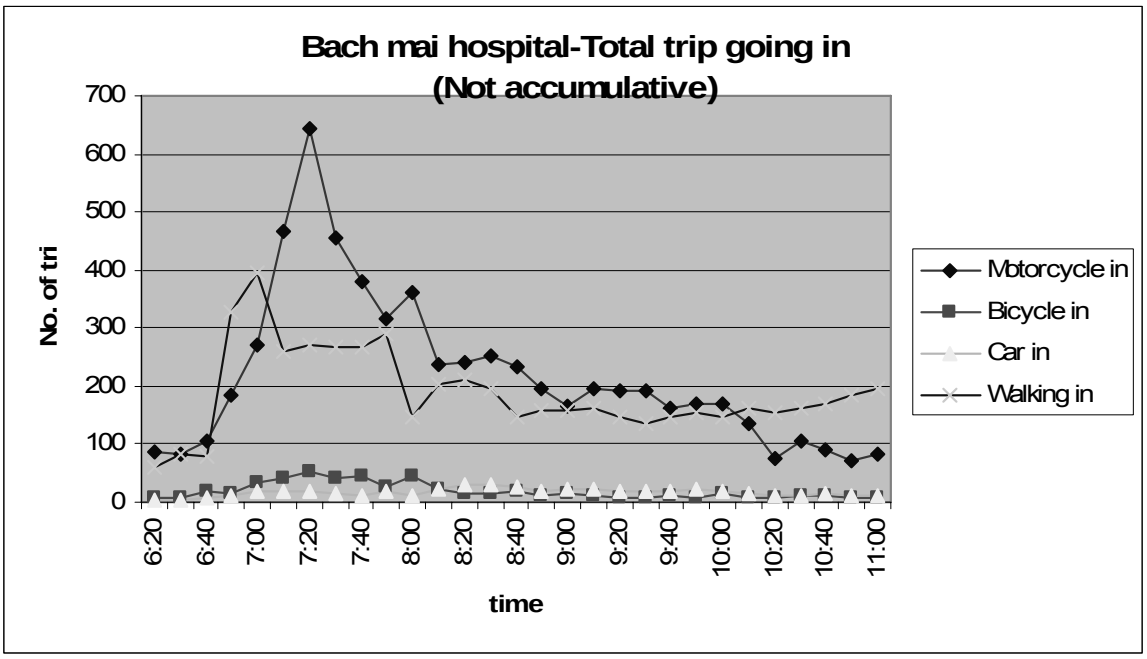
No.	Office name	Teacher and Staff			Relocation intention	New address	Type of relocation	Year of relocation
		Number of staff	No. of completed form	%				
1	**Ministry of Science and Technology**	300	15	5.00	Yes	Trung Hoa-Cau Giay-Hanoi	Whole	Before 2010
2	**Vietnam Railways Corporations**	450	150	33.33	No			

Table 4.3: Result of survey at government offices

4.2.4. Traffic count at cordons

Figure 4.4: Traffic count at cordons

In order to analyze the attraction of these organizations, the traffic counts at cordons method were applied. The traffic count was done for all transport means at all gates of these organizations. The traffic count was usually done from 6:00 or 6:30 AM till 9:00 AM in the morning and from 16:00 PM till 18:30PM. The survey reveals that hospitals are very attractive and the busiest time is from 7:00 AM to 8:00AM in the morning. For example till 9:00AM already has almost 9,000 trips going in Bach Mai hospital. Beside that the high rate of motorcycle can also be seen in an example below.



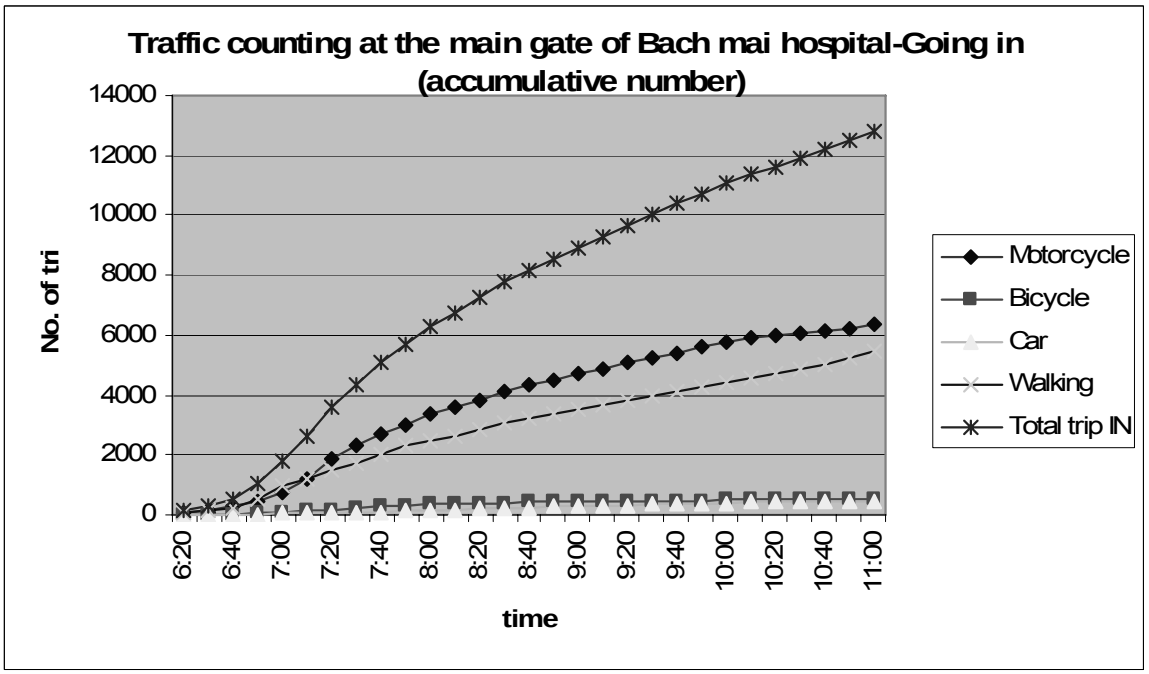


Figure 4.5: Result of traffic count at cordons

4.2.5. Measuring travel speed on some corridors

The travel time by motorcycle on some corridors was done. The purposes are:

- To evaluate and decide peak hours.
- To calculate average travel speed of the traffic flow on corridors in Non-peak and in Peak hours. This information will be used for calibration of road network later.

The survey was done by recording the travel time by motorcycle on one corridor before and after expected peak hours, usually from 6:30 AM till 11:00 AM and from 16:00PM till 19:00 PM. After that the travel speed was calculated by dividing travel length to travel time and then draw on graph as an example below. The survey was also done for both the way-in and the way-out.

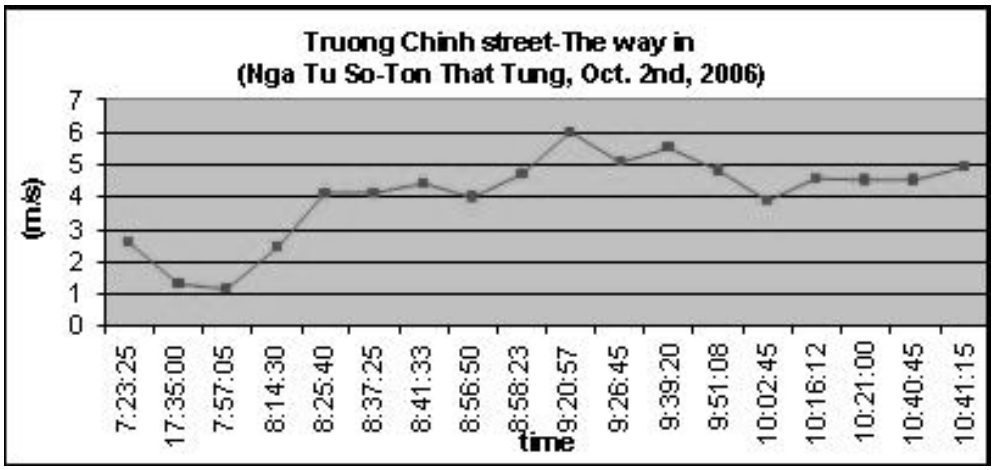


Figure 4.6: Travel speed on some corridors-Morning peak

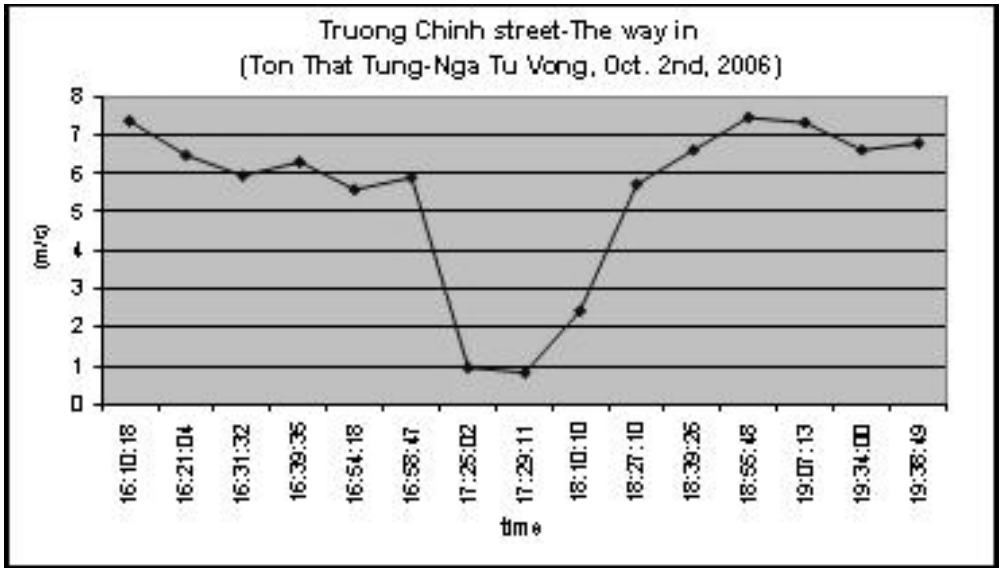


Figure 4.7: Travel speed on corridors-Afternoon peak

The survey reveals that:

- The morning peak is from 7:00AM to 8:00 AM, afternoon peak is from 17:00PM to 18:00PM,
- The most congested corridor is Truong Chinh Street, especially on the way-in in the afternoon.
- The average speed in non-peak hour is from 16km/h to 22km/h depending on the corridor. This information will be used for road network preparation later.

4.2.6. Collection of secondary data

Besides that some secondary data and related documents were collected:

- Ward's boundary in MapInfo format
- Statistics data for aggregation purpose
- Paper maps of Hanoi road network and Bus network.
- Report on current condition of road network from Public Work Service (2006)
- HAIDEP project documents, Transport Development Master Plan for 2020 by TEDI and some other related documents.
- Traffic count on some main roads and corridors.

4.3. Data preparation

4.3.1. Road network preparation

In this research, one important task is the preparation of the road network. The road network is prepared from a paper map since the research scholar could not get the road network of Hanoi in GIS format. The whole process of road network preparation is depicted in the flowchart below.

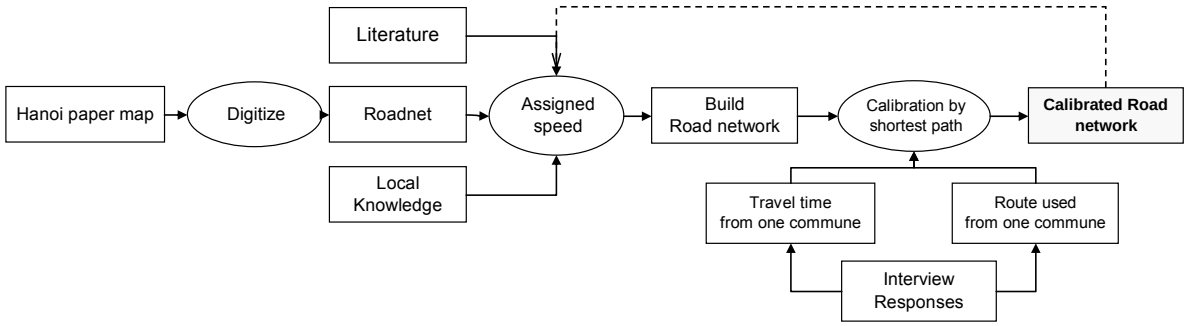


Figure 4.8: Process of road network preparation

Digitization process and the road network building is followed the instructions in Network Analysis & Linear Referencing tools (Bosch 2006).

The road net is digitized in quite detail with seven road classes: highway, main road, secondary road, minor road, link road, lane and internal road. A road is divided into segments, from junction to junction. The road class is decided based on the local knowledge of research scholar and the Report on Current Condition of Road Network from Public Work Service in 2006.

Basically, the speed for each road segment is decided based on its road-class and its length with a suggestion of road speed from table 4-7, chapter IV, Urban Road Design by Nguyen Khai in 1999(Nguyen Khai 1999) as in the table below.

Average Speed of Traffic Flow (table 4-7, pp88)

Distance between two intersections (m)	Maximum speed Vmax(km/h)	Average speed of traffic flow Vavg (km/h)
200	35-40	14-16
400	45-50	18-20
600	65-70	26-28
800	80-85	32-40
1000	95-100	38-40

Table 4.5: Average speed of traffic flow (Source: Table 4-7, Urban Road Design-Nguyen Khai)

4.3.2. Calibration of road network

From the suggestion in the table 4.5, the travel cost (or impedance) is calculated for each road segment for the way "From-To" and the reverse direction "To-From" (From-To is the direction of digitizing) by assigning travel speed. The assigning process is based on the road type and its length.

Finally, the whole road network is built and then calibrated based on the information extracted from interview responses. There are two important task need to be checked are the travel route and travel time from a ward to specified destination.

Route checking: Since the analysis in the next chapters is based on the shortest path algorism calculated from prepared road network in the previous steps. The shortest path from a ward to a specified destination is calculated based on the least accumulated cost of all possible road segments. The travel cost is depended on the length of the road segment and the assigned travel speed as mentioned in the previous step. If the travel speed assigned for one road segment is not correct, our road network model might give the wrong corridors for travel from a ward to a destination in our study area as compared with the real situation information which extracted from the interview and local knowledge of the research scholar. Therefore, it is necessary to calibrate the road network before using in the next chapters by checking the route used given by model and the corridors used from the same ward extracted from the interview. This process is called road network calibration.

The strategy applied is to divide the whole city into some bigger areas (bigger than commune) for example: Gia Lam area (from the other side of the river), Dong Anh area (from the North of the city), Thanh Xuan-Ha Dong area (from the South-West direction), Cau Giay-Dich Vong-Dien-Nhon area (from the West, etc. People from these areas must use some specific corridors. There is almost no other choice for them. For example, there is only one choice for people from the other side of the river to Bach Mai area: Chuong Duong bridge-Ba Trieu-Dai Co Viet; people from Cau Giay-Dich Vong-Nhon to Viet-Duc, K,C hospitals must use Cau Giay bridge-Kim Ma-Nguyen Thai Hoc; people from Thanh Xuan-Ha Dong must use Nguyen Trai-Nguyen Luong Bang-Kham Thien to urban core, etc. This strategy is based on the local knowledge of research scholar.

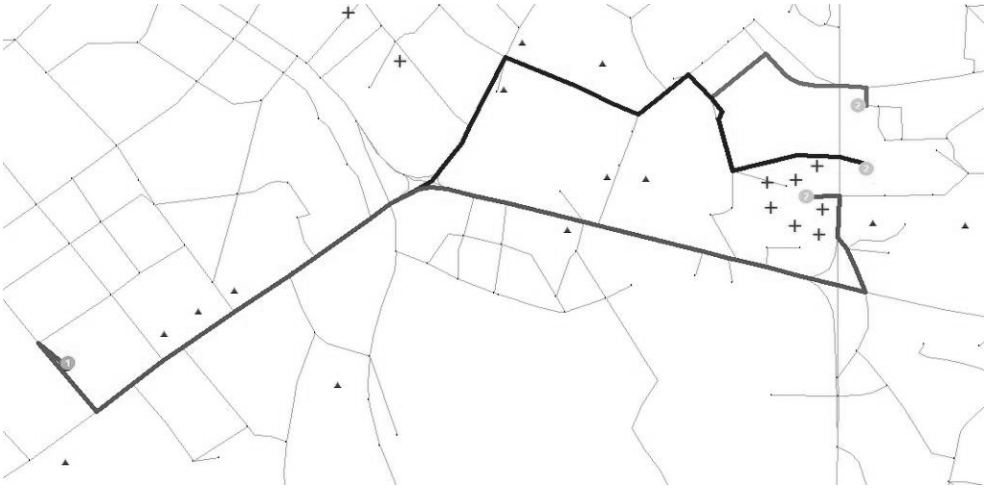


Figure 4.9: Route used from a ward to destination in the study area.

Travel time checking: The task is completed by comparing the travel time given by model and the information extracted from the interview.

After many times of adjustment, the travel speed of the road network is assigned with the value in the table 4.6 below.

Speed table Traffic Flow

No.	Road type	Road length	Travel speed (km/h)
1	Highway	L<1000m	40
		L>=1000m	60
2	Main road	L<200m	20(22)
		L=200-400m	22(25)
		L=400-600m	25(28)
		L=600-1000m	28(30)
		L>1500m	30(35)
3	Secondary road	L<200m	12(16)
		L=200-400m	16(20)
		L=400-600m	20(22)
		L=600-1000m	22(25)
		L=1000-1500m	25(28)
		L>1500m	28(30)
4	Minor road	L<400m	8
		L=400-600m	12(16)
		L=600-1000m	16(20)
		L=1000-1500m	20(22)
		L>1500m	22(25)
		B<=3m, L<500m	8
		B<=3m, L=500-1000m	12
		B<=3m, L>1000m	15
5	Link road	L<500m	8
		L=500-1000m	12
		L>=1000m	15
6	Lane		5
7	Internal		12

Note: Number in bracket is applied for Oneway road

Table 4.6: Speed table of road network

After calibration the road network is valid and ready for analyse in the next step.

4.3.3. Calculate road capacity in normal condition

The following part is summarizing from chapter IV, Urban Road Design by Nguyen Khai, published by Transport Publisher in 1999(Nguyen Khai 1999).

4.3.3.1. Definition of road capacity:

Road capacity in normal condition is the maximum number of vehicle that can run through a road section in a certain unit of time. It is also considered as road capacity at a certain expected speed of traffic flow running on the road. If the actual traffic volume on the road is over the road capacity, the running speed of the vehicle will be lower than the expected speed. The unit usually used is passenger car unit per hour (pcu/h).

Therefore, by comparison between road capacity and the actual volume of vehicle running on road we can evaluate congestion level of the roads.

Road capacity of a road depends on the number of lane, average speed, travel length between two cross sections and type of intersection.

4.3.3.2. Capacity of one lane:

In perfect condition, the capacity of one lane is calculated as follows:

$$N = \frac{1000V}{\frac{V}{3.6}*t + \frac{V^2*K}{254(\varphi+i)} + L + Lo} \quad (1)$$

With:

N: Road capacity (pcu/h/lane)

V: Average speed (Km/h)

L: Car's length (L=5m for passenger car)

Lo: Safety distance between 2 cars. (Lo=3-5m.)

i: Longitudinal inclination of the road.

t: Safety time for action of driver. (t=1-1.2 seconds)

φ: Friction coefficient between car tire and road surface (φ=0.2-1, depends on the condition of road surface).

4.3.3.3. Some factors affect to road capacity

a. Influence of number of lane to road capacity:

The capacity of each lane is not the same, even in the same running direction. The lane near the centre line of the road has higher capacity than outside lanes. According to observation, the capacity of lanes is as follows:

Lane position (count from road center line)	Capacity coefficient (γn)
1	1
2	0.85
3	0.7
4	0.5
5	0.4

Number of lane in the same running direction	Average capacity coefficient (γ)
1	1
2	0.92
3	0.85
4	0.76
5	0.69

Table 4.7: Lane coefficient

The capacity of lane n will be calculated as follows: Nn=N1* γn
N1: Capacity of lane number 1.
γn: Capacity coefficient of the lane n.

Therefore, the capacity of the road depend on the number of the lane in the same direction

b. Influence of intersections at the same level

Intersection at the same level has great influence to the capacity of the road, especially at intersection with traffic lights. The average speed of vehicle is reduced depending on the distance between two intersections. As observation, the average speed of traffic flow is recommended in the table below:

Distance between two intersections (m)	Maximum speed Vmax(km/h)	Average speed of traffic flow Vavg (km/h)
200	35-40	14-16
400	45-50	18-20
600	65-70	26-28
800	80-85	32-40
1000	95-100	38-40

Table 4.8: Average speed of traffic flow

This suggestion is also fit with the survey by research scholar during fieldwork. For example, Truong Chinh Street has average distance between interruption is 200m and the survey speed is around 16km/h (4.65 m/s * 3,600 s=16.74km/h) as depicted in the figure 4.9.

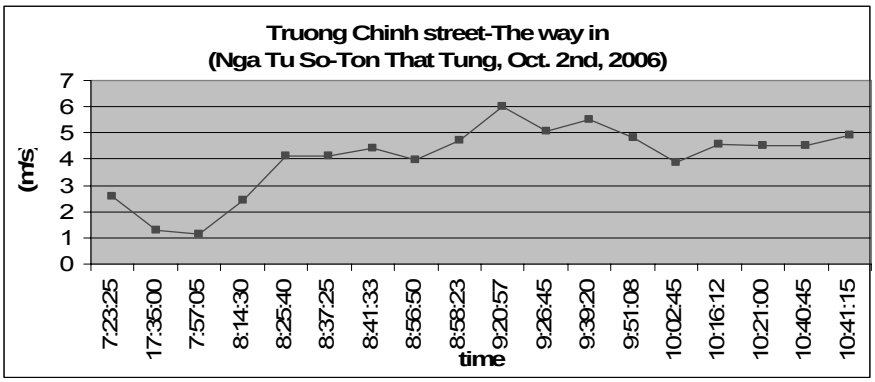


Figure 4.10: Travel speed on corridors

Due to the same level intersection, vehicle must stop at intersection waiting and the travel time between two section increases. Therefore, road capacity is reduced with coefficient α.

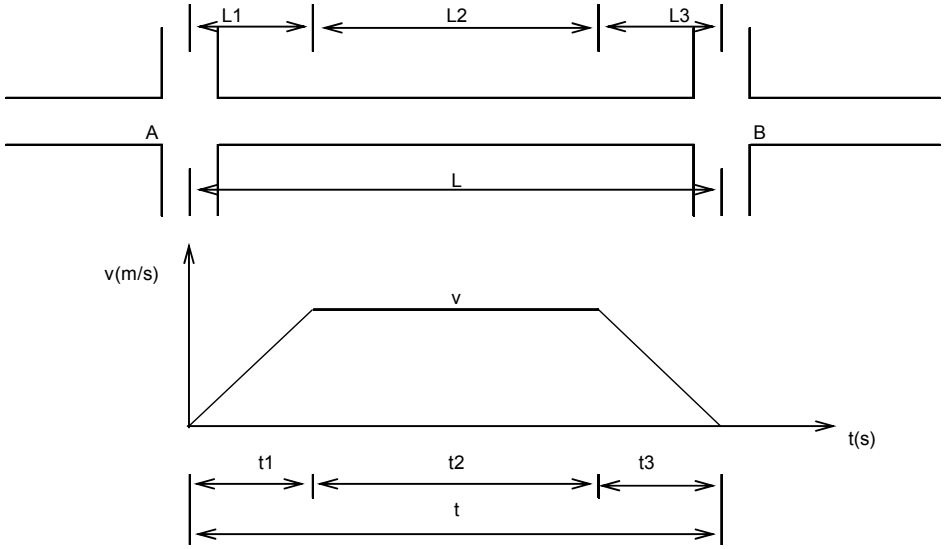


Figure 4.11: Chart for calculation of coefficient α

Coefficient α is calculated as follows:

$$\alpha = \frac{tAB}{t1+t2+t3+\Delta} = \frac{\frac{l}{v}}{\frac{v}{a} + \frac{l2}{v} + \frac{v}{b} + \Delta} \quad (2)$$

In which:
v: average speed (m/s)
l: Distance between two intersections (m)
a: Average acceleration of vehicle when starting (m/s2) (a=0.60-0.67m/s2 for passenger car)
b: Average acceleration of vehicle when stopping (m/s2)(b=1.66 m/s2for passenger car)
Δ: Average stopping time for street light (s) (Δ=15-20s)

From this formula, we can see that if the α1 smaller if the distance between two intersections small and the speed high.

c. Influence of the lane width (K1).

If the lane width (b) is smaller than 3.5 the average speed will be reduced. Therefore, the road capacity will be reduced also. The factor K1 is determined as recommended in the table below:

Lane width (m)	K 1
3.50	1.00
3.25	0.94
3.00	0.85
2.75	0.77

Table 4.9: Coefficient of lane width

d. Influence of pedestrian across the road (K2)

K2=0.63 if the number of pedestrian is over 500 persons/h, otherwise K2=1. This coefficient K2 is not applied in this research.

e. Other factors (K3)

There are some more factors that can have influence to road capacity like railway crossing, mode share and driver behaviour, etc. This factor should be collected on the field. The coefficient K3 is not applied in this research.

4.3.3.4. Road capacity

From theory discussed above, we can calculate the capacity for one running direction of a road as follows:

$$No = N * (\alpha * \gamma * K1 * K2 * K3) \quad (3)$$

Or

$$N_0 = N*(\gamma*\alpha*K1*K2*K3) = \frac{1000V}{\frac{V}{3.6}*t + \frac{V^2*K}{254(\varphi+i)} + L + Lo} *(\gamma*\alpha*K1*K2*K3) \quad (4)$$

According to Road Design Specification 20TCN-104-83, the road capacity of one lane can be referred in the table below:

Average capacity of one lane (pcu)

Converted vehicle	Grade-separated intersection (pcu)		Intersection with the same level (pcu)
	Highway	Main road	
Passenger car	1200-1500	1000-1200	600-700
Truck	600-800	500-600	300-400
Bus	200-300	150-250	100-150
Tram		110-130	70-90

Table 4.10: Suggestion of road capacity of one lane

In Hanoi case, most of roads intersect with each other at the same level therefore the average capacity of one lane is about 600-700 pcu/h.

In this research, all main corridors and congested roads are selected for capacity calculation. The result is listed in the table below:

Capacity of some main roads and corridors

No.	Road name	Corridor code	Road width(m)	Oneway	Road type	Number of lane	Average length (m)	Average speed (km/h)	Average speed (m/s)	Lane width (m)	K1	α	Σγn	γ	Road capacity (pcu/h)
1	Chua Boc street	No. 1-Cboc	13.5	FALSE	Secondary	2	386.68	20	5.56	3.5	1	0.72942	1.85	0.925	1,595
2	Pham Ngoc Thach street	No. 2-PNThach	14	FALSE	Secondary	2	247	16	4.44	3.5	1	0.69269	1.85	0.925	1,388
3	Ton That Tung street	No. 3-TTTung	8	FALSE	Secondary	1	219.74	16	4.44	3.5	1	0.66725	1	1	723
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	11	FALSE	Secondary	2	191.46	16	4.44	2.75	0.77	0.636	1.85	0.925	981
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	12	FALSE	Secondary	2	222.79	16	4.44	3	0.85	0.67031	1.85	0.925	1,142
6	Kham Thien	No. 5-KThien	11	FALSE	Secondary	2	238	16	4.44	2.75	0.77	0.68473	1.85	0.925	1,056
7	Nguyen Thai Hoc	No. 6-NTHoc	12	TRUE	Secondary	4	208.16	18	5.00	3	0.85	0.62259	3.05	0.7625	1,836
8	Cau Giay	No. 7-CG	21	FALSE	Main	3	249	25	6.94	3	0.85	0.56797	2.55	0.85	1,551
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	14	FALSE	Main	2	734	28	7.78	3.5	1	0.77026	1.85	0.925	1,835
10	Le Thanh Nghi street	No. 9-LTNghi	17	FALSE	Minor	2	243	16	4.44	3.5	1	0.68921	1.85	0.925	1,381
11	Giai Phong(DCV-LTN)	No. 10-Gphong	37	FALSE	Main	4	307.918	25	6.94	3.5	1	0.61915	3.05	0.7625	2,379
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	37	FALSE	Main	4	235.25	25	6.94	3.5	1	0.55398	3.05	0.7625	2,128
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	37	FALSE	Main	4	206.25	20	5.56	3.5	1	0.58981	3.05	0.7625	2,127
14	Pho Hue street	No. 11-Phue	14	TRUE	Secondary	4	152	18	5.00	3.5	1	0.5464	3.05	0.7625	1,896
15	Ba Trieu street	No. 12-BT	8	TRUE	Secondary	2	196	18	5.00	3.5	1	0.60834	1.85	0.925	1,280
16	Nguyen Luong Bang	No. 13-N.L.Bang	16	FALSE	Secondary	2	404.4	20	5.56	3.5	1	0.73817	1.85	0.925	1,615
17	Thai Ha	No. 14-ThaiHa	14	FALSE	Secondary	2	430	20	5.56	3.5	1	0.74986	1.85	0.925	1,640
18	Kim Ma	No. 15-KimMa	21	FALSE	Secondary	3	275.65	18	5.00	3	0.85	0.68597	2.55	0.85	1,691
19	Nguyen Trai street	No. 16-Ntrai	30	FALSE	Main	3	290	25	6.94	3.5	1	0.60492	2.55	0.85	1,943
20	Duong Lang 1(Cgiay-N.C.Thanh)	No. 17-Dlang	11	FALSE	Secondary	2	321.15	18	5.00	2.75	0.77	0.71792	1.85	0.925	1,163
21	Duong Lang 2(N.C.Thanh-L.Ha)	No. 17b-Dlang	11	FALSE	Secondary	2	410.68	18	5.00	2.75	0.77	0.76496	1.85	0.925	1,240
22	Duong Lang 3(L.Ha-N.T.So)	No. 17c-Dlang	11	FALSE	Secondary	2	241.83	16	4.44	2.75	0.77	0.68817	1.85	0.925	1,062
23	La Thanh 1(Voiphuc-N.C.Thanh)	No. 18-LaThanh	9	FALSE	Minor	1	189.31	14	3.89	3.5	1	0.66911	1	1	680
24	La Thanh 2(N.C.Thanh-L.Ha)	No.18b-LaThanh	9	FALSE	Minor	1	156.53	12	3.33	3.5	1	0.66655	1	1	624
25	La Thanh 3(L.Ha-T.D.Thang)	No.18c-LaThanh	9	FALSE	Minor	1	234.16	14	3.89	3.5	1	0.71438	1	1	726
26	Duong Buoi	No. 19-D.Buoi	7	FALSE	Minor	1	337.04	14	3.89	3.5	1	0.78261	1	1	796
27	Cat Linh	No. 20-CatLinh	16	FALSE	Secondary	2	247.41	16	4.44	3.5	1	0.69305	1.85	0.925	1,389
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	21	FALSE	Secondary	3	304.59	20	5.56	3.5	1	0.67984	2.55	0.85	2,050
29	Nguyen Chi Thanh(HTKhang-LaThan	No.21b-N.C.Thanh	21	FALSE	Secondary	3	328	20	5.56	3.5	1	0.69574	2.55	0.85	2,098
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	21	FALSE	Secondary	3	237.72	16	4.44	3	0.85	0.68448	2.55	0.85	1,607
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	21	FALSE	Secondary	3	453.45	20	5.56	3	0.85	0.75969	2.55	0.85	1,947
32	Tran Duy Hung	No. 23-T.D.Hung	30	FALSE	Main	4	406	26	7.22	3.5	1	0.67098	3.05	0.7625	2,600
33	Giang Vo(Lang Ha-Ngoc Khanh)	No. 24-G.Vo	30	FALSE	Secondary	3	195	14	3.89	3.5	1	0.67563	2.55	0.85	1,752
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	30	FALSE	Secondary	3	327.48	18	5.00	3.5	1	0.72185	2.55	0.85	2,094
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	19	FALSE	Secondary	3	178.08	16	4.44444	3	0.85	0.61906	2.55	0.85	1,453
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	29	FALSE	Secondary	4	799.178	40	11.1111	3.5	1	0.6945	3.05	0.7625	2,793

Note:

- For road capacity calculationy, all transport modes are converted into tourist car (PCU).
- Average speed is refered from table 4-7 (Urban Road Design -Nguyen Khai,1999)
- If road type is Secondary and the road is oneway road, the low speed value of one upper level will be applied
- If road type is Main road, the upper value of one upper level is applied.

Table 4.11: Road Capacity of some corridors

The calculated road capacity will be used for evaluating congestion level by comparing with the current traffic volume and traffic volume in scenarios in the next chapters.

5. Contribution of some selected major land uses to congestion

5.1. Selected corridors

5.1.1. Corridor selection

To evaluate the contribution of some major land-uses to traffic congestion, the main corridors leading to these locations and congested roads have been selected and then divided into 36 segments. Based on traffic counts on selected corridors as provided by ALMEC Corporation and based on local knowledge of the research scholar, these segments have been divided into 2 groups: Group 1 are road segments which suffer severe congestion in current situation or are main corridors leading to the city centre. They are listed in the table 5.1 below.

Corridor group 1

No.	Road name	Corridor code	No.	Road name	Corridor code
1	Chua Boc street	No. 1-Cboc	12	Giai Phong(LTN-NTVong)	No. 10b-Gphong
2	Pham Ngoc Thach street	No. 2-PNThach	13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong
3	Ton That Tung street	No. 3-TTTung	14	Pho Hue street	No. 11-Phue
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	15	Ba Trieu street	No. 12-BT
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	16	Nguyen Luong Bang	No. 13-N.L.Bang
6	Kham Thien	No. 5-KThien	17	Thai Ha	No. 14-ThaiHa
7	Nguyen Thai Hoc	No. 6-NTHoc	18	Kim Ma	No. 15-KimMa
8	Cau Giay	No. 7-CG	19	Nguyen Trai street	No. 16-Ntrai
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh
10	Le Thanh Nghi street	No. 9-LTNghi	21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh
11	Giai Phong(DCV-LTN)	No. 10-Gphong	22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh

Table 5.1: List of corridor group 1

Group 2 are road segments which have congestion potential in the different scenarios (*). They are listed in the table 5.3 below.

Corridor group 2

No.	Road name	Corridor code	No.	Road name	Corridor code
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	32	Tran Duy Hung	No. 23-T.D.Hung
26	Duong Buoi	No. 19-D.Buoi	33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo
27	Cat Linh	No. 20-CatLinh	34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang
29	Nguyen Chi Thanh(HTKhang-LaThanh	No.21b-N.C.Thanh	36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet

Table 5.2: List of corridor group 2

(*) The different scenarios will be introduced in chapter 6.

Corridor group 1 are segments depicted in red colour, while corridor group 2 segments are in blue colour in figure 5.1 below.

Figure 5.1: Corridor group 1 and 2

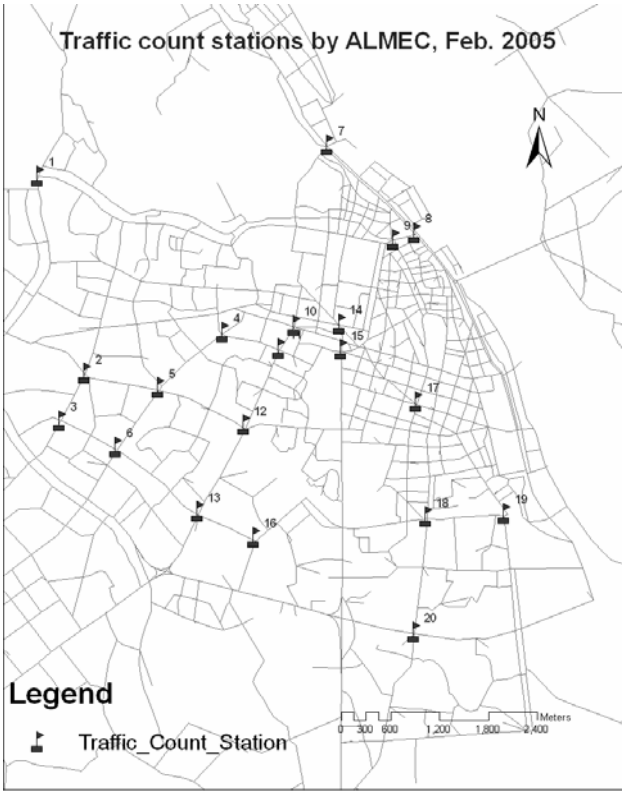


Figure 5.2: Traffic count station by the ALMEC

5.1.2. Peak hours

Traffic counts as done by ALMEC in February, 2005 reveal that the morning peak hour is generally from 7:00AM to 8:00AM and the afternoon peak hour is from 17:00PM to 18:00PM. In Appendix B, the counts are listed.

5.1.3. Calculate traffic volume on road segments in peak hours

The ALMEC study only provides traffic counts for some selected locations. Therefore, based on these counts, estimates have been made for traffic on the other segments, for this research considered important. This is done by applying a so-called Q-factor separately for each corridor group. Based on the traffic count by ALMEC, the Q-factor is calculated as follows:

Q-factor = ALMEC traffic count/Road capacity. (5)

After that we will calculate the means (μ) of the Q-factors separately for each corridor group and separately for morning peak as well as for afternoon peak. The means (μ) of the Q-factors is used to determine the traffic volume for all remaining **corridors, which do not have a traffic count**. The calculation is also done separately for morning and afternoon peaks, and for the way in and the way out of city centre.

The results of the calculation are shown in the table below:

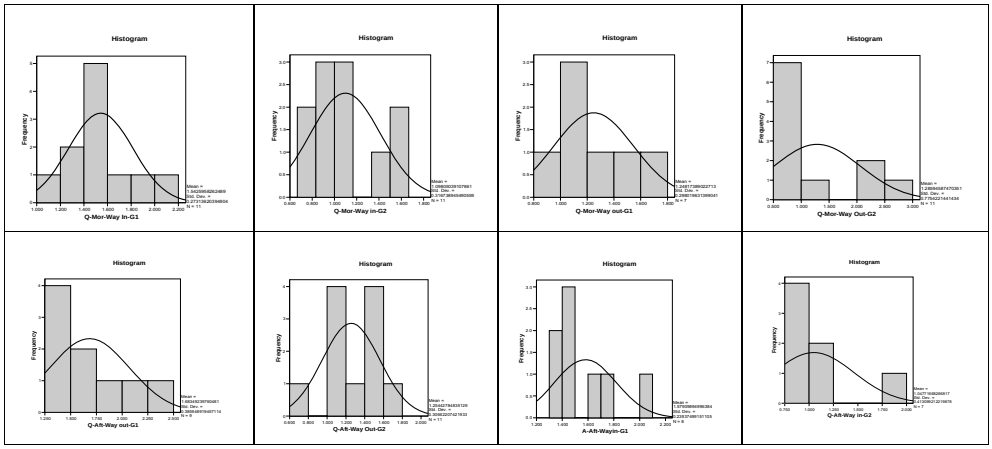


Figure 5.3: Histogram of Q-means

Peak Volume calculation - Morning

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Morning-Way in				Morning-Way out			
					Traffic count by ALMEC (pcu/h)	Q-factor	Mean of Q-factor	New Peak volume-Way In (pcu)	Traffic count by ALMEC (pcu/h)	Q-factor	Mean of Q-factor	New Peak volume-Way out (pcu)
1	Chua Boc street	No. 1-Cboc	1	1,595	2,552	1.59959		2,552	2,575	1.61401		2,575
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	2,204	1.58801		2,204	2,206	1.58945		2,206
3	Ton That Tung street	No. 3-TTTung	1	723	892	1.23432		892	841	1.16375		841
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	981				1,514				1,225
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,142				1,761				1,425
6	Kham Thien	No. 5-KThien	1	1,056	1,681	1.59124		1,681	929	0.87939		929
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	3,682	2.00545		3,682				
8	Cau Giay	No. 7-CG	1	1,551				2,393				1,935
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835				2,832				2,290
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381				2,131				1,723
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379				3,670				2,968
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128			1.543	3,284			1.248	2,656
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127				3,282				2,654
14	Pho Hue street	No. 11-Phue	1	1,896	3,608	1.90308		3,608				
15	Ba Trieu street	No. 12-BT	1	1,280					1,412	1.10284		1,412
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,559	1.58496		2,559	1,795	1.11177		1,795
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,703	1.03834		1,703	2,908	1.77305		2,908
18	Kim Ma	No. 15-KimMa	1	1,691				2,610				2,111
19	Nguyen Trai street	No. 16-Ntrai	1	1,943				2,998				2,425
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	680	943	1.38609		943	910	1.33758		910
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	624	890	1.42535		890	910	1.45738		910
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	726	1,171	1.61213		1,171	781	1.07521		781
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,163				1,277				1,496
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,240				1,361				1,594
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,062				1,166				1,365
26	Duong Buoi	No. 19-D.Buoi	2	796				874				1,023
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	0.74895		1,040	1,172	0.84401		1,172
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	1,770	0.86358		1,770	1,695	0.82699		1,695
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	1,906	0.90848		1,906	1,468	0.69971		1,468
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,132	0.7045	1.098	1,132	2,319	1.44322	1.286	2,319
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	2,085	1.071		2,085	1,331	0.68369		1,331
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600				2,854				3,343
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,923	1.0976		1,923	1,614	0.92123		1,614
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,923	0.91831		1,923	1,252	0.59788		1,252
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	1.39893		2,033	1,169	0.8044		1,169
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793				3,067				3,592

Table 5.3: Calculation of current traffic volume on corridors-Morning Peak

Peak Volume calculation-Afternoon

No.	Road name	Corridor code	Corridor group	Road capacity (pcu/h)	Afternoon-Way Out				Afternoon-Way In			
					Traffic count by ALMEC (pcu/h)	Q-factor	Mean of Q-factor	New Peak volume (pcu)	Traffic count by ALMEC (pcu/h)	Q-factor	Mean of Q-factor	New Peak volume (pcu)
1	Chua Boc street	No. 1-Cboc	1	1,595	4,128	2.58743		4,128	2,813	1.76319		2,813
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	3,294	2.37337		3,294	1,968	1.41797		1,968
3	Ton That Tung street	No. 3-TTTung	1	723	1,708	2.36347		1,708	780	1.07934		780
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	981				1,652				1,549
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,142				1,922				1,803
6	Kham Thien	No. 5-KThien	1	1,056	1,362	1.28927		1,362	1,521	1.43978		1,521
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,805					3,699	2.04987		3,699
8	Cau Giay	No. 7-CG	1	1,551				2,611				2,448
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835				3,090				2,898
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381				2,325				2,180
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379				4,005				3,756
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128			1.684	3,584			1.579	3,360
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127				3,582				3,358
14	Pho Hue street	No. 11-Phue	1	1,896					2,651	1.3983		2,651
15	Ba Trieu street	No. 12-BT	1	1,280	2,304	1.79953		2,304				
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,750	1.70326		2,750	2,206	1.36633		2,206
17	Thai Ha	No. 14-ThaiHa	1	1,640	4,080	2.48763		4,080	2,472	1.50721		2,472
18	Kim Ma	No. 15-KimMa	1	1,691				2,848				2,671
19	Nguyen Trai street	No. 16-Ntrai	1	1,943				3,272				3,068
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	680	690	1.38609		690	973	1.43019		973
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	624	891	1.42535		891	1,030	1.64956		1,030
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	726	959	1.61213		959	1,089	1.49924		1,089
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,163				1,459				1,219
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,240				1,555				1,299
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,062				1,332				1,113
26	Duong Buoi	No. 19-D.Buoi	2	796				998				834
27	Cat Linh	No. 20-CatLinh	2	1,389	914	0.65821		914	2,664	1.91847		2,664
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	3,030	1.47833		3,030	1,588	0.77478		1,588
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	2,119	1.01001		2,119	1,830	0.87226		1,830
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,693	1.05363	1.2544	1,693	1,864	1.16006	1.048	1,864
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	2,195	1.1275		2,195	2,052	1.05405		2,052
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600				3,261				2,724
33	Giang Vo (Lang Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	2,619	1.49486		2,619				1,836
34	Giang Vo(Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	2,619	1.25067		2,619	1,572	0.75069		1,572
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,129	1.46499		2,129	1,168	0.80371		1,168
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793				3,504				2,927

Table 5.4: Calculation of current traffic volume on corridors-Afternoon peak

5.2. Congestion level

In order to evaluate the congestion in current situation and scenarios congestion levels are applied. Congestion level is proposed to measure by ratio of actual traffic volume and road capacity:

$$\text{Congestion level} = \frac{\text{Actual Traffic volume (pcu)}}{\text{Road capacity (pcu)}} \quad (6)$$

For calculation of road capacity, please refer to paragraph 4.3.4.

Nine grades of congestion are proposed for evaluation of congestion in the current situation and scenarios, which will be constructed later.

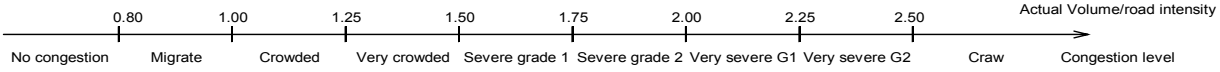


Figure 5.4: Congestion level

From the traffic counts by ALMEC, the maximum of traffic volume and road capacity ratio is 2.587 on the way out at Chua Boc Street in the afternoon. The grade is proposed based on the local knowledge of the research scholar, for example in Chua Boc, Thai Ha streets in the afternoon it hardly moves because the roads are almost full of vehicles, while in the morning it is somehow better and by comparison it is between some of the most severe congested roads and other roads in Hanoi.

Based on this definition, the congestion level of the current situation is calculated as in the table below. The calculation is separated for the way in, the way out of the city centre; and separated for the morning and afternoon peaks as well as for corridor groups 1 and 2.

Congestion level of corridors-Current situation

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Morning				Afternoon			
					Way In		Way Out		Way In		Way Out	
					New Peak volume-Way In (pcu)	Congestion level	New Peak volume-Way Out (pcu)	Congestion level	New Peak volume-Way In (pcu)	Congestion level	New Peak volume-Way Out (pcu)	Congestion level
1	Chua Boc street	No. 1-Cboc	1	1,595	2,552	Severe G1	2,575	Severe G1	2,813	Severe G2	4,128	Craw
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	2,204	Severe G1	2,206	Severe G1	1,968	Very crowded	3,294	Very severe G2
3	Ton That Tung street	No. 3-TTTung	1	723	892	Crowded	841	Crowded	780	Crowded	1,708	Very severe G2
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	981	1,514	Severe G1	1,225	Crowded	1,549	Severe G1	1,652	Severe G1
5	Truong Chinh 2(T.T.Tung-N.T.Vong	No.4b-Tchinh	1	1,142	1,761	Severe G1	1,425	Crowded	1,803	Severe G1	1,922	Severe G1
6	Kham Thien	No. 5-KThien	1	1,056	1,681	Severe G1	929	Migrate	1,521	Very crowded	1,362	Very crowded
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	3,682	Very severe G1			3,699	Very severe G1		
8	Cau Giay	No. 7-CG	1	1,551	2,392	Severe G1	1,935	Crowded	2,449	Severe G1	2,610	Severe G1
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835	2,831	Severe G1	2,290	Crowded	2,898	Severe G1	3,089	Severe G1
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381	2,130	Severe G1	1,724	Crowded	2,181	Severe G1	2,325	Severe G1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379	3,669	Severe G1	2,969	Crowded	3,756	Severe G1	4,004	Severe G1
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128	3,283	Severe G1	2,656	Crowded	3,361	Severe G1	3,583	Severe G1
13	Giai Phong(Pho Vong-Bxe GiapBat	No. 10c-Gphong	1	2,127	3,281	Severe G1	2,654	Crowded	3,358	Severe G1	3,580	Severe G1
14	Pho Hue street	No. 11-Phue	1	1,896	3,608	Severe G2			2,651	Very crowded		
15	Ba Trieu street	No. 12-BT	1	1,280			1,412	Crowded			2,304	Severe G2
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,559	Severe G1	1,795	Crowded	2,206	Very crowded	2,750	Severe G1
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,703	Crowded	2,908	Severe G2	2,472	Severe G1	4,080	Very severe G2
18	Kim Ma	No. 15-KimMa	1	1,691	2,609	Severe G1	2,111	Crowded	2,671	Severe G1	2,848	Severe G1
19	Nguyen Trai street	No. 16-Ntrai	1	1,943	2,997	Severe G1	2,425	Crowded	3,068	Severe G1	3,271	Severe G1
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	680	943	Very crowded	910	Very crowded	973	Very crowded	690	Crowded
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	624	890	Very crowded	910	Very crowded	1,030	Severe G1	891	Very crowded
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	726	1,171	Severe G1	781	Crowded	1,089	Very crowded	959	Very crowded
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,163	1,277	Crowded	1,496	Very crowded	1,219	Crowded	1,459	Very crowded
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,240	1,361	Crowded	1,594	Very crowded	1,299	Crowded	1,555	Very crowded
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,062	1,166	Crowded	1,365	Very crowded	1,112	Crowded	1,332	Very crowded
26	Duong Buoi	No. 19-D.Buoi	2	796	874	Crowded	1,023	Very crowded	834	Crowded	998	Very crowded
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	No congestion	1,172	Migrate	2,664	Severe G2	914	No congestion
28	Nguyen Chi Thanh(Dlang-HTKhang	No.21-N.C.Thanh	2	2,050	1,770	Migrate	1,695	Migrate	1,588	No congestion	3,030	Very crowded
29	Nguyen Chi Thanh(HTKhang-LaTha	No.21b-N.C.Thanh	2	2,098	1,906	Migrate	1,468	No congestion	1,830	Migrate	2,119	Crowded
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,132	No congestion	2,319	Very crowded	1,864	Crowded	1,693	Crowded
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	2,085	Crowded	1,331	No congestion	2,052	Crowded	2,195	Crowded
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600	2,854	Crowded	3,343	Very crowded	2,724	Crowded	3,261	Very crowded
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,923	Crowded	1,614	Migrate	1,836	Crowded	2,619	Very crowded
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,923	Migrate	1,252	No congestion	1,572	No congestion	2,619	Very crowded
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	Very crowded	1,169	Migrate	1,168	Migrate	2,129	Very crowded
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793	3,067	Crowded	3,592	Very crowded	2,927	Crowded	3,504	Very crowded

Note: Nguyen Thai Hoc street, Ba Trieu street and Pho Hue street are one way streets.

Table 5.5: Congestion level-Current situation

In reality, Truong Chinh Street is as congested as Chua Boc Street, especially on the way-out in the afternoon, but we do not have traffic count at this corridor. Anyway, this calculated result can be acceptable and in future this calculation should be updated with new traffic count if we have.

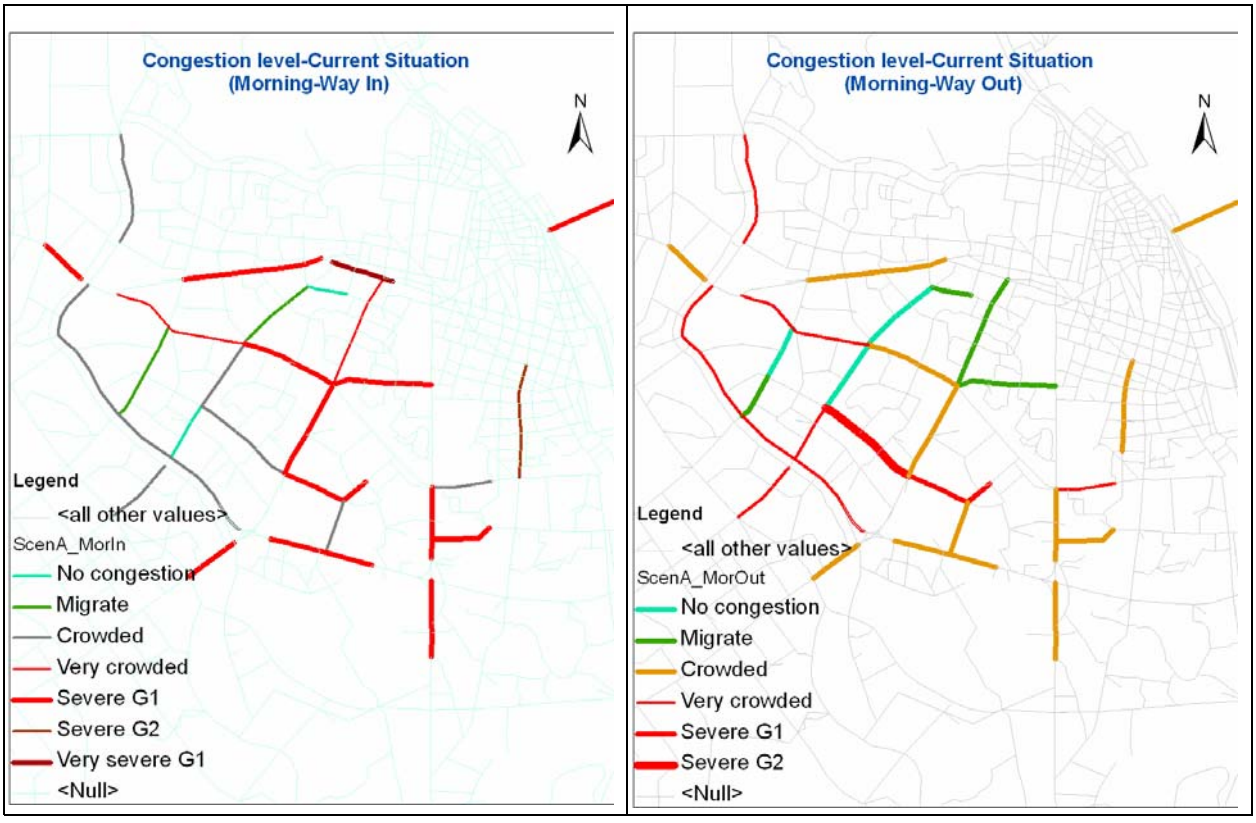
The result is summarized in the table 5.6 below. The number of segments and their congestion level for the different situations is indicated.

	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

Table 5.6: Summarize result of congestion level-Current situation

From this summary table 5.6, we can see clearly that the way-out in the afternoon is the most severely congested and in the morning the way-in is more severe than the way out.

The current situation is developed as shown below in figure 5.7. The different segments are coloured according to their congestion level.



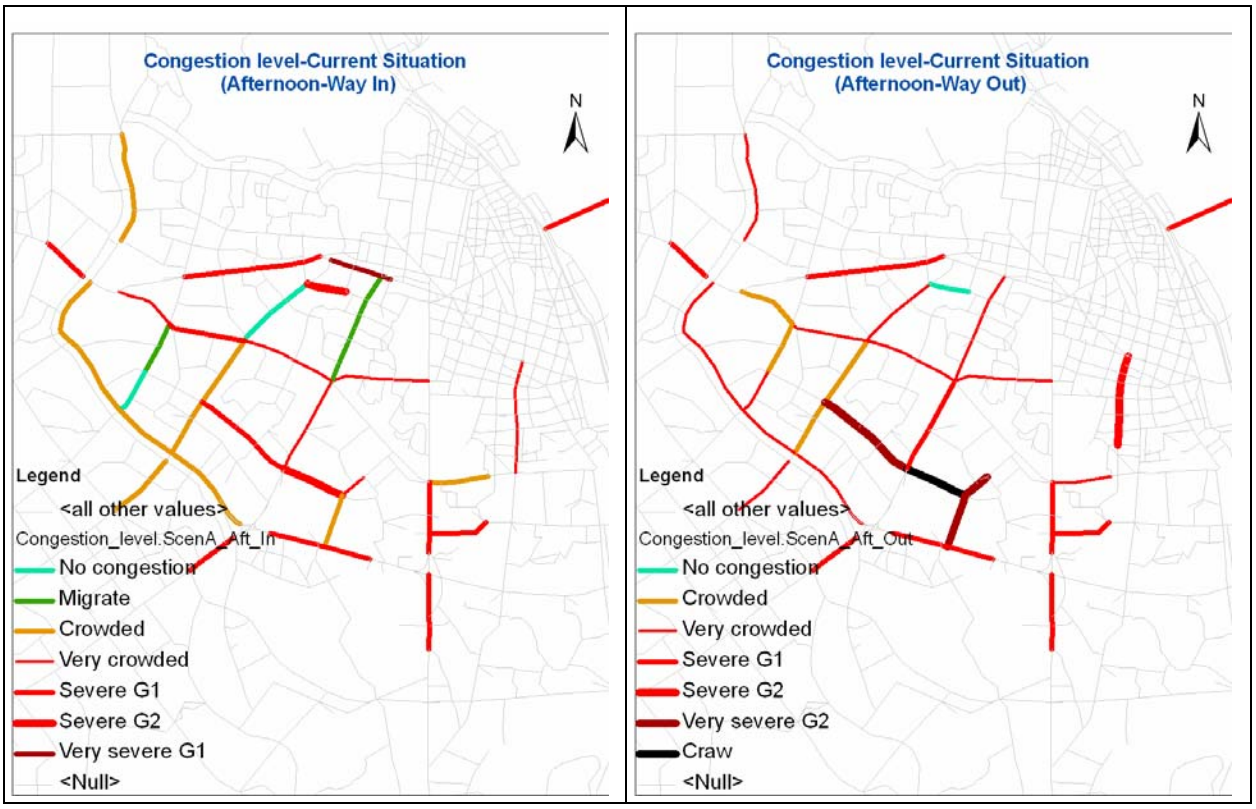


Figure 5.5: Congestion level-Current situation

5.3. Congestion mark

In our scenarios, the congestion situation might be reduced in one direction but might be increased in the reverse direction or it reduces on some corridors but increase on another corridors. How can we evaluate and know which scenario is better than the other?

This matter can be solved by introducing a marking system and introduce a weight for each congestion level as defined above. The idea is based on EIA (Environmental Impact Assessment) and MCE (Multi Criteria Evaluation) methods.

The marks and weights are usually given with the consensus between experts depend on the importance of the criteria. In this research, these values are given with the consensus between the research scholar and his advisors.

No.	Congestion level	Mark	weight
1	No congestion	10	1
2	Migrate	8	1
3	Crowded	2	1
4	Very crowded	-2	1
5	Severe grade 1	-3	2
6	Severe grade 2	-4	2
7	Very severe G1	-6	3
8	Very severe G2	-8	3
9	Craw	-10	3

The mark is given from -10 to +10. A weight is given from 1 to 3: (+)10 is given to "No congestion", (-)10 is given to "Craw". Weight is given with a notion that if one scenario produces one more severe grade 2 it should also produce one migrate or 4 crowded segments for compensation or in other words it is not preferred to see severe, very severe and caw cases.

Table 5.7: congestion mark and weight

Based on this idea, congestion mark of the current situation is calculated in the table below. A good congestion mark for a scenario is positive, otherwise negative.

Congestion Mark-Current situation

Regime	Congestion level	Mark	Weight	Morning Way In	Morning - Way Out	Afternoon-Way In	Afternoon-Way Out	Sum	**Total Mark**
Flow Regime	No congestion	10	1	2	3	2	1	8	**80**
	Migrate	8	1	3	5	2	0	10	**80**
	Crowded	2	1	10	14	10	4	38	**76**
No Flow Regime	Very crowded	-2	1	3	9	6	13	31	**-62**
	Severe G1	-3	2	15	2	12	11	40	**-240**
	Severe G2	-4	2	1	1	2	1	5	**-40**
	Very severe G1	-6	3	1	0	1	0	2	**-36**
	Very severe G2	-8	3	0	0	0	3	3	**-72**
	Craw	-10	3	0	0	0	1	1	**-30**
Sum									**-244**

Table 5.8: Congestion mark-Current situation

In the current situation, the total congestion mark is -244. This situation will be compared with the congestion situation in the scenarios, which will be developed in the chapter 6.

5.4. Characteristics of the selected major land uses

5.4.1. General information

This section will give you a general idea about the locations that will be moved in the scenarios. Study area 1 is where 3 universities and 7 hospitals are located while study area 2 is in the urban core.

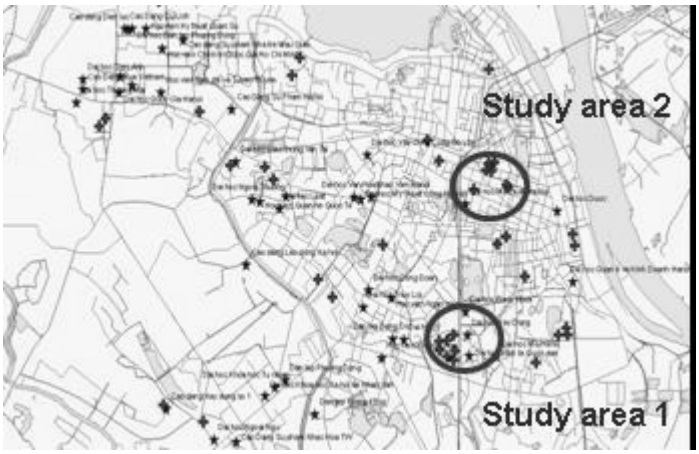


Figure 5.6: Study areas

5.4.2. Study area No. 1

Study area No. 1 includes 3 universities and 7 hospitals within Bach Mai hospital boundary.

Three universities:

Three universities are Polytechnics University, Construction University and Economics University (PCE Uni.). These universities were founded about 50 years ago. The total numbers of student study at base camp are almost 70,000 students among them Hanoi students are just account for 23.7%, the rest are coming from other provinces (called outside students).

No.	University name	No. of staff	Total number of students	No. of students study at Hanoi base	Reference
1	**Construction University**	832	23,060	23,060	Construction University's Bulletin No. 32, September, 2006
2	**Economics University**	1,950	30,000	30,000	Economics University-50 years of Construction and Development,2006.
3	**Polytechnics University**	1,130	27,996	18,700	Polytechnics University-50 years Keynote, 2006.

(Bulletin 2006; Eco_Keynote 2006; Keynote 2006)

Table 5.9: Summarize information of three universities

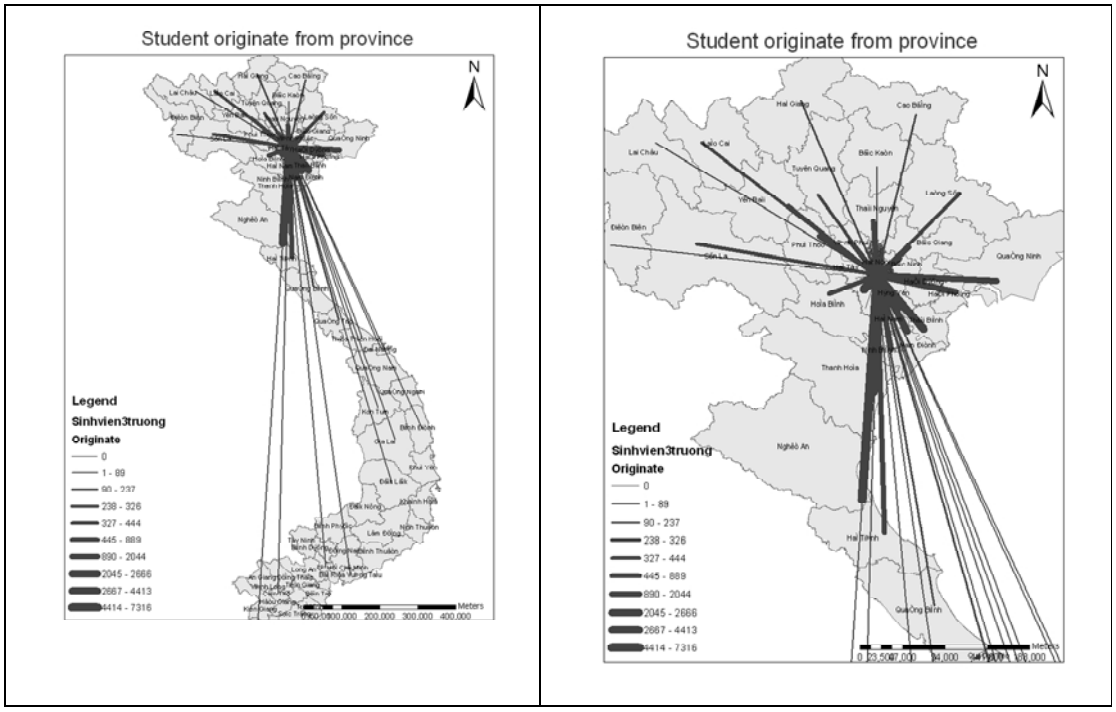


Figure 5.7: Origin of students.

The universities are the main destination not only for bachelor students but also for Msc., PhD. students as well as Second Degree and In-service students. Bachelor students account for about 50% of total students(Bulletin 2006; Eco_Keynote 2006; Keynote 2006).

No.	University name	Bachelor	Other courses	Total	Reference
1	Construction University	13,200	9,860	23,060	Construction University's Bulletin No. 32, September, 2006.
2	Economics University	13,732	12,281	26,013	Economics University-50 years of Construction and Development,2006.
3	Polytechnics University	15,800	14,280	30,080	Polytechnics University-50 years Keynote, 2006.

Table 5.10: Bachelor students compared with total students

One more important characteristic of these universities is that they have 3-shifts classes: Morning class, Afternoon class and Night class. Morning class starts very early in the morning, usually at 6:45AM. Therefore, only few students commute during morning peak hour. But in the afternoon, the afternoon classes finish around 17:00 to 17:15 PM and Night classes start at 18:00 PM. Therefore, in the afternoon peak hour universities attract and release quite a lot trips. Traffic count at cordons and questionnaire responses performed in this study reveal that only 5.5% of students commute during morning peak while 97.2% of students commute during afternoon peak hour. It also means that 97.2% of students contribute to congestion.

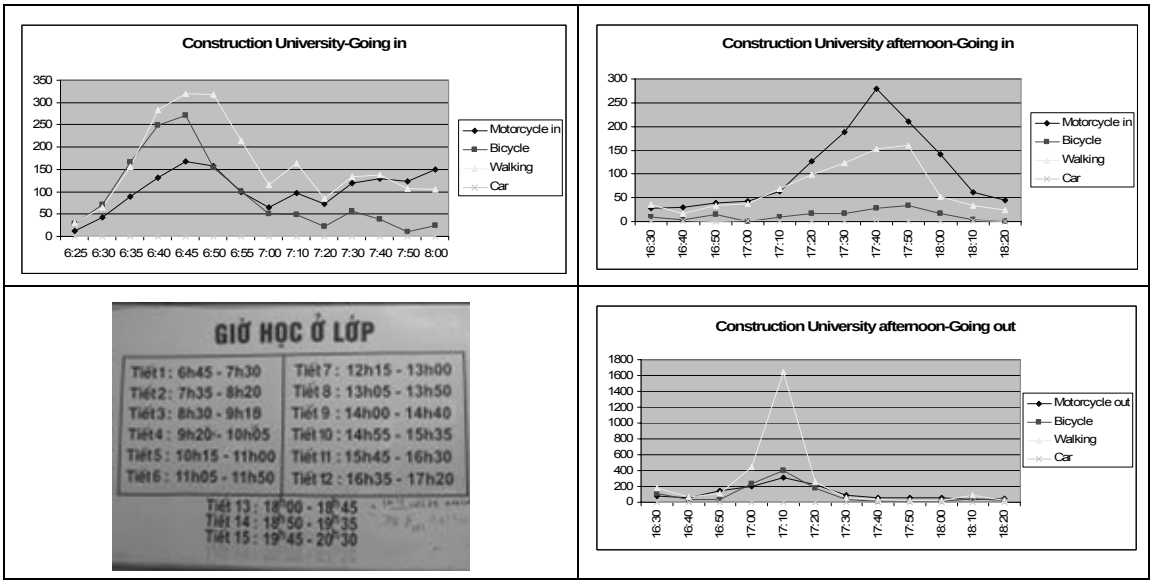


Figure 5.8: Traffic count at cordon of Construction University

Mode share: 39.4% of students commuting by bicycle or walk, 20.1% use Hanoi bus and only 37.5% uses a motorcycle.

In the future, these universities will develop and expand; the number of student will increase also. For example Polytechnics University is expected to increase the number of students up to 37,000 students by 2010, while the existing facilities are already overloaded. Therefore, in 2001 the minister of education proposed to build new university village with total area of 350 ha at Tay Mo commune for expansion as mentioned in the document 2236/KHTC dated March 23rd, 2001 to the prime minister which was approved by issuance 564/CP-KG dated June 22nd, 2001. The new locations are in Tay Mo village on the West direction as shown in the figure below(MOE 2005).

Figure 5.9: Location of university village

However, details of the expansion are not clearly mentioned in the document, as well as project report; for example there is no information on which department will be moved out, which student group will study at the new base, etc.

Bach Mai hospital and other hospitals within Bach Mai boundary:

Bach Mai hospital was founded in 1911. Bach Mai is one of the biggest hospitals at national level. It means that Bach Mai is the last destination for patient after the treatment at provincial level failed. Bach Mai is well-known with good quality and services. Recently, some departments have dispatched from Bach Mai hospital like National Institute of Hematology and Blood Transfusion, National Institute of Infection and Tropical Diseases and 4 other Institutes as depicted in the figure above. The Interview of Management Board reveals that most of them have the intention to relocate but they do not have clear idea where to go till now. 'It is far future" as they said, except National Institute of Hematology and Blood Transfusion already have land for a new base at Nhan Hoa-Trung Kinh-Hanoi. All of them are temporarily located within the same boundary at this moment.

No.	Hospital name	No. of patient bed	Staff			Patient			Relocation intention	New address	Type of relocation	Year of relocation
			Number of staff	No. of completed form	%	Average number of patient daily	No. of completed form	%				
1	**Bach Mai hospital consortium**	1700	2875	684	23.79	2651	637	24.03				
a	Bach Mai Hospital	1150	1925			1516 (33362/22 days)			Not yet	Waiting for permission		
b	National Institute of Infectuous and Tropical Diseases (Vien Lay)	120	200			80			Yes	Not clear now		
c	National Institute of Hematology and Blood Transfusion (Vien Huyet hoc)	200	300			35			Yes	Nhan Hoa-Trung Kinh-Hanoi	Move all	2010
d	National Institute of Dermato-Venereology (Vien Da lieu)	100	200			400-700			Yes	Not clear now		
e	Vietnam National Institute of Gerontology (Vien Lao khoa)	30	50			20			Yes	Not clear now		
f	Vietnam-French Hospital	100	200			300			No			

Table 5.11: General information of hospitals within Bach Mai hospitral boundary

All locations are suffering from overcrowding and overloading situation. One can see that hospitals are always full of people. Cordons traffic counts conducted in this area and pictures

below can give you some idea of how busy they are. Many people go in the hospitals during peak hour and up to 9:00AM almost 9,000 people going in hospitals in total.

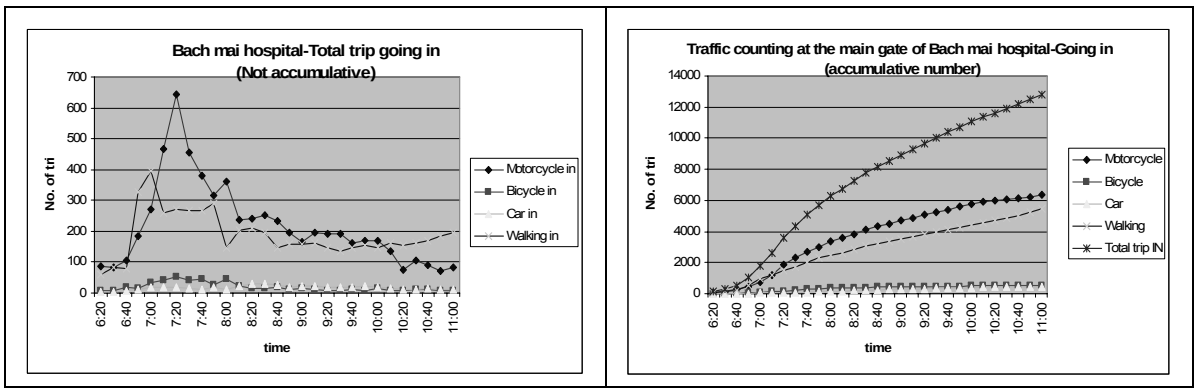


Figure 5.10: Traffic count at Bach Mai cordons

Figure 5.11: How busy they are-In Bach Mai hospital

Interview results show that Hanoi patients just account for only 33.6%, the rest are coming from almost half of the country, especially provinces around Hanoi like Vinh Phuc, Ha Tay, Ha Nam, Nam Dinh, Thai Binh provinces, etc. Only 51.3% of them use motorcycle, 28.6% going by intercity bus, 8.2% going by Hanoi bus, only 11.2% going by green modes.

Questionnaire responses also revealed that 87.3% (440 peak cases/504 responses) of Bach Mai staff commute during morning peak hour and 84.12% (482 peak cases/573 responses) in the afternoon peak. And among them 83% use motorcycle in the morning and 85% in the afternoon peak hour. Total number of people use green modes is less than 15%.

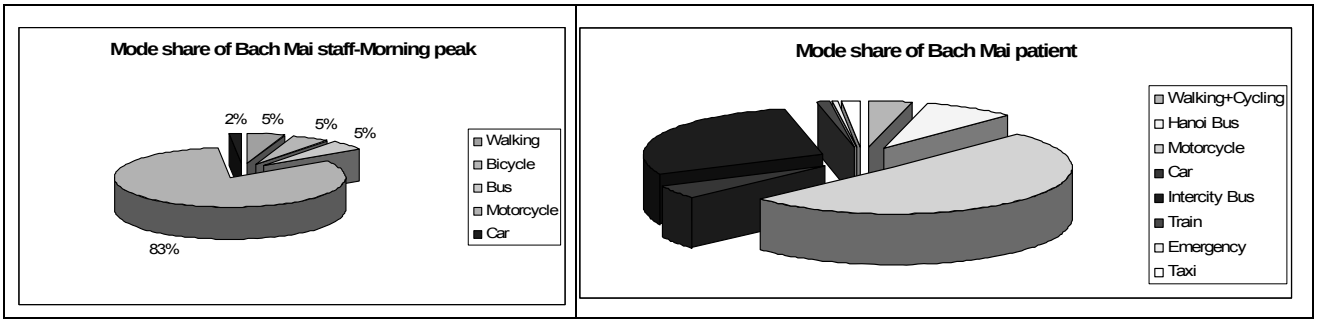


Figure 5.12: Mode share of Bach Mai staff and patient

Like teaching staff and students for the university locations, travel time by bus is almost double travel time by motorcycle and travel time back home in the afternoon is about 10 minutes longer than in the morning. It explains why people prefer motorcycle than bus and it also gives us an idea that congestion in the afternoon is more severe than in the morning.

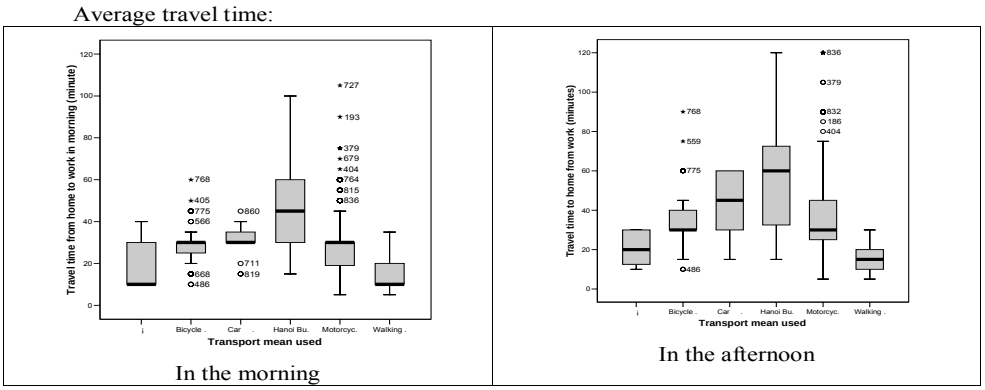


Figure 5.13: Travel time of Bach Mai hospital staff

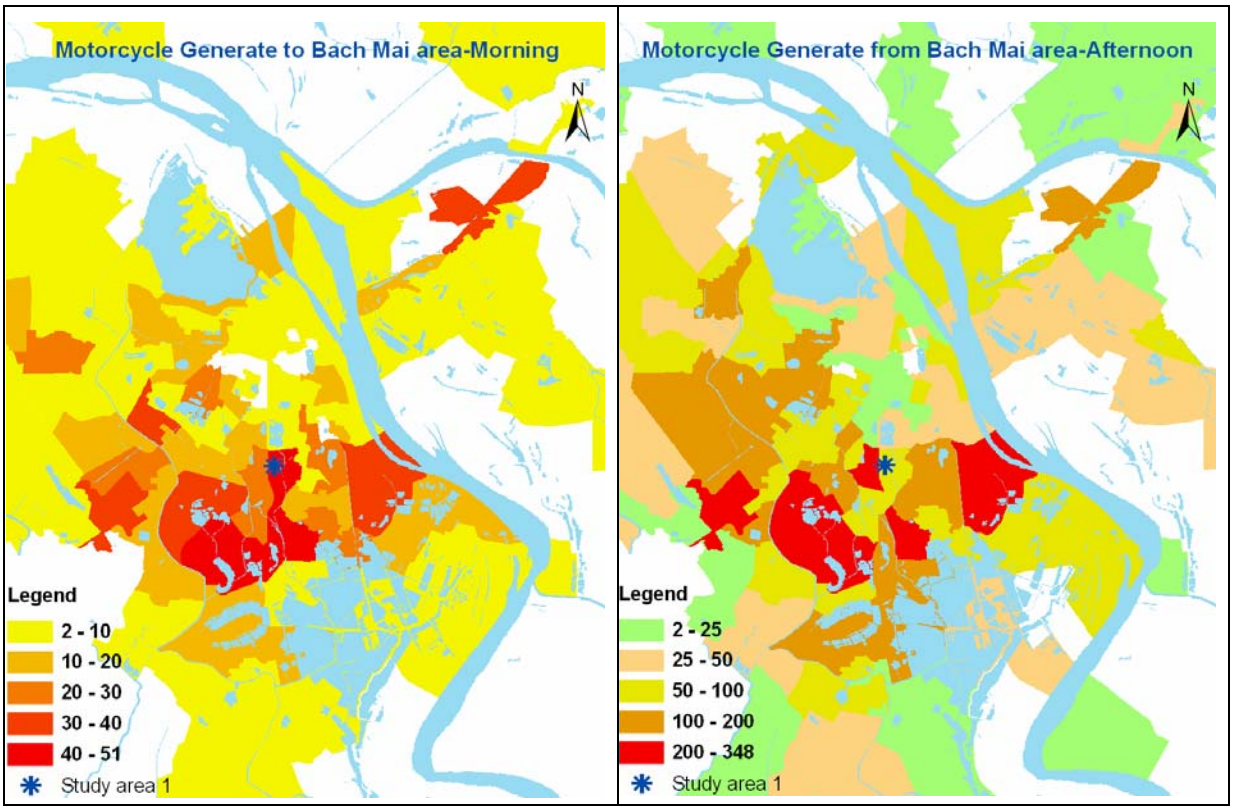


Figure 5.14: Motorcycle generation and return from study area No.1

The figures above indicate origin locations densities of staffs, patients and students, and thus give us an idea where people live. Most of them live in the South and the West of our study area.

5.4.3. Study area No. 2

Study area No. is in the Hoan Kiem district or urban core. Nowadays, urban core become a business centre and tourist centre.

Government offices:

According to the survey of economics enterprises, administration enterprises within Hanoi area by General Department of Statistics in July, 2002, Hoan Kiem district has 16,218 staffs working in administration offices at national level and 22,030 people working in business enterprises; Ba Dinh district has 93,331 staffs and 9840 people respectively(Statistics 2003). That is why Ba Dinh district is considered as administration district and Hoan Kiem district is considered as business centre.

Figure 5.15: Urban core

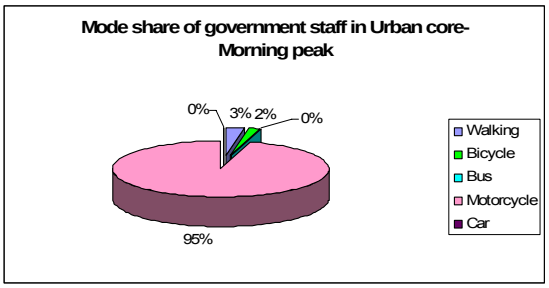


Figure 5.16: Mode share of government staff

Interview result reveals that 95% of government staff uses motorcycle and 95.5% of them commute during morning peak hour and 79.85% commute during afternoon peak hour. The number of staff that uses green modes is less than 5%.

Viet-Duc, K and C hospitals

Similar with Bach Mai hospital, these three hospitals are hospitals at national level and are the last destination for patient after the treatment at provincial level failed. Hanoi patients just account for 32.9% and 52.6% of them use motorcycle going to the hospital, 22.7% going by intercity bus and 10.2% uses green modes. Many of them lost 3-5 hours on average to go to hospitals.

According to the interview result, 72.33% of the hospital staff use motorcycle and 77.24% of them commute during morning peak hour and 74.44% commute during afternoon peak hour.

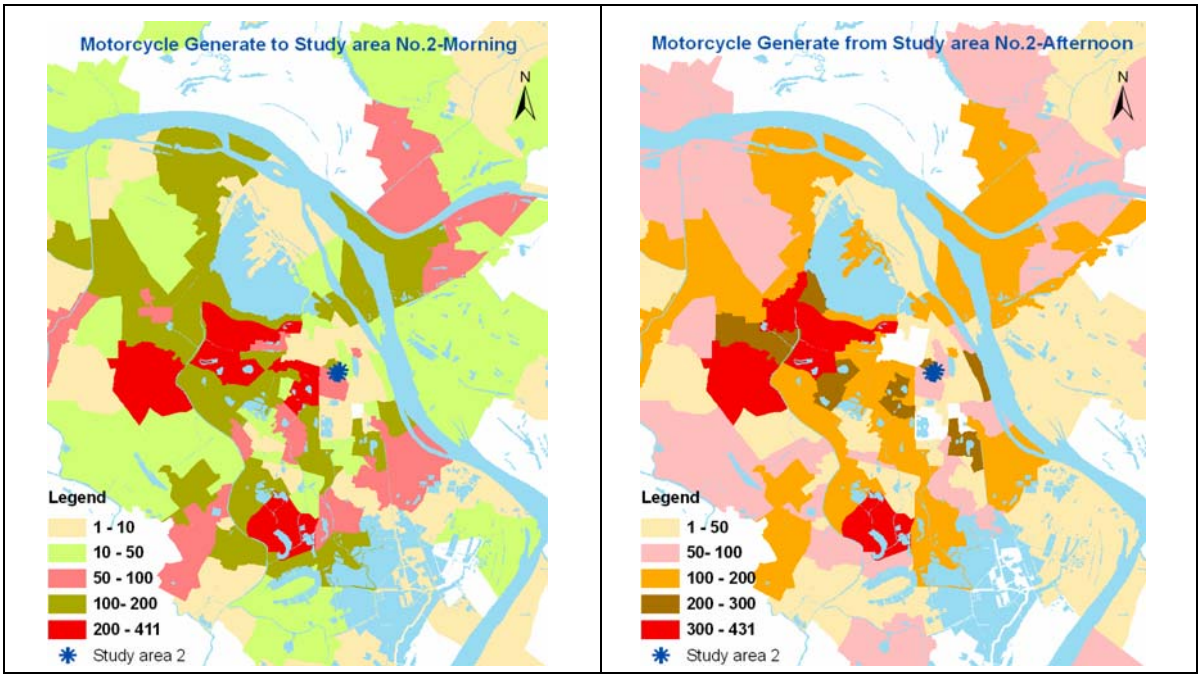


Figure 5.17: Motorcycle generate and return from urban core.

The figures show that most of people are living in the South and in the West of our study area.

5.5. Contribution to congestion of the selected land uses.

5.5.1. Methodology

To answer the research question "How much these land uses contribute to traffic congestion on the selected corridors?" we need to know how many pcu (passenger car unit) per ward are generated (in the morning) and attracted (in the afternoon); and which routes one use TO and RETURN from one commune to destinations in our study areas. The general methodology flowchart is as follows:

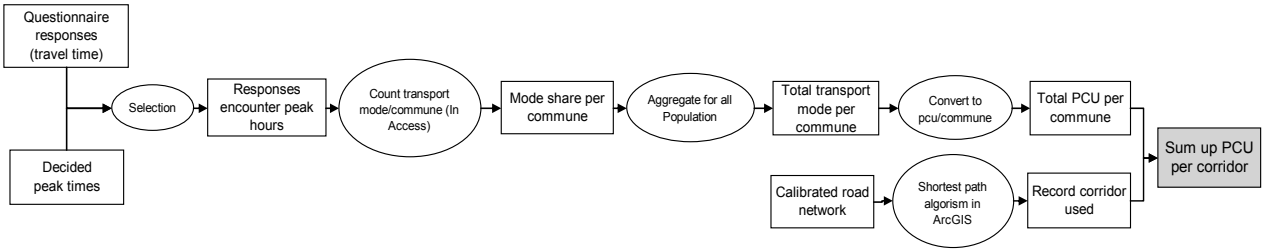


Figure 5.18: Congestion contribution flowchart

Firstly, we must select all records of people who commute during peak hours from the questionnaire responses. The selection is separately for morning peak and afternoon peak. The work is completed easily in spreadsheet.

The result is summarized in table 5.12 below:

No.	Organization name	Total Population	Morning peak encounter/Responses	Percentage (%)	Afternoon peak encounter/Responses	Percentage (%)
I	Study area No. 1					
1	Bach Mai staff	2875	440/504	87.3	482/573	84.12
2	Bach Mai patient	2651	234/531	44.07		
3	Polytechnics staff	1950	53/76	69.74	24/36	66.67
4	Polytechnics students	30,000	7/158	4.43	340/369	92.14
5	Construction staff	832	31/122	25.41	31/38	81.58
6	Construction student	23,000	25/537	4.66	613/619	99.03
7	Economics staff	1130	31/48	64.58	29/48	60.42
8	Economics student	18,700			436/577	75.56
II	Study area No. 2					
1	Government Office staff	16,218	128/134	95.52	191/196	97.45
2	Viet-Duc hospital staff	982	209/255	81.96	172/245	70.21
3	Viet-Duc hospital patient	400	57/137	41.61		
4	K hospital staff	557	186/217	85.71	174/217	80.18
5	K hospital patient	800	98/152	64.47		
6	C hospital staff	600	173/207	83.58	152/207	73.43
7	C hospital patient	250	53/108	49.07		

Table 5.12: Number of people commutes during peak hours

From the selected records as mentioned above, we need to know how many cars; motorcycles and bicycles are generated or attracted from one ward. This task is completed by applying grouping queries in the questionnaire database.

The number of all transport mean is recorded for each commune and sum up in table 5.13. After that these numbers are aggregated from the sample to the whole population with the assumption that the whole population have the same characteristics as the sampling population.

$$\text{Total number of vehicle in sample ward} = \frac{\text{Counted number of vehicle}}{\text{Total number of response}} * \text{Total number of whole population} \quad (7)$$

There is one note here is that universities have 3 shift classes as noted before, and that we assume that facilities (class rooms) are utilized fully. Therefore, one third of the student population will go to class in the morning, one third will go in the afternoon and remaining one third will attend night classes.

And then the aggregated number of car and motorcycles are converted into passenger car unit (PCU).

$$PCU = \text{Number of car} * 1.0 + \text{number of motorcycle} * 0.3 \quad (8)$$

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. A short table below is an example.

From commune	Bach Mai hospital staff (Afternoon peak)										PCU
	No. of respone among 482 cases (482/573)					Summarize for whole Bach Mai hospital staff (2875 staffs)					
	Walking	Bicycle	Bus	Motorcycle	Car	Walking	Bicycle	Bus	Motorcycle	Car	
Bach Dang				2					10		3
Bach Khoa	1	1		2		5	5		10		3
Bach Mai				2					10		3
Bat Trang				1					5		2

Table 5.13: Example of pcu calculation

The remaining task is to record the routes one used from one commune to the destination and return. This task is completed by applying a Shortest Path Algorithm in ArcGIS with some assumptions as follows:

- People go and return from a ward's centre directly.
- People use the route which has least cost trip measured in time unit (seconds).

This task is done separately for each organization since people might use different ways to go to organizations in the same study area even they start from the same origin point as depicted in the figure below.

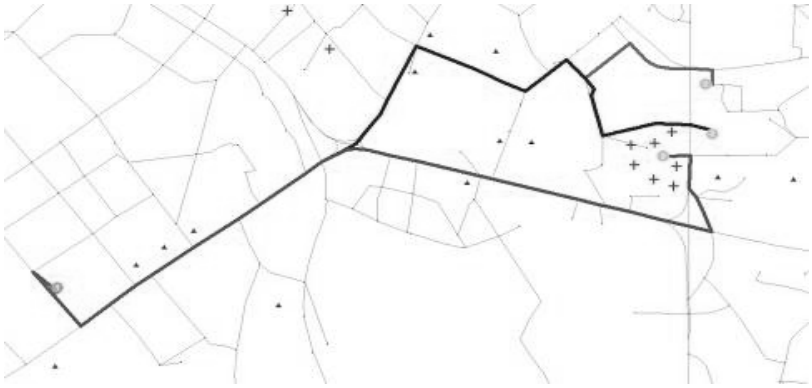


Figure 5.19: Different routes used to organizations in the same study area

Accordingly the corridors that are used are recorded in a route count table as depicted in table 5.14 below. This work is done by hand since the research scholar has not found a better way in ArcMap. It is time consuming work and could be done faster if it was programmed. As students in afternoon classes will return home and students in the night classes will come to universities for study, both the way in and the way out should be taken into consideration for universities in the afternoon.

No.	Commune name	Travel length bach home from Bach Mai hospital (m)	Corridor used to Bach Mai hospital (shortest path)										
			No. 1-Cboc	No. 2-PNThach	No. 3-TTTung	No. 4-Tchinh	No.4b-Tchinh	No. 5-KThien	No. 6-NTHoc	No. 7-CG	No. 8-CauCD	No. 9-LTNghi	No. 10-Gphong
1	Ba Vi-Hatay												
2	Bac Giang	60,000.0									1		1
3	Bac Hong	33,066.5									1		1
4	Bac Ninh										1		1
5	Bac Phu	47,494.0	1	1						1			
6	Bac Son	53,832.0	1	1						1			
7	Bach Dang	4,777.0											1
8	Bach Khoa	1,110.2										1	
9	Bach Mai	1,332.0										1	
10	Bat Trang	17,205.9									1		1

Table 5.14: Example of corridor count table

Next, total numbers of trip running on the selected corridors is calculated by multiplying aggregated PCUs with the corridor count and then sum up in a table for each study area separately the way in and the way out. The following tables are an example.

		Travel length bach home from Bach Mai area (m)	Corridor used to Bach Mai area (shortest path)				PCU				
			No. 1-Cboc	No. 2-PNThach	No. 25-T.D.Thang	No. 26-D.C.Viet		No. 1-Cboc	No. 2-PNThach	No. 3-TTTung	No. 4-Tchinh
16	Chuong Duong Do					1	4				
17	Chuong My-Hatay		1	1			2	2	2		
18	Co Bi					1	2				
19	Co Loa					1					
20	Co Nhue		1	1			2	2	2		
21	Cong Vi		1	1			6	6	6		
22	Cu Khoi					1					

Table 5.15: Example of aggregation of total trip on corridors (go to Bach Mai hospital).

Summarized trip to study area No. 1-Morning-Way In

	No. 1-Cboc	No. 2-PNThach	No. 3-TTTung	No. 4-Tchinh	No.4b-Tchinh	No. 5-KThien	No. 6-NTHoc	No. 7-CG	No. 8-CauCD	No. 9-LTNghi	No. 10-Gphong
Bach Mai staff	234	247	0	11	29	55	25	29	51	19	230
Bach Mai Patient	118	120	0	0	3	0	7	47	90	3	125
Poly staff	94	94	0	17	34	9	26	34	17	17	128
Poly student	63	63	0	0	0	0	0	63	0	0	0
Const. staff	14	14	0	2	14	0	7	0	2	20	9
Const. Student	19	19	0	0	5	0	0	5	5	0	24
Economics staff	47	47	0	0	0	0	8	8	16	16	71

Table 5.16: Example of sum up total trip table to study area no.1 –Morning-way in

Finally, a summarize table is made for both study area no.1 and no.2 to calculate the contribution of our study areas to congestion by comparing with current traffic volume calculated before (For detailed, please see Appendix C)

5.5.2. Contribution to congestion of the selected land uses

The summarize table below has shown that the selected land uses have considerable contribution to congestion on the selected corridors for example: at Chua Boc and Pham Ngoc Thach streets in the morning, study area no.1 contributes just about 23% and 32% respectively on the way in but in the afternoon they contribute 55% and 81% in the same direction and contributes 43% and 56% on the way out; at Kham Thien street in the morning, study area no.2 contribute 69% on the way-in and 73% in the afternoon in the reverse direction and in total both study areas contribute 73% in the morning and 93% in the afternoon.

Contribution to Congestion of the selected study areas

No.	Road name	Corridor code	Morning						Afternoon					
			Way In			Way Out			Way In			Way Out		
			Study area 1 (%)	Study area 2 (%)	Total (%)	Study area 1 (%)	Study area 2 (%)	Total (%)	Study area 1 (%)	Study area 2 (%)	Total (%)	Study area 1 (%)	Study area 2 (%)	Total (%)
1	Chua Boc street	No. 1-Cboc	23.1		23.1				54.7		**54.7**	43.7		**43.7**
2	Pham Ngoc Thach street	No. 2-PNThach	27.4	4.5	**32.0**				81.3		**81.3**	56.5		**56.5**
3	Ton That Tung street	No. 3-TTTung		1.2	1.2							9.2		9.2
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	2.0	23.4	25.4				7.7		7.7	33.5	0.9	**34.4**
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	4.8		4.8				11.7		11.7	28.6	0.8	29.4
6	Kham Thien	No. 5-KThien	3.8	68.7	**72.5**				13.9		13.9	20.4	72.8	**93.2**
7	Nguyen Thai Hoc	No. 6-NTHoc	1.9	42.5	**44.4**				4.3		4.3			
8	Cau Giay	No. 7-CG	7.7	12.8	20.5				9.8		9.8	14.0	11.8	25.8
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	6.4	9.1	15.5				12.9		12.9	14.8	14.0	28.8
10	Le Thanh Nghi street	No. 9-LTNghi	3.5		3.5				7.3		7.3	10.1		10.1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	16.0	25.7	**41.7**				40.1		**40.1**	38.6	19.1	**57.7**
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	19.1	23.3	**42.4**				37.3		**37.3**	44.2	20.1	**64.4**
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	10.4	22.0	**32.3**				21.5		21.5	35.9	18.2	**54.1**
14	Pho Hue street	No. 11-Phue		17.4	17.4					31.7	**31.7**			
15	Ba Trieu street	No. 12-BT				25.4		25.4					51.1	**51.1**
16	Nguyen Luong Bang	No. 13-N.L.Bang		17.1	17.1								20.0	20.0
17	Thai Ha	No. 14-ThaiHa	23.0		23.0				43.9		**43.9**	27.6		27.6
18	Kim Ma	No. 15-KimMa		26.2	26.2								37.8	**37.8**
19	Nguyen Trai street	No. 16-Ntrai	6.3	12.3	18.6				14.5		14.5	21.2	13.8	**35.0**
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	19.6		19.6				24.6		24.6	52.9		**52.9**
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh			0.0									
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh			0.0									
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang		9.8	9.8							21.2		21.2
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang			0.0									
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang			0.0							11.7		11.7
26	Duong Buoi	No. 19-D.Buoi	1.1	5.0	6.0				7.5		7.5	6.9	4.4	11.3
27	Cat Linh	No. 20-CatLinh			0.0									
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2.0	0.5	2.5				8.4		8.4	1.5	0.1	1.6
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	9.7		9.7				13.1		13.1	17.2	0.2	17.4
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa		0.3	0.3								2.9	2.9
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	1.2	8.5	9.8				3.9		3.9	11.3	11.9	23.1
32	Tran Duy Hung	No. 23-T.D.Hung	1.2	1.9	3.1				4.9		4.9	1.4	0.1	1.5
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo		9.2	9.2							6.6	10.0	16.6
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo		9.2	9.2							6.6	10.0	16.6
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang			0.0									
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	11.7		11.7				25.1		25.1	24.0	18.6	**42.6**

Note: The number in the table is the percentage compared with the current traffic volume on the selected corridors

Table 5.17: Contribution to congestion of the selected land uses.

5.6. Conclusions

To figure out the contribution to congestion, 36 road segments of all main corridors and congested roads are selected to evaluate the contribution of people from two study areas. The study area no. 1 is Bach Mai area where 3 big universities with almost 70,000 students and a group of 7 hospitals are located. The research reveals that this area 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 in the way-in and 43.7%, 56.5% and 27.6% respectively in the way-out; The study area no.2 is in the urban core where 161 government offices with 16218 staffs at national level and 3 hospitals are located. The survey reveals that 95% of government staffs use motorcycle and 95.5% of them commute during peak hours. That is why some main corridors like Kham Thien, Nguyen Thai Hoc, and Kim Ma streets are always under high congestion pressure. The contribution of study area no. 2 to these corridors are 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).

Nine grades of congestion and congestion mark have been proposed to evaluate the current situation of congestion. In chapter 6, it is studied how much can we improve by relocating these land uses in our scenarios developed.

6. Scenarios for relocating some major land uses

This chapter discuss on some scenarios of relocation and their effect on congestion in Hanoi's city centre. The scenarios are designed as such to study different combinations 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 are expanded (in line with current ideas in Hanoi).

Six basic scenarios are proposed for evaluation.

	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**

Scenario O is the base situation when we assume 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.

After that 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 locations

6.1. Scenario 0: No activity

This scenario is proposed to see the maximum possibility we can achieve in case there is no activity in our study areas. This task is easily completed by subtracting the contribution of these land uses and recalculate the congestion level and congestion mark (For detailed calculations, please refer to appendix D). The results are summarized in the table below:

Congestion Mark-Scenario O-No Activity (frequencies)

	Mark	Weight	Morning Way In	Morning -Way Out	Afternoon-Way In	Afternoon-Way Out	Sum Scenario B	**Total Mark**
No congestion	10	1	4	3	6	7	20	**200**
Migrate	8	1	9	6	7	4	26	**208**
Crowded	2	1	13	13	10	13	49	**98**
Very crowded	-2	1	7	9	8	7	31	**-62**
Severe G1	-3	2	2	2	2	1	7	**-42**
Severe G2	-4	2		1	2	1	4	**-32**
Very severe G1	-6	3				1	1	**-18**
Very severe G2	-8	3						**0**
Craw	-10	3						**0**
Sum								**352**

Table 6.1: Summarize Congestion level-Scenario O-No Activity

Comparing the current situation with this scenario, the summary table 6.2 can be obtained.

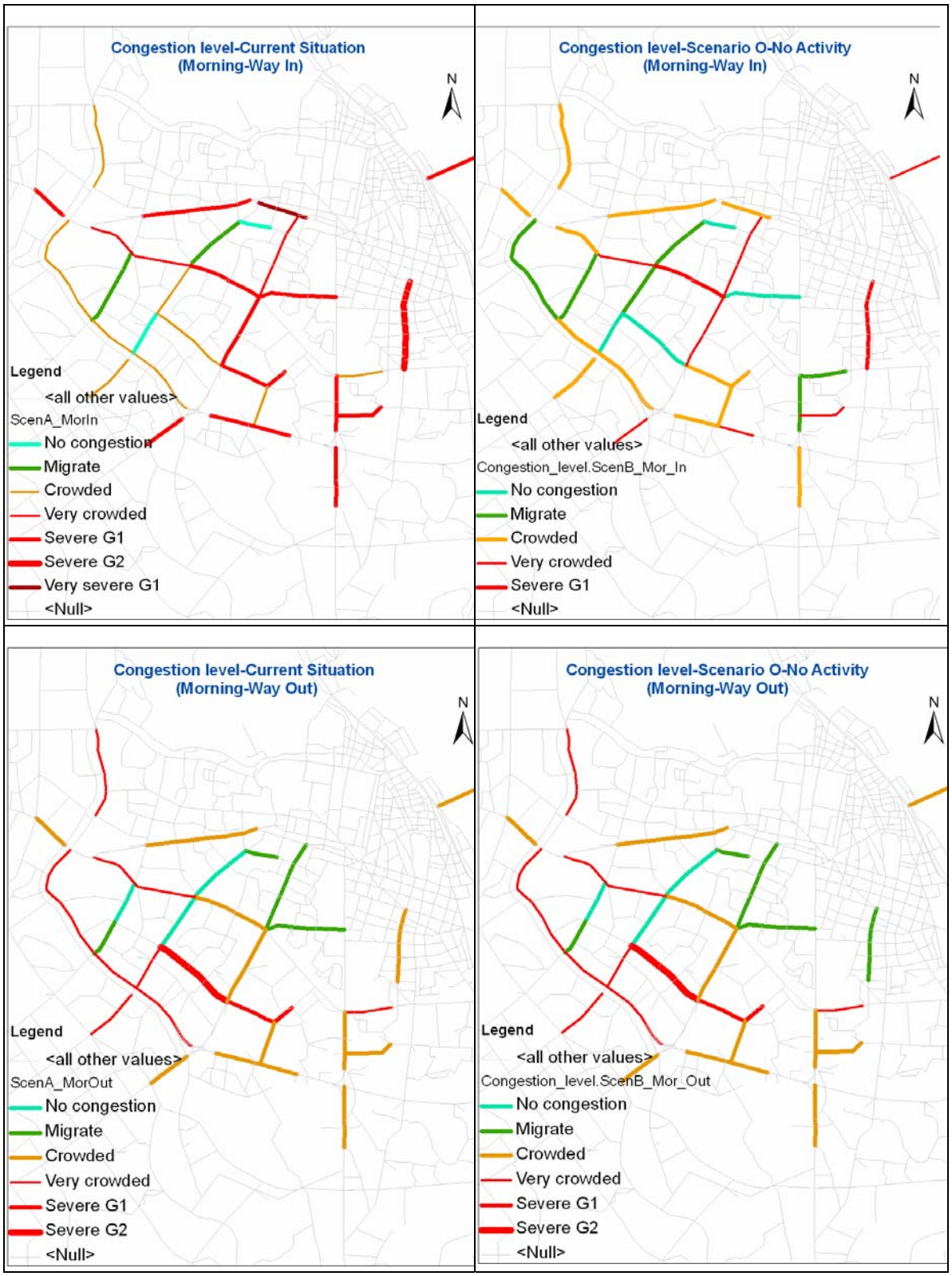
Comparision of congestion level

	Sum case							**Congestion mark**						
	Current situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Current situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
No congestion	8	20						80	200					
Migrate	10	26						80	208					
Crowded	38	49						76	98					
Very crowded	31	31						-62	-62					
Severe G1	40	7						-240	-42					
Severe G2	5	4						-40	-32					
Very severe G1	2	1						-36	-18					
Very severe G2	3							-72	0					
Craw	1							-30	0					
Sum								-244	352					

Table 6.2: Comparison between Current Situation and scenario O

From table 6.2, we can see that in Scenario O we can cut down almost of severe G1 cases, from 40 to 7 cases only, and increase quite a lot “No congestion” and “Migrate” cases, from 8 to 20 and from 10 to 26 respectively.

The figures below will give us a view of the ideal scenario, scenario O, in case of no activity. The scenario is compared with current situation by putting them together side by side.


Congestion level-Current Situation
(Morning-Way In)
N
Legend
<all other values>
ScenA_MorIn
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
<Null>
Congestion level-Scenario O-No Activity
(Morning-Way In)
N
Legend
<all other values>
Congestion_level.ScenB_Mor_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
<Null>
Congestion level-Current Situation
(Morning-Way Out)
N
Legend
<all other values>
ScenA_MorOut
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Scenario O-No Activity
(Morning-Way Out)
N
Legend
<all other values>
Congestion_level.ScenB_Mor_Out
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>

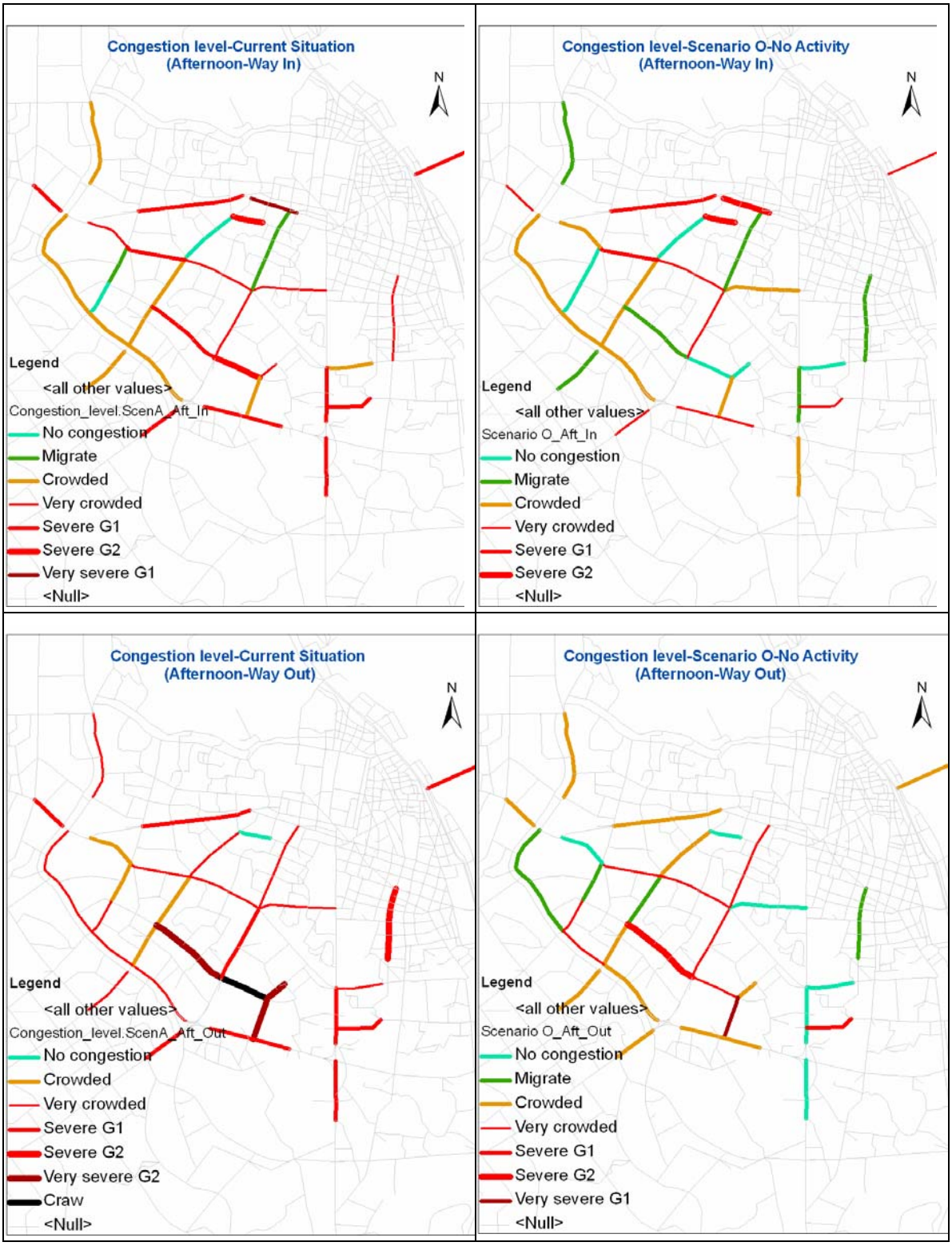


Figure 6.1: Comparison between Current Situation and Scenario O

Comparision of congestion level of some selected corridors										
No.	Corridor name	Corridor code	Current Situation				Scanrio O			
			Morning-Way In	Morning - Way Out	Afternoon-Way In	Afternoon-Way Out	Morning-Way In	Morning - Way Out	Afternoon-Way In	Afternoon-Way Out
1	Chua Boc street	No. 1-Cboc	Severe G1	Severe G1	Severe G2	Craw	Crowded	Severe G1	No congestion	Very crowded
2	Pham Ngoc Thach street	No. 2-PNThach	Severe G1	Severe G1	Very crowded	Very severe G2	Crowded	Severe G1	No congestion	Crowded
3	Ton That Tung street	No. 3-TTTung	Crowded	Crowded	Crowded	Very severe G2	Crowded	Crowded	Crowded	Very severe G1
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	Severe G1	Crowded	Severe G1	Severe G1	Crowded	Crowded	Very crowded	Crowded
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	Severe G1	Crowded	Severe G1	Severe G1	Very crowded	Crowded	Very crowded	Crowded
6	Kham Thien	No. 5-KThien	Severe G1	Migrate	Very crowded	Very crowded	No congestion	Migrate	Crowded	No congestion
7	Nguyen Thai Hoc	No. 6-NTHoc	Very severe G1		Very severe G1		Crowded		Severe G2	
8	Cau Giay	No. 7-CG	Severe G1	Crowded	Severe G1	Severe G1	Crowded	Crowded	Very crowded	Crowded
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	Severe G1	Crowded	Severe G1	Severe G1	Very crowded	Crowded	Very crowded	Crowded
10	Pho Hue street	No. 11-Phue	Severe G2		Very crowded		Severe G1		Migrate	
11	Ba Trieu street	No. 12-BT		Crowded		Severe G2		Migrate		Migrate
12	Thai Ha	No. 14-ThaiHa	Crowded	Severe G2	Severe G1	Very severe G2	No congestion	Severe G2	Migrate	Severe G2

Table 6.3: Comparison of congestion level on some selected corridors

From figure 6.1, one can still observe some congestion symbol, particularly on some main corridors. However, from table 6.3, one can see that the congestion grade of these corridors is much better because the congestion grade of these corridors is much lower than before, for example Chua Boc street will move from "Craw" level to "Very crowded" on the way out in the afternoon and Thai Ha from Severe G1 to Migrate on the way-in in the afternoon.

This scenario, however, is not realistic, therefore in next paragraphs a scenario will be presented and discussed that more resemble current thinking in Hanoi.

6.2. 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. We will test this situation to see how much can we achieve by doing this.

6.2.1. Road to be expanded

According to plan of transport sector, 4 new bridges will be built: Thanh Tri Bridge, Vinh Tuy Bridge, Nhat Tan Bridge and Tu Lien Bridge. Thanh Tri Bridge has been put on operation on February 3rd, 2007. Besides that the ring road no. 1, no.2, no. 2.5 and ring road no.3 will be expanded. Most of them will be constructed before 2010 (M.O.T 2004).

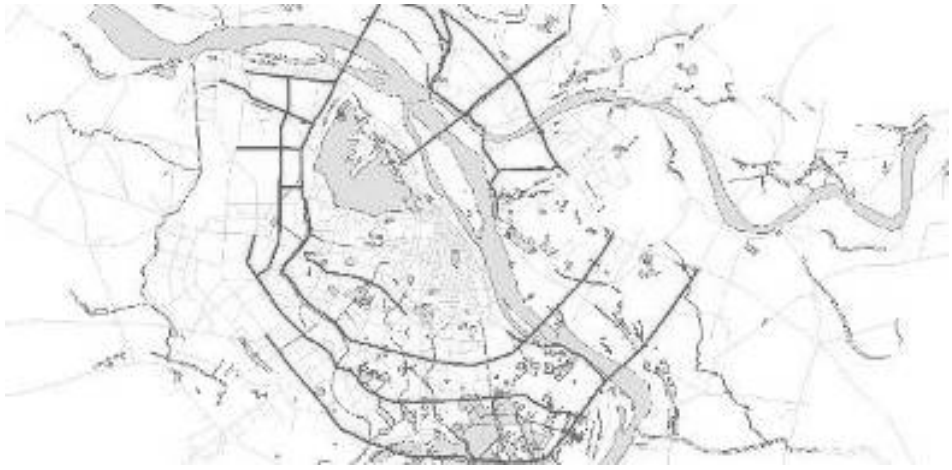


Figure 6.2: Roads to be expanded

One characteristic of Hanoi road network as mentioned before is that within the ring road no.2 it is very difficult to expand due to population density and the cost for land acquisition are very high. Therefore, most of the roads to be constructed or expanded are outside ring road no.2, except for ring road no. 1 only. Some parts of ring road no. 3 have already been completed for the SEAGAME 22.

No.	Road name	Road width (m)	No. of lane/ direction	Year of construction (planned)	Note
1	Ring road No.1 (La Thanh and Buoi streets)	50-60	3	2005-2007	Under construction
2	Ring road No. 2 (Truong Chinh and Lang streets)	53.5	3	Before 2010	Not start yet
3	Ring road no. 2.5	50-60	3	Before 2010	Not start yet
4	Ring road no. 3	68-74	4	Before 2010	Already started

Table 6.4: Plan for expanded roads

6.2.2. Their new capacity in Non-peak hour

Based on this information, the whole road network is updated and road capacity of some corridors is re-calculated as shown in table 6.5 below. This new road capacity will be applied in calculation of congestion level in this scenario as well as in scenarios 4, 5, 5A, 5B.

Capacity of some main roads and corridors_After Expansion

No.	Road name	Corridor code	Road width(m)	Oneway	Road type	Number of lane	Average length (m)	Average speed (km/h)	Average speed (m/s)	Lane width (m)	K1	α	Σγn	γ	Road capacity (pcu/h)
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	11	FALSE	Secondary	3	287.19	20	5.56	3.5	0.77	0.66691	2.55	0.85	1,548
5	Truong Chinh 2(T.T.Tung-N.T.Vong	No.4b-Tchinh	12	FALSE	Secondary	3	222.79	20	5.56	3.5	0.85	0.60833	2.55	0.85	1,559
20	Duong Lang 1(Cgiay-N.C.Thanh)	No. 17-Dlang	11	FALSE	Secondary	3	321.15	20	5.56	2.75	0.77	0.69125	2.55	0.85	1,605
21	Duong Lang 2(N.C.Thanh-L.Ha)	No. 17b-Dlang	11	FALSE	Secondary	3	410.68	25	6.94	2.75	0.77	0.68437	2.55	0.85	1,693
22	Duong Lang 3(L.Ha-N.T.So)	No. 17c-Dlang	11	FALSE	Secondary	3	241.83	20	5.56	2.75	0.77	0.62769	2.55	0.85	1,457
23	La Thanh 1(Voiphuc-N.C.Thanh)	No. 18-LaThanh	9	FALSE	Minor	3	189.31	20	5.56	3.5	1	0.56892	2.55	0.85	1,715
24	La Thanh 2(N.C.Thanh-L.Ha)	No.18b-LaThanh	9	FALSE	Minor	3	156.53	20	5.56	3.5	1	0.52182	2.55	0.85	1,573
25	La Thanh 3(L.Ha-T.D.Thang)	No.18c-LaThanh	9	FALSE	Minor	3	234.16	20	5.56	3.5	1	0.62013	2.55	0.85	1,870
26	Duong Buoi	No. 19-D.Buoi	7	FALSE	Minor	3	337.04	20	5.56	3.5	1	0.70146	2.55	0.85	2,115

Table 6.5: New capacity of expanded corridors

6.2.3. Change in route used

Due to the road expansion, the characteristics of different corridors in our study areas will change. Newly-expanded roads will attract more traffic and traffic volume on some corridors can be cut down as shown in the figures bellow. The process of route recording in 5.5.1 is repeated.

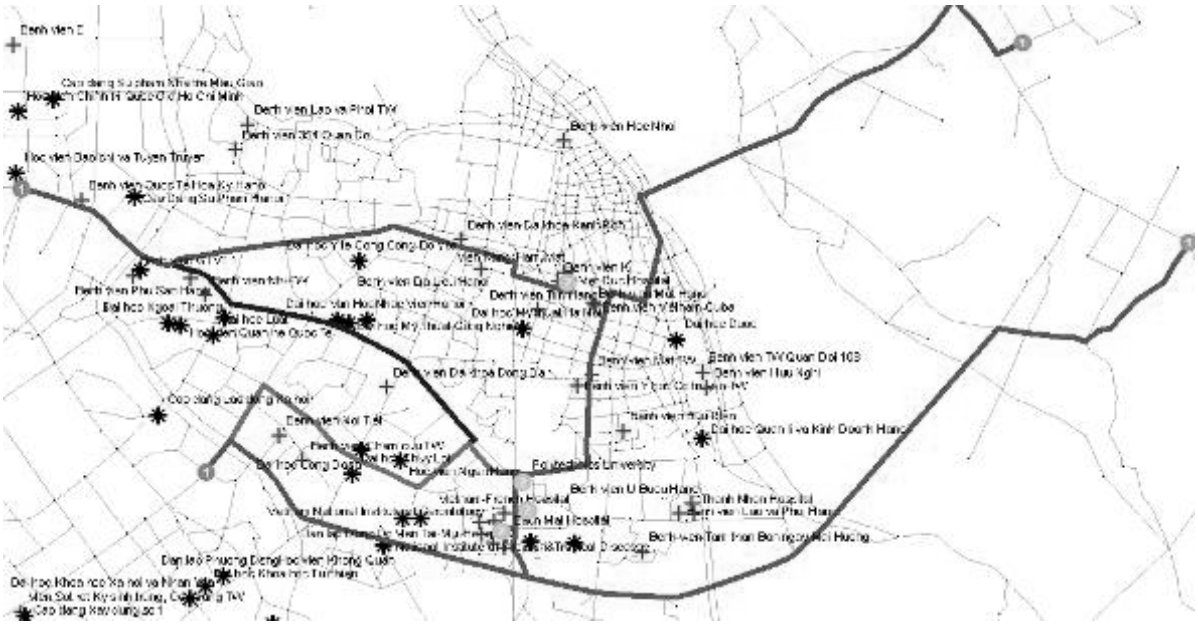


Figure 6.3: Change in route used

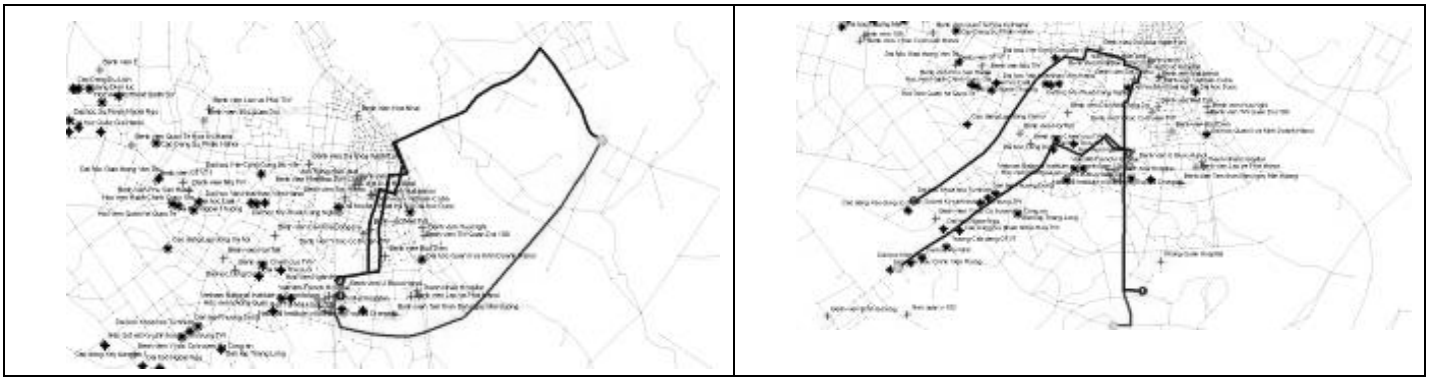


Figure 6.4: Change in route used for people from the East and the South

We can see quite clearly that people living in the South and the South West still use the same routes to our study areas; People living in the North West will use ring road no.1 instead of Thai Ha-Chua Boc-Pham Ngoc Thach route to study area no.1 but they keep the same route to study area no.2; People living in the East use the same route to Polytechnics University, but use different route to the remaining destinations; People living in the North will use Tu Lien or Nhat Tan bridges instead of Chuong Duong bridge. Routes are recorded separately for each organization and for both the way-in and the way-out.

In general, the traffic volume on corridors: Chua Boc, Pham Ngoc Thach, Cau Giay, Cau Chuong Duong, Ba Trieu and Pho Hue may have some cut down. The matter here is that most of our trip origins are from the South and South West. So we just know how much can we reduce after calculation in the next part.

6.2.4. Change in the congestion situation

New traffic volume on corridors during peak hours is re-calculated by adding the extra volume contributed by scenario 1 with traffic volume of scenario O in case no activity happens at our study. The calculation is done as follow:

New Traffic Volume = Traffic Volume of Scenario O + Contribution of scenario 1 (9)

(For detailed, please see appendix E & F)

And then congestion level and congestion mark are calculated. The result is summarized as follows:

Congestion Mark-Scenario 1-Road Expand-No Relocate (frequency)

	Mark	Weight	Morning Way In	Morning -Way Out	Afternoon-Way In	Afternoon-Way Out	Sum Scenario 1	**Total Mark**
No congestion	10	1	7	9	8	6	30	**300**
Migrate	8	1	6	7	3	2	18	**144**
Crowded	2	1	7	12	8	4	31	**62**
Very crowded	-2	1	3	3	5	3	14	**-28**
Severe G1	-3	2	9	2	9	12	32	**-192**
Severe G2	-4	2	3	1	1	3	8	**-64**
Very severe G1	-6	3			1	3	4	**-72**
Very severe G2	-8	3				1	1	**-24**
Craw	-10	3						**0**
Sum								**126**

Table 6.6: Summarize table of congestion level and congestion mark-Scenario 1

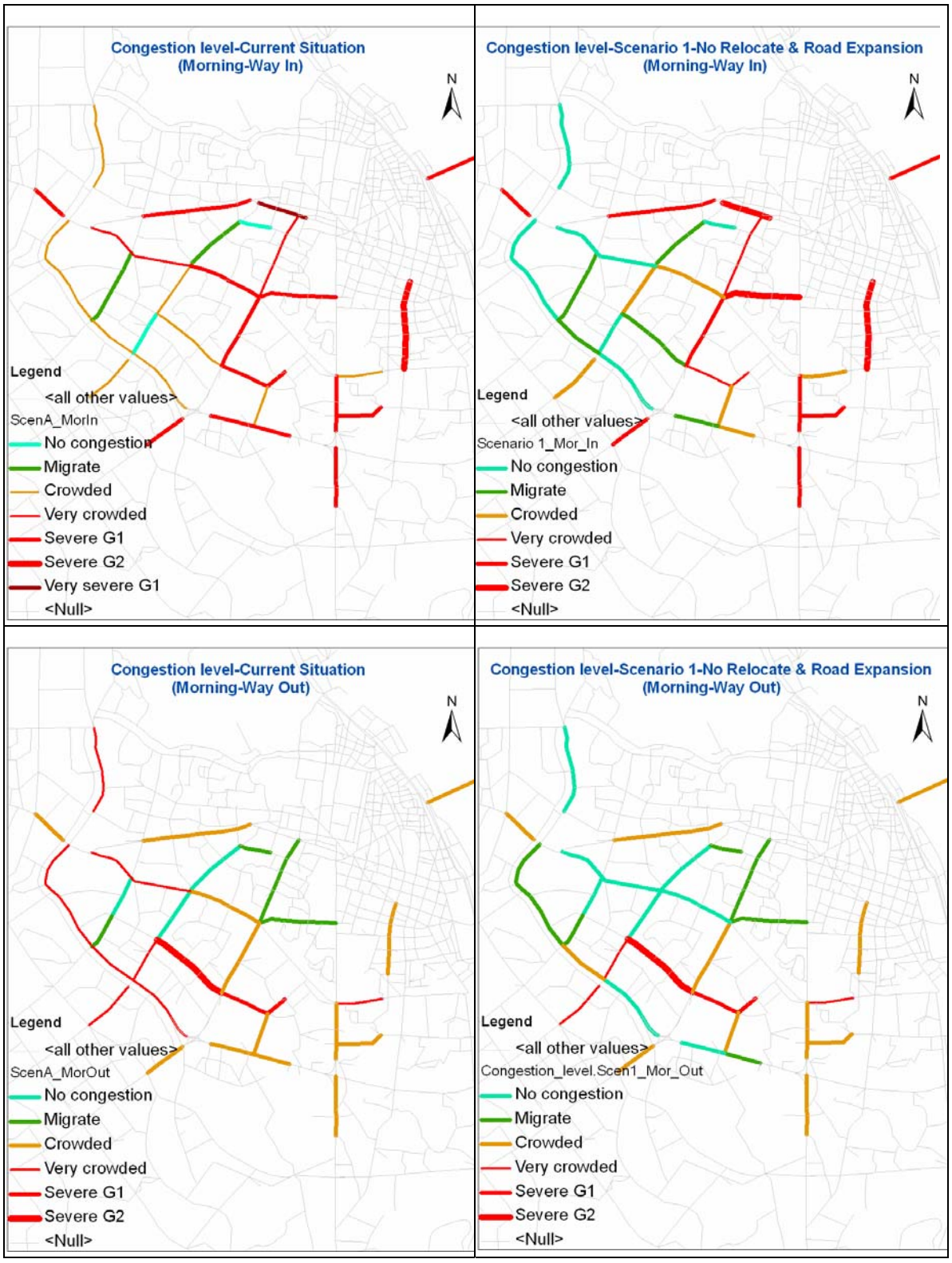
A comparison with Current Situation and Scenario O is also made.

Comparision of congestion level

	Sum case							**Congestion mark**						
	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
No congestion	8	20	30					80	200	300				
Migrate	10	26	18					80	208	144				
Crowded	38	49	31					76	98	62				
Very crowded	31	31	14					-62	-62	-28				
Severe G1	40	7	32					-240	-42	-192				
Severe G2	5	4	8					-40	-32	-64				
Very severe G1	2	1	4					-36	-18	-72				
Very severe G2	3		1					-72	0	-24				
Craw	1							-30	0	0				
Sum								-244	352	126				

Table 6.7: Comparison between Current Situation, Scenario O and Scenario 1

We can see that the situation has been improved a lot, but the number of cases at “Severe G1”, “Severe G2” and “Very Severe G1” is still high. That is why the total congestion mark is only 126.


Congestion level-Current Situation
(Morning-Way In)
N
Legend
<all other values>
ScenA_MorIn
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
<Null>
Congestion level-Scenario 1-No Relocate & Road Expansion
(Morning-Way In)
N
Legend
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Scenario 1_Mor_In
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Crowded
Very crowded
Severe G1
Severe G2
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Congestion level-Current Situation
(Morning-Way Out)
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Legend
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ScenA_MorOut
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
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Congestion level-Scenario 1-No Relocate & Road Expansion
(Morning-Way Out)
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Legend
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Congestion_level.Scen1_Mor_Out
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Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>

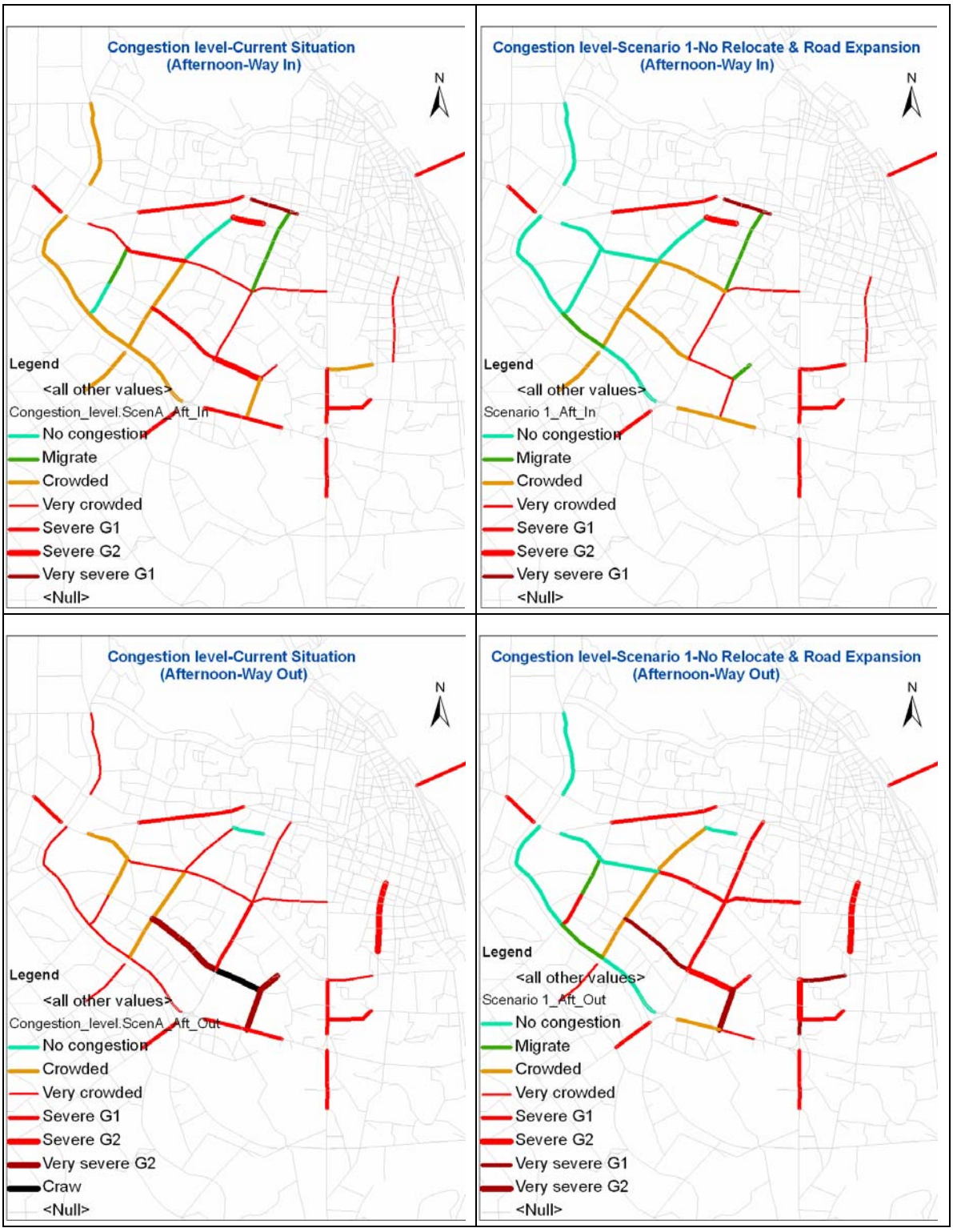


Figure 6.5: Comparison between Current Situation and scenario 1

In the morning peak hour, there is some improvement for ring road no.1 and ring road no. 2, and a small improvement for the other corridors. But in the afternoon, the congestion situation is almost the same. Therefore, we can conclude that road expansion alone can not relieve the congestion.

Therefore, in the next scenario, Scenario 2: “Relocate all organizations to the West & No road expansion” is studied to see now relocation can improve the situation.

6.3. Scenario 2: Relocate all to the West direction & No road expansion

This scenario is proposed since many organizations want to move out of the city centre. The current office is so narrow and it is quite difficult to expand the office because of some restrictions such as strict construction regulation and other regulations on construction tax in the urban core, etc. The second reason is that the existing land in the city centre has a high value. Therefore, by selling the existing land they can buy much bigger space in the outskirts. Land-use is moved to Western direction because the government has a policy to expand the city into this direction and in reality this area has less affect from Red river in the rainy season, cheap open land and good infrastructure which have been prepared in recent years. In near future, one highway Lang-Hoa Lac will be built with 100-140m road width. This area is also in connection between the existing the city centre and some new satellite cities on the West like Mieu Mon, Hoa Lac, Son Tay, Vinh Phuc, etc in the future. Some organizations have moved there and many others also want to move like Ministry of Science and Technology, Ministry of Agriculture, Ministry of Post and Telecommunications, National Assembly House, etc.

This scenario studies what will happen if all of them will move to the West direction. This scenario is also TRUE in case only 50% of government offices move to the West and another 50% of business enterprises also move to the West since the total number of people in business enterprises is almost the same with government staff as mentioned before.

In this scenario, it is assumed that people's residences in the wards stay the same. Furthermore, it is assumed that people remain travelling to these locations. In other words, relocation 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.

6.3.1. New locations

For universities, the new location are known for the new base is in between Tay Mo and Dong Mo wards as mentioned in the proposal of Ministry of Education (please refer to 5.4.2).

For hospitals and government offices, it is assumed that the new location is the same or near the newly planned location of Ministry of Science and Technology and National Institute of Hematology and Blood Transfusion as mentioned before, in 5.4. It does not change very much on route uses if their new locations are around the specified location.

6.3.2. Change in traffic flow and route used

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. This is depicted in the figure below.

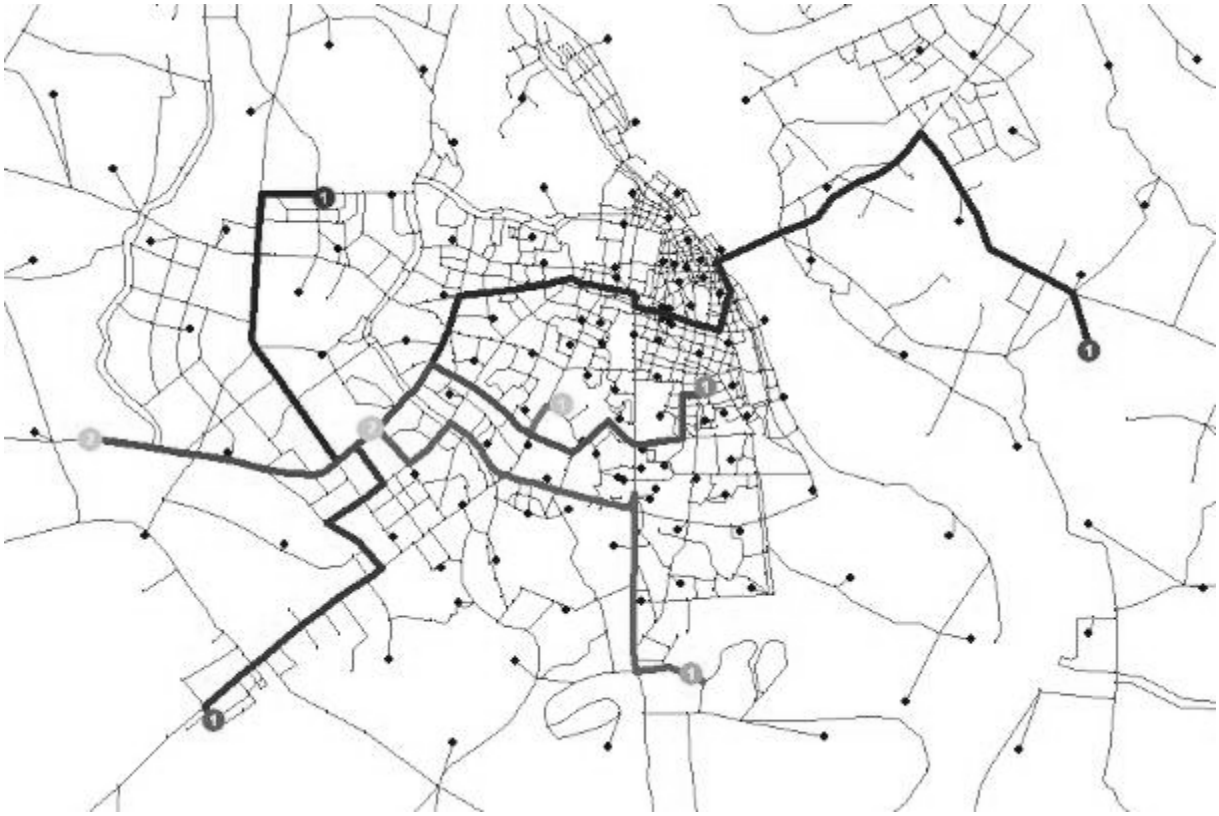


Figure 6.6: Change in routes used-Scenario 2-Relocate all to the West

It can be observed that people from the West or South West direction will not use the selected corridors. But people from the South and people from the city centre still use the selected corridors but in the reverse directions. People from the other side of the river still use Chuong Duong Bridge as an exclusive choice.

6.3.3. Congestion level & congestion mark

There is one aspect that needs to be taken into consideration. People take reverse directions with before to go and return from new locations.

The traffic volume on corridors is re-calculated as follow:

Traffic Volume (Morning-Way In) = Volume in Scenario O (10)

And the equation below is applied for the rest.

New Traffic volume =Volume in Scenario O + new contribution of scenario 2 (11)

And then congestion level and congestion mark are re-calculated and summarized in the table below. (For more details, please refer to Appendix G)

Congestion Mark-Scenario 2-Relocate All to the West (frequency)

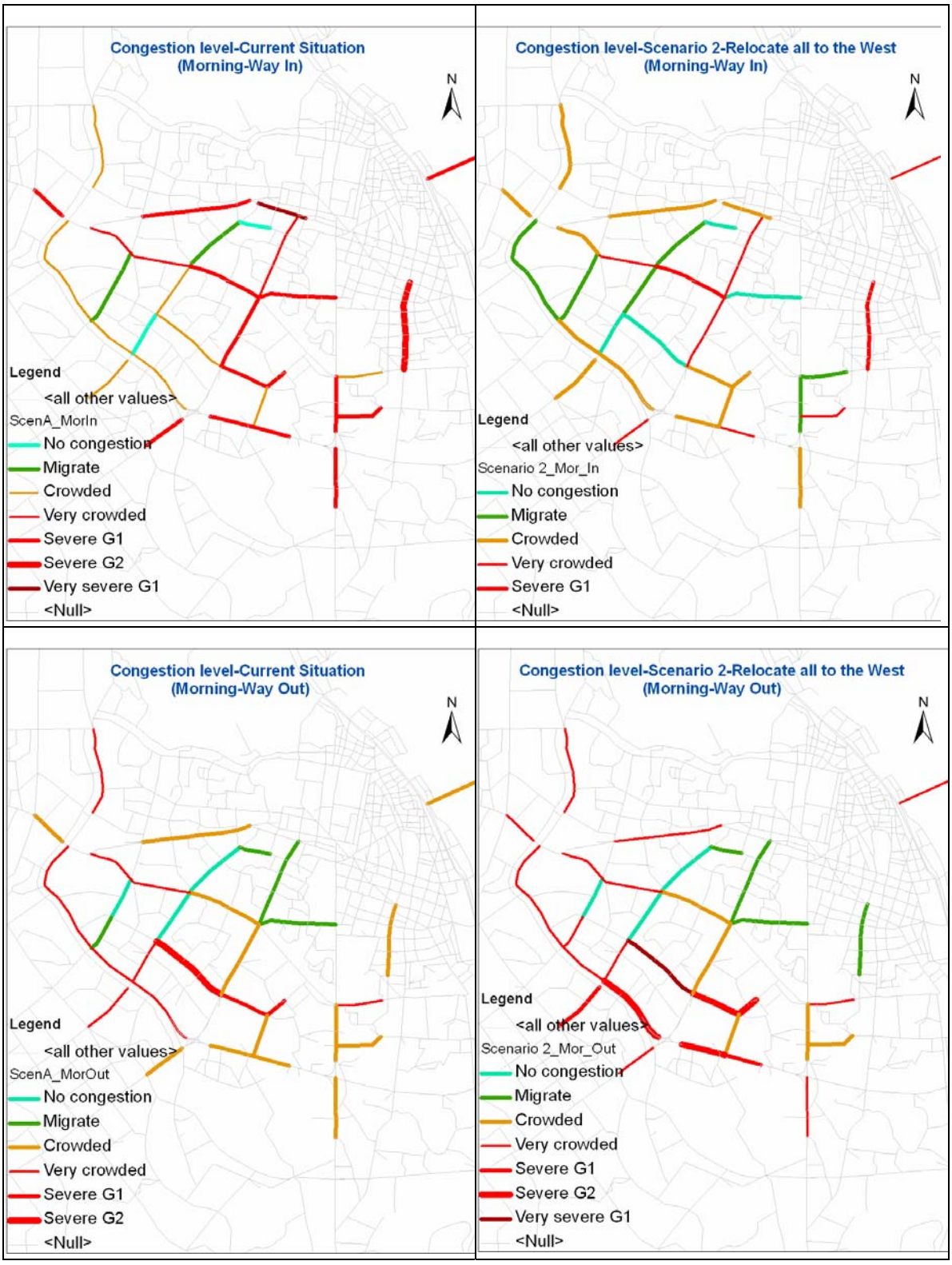
	Mark	Weight	Morning Way In	Morning -Way Out	Afternoon-Way In	Afternoon-Way Out	Sum Scenario 2	**Total Mark**
No congestion	10	1	4	3	3	6	16	**160**
Migrate	8	1	9	5	6	4	24	**192**
Crowded	2	1	13	6	7	6	32	**64**
Very crowded	-2	1	7	13	7	8	35	**-70**
Severe G1	-3	2	2	2	4	6	14	**-84**
Severe G2	-4	2		4	3	1	8	**-64**
Very severe G1	-6	3		1	2	3	6	**-108**
Very severe G2	-8	3			2		2	**-48**
Craw	-10	3			1		1	**-30**
Sum								**12**

Table 6.8: Summarize table-Scenario 2-Relocate all to the West

Comparision of congestion level & Congestion Mark between Scenarios (frequency)

	Sum case							**Congestion mark**						
	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
No congestion	8	20	30	16				80	200	300	160			
Migrate	10	26	15	24				80	208	144	192			
Crowded	38	49	31	32				76	98	62	64			
Very crowded	31	31	14	35				-62	-62	-28	-70			
Severe G1	40	7	32	14				-240	-42	-192	-84			
Severe G2	5	4	8	8				-40	-32	-64	-64			
Very severe G1	2	1	4	6				-36	-18	-72	-108			
Very severe G2	3		1	2				-72	0	-24	-48			
Craw	1			1				-30	0	0	-30			
Sum								-244	352	126	12			

Table 6.9: Comparison of congestion level and congestion mark between scenarios


Congestion level-Current Situation
(Morning-Way In)
N
Legend
<all other values>
ScenA_MorIn
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
<Null>
Congestion level-Scenario 2-Relocate all to the West
(Morning-Way In)
N
Legend
<all other values>
Scenario 2_Mor_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
<Null>
Congestion level-Current Situation
(Morning-Way Out)
N
Legend
<all other values>
ScenA_MorOut
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Scenario 2-Relocate all to the West
(Morning-Way Out)
N
Legend
<all other values>
Scenario 2_Mor_Out
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
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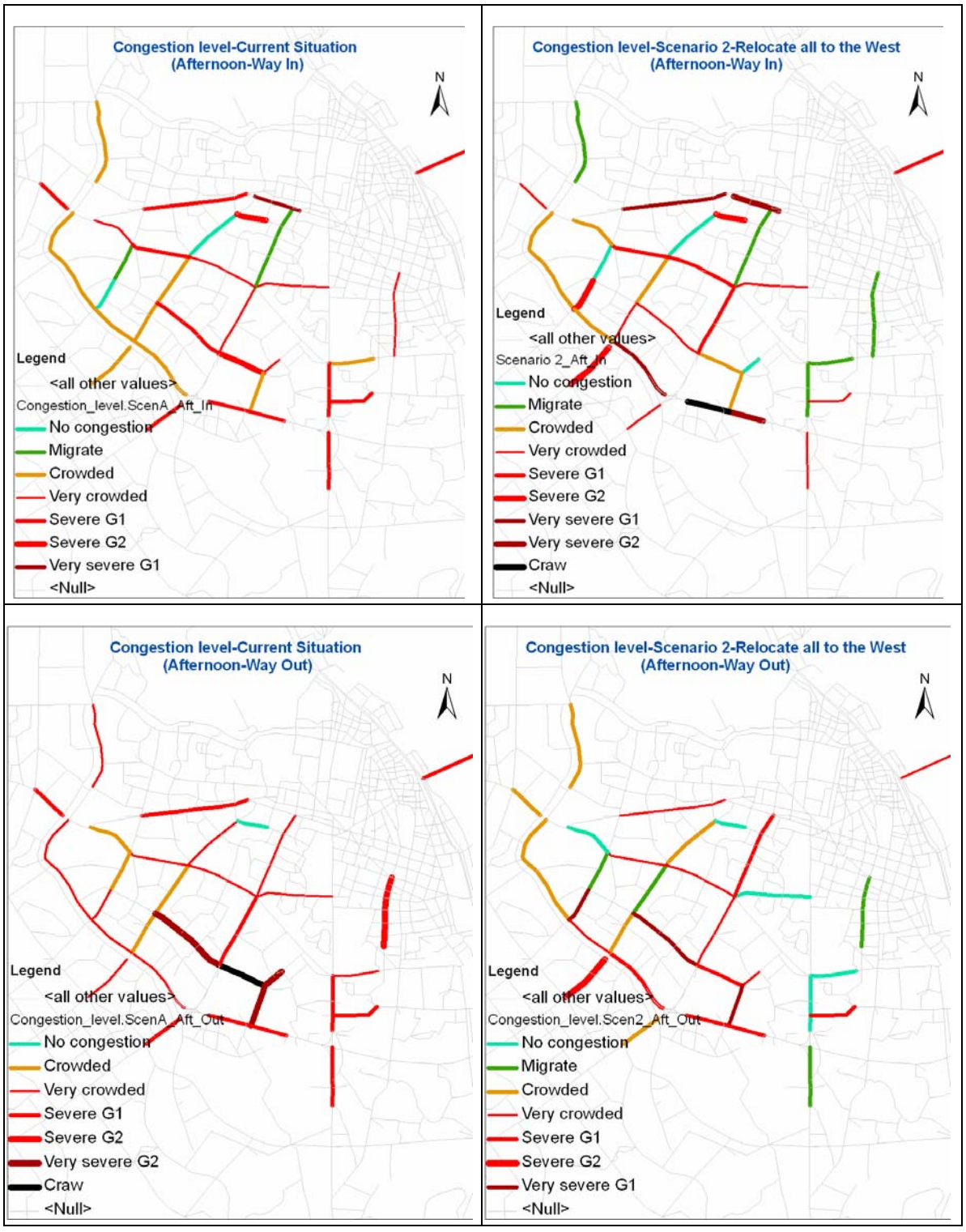


Figure 6.7: Congestion situation before and after relocating all to the West

It can be seen that the situation is worse than scenario 1, since it produces more congestion in the reverse directions, even the number of severe cases and very severe cases are more than in the current situation, especially the way-in in the afternoon.

Therefore, it can be concluded that traffic congestion can not be relieved by relocation alone. In the next scenario, scenario 3-"Relocate 50-50 & No road Expansion", a combination of relocation and road based measures will be investigated.

6.4. Scenario 3: Relocate 50-50 & No road expansion

This scenario is constructed because when we relocate 50% the selected land-uses 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. The second reason is that it is more realistic than scenario 2-Relocate all. And finally, the third 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 commercial, residential, etc.

6.4.1. New traffic volume on corridors

It is necessary need to re-calculate traffic volume on corridors with a consideration that in the morning 50% of them will use the way-in, 50% of them will use the way-out and in the reverse directions in the afternoon. Therefore, new traffic volume on corridors is calculated as follows:

New Vol. =Vol. of Scenario O + (Current contribution + Contribution of scenario2)/2 (12)

Then the congestion level and congestion mark are also recalculated (For details, please refer to appendix H).

6.4.2. Congestion situation

The result is summarized in the table below.

Congestion Mark-Scenario 3-Relocate 50-50_No Road Expansion (frequency)

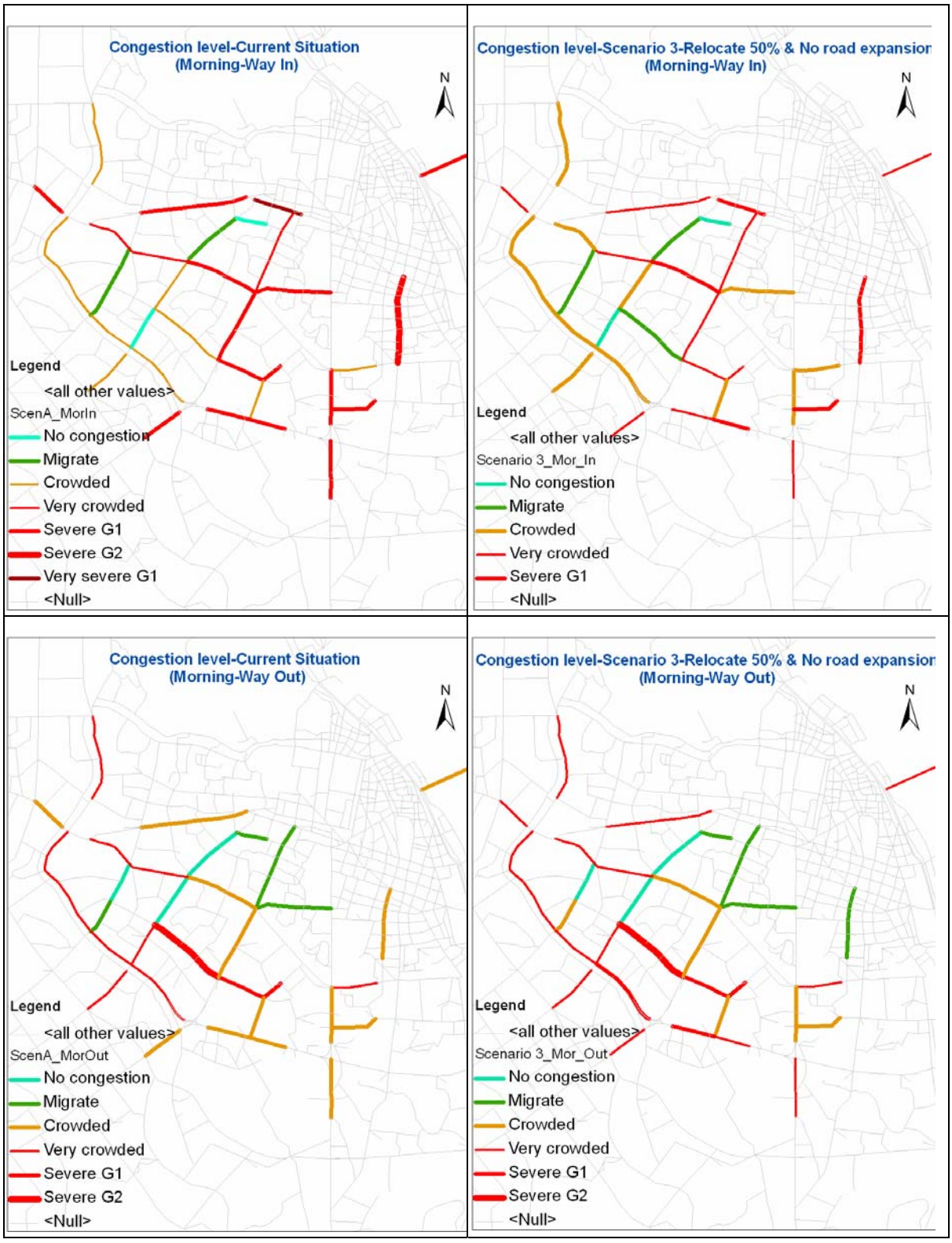
	Mark	Weight	Morning Way In	Morning - Way Out	Afternoon-Way In	Afternoon-Way Out	Sum Scenario 3	Total Mark
No congestion	10	1	2	3	1	3	9	**90**
Migrate	8	1	4	5	3	1	13	**104**
Crowded	2	1	13	7	10	9	39	**78**
Very crowded	-2	1	11	14	11	9	45	**-90**
Severe G1	-3	2	5	4	6	7	22	**-132**
Severe G2	-4	2		1	2	2	5	**-40**
Very severe G1	-6	3				1	1	**-18**
Very severe G2	-8	3				2	2	**-48**
Craw	-10	3					0	**0**
Sum								**-56**

Table 6.10: Congestion level & congestion mark-Scenario 3_Relocate 50-50 & No Expansion

Comparision of congestion level & Congestion Mark between Scenarios (frequency)

	Sum case							Congestion mark						
	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
No congestion	8	20	30	16	9			80	200	300	160	90		
Migrate	10	26	15	24	13			80	208	144	192	104		
Crowded	38	49	31	32	39			76	98	62	64	78		
Very crowded	31	31	14	35	45			-62	-62	-28	-70	-90		
Severe G1	40	7	32	14	22			-240	-42	-192	-84	-132		
Severe G2	5	4	8	8	5			-40	-32	-64	-64	-40		
Very severe G1	2	1	4	6	1			-36	-18	-72	-108	-18		
Very severe G2	3		1	2	2			-72	0	-24	-48	-48		
Craw	1			1	0			-30	0	0	-30	0		
Sum								-244	352	126	12	-56		

Table 6.11: Comparison between scenarios


Congestion level-Current Situation
(Morning-Way In)
N
Legend
<all other values>
ScenA_MorIn
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
<Null>
Congestion level-Scenario 3-Relocate 50% & No road expansion
(Morning-Way In)
N
Legend
<all other values>
Scenario 3_Mor_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
<Null>
Congestion level-Current Situation
(Morning-Way Out)
N
Legend
<all other values>
ScenA_MorOut
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Scenario 3-Relocate 50% & No road expansion
(Morning-Way Out)
N
Legend
<all other values>
Scenario 3_Mor_Out
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>

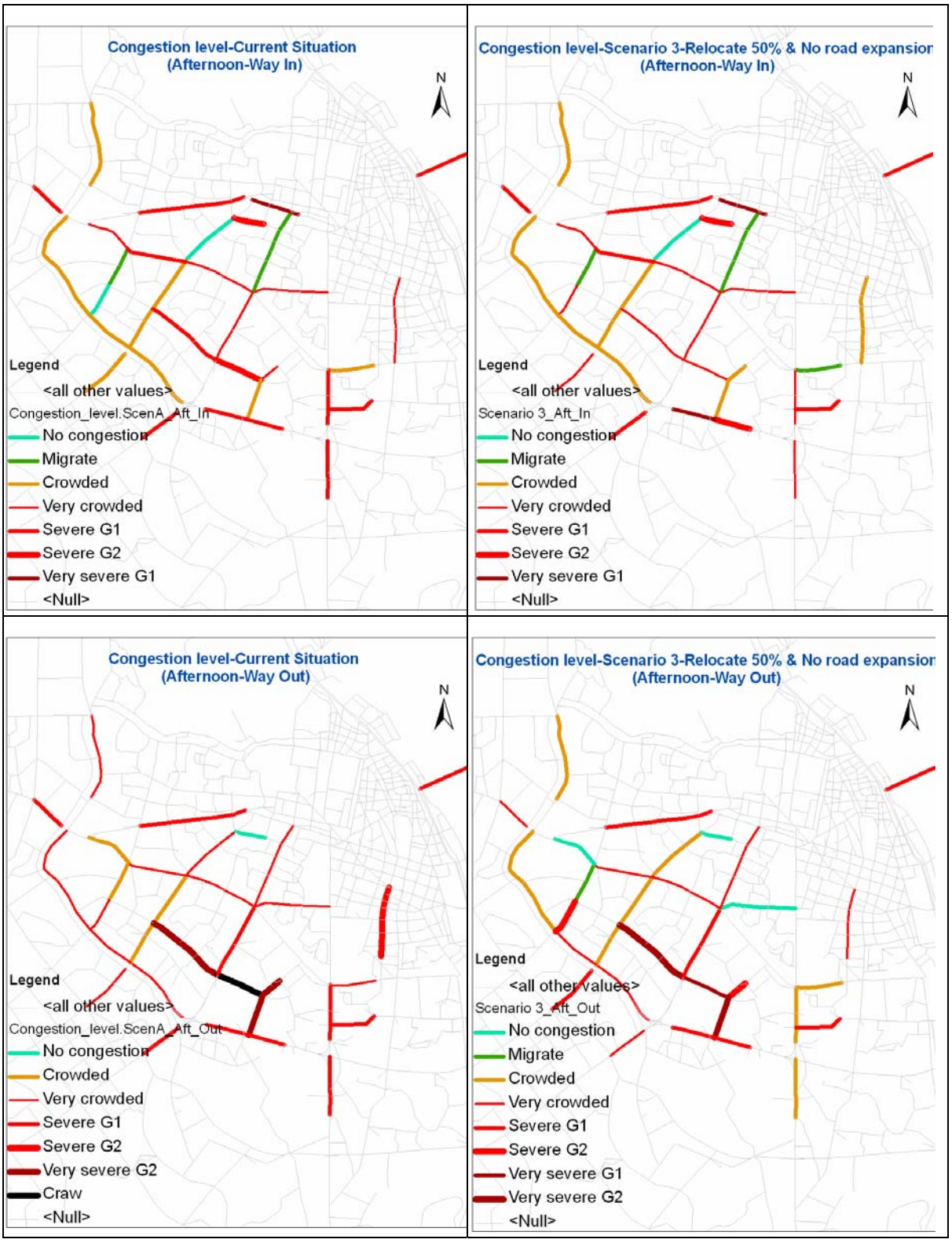


Figure 6.8: Comparison Current Situation and Scenario 3

It can be seen that this scenario can reduce the number of "Severe G1" cases from 40 to 22, but at the same time increase the "Very Crowded" cases from 31 to 45. This solution has considerable effect in terms of relieving traffic congestion as compared to the current situation. In the next scenario, scenario 4-Relocate all to the West combines with road expansion, all land-uses will be relocated while road capacity is also expanded.

6.5. Scenario 4: Relocate all & Road expansion

From scenarios 1 and 2, it can be seen that the situation is improved quite a lot. Therefore, in this scenario all strong points of these solutions are combined.

6.5.1. Change in route used

To apply this scenario all the corridors used to travel from one ward to the new locations have re-calculated because newly-expanded roads are more attractive and people can run faster to the new locations on those roads. This is true for people living outside the ring road no.2, for people who live within the ring road no. 2 the situation does not change very much since they have no choice. This is shown in the figure below.

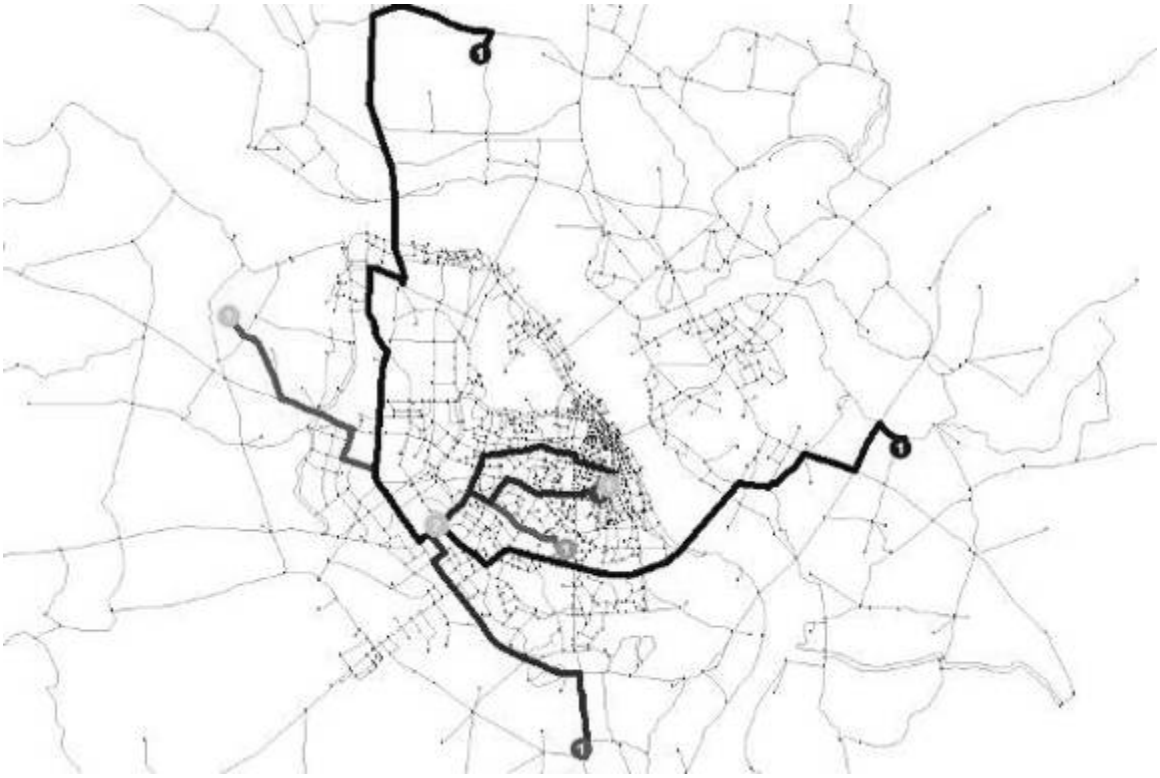


Figure 6.9: Change in route used-Scenario 4-Relocate all & Road Expand

6.5.2. New congestion level and congestion mark

New traffic volume running on corridors is re-calculated as follows:

New volume = Volume of Scenario O + New contribution of scenario 4 (13)

(For more details, please refer to Appendix I)

And then the congestion level and congestion mark are recalculated (using the expanded road capacity) and summarized in the table below.

Congestion Mark-Scenario 4-Relocate All & Road Expansion (frequency)

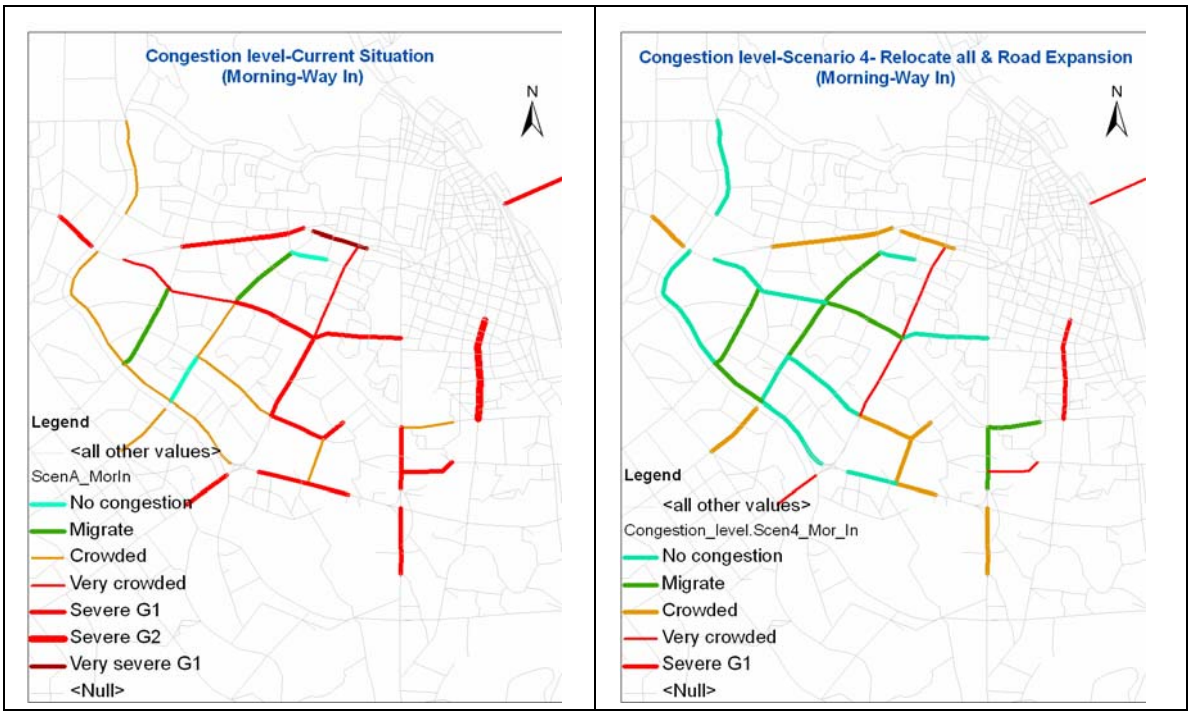
	Mark	Weight	Morning Way In	Morning -Way Out	Afternoon-Way In	Afternoon-Way Out	Sum Scenario 4	**Total Mark**
No congestion	10	1	10	7	7	12	36	**360**
Migrate	8	1	10	6	6	2	24	**192**
Crowded	2	1	9	8	4	7	28	**56**
Very crowded	-2	1	5	9	10	6	30	**-60**
Severe G1	-3	2	1	2	4	4	11	**-66**
Severe G2	-4	2		2	1		3	**-24**
Very severe G1	-6	3			3	3	6	**-108**
Very severe G2	-8	3					0	**0**
Craw	-10	3					0	**0**
Sum								**350**

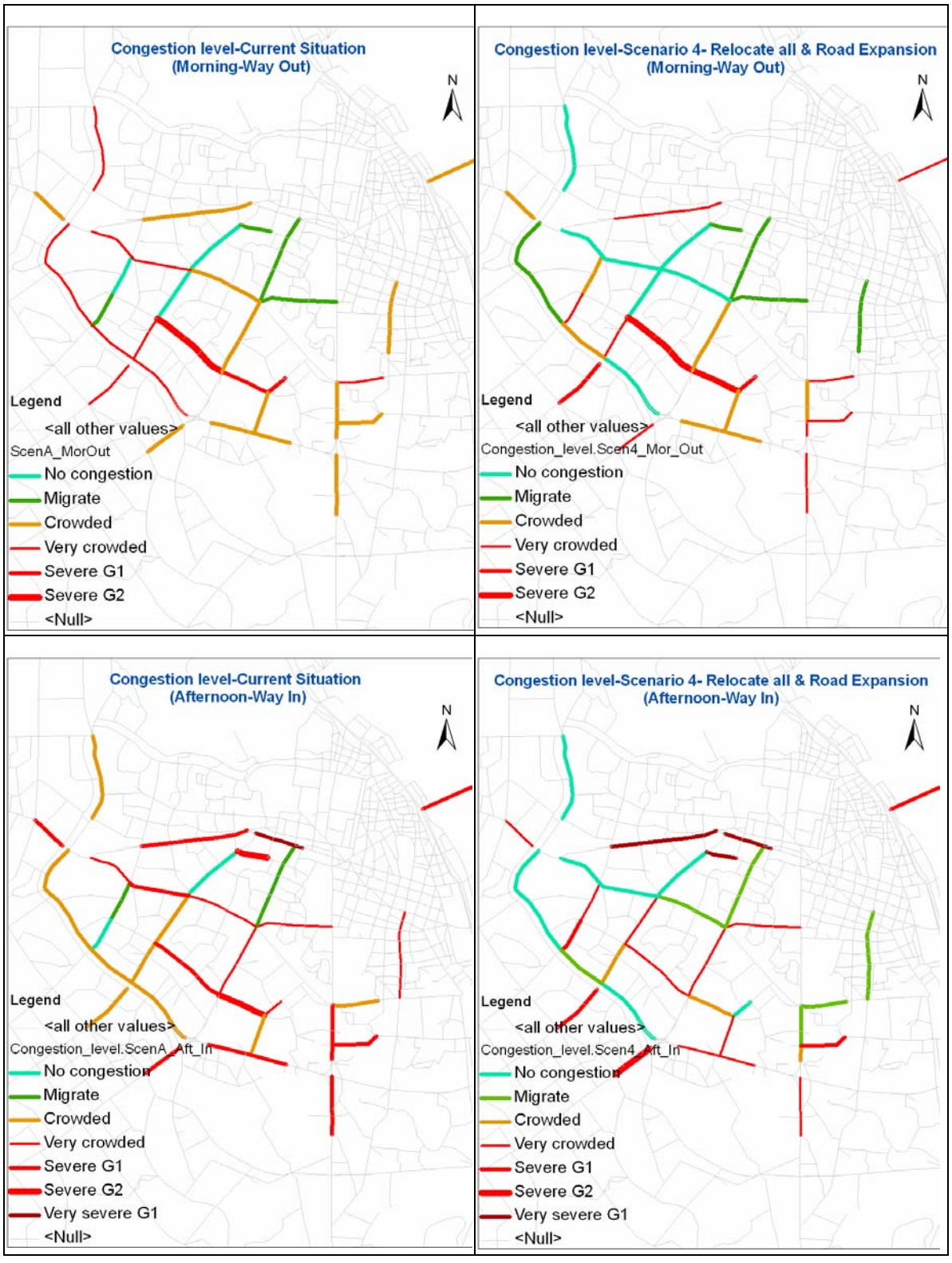
Table 6.12: Congestion level and congestion mark-Scenario 4

Comparision of congestion level & Congestion Mark between Scenarios

	Sum case							**Congestion mark**						
	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
No congestion	8	20	30	16	9	36		80	200	300	160	90	360	
Migrate	10	26	15	24	13	24		80	208	144	192	104	192	
Crowded	38	49	31	32	39	28		76	98	62	64	78	56	
Very crowded	31	31	14	35	45	30		-62	-62	-28	-70	-90	-60	
Severe G1	40	7	32	14	22	11		-240	-42	-192	-84	-132	-66	
Severe G2	5	4	8	8	5	3		-40	-32	-64	-64	-40	-24	
Very severe G1	2	1	4	6	1	6		-36	-18	-72	-108	-18	-108	
Very severe G2	3		1	2	2	0		-72	0	-24	-48	-48	0	
Craw	1			1	0	0		-30	0	0	-30	0	0	
Sum								-244	352	126	12	-56	350	

Table 6.13: Comparison between scenarios (A,B,1,2,3,4)




Congestion level-Current Situation
(Morning-Way Out)
N
Legend
<all other values>
ScenA_MorOut
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Scenario 4- Relocate all & Road Expansion
(Morning-Way Out)
N
Legend
<all other values>
Congestion_level.Scen4_Mor_Out
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Current Situation
(Afternoon-Way In)
N
Legend
<all other values>
Congestion_level.ScenA_Aft_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
<Null>
Congestion level-Scenario 4- Relocate all & Road Expansion
(Afternoon-Way In)
N
Legend
<all other values>
Congestion_level.Scen4_Aft_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
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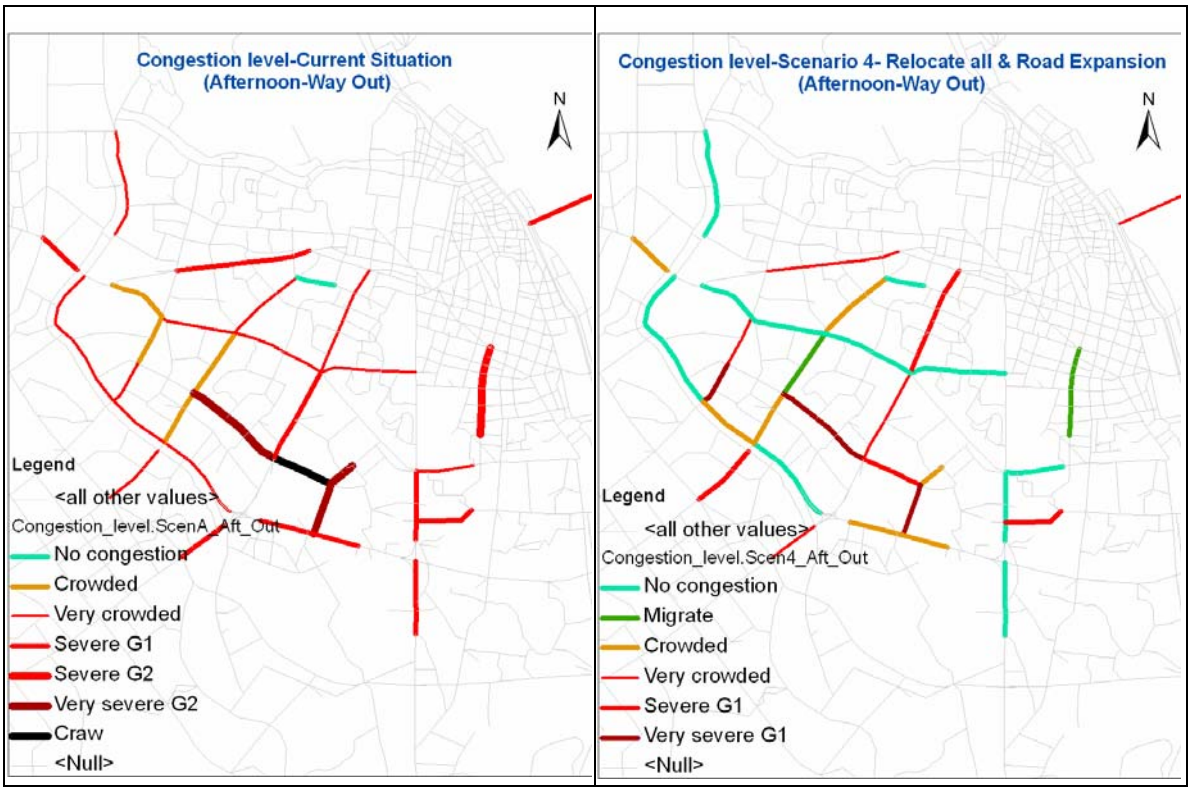


Figure 6.10: Comparison between Current Situation and Scenario 4

It can be seen that the situation has been improved very much. Compared with ideal Scenario O, this solution can achieve 99.43% (350/352) of ideal situation. Anyway, some corridors are still very busy such as Kim Ma, Nguyen Thai Hoc, Cat Linh on the way-in in the afternoon and Ton That Tung, Thai Ha on the way-out in the afternoon. Therefore, in scenario 5: Relocate 50% combine with road expansion is proposed to see if the situation can be improved.

6.6. Scenario 5: Relocate 50-50 & Road expansion

This scenario is constructed with an idea that after expanding road only 50% of the organizations will move to their new locations, 50% of them remains at the existing bases. They still keep the existing bases as head quarter (for government offices), or for higher education or treatment (for universities and hospitals). They do not convert land to other purposes like commercial, residential, etc.

6.6.1. Calculate new traffic volume

Since after expanding roads, 50% of the people will go to new bases and 50% still stays at the existing locations. Therefore, the traffic volume on corridors is re-calculated (with upgraded road capacity) for both the way-in and the way-out as follows:

New Volume = Volume of Scenario O + (Volume of scenario 1+Volume of scenario 4)/2 (14)

(For more details, please refer to appendix K)

6.6.2. Congestion situation

Again calculate congestion level and congestion mark are calculated. The result is summarized in the table below:

Congestion Mark-Scenario 5-Relocate 50-50_Road Expansion (frequency)

	Mark	Weight	Morning Way In	Morning -Way Out	Afternoon-Way In	Afternoon-Way Out	Sum Scenario 5	**Total Mark**
No congestion	10	1	8	7	7	6	28	**280**
Migrate	8	1	6	8	2	1	17	**136**
Crowded	2	1	9	7	9	8	33	**66**
Very crowded	-2	1	9	9	10	9	37	**-74**
Severe G1	-3	2	3	2	4	6	15	**-90**
Severe G2	-4	2		1	2	2	5	**-40**
Very severe G1	-6	3				1	1	**-18**
Very severe G2	-8	3				1	1	**-24**
Craw	-10	3					0	**0**
Sum								**236**

Table 6.14: Congestion level and congestion mark-Scenario 5

Comparision of congestion level & Congestion Mark between Scenarios

	Sum case							**Congestion mark**						
	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
No congestion	8	20	30	16	9	36	28	80	200	300	160	90	360	280
Migrate	10	26	15	24	13	24	17	80	208	144	192	104	192	136
Crowded	38	49	31	32	39	28	33	76	98	62	64	78	56	66
Very crowded	31	31	14	35	45	30	37	-62	-62	-28	-70	-90	-60	-74
Severe G1	40	7	32	14	22	11	15	-240	-42	-192	-84	-132	-66	-90
Severe G2	5	4	8	8	5	3	5	-40	-32	-64	-64	-40	-24	-40
Very severe G1	2	1	4	6	1	6	1	-36	-18	-72	-108	-18	-108	-18
Very severe G2	3		1	2	2	0	1	-72	0	-24	-48	-48	0	-24
Craw	1			1	0	0	0	-30	0	0	-30	0	0	0
Sum								-244	352	126	12	-56	350	236

Table 6.15: Comparison between all scenarios

It can be seen that scenario 4 has the highest mark of all scenarios, just after the ideal situation in Scenario O, which assumes that there is no activity at all. By comparison scenario 5-Relocate 50% combined with road expansion can achieve about 67% (236/352) of the congestion mark for the ideal situation. It is a considerable achievement.

By relocating 50% of organizations combined with road expansion, the "Severe G1" cases can be reduced from 40 to 15 and increases the number of "No congestion" segments from 8 to 28, also increasing the number of "Migrate" segments from 10 to 17.

A comparison between scenarios is made for each travel direction as in the tables below

Morning-Way In (frequency)

No.	Congestion level	Current situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
1	No congestion	2	4	7	4	2	10	8
2	Migrate	3	9	6	9	4	10	6
3	Crowded	10	13	7	13	13	9	9
4	Very crowded	3	7	3	7	11	5	9
5	Severe G1	15	2	9	2	5	1	3
6	Severe G2	1		3				
7	Very severe G1	1						
8	Very severe G2							
9	Craw							

Morning-Way Out (frequency)

No.	Congestion level	Current situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
1	No congestion	3	3	9	3	3	7	7
2	Migrate	5	6	7	5	5	6	8
3	Crowded	14	13	12	6	7	8	7
4	Very crowded	9	9	3	13	14	9	9
5	Severe G1	2	2	2	2	4	2	2
6	Severe G2	1	1	1	4	1	2	1
7	Very severe G1				1			
8	Very severe G2							
9	Craw							

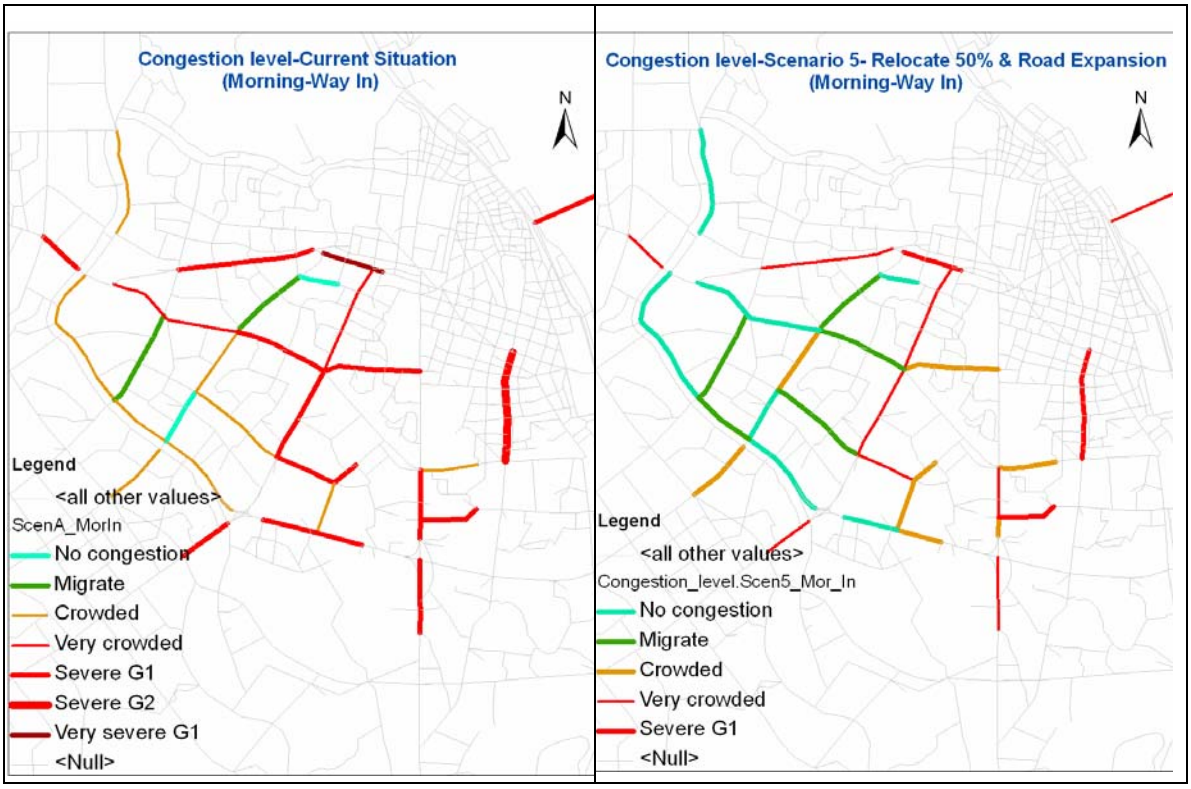
Afternoon-Way In (frequency)

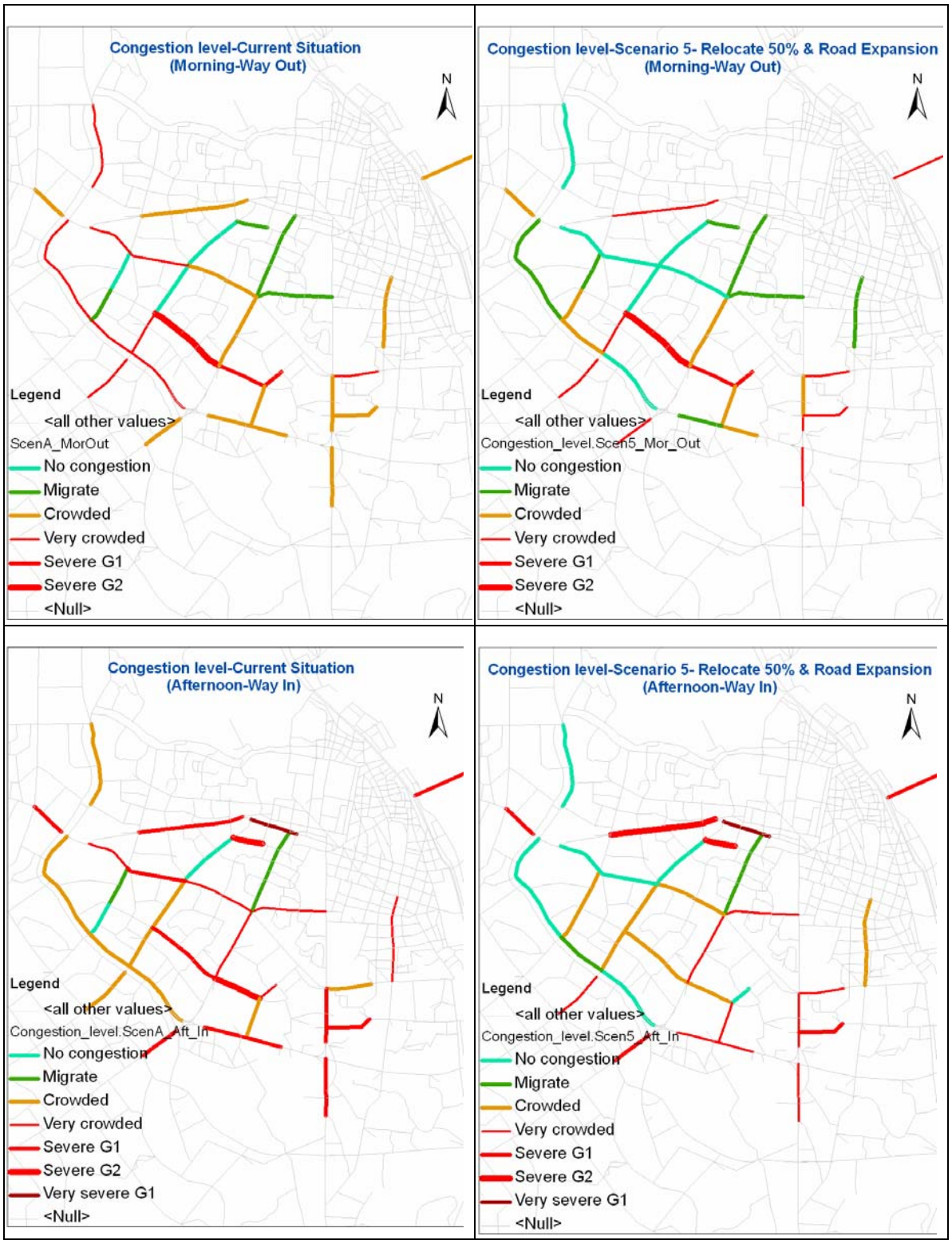
No.	Congestion level	Current situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
1	No congestion	2	6	8	3	1	7	7
2	Migrate	2	7		6	3	6	2
3	Crowded	10	10	8	7	10	4	9
4	Very crowded	6	8	5	7	11	10	10
5	Severe G1	12	2	9	4	6	4	4
6	Severe G2	2	2	1	3	2	1	2
7	Very severe G1	1		1	2		3	
8	Very severe G2				2			
9	Craw				1			

Afternoon-Way Out (frequency)

No.	Congestion level	Current situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
1	No congestion	1	7	6	6	3	12	6
2	Migrate		4	2	4	1	2	1
3	Crowded	4	13	4	6	9	7	8
4	Very crowded	13	7	3	8	9	6	9
5	Severe G1	11	1	12	6	7	4	6
6	Severe G2	1	1	3	1	2		2
7	Very severe G1		1	3	3	1	3	1
8	Very severe G2	3		1		2		1
9	Craw	1						

Table 6.16: Comparison of congestion level of all scenarios for each direction




Congestion level-Current Situation
(Morning-Way Out)
N
Legend
<all other values>
ScenA_MorOut
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Scenario 5- Relocate 50% & Road Expansion
(Morning-Way Out)
N
Legend
<all other values>
Congestion_level.Scen5_Mor_Out
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Current Situation
(Afternoon-Way In)
N
Legend
<all other values>
Congestion_level.ScenA_Aft_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
<Null>
Congestion level-Scenario 5- Relocate 50% & Road Expansion
(Afternoon-Way In)
N
Legend
<all other values>
Congestion_level.Scen5_Aft_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
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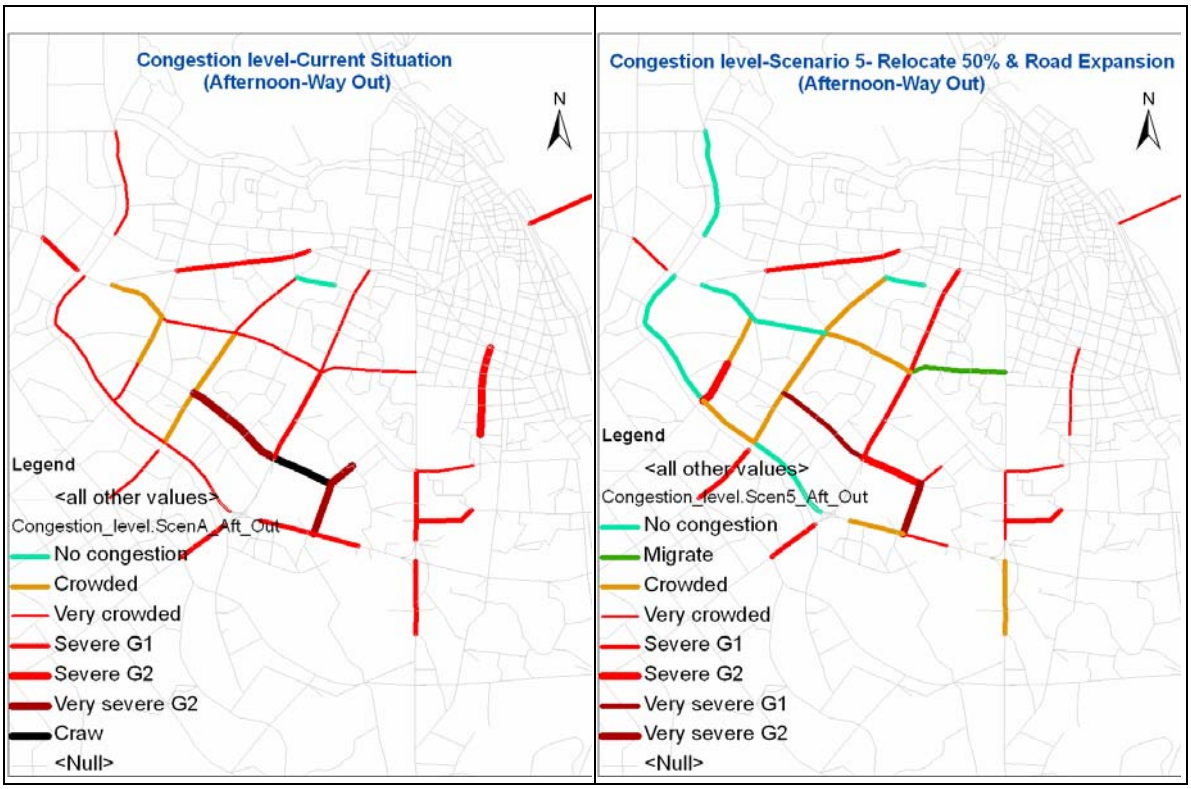
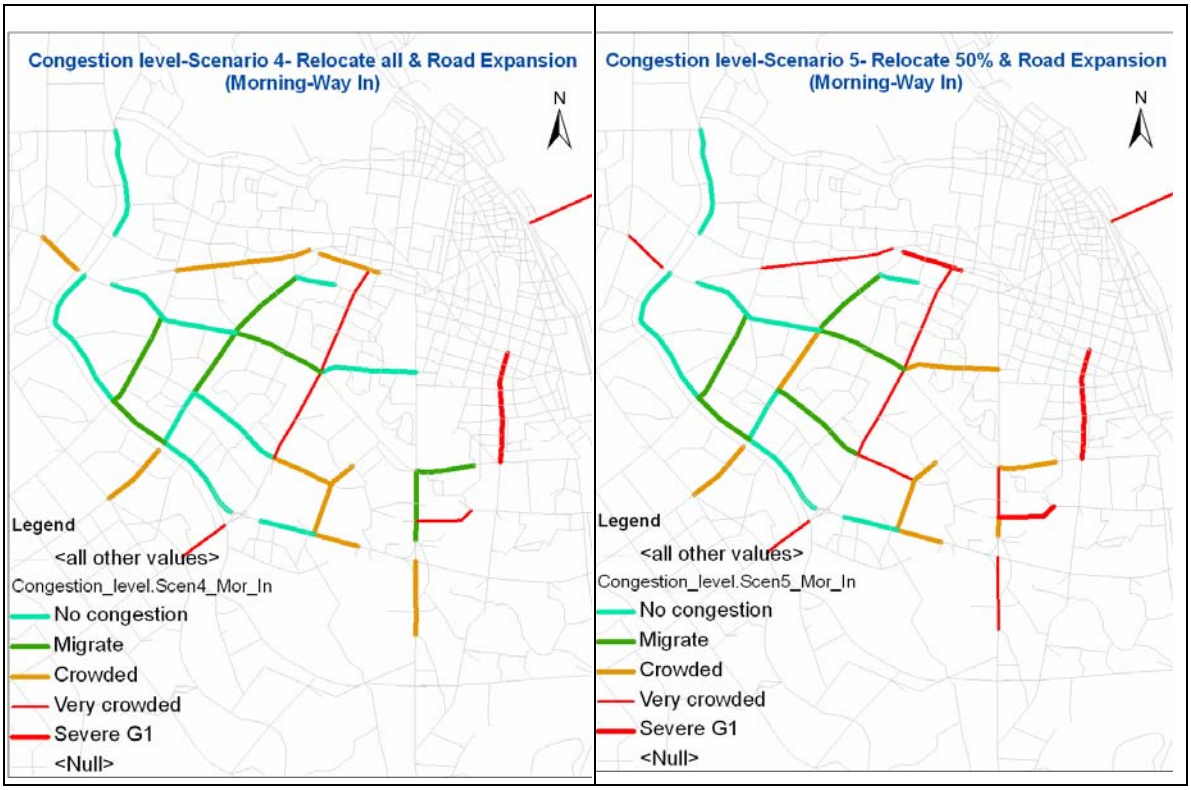
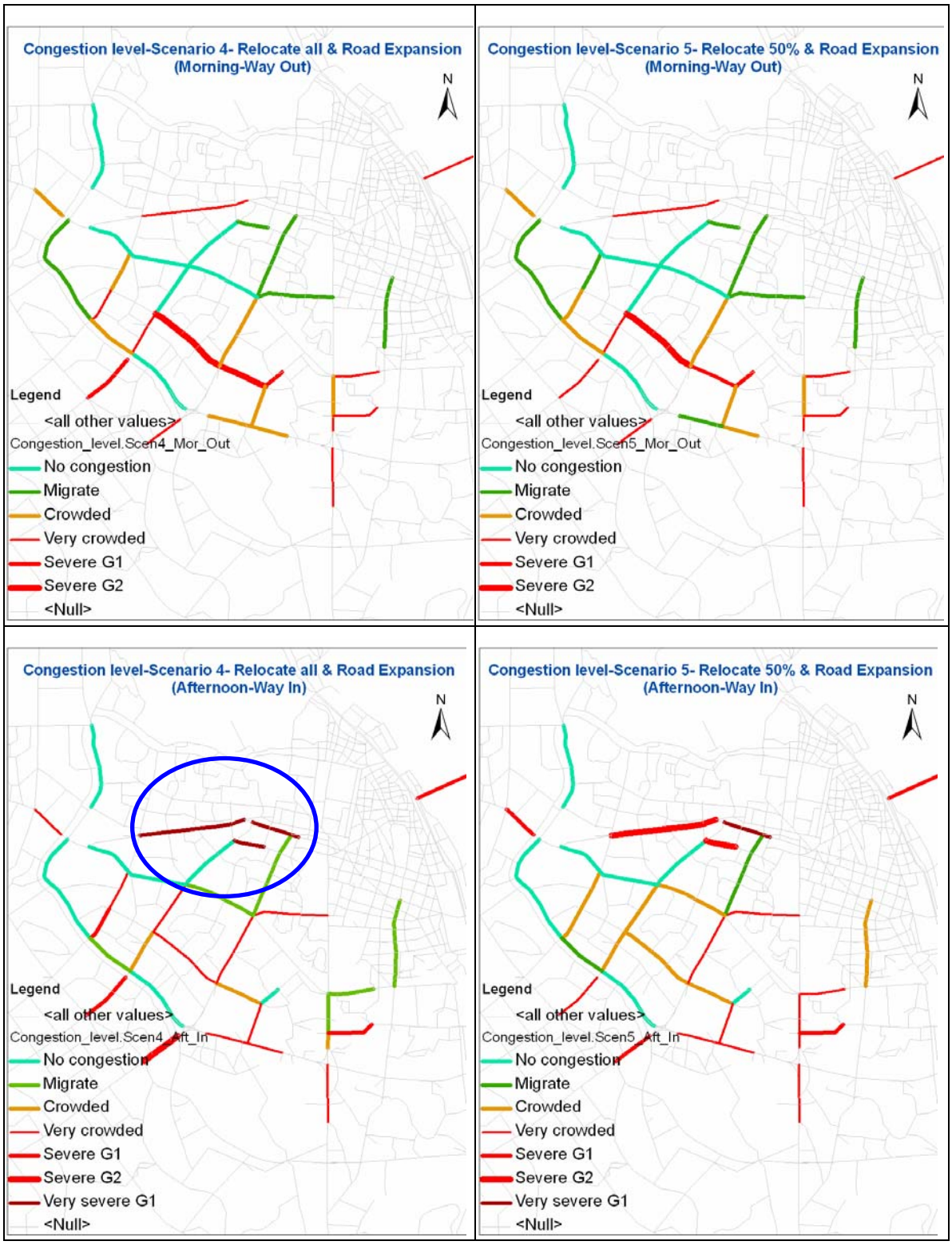


Figure 6.11: Comparison between Current Situation and Scenario 5

In general, the congestion has been relieve quite a lot except for Ton That Tung, Thai Ha streets in the afternoon-the way-out which is still under high pressure.

6.7. Comparision between Scenario 4 and Scenario 5




Congestion level-Scenario 4- Relocate all & Road Expansion (Morning-Way Out)
N
Legend
<all other values>
Congestion_level.Scen4_Mor_Out
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Scenario 5- Relocate 50% & Road Expansion (Morning-Way Out)
N
Legend
<all other values>
Congestion_level.Scen5_Mor_Out
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
<Null>
Congestion level-Scenario 4- Relocate all & Road Expansion (Afternoon-Way In)
N
Legend
<all other values>
Congestion_level.Scen4_Aft_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
<Null>
Congestion level-Scenario 5- Relocate 50% & Road Expansion (Afternoon-Way In)
N
Legend
<all other values>
Congestion_level.Scen5_Aft_In
No congestion
Migrate
Crowded
Very crowded
Severe G1
Severe G2
Very severe G1
<Null>

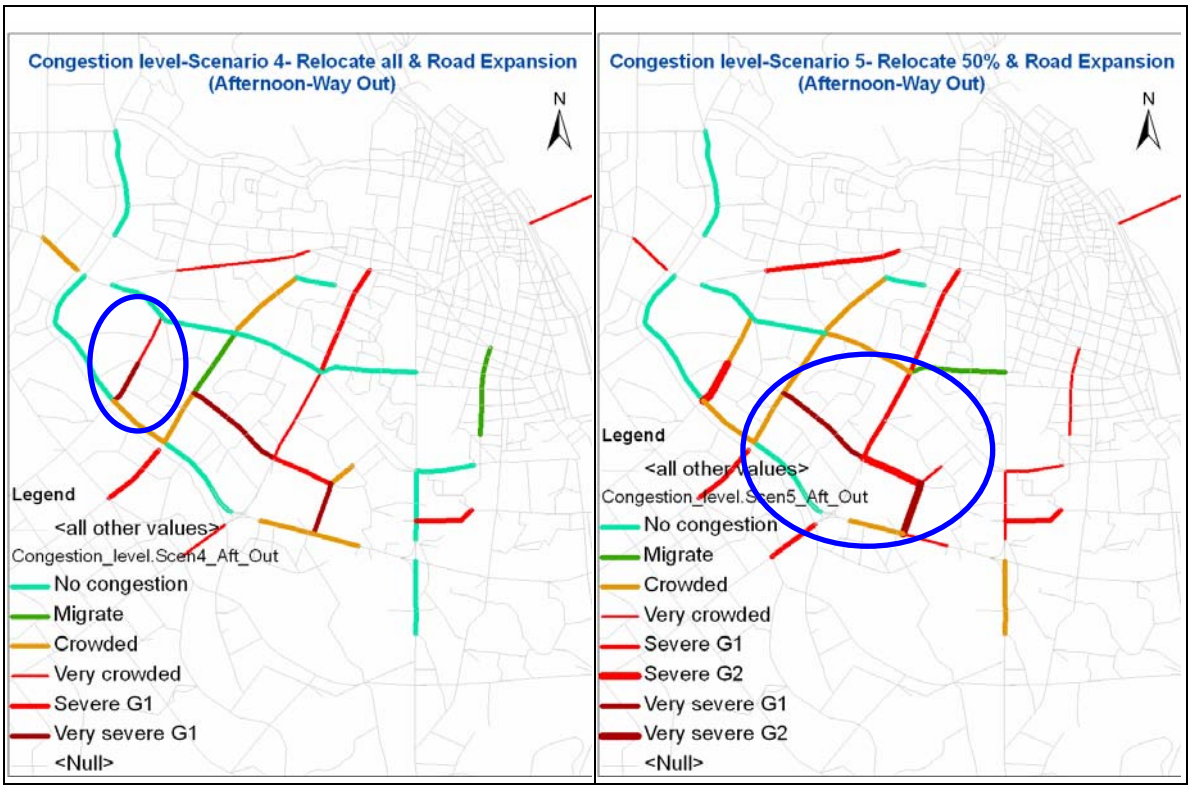


Figure 6.12: Comparison between scenario 4 and scenario 5

The most critical now is the way-out situation in the afternoon at Ton That Tung, Chua Boc, Thai Ha streets. By comparing scenarios 4 and scenario 5, it can be recognized that in the afternoon for both the way-in and the way-out, the scenario 5 is more in balance than scenario 4, because in scenario 4 even it produces more "No congestion" and "Migrate" cases, but the congestion level on some corridors like Nguyen Chi Thanh street is more severe than in scenario 5. Therefore, even scenario 4 has a higher congestion mark than scenario 5, but in general scenario 5 is more in balance.

6.8. Change in trip origin

This scenario is 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, many newly-built residential areas have been constructed with good infrastructure as depicted in the figure below.

Figure 6.13: Newly-built residential areas

In recent years, from 1999 to 2005, population in these areas (Thanh Xuan, Cau Giay, Tu Liem, and Hoang Mai district) have increased with about 6% on average as indicated in the table 3.1. In the future, the number of people moving out is expected to be more since the construction has been accelerated, the house quality is better, and the price is getting cheaper. That is the policy of government to attract people moving out from the city centre.

6.8.1. Scenario 5A

If we assume that 18.0 % (6% * 3 times) of people in the city centre (Hoan Kiem, Ba Dinh, Dong Da, and Hai Ba Trung districts) will move out to new residential areas, especially Dinh Cong, Hoang Liet, Thanh Xuan, Trung Hoa, Me Tri, My Dinh wards.

This calculation is applied for Scenario 5, named Scenario 5A. We will cut down 18.0% of all trips from the city centre and distribute equally the total number of cut-down trips to 6 wards mentioned above. This calculation is applied for each organization separately for morning peak and afternoon peak hour (The reason is that people use different routes to the organizations); the traffic volumes on the corridors for scenarios 1, 4 and 5 have been re-calculated. 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 for both morning and afternoon. Therefore, the calculation is basically done with 18% cut-down of all the trips from the city centre.

The result is summarized in the table below.

Comparision of congestion level & Congestion Mark between Scenarios

	Sum case								Congestion mark							
	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 5A	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 5A
No congestion	8	20	30	16	9	36	28	29	80	200	300	160	90	360	280	290
Migrate	10	26	15	24	13	24	17	16	80	208	144	192	104	192	136	128
Crowded	38	49	31	32	39	28	33	32	76	98	62	64	78	56	66	64
Very crowded	31	31	14	35	45	30	37	39	-62	-62	-28	-70	-90	-60	-74	-78
Severe G1	40	7	32	14	22	11	15	15	-240	-42	-192	-84	-132	-66	-90	-90
Severe G2	5	4	8	8	5	3	5	5	-40	-32	-64	-64	-40	-24	-40	-40
Very severe G1	2	1	4	6	1	6	1		-36	-18	-72	-108	-18	-108	-18	
Very severe G2	3		1	2	2		1	1	-72		-24	-48	-48		-24	-24
Craw	1			1					-30			-30				
Sum									-244	352	126	12	-56	350	236	250

Table 6.17: Summary congestion level and congestion mark of scenario 4A, 5A

We can see that the situation has been improved, but not very much. Therefore, in the next scenario 5B, it is assumed that 50% of people will move along to the new locations.

6.8.2. Scenario 5B

This scenario is constructed with an assumption that government's policy is successful, which attracts 50% of staffs moving out from the city centre to live in new residential areas. Assume that those persons will work at new bases. The calculation is similar to scenario 5A with the cut-sown of 50% all the trips from the city centre.

The result is summarized as follows (For more details, please refer to appendix L).

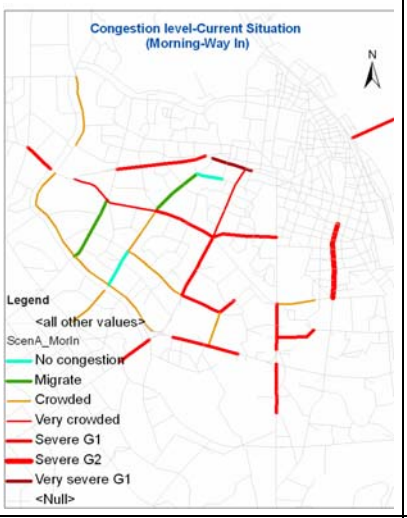
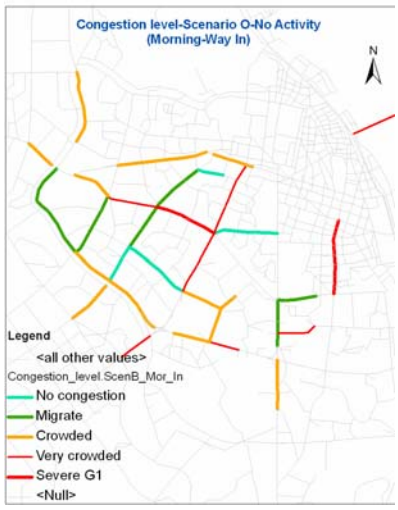
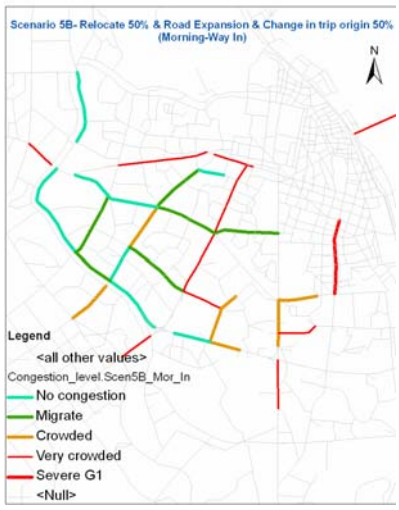
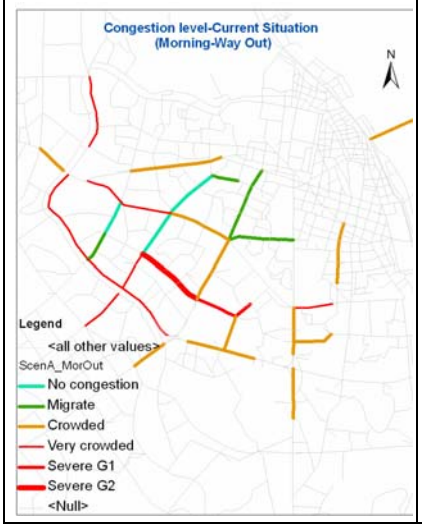
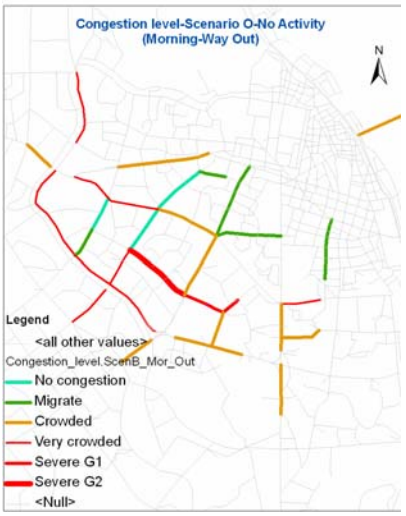
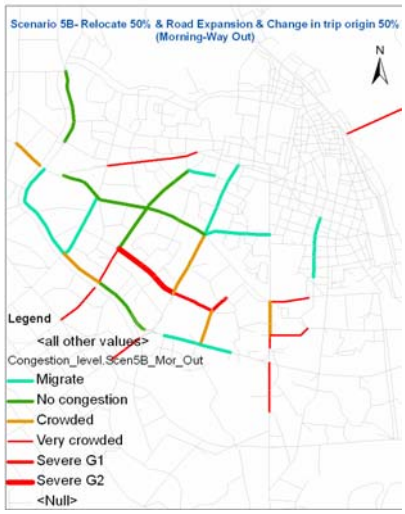
Comparision of congestion level & Congestion Mark between Scenarios

	Sum case									Congestion mark								
	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 5A	Scenario 5B	Current Situation	Scenario O	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 5A	Scenario 5B
No congestion	8	20	30	16	9	36	28	29	29	80	200	300	160	90	360	280	290	290
Migrate	10	26	15	24	13	24	17	16	20	80	208	144	192	104	192	136	128	160
Crowded	38	49	31	32	39	28	33	32	35	76	98	62	64	78	56	66	64	70
Very crowded	31	31	14	35	45	30	37	39	34	-62	-62	-28	-70	-90	-60	-74	-78	-68
Severe G1	40	7	32	14	22	11	15	15	14	-240	-42	-192	-84	-132	-66	-90	-90	-84
Severe G2	5	4	8	8	5	3	5	5	4	-40	-32	-64	-64	-40	-24	-40	-40	-32
Very severe G1	2	1	4	6	1	6	1		1	-36	-18	-72	-108	-18	-108	-18		-18
Very severe G2	3		1	2	2		1	1		-72		-24	-48	-48		-24	-24	
Craw	1			1						-30			-30					
Sum										-244	352	126	12	-56	350	236	250	318

Table 6.18: Comparison congestion level and congestion mark of Scenario 5B with others

It can be seen that the situation is improved a lot. It comes near to the ideal situation, scenario O, which assumed that no activity happens at the study areas.

This will be compared with the current situation, situation in Scenario 5B and ideal situation of Scenario O.

Current situation	Ideal situation-Scenario O	Scenario 5B
		
		

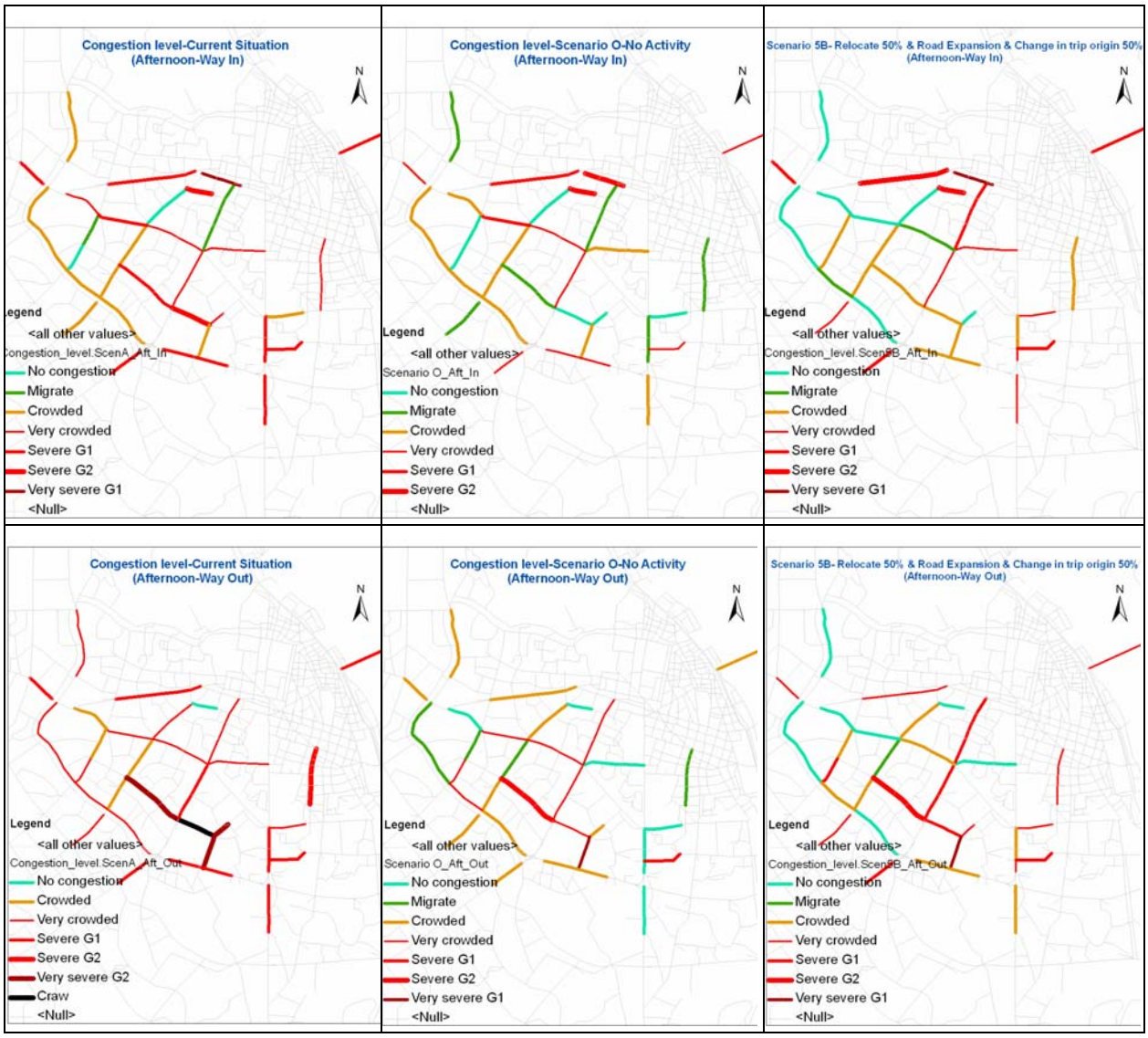


Figure 6.14: Comparison between Current situation, Scenario O and Scenario 5B

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.

6.9. Conclusions

In this chapter, six scenarios have been constructed for evaluation of traffic congestion. The result of scenarios gives us a clear view that infrastructure alone or relocation alone can not solve traffic congestion, only by a combination between infrastructure and relocation we can have achievement in relief traffic congestion. Even scenario 4 has higher congestion mark than scenario 5 but scenario 5, relocate 50% combine with road expand, is more balance between the way-in and the way-out. Further more, relocate 50% is more realistic in Hanoi situation. Finally, scenario 5B is a modification of scenario 5 with an assumption that 50% of people will move out of the city centre to live in the newly-built residential areas and work at new locations shows that it comes near to the ideal situation in scenario O with 90% (318/352). 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.

In conclusion, by integration between land-use and transport and in this case is the combination between road expansion and relocation, the traffic congestion can be relived considerably.

7. Conclusions and Recommendations

7.1. 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.

Based on existing government plans, two study areas have been proposed for evaluation, i.e. study area no.1, which is Bach Mai area, where three big universities with almost 70,000 students and a group of hospitals are located, and study area no. 2, which is in the urban core (Hoan Kiem district), where three big hospitals and 161 government offices at the national level with around 16,218 staffs are located. In total, five hospitals, three universities and two government offices were therefore targeted for cordon counts and office-based interviews to retrieve information on total numbers of trips arriving at these locations in and outside peak hours, the trip origins, travel time, travel length, transport mode and routes used.

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, and Thai Ha streets with shares of about 23%, 27% and 23% respectively just on the way-in in the morning peak hour while in the afternoon peak hour they contribute to both the way-in and the way-out as for about 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 since universities release students from afternoon-classes around 17:15 PM and attract students to night-classes from 17:30 to 18:00PM. About 97.2% of students commune on these corridors during the afternoon peak hour. Study area no.2 contributes considerably to the other corridors such as Kham Thien, Nguyen Thai Hoc and Kim Ma with a contribution of about 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. About 95% of government staff uses motorcycle and 95.5% of them commune on these corridors during peak hours.

The possibility for relieving the current congestion situation by expanding and building some roads and bridges alone, which is planned by Ministry of Transport, is investigated in the first scenario. Scenario no.1 shows that the situation can be improved by expanding road capacity, but the number of severe congested and very severe congested cases is still very high. Therefore, this strategy is fails in dealing with congestion appropriately.

A full relocation, without infrastructure measures, is studied in the next scenarios. Scenario 2 relocates all land-uses to the west, while in the following scenario 3 only 50% is relocated to the west. Both scenarios show that the situation even worse than scenario 1 because instead of

relieving congestion it produces more congestion on the roads in the reverse directions, while the number of severe and very severe cases is even more than in the current situation. Therefore, it can be concluded that relocation alone also fails in dealing with congestion.

In the next scenario, a combination between road expansion and relocation is studied. It can be seen from this scenario 4 where all the land-uses are relocated to the west in combination with road expansion that the situation is improved very much and it already comes near with the "ideal" base-line situation in scenario O. The base-line scenario assumes that there is no activity at all in our study areas anymore and that people simply abort making these trips. The number of segments with traffic segments rated "No congestion" and "Migrate" have been increased from 8 to 36, and from 10 to 24 respectively, the number of "Severe G1" is cut down from 40 to 11 cases, except for "very severe G1" which have increased in number from 2 to 6. Anyway, this scenario is not too realistic as it is very difficult to move all these organizations out of the city centre. Besides that the situation might be worse if the purpose of land-use changes to commercial or residential one. For that reason, in scenario 5 it is proposed that only 50% of organizations will move to new locations. The result shows us that the situation is improved very much as compared to scenario 1, which is expansion of road alone, and scenario 3, which is relocation alone. This scenario achieves 67% of the "lowest possible" congestion mark from the ideal situation of scenario 0. In short, it can be concluded that by combining road expansion and partly relocation, a considerable congestion relief can be achieved.

In addition, scenarios 5A and 5B have been proposed that assume 18% and 50% of people respectively will move to the newly-built residential areas for living, so a realistic change in trip origin is also assumed. Scenario 5A is not very much different from scenario 5. The result of scenario 5B shows that it comes very near to the ideal situation from scenario 0 with 90% of the "lowest possible" score. This 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.

All these analyses have been done by applying advanced spatial and network capabilities of GIS. The travel data has been gathered by performing a large-scale workplace survey and cordon traffic counts.

In conclusion, a further integration of land-use and transport can be achieved congestion relief if it is done in a combination between road expansion and relocation.

7.2. Limitations of this research

Due to limit in time, for this research only one indicator, i.e. the number of vehicles on corridors is applied for the evaluation. Other indicators like total travel length, total travel time, number of people shifting from motorcycle to green modes (walking, cycling, and bus) could have been used also for the evaluation because these will also benefit from relocating and road expansion policies.

In addition, current calculations have been based on some assumptions such as:

- People go from or return to their commune centre (homes). It means that the commune centre is used as the trip origin/trip destination.
- People use shortest route measured in travel time.

- 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.
- Assume all government offices in the urban core have the same characteristics (trip origin, mode share, travel time) with the surveyed ones.

The corridors used were recorded by hand. Since this is a time consuming task counts have only been performed in one representative peak per location. This may have caused some errors.

7.3. Recommendations

7.3.1. Recommendations for transport and land-use policy in Hanoi

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 for redistribution and relocation, especially offices in the urban core 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.
- Bachelor students (account for 50% of total students as mentioned in 5.4.2) should be stimulated to move out to new locations. The existing bases should be kept for higher education and other courses like second-degree course, and in-service courses.
- 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.
- 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. For example, offices which have more than 50 staff should be moved out, especially government offices, foreign offices, and business enterprises; only head-quarter offices can be remained in the urban core; new high-rise buildings is not allowed to construct in the urban core, etc.
- Facilities for cycling and walking like cycling path, cycling and walking signals, etc should be installed to further encourage people to use these green modes instead of using private vehicles (The existing policy does not encourage people using these mode as mentioned in 3.5).
- Some basic social facilities like hospitals and universities should be redistributed to achieve equity and better accessibility for people in the whole city.

7.3.2. Recommendations for further studies and improvement

Due to the time limit, for this research only one indicator (number of vehicles on a corridor) is applied for evaluation. It is recommended to apply the other indicators like total travel length, total travel time, number of people shifting from motorcycle to green modes (walking, cycling, and bus) for evaluation the benefit of relocating some major land-uses.

It is recommended to apply GIS application for facility improvement to encourage people using green modes using GIS application like designing cycling paths, private bus routes, etc.

It is recommended to study the criteria to suggest which group of offices and enterprises should be the best to move from the urban core and Ba Dinh district.

It is recommended to study how basic social facilities like hospitals, universities and schools should be redistributed to achieve social equity and better accessibility for people in the whole city.

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Appendixes

Appendix A:

Giao thông Hà Nội: xây dựng mới, hay cơi nới cũ? (http://hinet.net.vn/news)

Để đạt chỉ tiêu đất dành cho giao thông đạt 20-25% đất đô thị tại nội thành Hà Nội, thành phố cần 15 triệu m2 với số tiền GPMB lên đến 210.000 tỷ đồng (khoảng 14 tỷ USD).

Bài toán khó: Giải thế nào?

9 quận nội thành Hà Nội có diện tích khoảng 110 km2. Tuy nhiên diện tích đường bộ của Hà Nội chỉ đạt khoảng 6km2 (gần 400 km đường), tương đương 6% diện tích đô thị.

Không chỉ diện tích đường thấp mà đường còn phân bố không đều. Quận Hoàn Kiếm có tỷ lệ đường giao thông đạt 12% so với diện tích đô thị, trong khi các quận còn lại tỷ lệ chỉ đạt 5%.

Tại các nước phát triển, quỹ đất dành cho giao thông đạt 20- 25% đất đô thị (đó là chưa kể diện tích ngầm và diện tích khoảng không xây dựng các công trình giao thông).

Để có thể giải quyết căn bản tình trạng ùn tắc giao thông tại Hà Nội, theo các chuyên gia, Hà Nội phải nâng quỹ đất dành cho giao thông lên 20% đất đô thị (tương ứng 20km2). Như vậy Hà Nội cần thêm 15km2 đất (14 triệu m2).

" ... Cho đến nay Thủ đô Hà nội chưa có được một quy hoạch chuyên ngành, đồng bộ, toàn diện về phát triển giao thông vận tải được tôn trọng và đầu tư có hệ thống theo một chương trình đầu tư trọng điểm quốc gia tương xứng với vai trò, vị trí của Thủ đô"

Trích Văn bản góp ý cho " Quy hoạch phát triển GTVT Thủ đô Hà Nội đến năm 2020" của UBND TP Hà Nội gửi Bộ GT-VT.

Nếu lấy dự án đường Kim Liên-Ô Chợ Dừa làm chuẩn thì mỗi m2 đất có giá đền bù GPMB khoảng 14 triệu đồng.

Để nâng diện tích đất giao thông lên 20%, Hà Nội cần đầu tư thêm 210.000 tỷ đồng (14 tỷ đô la) cho việc GPMB. Nếu tính cả tiền xây lắp đường (khoảng 20% tổng mức đầu tư) thì mức đầu tư lên đến 17 tỷ đô la, (khoảng 250.000 tỷ đồng).

Và nếu xây dựng đường tàu điện ngầm và đường sắt chi phí này còn cao hơn nhiều.

Trước số tiền khổng lồ trên có hai luồng quan điểm. Một là: Hà Nội nên dành tiền đầu tư hạ tầng giao thông và phát triển khu đô thị mới với các loại hình dịch vụ, hạ tầng xã hội hoàn hảo, giá bán nhà rẻ. Khu vực từ vành đai 2 trở vào nên giữ nguyên hiện trạng, chỉ sửa chữa nhỏ.

Quan điểm này có ưu điểm là chi phí đầu tư thấp, sẽ giãn mật độ dân cư nội thành Hà Nội, theo đó giảm sức ép giao thông và kéo tụt giá nhà đất tại nội thành, tạo điều kiện để sau này mở mang, chỉnh trang đô thị. Tuy nhiên, làm được việc này cần phải có thời gian dài và bức xúc giao thông tại nội thành sẽ rất căng thẳng.

Quan điểm 2, vừa đầu tư xây dựng hạ tầng giao thông trong nội thành, vừa đẩy nhanh xây dựng mới các khu đô thị hấp dẫn người dân nội thành đến ở. Ưu điểm của phương án này là vừa giãn dân (lượng dân phải di dời do GPMB để xây dựng các công trình giao thông), đồng thời "xoa dịu" tình trạng ùn tắc giao thông trong nội thành.

Kèm theo đó, chính sách hạn chế phát triển khu vực nội thành phải được thực hiện nghiêm ngặt. Vậy nhưng, nếu cứ chú trọng xây dựng hạ tầng giao thông tại nội thành sẽ dẫn đến người dân không mặn mà đến các khu đô thị mới. Giá đất vẫn cao và cuộc "cách mạng" sẽ không đem lại kết quả cao. Thêm nữa, chi phí đầu tư của phương án này sẽ rất cao. Có điểm chung, cả hai quan điểm đều thống nhất "giãn khỏi trung tâm"!

Giãn cơ quan Nhà nước ra khỏi trung tâm

Với 15 tỷ đô la, các chuyên gia kinh tế cho rằng Hà Nội có thể hoàn toàn xây dựng được một trung tâm chính trị, kinh tế, y tế, giáo dục... mới nằm ngoài đường vành đai 3. Tuy nhiên, vấn đề đặt ra là ai sẽ là người chịu di dời khỏi trung tâm Hà Nội? Giãn dân! Tất nhiên rồi, nhưng TP Hà Nội chưa hấp dẫn được người dân ra ngoại ô sinh sống.

Lý do là: hạ tầng xã hội yếu kém (chợ, bệnh viện, trường học, ngân hàng, khu vui chơi, giải trí...) chưa có. Thứ hai, giá nhà, đất tại các đô thị mới quá cao vượt sức mua của đại đa số người dân. Điều quan trọng là hầu hết trụ sở làm việc của các cơ quan, đơn vị vẫn nằm trong nội thành. Vì lý do đó, nhu cầu và quãng đường đi lại của người dân tại các khu đô thị mới tăng lên. ùn tắc giao thông không giảm. Người dân "cố thủ" tại nội thành.

Vì vậy, để có thể "giãn cư", Hà Nội cần phải có chính sách giãn các cơ quan ra ngoại ô. Năm 2001, quy hoạch chi tiết Làng đại học tại Đại Mỗ và Tây Mỗ (huyện Từ Liêm) được phê duyệt. Nếu như các trường Bách khoa, Kinh tế Quốc dân, Xây dựng được di chuyển, chắc chắn sức ép về giao thông đô thị tại khu vực đường Giải Phóng, Bạch Mai sẽ được cải thiện đáng kể.

Rất tiếc dự án này đến nay chưa được triển khai. Bên cạnh các trường học, một số bệnh viện lớn cũng cần được giãn ra ngoài đường vành đai 3 thuận tiện cho việc ra vào viện của bệnh nhân từ các tỉnh đến như bệnh viện Bạch Mai, Việt Đức, Viện K, Viện C... Làm được việc này, một mặt chúng ta có điều kiện đầu tư một cách bài bản cho các bệnh viện, mặt khác làm giảm ùn tắc cho khu vực nội thành.

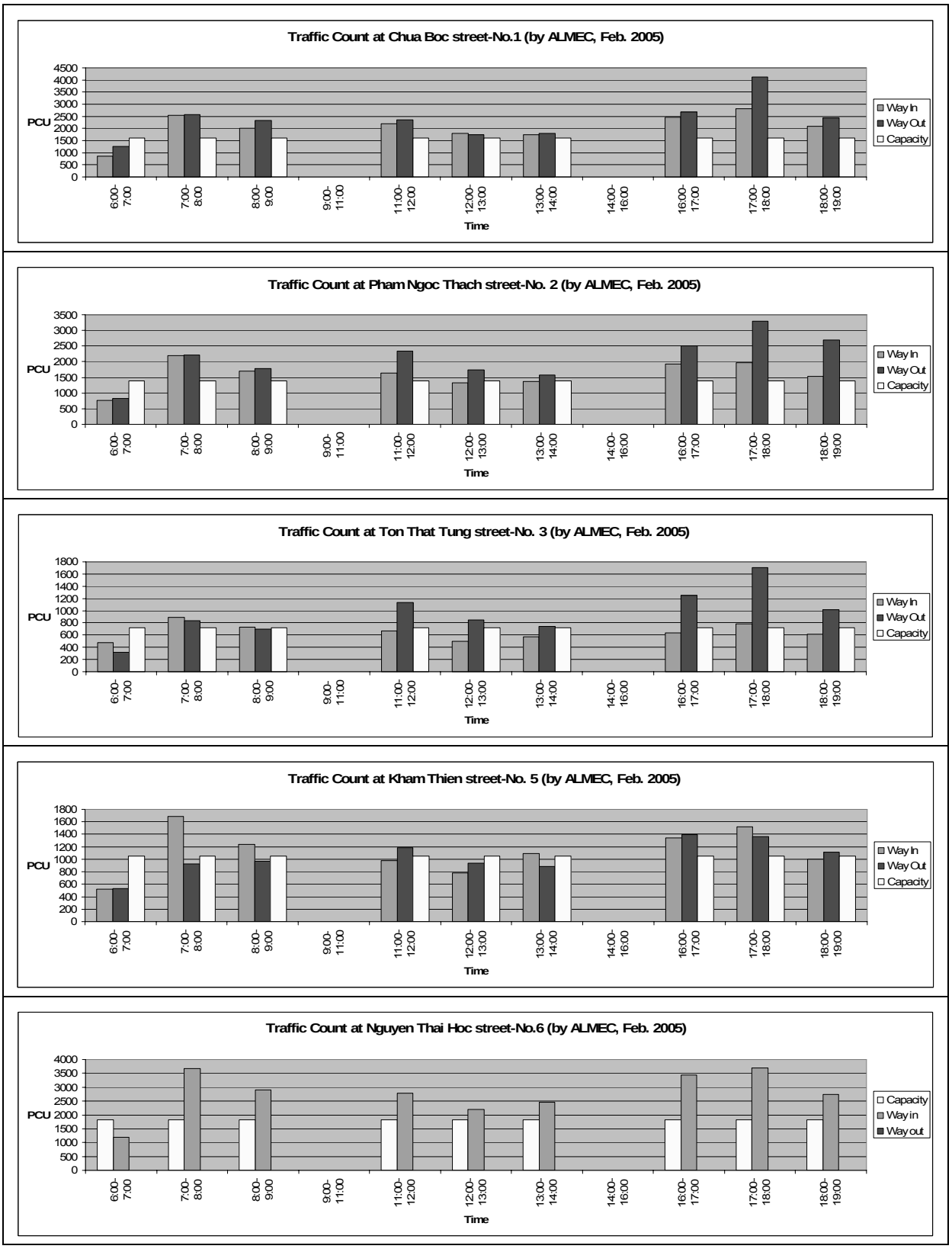
Đối với cơ quan hành chính? Năm 2004, Trung tâm Hội nghị quốc gia được xây dựng tại Mễ Trì. Dư luận kỳ vọng đây sẽ là dấu hiệu của một cuộc di chuyển các cơ quan hành chính ra khỏi trung tâm Hà Nội. Nhưng không, trụ sở một số Bộ tiếp tục được xây dựng hoành tráng ngay trung tâm phố cũ.

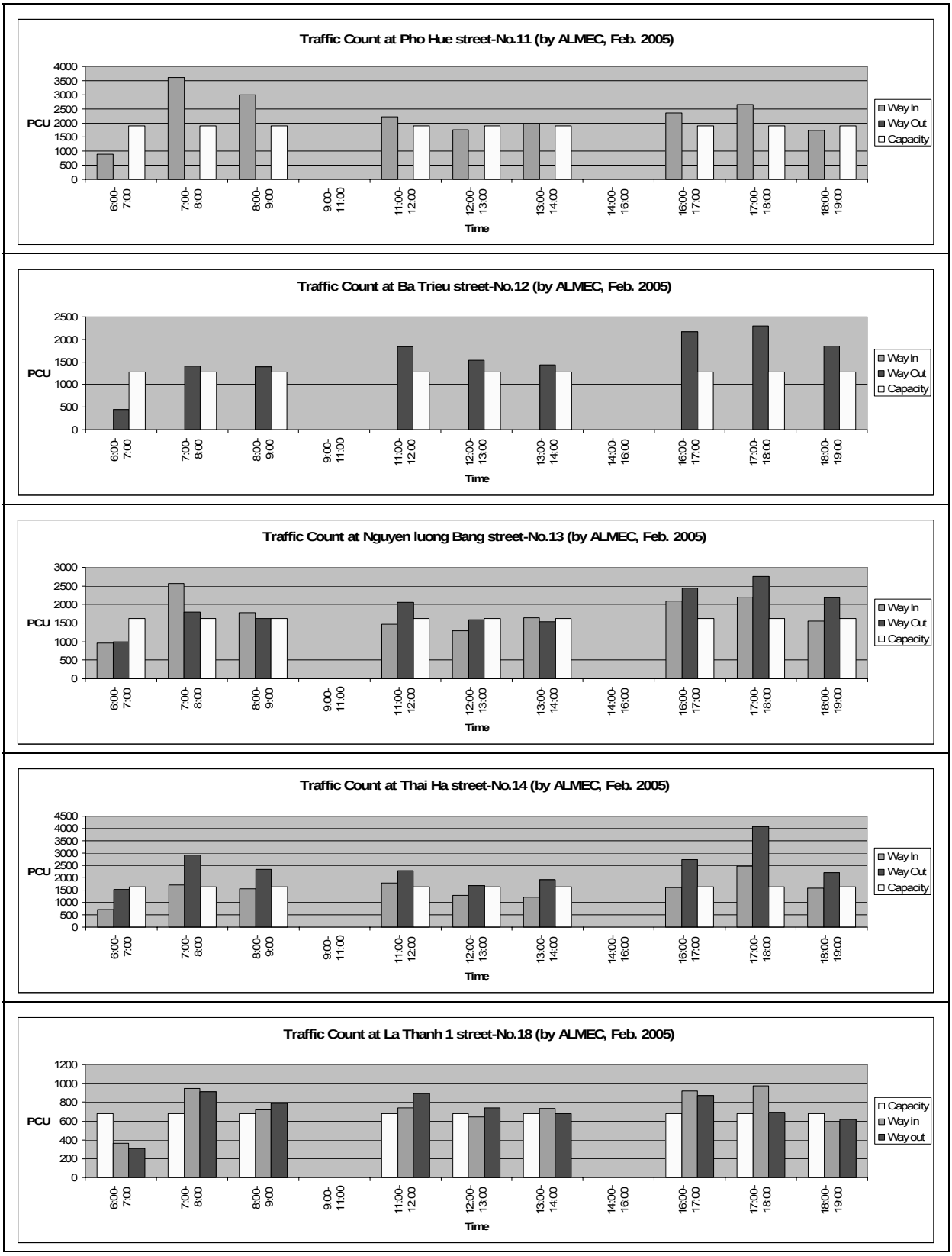
Trong bối cảnh ùn tắc giao thông nghiêm trọng, đầu tư xây dựng hạ tầng vô cùng khó khăn, để hóa giải bài toán giao thông, việc giãn dân ra khỏi nội thành là hết sức cần thiết. Tuy nhiên, để làm được việc này, Hà Nội cần phải có những chính sách cụ thể.

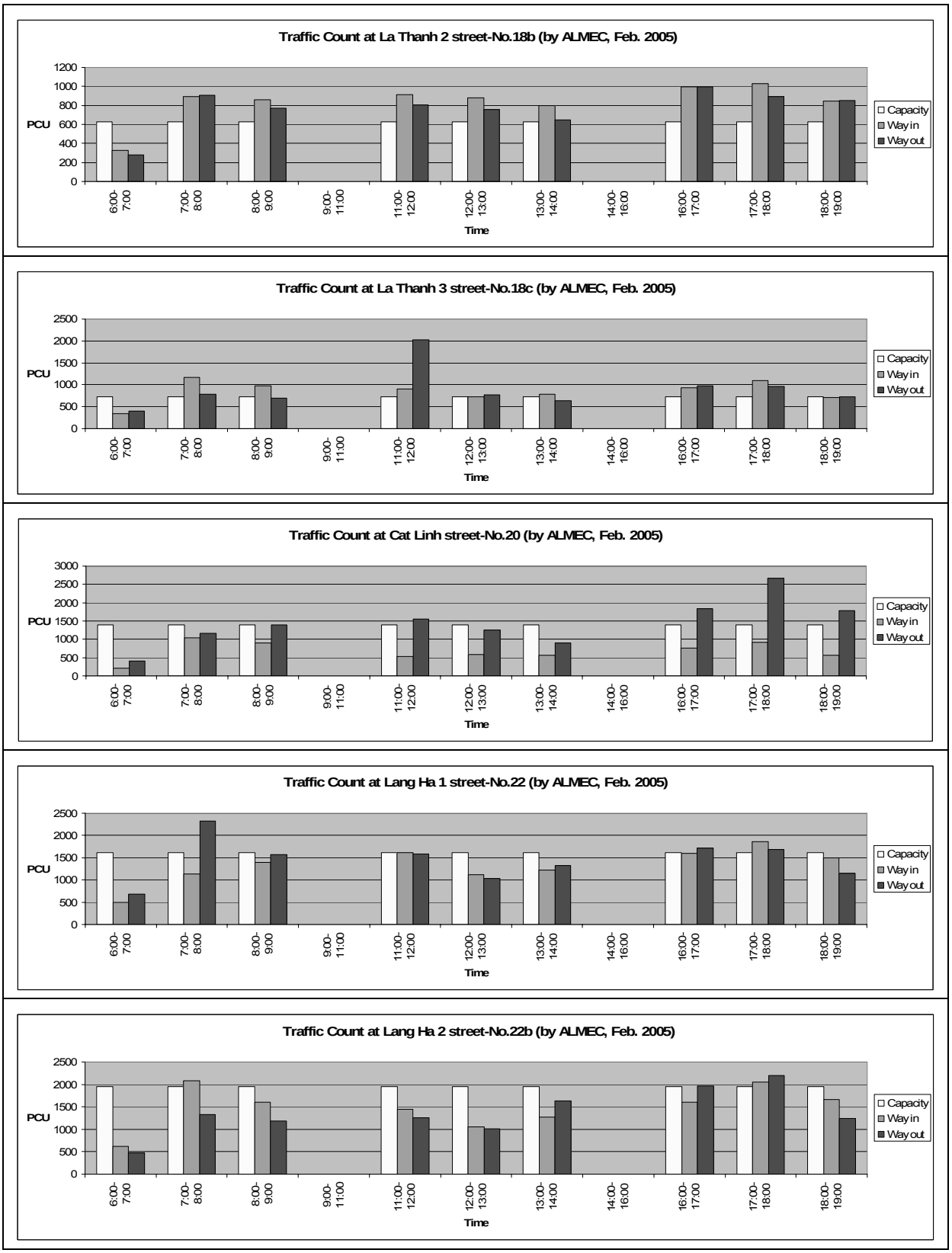
Ví như: chính sách bán nhà trả góp, hạ giá bán nhà chung cư, xây dựng hạ tầng kỹ thuật, hạ tầng xã hội cho đô thị mới tốt...Điều quan trọng, để khuyến khích người dân di dời khỏi trung tâm thành phố, thì bản thân các cơ quan hành chính của Trung ương và Hà Nội, các bệnh viện, trường học phải làm gương trước.

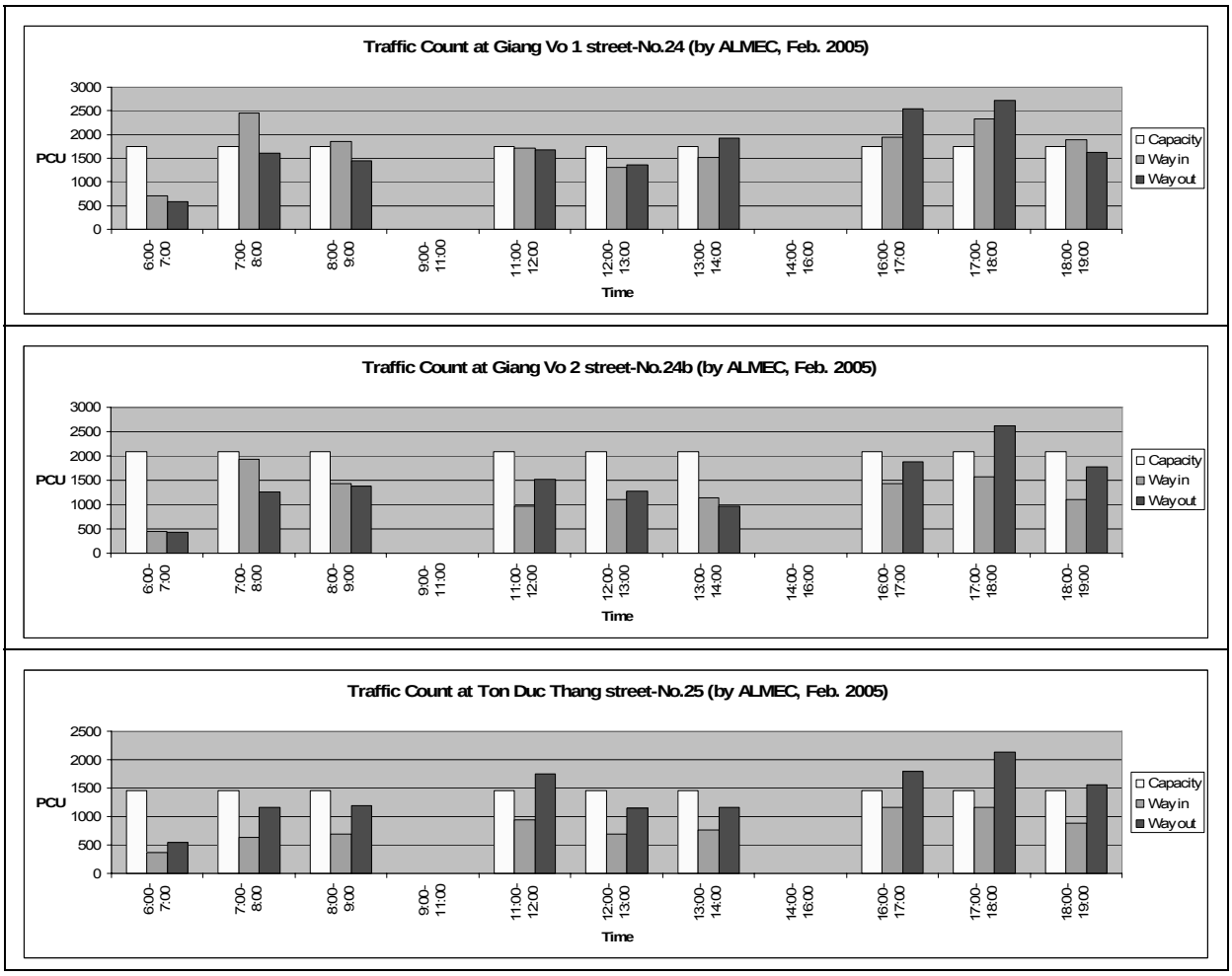
Theo TP

Appendix B: Traffic count by ALMEC, February 2005




Traffic Count at Pho Hue street-No.11 (by ALMEC, Feb. 2005)
PCU
Time
Way In
Way Out
Capacity
Traffic Count at Ba Trieu street-No.12 (by ALMEC, Feb. 2005)
PCU
Time
Way In
Way Out
Capacity
Traffic Count at Nguyen luong Bang street-No.13 (by ALMEC, Feb. 2005)
PCU
Time
Way In
Way Out
Capacity
Traffic Count at Thai Ha street-No.14 (by ALMEC, Feb. 2005)
PCU
Time
Way In
Way Out
Capacity
Traffic Count at La Thanh 1 street-No.18 (by ALMEC, Feb. 2005)
PCU
Time
Capacity
Way in
Way out
6:00-7:00
7:00-8:00
8:00-9:00
9:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00


Traffic Count at La Thanh 2 street-No.18b (by ALMEC, Feb. 2005)
PCU
Time
Capacity
Way in
Way out
Traffic Count at La Thanh 3 street-No.18c (by ALMEC, Feb. 2005)
PCU
Time
Capacity
Way in
Way out
Traffic Count at Cat Linh street-No.20 (by ALMEC, Feb. 2005)
PCU
Time
Capacity
Way in
Way out
Traffic Count at Lang Ha 1 street-No.22 (by ALMEC, Feb. 2005)
PCU
Time
Capacity
Way in
Way out
Traffic Count at Lang Ha 2 street-No.22b (by ALMEC, Feb. 2005)
PCU
Time
Capacity
Way in
Way out


Traffic Count at Giang Vo 1 street-No.24 (by ALMEC, Feb. 2005)
PCU
3000
2500
2000
1500
1000
500
0
6:00-7:00
7:00-8:00
8:00-9:00
9:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
Time
Capacity
Way in
Way out
Traffic Count at Giang Vo 2 street-No.24b (by ALMEC, Feb. 2005)
PCU
3000
2500
2000
1500
1000
500
0
6:00-7:00
7:00-8:00
8:00-9:00
9:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
Time
Capacity
Way in
Way out
Traffic Count at Ton Duc Thang street-No.25 (by ALMEC, Feb. 2005)
PCU
2500
2000
1500
1000
500
0
6:00-7:00
7:00-8:00
8:00-9:00
9:00-11:00
11:00-12:00
12:00-13:00
13:00-14:00
14:00-16:00
16:00-17:00
17:00-18:00
18:00-19:00
Time
Capacity
Way in
Way out

Appendix C: Contribution to congestion of the selected land uses

Contribution of Organizations in the Morning-The Way in

No.	Road name	Corridor code	Road intensity (pcu/h)	Current traffic Volume_Morning Peak (pcu)	Study area No. 1																Study area No. 2												Sum Total (Area 1+2)	
					Bach Mai hospital				Polytechnics Uni.				Construction Univ.				Economics Univ.				Sum area No. 1		Viet Duc Hospital		C hospital		K hospital				Government Offices		Sum area No. 2		
					Staff		Patient		Teacher& Staff		Students		Teacher& Staff		Students		Teacher& Staff		Students				Staff		Patient		Staff		Patient		Staff		Patient							
					(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%
1	Chua Boc street	No. 1-Cboc	1,595	2,552	234	9.16	118	4.63	94	3.69	63	2.48	14	0.53	19	0.75	47	1.84			589	23.09	0		0		0		0		0		0				589	23
2	Pham Ngoc Thach street	No. 2-PNThach	1,388	2,204	247	11.22	120	5.44	94	4.27	63	2.87	14	0.62	19	0.86	47	2.14			604	27.41	10	0.47	0		5	0.22	0		4	0.19	0		81	3.66	100	4.54	704	32
3	Ton That Tung street	No. 3-TTTung	723	892	0		0		0		0		0		0		0						4	0.43	0		5	0.54	0		2	0.19	0		0		10	1.17	10	1
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	981	1,514	11	0.75	0		17	1.13	0		2	0.15	0		0				31	2.03	17	1.10	0		8	0.51	2	0.10	3	0.23	2	0.12	323	21.32	354	23.38	385	25
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1,142	1,761	29	1.62	3	0.19	34	1.94	0		14	0.77	5	0.27	0				84	4.80	0		0		0		0		0		0				84	5
6	Kham Thien	No. 5-KThien	1,056	1,681	55	3.28	0		9	0.51	0		0		0		0				64	3.79	37	2.21	0		27	1.61	2	0.09	33	1.99	7	0.42	1,049	62.40	1,155	68.72	1,219	73
7	Nguyen Thai Hoc	No. 6-NTHoc	1,836	3,682	25	0.67	7	0.18	26	0.70	0		7	0.19	0		8	0.21			72	1.95	78	2.13	9	0.24	48	1.31	5	0.15	41	1.12	11	0.29	1,372	37.25	1,564	42.48	1,636	44
8	Cau Giay	No. 7-CG	1,551	2,392	29	1.19	47	1.95	34	1.43	63	2.65	0		5	0.20	8	0.33			185	7.74	28	1.18	6	0.24	10	0.40	2	0.08	19	0.79	0		242	10.12	306	12.80	491	21
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1,835	2,831	51	1.81	90	3.17	17	0.60	0		2	0.08	5	0.17	16	0.55			181	6.40	6	0.23	9	0.31	8	0.27	5	0.16	6	0.21	23	0.81	202	7.13	258	9.12	439	16
10	Le Thanh Nghi street	No. 9-LTNghi	1,381	2,130	19	0.89	3	0.16	17	0.80	0		20	0.96	0		16	0.74			76	3.55	0		0		0		0		0		0				76	4
11	Giai Phong(DCV-LTN)	No. 10-Gphong	2,379	3,669	230	6.27	125	3.40	128	3.50	0		9	0.25	24	0.65	71	1.92			587	15.99	40	1.08	8	0.21	14	0.39	2	0.04	21	0.56	12	0.33	847	23.09	944	25.72	1,530	42
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	2,128	3,283	266	8.11	92	2.79	163	4.95	0		41	1.25	10	0.29	55	1.67			626	19.06	36	1.09	4	0.12	11	0.32	2	0.05	16	0.50	12	0.37	686	20.89	766	23.34	1,392	42
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	2,127	3,281	150	4.58	82	2.49	86	2.61	0		2	0.07	5	0.15	16	0.48			340	10.36	32	0.98	4	0.12	10	0.29	2	0.05	16	0.50	12	0.37	645	19.67	721	21.98	1,061	32
14	Pho Hue street	No. 11-Phue	1,896	3,608	0		0		0		0		0		0		0						51	1.42	3	0.08	22	0.62	2	0.06	20	0.55	4	0.10	524	14.54	626	17.36	626	17
15	Ba Trieu street	No. 12-BT	1,280		103		103		77		0		2		19		55				359		0		0		0		0		0		0		0				359	
16	Nguyen Luong Bang	No. 13-N.L.Bang	1,615	2,569	0		0		0		0		0		0		0						21	0.80	0		21	0.83	2	0.08	25	0.97	5	0.21	363	14.19	437	17.06	437	17
17	Thai Ha	No. 14-ThaiHa	1,640	1,703	148	8.71	73	4.30	68	4.02	63	3.72	9	0.53	14	0.84	16	0.92			392	23.04	0		0		0		0		0		0		0				392	23
18	Kim Ma	No. 15-KimMa	1,691	2,609	0		0		0		0		0		0		0						43	1.72	8	0.30	26	1.00	2	0.09	28	1.08	9	0.34	565	21.65	683	26.17	683	26
19	Nguyen Trai street	No. 16-Ntrai	1,943	2,997	74	2.47	47	1.55	26	0.86	0		7	0.23	5	0.16	31	1.05			189	6.32	10	0.34	0		13	0.42	1	0.03	19	0.63	4	0.12	323	10.77	369	12.30	558	19
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	680	943	29	3.02	47	4.94	34	3.63	63	6.71	0		5	0.50	8	0.83			185	19.64	0		0		0		0		0		0		0				185	20
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	624	890	0		0		0		0		0		0		0						0		0		0		0		0		0		0				0	0
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	726	1,171	0		0		0		0		0		0		0						0		0		0		0		0		0		0				0	0
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	1,163	1,277	0		0		0		0		0		0		0						3	0.20	0		1	0.08	0		0		0		121	9.47	125	9.75	125	10
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	1,240	1,361	0		0		0		0		0		0		0						0		0		0		0		0		0		0				0	0
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	1,062	1,166	0		0		0		0		0		0		0						0		0		0		0		0		0		0				0	0
26	Duong Buoi	No. 19-D.Buoi	796	874	8	0.87	2	0.19	0		0		0		0		0				9	1.06	1	0.15	0		1	0.11	0		1	0.10	0		40	4.62	43	4.97	53	6
27	Cat Linh	No. 20-CatLinh	1,389	1,040	0		0		0		0		0		0		0						0		0		0		0		0		0		0				0	0
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2,050	1,770	17	0.97	5	0.28	9	0.48	0		5	0.26	0		0				35	1.99	0		0		1	0.05	0		3	0.15	5	0.30	0		9	0.50	44	2
29	Nguyen Chi Thanh(HTKhang-LaThan	No.21b-N.C.Thanh	2,098	1,906	29	1.50	47	2.44	34	1.79	63	3.32	0		5	0.25	8	0.41			185	9.72	0		0		0		0		0		0		0				185	10
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	1,607	1,132	0		0		0		0		0		0		0						0		0		2	0.17	0		2	0.15	0		0		4	0.32	4	0
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	1,947	2,085	15	0.73	0		9	0.41	0		2	0.11	0		0				26	1.25	8	0.37	1	0.05	4	0.19	1	0.04	3	0.16	0		161	7.74	178	8.54	204	10
32	Tran Duy Hung	No. 23-T.D.Hung	2,600	2,854	17	0.60	5	0.17	9	0.30	0		5	0.16	0		0				35	1.23	3	0.09	0		3	0.10	0		3	0.12	5	0.18	40	1.41	54	1.91	90	3
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	1,752	1,923	0		0		0		0		0		0		0						8	0.40	0		4	0.20	1	0.04	3	0.18	0		161	8.39	177	9.21	177	9
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2,094	1,923	0		0		0		0		0		0		0						8	0.40	0		4	0.20	1	0.04	3	0.18	0		161	8.39	177	9.21	177	9
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	1,453	2,033	0		0		0		0		0		0		0						0		0		0		0		0		0		0				0	0
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2,793	3,067	103	3.35	103	3.36	77	2.51	0		2	0.07	19	0.62	55	1.79			359	11.71	0		0		0		0		0		0		0				359	12

Contribution of Organizations in the Morning-The Way Out

No.	Road name	Corridor code	Road intensity (pcu/h)	Current traffic Volume_Morning Peak (pcu)	Study area No. 1																Study area No. 2												Sum Total (Area 1+2)	
					Bach Mai hospital				Polytechnics Uni.				Construction Univ.				Economics Univ.				Sum area No. 1		Viet Duc Hospital		C hospital		K hospital				Government Offices		Sum area No. 2		
					Staff		Patient		Teacher& Staff		Students		Teacher& Staff		Students		Teacher& Staff		Students				Staff		Patient		Staff		Patient		Staff		Patient							
					(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%
1	Chua Boc street	No. 1-Cboc	1,595	2,575																															0	0
2	Pham Ngoc Thach street	No. 2-PNThach	1,388	2,206																															0	0
3	Ton That Tung street	No. 3-TTTung	723	841																															0	0
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	981	1,225																															0	0
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1,142	1,425																															0	0
6	Kham Thien	No. 5-KThien	1,056	929																															0	0
7	Nguyen Thai Hoc	No. 6-NTHoc	1,836																																	
8	Cau Giay	No. 7-CG	1,551	1,935																															0	0
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1,835	2,290																															0	0
10	Le Thanh Nghi street	No. 9-LTNghi	1,381	1,724																															0	0
11	Giai Phong(DCV-LTN)	No. 10-Gphong	2,379	2,969																															0	0
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	2,128	2,656																															0	0
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	2,127	2,654																															0	0
14	Pho Hue street	No. 11-Phue	1,896																																	
15	Ba Trieu street	No. 12-BT	1,280	1,412	103	7.27	103	7.31	77	5.45	0		2	0.16	19	1.35	55	3.89			359	25.43															359	25
16	Nguyen Luong Bang	No. 13-N.L.Bang	1,615	1,795																															0	0
17	Thai Ha	No. 14-ThaiHa	1,640	2,908																															0	0
18	Kim Ma	No. 15-KimMa	1,691	2,111																															0	0
19	Nguyen Trai street	No. 16-Ntrai	1,943	2,425																															0	0
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	680	910																															0	0
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	624	910																															0	0
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	726	781																															0	0
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	1,163	1,496																															0	0
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	1,240	1,594																															0	0
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	1,062	1,365																															0	0
26	Duong Buoi	No. 19-D.Buoi	796	1,023																															0	0
27	Cat Linh	No. 20-CatLinh	1,389	1,172																															0	0
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2,050	1,695																															0	0
29	Nguyen Chi Thanh(HTKhang-LaThan	No.21b-N.C.Thanh	2,098	1,468																															0	0
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	1,607	2,319																															0	0
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	1,947	1,331																															0	0
32	Tran Duy Hung	No. 23-T.D.Hung	2,600	3,343																															0	0
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	1,752	1,614																															0	0
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2,094	1,252																															0	0
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	1,453	1,169																															0	0
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2,793	3,592																															0	0

Contribution of Organizations in the Afternoon-The Way Out

No.	Road name	Corridor code	Road intensity (pcu/h)	Current Traffic Volume_Afternoon Peak-Way out (pcu)	Study area No. 1														Study area No. 2								Sum Area 1+2	
					Bach Mai hospital		Polytechnics Uni.			Construction Univ.			Economics Univ.				Sum area No. 1		Viet Duc Hospital		C hospital		K hospital		Government Offices		Sum area No. 2			
					Staff		Teacher& Staff		Students	Teacher& Staff		Students	Teacher& Staff		Students				Staff		Staff		Staff							
					(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%
1	Chua Boc street	No. 1-Cboc	1,595	4,128	229	5.55	144	3.50	994	24.07	36	0.88	153	3.70	16	0.38	230	5.58	1,803	43.67	0		0		0		0				1,803	44
2	Pham Ngoc Thach street	No. 2-PNThach	1,388	3,294	246	7.46	163	4.93	1,012	30.71	36	1.11	157	4.76	16	0.48	230	7.00	1,860	56.45	0		0		0		0				1,860	56
3	Ton That Tung street	No. 3-TTTung	723	1,708	30	1.76	36	2.11	90	5.29	0		0		0		0		157	9.17	0		0		0		0				157	9
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	981	1,652	35	2.13	0		18	1.09	73	4.42	198	12.00	31	1.90	198	11.99	554	33.53	7	0.40	6	0.35	3	0.16	0		15	0.91	569	34
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1,142	1,922	5	0.26	0		18	0.94	88	4.56	202	10.53	31	1.63	205	10.68	550	28.60	7	0.35	6	0.30	3	0.13	0		15	0.78	565	29
6	Kham Thien	No. 5-KThien	1,595	1,362	49	3.56	18	1.33	126	9.29	0		41	3.03	0		43	3.17	278	20.38	23	1.67	28	2.06	33	2.39	909	66.71	992	72.82	1,269	93
7	Nguyen Thai Hoc	No. 6-NTHoc	1,388		0		0		0		0		0		0		0				0		0		0		0					
8	Cau Giay	No. 7-CG	723	2,610	30	1.15	18	0.69	154	5.88	7	0.28	62	2.37	8	0.30	86	3.31	365	13.99	28	1.07	15	0.59	23	0.88	242	9.27	309	11.83	674	26
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	981	3,089	54	1.73	18	0.58	280	9.06	7	0.24	37	1.20	8	0.25	54	1.75	458	14.82	13	0.43	8	0.25	8	0.25	403	13.06	432	13.99	890	29
10	Le Thanh Nghi street	No. 9-LTNghi	1,142	2,325	17	0.72	0		63	2.72	36	1.57	74	3.20	24	1.01	22	0.93	236	10.15	0		0		0		0				236	10
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1,056	4,004	212	5.30	90	2.25	641	16.02	15	0.36	231	5.77	47	1.18	310	7.73	1,547	38.63	36	0.90	20	0.51	22	0.56	686	17.13	764	19.09	2,311	58
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1,805	3,583	219	6.12	108	3.02	759	21.18	139	3.87	359	10.03	0		0		1,584	44.22	35	0.97	17	0.49	24	0.67	645	18.02	722	20.14	2,306	64
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1,551	3,580	199	5.56	90	2.52	687	19.17	36	1.02	116	3.23	31	0.88	126	3.52	1,285	35.90	20	0.56	12	0.32	15	0.43	605	16.90	652	18.22	1,938	54
14	Pho Hue street	No. 11-Phue	1,835		99		54		425		15		120		24		104		840		0		0		0		0				840	
15	Ba Trieu street	No. 12-BT	1,381	2,304	0		0		0		0		0		0		0				83	3.60	42	1.80	45	1.97	1,009	43.78	1,178	51.14	1,178	51
16	Nguyen Luong Bang	No. 13-N.L.Bang	2,379	2,750	0		0		0		0		0		0		0				16	0.58	23	0.84	27	0.96	484	17.60	550	20.00	550	20
17	Thai Ha	No. 14-ThaiHa	2,128	4,080	122	2.99	72	1.77	506	12.40	36	0.89	153	3.74	16	0.38	220	5.38	1,125	27.57	0		0		0		0				1,125	28
18	Kim Ma	No. 15-KimMa	2,127	2,848	0		0		0		0		0		0		0				43	1.50	33	1.15	33	1.14	968	34.00	1,076	37.80	1,076	38
19	Nguyen Trai street	No. 16-Ntrai	1,896	3,271	69	2.10	36	1.10	298	9.11	29	0.89	103	3.16	31	0.96	126	3.85	693	21.18	11	0.33	14	0.44	22	0.68	403	12.33	451	13.78	1,143	35
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1,280	690	30	4.36	18	2.62	154	22.26	7	1.06	62	8.98	8	1.14	86	12.52	365	52.93	0		0		0		0				365	53
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1,615	891	0		0		0		0		0		0		0				0		0		0		0					
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1,640	959	0		0		0		0		0		0		0				0		0		0		0					
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	1,691	1,459	22	1.49	18	1.24	117	8.05	7	0.50	54	3.68	8	0.54	83	5.67	309	21.16	0		0		0		0				309	21
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	1,943	1,555	0		0		0		0		0		0		0				0		0		0		0					
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	680	1,332	15	1.13	0		72	5.43	7	0.55	29	2.17	0		32	2.43	156	11.71	0		0		0		0				156	12
26	Duong Buoi	No. 19-D.Buoi	624	998	7	0.67	0		36	3.62	0		8	0.83	0		18	1.80	69	6.92	1	0.13	1	0.10	1	0.09	40	4.04	44	4.36	113	11
27	Cat Linh	No. 20-CatLinh	726	914	0		0		0		0		0		0		0				0		0		0		0					
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	1,163	3,030	8	0.28	0		36	1.19	0		0		0		0		44	1.47	0		1	0.03	3	0.08	0		4	0.12	48	2
29	Nguyen Chi Thanh(HTKhang-LaThan	No.21b-N.C.Thanh	1,240	2,119	30	1.42	18	0.85	154	7.25	7	0.34	62	2.92	8	0.37	86	4.08	365	17.24	0		1	0.05	3	0.12	0		4	0.17	369	17
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	1,062	1,693	0		0		0		0		0		0		0				3	0.16	5	0.29	2	0.10	40	2.38	50	2.93	50	3
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	796	2,195	27	1.22	18	0.82	126	5.76	22	1.00	29	1.32	0		25	1.15	247	11.27	9	0.43	6	0.26	3	0.16	242	11.03	261	11.87	508	23
32	Tran Duy Hung	No. 23-T.D.Hung	1,389	3,261	8	0.26	0		36	1.11	0		0		0		0		44	1.36	0		1	0.03	3	0.08	0		4	0.11	48	1
33	Giang Vo (Lang Ha-Ngoc Khanh)	No. 24-G.Vo	2,050	2,619	22	0.83	0		99	3.79	22	0.84	17	0.63	0		14	0.55	174	6.64	9	0.36	6	0.22	3	0.13	242	9.24	261	9.95	435	17
34	Giang Vo(Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2,098	2,619	22	0.83	0		99	3.79	22	0.84	17	0.63	0		14	0.55	174	6.64	9	0.36	6	0.22	3	0.13	242	9.24	261	9.95	435	17
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	1,607	2,129	0		0		0		0		0		0		0				0		0		0		0					
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	1,947	3,504	99	2.82	54	1.55	425	12.12	15	0.42	120	3.42	24	0.67	104	2.98	840	23.96	20	0.57	12	0.33	15	0.44	605	17.27	652	18.61	1,492	43

Contribution of Organizations in the Afternoon-The Way In

No.	Road name	Corridor code	Road intensity (pcu/h)	Current traffic volume-Afternoon-Way In (pcu)	Polytechnics Students		Construction Students		Economics Students		Sum area No. 1		Sum area No. 2		Sum total	
					(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%	(pcu)	%
1	Chua Boc street	No. 1-Cboc	1,595	2,813	876	31.15	285	10.13	378	13.44	1,539	54.72			1,539	54.72
2	Pham Ngoc Thach street	No. 2-PNThach	1,388	1,968	921	46.82	293	14.90	385	19.58	1,600	81.29			1,600	81.29
3	Ton That Tung street	No. 3-TTTung	723	780	0		0		0							
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	981	1,549	36	2.33	58	3.73	25	1.63	119	7.69			119	7.69
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1,142	1,803	90	5.01	70	3.89	50	2.80	211	11.70			211	11.70
6	Kham Thien	No. 5-KThien	1,056	1,521	126	8.31	41	2.71	43	2.84	211	13.87			211	13.87
7	Nguyen Thai Hoc	No. 6-NTHoc	1,805	3,699	81	2.20	50	1.34	29	0.78	160	4.32			160	4.32
8	Cau Giay	No. 7-CG	1,551	2,449	117	4.80	54	2.19	68	2.79	240	9.78			240	9.78
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1,835	2,898	280	9.66	37	1.28	58	1.99	375	12.93			375	12.93
10	Le Thanh Nghi street	No. 9-LTNghi	1,381	2,181	63	2.90	74	3.41	22	0.99	159	7.30			159	7.30
11	Giai Phong(DCV-LTN)	No. 10-Gphong	2,379	3,756	894	23.81	297	7.91	313	8.34	1,505	40.07			1,505	40.07
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	2,128	3,361	894	26.61	297	8.85	61	1.82	1,253	37.28			1,253	37.28
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	2,127	3,358	524	15.60	87	2.58	112	3.32	722	21.51			722	21.51
14	Pho Hue street	No. 11-Phue	1,896	2,651	0		0		0				840	31.69	840	31.69
15	Ba Trieu street	No. 12-BT	1,280		461		132		140		733				733	
16	Nguyen Luong Bang	No. 13-N.L.Bang	1,615	2,206	0		0		0							
17	Thai Ha	No. 14-ThaiHa	1,640	2,472	596	24.12	219	8.85	270	10.92	1,085	43.90			1,085	43.90
18	Kim Ma	No. 15-KimMa	1,691	2,671	0		0		0							
19	Nguyen Trai street	No. 16-Ntrai	1,943	3,068	253	8.24	83	2.69	108	3.52	444	14.46			444	14.46
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	680	973	117	12.07	54	5.52	68	7.03	240	24.62			240	24.62
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	624	1,030	0		0		0							
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	726	1,089	0		0		0							
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	1,163	1,219	0		0		0							
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	1,240	1,299	0		0		0							
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	1,062	1,112	0		0		0							
26	Duong Buoi	No. 19-D.Buoi	796	834	36	4.33	8	0.99	18	2.16	62	7.48			62	7.48
27	Cat Linh	No. 20-CatLinh	1,389	2,664	0		0		0							
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2,050	1,588	72	4.55	29	1.82	32	2.04	134	8.41			134	8.41
29	Nguyen Chi Thanh(HTKhang-LaThan	No.21b-N.C.Thanh	2,098	1,830	117	6.42	54	2.93	68	3.74	240	13.09			240	13.09
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	1,607	1,864	0		0		0							
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	1,947	2,052	45	2.20	21	1.01	14	0.70	80	3.91			80	3.91
32	Tran Duy Hung	No. 23-T.D.Hung	2,600	2,724	72	2.65	29	1.06	32	1.19	134	4.90			134	4.90
33	Giang Vo (Lang Ha-Ngoc Khanh)	No. 24-G.Vo	1,752	1,836	0		0		0							
34	Giang Vo(Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2,094	1,572	0		0		0							
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	1,453	1,168	0		0		0							
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2,793	2,927	461	15.74	132	4.51	140	4.80	733	25.05			733	25.05

Appendix D: Congestion level-Scenario O-No activity

Congestion level of corridors-Scenario B-"No Activity"

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Current situation				Contribution of study areas				Scenario B: No activity							
					Morning		Afternoon		Morning		Afternoon		Morning				Afternoon			
													Way In		Way Out		Way In		Way Out	
					Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level
1	Chua Boc street	No. 1-Cboc	1	1,595	2,552	2,575	2,813	4,128	589		1,539	1,803	1,963	Crowded	2,575	Severe G1	1,274	No congestion	2,325	Very crowded
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	2,204	2,206	1,968	3,294	704		1,600	1,860	1,500	Crowded	2,206	Severe G1	368	No congestion	1,434	Crowded
3	Ton That Tung street	No. 3-TTTung	1	723	892	841	780	1,708	10			157	882	Crowded	841	Crowded	780	Crowded	1,551	Very severe G1
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	981	1,514	1,225	1,549	1,652	385		119	569	1,129	Crowded	1,225	Crowded	1,430	Very crowded	1,083	Crowded
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,142	1,761	1,425	1,803	1,922	84		211	565	1,677	Very crowded	1,425	Crowded	1,592	Very crowded	1,357	Crowded
6	Kham Thien	No. 5-KThien	1	1,056	1,681	929	1,521	1,362	1,219		211	1,269	462	No congestion	929	Migrate	1,310	Crowded	93	No congestion
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	3,682		3,699		1,636		160		2,046	Crowded			3,539	Severe G2	0	
8	Cau Giay	No. 7-CG	1	1,551	2,392	1,935	2,449	2,610	491		240	674	1,901	Crowded	1,935	Crowded	2,209	Very crowded	1,936	Crowded
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835	2,831	2,290	2,898	3,089	439		375	890	2,392	Very crowded	2,290	Crowded	2,523	Very crowded	2,199	Crowded
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381	2,130	1,724	2,181	2,325	76		159	236	2,055	Very crowded	1,724	Crowded	2,021	Very crowded	2,089	Severe G1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379	3,669	2,969	3,756	4,004	1,530		1,505	2,311	2,139	Migrate	2,969	Crowded	2,251	Migrate	1,693	No congestion
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128	3,283	2,656	3,361	3,583	1,392		1,253	2,306	1,891	Migrate	2,656	Crowded	2,108	Migrate	1,277	No congestion
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127	3,281	2,654	3,358	3,580	1,061		722	1,938	2,220	Crowded	2,654	Crowded	2,636	Crowded	1,643	No congestion
14	Pho Hue street	No. 11-Phue	1	1,896	3,608		2,651		626		840		2,982	Severe G1			1,811	Migrate	0	
15	Ba Trieu street	No. 12-BT	1	1,280		1,412		2,304		359	733	1,178			1,053	Migrate	0		1,126	Migrate
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,559	1,795	2,206	2,750	437			550	2,122	Very crowded	1,795	Crowded	2,206	Very crowded	2,200	Very crowded
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,703	2,908	2,472	4,080	392		1,085	1,125	1,311	No congestion	2,908	Severe G2	1,387	Migrate	2,955	Severe G2
18	Kim Ma	No. 15-KimMa	1	1,691	2,609	2,111	2,671	2,848	683			1,076	1,926	Crowded	2,111	Crowded	2,671	Severe G1	1,771	Crowded
19	Nguyen Trai street	No. 16-Ntrai	1	1,943	2,997	2,425	3,068	3,271	558		444	1,143	2,439	Very crowded	2,425	Crowded	2,624	Very crowded	2,127	Crowded
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	680	943	910	973	690	185		240	365	758	Crowded	910	Very crowded	733	Crowded	325	No congestion
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	624	890	910	1,030	891	0				890	Very crowded	910	Very crowded	1,030	Severe G1	891	Very crowded
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	726	1,171	781	1,089	959	0				1,171	Severe G1	781	Crowded	1,089	Very crowded	959	Very crowded
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,163	1,277	1,496	1,219	1,459	125			309	1,153	Migrate	1,496	Very crowded	1,219	Crowded	1,151	Migrate
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,240	1,361	1,594	1,299	1,555	0				1,361	Crowded	1,594	Very crowded	1,299	Crowded	1,555	Very crowded
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,062	1,166	1,365	1,112	1,332	0			156	1,166	Crowded	1,365	Very crowded	1,112	Crowded	1,176	Crowded
26	Duong Buoi	No. 19-D.Buoi	2	796	874	1,023	834	998	53		62	113	821	Crowded	1,023	Very crowded	771	Migrate	886	Crowded
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	1,172	2,664	914	0				1,040	No congestion	1,172	Migrate	2,664	Severe G2	914	No congestion
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	1,770	1,695	1,588	3,030	44		134	48	1,726	Migrate	1,695	Migrate	1,454	No congestion	2,982	Very crowded
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	1,906	1,468	1,830	2,119	185		240	369	1,721	Migrate	1,468	No congestion	1,590	No congestion	1,750	Migrate
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,132	2,319	1,864	1,693	4			50	1,128	No congestion	2,319	Very crowded	1,864	Crowded	1,643	Crowded
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	2,085	1,331	2,052	2,195	204		80	508	1,881	Migrate	1,331	No congestion	1,972	Crowded	1,687	Migrate
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600	2,854	3,343	2,724	3,261	90		134	48	2,765	Crowded	3,343	Very crowded	2,590	Migrate	3,213	Crowded
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,923	1,614	1,836	2,619	177			435	1,746	Migrate	1,614	Migrate	1,836	Crowded	2,184	Crowded
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,923	1,252	1,572	2,619	177			435	1,746	Migrate	1,252	No congestion	1,572	No congestion	2,184	Crowded
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	1,169	1,168	2,129	0				2,033	Very crowded	1,169	Migrate	1,168	Migrate	2,129	Very crowded
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793	3,067	3,592	2,927	3,504	359		733	1,492	2,708	Migrate	3,592	Very crowded	2,193	No congestion	2,012	No congestion

Note: Nguyen Thai Hoc street, Ba Trieu street and Pho Hue street are one way streets.

Appendix E: Calculation of new traffic volume –Scenario 1

Contribution of Organizations -Scenario 1-in the Morning-The Way in

No.	Road name	Corridor code	Study area No. 1								Sum area No. 1	Study area No. 2							Sum area No. 2	Sum area 1+2	
			Bach Mai hospital		Polytechnics Uni.		Construction Univ.		Economics Univ.			Viet Duc Hospital		C hospital		K hospital		Government Offices			
			Staff	Patient	Teacher&	Students	Teacher&	Students	Teacher&	Students		Staff	Patient	Staff	Patient	Staff	Patient				
			(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	%
1	Chua Boc street	No. 1-Cboc	84	73	51	63	14	10	0		295	0	0	0	0	0	0	0		295	
2	Pham Ngoc Thach street	No. 2-PNThach	97	75	68	63	14	10	0		327	12	0	2	0	5	0	81	99	426	
3	Ton That Tung street	No. 3-TTTung	0	0	17	0	0	0	0		17	0	0	0	0	0	0	0		17	
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	76	15	17	0	2	0	31		142	9	0	8	1	3	2	0	23	164	
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	82	17	17	0	11	5	31		163	0	0	0	0	0	0	0		163	
6	Kham Thien	No. 5-KThien	19	0	0	0	0	0	0		19	44	0	34	2	33	7	1,291	1,410	1,429	
7	Nguyen Thai Hoc	No. 6-NTHoc	23	3	26	0	7	0	8		66	77	9	46	5	40	11	1,170	1,357	1,424	
8	Cau Giay	No. 7-CG	21	43	34	63	0	5	8		174	28	6	10	2	19	0	242	306	480	
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	30	87	17	0	2	5	16		157	6	9	6	5	6	23	202	256	413	
10	Le Thanh Nghi street	No. 9-LTNghi	19	3	0	0	20	0	16		58	0	0	0	0	0	0	0		58	
11	Giai Phong(DCV-LTN)	No. 10-Gphong	348	168	120	63	32	33	78		843	40	8	14	2	20	12	847	942	1,785	
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	342	115	128	0	27	10	141		763	36	4	10	2	15	12	686	765	1,528	
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	173	88	94	0	5	5	16		380	32	4	9	2	15	12	645	719	1,100	
14	Pho Hue street	No. 11-Phue	0	0	0	0	0	0	0			36	0	17	2	17	4	282	358	358	
15	Ba Trieu street	No. 12-BT																			
16	Nguyen Luong Bang	No. 13-N.L.Bang	4	0	0	0	0	0	0		4	24	0	27	2	26	5	363	447	451	
17	Thai Ha	No. 14-ThaiHa	34	37	26	63	7	5	0		171	0	0	0	0	0	0	0		171	
18	Kim Ma	No. 15-KimMa	34	7	0	0	7	5	8		60	50	8	31	3	29	11	484	616	676	
19	Nguyen Trai street	No. 16-Ntrai	84	45	26	0	9	5	31		199	10	0	14	1	18	4	323	369	568	
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	21	43	34	63	0	5	8		174	0	0	0	0	0	0	0		174	
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	21	17	34	0	0	5	8		84	0	0	0	0	0	0	40	40	125	
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	95	25	34	0	0	10	16		179	10	0	5	0	5	0	363	383	563	
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	0	0	0	0	0	0	0			3	0	1	0	0	0	0	4	4	
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	6	3	0	0	0	0	0		9	0	0	0	0	0	0	0		9	
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	6	3	0	0	0	0	0		9	0	0	0	0	0	0	0		9	
26	Duong Buoi	No. 19-D.Buoi	2	2	0	0	0	5	0		8	8	0	5	0	1	2	81	96	104	
27	Cat Linh	No. 20-CatLinh	0	0	0	0	0	0	0			8	0	3	1	4	0	0	16	16	
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	4	5	9	0	2	0	0		20	3	1	3	0	3	5	161	176	196	
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	0	0	0	0	0	0		2	3	2	5	1	4	7	161	183	185	
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	11	0	17	0	0	5	0		33	4	0	4	1	6	0	81	95	128	
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	6	2	9	0	2	0	0		18	8	0	5	1	6	0	282	302	320	
32	Tran Duy Hung	No. 23-T.D.Hung	4	5	9	0	5	0	0		22	3	2	5	1	4	7	161	183	205	
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	38	7	0	0	0	5	8		57	8	0	5	1	6	0	81	100	157	
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	0	0	0	0	0	0	0			8	0	3	1	4	0	81	96	96	
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	8	3	9	0	2	0	0		22	0	0	2	0	2	0	40	44	66	
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	89	100	334	0	5	19	55		601	0	0	0	0	0	0	0		601	

Contribution of Organizations-Scenario 1- in the Morning-The Way in

No.	Road name	Corridor code	Study area No. 1									Study area No. 2								Sum area 1+2	
			Bach Mai hospital		Polytechnics Uni.		Construction Univ.		Economics Univ.		Sum area No. 1	Viet Duc Hospital		C hospital		K hospital		Goverment Offices	Sum area No. 2		
			Staff	Patient	Teacher&	Students	Teacher&	Students	Teacher&	Students		Staff	Patient	Staff	Patient	Staff	Patient				
			(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	%
1	Chua Boc street	No. 1-Cboc																			
2	Pham Ngoc Thach street	No. 2-PNThach																			
3	Ton That Tung street	No. 3-TTTung																			
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh																			
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh																			
6	Kham Thien	No. 5-KThien																			
7	Nguyen Thai Hoc	No. 6-NTHoc																			
8	Cau Giay	No. 7-CG																			
9	Cau Chuong Duong-NV Cu	No. 8-CauCD																			
10	Le Thanh Nghi street	No. 9-LTNghi																			
11	Giai Phong(DCV-LTN)	No. 10-Gphong																			
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong																			
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong																			
14	Pho Hue street	No. 11-Phue																			
15	Ba Trieu street	No. 12-BT	91	100	77	0	2	19	55		344	0	0	0	0	1	0	0	1	345	
16	Nguyen Luong Bang	No. 13-N.L.Bang																			
17	Thai Ha	No. 14-ThaiHa																			
18	Kim Ma	No. 15-KimMa																			
19	Nguyen Trai street	No. 16-Ntrai																			
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh																			
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh																			
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh																			
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang																			
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang																			
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang																			
26	Duong Buoi	No. 19-D.Buoi																			
27	Cat Linh	No. 20-CatLinh																			
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh																			
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh																			
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa																			
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa																			
32	Tran Duy Hung	No. 23-T.D.Hung																			
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo																			
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo																			
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang																			
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet																			

Contribution of Organizations-Scenario 1-Road Expand-No Relocate (Afternoon-The Way in)

No.	Road name	Corridor code	Study area No. 1									Study area No. 2								Sum area 1+2	
			Bach Mai hospital		Polytechnics Uni.		Construction Univ.		Economics Univ.		Sum area No. 1	Viet Duc Hospital		C hospital		K hospital		Goverment Offices	Sum area No. 2		
			Staff	Patient	Teacher & Staff	Students	Teacher & Staff	Students	Teacher & Staff	Students		Staff	Patient	Staff	Patient	Staff	Patient				
			(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	%
1	Chua Boc street	No. 1-Cboc				461		206		76	743									743	
2	Pham Ngoc Thach street	No. 2-PNThach				569		215		18	802									802	
3	Ton That Tung street	No. 3-TTTung				63		0		76	139									139	
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh				36		4		234	274									274	
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh				27		12		306	346									346	
6	Kham Thien	No. 5-KThien				45		17		14	76									76	
7	Nguyen Thai Hoc	No. 6-NTHoc				72		50		29	151									151	
8	Cau Giay	No. 7-CG				108		54		61	223									223	
9	Cau Chuong Duong-NV Cu	No. 8-CauCD				244		21		36	301									301	
10	Le Thanh Nghi street	No. 9-LTNghi				0		74		22	96									96	
11	Giai Phong(DCV-LTN)	No. 10-Gphong				813		417		353	1,583									1,583	
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong				696		223		670	1,588									1,588	
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong				587		116		133	836									836	
14	Pho Hue street	No. 11-Phue	82		54	343	15	111	24	115	744									744	
15	Ba Trieu street	No. 12-BT																			
16	Nguyen Luong Bang	No. 13-N.L.Bang				18		4		0	22									22	
17	Thai Ha	No. 14-ThaiHa				163		95		65	322									322	
18	Kim Ma	No. 15-KimMa				172		29		47	247									247	
19	Nguyen Trai street	No. 16-Ntrai				235		111		140	487									487	
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh				108		54		61	223									223	
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh				108		54		61	223									223	
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh				361		111		126	599									599	
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang				0		0		0											
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang				0		0		7	7									7	
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang				0		0		40	40									40	
26	Duong Buoi	No. 19-D.Buoi				27		12		4	43									43	
27	Cat Linh	No. 20-CatLinh				0		0		0											
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh				63		50		0	113									113	
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh				27		4		32	64									64	
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa				54		21		0	75									75	
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa				72		33		11	116									116	
32	Tran Duy Hung	No. 23-T.D.Hung				90		54		32	176									176	
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo				172		37		47	256									256	
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo				0		0		0											
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang				54		21		11	86									86	
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet				2,294		149		140	2,584									2,584	

Contribution of Organizations-Scenario 1-Road Expand-No Relocate (Afternoon-The Way Out)

No.	Road name	Corridor code	Study area No. 1									Study area No. 2								Sum area 1+2	
			Bach Mai hospital		Polytechnics Uni.		Construction Univ.		Economics Univ.		Sum area No. 1	Viet Duc Hospital		C hospital		K hospital		Government Offices	Sum area No. 2		
			Staff	Patient	Teacher & Staff	Students	Teacher & Staff	Students	Teacher & Staff	Students		Staff	Patient	Staff	Patient	Staff	Patient				
			(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	(pcu)	%
1	Chua Boc street	No. 1-Cboc	23		72	452	0	25	0	65	637	0		0		0		0		637	
2	Pham Ngoc Thach street	No. 2-PNThach	35		108	578	0	33	0	7	762	9		2		4		0	16	777	
3	Ton That Tung street	No. 3-TTTung	0		36	63	0	0	0	65	164	7		6		3		0	15	179	
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	129		36	36	58	194	24	241	718	7		6		3		0	15	733	
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	134		0	27	88	202	24	295	770	0		0		0		0		770	
6	Kham Thien	No. 5-KThien	13		18	45	0	17	0	14	108	24		28		29		1,372	1,453	1,560	
7	Nguyen Thai Hoc	No. 6-NTHoc	0		18	0	0	4	0	7	29	0		0		0		0		29	
8	Cau Giay	No. 7-CG	22		18	145	7	54	8	61	314	28		11		22		242	303	617	
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	30		18	154	7	21	8	32	270	13		7		8		403	431	701	
10	Le Thanh Nghi street	No. 9-LTNghi	17		0	0	36	74	24	22	173	0		0		0		0		173	
11	Giai Phong(DCV-LTN)	No. 10-Gphong	328		163	831	124	438	63	360	2,306	29		13		19		686	747	3,053	
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	380		90	696	131	384	133	673	2,488	28		10		18		645	701	3,189	
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	201		72	587	36	136	39	140	1,212	20		10		15		605	649	1,862	
14	Pho Hue street	No. 11-Phue										0		0		0		0			
15	Ba Trieu street	No. 12-BT				18		8		7	34	79		41		44		1,009	1,172	1,205	
16	Nguyen Luong Bang	No. 13-N.L.Bang	2		18	18	0	4	0	0	42	16		22		23		484	545	587	
17	Thai Ha	No. 14-ThaiHa	22		54	181	0	37	0	54	348	0		0		0		0		348	
18	Kim Ma	No. 15-KimMa	25		0	117	7	25	8	40	222	49		29		34		847	960	1,182	
19	Nguyen Trai street	No. 16-Ntrai	80		36	235	44	165	24	112	695	11		14		19		403	446	1,142	
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	22		18	145	7	54	8	61	314	0		0		0		0		314	
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	22		18	145	7	54	8	61	314	0		0		0		40	40	355	
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	95		36	407	15	111	16	137	817	0		4		5		484	493	1,310	
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	0		0	0	0	0	0	0		3		2		0		0	5	5	
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	5		0	0	0	0	0	7	12	0		0		0		0		12	
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	8		0	0	0	25	0	40	73	0		0		0		0		73	
26	Duong Buoi	No. 19-D.Buoi	5		0	27	0	12	0	4	48	8		2		3		81	94	142	
27	Cat Linh	No. 20-CatLinh	8		0	45	22	4	0	7	87	7		2		5		0	14	101	
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	0		0	90	0	4	0	0	94	3		6		3		202	214	308	
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	3		0	90	0	8	0	29	131	3		4		3		121	130	261	
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	12		36	54	0	12	0	0	114	4		3		7		121	135	249	
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	5		18	27	0	12	0	11	73	7		4		7		363	380	454	
32	Tran Duy Hung	No. 23-T.D.Hung	3		0	90	0	29	0	32	155	3		4		3		121	130	285	
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	40		0	181	7	37	8	47	320	7		4		7		40	58	378	
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	0		0	0	0	0	0	0		7		4		7		0	17	17	
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	18		36	81	22	58	8	29	252	0		0		0		0		252	
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	89		361	2,222	15	116	31	133	2,967	25		11		17		605	658	3,625	

Appendix F: Congestion level-Scenario 1-Road Expand-No Relocate

Congestion level of corridors-Scenario 1-"Road Expand-No Relocate"

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Traffic Volume-Scenario B				Contribution of study areas				Scenario 1: Road Expand-No Relocate							
					Morning peak		Afternoon peak		Morning		Afternoon		Morning				Afternoon			
													Way In		Way Out		Way In		Way Out	
					Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level
1	Chua Boc street	No. 1-Cboc	1	1,595	1,963	2,575	1,274	2,325	295		743	637	2,257	Very crowded	2,575	Severe G1	2,017	Very crowded	2,962	Severe G2
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	1,500	2,206	368	1,434	426		802	777	1,926	Very crowded	2,206	Severe G1	1,170	Migrate	2,212	Severe G1
3	Ton That Tung street	No. 3-TTTung	1	723	882	841	780	1,551	17		139	179	899	Crowded	841	Crowded	919	Very crowded	1,731	Very severe G2
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	1,548	1,129	1,225	1,430	1,083	164		274	733	1,293	Migrate	1,225	No congestion	1,705	Crowded	1,816	Crowded
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,559	1,677	1,425	1,592	1,357	163		346	770	1,840	Crowded	1,425	Migrate	1,937	Crowded	2,127	Very crowded
6	Kham Thien	No. 5-KThien	1	1,056	462	929	1,310	93	1,429		76	1,560	1,892	Severe G2	929	Migrate	1,386	Very crowded	1,653	Severe G1
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	2,046		3,539	0	1,424		151	29	3,470	Severe G2			3,690	Very severe G1	29	
8	Cau Giay	No. 7-CG	1	1,551	1,901	1,935	2,209	1,936	480		223	617	2,381	Severe G1	1,935	Crowded	2,432	Severe G1	2,554	Severe G1
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835	2,392	2,290	2,523	2,199	413		301	701	2,805	Severe G1	2,290	Crowded	2,824	Severe G1	2,900	Severe G1
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381	2,055	1,724	2,021	2,089	58		96	173	2,113	Severe G1	1,724	Crowded	2,117	Severe G1	2,261	Severe G1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379	2,139	2,969	2,251	1,693	1,785		1,583	3,053	3,923	Severe G1	2,969	Crowded	3,834	Severe G1	4,746	Severe G2
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128	1,891	2,656	2,108	1,277	1,528		1,588	3,189	3,419	Severe G1	2,656	Crowded	3,696	Severe G1	4,466	Very severe G1
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127	2,220	2,654	2,636	1,643	1,100		836	1,862	3,319	Severe G1	2,654	Crowded	3,472	Severe G1	3,505	Severe G1
14	Pho Hue street	No. 11-Phue	1	1,896	2,982		1,811	0	358		744		3,339	Severe G2			2,555	Very crowded	0	
15	Ba Trieu street	No. 12-BT	1	1,280		1,053	0	1,126		345		1,205			1,398	Crowded			2,331	Severe G2
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,122	1,795	2,206	2,200	451		22	587	2,573	Severe G1	1,795	Crowded	2,228	Very crowded	2,788	Severe G1
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,311	2,908	1,387	2,955	171		322	348	1,482	Migrate	2,908	Severe G2	1,709	Crowded	3,303	Very severe G1
18	Kim Ma	No. 15-KimMa	1	1,691	1,926	2,111	2,671	1,771	676		247	1,182	2,602	Severe G1	2,111	Crowded	2,918	Severe G1	2,953	Severe G1
19	Nguyen Trai street	No. 16-Ntrai	1	1,943	2,439	2,425	2,624	2,127	568		487	1,142	3,007	Severe G1	2,425	Crowded	3,111	Severe G1	3,269	Severe G1
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	1,605	758	910	733	325	174		223	314	932	No congestion	910	No congestion	957	No congestion	639	No congestion
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	1,693	890	910	1,030	891	125		223	355	1,015	No congestion	910	No congestion	1,253	No congestion	1,246	No congestion
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	1,457	1,171	781	1,089	959	563		599	1,310	1,734	Crowded	781	No congestion	1,688	Crowded	2,269	Severe G1
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,715	1,153	1,496	1,219	1,151	4			5	1,156	No congestion	1,496	Migrate	1,219	No congestion	1,155	No congestion
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,573	1,361	1,594	1,299	1,555	9		7	12	1,370	Migrate	1,594	Crowded	1,306	Migrate	1,567	Migrate
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,870	1,166	1,365	1,112	1,176	9		40	73	1,175	No congestion	1,365	No congestion	1,152	No congestion	1,249	No congestion
26	Duong Buoi	No. 19-D.Buoi	2	2,115	821	1,023	771	886	104		43	142	925	No congestion	1,023	No congestion	814	No congestion	1,028	No congestion
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	1,172	2,664	914	16			101	1,056	No congestion	1,172	Migrate	2,664	Severe G2	1,015	No congestion
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	1,726	1,695	1,454	2,982	196		113	308	1,922	Migrate	1,695	Migrate	1,567	No congestion	3,290	Severe G1
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	1,721	1,468	1,590	1,750	185		64	261	1,906	Migrate	1,468	No congestion	1,654	No congestion	2,011	Migrate
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,128	2,319	1,864	1,643	128		75	249	1,257	No congestion	2,319	Very crowded	1,939	Crowded	1,893	Crowded
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	1,881	1,331	1,972	1,687	320		116	454	2,201	Crowded	1,331	No congestion	2,088	Crowded	2,141	Crowded
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600	2,765	3,343	2,590	3,213	205		176	285	2,969	Crowded	3,343	Very crowded	2,766	Crowded	3,498	Very crowded
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,746	1,614	1,836	2,184	157		256	378	1,903	Crowded	1,614	Migrate	2,091	Crowded	2,562	Very crowded
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,746	1,252	1,572	2,184	96			17	1,842	Migrate	1,252	No congestion	1,572	No congestion	2,202	Crowded
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	1,169	1,168	2,129	66		86	252	2,099	Very crowded	1,169	Migrate	1,254	Migrate	2,381	Severe G1
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793	2,708	3,592	2,193	2,012	601		2,584	3,625	3,309	Crowded	3,592	Very crowded	4,777	Severe G1	5,637	Very severe G1

Note: Nguyen Thai Hoc street, Ba Trieu street and Pho Hue street are one way streets.

Appendix G: Congestion level-Scenario 2-Relocate all to the West

Congestion level of corridors-Scenario 2-Relocate all to the West

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Traffic Volume-Scenario B				Contribution of study areas				Scenario 2-Relocate all to the West							
					Morning		Afternoon		Morning		Afternoon		Morning				Afternoon			
													Way In		Way Out		Way In		Way Out	
					Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level
1	Chua Boc street	No. 1-Cboc	1	1,595	1,963	2,575	1,274	2,325		280	523	375	1,963	Crowded	2,855	Severe G2	1,796	Crowded	2,700	Severe G1
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	1,500	2,206	368	1,434		280	523	375	1,500	Crowded	2,486	Severe G2	891	No congestion	1,809	Very crowded
3	Ton That Tung street	No. 3-TTTung	1	723	882	841	780	1,551		0	0	0	882	Crowded	841	Crowded	780	Crowded	1,551	Very severe G1
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	981	1,129	1,225	1,430	1,083		506	1,168	611	1,129	Crowded	1,731	Severe G2	2,598	Craw	1,694	Severe G1
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,142	1,677	1,425	1,592	1,357		418	1,012	544	1,677	Very crowded	1,843	Severe G1	2,604	Very severe G2	1,901	Severe G1
6	Kham Thien	No. 5-KThien	1	1,056	462	929	1,310	93		50	96	43	462	No congestion	979	Migrate	1,406	Very crowded	135	No congestion
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	2,046		3,539	0		0	684	0	2,046	Crowded			4,223	Very severe G2	0	
8	Cau Giay	No. 7-CG	1	1,551	1,901	1,935	2,209	1,936		44	10	0	1,901	Crowded	1,979	Very crowded	2,219	Very crowded	1,936	Crowded
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835	2,392	2,290	2,523	2,199		178	380	273	2,392	Very crowded	2,469	Very crowded	2,903	Severe G1	2,472	Very crowded
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381	2,055	1,724	2,021	2,089		0	0	0	2,055	Very crowded	1,724	Crowded	2,021	Very crowded	2,089	Severe G1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379	2,139	2,969	2,251	1,693		0	0	0	2,139	Migrate	2,969	Crowded	2,251	Migrate	1,693	No congestion
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128	1,891	2,656	2,108	1,277		0	0	0	1,891	Migrate	2,656	Crowded	2,108	Migrate	1,277	No congestion
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127	2,220	2,654	2,636	1,643		127	238	85	2,220	Crowded	2,781	Very crowded	2,874	Very crowded	1,728	Migrate
14	Pho Hue street	No. 11-Phue	1	1,896	2,982		1,811	0		0	0	0	2,982	Severe G1			1,811	Migrate	0	
15	Ba Trieu street	No. 12-BT	1	1,280		1,053	0	1,126		76	0	26			1,129	Migrate	0		1,152	Migrate
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,122	1,795	2,206	2,200		84	236	127	2,122	Very crowded	1,879	Crowded	2,442	Severe G1	2,328	Very crowded
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,311	2,908	1,387	2,955		393	820	548	1,311	No congestion	3,301	Very severe G1	2,207	Very crowded	3,503	Very severe G1
18	Kim Ma	No. 15-KimMa	1	1,691	1,926	2,111	2,671	1,771		396	816	581	1,926	Crowded	2,507	Very crowded	3,487	Very severe G1	2,353	Very crowded
19	Nguyen Trai street	No. 16-Ntrai	1	1,943	2,439	2,425	2,624	2,127		19	137	94	2,439	Very crowded	2,444	Very crowded	2,762	Very crowded	2,221	Crowded
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	680	758	910	733	325		0	0	0	758	Crowded	910	Very crowded	733	Crowded	325	No congestion
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	624	890	910	1,030	891		0	0	0	890	Very crowded	910	Very crowded	1,030	Severe G1	891	Very crowded
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	726	1,171	781	1,089	959		51	100	62	1,171	Severe G1	832	Crowded	1,189	Severe G1	1,021	Very crowded
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,163	1,153	1,496	1,219	1,151		52	42	26	1,153	Migrate	1,548	Very crowded	1,261	Crowded	1,177	Crowded
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,240	1,361	1,594	1,299	1,555		0	0	0	1,361	Crowded	1,594	Very crowded	1,299	Crowded	1,555	Very crowded
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,062	1,166	1,365	1,112	1,176		506	1,168	611	1,166	Crowded	1,871	Severe G2	2,280	Very severe G1	1,787	Severe G1
26	Duong Buoi	No. 19-D.Buoi	2	796	821	1,023	771	886		3	6	0	821	Crowded	1,027	Very crowded	777	Migrate	886	Crowded
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	1,172	2,664	914		7	12	8	1,040	No congestion	1,179	Migrate	2,676	Severe G2	922	No congestion
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	1,726	1,695	1,454	2,982		995	2,160	1,417	1,726	Migrate	2,690	Very crowded	3,615	Severe G2	4,399	Very severe G1
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	1,721	1,468	1,590	1,750		52	36	26	1,721	Migrate	1,520	No congestion	1,626	No congestion	1,777	Migrate
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,128	2,319	1,864	1,643		61	161	85	1,128	No congestion	2,380	Very crowded	2,025	Very crowded	1,728	Crowded
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	1,881	1,331	1,972	1,687		70	178	110	1,881	Migrate	1,401	No congestion	2,150	Crowded	1,797	Migrate
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600	2,765	3,343	2,590	3,213		1,047	2,128	1,443	2,765	Crowded	4,390	Severe G1	4,718	Severe G2	4,656	Severe G2
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,746	1,614	1,836	2,184		7	12	8	1,746	Migrate	1,621	Migrate	1,847	Crowded	2,193	Very crowded
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,746	1,252	1,572	2,184		7	12	8	1,746	Migrate	1,259	No congestion	1,584	No congestion	2,193	Crowded
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	1,169	1,168	2,129		29	170	62	2,033	Very crowded	1,198	Migrate	1,338	Migrate	2,191	Severe G1
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793	2,708	3,592	2,193	2,012		178	161	173	2,708	Migrate	3,771	Very crowded	2,354	Migrate	2,185	No congestion

Note: Nguyen Thai Hoc street, Ba Trieu street and Pho Hue street are one way streets.

Appendix H: Congestion level of Scenario 3-Relocate 50-50_No road Expand

Congestion level of corridors-Scenario 3-Relocate 50-50_No road Expand

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Traffic Volume-Scenario B				Current Contribution of study areas				Scenario 2 Contribution				Scenario 3: Relocate 50-50_No Road Expand							
					Morning		Afternoon		Morning		Afternoon		Morning		Afternoon		Morning				Afternoon			
																	Way In		Way Out		Way In		Way Out	
					Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level
1	Chua Boc street	No. 1-Cboc	1	1,595	1,963	2,575	1,274	2,325	589		1,539	1,803		280	523	375	2,257	Very crowded	2,715	Severe G1	2,305	Very crowded	3,414	Very severe G1
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	1,500	2,206	368	1,434	704		1,600	1,860		280	523	375	1,852	Very crowded	2,346	Severe G1	1,429	Crowded	2,552	Severe G2
3	Ton That Tung street	No. 3-TTTung	1	723	882	841	780	1,551	10			157		0	0	0	887	Crowded	841	Crowded	780	Crowded	1,630	Very severe G2
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	981	1,129	1,225	1,430	1,083	385		119	569		506	1,168	611	1,321	Very crowded	1,478	Severe G1	2,074	Very severe G1	1,673	Severe G1
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,142	1,677	1,425	1,592	1,357	84		211	565		418	1,012	544	1,719	Severe G1	1,634	Very crowded	2,203	Severe G2	1,912	Severe G1
6	Kham Thien	No. 5-KThien	1	1,056	462	929	1,310	93	1,219		211	1,269		50	96	43	1,072	Crowded	954	Migrate	1,464	Very crowded	749	No congestion
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	2,046		3,539	0	1,636		160			0	684	0	2,864	Severe G1			3,961	Very severe G1	0	
8	Cau Giay	No. 7-CG	1	1,551	1,901	1,935	2,209	1,936	491		240	674		44	10	0	2,146	Very crowded	1,957	Very crowded	2,334	Severe G1	2,273	Very crowded
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835	2,392	2,290	2,523	2,199	439		375	890		178	380	273	2,611	Very crowded	2,380	Very crowded	2,900	Severe G1	2,781	Severe G1
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381	2,055	1,724	2,021	2,089	76		159	236		0	0	0	2,092	Severe G1	1,724	Crowded	2,101	Severe G1	2,207	Severe G1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379	2,139	2,969	2,251	1,693	1,530		1,505	2,311		0	0	0	2,904	Crowded	2,969	Crowded	3,004	Very crowded	2,849	Crowded
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128	1,891	2,656	2,108	1,277	1,392		1,253	2,306		0	0	0	2,587	Crowded	2,656	Crowded	2,734	Very crowded	2,430	Crowded
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127	2,220	2,654	2,636	1,643	1,061		722	1,938		127	238	85	2,750	Very crowded	2,718	Very crowded	3,116	Very crowded	2,654	Crowded
14	Pho Hue street	No. 11-Phue	1	1,896	2,982		1,811	0	626		840			0	0	0	3,295	Severe G1			2,231	Crowded	0	
15	Ba Trieu street	No. 12-BT	1	1,280		1,053	0	1,126		359	733	1,178		76	0	26			1,271	Migrate	367		1,728	Very crowded
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,122	1,795	2,206	2,200	437			550		84	236	127	2,341	Very crowded	1,837	Crowded	2,206	Very crowded	2,539	Severe G1
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,311	2,908	1,387	2,955	392		1,085	1,125		393	820	548	1,507	Migrate	3,105	Severe G2	2,340	Very crowded	3,791	Very severe G2
18	Kim Ma	No. 15-KimMa	1	1,691	1,926	2,111	2,671	1,771	683			1,076		396	816	581	2,268	Very crowded	2,309	Very crowded	2,671	Severe G1	2,600	Severe G1
19	Nguyen Trai street	No. 16-Ntrai	1	1,943	2,439	2,425	2,624	2,127	558		444	1,143		19	137	94	2,718	Very crowded	2,435	Very crowded	2,915	Severe G1	2,746	Very crowded
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	680	758	910	733	325	185		240	365		0	0	0	850	Crowded	910	Very crowded	853	Very crowded	507	No congestion
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	624	890	910	1,030	891	0					0	0	0	890	Very crowded	910	Very crowded	1,030	Severe G1	891	Very crowded
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	726	1,171	781	1,089	959	0					51	100	62	1,171	Severe G1	806	Crowded	1,089	Very crowded	959	Very crowded
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,163	1,153	1,496	1,219	1,151	125			309		52	42	26	1,215	Crowded	1,522	Very crowded	1,219	Crowded	1,318	Crowded
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,240	1,361	1,594	1,299	1,555	0					0	0	0	1,361	Crowded	1,594	Very crowded	1,299	Crowded	1,555	Very crowded
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,062	1,166	1,365	1,112	1,176	0			156		506	1,168	611	1,166	Crowded	1,618	Severe G1	1,112	Crowded	1,559	Very crowded
26	Duong Buoi	No. 19-D.Buoi	2	796	821	1,023	771	886	53		62	113		3	6	0	847	Crowded	1,025	Very crowded	805	Crowded	942	Crowded
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	1,172	2,664	914	0					7	12	8	1,040	No congestion	1,176	Migrate	2,664	Severe G2	914	No congestion
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	1,726	1,695	1,454	2,982	44		134	48		995	2,160	1,417	1,748	Migrate	2,193	Crowded	2,601	Very crowded	3,714	Severe G2
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	1,721	1,468	1,590	1,750	185		240	369		52	36	26	1,813	Migrate	1,494	No congestion	1,728	Migrate	1,948	Migrate
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,128	2,319	1,864	1,643	4			50		61	161	85	1,130	No congestion	2,350	Very crowded	1,864	Crowded	1,711	Crowded
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	1,881	1,331	1,972	1,687	204		80	508		70	178	110	1,983	Crowded	1,366	No congestion	2,101	Crowded	1,996	Crowded
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600	2,765	3,343	2,590	3,213	90		134	48		1,047	2,128	1,443	2,809	Crowded	3,866	Very crowded	3,721	Very crowded	3,959	Severe G1
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,746	1,614	1,836	2,184	177			435		7	12	8	1,834	Crowded	1,618	Migrate	1,836	Crowded	2,406	Very crowded
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,746	1,252	1,572	2,184	177			435		7	12	8	1,834	Migrate	1,256	No congestion	1,572	No congestion	2,406	Crowded
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	1,169	1,168	2,129	0					29	170	62	2,033	Very crowded	1,184	Migrate	1,168	Migrate	2,129	Very crowded
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793	2,708	3,592	2,193	2,012	359		733	1,492		178	161	173	2,888	Crowded	3,681	Very crowded	2,641	Migrate	2,845	Crowded

Note: Nguyen Thai Hoc street, Ba Trieu street and Pho Hue street are one way streets.

Appendix I: Congestion level of scenario 4-Relocate all_Road Expand

Congestion level of corridors-Scenario 4-Relocate All_Road Expand

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Traffic Volume-Scenario B				Contribution of study areas				Scenario 4-Relocate All_Road Expand							
					Morning		Afternoon		Morning		Afternoon		Morning				Afternoon			
													Way In		Way Out		Way In		Way Out	
					Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level
1	Chua Boc street	No. 1-Cboc	1	1,595	1,963	2,575	1,274	2,325		230	471	316	1,963	Crowded	2,805	Severe G2	1,745	Crowded	2,641	Severe G1
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	1,500	2,206	368	1,434		193	276	189	1,500	Crowded	2,399	Severe G1	644	No congestion	1,624	Crowded
3	Ton That Tung street	No. 3-TTTung	1	723	882	841	780	1,551		0	166	0	882	Crowded	841	Crowded	946	Very crowded	1,551	Very severe G1
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	1,548	1,129	1,225	1,430	1,083		424	853	650	1,129	No congestion	1,648	Crowded	2,283	Very crowded	1,733	Crowded
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,559	1,677	1,425	1,592	1,357		310	632	489	1,677	Crowded	1,734	Crowded	2,223	Very crowded	1,846	Crowded
6	Kham Thien	No. 5-KThien	1	1,056	462	929	1,310	93		54	260	43	462	No congestion	983	Migrate	1,570	Very crowded	135	No congestion
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	2,046		3,539	0		0	488	0	2,046	Crowded			4,028	Very severe G1	0	
8	Cau Giay	No. 7-CG	1	1,551	1,901	1,935	2,209	1,936		0	18	0	1,901	Crowded	1,935	Crowded	2,227	Very crowded	1,936	Crowded
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835	2,392	2,290	2,523	2,199		148	349	174	2,392	Very crowded	2,439	Very crowded	2,872	Severe G1	2,373	Very crowded
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381	2,055	1,724	2,021	2,089		62	132	77	2,055	Very crowded	1,786	Very crowded	2,154	Severe G1	2,165	Severe G1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379	2,139	2,969	2,251	1,693		0	0	0	2,139	Migrate	2,969	Crowded	2,251	Migrate	1,693	No congestion
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128	1,891	2,656	2,108	1,277		50	53	17	1,891	Migrate	2,706	Very crowded	2,161	Crowded	1,294	No congestion
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127	2,220	2,654	2,636	1,643		35	43	4	2,220	Crowded	2,689	Very crowded	2,679	Very crowded	1,647	No congestion
14	Pho Hue street	No. 11-Phue	1	1,896	2,982		1,811	0		0	0	0	2,982	Severe G1			1,811	Migrate	0	
15	Ba Trieu street	No. 12-BT	1	1,280		1,053	0	1,126		81	0	44			1,134	Migrate	0		1,169	Migrate
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,122	1,795	2,206	2,200		18	126	49	2,122	Very crowded	1,813	Crowded	2,332	Very crowded	2,249	Very crowded
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,311	2,908	1,387	2,955		270	776	410	1,311	No congestion	3,178	Severe G2	2,163	Very crowded	3,365	Very severe G1
18	Kim Ma	No. 15-KimMa	1	1,691	1,926	2,111	2,671	1,771		392	723	475	1,926	Crowded	2,504	Very crowded	3,395	Very severe G1	2,246	Very crowded
19	Nguyen Trai street	No. 16-Ntrai	1	1,943	2,439	2,425	2,624	2,127		398	785	646	2,439	Very crowded	2,823	Very crowded	3,410	Severe G2	2,773	Very crowded
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	1,605	758	910	733	325		0	0	0	758	No congestion	910	No congestion	733	No congestion	325	No congestion
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	1,693	890	910	1,030	891		0	52	0	890	No congestion	910	No congestion	1,082	No congestion	891	No congestion
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	1,457	1,171	781	1,089	959		130	259	141	1,171	Migrate	911	No congestion	1,348	Migrate	1,100	No congestion
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,715	1,153	1,496	1,219	1,151		9	91	26	1,153	No congestion	1,505	Migrate	1,310	No congestion	1,177	No congestion
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,573	1,361	1,594	1,299	1,555		64	76	85	1,361	Migrate	1,658	Crowded	1,375	Migrate	1,640	Crowded
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,870	1,166	1,365	1,112	1,176		60	105	40	1,166	No congestion	1,425	No congestion	1,217	No congestion	1,216	No congestion
26	Duong Buoi	No. 19-D.Buoi	2	2,115	821	1,023	771	886		12	15	0	821	No congestion	1,035	No congestion	787	No congestion	886	No congestion
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	1,172	2,664	914		9	275	8	1,040	No congestion	1,181	Migrate	2,939	Very severe G1	922	No congestion
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	1,726	1,695	1,454	2,982		946	1,885	1,220	1,726	Migrate	2,641	Very crowded	3,340	Severe G1	4,202	Very severe G1
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	1,721	1,468	1,590	1,750		806	1,532	1,032	1,721	Migrate	2,274	Crowded	3,122	Very crowded	2,782	Very crowded
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,128	2,319	1,864	1,643		39	66	49	1,128	No congestion	2,358	Very crowded	1,930	Crowded	1,692	Crowded
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	1,881	1,331	1,972	1,687		152	682	188	1,881	Migrate	1,483	No congestion	2,653	Very crowded	1,875	Migrate
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600	2,765	3,343	2,590	3,213		1,019	1,809	1,331	2,765	Crowded	4,362	Severe G1	4,399	Severe G1	4,544	Severe G1
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,746	1,614	1,836	2,184		9	47	8	1,746	Migrate	1,623	Migrate	1,883	Crowded	2,193	Very crowded
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,746	1,252	1,572	2,184		9	39	8	1,746	Migrate	1,261	No congestion	1,611	No congestion	2,193	Crowded
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	1,169	1,168	2,129		34	135	62	2,033	Very crowded	1,203	Migrate	1,303	Migrate	2,191	Severe G1
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793	2,708	3,592	2,193	2,012		122	161	114	2,708	Migrate	3,715	Very crowded	2,354	Migrate	2,126	No congestion

Note: Nguyen Thai Hoc street, Ba Trieu street and Pho Hue street are one way streets.

Appendix K: Congestion level-Scenario 5: Relocate 50-50_Road Expand

Congestion level of corridors-Scenario 5-Relocate 50-50_Road Expand

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Traffic Volume-Scenario B				Traffic Volume-Scenario 1				Traffic Volume-Scenario 4				Scenario 5: Relocate 50-50_Road Expand							
					Morning		Afternoon		Morning		Afternoon		Morning		Afternoon		Morning				Afternoon			
																	Way In		Way Out		Way In		Way Out	
					Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level
1	Chua Boc street	No. 1-Cboc	1	1,595	1,963	2,575	1,274	2,325	295		743	637		230	471	316	2,110	Very crowded	2,632	Severe G1	1,881	Crowded	2,802	Severe G2
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	1,500	2,206	368	1,434	426		802	777		193	276	189	1,713	Crowded	2,303	Severe G1	907	No congestion	1,918	Very crowded
3	Ton That Tung street	No. 3-TTTung	1	723	882	841	780	1,551	17		139	179		0	166	0	890	Crowded	841	Crowded	932	Very crowded	1,641	Very severe G2
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	1,548	1,129	1,225	1,430	1,083	164		274	733		424	853	650	1,211	No congestion	1,436	Migrate	1,994	Very crowded	1,775	Crowded
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,559	1,677	1,425	1,592	1,357	163		346	770		310	632	489	1,758	Crowded	1,580	Crowded	2,080	Very crowded	1,987	Very crowded
6	Kham Thien	No. 5-KThien	1	1,056	462	929	1,310	93	1,429		76	1,560		54	260	43	1,177	Crowded	956	Migrate	1,478	Very crowded	894	Migrate
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	2,046		3,539	0	1,424		151			0	488	0	2,758	Severe G1			3,859	Very severe G1	0	
8	Cau Giay	No. 7-CG	1	1,551	1,901	1,935	2,209	1,936	480		223	617		0	18	0	2,141	Very crowded	1,935	Crowded	2,330	Severe G1	2,245	Very crowded
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835	2,392	2,290	2,523	2,199	413		301	701		148	349	174	2,598	Very crowded	2,364	Very crowded	2,848	Severe G1	2,637	Very crowded
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381	2,055	1,724	2,021	2,089	58		96	173		62	132	77	2,084	Severe G1	1,755	Very crowded	2,136	Severe G1	2,213	Severe G1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379	2,139	2,969	2,251	1,693	1,785		1,583	3,053		0	0	0	3,031	Very crowded	2,969	Crowded	3,043	Very crowded	3,219	Very crowded
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128	1,891	2,656	2,108	1,277	1,528		1,588	3,189		50	53	17	2,655	Crowded	2,681	Very crowded	2,928	Very crowded	2,880	Very crowded
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127	2,220	2,654	2,636	1,643	1,100		836	1,862		35	43	4	2,769	Very crowded	2,672	Very crowded	3,076	Very crowded	2,576	Crowded
14	Pho Hue street	No. 11-Phue	1	1,896	2,982		1,811	0	358		744			0	0	0	3,160	Severe G1			2,183	Crowded	0	
15	Ba Trieu street	No. 12-BT	1	1,280		1,053	0	1,126		345		1,205		81	0	44			1,266	Migrate	0		1,750	Very crowded
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,122	1,795	2,206	2,200	451		22	587		18	126	49	2,348	Very crowded	1,804	Crowded	2,280	Very crowded	2,518	Severe G1
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,311	2,908	1,387	2,955	171		322	348		270	776	410	1,396	Migrate	3,043	Severe G2	1,936	Crowded	3,334	Very severe G1
18	Kim Ma	No. 15-KimMa	1	1,691	1,926	2,111	2,671	1,771	676		247	1,182		392	723	475	2,264	Very crowded	2,307	Very crowded	3,156	Severe G2	2,599	Severe G1
19	Nguyen Trai street	No. 16-Ntrai	1	1,943	2,439	2,425	2,624	2,127	568		487	1,142		398	785	646	2,723	Very crowded	2,624	Very crowded	3,261	Severe G1	3,021	Severe G1
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	1,605	758	910	733	325	174		223	314		0	0	0	845	No congestion	910	No congestion	845	No congestion	482	No congestion
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	1,693	890	910	1,030	891	125		223	355		0	52	0	952	No congestion	910	No congestion	1,167	No congestion	1,068	No congestion
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	1,457	1,171	781	1,089	959	563		599	1,310		130	259	141	1,452	Migrate	846	No congestion	1,518	Crowded	1,684	Crowded
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,715	1,153	1,496	1,219	1,151	4			5		9	91	26	1,155	No congestion	1,501	Migrate	1,219	No congestion	1,166	No congestion
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,573	1,361	1,594	1,299	1,555	9		7	12		64	76	85	1,366	Migrate	1,626	Crowded	1,340	Migrate	1,604	Crowded
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,870	1,166	1,365	1,112	1,176	9		40	73		60	105	40	1,170	No congestion	1,395	No congestion	1,185	No congestion	1,232	No congestion
26	Duong Buoi	No. 19-D.Buoi	2	2,115	821	1,023	771	886	104		43	142		12	15	0	873	No congestion	1,029	No congestion	801	No congestion	957	No congestion
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	1,172	2,664	914	16			101		9	275	8	1,048	No congestion	1,176	Migrate	2,664	Severe G2	968	No congestion
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	1,726	1,695	1,454	2,982	196		113	308		946	1,885	1,220	1,824	Migrate	2,168	Crowded	2,454	Crowded	3,746	Severe G2
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	1,721	1,468	1,590	1,750	185		64	261		806	1,532	1,032	1,813	Migrate	1,871	Migrate	2,388	Crowded	2,397	Crowded
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,128	2,319	1,864	1,643	128		75	249		39	66	49	1,193	No congestion	2,338	Very crowded	1,934	Crowded	1,792	Crowded
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	1,881	1,331	1,972	1,687	320		116	454		152	682	188	2,041	Crowded	1,407	No congestion	2,371	Crowded	2,008	Crowded
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600	2,765	3,343	2,590	3,213	205		176	285		1,019	1,809	1,331	2,867	Crowded	3,852	Very crowded	3,583	Very crowded	4,021	Severe G1
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,746	1,614	1,836	2,184	157		256	378		9	47	8	1,825	Crowded	1,618	Migrate	1,987	Crowded	2,377	Very crowded
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,746	1,252	1,572	2,184	96			17		9	39	8	1,794	Migrate	1,256	No congestion	1,572	No congestion	2,197	Crowded
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	1,169	1,168	2,129	66		86	252		34	135	62	2,066	Very crowded	1,186	Migrate	1,278	Migrate	2,286	Severe G1
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793	2,708	3,592	2,193	2,012	601		2,584	3,625		122	161	114	3,009	Crowded	3,653	Very crowded	3,566	Very crowded	3,882	Very crowded

Note: Nguyen Thai Hoc street, Ba Trieu street and Pho Hue street are one way streets.

Appendix L: Congestion level-Scenario 5B: Relocate 50-50 & Road Expand & Change in trip origin 50%

Congestion level of corridors-Scenario 5B-Relocate 50-50 & Road Expansion & Change in Trip Origin 50%

No.	Road name	Corridor code	Corridor group	Road intensity (pcu/h)	Traffic Volume-Scenario B				Traffic Volume-Scenario 1				Traffic Volume-Scenario 4				Scenario 5B: Relocate 50-50 & Road Expansion & Change in Trip Origin							
					Morning		Afternoon		Morning		Afternoon		Morning		Afternoon		Morning				Afternoon			
					Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way-In	Way-out	Way In		Way Out		Way In		Way Out	
																	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level	New Peak volume-Way In	Congestion level	New Peak volume-Way Out	Congestion level
1	Chua Boc street	No. 1-Cboc	1	1,595	1,963	2,575	1,274	2,325	259		627	497		109	236	158	2,092	Very crowded	2,602	Severe G1	1,705	Crowded	2,653	Severe G1
2	Pham Ngoc Thach street	No. 2-PNThach	1	1,388	1,500	2,206	368	1,434	333		674	606		92	138	95	1,666	Crowded	2,252	Severe G1	774	No congestion	1,785	Very crowded
3	Ton That Tung street	No. 3-TTTung	1	723	882	841	780	1,551	17		87	132		0	143	0	890	Crowded	841	Crowded	895	Crowded	1,617	Very severe G1
4	Truong Chinh 1(N.T.So-T.T.Tung)	No. 4-Tchinh	1	1,548	1,129	1,225	1,430	1,083	154		258	701		293	593	487	1,206	No congestion	1,371	Migrate	1,856	Crowded	1,677	Crowded
5	Truong Chinh 2(T.T.Tung-N.T.Vong)	No.4b-Tchinh	1	1,559	1,677	1,425	1,592	1,357	155		302	712		196	370	342	1,754	Crowded	1,523	Migrate	1,928	Crowded	1,884	Crowded
6	Kham Thien	No. 5-KThien	1	1,056	462	929	1,310	93	1,093		55	1,214		25	148	21	1,009	Migrate	942	Migrate	1,412	Very crowded	710	No congestion
7	Nguyen Thai Hoc	No. 6-NTHoc	1	1,836	2,046		3,539	0	953		82	15		0	413	0	2,523	Very crowded			3,787	Very severe G1	7	
8	Cau Giay	No. 7-CG	1	1,551	1,901	1,935	2,209	1,936	480		223	617		0	18	0	2,141	Very crowded	1,935	Crowded	2,330	Severe G1	2,245	Very crowded
9	Cau Chuong Duong-NV Cu	No. 8-CauCD	1	1,835	2,392	2,290	2,523	2,199	413		301	701		149	349	174	2,598	Very crowded	2,365	Very crowded	2,848	Severe G1	2,637	Very crowded
10	Le Thanh Nghi street	No. 9-LTNghi	1	1,381	2,055	1,724	2,021	2,089	29		48	86		31	66	38	2,069	Very crowded	1,739	Very crowded	2,079	Severe G1	2,151	Severe G1
11	Giai Phong(DCV-LTN)	No. 10-Gphong	1	2,379	2,139	2,969	2,251	1,693	1,498		1,257	2,435		0	0	0	2,888	Crowded	2,969	Crowded	2,880	Crowded	2,911	Crowded
12	Giai Phong(LTN-NTVong)	No. 10b-Gphong	1	2,128	1,891	2,656	2,108	1,277	1,428		1,391	2,918		25	27	9	2,605	Crowded	2,669	Very crowded	2,817	Very crowded	2,740	Very crowded
13	Giai Phong(Pho Vong-Bxe GiapBat)	No. 10c-Gphong	1	2,127	2,220	2,654	2,636	1,643	1,092		811	1,811		34	43	4	2,765	Very crowded	2,671	Very crowded	3,063	Very crowded	2,550	Crowded
14	Pho Hue street	No. 11-Phue	1	1,896	2,982		1,811	0	236		744			0	0	0	3,099	Severe G1			2,183	Crowded	0	
15	Ba Trieu street	No. 12-BT	1	1,280		1,053	0	1,126		268		1,052		39	0	22			1,206	Migrate	0		1,662	Very crowded
16	Nguyen Luong Bang	No. 13-N.L.Bang	1	1,615	2,122	1,795	2,206	2,200	419		11	517		13	88	38	2,332	Very crowded	1,801	Crowded	2,256	Very crowded	2,478	Severe G1
17	Thai Ha	No. 14-ThaiHa	1	1,640	1,311	2,908	1,387	2,955	151		244	217		133	432	219	1,386	Migrate	2,974	Severe G2	1,724	Crowded	3,173	Severe G2
18	Kim Ma	No. 15-KimMa	1	1,691	1,926	2,111	2,671	1,771	577		176	875		265	577	338	2,215	Very crowded	2,244	Very crowded	3,048	Severe G2	2,378	Very crowded
19	Nguyen Trai street	No. 16-Ntrai	1	1,943	2,439	2,425	2,624	2,127	568		487	1,142		263	511	482	2,723	Very crowded	2,556	Very crowded	3,123	Severe G1	2,939	Severe G1
20	La Thanh 1(Voiphuc-N.C.Thanh)	No. 17-LaThanh	1	1,605	758	910	733	325	174		223	314		0	0	0	845	No congestion	910	No congestion	845	No congestion	482	No congestion
21	La Thanh 2(N.C.Thanh-L.Ha)	No.17b-LaThanh	1	1,693	890	910	1,030	891	105		223	335		0	26	0	942	No congestion	910	No congestion	1,155	No congestion	1,058	No congestion
22	La Thanh 3(L.Ha-T.D.Thang)	No.17c-LaThanh	1	1,457	1,171	781	1,089	959	393		464	931		59	129	70	1,367	Migrate	811	No congestion	1,386	Migrate	1,460	Crowded
23	Duong Lang 1(Cgiay-N.C.Thanh)	No. 18-Dlang	2	1,715	1,153	1,496	1,219	1,151	4			5		4	45	13	1,155	No congestion	1,498	Migrate	1,219	No congestion	1,159	No congestion
24	Duong Lang 2(N.C.Thanh-L.Ha)	No. 18b-Dlang	2	1,573	1,361	1,594	1,299	1,555	9		7	12		31	38	42	1,366	Migrate	1,609	Crowded	1,321	Migrate	1,582	Crowded
25	Duong Lang 3(L.Ha-N.T.So)	No. 18c-Dlang	2	1,870	1,166	1,365	1,112	1,176	9		40	73		45	74	22	1,170	No congestion	1,388	No congestion	1,169	No congestion	1,223	No congestion
26	Duong Buoi	No. 19-D.Buoi	2	2,115	821	1,023	771	886	104		43	142		10	15	0	873	No congestion	1,028	No congestion	801	No congestion	957	No congestion
27	Cat Linh	No. 20-CatLinh	2	1,389	1,040	1,172	2,664	914	10			52		4	156	4	1,045	No congestion	1,174	Migrate	2,664	Severe G2	942	No congestion
28	Nguyen Chi Thanh(Dlang-HTKhang)	No.21-N.C.Thanh	2	2,050	1,726	1,695	1,454	2,982	176		113	266		547	1,182	731	1,814	Migrate	1,969	Migrate	2,102	Crowded	3,481	Severe G1
29	Nguyen Chi Thanh(HTKhang-LaThanh)	No.21b-N.C.Thanh	2	2,098	1,721	1,468	1,590	1,750	161		37	241		484	1,005	637	1,802	Migrate	1,710	Migrate	2,112	Crowded	2,189	Crowded
30	Lang Ha (D.Lang-Thai Ha)	No. 22-LHa	2	1,607	1,128	2,319	1,864	1,643	68		91	149		19	33	24	1,162	No congestion	2,329	Very crowded	1,926	Crowded	1,730	Crowded
31	Lang Ha (Thai Ha-Giang Vo)	No. 22b-LHa	2	1,947	1,881	1,331	1,972	1,687	229		176	312		69	359	94	1,996	Crowded	1,365	No congestion	2,239	Crowded	1,890	Migrate
32	Tran Duy Hung	No. 23-T.D.Hung	2	2,600	2,765	3,343	2,590	3,213	202		181	285		582	1,144	786	2,865	Crowded	3,634	Very crowded	3,252	Very crowded	3,749	Very crowded
33	Giang Vo (L.Ha-Ngoc Khanh)	No. 24-G.Vo	2	1,752	1,746	1,614	1,836	2,184	91			272		4	24	4	1,791	Crowded	1,616	Migrate	1,836	Crowded	2,322	Very crowded
34	Giang Vo (Ngoc Khanh-Cat Linh)	No. 24b-G.Vo	2	2,094	1,746	1,252	1,572	2,184	50		58	13		4	19	4	1,771	Migrate	1,254	No congestion	1,611	No congestion	2,193	Crowded
35	Ton Duc Thang (Ochodua-CatLinh)	No. 25-T.D.Thang	2	1,453	2,033	1,169	1,168	2,129	38		2,027	126		19	93	45	2,052	Very crowded	1,179	Migrate	2,228	Severe G1	2,214	Severe G1
36	Dai Co Viet (Lduan-Batrieu)	No. 26-D.C.Viet	2	2,793	2,708	3,592	2,193	2,012	490		2,584	2,954		59	80	57	2,953	Crowded	3,621	Very crowded	3,525	Very crowded	3,518	Very crowded

Note: Nguyen Thai Hoc street, Ba Trieu street and Pho Hue street are one way streets.

Congestion Mark-Scenario 5B -Relocate 50-50 & Road Expansion & Change in Trip Origin 50%

	Mark	Weight	Morning Way In	Morning -Way Out	Afternoon-Way In	Afternoon-Way Out	Sum Scenario 5B	**Total Mark**
No congestion	10	1	8	7	7	7	29	**290**
Migrate	8	1	7	10	2	1	20	**160**
Crowded	2	1	9	5	12	9	35	**70**
Very crowded	-2	1	10	9	6	9	34	**-68**
Severe G1	-3	2	1	2	5	6	14	**-84**
Severe G2	-4	2		1	2	1	4	**-32**
Very severe G1	-6	3				1	1	**-18**
Very severe G2	-8	3					0	**0**
Craw	-10	3					0	**0**
Sum								**318**