TRANSPORTATION STUDY METROPOLITAN CEBU

A CASE STUDY

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Thesis report

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PREFACE

This is the final report of a transportation study that has been conducted within the framework of the thesis project at the Faculty of Civil Engineering and Geosciences at the Technical University of Delft. In this report traffic related topics are analyzed of Metropolitan Cebu, the second largest city in the Philippines.

The project is executed at the Faculty of Civil Engineering in Delft at the department Infrastructure, section Infrastructure planning. The stage of the data collection is executed at the Water Resources Center (WRC) in Cebu City. The staff members of this research unit at the University of San Carlos have been of a great help by providing all the facilities and giving helpful assistance during this first stage. Therefore I would like to express my sincere thanks to the staff members of the Water Resources Center. A special thanks also goes to ir. J.de Lange and R. Heijkoop for their assistance and guidance.

I would also like to extend my gratitude to all the consult and governmental agencies in Cebu City for providing their cooperation.

For this thesis project great help and support was provided by my supervisors drs. W. Ruiter, Prof.ir. F.M. Sanders, Dr. E.O. Akinyemi, P.C.H. Opstal and Ir. P. van Eck. I would like to express my sincerest gratitude for this and for providing me this opportunity.

Finally I wish to extend my deepest gratitude to my parents for their enormous support.

Khalid Tourabi

Delft, The Netherlands
February 7, 2002

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goede, overzichtelijke aanpak met strategieën en hun effecten;
wellicht wat dun, maar in moeilijke situatie voor gegevensverkrijging begrijpelijk
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SUMMARY

In this transportation study attention is paid to the most normative issues that influence the traffic circulation in a fast growing Metropolitan. Impacts of new infrastructure are being analyzed with the help of existing mathematical models in order to describe a new or adapted policy with regard to urban and transportation planning. This is done in general terms and also illustrated with the case Metropolitan Cebu, the second fast growing Metropolitan in the Philippines. In order to describe a proposed land use and transportation strategy for Metropolitan Cebu it is necessary to get insight in the actual (traffic) situation in Metropolitan Cebu. A distinction is made between demographic and transportation characteristics. A socio-economic profile is given in which several tables and maps illustrate trends and growth rates of among others demographic information. The combined population in Metropolitan Cebu is approximately 1.5 million; the total population of only Cebu City is approximately 700,000 Metropolitan Cebu is suffering from severe congestion and other related traffic problems that have laid a base for the objectives described in the Metro Cebu Development Projects (MCDP). Some of these projects have already been completed while other projects that are part of the MCDP phase 3 are still in the implementing phase. For the MCDP phase 3 a reclamation area and a coastal highway are being constructed. When completed the reclamation area will house approximately 100 000 employees. The coastal highway will serve the through traffic coming from the southern part of Metropolitan Cebu and going to the north and will also serve the extra generated traffic flows by the reclamation area.

Before using the available information and applying this data in a transportation model the theory behind transportation modeling is described. The classical four stage traffic model is explained. In this model four steps are distinguished which refer to four different quantities of traffic volume. The first two steps describe how often people make trips as a function of their personal and spatial conditions and how these trips are distributed over the different zones in the study area (trip generation and trip distribution). The third step is a sub model that determines which transport modes the travelers will use for their trips (modal split). The last step deals with how travelers choose routes through the network (traffic assignment).

Once the scientific theory is described and explained on the basis of the case Metropolitan Cebu the model can almost be applied. The first calculations can be made when the necessary input for the model is obtained. The necessary demographic characteristics, that are the main ingredients of the total input, will be put in order and in case of lack of data obtained by calculations such as linear trend extrapolation. It is important to keep in mind that only the demographic characteristics of population and employment are taken in consideration and that the obtained results are with regard to work-home trips. The first calculations are with regard to the total number of work-home trips that are produced and attracted (trip productions and attractions) by the 12 traffic zones in which Metropolitan Cebu is divided, this is done for both a present and future situation.

The calculated work-home trips will be distributed over the 12 traffic zones according a doubly constrained trip distribution model. Doubly constrained implies that the trip distribution model is both constrained to productions and attractions. The results of the trip distribution show that the largest traffic movements take place between the northern parts of Metropolitan Cebu. The new reclamation area will attract 24 000 workers every day from Cebu City, which can be considered as a great increase in the total of traffic movements that is made every day. However, the new reclamation area will be combined with a new coastal highway for processing the extra-generated traffic.

Whether the coastal highway is sufficient for processing the extra-generated traffic flows or not will come to order on the basis of a traffic assignment (i.e. the calculation of traffic flows in vehicles per hour for every road link). The traffic assignment will be performed for several scenarios, so that conclusions about the effects and benefits of the new coastal highway can be drawn. The following traffic assignments have been distinguished:

- The first traffic assignment will be performed for the base year (2000) and will describe the existing situation.
- The second traffic assignment will be performed for the future year (2010) and will describe a situation for which Metropolitan Cebu has new demographic characteristics but without the expansion of the road network (the so-called zero alternative). In this way bottlenecks in the network can be located if no changes or expansions of the road network are implemented.
- The third traffic assignment will also be performed for the future year (2010) but on the road network in which the coastal highway is included.

The results of these three traffic assignments show that the South Coastal Highway contributes to a decrease of the average traffic flow (thus also the travel times that are part of the output of a traffic assignment) on some parts of Cebu Highway. However, on the most routes in Cebu City especially in east-west direction the travel times show an increase if compared with the base year situation.

Subsequently a new policy will be described for preventing further the traffic problems in Metropolitan Cebu. The goal is to obtain a situation for which Cebu City has no increase of the average traffic flow on Cebu Highway and the travel times between the several traffic zones in Cebu City. Eventually an improved accessibility of the CBD areas in Cebu City can be obtained. The proposed land use and transportation planning will be worked out on the basis of two scenarios that describe a situation for which Cebu City has a new proposed redistribution of the demographic characteristics and a new proposed road network (i.e. a recommendation for the urban circumferential road through the mountainous area of Cebu City and an extension of the South Coastal Highway towards the northern parts of Metropolitan Cebu). The results will be visualized in the same way as for the evaluation of the existing situation.

The necessary calculations and results will be performed respectively visualized on the basis of the software package TransCAD that is perfectly suitable for dealing very easy and quickly with the problems that have been described for Metropolitan Cebu. The following table summarizes all the scenarios that will be worked out in TransCAD throughout the study.

Space of time	Scenario	Traffic assignment
Existing situation (2000)	1	Base year
Future situation (2010)	2	Zero alternative
	3	Future
Proposed future situation (2010)	4	Proposed future
	5	Complete proposed future

The results of the scenarios that have been worked out for the proposed strategies show that eventually the average traffic flow on Cebu Highway decreases from 3500 vehicles per hour in the base year (2000) to 2500 vehicles per hour in the future year (2010). The overall travel times in Cebu City also show a decrease if compared with the base year situation. It can be concluded that the obtained situation is better than the existing situation in Metropolitan Cebu if the described policies are implemented.

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1 INTRODUCTION

1.1 Background

There are different definitions that describe a Metropolitan. The US definition of 'Standard Metropolitan Areas' delimits what can be called 'functional regions' that include suburbs and other settlements outside the core city's built up area if the proportion of residents commuting to work in the central core exceeds a certain level and if the settlements meets other criteria of metropolitan 'character' (e.g. population density). In Europe, the tendency seems to be more to view metropolitan areas as areas that conveniently encompass all the continuously built up area of a metropolis but that exclude large and small urban centres and rural settlements nearby, even though their housing and labour markets are fully integrated into those of the metropolitan centre. No definition of urban areas is necessarily superior; each serves a particular purpose.

In 1990 the five world's largest urban agglomerations were Tokyo, New York, Mexico City, Sao Paulo and Shanghai. Manila was with its population of nearly 8 million on the twentieth place. Urban populations did grow rapidly in most parts of the world during the 1980s, but they actually grew faster during the 1950s. Population growth rates for most major cities in both the North and the South were slower during the 1980s, compared to the 1970s and 1960s. And for many of the world's largest cities, including many in the South, more people moved out of the city than in during the last intersensus period.

There are several causes that can be pointed out for the fast growth of cities and metropolitans. Trends in urbanisation are caused by economic and political changes, some long-rooted, some of more recent origin. For instance, the steady increase in the level of urbanisation world-wide since 1950 reflects the fact that the size of world's economy has grown many times since then and has also changed from one relatively closed national economies or trading blocs to one where most countries have more open economies and where production and the services it needs (including financial services) are increasingly integrated internationally. In 1950, most of the world's workforce worked in agriculture; by 1990, most worked in services. The period since 1950 has brought not only enormous changes in the scale and nature of economic activity but also in the size and nature of households, in the scale and distribution of incomes within and between nations and in the scale and nature of government. All, inevitably, influence settlements patterns. Perhaps the most fundamental influences on the world's settlement system in recent decades have come from the unprecedented changes in economic and political conditions

The continuing growth of urban activity and the expanding dimensions of city and suburbs are making it difficult to move in the metropolis, rendering urban areas less accessible and reducing the quality of urban living. The need for travel in the cities can be reduced by eliminating some of the conditions that create unmanageable traffic. What is required are urban development strategies governing the use of land and the densities, arrangements, and functions of buildings. There is evidence around the world that the architects of large-scale urban development are already designing communities in ways that get to the heart of the transportation problem. The approach is twofold. First, there is a move to build and rebuild communities and neighbourhoods with a view to mixing workplaces and housing with shopping, schools, and other services in a pleasant environment. Such developments reduce the frequency and length of trips and enhance the possibilities of walking. Second, these semi-independent communities or centres of activity are connected to limited-access highways or rail transit in order to assure close links with the central city and the region. These transportation corridors help to bring about some degree of order in the movement of traffic among the multiple centres of the urban region.

In other words two variables can be pointed out that influence movements of traffic and thus travel demand: spatial developments and the transport system. Spatial development is defined as the growth or reduction of activities with regard to land use (i.e. housing, working, recreation) in a certain geographic area. More traditional strategies were only using the spatial developments as an input and ignoring the fact that the transportation system also influences the travel demand. However both are necesarry and should be treated as input in a strategy concerning travel demand. Besides their influence on travel demand land use and transport influence each other and should not be treated as independent variables. For example industrial development may require special sites, good availability of water services and access to major roads and railway/port terminals. Office employment tends to be located close to good communication facilities and as close as possible to other office developments. Changes in accessibility are likely to affect the potential for development of different parts of a study area. Thus if a transport strategy significantly changes the accessibility this will change demand for land and generate new development in some areas; these will in turn affect the pattern of trips and therefore have an impact on the performance of the transport system. The interaction between land use, transportation system and travel demand is schematized in the following figure.

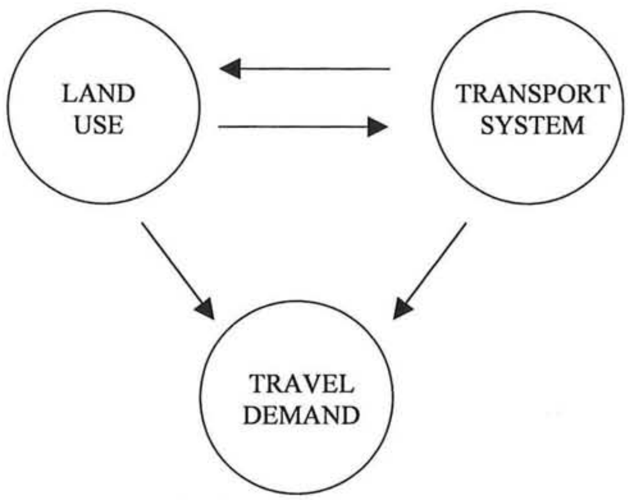


Figure 1.1 Interaction between land use, transport system and travel demand

Without an efficient transportation strategy the internal and external accessibility may become less resulting for example in congestion problems, negative impact on the environment etc. In this respect congestion may be defined as a phenomenon that arises when demand levels approach the capacity of a facility and the time required to use it (travel through it) increases well above the average under low demand conditions.

Different planning techniques are available in order to predict the growth and thus to 'lead' the city/metropolitan in a controlled manner by realising the right infrastructure measurements. In summary these planning techniques can be used for studying the effects of infrastructure measurements.

1.2 Problem definition

Political, economical and social issues have been pointed as factors that may cause the fast growth of a city or metropolitan. A requirement for a transportation planner before he can formulate an efficient transportation strategy is getting insight in these complicated factors, that lay the basis for many traffic related problems. In practice however many planners are restricted by time, money and available information. Only the most relevant information with regard to the two variables land use and transportation system needs to be studied. So that in the next step this information can be processed in a structurized way and new information can be obtained. In this respect the application of a transportation model seems inevitable because a model is not more than a very simplified representation of a complicated part of the real world. In this study this theory will be supported by working out the case of Metropolitan Cebu in a transportation model. Metropolitan Cebu is the second largest metropolitan in the Philippines that has grown very rapidly in the past decades and is because of this suffering from severe crowding in the central city. The combined pressures of population growth and economic development placed severe pressure on the transportation system that on many places lacks the capacity to process the large traffic movements in Metropolitan Cebu resulting in heavy traffic congestion, that causes a completely inaccessible CBD area. The problem that can be defined for Metropolitan Cebu is that without a systematic division of the major road network the traffic congestion will only increase more as a result of the rapid urban growth in combination with inefficient policies with regard to land use.

1.3 Goals and objectives of the study

The design and application of a modern travel demand technique (i.e. a transportation model) must help

- **finding a systematic classification of the major road network in Metropolitan Cebu**
- **formulating additional suitable transportation strategies with regard to traffic management**
- **and formulating rational land use strategies that focus on the creation of new opportunities for dwelling and commercial areas and at the same time on solving traffic related problems. Eventually the goal is to improve the road network so it can be utilized more efficiently and to improve the accessibility of the CBD area of Metropolitan Cebu.**

In order to apply the transportation model it is necessary to collect the right information or in case of lack of data to make the right assumptions supported by a theoretical background. A decent knowledge of the existing situation in Metropolitan Cebu is thus a requirement. But what kind of information is necessary or what kind of assumptions needs to be made? For knowing this one needs to realize that travel is a complicated phenomenon that results from the needs of people to move from place to place for the myriad activities that we all engage in. In addition to the movement of people the more concentrated people are, the larger the demand they place on the transportation system. Thus knowledge of the number of inhabitants, where they are found and their basic characteristics helps define our transportation needs.
In summary there is information necessary about:

- Population (forecasts, density)
- Employment (forecasts, density)
- Land area information (natural constraints can be determinative for urban growth)
- The transportation network and its characteristics (such as number of lanes and capacity)
- The public transportation system

- Projects that are planned or being implemented
- Conducted transportation studies

1.4 Structure of the thesis

In broad outlines the study will contain of three parts: collection of the necessary information, applying the model and formulating a proposed land use and transportation strategy. In the first stage the characteristics with regard to land use and transportation (the inputs for a transportation study) will be described thoroughly in the chapters 2 and 3 for the case Metropolitan Cebu. The description of the land use and transportation characteristics will take place seperately. The demographic characteristics will come to order in chapter 2 and in chapter 3 the transportation characteristics will be discussed.
This will help understanding the problems the study area is suffering from and will also give insight in the availability of data that will be used throughout the study. At this point the reader will be aware of the existing situation in Metropolitan Cebu and the projects that are being implemented or planned.

The second stage (the application of the transportation model) will start with a description of the needed theoretical background. The described characteristics and problems need to be translated into a transportation model. In chapter 4 this translation will be performed by the description of the theory in general terms and its consequences for the case Metropolitan Cebu. Once the several definitions and relations with regard to transportation modelling have been described the model will be applied for Cebu in the chapter 5,6 and 7. In a transportation model several steps are distinguished in order to achieve the goals and objectives of the study. The chapters 5,6 and 7 will be used for completing these steps. The existing situation in Cebu and as it is planned for Cebu will be evaluated in these 3 chapters. Whenever forecast of the planning variables population and employment are not available for a city or districts other methods needs to be developed for their estimation. Chapter 5 will among others describe how this estimation takes place. Information about the number of trips and how they are distributed in Metropolitan Cebu will come to order in chapter 6. Chapter 7 will describe the influence of these trips on the transportation network in Cebu. For completing the modelling work a decent software package is an absolute requirement. The software package TransCAD that will be used in this study is a worldwide used GIS package that is very suitable for dealing quickly and easy with these problems.

The final stage in this study concerns the description of a proposed policy with regard to land use and transportation. In chapter 8 several scenarios will describe a future situation in Metropolitan Cebu. The proposed land use and transportation strategy will point out the best locations for urban growth and at the same time will describe a transportation system that can catch up with the rapid urban growth. In chapter 9 the proposed land use and transportation strategy will be translated into the used transportation model, so that it can be evaluated on the effects. Chapter 8 and 9 will thus provide feedback with the goals and objectives mentioned in section 1.2. Strengths and weaknesses of the used model will be set out at the end of chapter 9. The model will be evaluated on the assumptions that have been made during the process, so that next recommendations can be done for optimizing the results of the model.

In the appendices of this report relevant information and also some background information such as newspaper articles can be found. Results of calculations and a detailed map of the streets in the study area can also be found in the appendices.

2 DEFINITION AND CHARACTERISTICS OF THE STUDY AREA METROPOLITAN CEBU

2.1 General information on Cebu

Metropolitan Cebu is located in the center of the Central Visayas Region (Region 7), 570 kms southeast of Manila. The Central Visayas Region consists of the islands Bohol, Negros and Cebu. Cebu Island is a long and narrow strip of land of about 200 kms in length and 41 kms across its widest point. Metro Cebu is the capital of province Cebu.

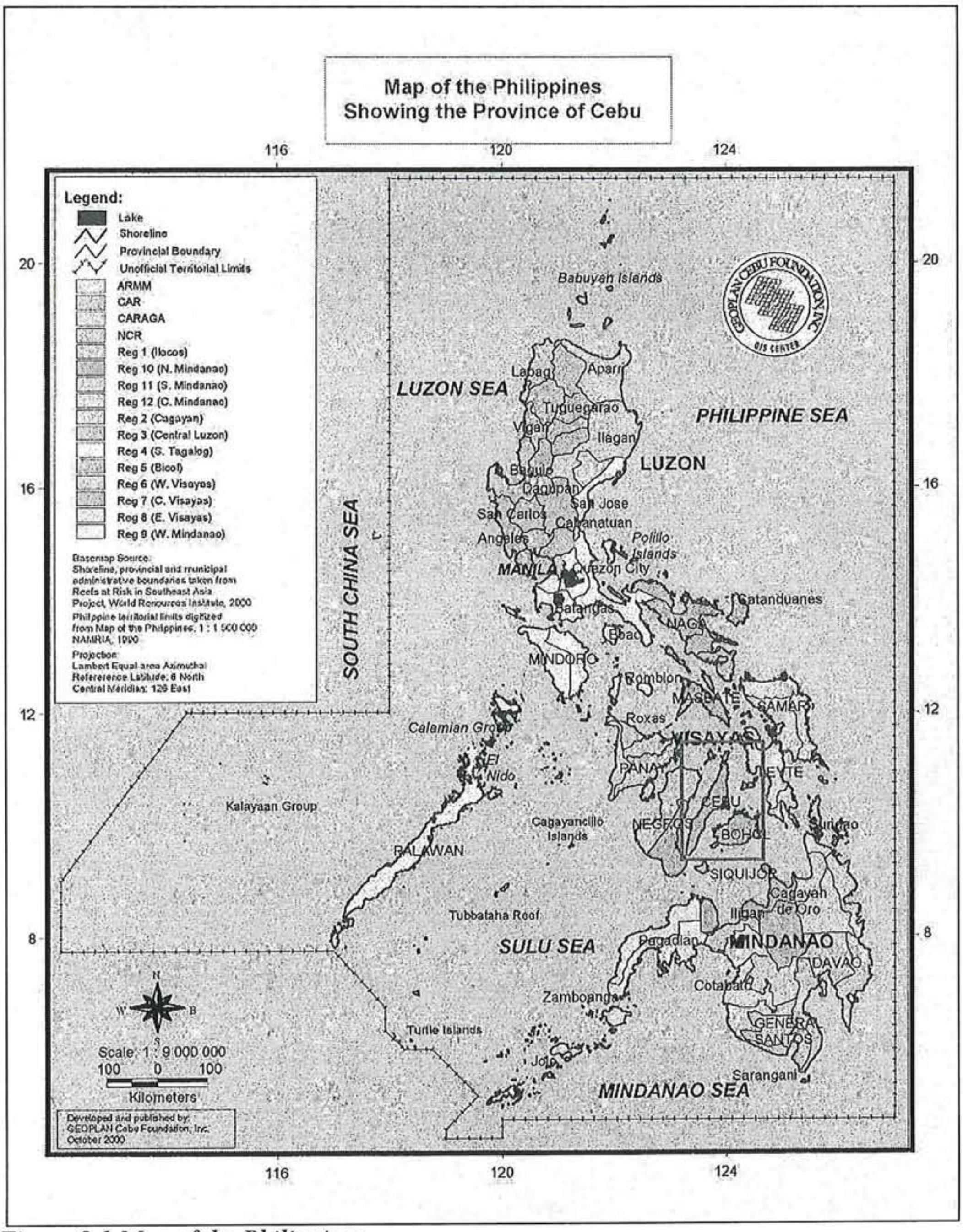


Figure 2.1 Map of the Philippines

Metropolitan Cebu has three cities and seven municipalities. The cities are Mandaue City, Lapulapu City and Cebu City (see also figure 2.2). Cebu City and Mandaue are in the north bounded by three municipalities (Consolation, Liloan and Compostela) and in the south Cebu City is bounded by three Municipalities (Talisay, Minglanilla and Naga). Lapulapu city is the capital of Mactan Island.

Cebu City has a total area of 32,880 hectares (328.80-sq. km.) approximately 6.84 percentage of Cebu Province and 2.20 percentage of the Central Visayas Region. 15% of the total land area of Metropolitan Cebu is flat and about 80% of its total land area is mountainous. The biggest part of this mountainous area is due its unfavourable topography and its bad soil conditions not suitable for urban development. That's why the relatively flat area is almost urbanised and it is still rapidly being densified.

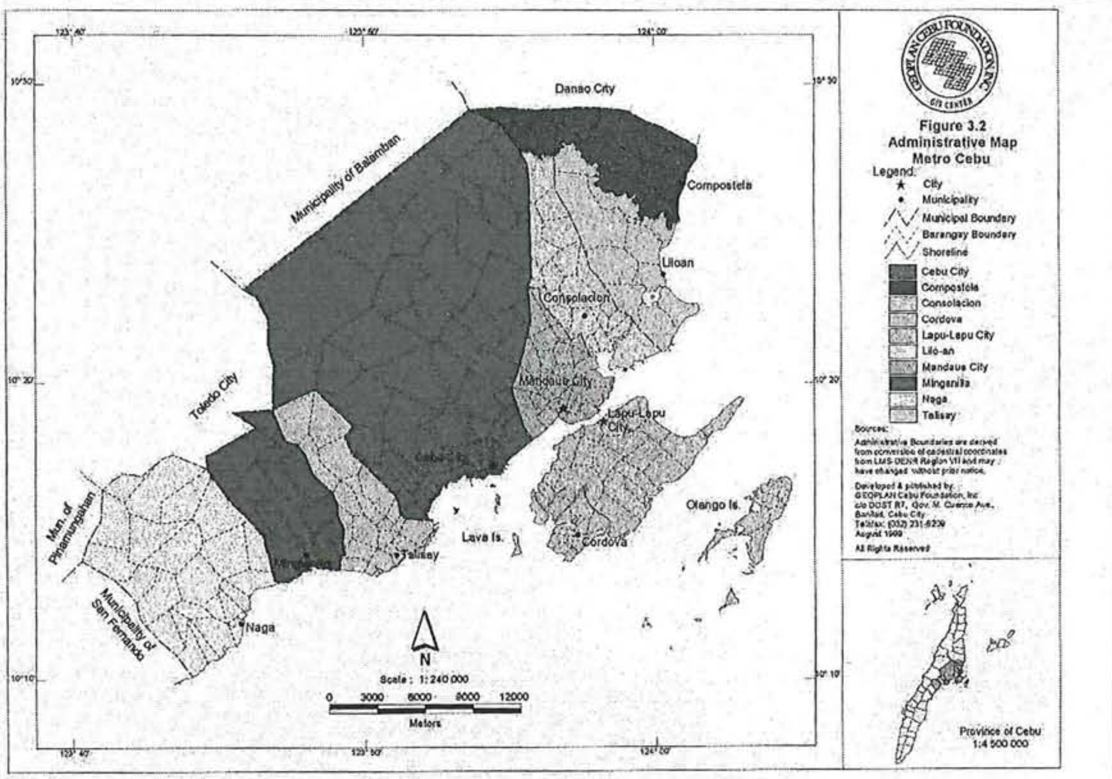


Figure 2.2 Map of Metropolitan Cebu

The municipalities and the cities are divided in a number of small administrative areas, the barangays. Cebu City is composed of 80 barangays, grouped into 46 South District barangays and 34 North District barangays.

2.2 Socio-economic profile

2.2.1 Economic characteristics of Metropolitan Cebu

As the second biggest city in the Philippines Cebu City provides more than 10 per cent of the income of the Philippines. This is due to the dominance of trade and service activities in the city. These activities are possible because of the strategic location in the central part of the Visayas and the presence of a national and international sea- and airport. Products from all over the world and the Philippines are transported to Cebu for processing and redistribution. Cebu City's top three markets in 1998 consisted of the USA, Japan and Hong Kong. Products that are traded mostly consists of electronic and computer components. These trade activities are mostly located in the seven economic zones of Metro Cebu. The two biggest economic zones are owned by the government and are located on Mactan Island. In 1999 MEPZ 1 and 2 (Mactan Economic Processing Zone) had 129 firms with a total employment of more than 43 thousand workers.

Because of these factors Cebu has always attracted many national and international investors to locate in the city, stimulating a healthy employment structure. Most people are employed in trade and service activities, the tertiary sector. The commercial activities account for almost 8 per cent of the total land area. The commercial establishments, consisting of banks, insurance companies, shopping malls etc. are located in the central part of the City, the Cebu Business District. Industrial activities, which account for 0.43 of Cebu City's total land area, are mostly located in the southern parts of the city near the harbour area. The institutional activities, consisting of universities, schools, hospitals etc. account for 5 per cent of the total land area.
The commercial and industrial activities do not account for more than 10 per cent of the total land area these activities still provide for more than 90 per cent of Cebu City's population employment. In 1995 73.2 percent of the city's employed labour force were found in trade and other related service activities. Some 18.8 percent were employed in industry while only 7.8 percent were engaged in agriculture and related activities.

Economic Sector/ Sub-sector	Cebu City [%]
Agriculture	7.80
Agri., Hunting,& For.	7.53
Fishing	0.27
Industry	18.77
Mining and Quarrying	0.15
Manufacturing	11.23
Elect., Gas and Water	1.21
Construction	6.18
Services	73.16
Trade	18.44
Services	54.72
Not Stated	0.28
All Sectors	100.00

Table 2.1 Employment percentages engaged in the different economic sectors
Source: 1995 Census (Cebu City Strategic Master Plan Study)

In April 2000 the labour force in Ceby City was 329 800. The city had an employment rate of 88.5 percent in the same period, which means an employed population of 291 900.

2.2.2 Demographic characteristics

At the beginning of the 20th century, the Philippine population was approximately 7.6 million. The 1995 census figure is nine times the Philippine population in 1903, when the first census in the Philippine was undertaken. Especially the urban population is growing very fast, which is also the case for Metropolitan Cebu. Among the three cities of Metropolitan Cebu, Cebu City has the highest population. Cebu City has a total population of almost 700,000 and about 89% of this population were found to live in urban Barangays, which comprise only about 17% of the city's total land area. The combined population of Metropolitan Cebu was 1.44 million in 1995.

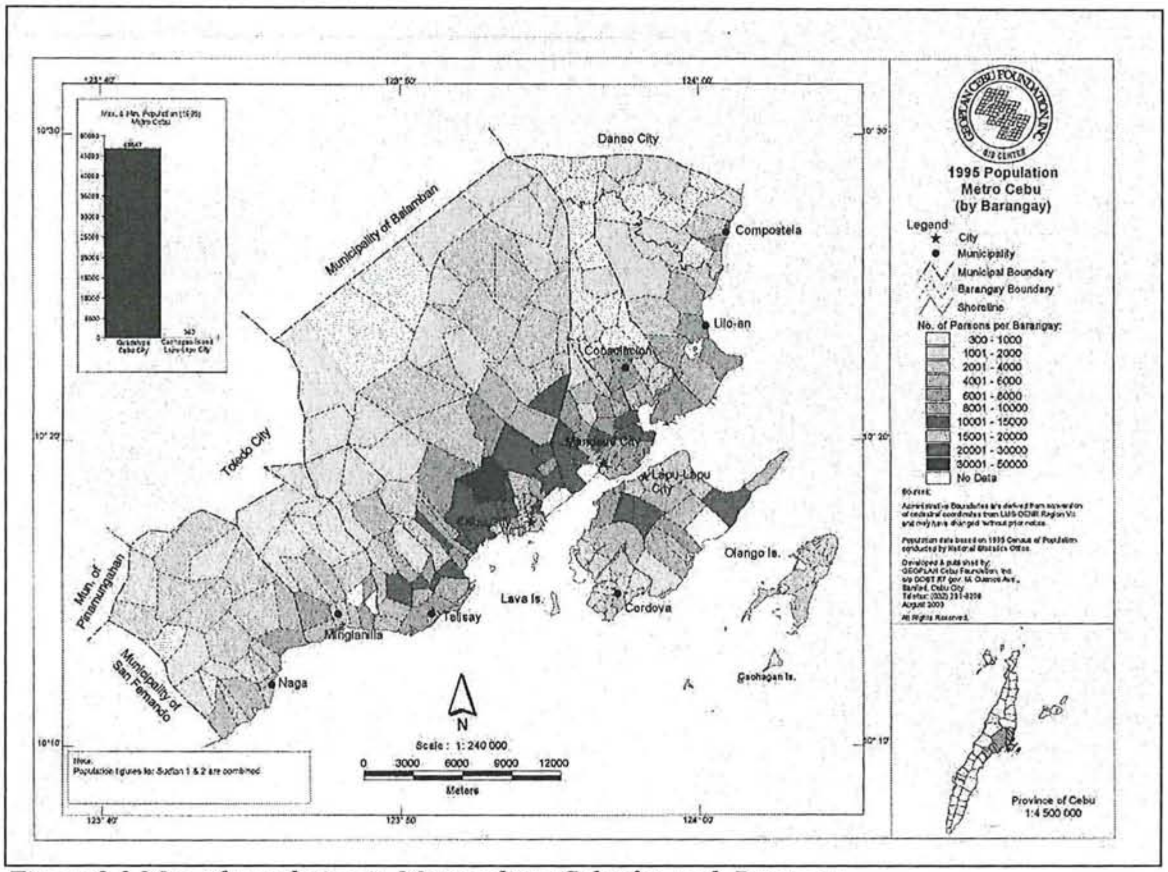


Figure 2.3 Map of population in Metropolitan Cebu for each Barangay

The last 30 years the population in Metropolitan Cebu has increased from 650,000 to 1,6 million; the annual growth rate is 2,42. However the annual growth rate of the three cities is declining since 1970, as on the other hand the growth rate of almost all the municipalities is increasing. The population growth rate of the combined population in the three cities is much lower than the population growth rate of the combined population in the seven municipalities, which is also illustrated by the next figure and two tables.

Note: In the following tables Talisay is listed as a municipality, because the tables are derived from previous studies. However this year (2001) Talisay has officialy been declared as a city.

	1970 [-]	1980 [-]	1990 [-]	1995 [-]
Combined population of the three cities	474,963	699,594	936,895	1,030,788
Combined population of the seven municipalities	178,276	247,892	337,141	411,115

Table 2.2 Total populations in Metropolitan Cebu since 1970

City	**1970-1980** **[%]**	**1980-1990** **[%]**	**1990-1995** **[%]**
Cebu	3.51	2.22	1.64
Mandaue	6.56	5.01	1.56
Lapulapu	3.61	4.00	3.51
Municipality			
Talisay	3.85	3.45	4.22
Consolation	4.55	4.15	3.60
Cordova	4.09	1.76	3.57
Naga	2.72	2.79	2.70
Minglanilla	2.92	2.82	4.23
Liloan	2.97	3.50	6.03
Compostela	2.31	2.31	3.80

Table 2.3 Population growth rates in Metropolitan Cebu since 1970

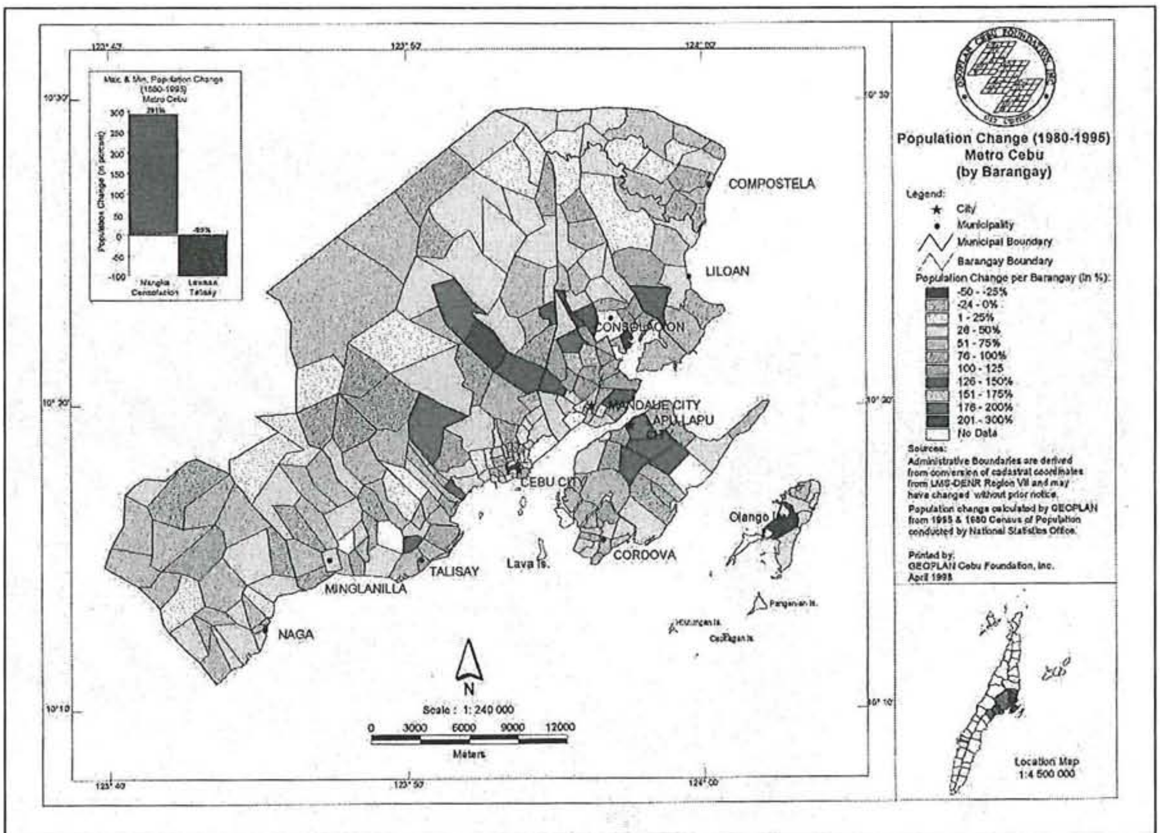


Figure 2.4 Map of population change in Metropolitan Cebu between 1980 and 1995

	1970-1980 [%]	1980-1990 [%]	1990-1995 [%]
Population growth rate of the combined population of the three cities	3.94	2.96	1.93
Combined city share of the population increase in Metro Cebu	76.3	72.7	55.9
Population growth rate of the combined population of the seven municipalities	3.35	3.12	4.04
Combined municipality share of the population increase in Metro Cebu	23.7	27.3	44.1

Table 2.4 Population growth rates in Metropolitan Cebu since 1970

The population in Metropolitan Cebu can be divided in rural and urban population. The majority forms part of the urban population. In 1995 89 per cent of Cebu City's population belonged to the urban population.

	Population [-]	Land area [sq.km.]	Density [pop./sq.km.]	Growth rate (1990-1995) [%]
Cebu City	662,299	326	2,031	1.54
Urban area	589,841	248	7,553	1.26
Rural area	72,458	78	292	3.99

Table 2.5 Demographic characteristics for the urban and rural area in Cebu City

2.3 Conclusions

Because of its strategic location in the central part of the Visayas (see also figure 2.1) Metropolitan Cebu has always played an important role of significance in the economic sector in the Philippines. Metropolitan Cebu has attracted a lot of local and foreign investors in the past decades, which was the most important reason for the rapid urban growth. The majority of the metropolitan's employed labour force can be found in the trade and services sector, the tertiary sector. However, because of the unsuitable physical attributes such as topography and soil type only a small percentage of the total land area in Metropolitan Cebu can be utilized for urban development. Almost 90% of the total population in Cebu City is found to live in an area that comprises approximately 15% of the total land area.

In the last decades the population growth in the three cities has shown a decline, this in contradiction with the surrounding municipalities. Between 1990 and 1995 the average population growth rate of the seven municipalities was 4.04 as on the other hand the average growth rate of the three cities was only 1.93. These urban developments had a tremendous influence on the travel demand in Metropolitan Cebu, which makes changes on the road network necessary to ensure a good accessibility of the central city.

3 TRANSPORTATION CHARACTERISTICS OF METROPOLITAN CEBU

3.1 Traffic

3.1.1 Introduction

The movement of people from the neighbouring islands and rural areas of Cebu Island to Cebu City is since the 1980s and 1990s shifting towards the periphery (the seven municipalities), as mentioned before. The major part of the municipalities' inhabitants is employed in Cebu City. Cebu City has a daytime population of approximately one million and a night time population of 700 000. These numbers show the tremendous effect on the traffic circulation within Cebu City and on the roads from and towards the periphery. The biggest part of this commuter traffic consists of commuters travelling by the Public Utility Jeepney (PUJ). Jeepneys are small buses that normally will carry about 15 passengers. The PUJ will take a commuter for about five pesos (0.10 euro) from a neighbouring municipality or city to another municipality or in this case Cebu City. At the moment the jeepneys have access to all places from Cebu's CBD to the outskirts in the mountainous area of Cebu. The rest of the commuters are consisting of the private car owner, which are like the PUJ-travellers also increasing.

	1995 [-]	**1996** [-]	**1997** [-]	**1998** [-]
Private	64,380	73,407	78,328	81,174
Government	1,700	2,020	2,287	2,386
For Hire	8,913	10,058	11,789	12,164
Total	74,993	85,485	92,404	95,724

Table 3.1 Overview of the number of vehicles Source: LTO, Cebu City

The traffic to Cebu Cities CBD can be divided in traffic coming from the municipalities, mainly Talisay and Mandaue City and Lapulapu City (the north-south traffic flow) and in traffic coming from the western outskirts of Cebu City. The north-south traffic flow makes use of the Cebu Highway. Cebu Highway can be divided in six parts. In north-south direction these parts are Cebu North Road, M.J. Cuenco Avenue, Imus Street, P.del Rosario Street, N. Bacalso Avenue and the Cebu South Road. A detailed road map of Cebu City is listed in the appendices 2 and 3.
During peak hours Cebu highway lacks the capacity to process the north-south traffic flow. At some places, mainly at the centre of Cebu City, congestion is the result. Looking for alternatives to avoid the traffic jam travellers are also making use of the roads in east-west direction, which are already being used by travellers from and to the outskirts of Cebu City.
So there are different bottlenecks in Cebu Cities' network that can be pointed out. Recently (2001) many of these problems are being solved by the construction of flyovers at intersections. However these flyovers solve the problem locally the underlying cause of the congestion problems is the expanding of the business activities in the centre that further will attract people coming from the fast-growing outskirts and municipalities in Metropolitan Cebu.

3.1.2 Cebu City's road network

In 1997 Cebu City's rural and urban road network had a total length of 690,736.52 m classified as follows: asphalt (58.94%), concrete (6.18%), dirt/gravel (25.99%), unclassified (8.89%).
Cebu City's major road network has a total length of 83.2 km classified as concrete (16.4 km), asphalt (62.0 km) and gravel (4.8 km).

wegbeheerder?

Classification	Length [kms.]	Percentage [%]
National Road	159.6	14.0
Provincial Road	112.5	9.9
City Road	171.1	15.0
Municipal Road	66.4	5.8
Barangay Road	630.6	55.3
Total	**1,140.2**	**100.0**

Table 3.2 Road classification in Metropolitan Cebu

The major roads are consisting of 4 or 6 lanes. The 4 lane roads sometimes lack the capacity to process the large flows. The J. Luna Avenue is an example of a road of 2 lanes in each direction. Because of the shortage of space in Cebu City there is not sufficient space to widen the roads. However recently some road widening projects have been completed, this was part of the MCDP 2. N.Bacalso Avenue, B. Rodrigues Street, Gen. Maxilom Avenue and N. Escario Street are examples. Mostly the outer lane is used for all kind activities, like walking area and places for jeepneys to pick up passengers. That's why the outer lane is in many cases wider than the inner lanes.

3.1.3 Causes of congestion

For a road map of Cebu City the reader is referred to appendix 2 and 3. The concerning roads are referred to by the numbers on the road map in appendix 2 and 3.

The underlying cause of congestion in Cebu City is the expanding of its CBD, which is still attracting more and more people from Cebu's periphery. The biggest traffic flows take place between Mandaue City, Lapulapu City and Talissay. This was also the result of a study conducted in 1992 by DOTC (Department of Transportation and Communication). Besides this underlying cause the following causes of congestion can be pointed out:

- PUJ related causes
  - Many stop places
  - A big variety of jeepneys
- Lack of space
  - Not enough parking area
  - Roads at some places not wide enough
  - Lack of facilities for pedants

The jeepneys have a great deal in the causes of congestion. More than 70 percent of the traffic is consisting of jeepneys. Normally the jeepneys are only allowed to pick up passengers at the marked places on the sides of the roads. At these places, that are located near shopping malls and schools, the roads are wider so the Jeepneys will not hinder the through traffic.

However these stopping places are during peak hours not wide enough to handle the large amount of jeepneys. That's why the PUJ drivers are forced to use the road. The first photo in appendix 4 shows an example of a stop place for PUJ's; this photo was taken at the Cebu highway near the bus station.

A PUJ driver is constantly looking for passengers standing at the sides of the road. He will stop many times, also at forbidden places, for trying to pick up new passengers.
There are many and also big varieties of operating Jeepneys. In many cases the waiting time for catching a Jeepney is not more than one minute. There are besides the normal Jeepneys also the small Jeepneys, the so-called minicabs that normally are being used for travelling to the neighbouring municipalities and Mandaue City. These Jeepneys mostly make use of the Jeepney terminals located in the northern and the southern part of the city, the north and the south Jeepney terminal. The location of these terminals was chosen here so the Jeepneys don't have to make use of the roads in the centre of Cebu City, causing less congestion. However because of the rapid growth of Cebu's centre these location are not far enough from Cebu's centre anymore resulting in a slowly expansion of the congestion to these parts of the city.

Lack of space is also a main issue in the causes of congestion. For expanding their commercial activities several shops use the sidewalks forcing the pedant to use the road. The major part of the outer lanes is used as walking area causing the traffic to stop constantly. On some of the major roads, like the Osmena Boulevard (2), putting large fences at the sides of the walking area is solving this problem. There is also lack of sufficient facilities for pedants to cross the full streets. Near Osmena Boulevard there are a number of skywalks, which are not being used because they have been constructed at the wrong places.

Lack of space gives the private car owners sometimes no other alternative than putting the car just at the side of the road hindering the through traffic. At four o'clock many students will be picked up by car at the school or university at which they are studying. In the city parts Sambag and Zapatera this is the case for the several universities and schools that are located there. As a result of the lack of parking area drivers will just stop at the universities or schools main entrance. The congestion in this area (especially Sambag) is also being enforced by the many jeepneys that will go here to pick up students. In Sambag there are during peak hours sometimes approximately 500 jeepneys.

The layout of the roads and the traffic lights sometimes also contribute to congestion. Part of MCDP was the placing of new traffic lights systems on important intersections. These traffic lights do not always function well causing only more congestion instead of solving it. At these intersections CITOM officers are guiding the large traffic flows.

3.1.4 Bottlenecks

The number one bottleneck is Cebu City's highway. This road consists of 6 lanes except the part, which is going through the centre of the City, P. del Rosario (1); here the road only has 4 lanes. However this city part has many institutions like the University of San Carlos, Cebu Technical School, Banks etcetera, that attract thousands of people every day. Especially the capacity of P.del Rosario (1) near the intersection with Osmena Boulevard (2) is far from sufficient to handle the traffic. This intersection is equipped with traffic lights, still there are CITOM officers necessary to guide the traffic flows. Part of the MCDP was the widening of the roads at many places in the city. The southern part of Cebu's highway, N. Bacalso Avenue (3), was also widened. Because of the lack of space this was not possible for the P.del Rosario part.

Osmena Boulevard (2) is a 6-lane road starting at the Provincial Capitol and running all the way to Plaza Independencia near Cebu's seaport. Especially at the intersections with the roads going from north to south, N. Escario St. (5), Gen. Maxilom Avenue (6) and P.del Rosario St. (1), this road is suffering from congestion. The eastern part of Osmena Boulevard (2) near Colon Street (7) is also almost all times of the day very much congested.

J. Luna Avenue (4) is a 4-lane road situated in the north of Cebu City. In the north of Cebu traffic problems do not occur at the same scale as in the centre but still this road is very much used by commuters going to or coming from Mandaue City. J.Luna Avenue starts at the North Reclamation Area near a big shopping mall, which is also attracting a lot of visitors from all over Metropolitan Cebu. The part J.Luna Avenue in front of the shopping mall consists of 6 lanes, which is necessary because of the many Jeepneys visiting this place. Because of lack of space the western part of the road only has 4 lanes, resulting in congestion. At the western end of J.Luna Avenue there has been recently (December 2000) a fly-over constructed. The goal of this fly-over, the Banilad fly-over, was to relieve the congested intersection with Arch. Reyes Avenue (11) but because of safety reasons this fly-over still isn't opened for all traffic.

Gorordo Avenue (8) and Gen. Maxilom Avenue (6) are near there intersection also very much congested. The reason for this is the number of schools that are located in this area combined with the lack of sufficient parking area. Possibilities for a fly-over for this intersection have been studied.

Other places at which congestion takes place are:

- The whole area of Central Proper, Kalibuhan, Pari-an and Ermita, the old centre of Cebu City near the harbour, is congested also between the peak hours. Institutions, public markets and tourist places are located here.
- M. Velez Street (9) especially near the bridge crossing Guadalupe River
- N. Escario Street. (5) This road has recently been widened.
- Intersection of Gorordo Avenue and Sallinas Drive (10) in Lahug

3.2 Results of studies done in the past

3.2.1 Metro Cebu Land Use and Transportation study 1979

The Metro Cebu Land Use and Transport Study (MCLUTS) was established in October 1978 by the then Ministry of Public Works, Transportation and Communication (MPWTC), with the cooperation of the National Economic and Development Authority (NEDA), Ministry of Human Settlements (MHS), Ministry of Public Highways (MPH), and other government agencies.

The objectives of the study were as follows:

- To formulate a Land Use and Transportation Strategy Plan for the Metropolitan Cebu Area
- To prepare, within the framework of the Strategy Plan, policies and guidelines, programs, and proposals to meet the short, medium and long term travel requirements to year 2000
- To undertake projects addressed towards the immediate alleviation of existing critical transport and traffic problems

The approach adopted was comprehensive, providing the information necessary to prepare land use and transportation proposals, policies and plans. A simulation model was used to facilitate the testing of alternative plans consisting of different distributions of population and employment and varying levels of highway investment.

The planning methodology was divides into six stages, namely data collection, forecasting, goal formulation, plan formulation, plan testing and plan evaluation.

In the plan formulation chapter several alternatives regarding land use were described. Each is based on issues such as:

- Reclamation or no reclamation
- Reclamation on the mainland, or reclamation on Mactan
- Stimulation of development of the mainland or Mactan Island or both
- Concentration of development within the cities of Cebu and Mandaue, or dispersal or decentralization of growth to new communities in Consolacion and Talisay and outer smaller municipalities
- Concentration of central area activities or dispersal to regional and district centers
- Continuation of current trends or high level of government intervention

These issues were reflected in the development alternatives for the year 2000 which are graphically illustrated in figure 3.1 and 3.2

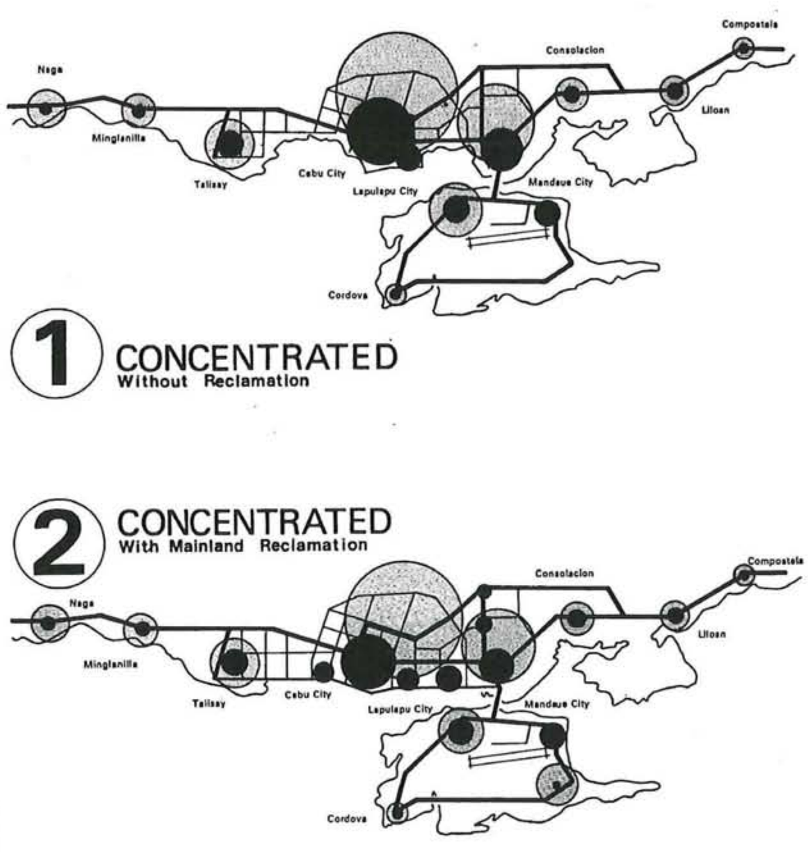


Figure 3.1 Possible options for land use for Metropolitan Cebu in the future

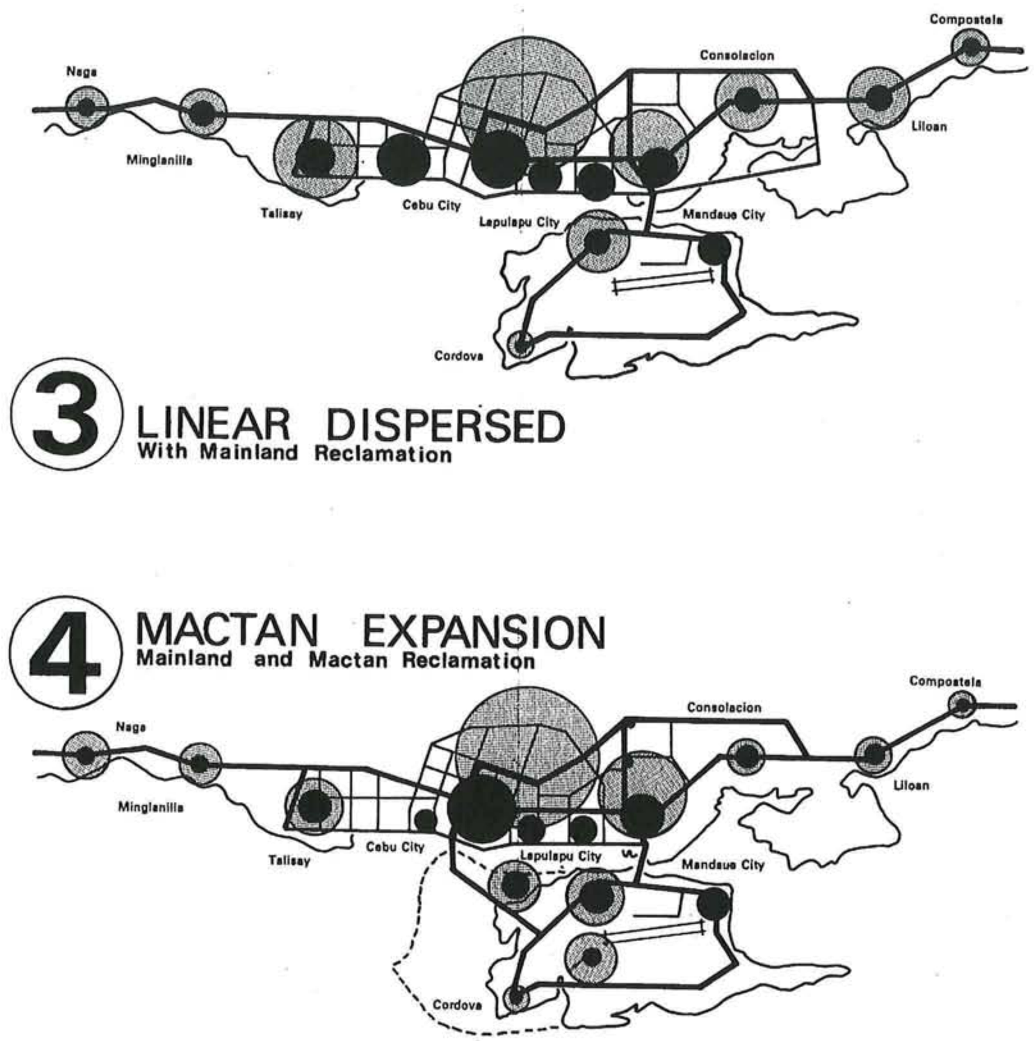


Figure 3.2 Possible options for land use for Metropolitan Cebu in the future

Todays most important infrastructure measurements are based on some of the following conclusions and recommendations that have been formulated in the MCLUTS report.

- *Plan 2, Concentrated, with Mainland Reclamation, has been selected following economic, operational, political and other planning considerations.*

- *The central business area should be encouraged to maintain its dominant position as the commercial, retail and cultural focus of Metro Cebu.*

- *The development of the Mactan Export Processing Zone (MEPZ) is expected to provide some 45,000 jobs by 1990. Total secondary and tertiary sector jobs are expected to reach approximately 65,000 by 1990, and 85,000 jobs by 2000. The preferred plan incorporates government intervention to stimulate Mactan population growth by an additional 60,000 population by 2000.*

- *A proposed new highway network has been described. This was not only necessary for correction of existing deficiencies but also to cater for the projected doubling of traffic by year 2000. New roads (circumferential roads) have been suggested and for several roads it is necessary to be upgraded.*

- *It was advised that public transport should remain road-based. However, if the mainland reclamation projects did not go ahead, then additional capacity would be required in the Talisay/Cebu City/Mandaue City corridor toward the late 1990. An option for providing additional capacity would be to construct a light rail transit (LRT) line.*

3.2.2 Transportation Study 1992

Besides a thorough description of the economic and demographic characteristics of Metropolitan Cebu also a traffic flow analysis has been performed for the transportation study of 1992, which of course always are important ingredients of a transportation study. The most important conclusions which can be drawn from the traffic flow analysis are as follows:

- Traffic is heavy on the urban triangle of Cebu, Mandaue and Lapu Lapu.
- On the mainland of Cebu, traffic is heavy along the Mandaue City – Cebu City – Talisay corridor.
- Most trips end in Cebu City. Trips originating south or north of the city have destinations also in Cebu City with a few passing through.
- The influence area of Cebu City extends throughout the entire metropolitan region.

It was estimated that the total number of person's trips in Metropolitan Cebu grew from 1.14 million in 1979 to about 1.5 million a day in 1992. The relatively rapid growth of private vehicle traffic contributes to the change in road-based traffic situation. The share of public transport has reached about 90% of the total traffic demand in 1979 but has been gradually declining since then. The current (1992) model split is estimated to be 20%:80% for private versus public transport.

Some other important data for both the 1979 and 1992 transportation study are summarized in the following table.

TRIP	**TRIP DEMAND**		**Annual Average Trip Growth [%]**	**1992/1997 [-]**
	1979 [-]	**1992 [-]**		
Private Mode Person-trips	110,500	305,666	13.6%	2.76
Public Mode Person-trips	1,028,900	1,180,408	1.13%	1.14
Total	1,139,400	1,486,074	2.34%	1.30
Trip Generation Trip (Trips per person per day)	1.26	1.26	-	-

Table 3.3 Trip demand by mode for the years 1979 and 1992

3.3 The Metro Cebu Development Projects

3.3.1 Introduction

The Metro Cebu Development Project (MCDP) was formerly identified as the Central Visayas Regional Project 2. The MCDP is an integrated area, multi-sectoral and multi phased program/project of the Regional Development Council (RDC) Region 7. It is funded under the Overseas Economic Cooperation Fund (OECF) Yen Credit Package (YCP) via Municipal Development Fund (MDF) arrangement of the Government of the Philippines and through the executing agency, the MCDP-Project Management Office (PMO). Its main concern was the enhancements of the economic potential for the region's urban centre particularly that of Metropolitan Cebu as an area of industrial development. The Project comprises of transport, industrial development, municipal services, shelter and provincial management component. MCDP is consisting of three phases:

- MDCP phase 1 comprises the realization of short-term measurements.
- MCDP phase 2 comprises the realization of both short and long-term measurements and allies the MCDP phase 1.
- MCDP phase 3 comprises the realization of the South Reclamation Area and the South Coastal Highway. The MCDP is at the moment in the implementing stage.

The project has the following goals and objectives:

- *To promote infrastructure activities to assist local governments of Metro Cebu in coping up with the rapid urban population growth and to enhance their potential for further economic growth consistent with national developments plans.*
- *To accommodate acute interim employment demands from the labour sector for the entire duration of the project in line with similar employment programs under the current administration.*
- *To provide the framework for strengthening the Regional Development Council, regional line agencies and the local government units in the implementation and management of the multi-agency programs and projects in pursuit of policy objectives on decentralization.*
- *To strengthen local government units primarily in financing, maintaining and rehabilitating urban infrastructure and services.*

Source:Project brief MCDP phase 3[12]

3.3.2 MCDP phase 1

MCDP phase 1 started in 1991 and comprises the realization of immediate programs. MCDP phase 1 consisted of the following components:

- roads and bridges
- street lights
- road diversion
- traffic management
- the South Bus Terminal

Construction and improvement of national roads means the pavement with asphalted concrete and with Portland cement concrete of some parts of existing 4 and 6 lanes road. The maintenance of the gutter and the sidewalks was also included.

The project of the construction of the South Bus Terminal had been completed on October 1992. The costs for this project were 25.66 million pesos. The South Bus Terminal is situated at the Cebu Highway, the N. Bacalso Avenue. In this project was also sufficient land area reserved for small sores, large shops and offices, passenger waiting area, walkways, parking bays for cars and taxis and circulation area for buses and utility vehicles entering the premises.
Procurement of traffic management includes intersection control, minor civil works and provision of street signs and road markings at 15 intersections.

3.3.3 MCDP phase 2

MCDP phase 2 started in 1993 and comprises short and medium term measurements with the following components:
- construction/improvement of arterial roads
- construction of Cebu North Bus Terminal
- upgrading of two public markets
- improvement of the solid waste disposal system

The road components consist of 13 road links programmed for widening/reconstruction and 2 new openings. The North Bus Terminal, located near the North Reclamation area, was completed in the same way as the South Reclamation Area. Two public markets, one in Talisay and the other one in Mandaue City were upgraded. For improvement of the solid waste disposal systems in the cities Cebu and Mandaue new techniques were used.

3.4 Present and future projects

3.4.1 MCDP phase 3

MCDP phase 3 includes the South Reclamation Project and a new South Coastal Highway. The reclamation boundary creates a new land with an area of about 330 hectares, with a reclamation volume of 13.4 million cubic meters. The total estimate cost of the project is 4.03 billion pesos. The Cebu South Reclamation Project generally encompasses the shoreline areas from Tangke, Talissay to the Port Area in Cebu City as the western boundaries. Figure 3.3 is showing the location map of the South Reclamation Area. The area is intended for light industrial activities, export-oriented/processing activities and for related facilities. When completed the South Reclamation Project (SRP) should easily provide 100 000 jobs. Because the location near the CBD, Cebu Port and Mactan airport the reclamation area can attract many local and foreign investors who will have the possibility of making use of all kind of facilities offered by Cebu City. In general terms the minimum requirements of industrial development are as follows:
- Able to get cheap labour wage with high educational level
- Completed transportation facility (inland)
- Sufficient electricity and water supply
- Completed communication network
- Completed international transportation facilities (Airport, Port, etc.)
- Easy access to health care facilities (clinic, hospital, etc.)

The South Reclamation project complies with these requirements and is thus perfectly suitable for new industrial development.

The following technical factors were considered in developing the reclamation plan:

- The project was designed to maintain the natural hydrology for rivers and streams and to prevent floods in the foreshore and reclaimed areas. This was one of the reasons that the South Reclamation Area could not be attached to the mainland.
- The existence of a Pier, the Pasil Fishing Port and navigational lanes were taken into consideration in the design of the reclamation project and the Cebu South Coastal Expressway.
- The project was designed to minimize negative impacts on the environment as much as possible. The drainage and sewerage system of water from the natural channels in the reclaimed areas was designed to minimize pollution in the adjoining sea waters. Protection plans were developed including stop walks and sand basins to protect the sea from pollution.

The South Coastal Highway consists of a land-based highway section, a causeway-based section, a viaduct section and a subway section. A viaduct section was necessary because of the fishing boats from Pasil Fishing Port that under all circumstances should have a free access to the sea. A subway section was necessary to preserve an area of a high cultural value in the center of Cebu City. The causeway is designed to carry a 4-lane highway.

The basic objective of the road is to provide a direct uninterrupted access from South Cebu City, Talissay and the southern towns to the ports at the CBD and the airport at Lapulapu City and the new developed South Reclamation Area. So besides an access way to the South Reclamation Area the coastal highway will also help solving the congestion problems in the center of Cebu City by providing an alternative route to commuters travelling to the northern parts of Metropolitan Cebu. The road will be a major component of the road network in Metropolitan Cebu.

The coastal road has two locations for ramps providing access from the viaduct section to the existing road network in Cebu City. There is one ramp fronting Carbon Market and another one at the South Reclamation Area near Ludo area. At the moment (December 2000) the design for these two ramps are not completed yet.

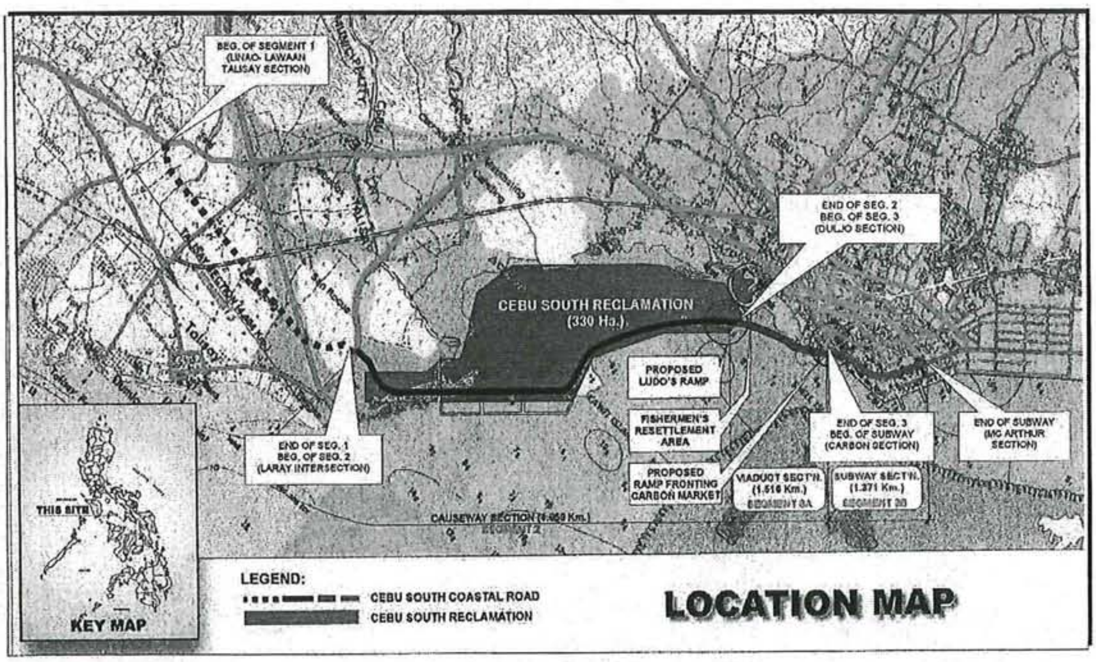


Figure 3.3 Location of the South Reclamation Area

3.4.2 Cebu Circumferential Road

Studies showed that one of the major problems in traffic congestion is the inadequacy of road infrastructure and poor traffic management. These studies, that were part of the Metro Cebu Land Use and Transportation Study and the MCDP phase 3 show that one of the immediate needs to decongest the CBD is the construction of a by-pass arterial road in order to divert traffic from Cebu City area. The Cebu circumferential road is one of the proposed long-term solutions to the traffic congestion in the CBD by diverting traffic using the North-South line and going towards the uptown areas of Cebu City. In the MCDP phase 3 four alternative alignments of the urban circumferential road has been studied. In the final technical design the circumferential road is proposed to be a 18 kilometres 4-lane highway. However in the initial stage of construction the road will have only 2 lanes. In order to be more functional the circumferential road will have 5 distributor roads to convey traffic towards the uptown portions of Cebu City.

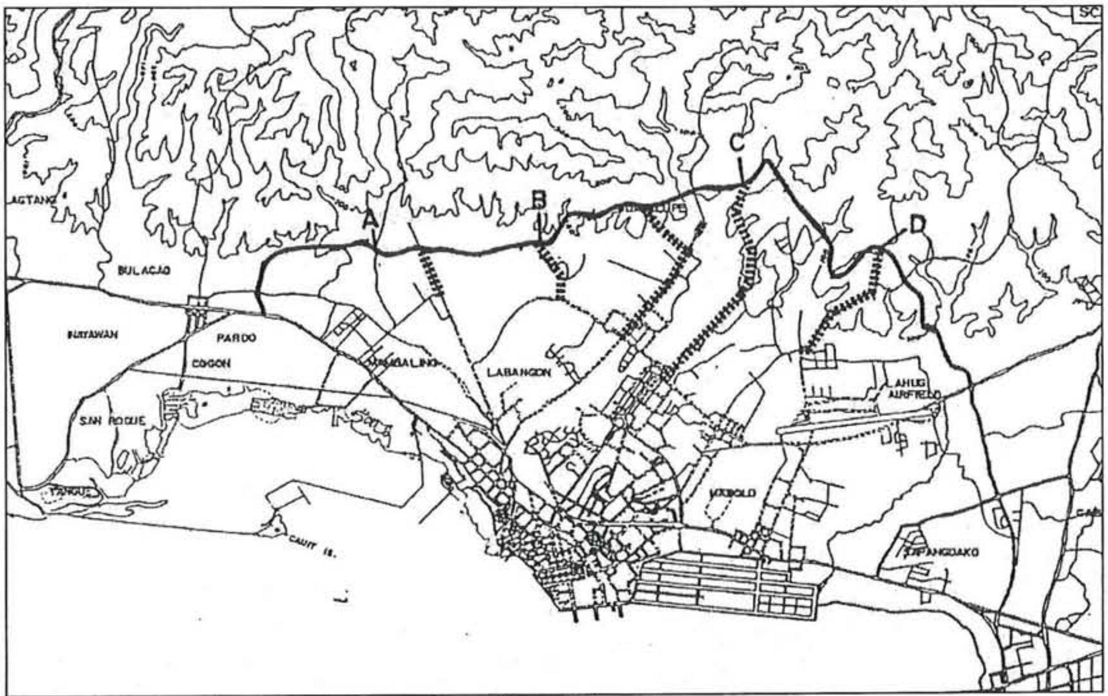


Figure 3.4 Map of proposed urban circumferential road

3.4.3 Light rail

For several years plans are made by order of the Cebu Municipal Government for a new public transportation system in Metropolitan Cebu, it concerns a rail-based mass transit system. Feasibility studies have been concocted by among others the consulting agencies Geoconsult and Schema Consult in Cebu City. The area where the planned Light Rail Transit (LRT) Line is located in the north-south corridor along Cebu highway between Talisay and Mandaue. It is envisaged that the introduction of LRT would increase the accessibility of outer areas and would there for encourage urban sprawl. It would further encourage the development of preferred growth centers. However the main advantage of introducing the LRT system is that it provides a satisfactory means of relieving existing capacity constraints in areas where expansion of road system is either too difficult and expensive or socially unacceptable.

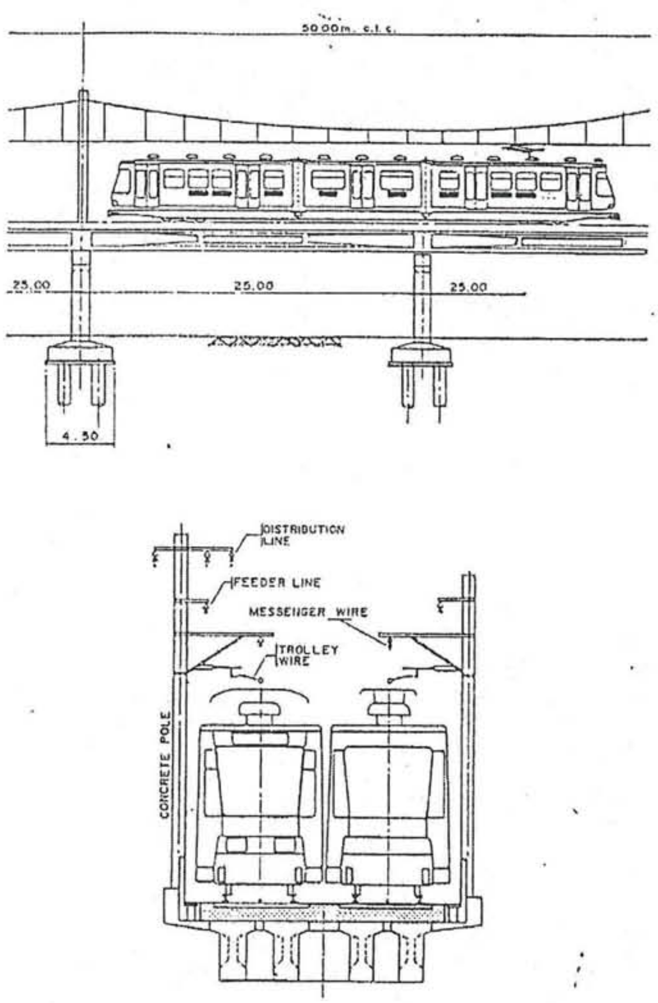


Figure 3.5 Metropolitan Cebu Mass Transit System

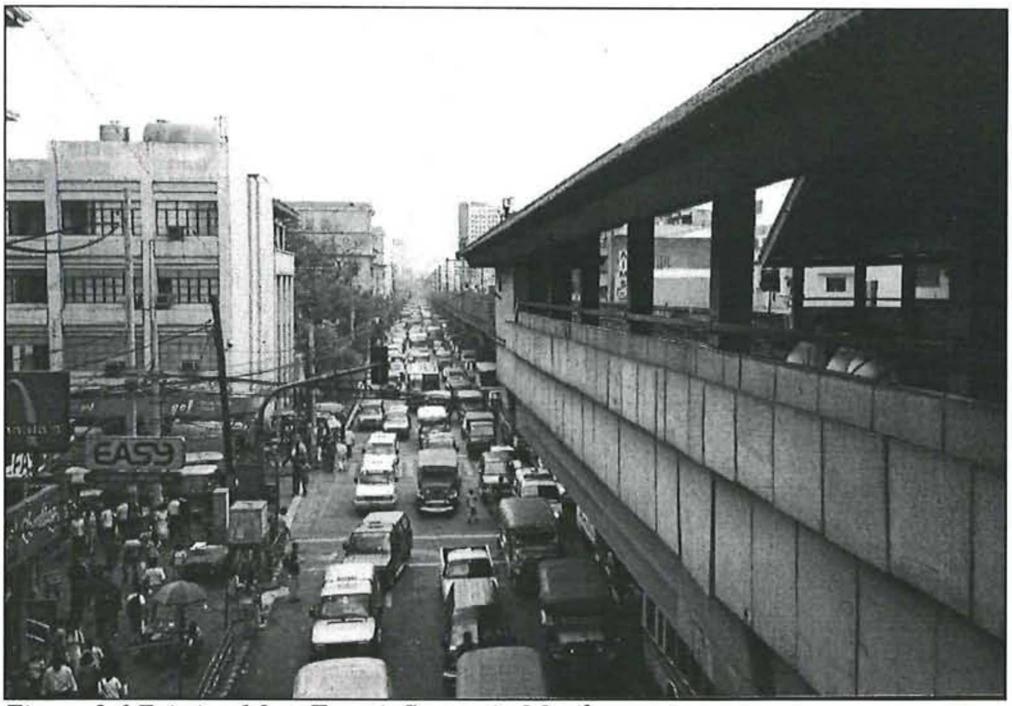


Figure 3.6 Existing Mass Transit System in Manila

The LRT has proven to be operational as can be seen in Manila (figure 3.6). For Metropolitan Cebu it was assumed that there will be two-car trains operating for the LRT with total capacity of 750 passengers per train. The LRT sytem will have a length of approximately 15 kilometres and will have 15 stations and 2 terminals with turnback facilities.

3.5 Participants

There are three organs which are responsible for projects concerning roads: DPWH (Department of Public Works and Highways), MCDP and the local government unit. DPWH's task is the planning, designing, constructing and maintenance of national roads. The national roads in Metropolitan Cebu are Pres. Osmena Boulevard, Cebu South Road, Cebu North Road en Gen. Maxilom Avenue (see also appendix 2 and 3). MCDP is about the planning and construction of roads, which are of major concern; this can also include local roads. MCDP covers whole metropolitan Cebu, which is also being referred to in the name.

Metropolitan Cebu is located in region 7, which consist of the 4 provinces Negros oriental, Bohol, Cebu and Siquijor. Each of the mentioned provinces is divided in engineering districts. Cebu province has in total 4 engineering districts. Metropolitan Cebu is subdivided in three engineering districts. Cebu First Engineering District covers Mandaue, Liloan, Consolation, Compostella, Lapu Lapu and Cordoba. Cebu Second Engineering District covers Talissay, Minglanella and Naga. Cebu City is under the Cebu City Engineering District. DPWH has for each engineering district a main office. Cebu Third Engineering District covers the rest of Cebu Island. These engineering district offices are responsible for road projects up to 15 million pesos (0.34 million euro).

Region 7 is under DPWH's regional office, which may implement national road projects between 15 and 50 million pesos. Before a district office can go over to implementing a road project it needs approval from the regional office.

For road projects above 50 million pesos (1.14 million euro) the main office of DPWH in Manila is the implementing agency. This is also the case for the South Coastal Highway. DPWH, the national government, is the owner of the road while Cebu Cities government is the owner of the South Reclamation Area. The road can be divided in three segments. Segment 2 and 3 are of a different loan package than segment 1, the Talisay segment. The loan package number for segment 2 and 3 is PH-P158. The loan package number for the reclamation area is PH-P157. The loan was provided by JBIC. One of the requirements was that Japan should be the implementing counterpart. For the road segments there are different Japanese Contractors. Segment 3 is implemented by Taisei-Marubeni J.V., Segment 2 by Toa Corporation and the reclamation area by Toyo Construction. The selection of these contractors is done by DPWH. Although this was not a loan requirement the design was also mostly undertaken by Japanese consultancies, which were also chosen by DPWH.

3.6 Conclusions

It can be concluded that the great increase in urbanisation and the economic developments had a tremendous effect on the travel demand in Metropolitan Cebu. In the last two decades many projects have been realized or planned that were aiming at solving the traffic problems that were related to this rapid urban growth.

The described problems can be distinguished in problems that are related to land use and in problems related to the transportation system.

- *With regard to land use the most important conclusions that can be drawn lie in the fact that the commercial center of Cebu City is attracting a lot of commuters every day from the entire metropolitan region.*
- *The most important problems with regard to the transportation system vary from poor traffic management, such as policies concerning the PUJ's, to the inadequacy of road infrastructure such as the lack of a perimeter road that could divert the metropolitan's north-south traffic from the city center.*

In this respect the completed or planned projects were either an application of long term strategies with regard to land use or short term strategies with regard to the transportation system. Short-term strategies comprised projects such as road widenings and fly-overs. Other important projects are the mass transit system, the urban circumferential road and the South Coastal Highway that should divert the Metropolitan's north-south traffic from the centre. The construction of the South Reclamation Area that has been recommended in the MCLUTS and that has been worked out technically in the MCDP phase 3 is an example of a long-term strategy concerning land use.

The in this chapter described transportation characteristics and the most important projects with regard to land use and the transportation system such as the projects formulated in the MCDP phase 3 will now be evaluated on their effects. This will happen on the basis of a transportation model of Metropolitan Cebu in which the most important demographic characteristics, as some of them already have been described in chapter 2, and the characteristics mentioned in this chapter are translated. In the following chapter this translation will be performed first by visualizing Metropolitan Cebu in an abstract way and by the description of a necessary theoretical background and its consequences for Metropolitan Cebu.

4 THEORETICAL BACKGROUND

4.1 Modelling transport in general terms

The theory described in this section is mostly derived from the book 'Modelling Transport'by J. de Ortuzar and L.G.Willumsen [4] and the book 'Transportation Modelling' by P.H.L. Bovy and N.J.van der Zijpp [6].

4.1.1 Introduction

A model can be defined as a simplified representation of a part of the real world, which concentrates on certain elements considered important for its analysis from a particular point of view. Although a model is a simplified representation, a model may be very complex and often requires large amounts of data. In case of transportation modelling one can say that the demand for transport is highly qualitative and differentiated. There is a whole range of specific demands for transport which are differentiated by time of day, day of week, journey purpose, type of cargo, importance of speed and frequency, and so on.

Typical applications where a modelling approach may contribute are:

- **Forecasting future developments**
- **Planning of new or improvement of existing infrastructure such as:**

1. Spatial planning impacts

The geographical location of housing, working and leisure areas influences transport flows. Transportation analysts are asked to calculate the probable transport and traffic implications of spatial planning. This refers e.g. to the consequences of new or residential areas or changes in employment levels in new business or industrial zones for the size of traffic flows.
However, spatial developments on their turn depend on the quality of the transport system. Models are being developed that can indicate the implications of transportation planning actions for spatial changes. Such model applications are important for the calculation of:
transport flows that are consistent with projections of population and employment, impact of bottlenecks in the road network on spatial developments, the influence a good public transport policy can have to counteract further desurbanization of the big cities.

2. Improvement of the road and railway network

3. Better utilization of available capacity

4. Stimulating public transport use

The scope of this study will be mainly on the spatial planning impacts.

The software that will be used for performing the modelling work is Transcad. Transcad is a worldwide used geographic information system (GIS) designed specifically for planning, managing, and analysing the characteristics of transportation systems and facilities.

A transportation model consists of several steps. The last step can be a traffic assignment. A model itself must be a part of a more general decision-making approach. The following framework is taken from *modelling transport by J. de D. Ortúzar and L.G. Willumsen* [4].

- **Formulation of the problem.** A problem can be defines as a mismatch between expectations and perceived reality.
- **Collection of data** about the present state of the system of interest in order to support the development of the analytical model.
- **Construction of an analytical model** of the system of interest.
- **Generation of solutions** for testing.
- In order to test the solutions or schemes proposed in the previous step it is necessary to **forecast the future values of the planning variables** which are used as inputs to the model.
- **Testing the model and solution.**
- **Evaluation of solutions** and recommending a plan/strategy/policy.
- **Implementation of the solution** and searching for another problem to tackle.

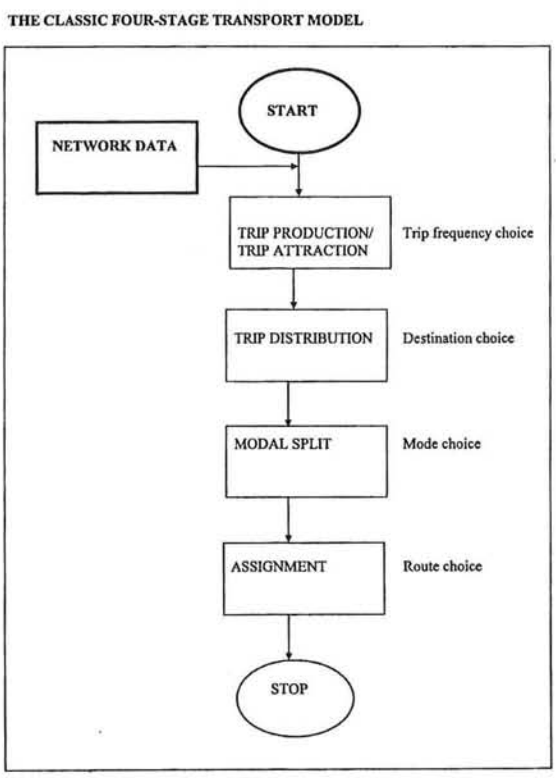


Figure 4.1 The classic four-stage transport model

Years of experimentation and development have resulted in a general structure that has been called the classic transport model. This structure is, in effect, a result from practice in the 1960s but has remained more or less unaltered despite major improvements in modelling techniques during the 1970s and 1980s.

The approach starts by considering a zoning and network system and the collection and coding of planning, calibration and validation data. These data would include base-year levels for population of different types in each zone of the study area as well as levels of economic activity including employment, shopping space, educational and recreational. These data are then used to estimate a model of the total number of trips generated and attracted by each zone of the study area (trip generation). The next step is the allocation of these trips to particular destinations, in other words their distribution over space, thus producing a trip matrix. The following stage normally involves modelling the choice of mode and this results in modal split, i.e. the allocation of trips in the matrix to different modes. Finally, the last stage in the classic model requires the assignment of the trips by each mode to their corresponding networks: typically private and public transport.

In the next sections these steps will be explained more specifically.

4.1.2 Study area

The study area is defined as the area within which transport flows will be analysed and modelled. For Metropolitan Cebu this implies that the urban area of Cebu City will be considered as study area. All area outside the study area is part of the impact area. For the case Metropolitan Cebu all the municipalities and the three cities Talisay, Mandaue and Lapu Lapu are part of the impact area. It is assumed that there is no travel demand generated outside the study area and impact area. This choice is based on the availability/lack of information. For example a detailed digital map of Mandaue is not available; a detailed analyse of the transport flows in Mandaue is impossible. Besides the urban area of Cebu City is more interesting to be studied since this area is suffering much more of traffic problems than the surrounding municipalities and cities.

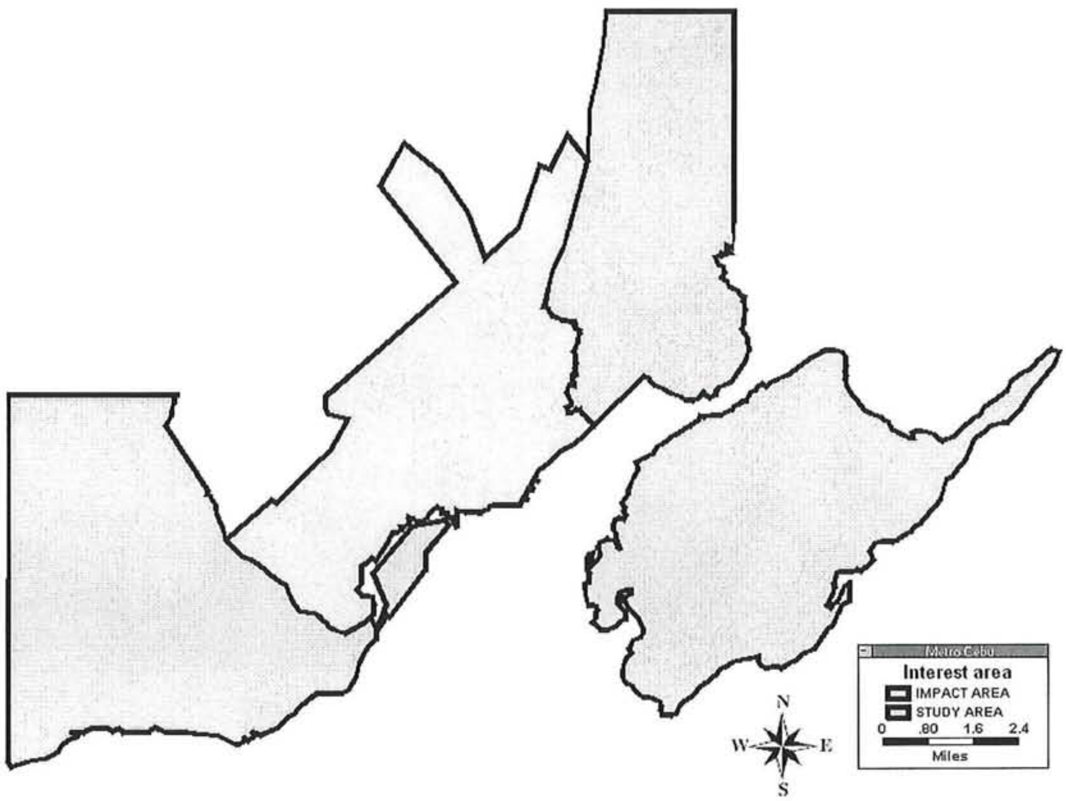


Figure 4.2 Interest area with subdivision in study and impact area

The study area itself is subdivided into a number of zones, also called traffic zones. These zones represent at a coarser level the origin and destination addresses of individual trips. To define the traffic zones a number of existing spatial systems can be used. This means that a traffic zone most favourably consists of one or more units of such an existing spatial system. Such systems are:

- municipalities
- census districts
- postal districts
- election districts
- etc.

For Cebu Cities these units consists of barangays. Depending on what is available zone sizes of about 1000 to 2000 inhabitants are advised. The characteristics of these spatial systems, consisting of data about the geographical definition of the sub areas and about their demographic or socio-economic content are available from various official institutions. Adopting such data reduces the costs of data collection and system design. For Cebu most of the information was collected from the GIS centres.

A traffic zone is represented by a single point of the zone, called centroid. It is the geographical representation of the zone. It is assumed that all trips start and end in that point. The centroid is part of the modelled transport network. It is a fictitious network node that connects the zone to the surrounding networks. It is linked to the network by so-called connectors which are fictitious links representing the underlying local network not included in the network model.

The location of the centroid is chosen such that it is needed the centre of gravity of the zone, which means that its location minimises the distance and time errors in geographically representing the individual trip addresses.

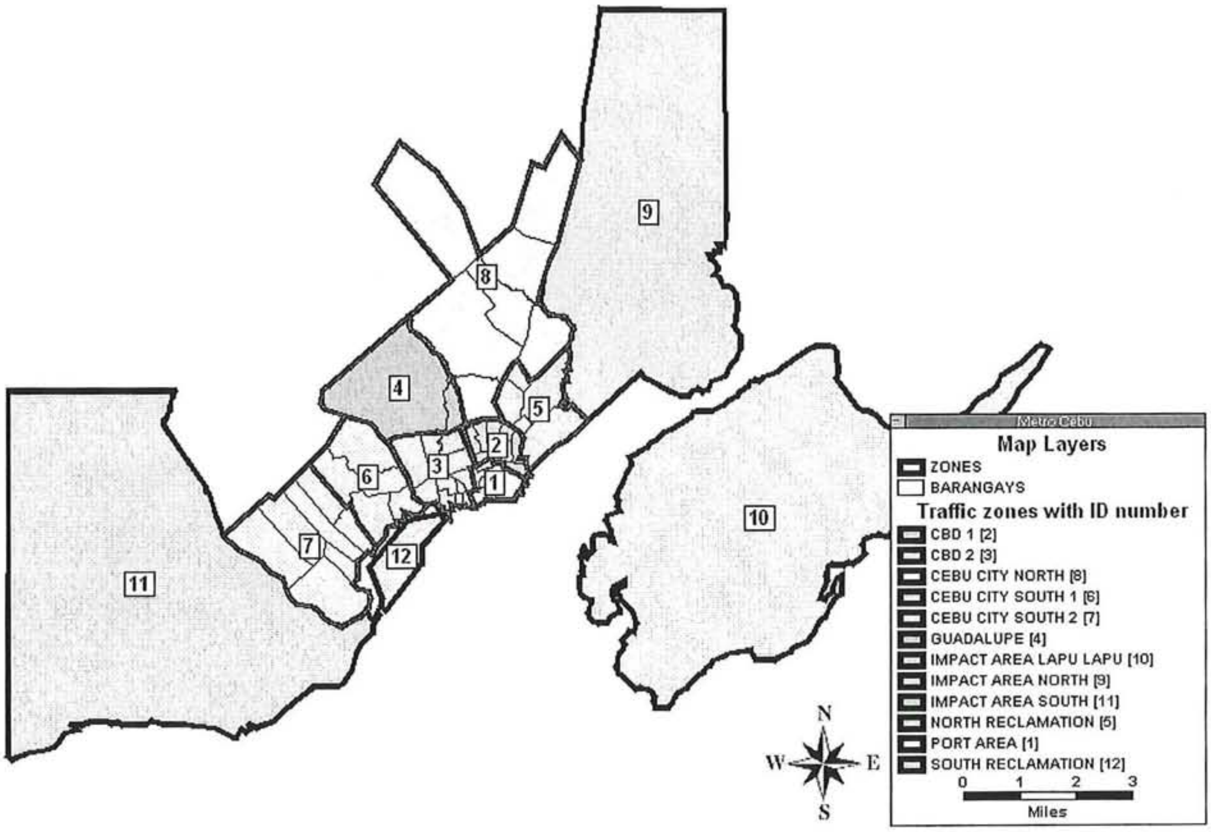


Figure 4.3 Metropolitan Cebu subdivided in 12 traffic zones

4.1.3 Network

Mostly the final aim of the analysis is to know loads of network elements. For correct choice modelling, travel distances and times in the various networks need to be known. For these purposes a computerized description of the various networks is needed that gives the geographical relations within the network as well as enables calculations of trip characteristics such as speed, travel time etc. Only the network within the study area needs to be modelled!

The following map represents the complete road map of Cebu City.

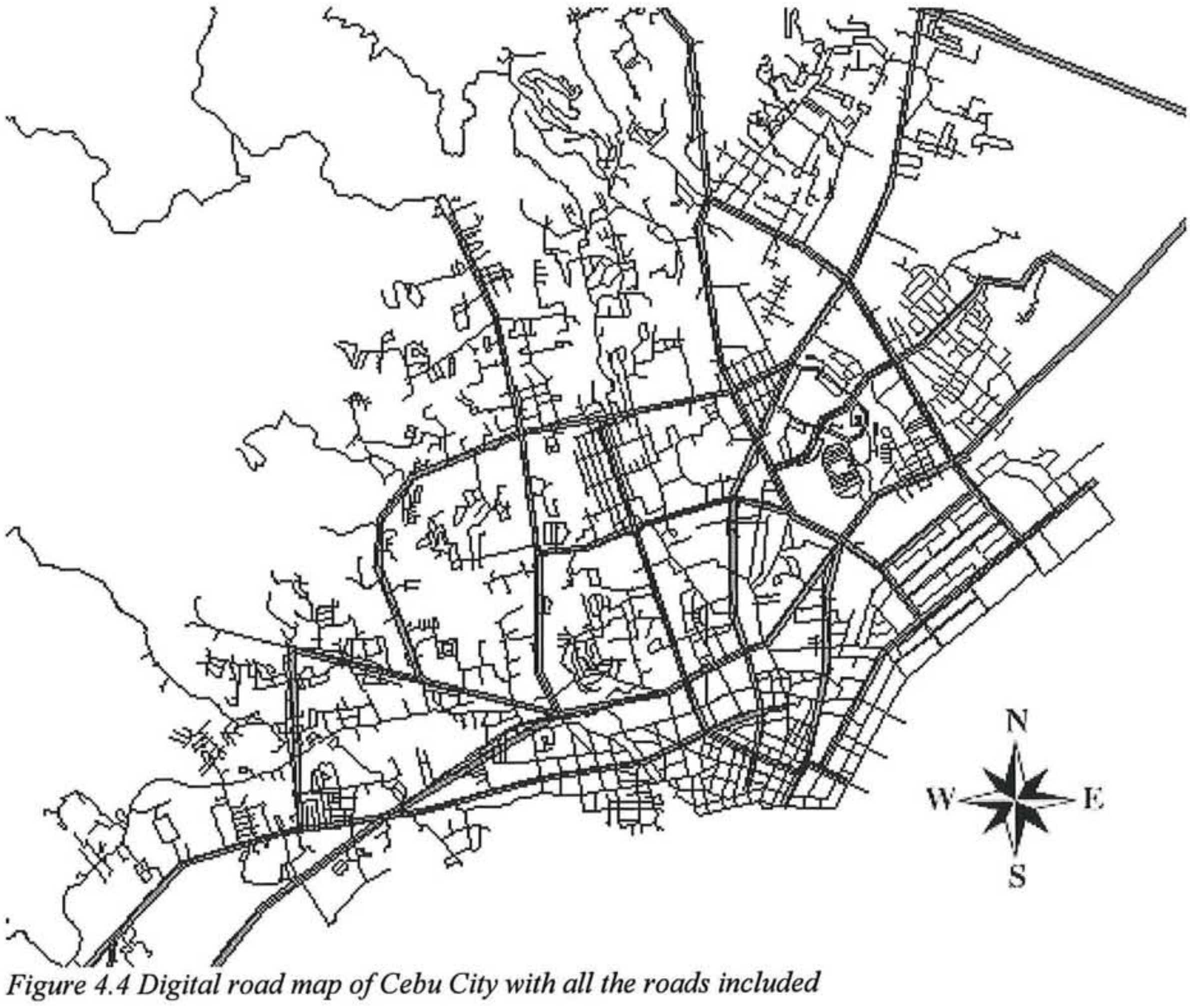


Figure 4.4 Digital road map of Cebu City with all the roads included

This map is showing all the roads varying from 6-lane major roads to small gravel roads in the mountainous area of Cebu City. These roads can be classified in asphalt, concrete and dirt/gravel (a small percentage is unclassified). The dirt/gravel roads are not normative for large traffic movements and will not be included in the transportation model. Only the major roads with 2,4 or 6 lane, as shown in the following map, will be included.

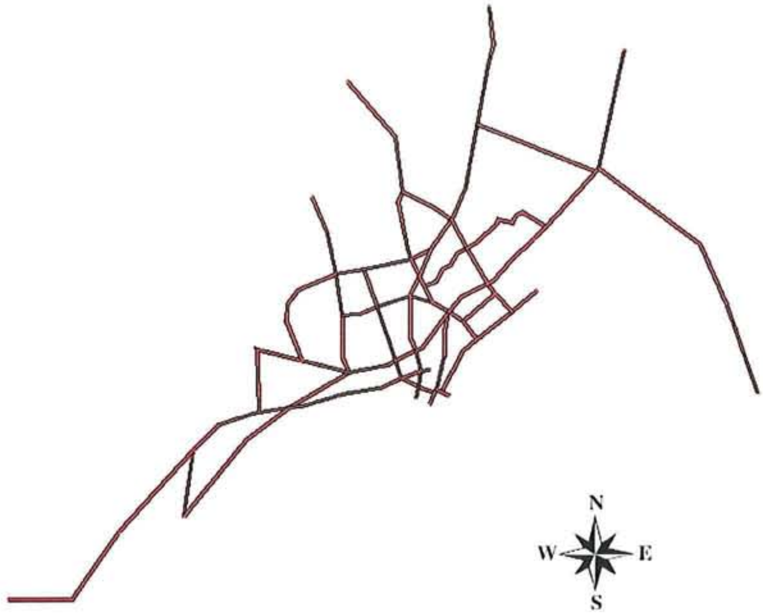


Figure 4.5 Digital road map of only the major roads in Cebu City

When combining the major road network with the zoning map, shown in section 4.1.2, a complete map can be obtained that will be used for the rest of the modelling work.

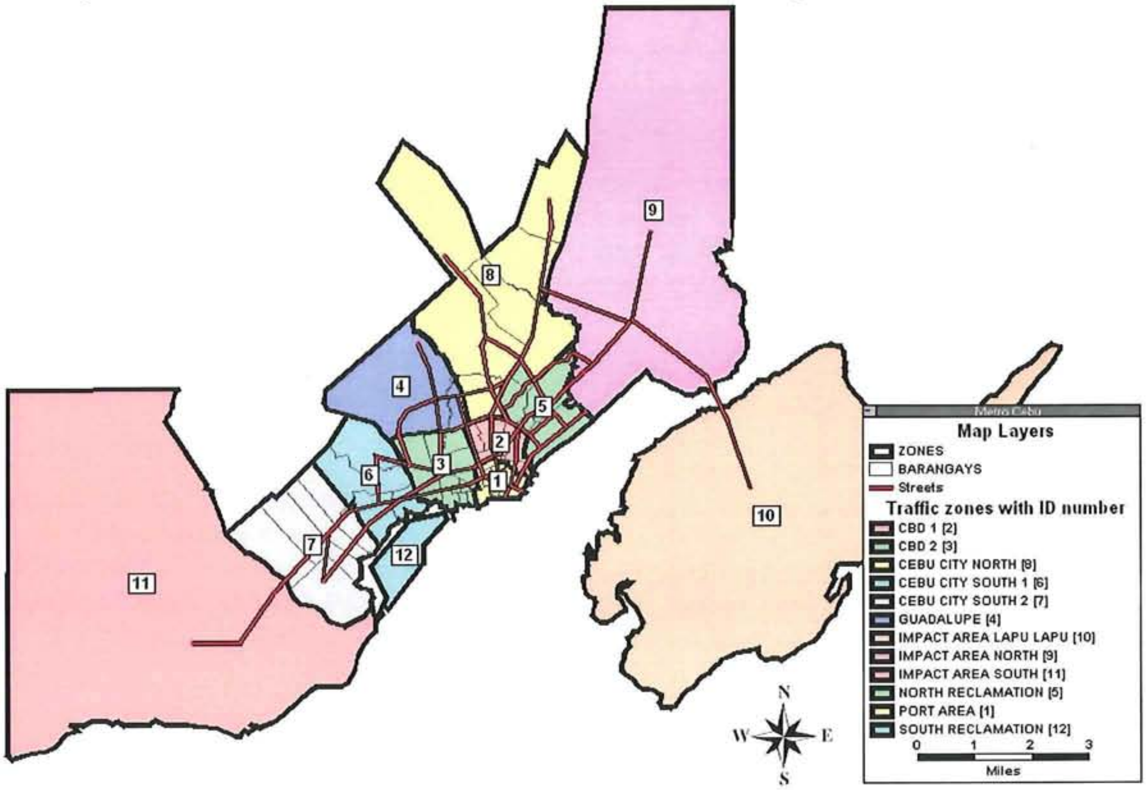


Figure 4.6 Zoning map combined with road network

4.1.4 Trip generation

The trip generation stage of the classical transport model aims at predicting the total number of trips produces in the zone and attracted by it respectively for each zone of the study area. This stage of the transportation planning process is only concerned with the number of trips that start and end in each zone, and not with making the connections between origins and destinations of trips. There a several methods available for performing the trip generation stage but before these methods will come to order some basic definitions will be described first.

A few basic definitions:

A journey is a one-way movement from a point of origin to a point of destination. Although the word 'trip' is literally defined as 'an outward and return journey, often for a specific purpose' (McLeod and Hanks 1986), in transport modelling both terms are used interchangeably.

A home-based (HB) trip is one where the home of the trip maker is either the origin or the destination of the journey. On the other hand a non-home-based trip is one where neither end of the trip is the home of the traveller.

Trip production is defined as the home end of an HB trip or as the origin of an NHB trip.

Trip attraction is defined as the non-home end of an HB trip or the destination of an NHB trip.

Trip Generation is often defined as the total number of trips generated by households in a zone. This is what most models would produce and the task then remains of allocating trips NHB trips to other zones as trip productions.

There are three primary tools that are used in modelling trip generation:

- Regression Models
  Two types of regression are commonly used. The first uses data aggregated at the zonal level, with average number of trips per household in the zone as the dependent variable and average zonal characteristics as the explanatory variables. The second uses disaggregated data at the household or individual level, with the number of trips made by a household and personal characteristics as the explanatory variables.
- Cross-Classification
  Cross-Classification methods separate the population in an urban area into relatively homogenous groups based on certain socio-economic characteristics. Then, average trip production rates per household or individual are empirically estimated for each class. This creates a lookup table that may be used to forecast trip productions.
- Discrete Choice Models
  Discrete choice models use disaggregated household or individual level data to estimate the probability with which any household or individual will make trips. The outcome can then be aggregated to predict the number of trips produced.

These methods can be used both for trip production and trip attraction. For more specific and detailed information about these methods the reader is referred to the TransCAD 3.0 manual. Once the trips have been calculated they should be balanced. The number of trips produced in an area is equal to the number of trips attracted to an area.

Trips have different purposes. In the case of HB trips, five categories are usually employed.
trips to work;
trips to school or college (education trips);
shopping trips;
social and recreational trips;
other trips.

These trips are often classified into peak and off-peak period trips; the proportion of journeys by different purposes usually varies greatly with time of day. TransCAD provides a procedure to balance trip productions and attractions in which productions and attractions from several trip purposes can be balanced in one step.

4.1.5 Trip distribution

After all available and relevant information on the number of trips departing or arriving in each zone has been collected; the next step in transport modelling is to distribute these trips over OD cells. Trip distribution is the step in transport modelling in which trips are distributed over origin-destination cells. There are different trips distribution models. Two basic categories of aggregate trip distribution methods predominate in urban transportation planning.

The first are called growth factor methods. These methods are usually encountered when there is no information available concerning the network interzonal distances, travel times, or generalized costs. Growth factor methods do not take into account any information about the transportation network, and thus cannot reflect impacts of changes in the network. This may be reasonable for very short term forecasts, but invalid for medium to long term forecasts for which the network has changed or to forecast scenarios that include changes in the network. As mentioned before the scope of this study will be mainly on the spatial planning impacts and therefore a description of the several growth factor methods will be left out of consideration.

The second basic category of aggregate trip distribution is the gravity model. The gravity model was originally motivated by the observation that flows decrease as a function of the distance separating zones, just as the gravitational pull between two objects decreases as a function of the distance between the objects. As implemented for planning models, the Newtonian analogy has been replaced with the hypothesis that the trips between zones i and j are a function of trips originating in zone i and the relative attractiveness and/or accessibility of zone j with respect to all zones. The assumption behind the gravity model is that the number of trips produced by zone i and attracted to zone j ($=T_{ij}$) proportional to:

- The forecast number of trips produced by zone i ($=P_{ij}$)
- The forecast number of trips attracted to zone j ($=A_{ij}$)
- The impedance between zone i and zone j ($=c_{ij}$). Many different measures of impedance may be used to represent the amount of difficulty of travelling between any pair of zones. Frequently used measures of impedance are travel time, travel distance, or cost.
- The friction factor (=accessibility) between zone i and zone j ($=f(c_{ij})$). Friction factors are inversely proportional to impedance; as the travel time for example between zones increases, the friction factor decreases and thus the total amount of trips between zones i and j.

A trip distribution model can be singly constrained to either productions or attractions or doubly constrained to both productions and attractions. When both productions and attractions are taken into consideration a trip distribution can be written as follows:

$$\mathbf{T_{ij} = a_i\, b_j\, P_i\, A_j\, f(c_{ij})}$$

with:
a_i = balancing parameter
b_j = balancing parameter
P_i = number of trips departing at zone i
A_j = number of trips arriving at zone j
$f(c_{ij})$ = accessibility of zone j from i

a_i is for example the average number of work-related trips per person per day and b_j the number of work-related trips arriving in a zone for each job.

The following table can also represent a doubly constrained trip distribution model.

Origins	Destination				$\sum_j T_{ij}$
	1	2	...	n	
1					P_1
2		?			P_2
...					...
m					P_m
$\sum_i T_{ij}$	A_1	A_2	...	A_n	

Figure 4.7 Representation of a doubly constrained trip distribution

With regard to the accessibility or friction factors Transcad provides the possibility of choosing between three more or less standard formulas. A commonly used equation is the following exponential distribution function:

Exponential $f(c_{ij})=e^{-0.03.(cij)}$ c_{ij} = travel distance, time or costs

Most derivations of the trip distribution model in the literature result in a model with an exponential distribution function. The function describes that a fixed absolute increase in travel distance, time or costs results in a fixed relative decrease in the (modelled) willingness to make a trip. The accessibility or friction factors that will be calculated for Cebu City are based on travel distance.

A singly constrained trip distribution model for zone j and zone i can be written as:

$$\mathbf{T_{ij} = a_i\, P_i\, X_j\, F_{ij}}$$

with:
a_i = balancing factor
P_i = trips departing from zone i
X_j = attraction potential of zone j
F_{ij} = accessibility of j from i

$$\mathbf{T_{ij} = b_j\, Q_i\, A_j\, F_{ij}}$$

with:
b_j = balancing factor
Q_i = production potential of i
A_j = trips arriving at zone j
F_{ij} = accessibility of j from i

4.1.6 Modal split

The choice of travel mode of travellers (e.g. car, public transit or non-motorized) depends on the availability of transport means, especially cars, and on the travel resistance for each mode from origin to destination. Apart from that, each travel mode has its specific advantages and disadvantages irrespective of travel time and travel costs. These are accounted for in the mode specific constants. For Metropolitan Cebu the assumptions will be made that there are besides PUJ's and private vehicles no other transportation modes.

4.1.7 Traffic assignment

Traffic assignment is the step in traffic analysis in which interzonal trips are assigned to the network this involves computing one or more optimal (usually shortest) routes between each origin and destination and distributing travel demand over these routes. The sum of all trips along these routes over all OD pairs results in a traffic load on all links and nodes.

Traffic assignment has different functions in traffic planning. The two most important ones are:

- Gaining insight in the characteristics of the network
  By performing several different assignments, insight may be gained in the shortcomings of the existing network (missing links, capacity deficiency), misusage of functional classes and prevention of large detours. Also, ideas can be gained for solving existing problems. The same analysis is useful for planned network scenarios in the future.
- Traffic forecast
  With regard to current and future network scenarios, a number of aspects are computed to be able to forecast the future traffic situation. These include, among others, link loads, travel time, speed, congestion, junction resistance and detour factors. All this information is used for the evaluation of alternative plans.

The necessary input for the assignment is:
- an OD table of trips between the zones, usually all trip purposes combined;
- a (computer)representation of the network;
- characteristics of the network elements (links and nodes);
- a route choice model.

Direct output of the assignment computation:
- the routes
- the route characteristics
- route loads: the number of trips per route;
- link and node loads: the number of trips per unit time (flow) on each link and each turn at junctions.

There are several methods to perform a traffic assignment.

In an All-Or-Nothing (AON) assignment, all traffic between an O-D pair is assigned to just one path (usually the shortest path) connecting the origin and destination. This model is unrealistic in

that only one path between every O-D pair is utilised even if there is another path with the same or nearly the same travel time or cost.
Also, traffic on links is assigned without consideration for whether or not there is adequate capacity or heavy congestion; travel time is a fixed input and does not vary depending on the congestion on a link.

In a deterministic user equilibrium (UE) model behavioural difference between travellers is not taken into account. Still a distribution of trips over multiple routes may arise if it is assumed that the traveller chooses the objective by shortest route, and level of service attribute of links depend on link loads. This method utilises an iterative process to achieve a convergent solution in which no traveller can improve his/her travel time by shifting routes. In each iteration, network link flows are computed, which incorporate link capacity restraint effects and flow-dependent travel times.

The stochastic user equilibrium is a generalisation of user equilibrium that assumes travellers do not have perfect information concerning network attributes and/or they perceive travel costs in different ways. SUE assignments produce more realistic results than the deterministic UE model, because SUE permits use of less attractive as well as the most attractive routes. Less attractive routes will have lower utilisation but will not have zero flow as they do under UE.

4.2 Approach

Because of its design TransCAD provides possibilities of completing the steps described in the previous sections in the same order and with the same theoretical background as described in a classic four-stage transport model.
The transportation study is completed when the steps are completed. However in practice all the steps are repeated for each distinct analysis case or scenario. An iterative calculation procedure is also required in order to achieve consistent final results. The traffic flows are known at the very end of the calculation cycle and if there are big differences between existing traffic counts and the calculated flows then the calculation should be repeated. Once realistic traffic flows have been found it is possible to discuss issues regarding infrastructure problems and perhaps to find solutions for traffic problems and other related problems, which of course was the main goal of the described procedure.

In the chapters 2 and 3 the demographic and transportation characteristics of the interest area Metropolitan Cebu were described. The complexity and diversity of the available information needs to be put in order before the model of Metropolitan Cebu can be applied. In case of lack information realistic assumptions needs to be made. This is a very complicated and time-consuming phase in the whole process of making and applying a model. However this process needs to be completed in a very careful way because mistakes made in this phase may influence the results in a negative way resulting in among others unreliable conclusions and recommendations. An additional complicated factor for the case Metropolitan Cebu is the quality of the available data and other problems concerning the available information. This is also confirmed by the following quotation that is derived from *Five Cities, Modelling Asian Urban Population-Environment Dynamics by Gayl D. Ness and Michael M.Low* [10].

Data Problem

The Philippines has no lack of data, but there are many problems, especially in locating data for local urban planning. Characteristics of the country's high degree of administrative centralization, most data are collected locally and forwarded to Manila for collation and publication. They become available usually long after the fact, if at all, and are presented in highly aggregated form, for the nation as a whole, or for a region of many provinces. Local level data collected by specific organizations are usually not available publicly. Moreover, there are many data collection agencies, both governmental and private, and there is little or no attempt to draw these different sources into a coherent system.
Data collection is often problem-driven and thus must wait until problems are recognized or become acute. Cebu has suffered from a severe water problem for decades because of population growth and radical deforestation. Data relating to that problem exists, but they are held by private research organizations. Some have become available through the Water Resources Center of the University of San Carlos. Air pollution has been bewailed as a health threat for some time, but no systematic public monitoring or documentation has been introduced, though the University of San Carlos department of Chemistry does collect some air pollution data. Electricity is provided not by communities such as Cebu City but by a central semi-government corporation and by private cooperatives. These sources started pooling their recourses ten years ago when the power plants in the country started to fall apart due to lack of maintenance. Nonetheless, information on demand and supply has not yet been pooled. Roads in the city are classified by the agencies responsible for maintaining them: there are national roads, city roads and barangay roads. It is difficult to sort out just who is supposed to keep track of what and who collects data for which roads.
Another data-related problem specific to Cebu City is that the city is tied into a larger geographic system: Meto Cebu. The latter usually serves as development unit, thus much information is assembled for the larger unit but not the city.

In chapter 5 the available information will be processed into usable input for the model. In this phase it is also very important to keep in mind the goals and objectives of this study (chapter 1), for this may help selecting useful information and filtering out the abundant information. This described procedure is summarized in the following framework.

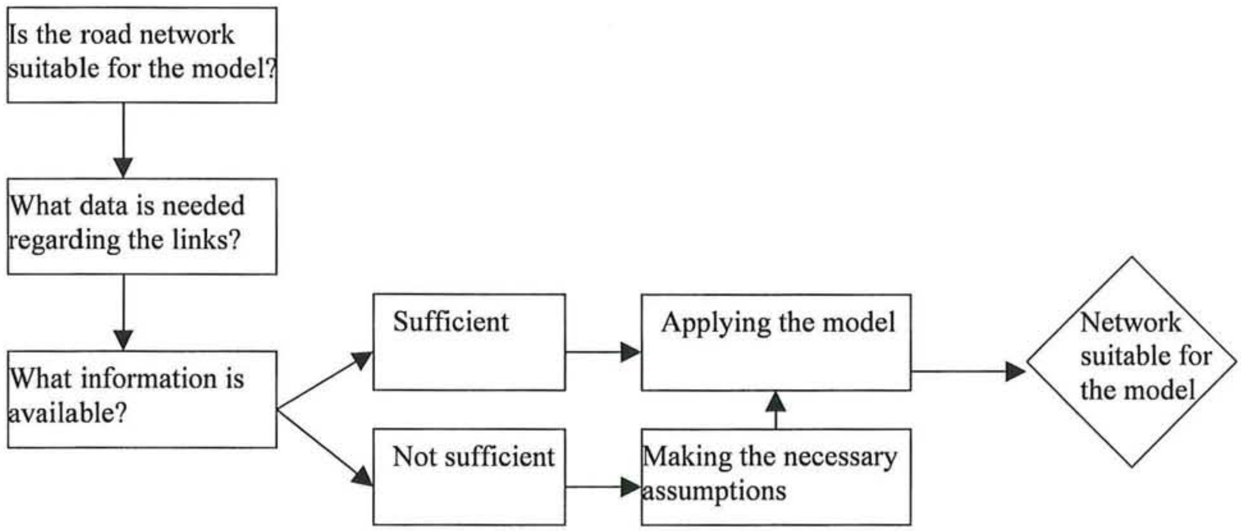


Figure 4.8 Framework for the applied approach for the first step in the modelling work

Once the model of Metropolitan Cebu can be applied successfully attention can be paid to the actual goal of this study as mentioned in chapter 1. This will happen on the basis of several scenarios that will be worked with the described model. These scenarios are based on the actual situation in Cebu, a future situation and a suggested future situation. Results will be presented on the basis of the maps that are shown in this chapter, so that the results can be compared easily.

Space of time	Scenario	Trip distribution	Traffic assignment
Existing situation	1	Base year trip distribution	Base year
Future situation	2	Future year trip distribution	Zero alternative
	3		Future
Proposed future situation	4		Proposed future
	5		Complete proposed future

Table 4.1 Summary of the study approach

The base year trip distribution and traffic assignment will help understanding the existing situation in Metropolitan Cebu and thus will confirm the in the chapters 2 and 3 described status quo.
The so-called zero alternative traffic assignment is the assignment for the future year, thus the situation for which Metropolitan Cebu has new demographic characteristics, but performed on the actual network (i.e. the network without the planned expansion). In this way effects and thus the benefits of the suggested measurements can be derived if the assignment is performed for the planned network in the future traffic assignment.
The proposed and complete proposed traffic assignment will describe Metropolitan Cebu if the several policies with regard to the suggested future measurements are implemented.

5 PRODUCTION AND ATTRACTION

In the previous chapter the classic four-stage transport model has been described. In this chapter the first step of this model will be carried out after the necessary information has been presented. Calculations will be made with the zoning and road map that has been made in the previous chapter.

5.1 Population and employment base year

The employment number is defined as the number of persons in the labour force who were reported either at work or with a job or business although not at work during the reference period. The labour force is defined as the number of persons that is 15 years old and over and that contributes to the production of goods and services in the country and either employed or unemployed (the Philippine Census defines a lower age limit at which a person can legitimately be a member of the labour force). In this section a list will be given of the population and employment numbers in Metropolitan Cebu. The data is among others based on the population projections presented in the *1995 census-based city/municipal* [7].
The employment numbers were obtained from DOLE (Department of Labor and Employment) and the NSO (National Statistics Office) in Cebu. The most recent employment numbers do not include the municipalities and the city of Talisay but only Cebu City, Lapu Lapu City and Mandaue City. The most recent census in which the municipalities were included was held in 1990. These numbers are presented in the volume *Cebu A Demographic & Socio-economic Profile Based On The 1990 Census by Wilhelm Flieger* [3]. This very important volume contains information for every city, municipality and barangay found in Cebu Province. For each of Cebu's 53 cities and municipalities, information is presented in 12 tables, eight graphic illustrations, and one geographic map. There were also some projections made for the employment in the municipalities in the *Metro Cebu Land Use And Transport Study* [1] in 1980. Together with the DOLE and NSO numbers good estimations can be made for the municipalities using linear trend extrapolation.

employment	**1980** **[-]**	**1990** **[-]**	**base year 2000** **[-]**
Cebu City	-	-	**291 900**
Mandaue City	-	-	**100 000**
Lapu Lapu City	-	-	**57 000**
City of Talisay	10 300	34 706	**59 112**
Minglanilla	5800	18 851	**31 902**
Naga	7200	17 168	**27 136**
Consolacion	4600	15 082	**25 564**
Liloan	4800	14 530	**24 260**
Compostela	3800	7193	**10 586**
Cordova	2600	7721	**12 842**
Total			**640 302**

Table 5.1 Available and forecasted employment numbers in Metropolitan Cebu

The numbers in the base year column can be obtained by adding the 1990 employment numbers and the difference of the 1980 and 1990 column. The city of Talisay has got an employment number of 59112 = (34706-10300) + 34706.

	Population in the base year [-]
Cebu City	**662 000**
Mandaue City	**256 000**
Lapu Lapu City	**207 811***
City of Talisay	**99 811**
Minglanilla	**72 574***
Naga	**78 853***
Consolacion	**37 871**
Liloan	**59 317***
Compostela	**29 662***
Cordova	**30 776***
Total	**1 434 864**

* these numbers are projections made in the *1995 census-based city/municipal* [7]

Table 5.2 Available population numbers in Metropolitan Cebu

By adding the numbers shown in these two tables the employment and population numbers of the impact areas, as they can be seen on the maps in chapter 4, can be calculated. For the urban area of Cebu City (the study area) a different approach is required for the calculations of these numbers. The urban area is divided in 8 zones, which consists of a number of barangays. The projections of the population numbers for these barangays were available on the digital map. They are also the 2000 projections made in the year 1995.For each of the 8 zones the matching 'barangay population numbers' can now be added. The 'barangay employment numbers' however are not available. But there is information about the different types of land use for each barangay, which was obtained from the GIS office in Cebu City. The area in square meters for the commercial and industrial land use in a barangay can be used for the estimation of the employment numbers. In the year 2000 (the base year) the total number of employers in Cebu City was 291 900. It is known that 19% of all the employers is working in the industry and 73% is engaged in the commercial activities (chapter 2). For each barangay, and thus the 8 zones, the total number of employers can now be estimated. A calculation example for one barangay is shown in the figure below.

Total area commercial land use in Cebu City = 4 151 871 m²
Total area industrial land use in Cebu City = 185 913 m²
73% of 291 900 = 213 087 employers
19% of 291 900 = 55 461 employers
Commercial: 0.0513 employers/m²
Industrial: 0.298 employers/m²

BARANGAY NAME	*LAND USE*	*AREA IN SQ.M*
KASAMBAGAN	*COMMERCIAL*	***126,984.69***
	INDUSTRIAL	***31,873.60***
	INSTITUTION	***28,380.23***
	RESIDENTIAL	***837,403.72***
	ROAD	***86,836.98***
	SPORTS & RECREATION	***647,045.98***
	UNCLASSIFIED	***0.02***
	VACANT LAND	***132,149.53***

Total employment in Kasambagan = 126 985 * 0.0513 + 31 874 * 0.298 = 16 013

Figure 5.1 Calculation example for the employment in a barangay

A number for the labour force (the working population) can now be estimated by multiplication of the population number with a factor. This factor is also derived from *Cebu A Demographic & Socio-economic Profile Based On The 1990 Census by Wilhelm Flieger* [3]. In 1990 the labour force rate in Cebu Province was 59.6% (for the Philippines this rate was 57.7% in the same year). For this case it is assumed that this rate will not change much and thus will stay the same in the base year and the future year. To obtain the numbers for the working population the population numbers will be multiplied by 0.6. In the figure below the results are presented as they also can be seen in TransCAD. For the sake of completeness also the matching map is shown.

ZONES

ID	District_ID	population	employment	work_pop
36	1	24678	21770	14807
38	2	74338	15121	44603
34	3	151899	60566	91139
32	4	64396	13542	38638
40	5	64660	79204	38796
28	6	114581	8933	68749
30	7	81767	14107	49060
42	8	102226	54956	61336
45	9	382850	160410	229710
18	10	238587	69842	143152
57	11	251238	118150	150743
47	12	0	0	0

Figure 5.2 Dataview in Transcad of the demographic characteristics in the base year

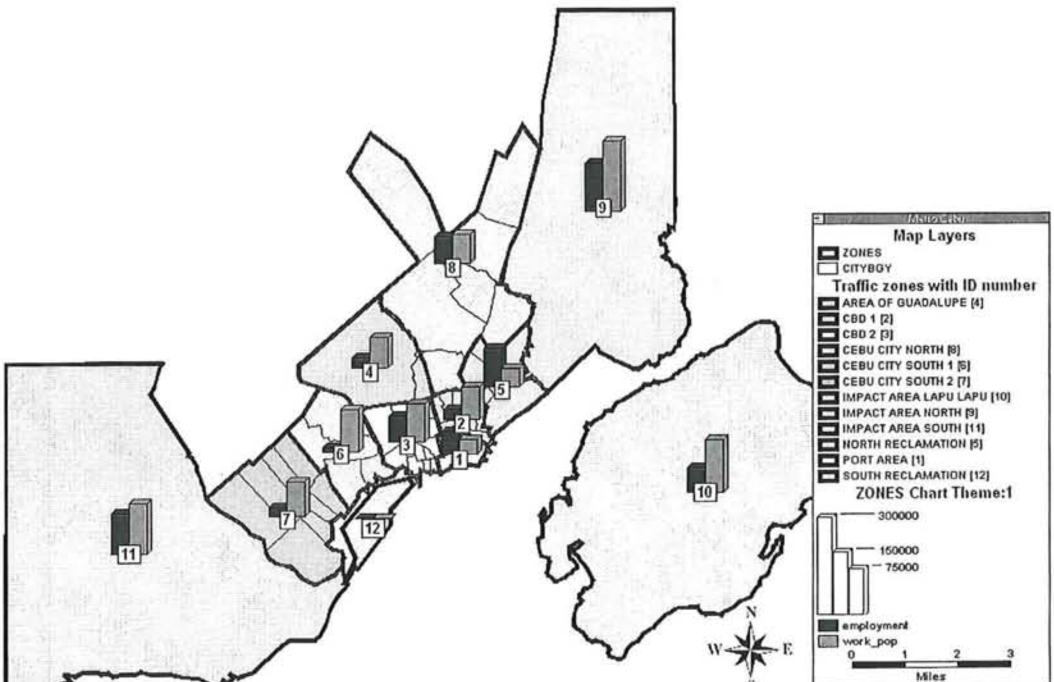


Figure 5.3 Overview of employment and working population in Metropolitan Cebu for the base year

5.2 Production and attraction base year

For performing the calculation of the production and attraction a few assumptions were made. For estimating the balancing parameters the total number of trips per person per day calculated in the 1992 study is used. The number of trips per person per day is in general terms relatively stable during the years which is also the case for Metropolitan Cebu as is shown in table 3.3 in section 3.2.2. That's why this number of 1.26 will be used for both the present and the future situation.

The second assumption is with regard to the distribution of trips by trip purpose. Because of the availability of data only a trip distribution for the work-home trips can be made. Therefore it is necessary to estimate a percentage for this portion. In the MCLUTS [1] 30% of all trips were between home and work. The total demand for travel contained a high proportion of trips to and from places of education, accounting for at least 36 percent of all trip-making. This was because of the young age structure and the fact that Metropolitan Cebu is the main education centre in the Visayan region. In the figure the other percentages for trip purposes in 1980 can be read.
For the present and future situation the assumption will be made that of all trips 35% is between home and work.

It is important to keep in mind that obtained results through out the study are based on population and employment numbers and thus will not completely visualize the realistic situation. However they will provide insight in the work-home trips and eventually will help to study effects of developments of demographic characteristics or in this case a new location for employment (the South Reclamation Area).

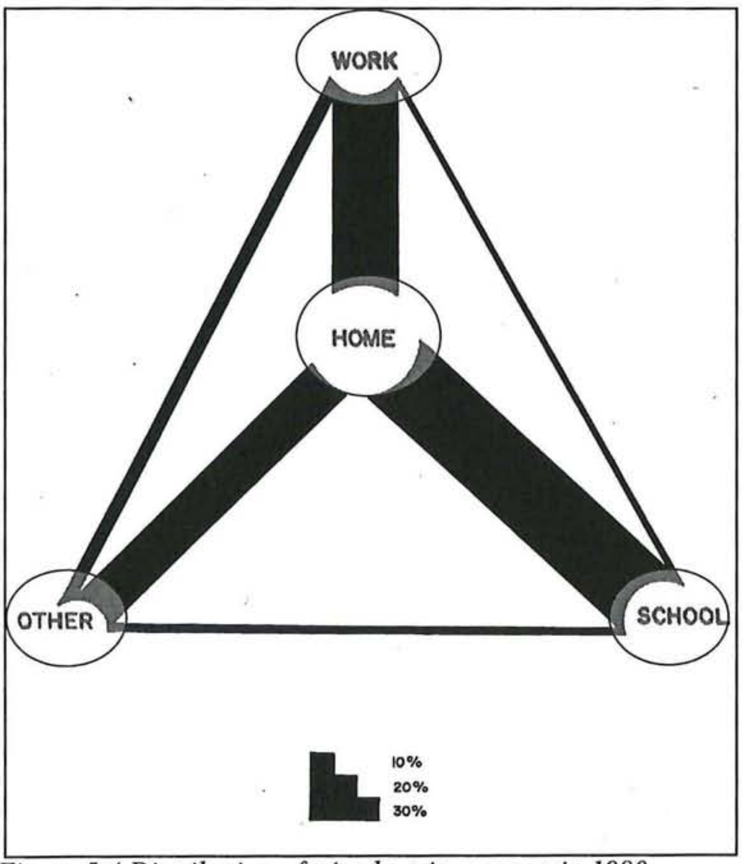


Figure 5.4 Distribution of trips by trip purpose in 1980

The balancing parameter a_i (in TransCAD equal to R_HBWA) is the average number of work-related trips per person per day which is equal to 35% of 1.26 (=**0.4**).
The balancing parameter b_j (in TransCAD equal to R_HBWP) is the number of work-related trips arriving in a zone for each job. For Metropolitan Cebu b_j is equal to (35% of 1.26)*(total working population)/(total employment) = (35% of 1.26)*(930733)/(616601) = **0.6**.
With these parameters and the population and employment numbers the Home-Work Based Productions and Attractions (HWBP&HWBA) can be calculated. The number of arrivals and departs has to be equal. In other words the trip productions and attractions needs to be balanced. In TransCAD this can be done by holding the productions constant and adjusting the attractions, so that the sum of both productions and attractions is equal. In TransCAD the balanced productions and attractions are called BAL.HBWP and BAL.HBWA.

ZONES + PROD+ATTR+BAL

ZONES.ID	District_ID	population	employment	work_pop	R_HBWP	R_HBWA	PROD.HBWP	ATTR.HBWA	BAL.HBWP	BAL.HBWA
36	1	24678	21770	14807	0.40	0.60	5922.80	13062.00	5922.80	13144.36
38	2	74338	15121	44603	0.40	0.60	17841.20	9072.60	17841.20	9129.80
34	3	151899	60566	91139	0.40	0.60	36455.60	36339.60	36455.60	36568.72
32	4	64396	13542	38638	0.40	0.60	15455.20	8125.20	15455.20	8176.43
40	5	64660	79204	38796	0.40	0.60	15518.40	47522.40	15518.40	47822.03
28	6	114581	8933	68749	0.40	0.60	27499.60	5359.80	27499.60	5393.59
30	7	81767	14107	49060	0.40	0.60	19624.00	8464.20	19624.00	8517.57
42	8	102226	54956	61336	0.40	0.60	24534.40	32973.60	24534.40	33181.50
45	9	382850	160410	229710	0.40	0.60	91884.00	96246.00	91884.00	96852.83
18	10	238587	69842	143152	0.40	0.60	57260.80	41905.20	57260.80	42169.41
57	11	251238	118150	150743	0.40	0.60	60297.20	70890.00	60297.20	71336.96
47	12	0	0	0	0.40	0.60	0.00	0.00	0.00	0.00

Figure 5.5 Dataview of the calculated productions and attractions for the base year

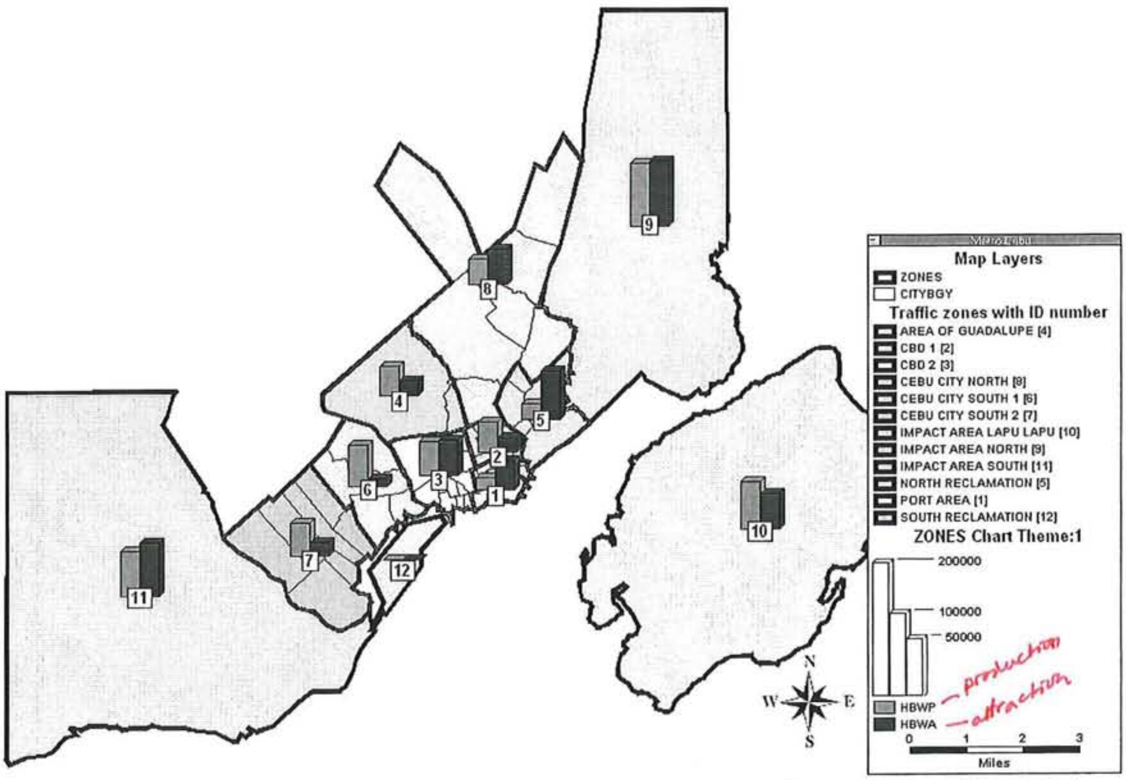


Figure 5.6 Base year productions and attractions for each municipality and city in Metro Cebu

5.3 Population and employment future year

In this section estimations will be made for the population and employment numbers in the year 2010. In this case it is assumed that a period of almost 10 years is necessary for the South Reclamation Area to be fully developed and thus to house approximately 100 000 employers. The projections will not differ much from an actual situation because only a short period of 10 years is considered.

To project populations of cities and municipalities, the ratio method, rather than the cohort component method, was utilized because of the unavailability of data on fertility, mortality and migration at he city/municipality level. The ratio method of estimating the future population of cities and municipalities makes use of the levels and trends in the ratios of the population of cities and municipalities to the population of their respective provinces observed in previous censuses. These ratios are then projected on the assumption that after some time stability will be attained. The following table contains the population numbers for Metropolitan Cebu in the year 2010.

	Population in 2010 [-]
Cebu City	**870 793**
Mandaue City	**249 925**
Lapu Lapu City	**282 899**
City of Talisay	**187 328**
Minglanilla	**93 501**
Naga	**98 695**
Consolacion	**73 741**
Liloan	**76 777**
Compostela	**35 578**
Cordova	**39 380**
Total	**200 8617**

Table 5.3 Forecasted population numbers in Metropolitan Cebu for the year 2010

The population number in Cebu City in the year 2010 is 870793, which means an increase of 31,5% if compared with the value of 662000 in the base year. This percentage will be used for estimating the population numbers in the 8 traffic zones in the study area.

Detailed information about employment on municipality level is not available. Therefore it is necessary to calculate an average growth number for the three cities. This growth percentage will also be used for the municipalities. The in Cebu City available data on employment is represented in the next table.

	Cebu City [-]	Mandaue [-]	Lapu Lapu [-]
2000	291900	100000	57000
1999	284000	95000	53000
1998	279000	87000	57000
1997	261000	89000	57000
1996	245000	82000	56000
1995	239000	71000	-
1994	238000	74000	-
1993	219000	68000	-
1992	240000	63000	-
1990	216000	65000	51000
1980	182400	31500	15100

Table 5.4 Available information on employment in Metropolitan Cebu

The following growth percentages can be derived.

	1980-1990 [%]	1990-2000 [%]
Cebu City	18	35
Mandaue	110	54
Lapu Lapu	240	12

Table 5.5 Derived growth percentages on employment in Metropolitan Cebu

As it can be seen the employment is showing a tremendous increase in Mandaue and Lapu Lapu during the eighties. This was among others caused by the new airport in Lapu Lapu and by the development of new industrial areas on Mactan Island. The past years the growth is more or less stabilized and in the coming years there is no fast economic growth expected. This is due to the slowly recovery from the Asia crisis in 1997 and the political crisis this year the Philippines is suffering from.

For estimating one growth percentage the percentages of 110% and 240% will be left out of consideration because these are very high and unlikely to represent a realistic situation. (18%+35%+54%+12%)/4 = 30% is the percentage that will be used for calculating the 2010 employment numbers using the numbers in table 5.1. This percentage is almost the same as the growth percentage of the population in Cebu City (31,5%), which confirms in a way the correctness of this assumption.
For example the future employment in Talisay will be (30% of 59112)+59112=76846. The rest can be calculated in the same way; results can be seen in figure 5.12.

	Employment in 2010 [-]
Cebu City	**291 900**
Mandaue City	**117 570**
Lapu Lapu City	**74 100**
City of Talisay	**76 846**
Minglanilla	**41 473**
Naga	**35 277**
Consolacion	**33 233**
Liloan	**31 538**
Compostela	**13 762**
Cordova	**16 695**
South Reclamation Area	**100 000**
Total	**832 394**

Table 5.6 Forecasted employment numbers in Metropolitan Cebu for the year 2010

These are the forecasted numbers for the employment in the municipalities and the cities, that will be used for the calculations in the future year. The total number of 832394 is 30% more than the total number of 640302, which can be found in table 5.1. The reclamation area will provide 100000 jobs. The assumptions that will be made here is that the employment number in Cebu City will stay the same as in the base year (i.e.291900) while the increase of 30% (30% of 291900 = 87570) will be employed on the reclamation area; the rest of the 100 000-87570 =12430 will come from Mandaue City. Mandaue City will house 130000-12430=117570 employers.
The numbers for the workers (labour force) will be calculated in the same way as explained in section 5.1, thus by multiplication of the population numbers with a factor of 0.6.

ZONES

ID	District_ID	population	employment	work_pop
36	1	32461	21770	19477
38	2	97754	15121	58652
34	3	199747	60566	119848
32	4	84681	13542	50809
40	5	85028	79204	51017
28	6	150674	8933	90404
30	7	107524	14107	64514
42	8	134427	54956	80656
45	9	436021	196103	261613
18	10	322279	90795	193367
57	11	379524	153596	227714
47	12	0	100000	0

Figure 5.7 Dataview in Transcad of the demographic characteristics in the future year

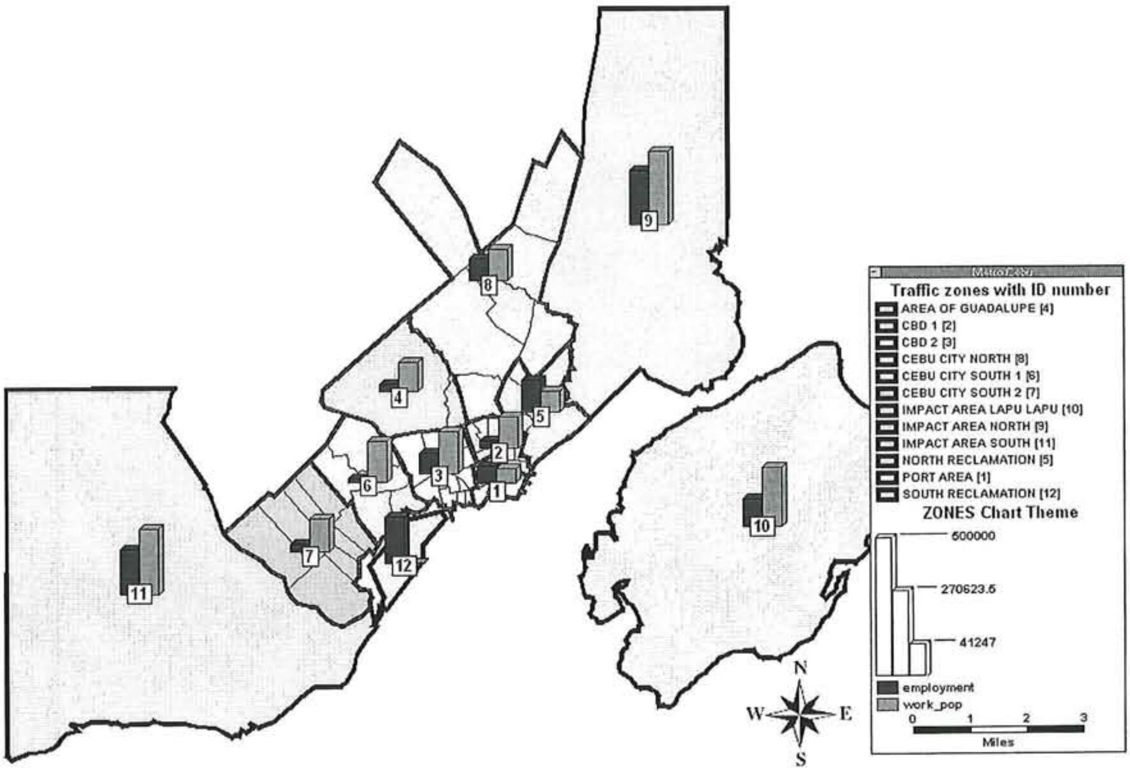


Figure 5.8 Overview of employment and working population in Metropolitan Cebu for the future year

5.4 Production and attraction future year

The same calculations for the production and attraction can now be performed for the future situation.

ZONES + PROD+ATTR+BAL

ZONES.ID	District_ID	population	employment	work_pop	R_HBWP	R_HBWA	PROD.HBWP	ATTR.HBWA	BAL.HBWP	BAL.HBWA
36	1	32461	21770	19477	0.40	0.60	7790.80	13062	7790.80	13116.15
38	2	97754	15121	58652	0.40	0.60	23460.80	9073	23460.80	9110.61
34	3	199747	60566	119848	0.40	0.60	47939.20	36340	47939.20	36490.64
32	4	84681	13542	50809	0.40	0.60	20323.60	8125	20323.60	8158.68
40	5	85028	79204	51017	0.40	0.60	20406.80	47522	20406.80	47719.00
28	6	150674	8933	90404	0.40	0.60	36161.60	5360	36161.60	5382.22
30	7	107524	14107	64514	0.40	0.60	25805.60	8464	25805.60	8499.09
42	8	134427	54956	80656	0.40	0.60	32262.40	32974	32262.40	33110.69
45	9	436021	196103	261613	0.40	0.60	104645.20	117662	104645.20	118149.75
18	10	322279	90795	193367	0.40	0.60	77346.80	54477	77346.80	54702.83
57	11	379524	153596	227714	0.40	0.60	91085.60	92158	91085.60	92540.03
47	12	0	100000	0	0.40	0.60	0.00	60000	0.00	60248.72

Figure 5.9 Dataview of the calculated productions and attractions for the future year

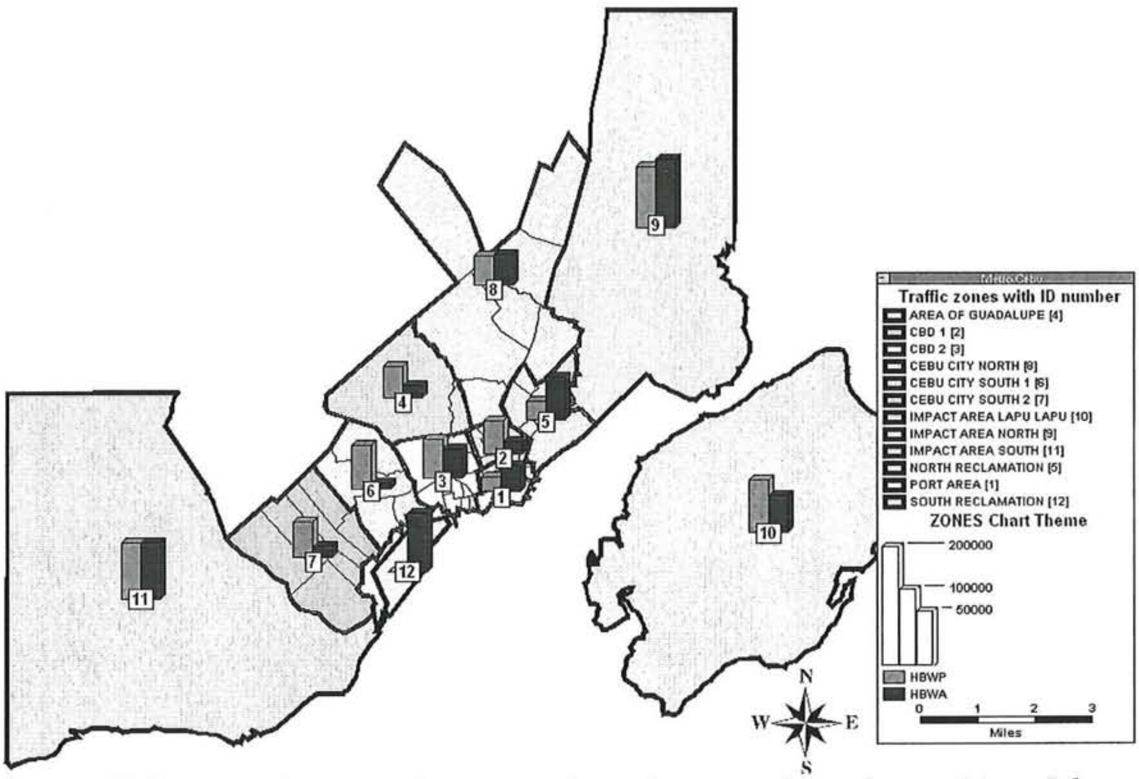


Figure 5.10 Future productions and attractions for each municipality and city in Metro Cebu

5.5 Analysis of the results

The first step in the classic four-stage transport model has now been completed. The results of the trip production and attraction calculations are the input for the second step in the transport model. In the second step the calculated values of the balanced productions and attractions, that can be found in the last two colums of the figures 5.5 and 5.9, will be distributed over the 12 traffic zones in Metropolitan Cebu. This base year and future year trip distribution will be performed in chapter 6.

The calculated values of the productions and attractions were mainly based on population and employment forecasts. Unfortunately the base year population and employment numbers for all the municipalities and cities are not available in Metropolitan Cebu. So it was necessary to use forecasted values based on 1980,1990 and 1995 numbers. For estimating the future year numbers an average growth percentage of approximately 30% is used for both population and employment. An average growth number of approximately 3% for each year for every municipality and city can also be derived from table 2.3 in chapter 2.

For the CBD of Cebu City, the port area and the North Reclamation Area the calculated base year and future attractions are more than the productions. Larger traffic flows can be expected towards these areas. The South Reclamation Area will also attract a lot of extra employers; the attraction of the South Reclamation Area is 60000 people a day (figure5.9). Because of this and the larger attractions in the centre of Cebu City more traffic will be generated towards these area, which makes the need of new infrastructure necessary. These conclusions can also be drawn when visiting the area and reading the several feasibility studies (chapter 3); however working with the population and employment numbers (and thus calculating and visualising attractions and productions) has provided more insight in the underlying causes of the current traffic problems.

6 TRIP DISTRIBUTION

6.1 Trip distribution base year

When the total number of trips between the traffic zones has been calculated and balanced they can be distributed over the zones. The trip distribution will make it possible to draw the first conclusions about large traffic movements and about impacts of future developments and projects. The in chapter 4 described gravity model will be used for distributing the trips.

$$\mathbf{T_{ij} = a_i\, b_j\, P_i\, A_j\, f(c_{ij})}$$

with:

a_i = balancing parameter (=0.4)
b_j = balancing parameter (=0.6)
P_i = number of trips departing at zone i (population related)
A_j = number of trips arriving at zone j (employment related)
$f(c_{ij})$ = accessibility of zone j from i ($f(c_{ij}) = e^{-0.03.(cij)}$)

With TransCAD it is possible to distribute the productions and attractions over the different zones. The results for the base year are shown in the next figure.

STUDY AREA **INFLUENCE AREA**

Gravity with F-Factors (Matrix 1)

	1	2	3	4	5	6	7	8	9	10	11	12	Sum
1	199	133	521	114	652	75	115	423	1830	615	1246	0	5923
2	578	415	1561	341	1982	221	340	1285	5560	1870	3688	0	17841
3	1158	801	3422	727	3920	477	734	2542	10998	3700	7976	0	36456
4	479	331	1377	357	1679	194	299	1160	4733	1592	3252	0	15455
5	465	326	1257	284	1827	177	273	1150	5081	1709	2968	0	15518
6	856	584	2463	530	2860	414	608	1855	8025	2699	6604	0	27500
7	595	406	1711	368	1987	274	484	1289	5574	1875	5061	0	19624
8	687	481	1857	447	2620	262	404	2252	8334	2803	4386	0	24534
9	3898	2732	10536	2395	15185	1488	2292	10934	0	17535	24890	0	91884
10	1765	1237	4770	1084	6875	674	1037	4950	23600	0	11269	0	57261
11	2465	1683	7094	1528	8236	1137	1932	5342	23108	7773	0	0	60297
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	13145	9130	36569	8177	47823	5394	8518	33182	96844	42172	71340	0	372293

STUDY AREA
INF. AREA

Figure 6.1 Trip distribution matrix with work-home trips for Metropolitan Cebu in the base year

The matrix contains the total number of work-home trips that are made every day between the traffic zones. A lot of information can be derived from the matrix. First of all a division of the matrix can be made in 4 parts, that represent the trips within the study area, the influence area and trips between study and influence area (in both directions). The numbers in the sum row and column are logically equal to the productions and attractions that already were calculated in chapter 5 (see also figure 5.5). The trip numbers can be added and visualized. The total number of trips between the Northern Impact Area (traffic zone with ID number 9) and the urban area of Cebu City (i.e. the study area represented by the ID numbers 1 to 8) can be obtained by adding the numbers in column 9 for the first 8 rows and the numbers in row 9 for the first 8 columns. A total number of almost 100 000 work-home trips (and vice versa) are made between the Northern Impact Area and Cebu City. The following figure can be obtained if the same calculation is done for the other impact areas. The numbers in row 12 and column 12 are logically equal to 0.

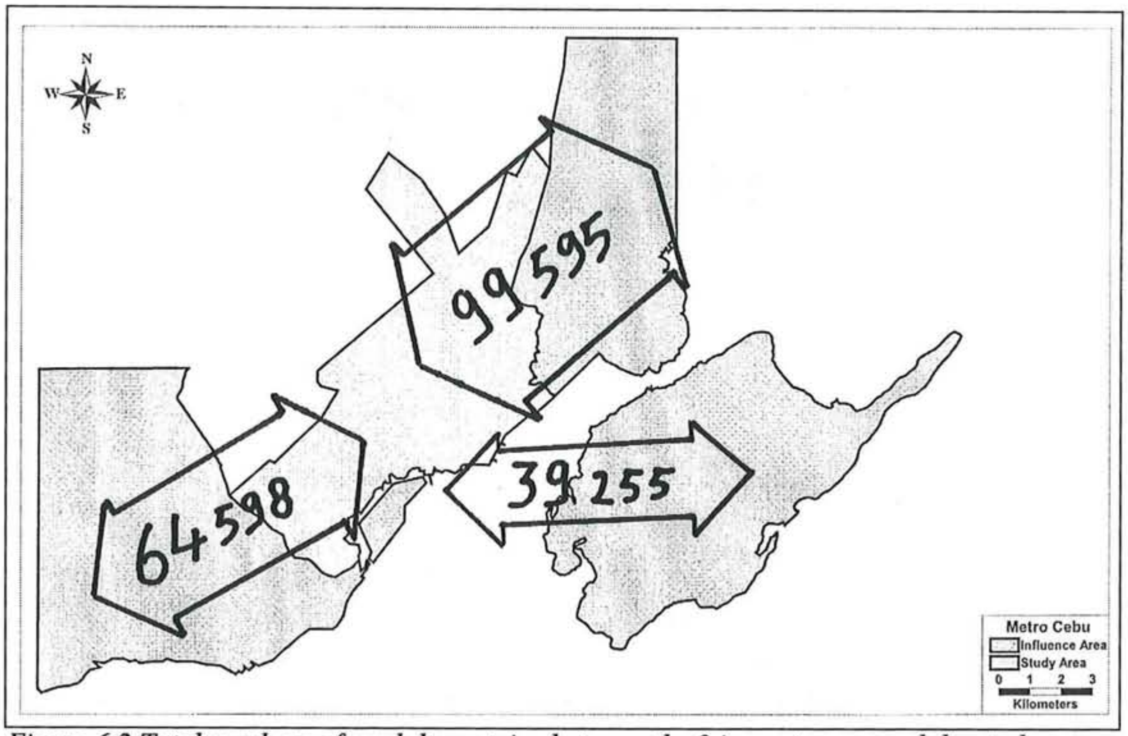


Figure 6.2 Total numbers of work-home trips between the 3 impact areas and the study area Cebu City for the base year

6.2 Trip distribution future

In this section the same calculation will be performed for the future year 2010 as for the base year. The trip distribution matrix is showing that the total number of trips increases to 487 228, which means an increase of 31% if compared with the value in the base year. The numbers of the trips in the study area stay relatively constant, this because of the assumption that all the extra employment in the study area and partly in Mandaue comes to the account of the South Reclamation Area (traffic zone with ID number 12). The South Reclamation Area will only house employment resulting in a production of 0 as can be seen in row 12. The new reclamation area has got an attraction number of 60 249, which is more than 50% of the total increase of the total number of trips!

STUDY AREA | INFLUENCE AREA

Gravity with F-Factors (Matrix 1)

		1	2	3	4	5	6	7	8	9	10	11	12	Sum
STUDY AREA	1	202	135	527	115	664	75	115	432	2134	834	1701	856	7791
	2	587	421	1583	346	2023	223	342	1316	6498	2539	5046	2538	23461
	3	1168	808	3444	733	3972	478	734	2584	12758	4985	10830	5447	47939
	4	486	336	1393	362	1711	196	301	1185	5521	2157	4441	2233	20324
	5	476	334	1285	291	1882	181	278	1188	5991	2341	4097	2061	20407
	6	855	584	2454	529	2869	411	602	1867	9217	3601	8879	4295	36162
	7	594	406	1705	368	1993	272	479	1297	6402	2502	6805	2984	25806
	8	709	498	1913	462	2719	269	413	2344	9900	3868	6099	3067	32262
INF. AREA	9	3306	2319	8919	2030	12942	1255	1926	9346	0	19873	28430	14299	104645
	10	1885	1323	5086	1158	7380	716	1098	5330	29005	0	16212	8154	77347
	11	2849	1946	8181	1764	9564	1306	2212	6222	30721	12004	0	14316	91086
	12	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sum	13116	9111	36491	8159	47719	5382	8499	33111	118147	54704	92541	60249	487228

Figure 6.3 Trip distribution matrix with work-home trips for Metropolitan Cebu in the future year

The trip numbers for the influence areas are 0 on the diagonal of the two matrices. This was done because of the fact that the traffic movements within the influence areas (and thus not between the influence areas) are not of concern for the traffic movements in the study area Cebu City. The trips to Cebu City can be visualized in the same way as in the previous section.

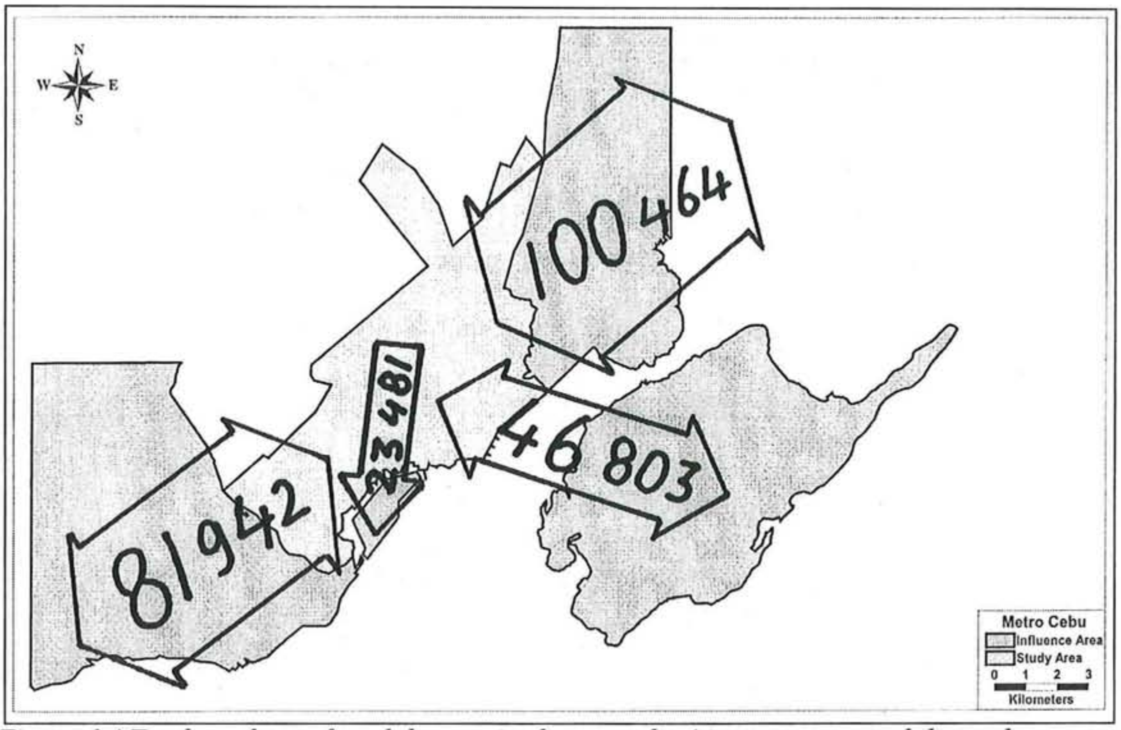


Figure 6.4 Total numbers of work-home trips between the 4 impact areas and the study area Cebu City for the future year

6.3 Analysis of the results

The three largest work-home traffic movements take place between the four cities Mandaue, Lapu Lapu, Talisay and Cebu. When considering the trips between Cebu City and the rest of Metropolitan Cebu one can see that the first place is taken by the Northern Impact Area followed by the Southern Impact Area and Lapu Lapu. These three flows can be held responsible for the traffic problems that Cebu City at the moment is suffering from. The future situation is showing that these flows will increase as of course is expected when looking at the population and employment forecasts. The total number of trips will increase from approximately 370 000 in the base year to 490 000 trips per day in the year 2010. This 30% increase is logically the same as the growth of the population and employment numbers, as estimated in the previous chapter.
The major part of the extra traffic will still have to make use of the existing network that already is very much congested, which is certainly the case for the 24 000 work-home trips from Cebu City to the South Reclamation Area.

The reliability of the output of the trip distribution can be checked very easily. In section 3.1.1 it was mentioned that Cebu City has a daytime population of approximately one million and a night-time population of approximately 700 000 (this is with regard to the actual situation of course). A flow of 300 000 travellers every day enters Cebu City. In section 5.2 it was also explained that 1/3 of all the trips that are made every day was between home and work.

This means that 100 000 (1/3 of 300 000) commuters every day travel to Cebu City for work. Figure 6.2 (the base year trip distribution) shows a total number of approximately 200 000 trips per day between Cebu City and the surrounding municipalities and cities (in both directions!). In one direction (only to Cebu City) the flow is approximately 100 000 which is exactly the same as the roughly calculated value on the basis of existing counts. This confirms the fact that the results of the model so far are correct and realistic.

When looking at the pictures one can easily see that there is no balanced situation. The northern Municipalities and Mandaue have a great deal in the total number of trips to Cebu City. The pictures that are made only show trips starting end ending in Cebu City. But of course there are also trips made every day between the 3 (or 4) impact areas. In the base year the total number of trips between the 'Talisay area' and the 'Mandaue area' are almost 50 000 trips. This great number of travellers every day makes use of the network in Cebu City. A new and better equilibrium can be reached if this through traffic is separated from traffic with an origin or destination in Cebu City. This can be achieved by providing new alternative routes. This is partly already being accomplished by the construction of the new coastal highway. However, it isn't until in the final step in the classic four-stage transport model (the traffic assignment step) that such issues regarding the road network can be discussed and that large traffic movements can be studied on their effects on an actual and future road network. The traffic assignment will be performed in the next chapter. The calculated work-home trip distribution matrices, represented in the figures 6.1 and 6.3, will be used as input for the traffic assignment after the necessary mathematical modifications on these matrices.

7 TRAFFIC ASSIGNMENT

7.1 Introduction

In this chapter the traffic assignment for Cebu City will be performed. The general requirements for completing a traffic assignment are mentioned in chapter 4. However, before performing the necessary traffic assignments the more specific requirements and inputs will be described first.

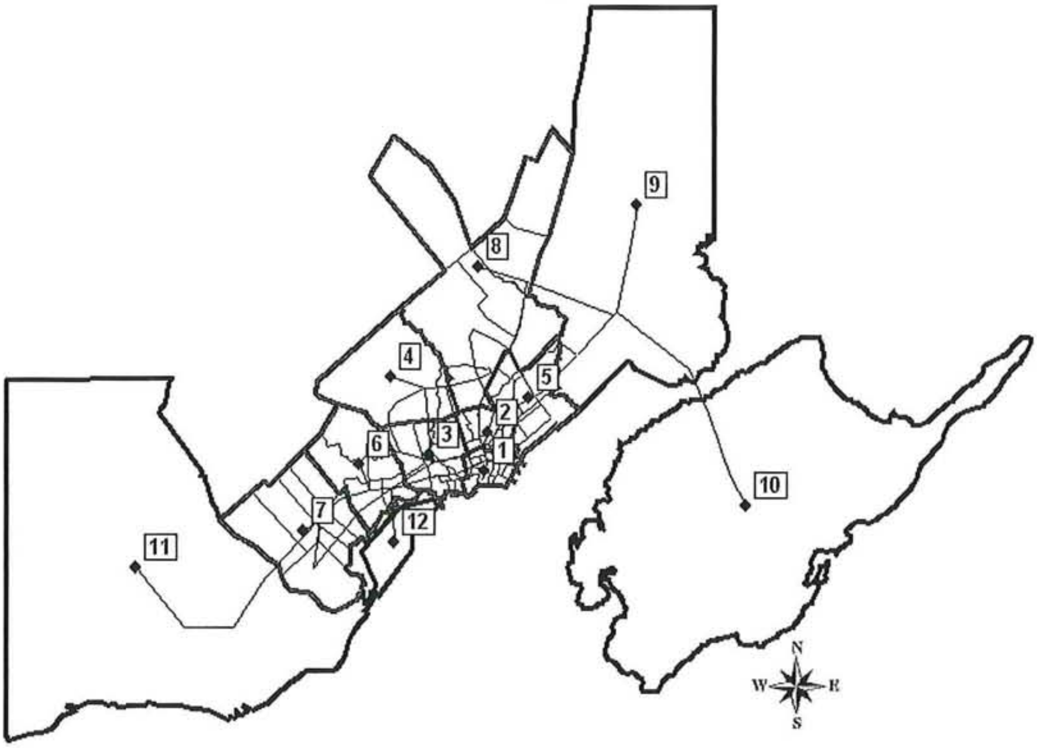


Figure 7.1 Road network with the centroids and connectors

As mentioned in chapter 4 all the demographic characteristics of a traffic zone will be concentrated in a centroid (i.e. centre of gravity of a zone). Subsequently TransCAD automatically draws the connectors as can be seen on the figure above. A connector is a fictious link representing the underlying network that is not included in the network model. These connectors are drawn from the centroid of the concerned traffic zone to the nearest endpoint of a link in the traffic zone. The network for which the traffic flows will be calculated contains only the major roads as they can be found on a good tourist map of Cebu. Mostly the roads in Cebu contain 4 or 6 lanes. The following standard geometric profile is derived from a study conducted for the Metro Cebu Development Project Phase 3.

CLASSIFICATION	RECOMMENDED DESIGN STANDARD
Status and Function	Urban Arterial Road
Average Daily Traffic (ADT)	20 000 > ADT
Design Speed (km/hr)	60
Carriage Width (m)	3.25 x 2
Minimum Stopping Sight Distance (m)	75
Minimum Passing Sight Distance (m)	250
Minimum Horizontal Curve Radius (m)	120

Table 7.1 Geometric standard design for a road

The different road links and the connectors can be given a number of characteristics. In this study the roads and the connectors are given a **speed, capacity and impedance**.

Impedance depends on the properties of the links, such as width, sight etc. The value of the impedance can be for example 1 or 2. It only indicates that a person takes twice the effort travelling a link with impedance 2, than it takes to travel a link with impedance 1. The traffic zones with ID numbers 1,2 and 3 (i.e. the central city) will be given an impedance of 2. This intuitive estimation is based on the previously described problems with regard to the traffic situation in chapter 3. The rest of the road links in the study area have been assigned an impedance of 1.

For the average speed on the roads and the connectors a value of 15 km/h is estimated. The roads in the outskirts of Cebu City have been assigned a speed of 30 km/h. These areas don't suffer as much from traffic problems as the central city resulting in a higher free flow travel speed.

A 2 lane road is designed to process an average daily traffic quantity of 20 000 vehicles. The average capacity of a 2 lane road will be estimated on 1000 vehicles per hour. For a 4 lane road the capacity is 2000 veh/h and for a 6 lane road the capacity is 4000 veh/h. It is important to keep in mind that in the real situation the capacity of the roads and an average speed are difficult to define because of the described situation in Cebu (see also chapter 3).

Before the traffic assignment can be performed it is required to calculate a matrix containing the daily trips between the traffic zones. This was already done in chapter 6. Subsequently it is necessary to multiply/divide this matrix with two factors. The OD-matrix must be divided by the average number of persons per vehicle and multiplied with the estimated percentage of the total flow that makes use of the network during rush hour.
Before the average number of persons per vehicle can be estimated it is necessary to know the modal split. A great deal of the people is using the PUJ as transportation mode. In 1992 the modal split for Cebu was estimated on 20% private and 80% public mode (light rail feasibility study). However the modal split is gradually decreasing since the eighties, which leads to the following estimation of the modal split of 30% private and 70% public mode. The average number of persons per vehicle in the private mode is 3.2. Fully loaded a Jeepney may carry approximately 16 people (this information was derived from a master plan study on Visayas and Mindanao Islands Strategic road network development project [11]). Table 7.2 represents these average numbers of passengers for the islands in the Central Visayas Region. The numbers in the fourth column must not be included; after all there are no buses in Metropolitan Cebu. The total average number of persons per vehicle can now be calculated: $0.7 * 15.7 + 0.3 * 3.2 = 12$ persons/vehicle. However, this number contains also travellers with other trip purposes than work-home trips. In chapter 5 it was mentioned that of all the trips 35% is based on work-home trips (and vice versa). For obtaining the number of persons in each vehicle with a work-home trip purpose the number of 12 needs to be multiplied with the factor 0.35, which results in average value of $12*0.35 =$ **4.2** persons for each vehicle in Metropolitan Cebu.

Island	Car [-]	Jeepney [-]	Bus [-]	Average [-]
Panay	4.7	13.4	35.7	11.7
Negros	2.9	16.5	38.6	10.5
Cebu	2.9	17.8	44.3	8.4
Samar/Leyte/Biliran	3.2	14.9	32.3	12.4
Mindanao	3.4	16.0	45.9	11.9
Average	**3.2**	**15.7**	40.8	10.3

Table 7.2 The average number of passengers (persons/vehicle) for the islands in the Central Visayas Region

Now the occupation rate for the vehicles is known only the proportion of the trips that uses the network during rush hour needs to be estimated. Trips are often classified into peak and off-peak period trips; the proportion of journeys by different purposes usually varies greatly with time of day. Common accepted values for the factor representing the peak hour proportion vary from 15% to 20%. For Metropolitan Cebu the assumptions will be made that 15 % of the total number of trips uses the network during rush hour.

The two work-home trip distribution matrices represented in the previous chapter can now be divided by 4.2 and subsequently multiplied by the factor 0.15. The new obtained matrices contain the number of vehicle trips between the 12 traffic zones during the peak hour. Now these vehicles can be assigned to the road links for both a present and a future road network. The traffic flows in vehicles per hour will be calculated according the user equilibrium assignment (see also chapter 4) on the basis of a link performance function. A link performance function is a mathematical description of the relationship between travel time and link volume. The BPR (Bureau of Public Roads) formulation is one of the most-commonly-used link performance functions. The BPR function relates link travel times as a function of the volume/capacity ratio according to:

$$\mathbf{t = t_f\,[1 + a^*(q/C)^b]}$$

where:

t	= the congested link travel time
$\mathbf{t_f}$	= the link free-flow travel time (travel time for a link intensity of 0)
q	= the link intensity
C	= the link capacity
a,b	= parameters

Common values for parameters a and b are 0.15 and 4.0, respectively.

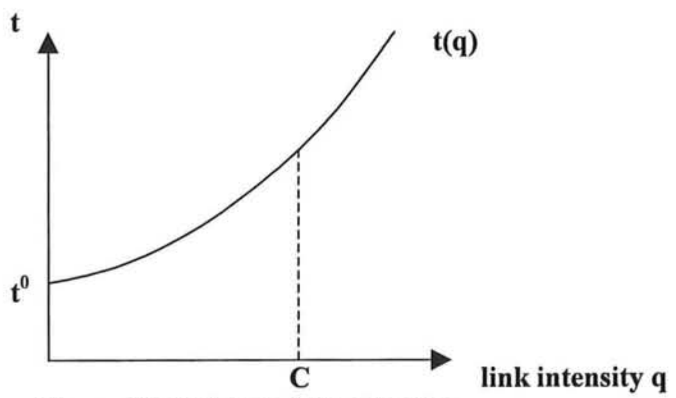


Figure 7.2 Link travel time function

This link performance function is also used by the traffic assignment models in TransCAD.

Now the required attributes are defined the traffic assignment can be performed in the following section. This will happen on the basis of three scenarios that describe:

- the existing situation (i.e. the base year traffic assignment or scenario 1)
- the future situation if no changes with regard to the road network are implemented (i.e. the zero alternative traffic assignment or scenario 2)
- the future situation with changes in the road network included (i.e. the future year traffic assignment or scenario 3).

7.2 Traffic assignment

7.2.1 Traffic assignment base year (scenario 1)

The base year traffic flows have been calculated and visualized in the following map. The thickness of the road links is proportional with the traffic flows that can be found on them. The matching traffic flows in both directions in numbers for every road link can be found on appendix 9. In table 7.3 the average free-flow travel time (travel time when the intensity is equal to 0) and congested travel times have been presented for the entire network. For convenience from now on the term congested travel time will be used for indicating the real travel time, which doesn't necessarily have to be a congested one. The average congested travel times for a major route, such as the travel time along Cebu Highway from the Talisay area to the North Reclamation Area (i.e. between the traffic zones with ID numbers 5 and 7) also have been visualized (table 7.4).

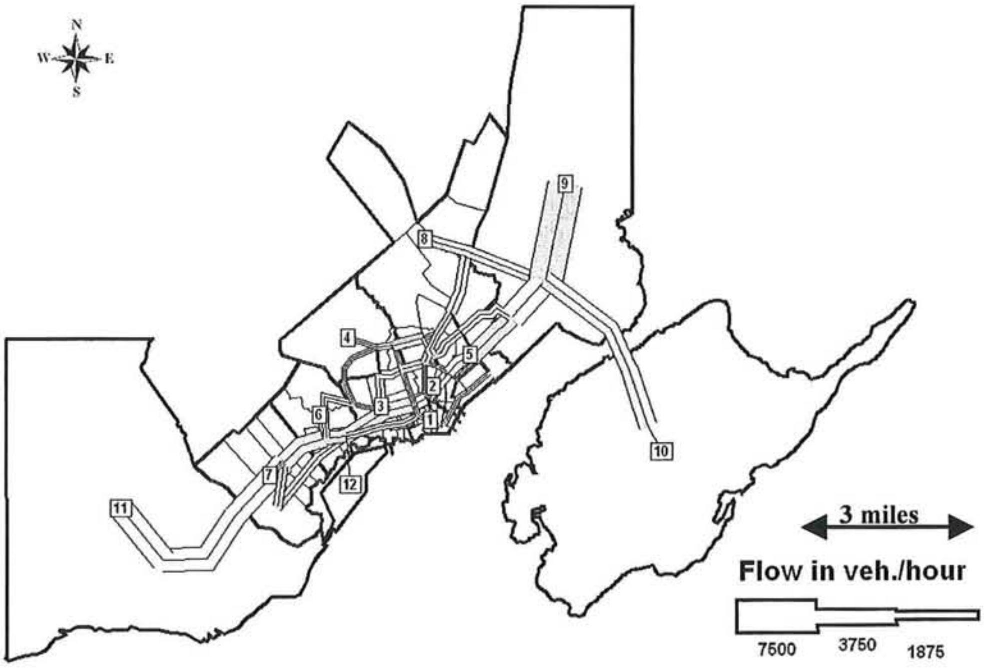


Figure 7.3 Traffic assignment for the base year (2000)

figures for every user over entire network	scenario 1
average free-flow travel time [min.]	55
average congested travel time [min.]	110
average travel distance [km]	12

Table 7.3 Travel times and distance for the base year traffic assignment

average congested travel times between mentioned traffic zones for every user		scenario 1
traffic zone A	traffic zone B	[min.]
8	7	124
5	7	97
8	1	61

Table 7.4 Travel times for the base year traffic assignment

7.2.2 Traffic assignment zero alternative (scenario 2)

In this section a traffic assignment will be presented for the future year 2010 (i.e. the situation with a new extrapolated population and employment number) but performed on the actual network, the so-called zero alternative. The actual network is the network for which no changes at all are implemented. In this way effects (and thus benefits) of planned infrastructure can be studied. The traffic flows in numbers for this scenario are given in appendix 12.

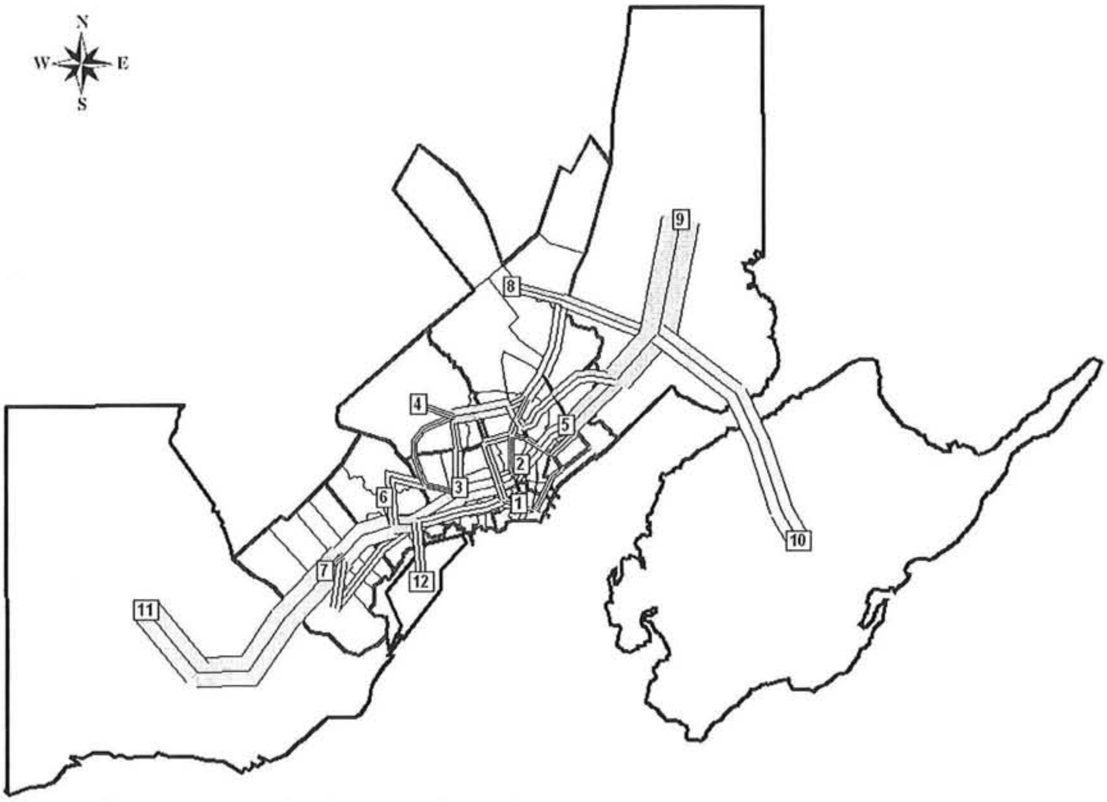


Figure 7.4 Traffic assignment for the zero alternative

figures for every user over entire network	scenario 2
average free-flow travel time [min.]	56
average congested travel time [min.]	328
average travel distance [km]	12.3

Table 7.5 Travel times and distance for the zero alternative traffic assignment

average congested travel times between mentioned traffic zones for every user		scenario 2
traffic zone A	traffic zone B	[min.]
8	7	238
5	7	194
8	1	78

Table 7.6 Travel times for the zero alternative traffic assignment

7.2.3 Traffic assignment future (scenario 3)

The third scenario is with regard to the future situation with both demographic changes and changes implemented at the road network. The coastal highway starts in the city of Talisay (traffic zone with ID number 11) and ends in the heart of Cebu City (traffic zone with ID number 1). Other changes implemented at the road network such as road widenings and extra links are left out of consideration because it is assumed that the coastal highway is the most radical project and that no other changes will be implemented.

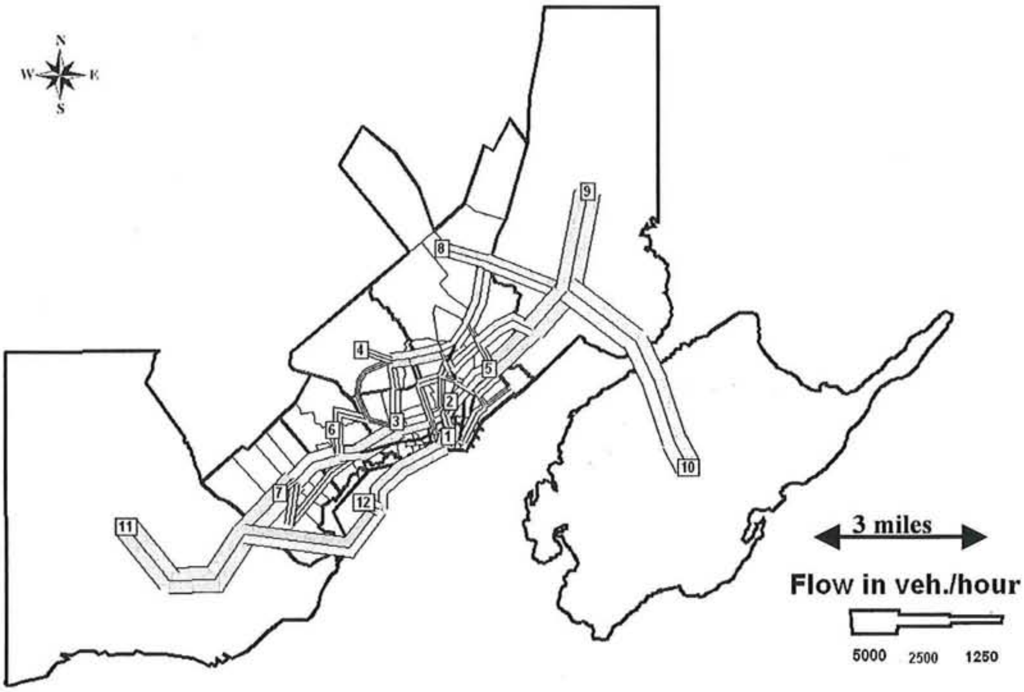


Figure 7.5 Traffic assignment for the future year (2010)

figures for every user over entire network	scenario 3
average free-flow travel time [min.]	49
average congested travel time [min.]	150
average travel distance [km.]	12.5

Table 7.7 Travel times and distance for the future year traffic assignment

average congested travel times between mentioned traffic zones for every user		scenario 3
traffic zone A	**traffic zone B**	**[min.]**
8	7	135
5	7	92
8	1	82

Table 7.8 Travel times for the zero alternative traffic assignment

7.3 Analysis of the results

7.3.1 Introduction

Before a proposed land use and transportation strategy can be formulated it is necessary to know the existing and planned situation in Metropolitan Cebu. The traffic assignments that have been performed in this chapter on the basis of the three scenarios provide this information.
The numerical results of these three traffic assignments have been listed in the appendices 7 to 15. In this section these results will be compared and conclusions will be drawn with regard to the effects of the MCDP 3 projects and the future traffic situation in Metropolitan Cebu, so that in chapter 8 a rational formulation can be given for among others a proposed land use and transportation strategy.

The visualized results of the traffic assignment for the base year show that the largest traffic flows can be found on Cebu Highway. On the basis of the in chapters 2 and 3 described situation in Metropolitan Cebu and on the basis of the trip distribution results of chapter 6 the conclusion can be drawn that the largest traffic movements can be found between the surrounding areas and the study area Cebu City. So Cebu Highway is mainly used by commuters coming from or going to the periphery. In what way the South Coastal Highway will contribute for diverting this north-south traffic flow from the city centre will come to order on the basis of the calculated characteristics such as travel time and travel distance. However, when only considering the visualized results in this chapter the following conclusions already can be drawn:

- Cebu Highway has to process very high traffic flows for both present and future situation.
- Roads at the North Reclamation Area (traffic zone with ID number 5) do not process large traffic flows and may in this respect provide expansion opportunities for the future.
- The South Reclamation Area will attract a lot of extra traffic.
- The South Coastal Highway will be of a great benefit but mainly for traffic coming from the south and going to the north (thus along Cebu Highway).
- High traffic flows can be found at the entrance of Cebu Highway (traffic zone with ID number 1).

7.3.2 Comparison of the three scenarios

The in section 7.2 calculated characteristics can be used for the comparison of the three scenarios and thus for getting insight in the exact effects of among others the MCDP 3 projects.
The average free-flow travel time over the entire network can be calculated and can provide information with regard to the correctness of the obtained results. After all, the free-flow travel time for both the base year and zero alternative traffic assignment (i.e. a future traffic assignment but performed on the actual road network) should be the same.

The average travel times are calculated over the entire network in Metropolitan Cebu; in other words also the connectors and some road links on the impact areas are included (these links represent the total underlying network in the impact areas). The average travel times over the network in the study area Cebu City are logically lower. However if obtained consistently then there is no worth mentioning disadvantage of using the travel times for a comparison purpose.

The calculated congested travel times on each road link have been translated into congested travel times between the 12 traffic zones and visualized for each traffic assignment in a matrix; they can be found on the appendices 7,10 and 13. In table 7.9 the average values of the entire network in Metropolitan Cebu are presented. The travel times for the most important routes in the study area Cebu City are compared for the three scenarios in table 7.10.

figures for every user over entire network	scenario 1 (base year)	scenario 2 (zero alternative)	scenario 3 (future year)
Average free-flow travel time [min.]	55	56	49
Average congested travel time [min.]	110	328	150
Average travel distance [km]	12.1	12.3	12.5

Table 7.9 Overview travel times and distance over the entire network in Metropolitan Cebu compared for the three scenarios

average congested travel times between mentioned traffic zones for every user		scenario 1 (base year)	scenario 2 (zero alternative)	scenario 3 (future year)
traffic zone A	**traffic zone B**	**[min.]**	**[min.]**	**[min.]**
8	7	124	238	135
5	7	97	194	92
8	1	61	78	82
3	2	34	53	49
6	2	74	174	79

Table 7.10 Overview travel times along the most important routes in Cebu City compared for the three scenarios

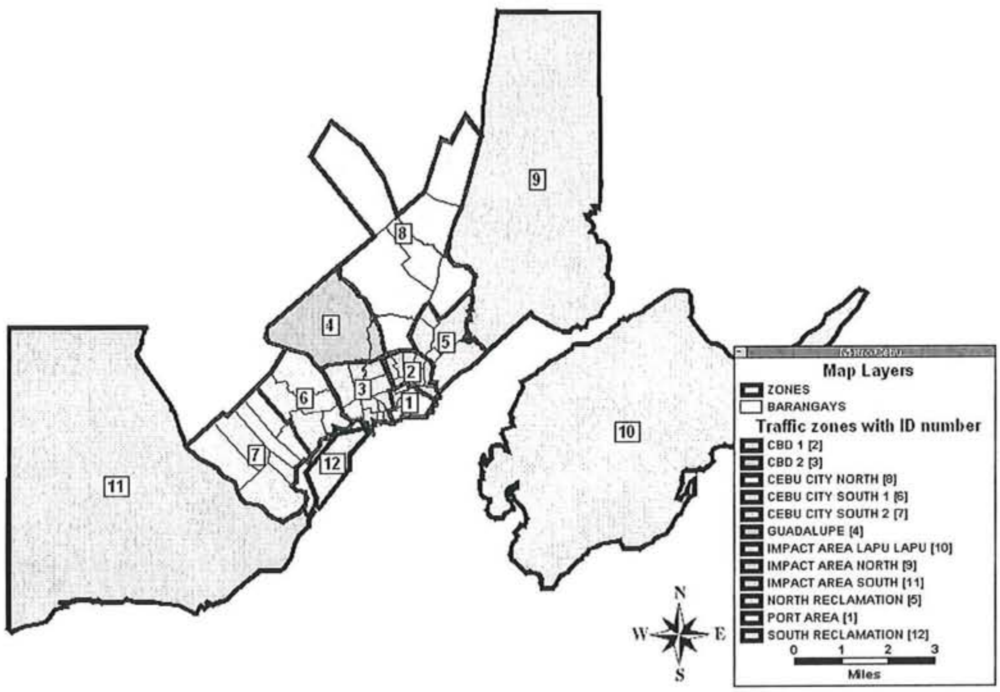


Figure 7.6 Zoning map of Metropolitan Cebu

7.3.3 Conclusions

The average free-flow travel times for scenario 1 and scenario 2 are approximately the same (i.e. 55 min.), which produces evidence for the fact that the traffic assignment calculations are performed correctly and consistently. It is important to keep in mind that the obtained results are with regard to the peak hour. For the base year the average congested travel time is twice as large as the free-flow travel time, which indicates that it takes twice the effort for a commuter to travel in the peak hour if compared for the situation that no other commuters are making use of the road network.

Table 7.9 shows that the calculated average congested travel time over the entire network increases from 110 minutes for the base year traffic assignment to 150 minutes for the future year traffic assignment, which indicates a deterioration of the existing situation in Metropolitan Cebu. The same conclusion can also be drawn for the study area Cebu City when studying the results in table 7.10. The major part of the calculated travel times on the major routes shows an increase. The construction of the South Coastal Highway will only contribute to a worth mentioning decrease of the average travel time on the major route along Cebu Highway (i.e. the north-south corridor) between traffic zone 5 and 7. However on the most routes especially in east-west direction a great increase of the travel times can be noticed.

The following conclusions can be drawn:

- *The base year traffic assignment confirms the described situation in chapter 3. Cebu Highway has to process large traffic flows that mainly originate in the surrounding municipalities and cities.*

- *The construction of the South Reclamation Area with 100 000 employees and the rapid urban growth will cause a great increase in the travel times if no changes are implemented on the road network in Cebu City (scenario 2).*

- *The South Coastal Highway will on some parts contribute to a relief of the heavy congested highway through the centre of Cebu City, but on the most routes in Cebu City especially in east-west direction the travel times will increase if compared with the base year situation. This will result in a further decrease of the accessibility of the CBD area in Cebu City (scenario 3).*

In this chapter the final stage in the classic four-stage transportation model has been completed for both a base year and future year situation as it is planned according the MCDP 3 projects. The several steps in the classic four-stage transportation model should be repeated until a situation is obtained that satisfies the goals and objectives mentioned in the first chapter or lower travel times on the major routes if formulated in modelling terms. After formulating a proposed land use and transportation strategy in the next chapter the same characteristics will be calculated for these planning strategies and compared with the obtained results in table 7.9 and table 7.10.

8 PROPOSED LAND USE AND TRANSPORTATION STRATEGY

8.1 Introduction

In this chapter a proposed land use and transportation strategy will be formulated. In the previous chapters the existing and the planned future situation have been described; the current land use and transportation characteristics were described separately in the chapters 2 and 3. In the next step they were translated into the designed transportation model and worked out with TransCAD on the basis of three scenarios. The same approach will be applied with regard to the proposed land use and transportation planning. First the planning objectives and constraints will be described more specifically. Subsequently a proposed land use planning will be formulated. In section 8.5 a proposed transportation strategy will be described; a distinction will be made between traffic management and infrastructure measurements. Once the best strategy has been formulated the next step will be the translation of this proposal into the transportation model so that it can be worked out in TransCAD and evaluated on the effects. The translation of the suggested approach into the transportation model will be done in the next chapter.

Although they are described separately it is important to keep in mind that these two planning variables influence each other besides their influence on the travel demand (see also chapter 1) and should therefore not be treated as independent variables. The results of the trip distribution in chapter 6 and the traffic assignments in chapter 7 have shown that the planning of new locations for dwelling and commercial areas influence the pattern of trips and thus also the performance of the transportation system. In this respect it can be concluded that spatial planning often requires new infrastructure. On the other hand, new infrastructure may generate new spatial development in some areas and may even result in extra generated traffic for which the infrastructure measurement wasn't designed in the first place. An improved accessibility of the central city in Metropolitan Cebu (see also section 8.2 for the planning objectives) only can be obtained if land use and transportation planning is not considered as a mono-sectoral activity that studies the effects of a certain infrastructure measurement seperately from the spatial developments.

8.2 Planning objectives

Some fundamental goals for any land use and transportation strategy formulated for a city or metropolitan are as follows:

- Promotion of maximum feasible economic growth
- Promotion of social development
- Provision of a more equitable distribution of income and wealth
- Maximum labour force utilization
- Preservation of environmental stability
- National integration

These fundamental goals were also formulated in the *Metro Cebu Land Use and Transportation Study* [1], which was a comprehensive transportation study. However, more specific guidelines are required for the formulation of an efficient land use and transportation strategy. So it is necessary to translate these fundamental goals into more operational objectives. If translated into more operational objectives then the following list that also has been presented in the first chapter can be obtained.

The proposed land use and transportation strategy should satisfy the following goals and objectives:

- developping a systematic classification of the major road network in Metropolitan Cebu
- formulating additional suitable transportation strategies with regard to traffic management
- and formulating rational land use strategies that focus on the creation of new opportunities for dwelling and commercial areas and at the same time on solving traffic related problems. Eventually the goal is to improve the road network so it can be utilized more efficiently and to improve the accessibility of the CBD area of Metropolitan Cebu.

8.3 Planning constraints

The planning constraints for Metropolitan Cebu are dominated by the natural constraints. Metropolitan Cebu is on the one hand bounded by the mountain area that is not suitable for any kind of urban development and on the other hand by the sea that in spite of possibilities of reclamating new land should be considered as a final way out because of the high financial costs that involve with such projects. However these natural borders can be considered as a practical guide that can be used in the preparation of strategies regarding urban expansion.
Other natural constraints refer to the negative impacts on the environment of proposed land use and transportation strategies; these should be minimized as much as possible. Creating new opportunities for employment in a congestion sensitive area will probably only cause more congestion and thus negative impacts on the environment such as air pollution and noise. At the moment air pollution is a serious problem in Cebu City and it is the cause of much complaining. Cebu City has little heavy industry, thus air pollution from industry is not a real problem. The greater source of air pollution comes from the combination of vehicular traffic and roads. The already described congestion problems in the centre of the city together with the poor condition of the roads contribute a great deal in the decrease of the air quality in Cebu City. The great majority of the roads in and around the city are dirt or gravel, which spew clouds of dust from moving vehicles. An estimate made in the City's Geographic Information System Office in 1993 showed that only 52 of the city's 627 kilometres of roads were paved with concrete or asphalt.

The social and political planning constraints are more complicated and sometimes contradictorily. On the one hand there is a tendency to promote the strong economic position of Cebu City and on the other hand there are policies to integrate more the smaller municipalities and cities such as the City of Talisay in which lately many investments are made to promote its economic position. It was concluded that the large traffic movements in Cebu City mainly originate in the surrounding municipalities and cities.
From the point of view of preventing heavy traffic congestion preference should be given to policies that promote an integral approach in which the smaller municipalities and cities can be given the same opportunities for urban growth as Cebu City.

The economical planning constraints will in this study not be completely determinative for the formulation of the proposed land use and transportation strategy. Although the financial aspect does not play an important role of significance very complicated and expensive projects should be avoided as much as possible when formulating new strategies. Land reclamations are very expensive projects and they are mostly financed by the commitment of high lones. Besides there are great risks involved with these projects. Unexpected problems in the realization phase can lead to high financial costs and in the worst-case scenario to an early end of the project. The South Reclamation Area for example has suffered from many problems that have resulted in a not completely filled up reclamation area. A great part of the reclamation area, generally known as Pond A still needs to be filled up.

The most important planning constraints are summarized in the following list:

- The proposed traffic and urban strategies should minimize any negative impacts on the environment
- Valuable areas such as forestry zones, reservations and water catchments should be preserved
- The proposed land use and transportation strategy should make full use of any existing infrastructure facilities.
- The surrounding municipalities and cities should be made more integral to Cebu City
- The designed transportation network should be flexible with regard to future growth

When formulating a land use and transportation strategy the whole Metropolitan area should be considered. Urban development is not possible on the westerns parts of Metropolitan Cebu where the physical attributes such as soil type and slope are not suitable. The 30% slope is generally considered as not suitable for urban development. Besides these areas consist of valuable forestry zones and reservations. These limits for urban growth are among others visualized on the following two maps of Metropolitan Cebu. Figure 8.1 is also showing that urban growth is inclined to take place along existing infrastructure facilities, in this case Cebu Highway.

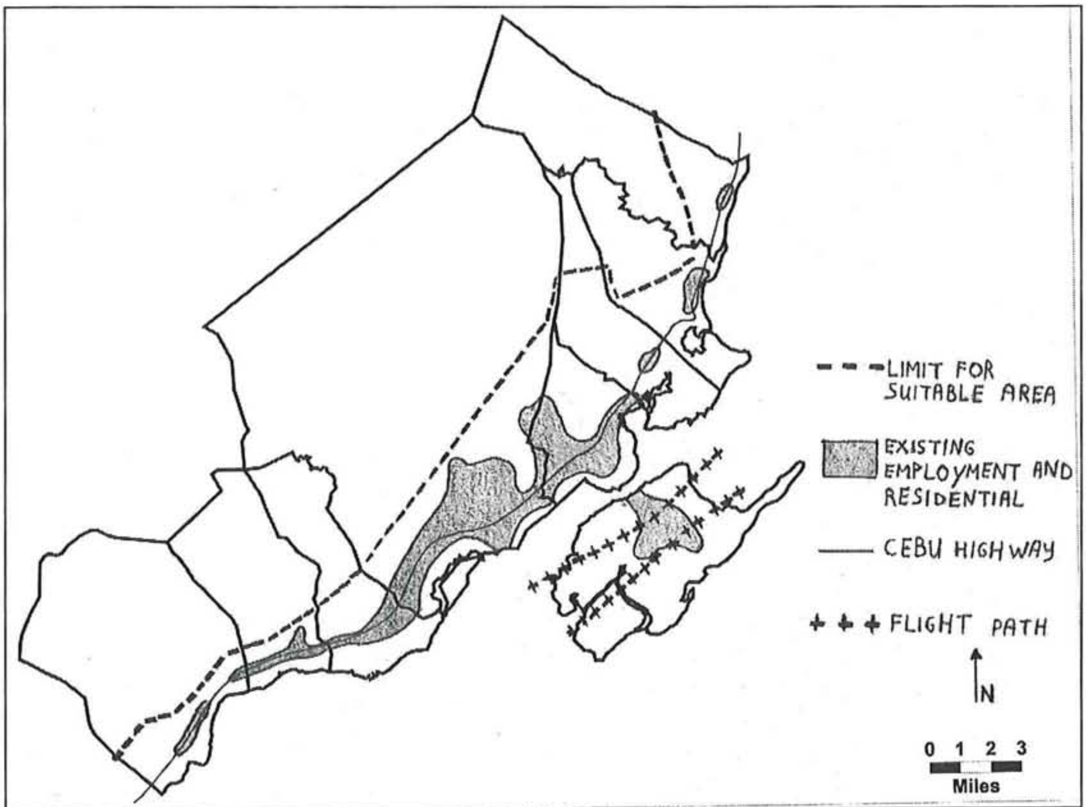


Figure 8.1 Existing distribution of employment and population in Metropolitan Cebu

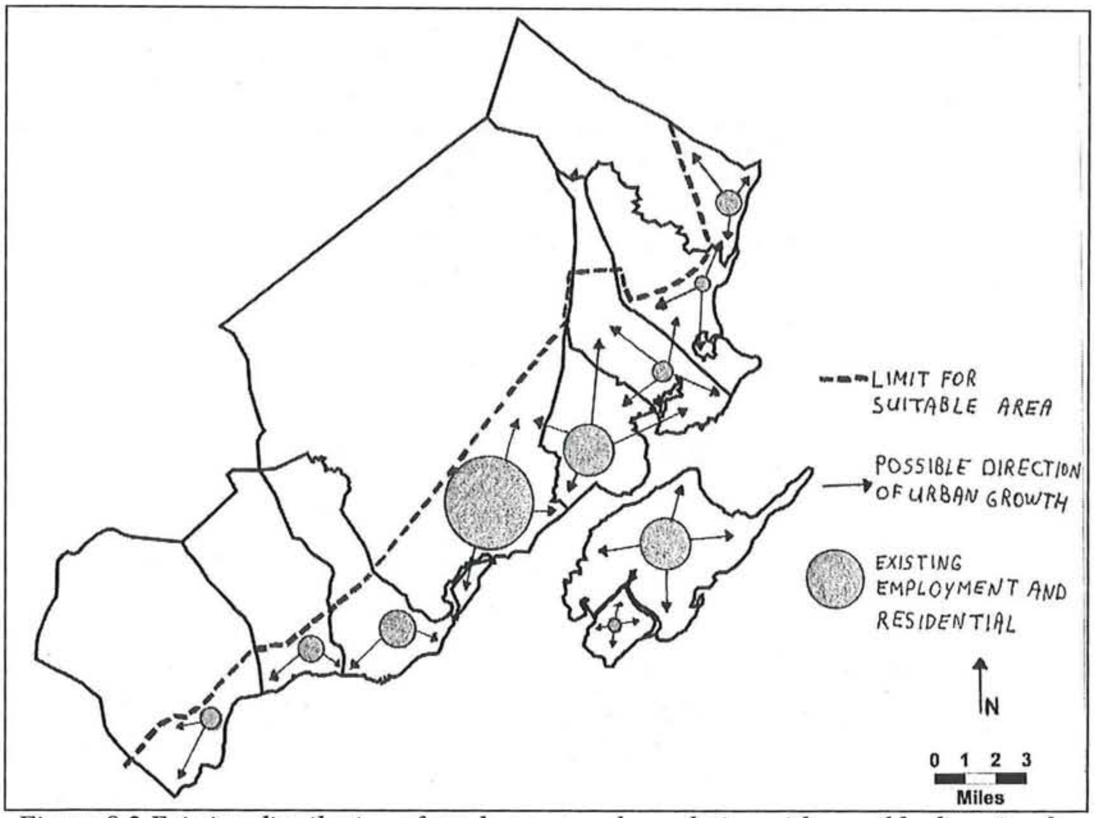
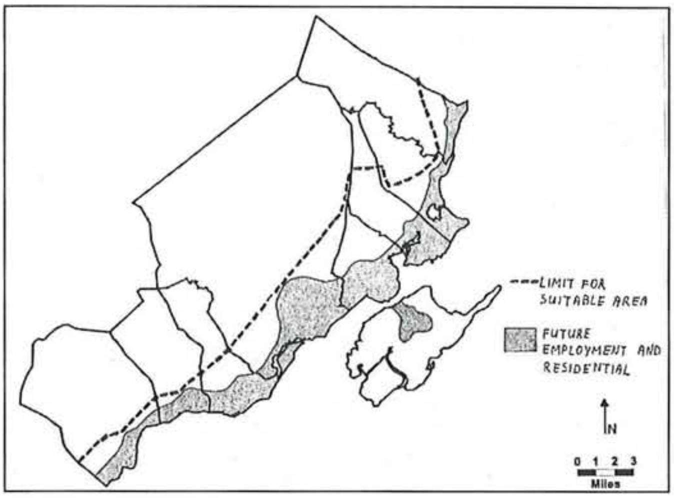


Figure 8.2 Existing distribution of employment and population with possible direction for urban growth in Metropolitan Cebu

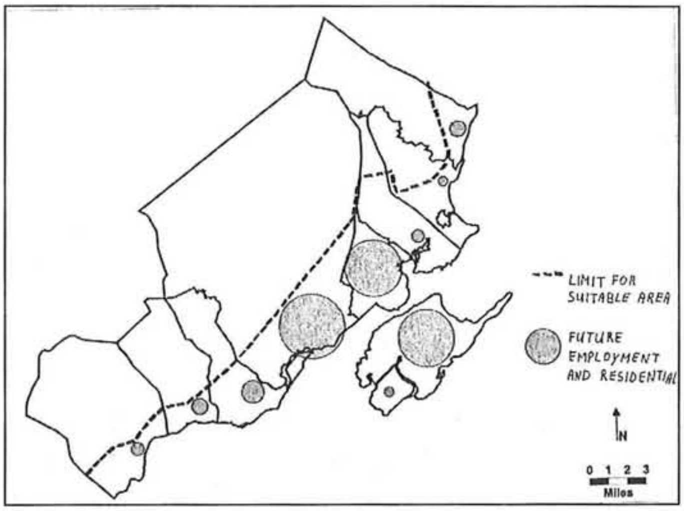
8.4 Proposed land use strategy

<u>8.4.1 Possible land use strategies for Metropolitan Cebu</u>

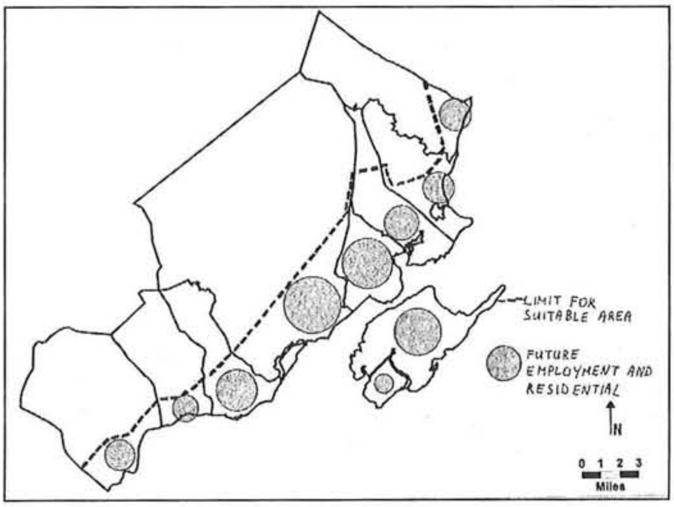
The best opportunities for urban growth can be found in Mandaue, the northern municipalities and Mactan Island (see also the figures 8.1 and 8.2 in section 8.3). Several ways can be pointed out for which these opportunities can be utilized. The best strategy is the one that provides the best possibilities for urban growth and at the same time can contribute to the decongestion of Cebu City. In the following figure three possible strategies for urban growth have been visualized. The best strategy will be worked out more specifically for Cebu City in the next section.



Strategy 1 *A possible option for dealing with the rapid urban growth is the development of a long coastal strip with new locations for mainly employment. The physical attributes such as soil type and slope make the coastal plain in Metropolitan Cebu very suitable for urban development. Besides in this way all the smaller municipalities and cities are included in the same way as Cebu City.*



Strategy 2 *A counter part of the first strategy is the development of only a few strategic locations (Cebu City, Mandaue and Mactan Island) with keeping open the possibility of developing the smaller municipalities and cities in the far future. The already existing facilities in Mandaue and Mactan Island and the neighborhood of Cebu City make these two cities the best locations for new employment and residential in Metropolitan Cebu.*



Strategy 3 *A middle course of strategy 1 and 2 is developing all the municipalities and cities independently. This strategy describes a shift of the economic center of gravity to all the surrounding municipalities and cities and is thus aiming for a same economic position for these areas.*

Figure 8.3 Possible land use strategies for Metropolitan Cebu in the future

Although all the described land use strategies provide new opportunities for urban growth several differences can be pointed out with regard to the influence on the traffic movements in Metropolitan Cebu. For example the development of a long urban strip in the coastal plain (strategy 1) requires a different approach concerning public transport if compared with strategy 2 and 3. The first strategy requires a public transportation system that has many stops. One of the described problems in the previous section and in chapter 3 is that the PUJ's are already hindering the through traffic because PUJ drivers are sometimes forced to stop at many places for picking up/dropping passengers. From the point of view of preventing traffic congestion in Metropolitan Cebu strategy 2 and 3 are preferable to the first one.

Commercial and industrial activities are inclined to locate near already existing activities and facilities. In the case of Metropolitan Cebu it can be concluded that Cebu City complies very well with these requirements for new locations. Strategy 2 describes among others a fully development of Cebu City, which is in practice already being accomplished by the realization of the South Reclamation Area. However from the traffic point of view it can be concluded from the trip distribution and traffic assignment in the previous chapters that urban development on a few strategic locations such as the South Reclamation Area will attract a lot of traffic from the surrounding municipalities and cities. For preventing traffic related problems and at the same meeting with the need for new area for urban development a middle course is recommended between an approach that describes a fully development of Cebu City and one that only includes the northern municipalities and cities in Metropolitan Cebu. In this respect strategy 3 seems the best possible option.

Also with regard to the previously formulated planning constraints strategy 3 seems to the best possible strategy. Strategy 3 complies the best with the planning constraint of including the surrounding cities and municipalities more integraly to Cebu City. This strategy also minimizes the negative impacts on the environment because this strategy describes a development of all the surrounding areas and doesn't focus on a few already from congestion suffering locations resulting in a minimum impact on the environment.

In the following section strategy 3 will be worked out more precisely, especially on the consequences for the study area Cebu City.

8.4.2 Proposed land use strategy for the study area Cebu City

The North Reclamation Area (NRA) was constructed in order to house new employment. This objective was unfortunately not completely achieved, because in practice this well located area is only used by private owners to make money. The local government doesn't own the reclamation area and speculators are offering the plots for sale. Therefore the approach for the South Reclamation Area (SRA) was a different one. This time the local government owns the area and is offering the plots to investors to rent it. Like the North Reclamation Area the South Reclamation Area is well located near the CBD and the port area and thus perfectly suitable for employment.

However because of the recent economic crisis it is not likely that within a period of several years the SRA is fully developed to an area that houses at least 100 000 employers. This gives time for reconsidering other alternatives for the SRA's destiny if the SRA doesn't turn out to be used by new investors. An option may be the development of the NRA into a 'successful' business area with reconsidering the change of the SRA into a place that is also suitable for living. A question that may rise is: what makes the NRA more suitable for employment than the SRA? Several reasons can be given that support the idea of redeveloping the NRA.

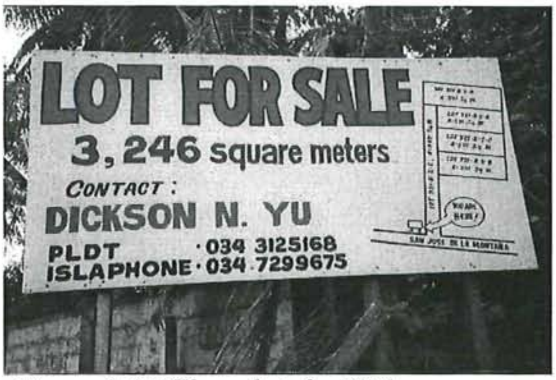


Figure 8.4 Billboard at the NRA

Figure 8.5 Unused space at the NRA

The results of the trip distribution show that the largest traffic flows come from Mandaue and the northern Municipalities in Metropolitan Cebu. Cebu Cities CBD and port area attract a lot of workers every day. Developing a new economic zone near Mandaue prevents new traffic flows going through the heart of Cebu City every day, as will be the case for the SRA. Besides, the NRA has already got an extensive road network that only needs to be maintained and repaired at some places. During the years maintenance of the road network wasn't the issue because of the fact that the local government did not own the NRA. This has resulted in a very bad condition of the roads here.
Using the NRA doesn't require tremendous investments for new infrastructure facilities. For the SRA it was necessary to build a new coastal highway that consists of a few bridges and a tunnel!

Figure 8.6 An unmaintained road at the NRA with some large companies at the background

Figure 8.7 An intersection at the NRA with some illegal settlements

However, the NRA has played an important role of significance in the economic developments in Metropolitan Cebu. Some large companies has already settled down here and succeeded in giving Cebu City a great economic impulse. A few 'mega stores' can be found here, like SM and the MACRO (since 2001), that provide a large scale of services varying from travel agencies and stores for office equipment to restaurants and cinemas. The presence of these facilities will make it for new investors attractive to locate here. In general terms one of the most important factors that influence the choice for a new place to locate is the presence of other companies and existing infrastructure facilities.

Both a PUJ and a bus terminal can be found at the NRA. In other words this area is also very well accessible with public transport. Location of these terminals here were part of the several MCDP projects.

The construction of the SRA was a very complicated project to realize because of the varying interests that were involved. The reclamated area could not be attached to the mainland of Cebu City on account of the fishermen that are making a living of the sea and thus always needs access to the sea. Besides, ecological factors are also playing a great role of importance. In this part of Cebu City a few rivers discharge into the sea. An ecological circle, that under all circumstances always needs to be maintained, had to be taken into account by the construction of the SRA.
All these complicated factors don't apply for the NRA, which makes the NRA a very attractive area with regard to long term planning. Although the presence of the port the NRA provides possibilities for expansion that are easier to realize than for the SRA. A successful policy with regard to developing new economic zones can be continued more easily, which makes the NRA more suitable for new employment than the SRA.

The advantages of developing the NRA into a business area can be summarized as follows:

- Neighbourhood of companies that already have settled down in this area
- Perfectly located near the port area and the Central Business District of Cebu City and Mandaue City.
- Strategic location near Mandaue City prevents large traffic flows through the centre of Cebu City
- Use of existing infrastructure facilities
- Great accessibility with public transport

8.5 Proposed transportation strategy

8.5.1 Proposed traffic management

The proposed traffic management strategy comprises of measurements regarding public transport policies that is measurements regarding the PUJ's. The PUJ's have a great deal in the causes of congestion. As a matter of fact they are the main cause of all the traffic problems Metropolitan Cebu is suffering from. Implementing new measurements of traffic management for Jeepneys can solve problems. However in practice new rules or measurements often result in heavy resistance from the PUJ drivers, who are well organized in interest groups. Introducing new traffic management in Cebu may be considered as extremely complicated but challenging activity.

It is not the main scope of this study to formulate new policies regarding the PUJ's because of the social and political complexity of implementing these policies in Cebu. Besides these measurements are difficult to work out in the model that was made in TransCAD because of lack of specific information about the number of Jeepney's, Jeepney stops etc. Still a suggested approach will be described very shortly, so that in the next chapter these measurements can be taken into account by changing the average speed that was assigned to the road links in the study area.

The competition between the many PUJ's is forcing the drivers to pick up passengers as much as possible and thus to stop everywhere to pick up travellers. At some places CITOM officers are put in to stop the PUJ's of picking up passengers at these forbidden places. This in combination with a very large number and variety of Jeepney's has lead to a waiting time for passengers that is less than a minute! By reducing the total number of Jeepney's it is assumed that this waiting time can be changed for example to two minutes without the expectation of protests among the users. Other measurements that also can contribute to an increase of the average speed that was assigned to the road links are as follows:

- The re-construction of existing PUJ stops to more recognizable places for travellers. Wider and larger Jeepney stops are recommended.
- More and stricter supervision by CITOM officers.
- Reducing the number of PUJ's by introducing a well thought tariff system. This measurement needs more explanation. First of all it is necessary to map in a very detailed manner the total number of PUJ's and their routes. This will provide information about the abundance or shortage of PUJ's at some places and thus will help formulating a policy with the objective of 'spreading out' the PUJ's more evenly in Cebu than is the case at the moment. This may lead to a reduce of the income of the Jeepney drivers who prefer to work in very crowded areas. To avoid this a new tariff system can be introduced that is not based on travel distance but on the more ambitious objective of preventing congestion and reducing a loss of income that PUJ drivers will suffer from.

8.5.2 Proposed new infrastructure

PUJ drivers prefer to work in very crowded areas. In this respect it is also very complicated to implement new infrastructure measurements. The function of a new road is strongly related to the number of Jeepney's that eventually will make use of the new link. Knowing that the modal split is 70% public transport it is obvious that a new road in a very remote area will not attract much traffic although the new link may provide a travel time that is less than travelling on an already congested road. So a new policy with regard to the PUJ's is also strongly recommended when it comes to the implementation of new infrastructure measurements.

However a proposal will be formulated here for new infrastructure. In chapter 7 it was concluded that the new South Coastal Highway contributes a great deal in relieving Cebu Highway by a shift off the largest traffic flows towards the South Reclamation Area. The South Coastal Highway stops in the centre of Cebu City. In this respect also a shift of the largest traffic flows towards the North Reclamation Area is recommended. In order to achieve this an upgrade of the roads on the North Reclamation Area is recommended and an extension of the roads to the Mactan Bridges and further (see also figure 8.8). This will prevent large traffic flows through the centre of Mandaue City and further relieve Cebu Highway.

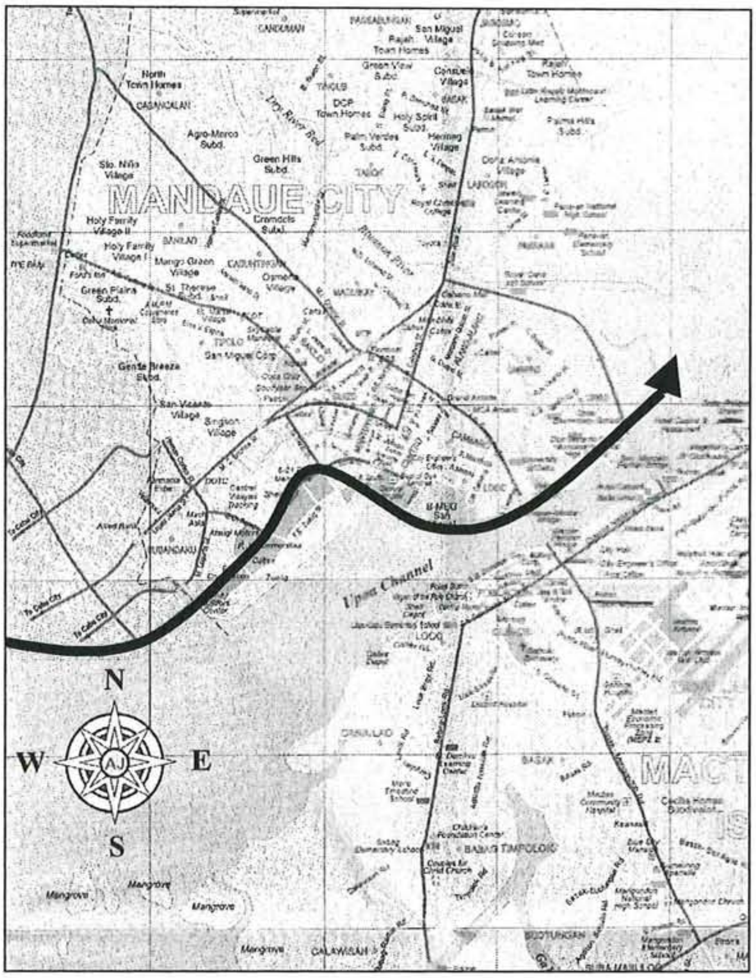


Figure 8.8 Suggested extension of the main road on the reclamation areas of Mandaue and Cebu City

In section 3.4 a description was given of a new road through the mountain area of Cebu City (see also figure 8.9). This road link is a by-pass arterial road connecting the north-south corridor of Metropolitan Cebu with the goal to divert traffic from and to Cebu City and thus to decongest the CBD. Plans for this road were just like the South Coastal Highway a part of the several MCDP 3 plans. In contrast to the South Coastal Highway this road is not being constructed yet and this could probably take several years if the road is constructed at all! However the need of radical measurements is very high as also can be confirmed from the results of the three traffic assignments performed in chapter 7. In chapter 7 the conclusion was drawn that the South Coastal Highway has proven to be effective in processing a part of the north-south traffic flows. However in the opposite directions (i.e. the east-west direction) the traffic flows and thus the travel times still show an increase if compared with the base year situation resulting in a further deterioration of the accessibility of the CBD area in east-west direction. The new coastal highway will only contribute to a decongestion of Cebu City if it is a part of a integral package of radical measures. In this respect the need of the circumferential road is strongly recommended here in order to achieve an overall decrease of the travel times and not only on some parts of Cebu Highway.

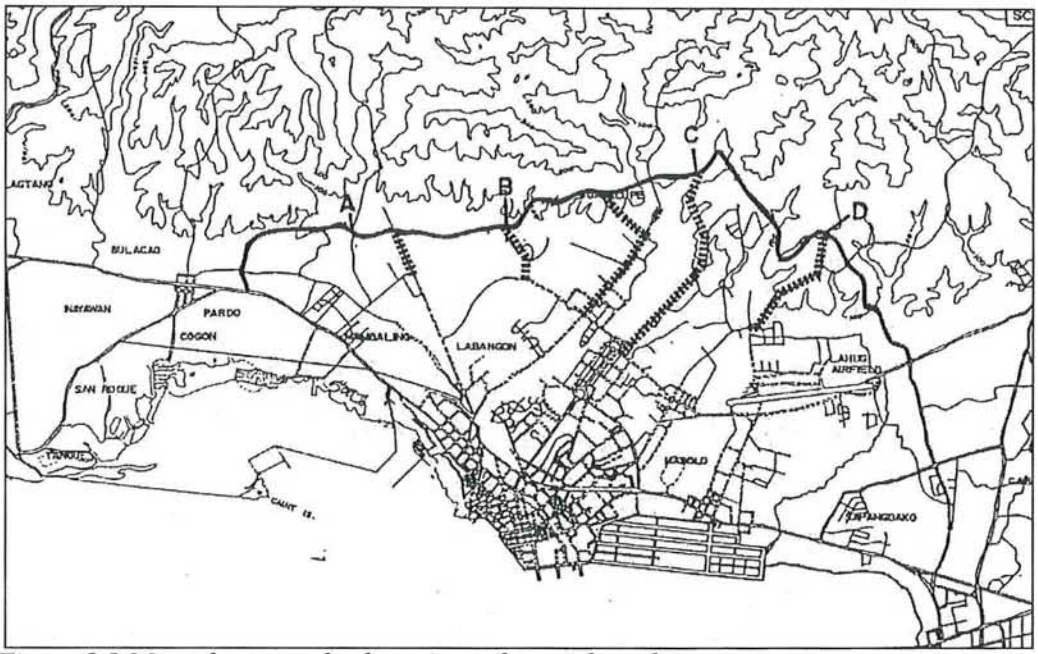


Figure 8.9 Map of proposed urban circumferential road

8.6 Conclusions

In this chapter several strategies with regard to land use and the transportation system have been pointed out.

With regard to the transportation system the following measurements were formulated

- *new measurements of traffic management for the PUJ's*
- *an upgrade of the roads on the North Reclamation Area and an extension of the main road on the North Reclamation Aea towards the Mactan Bridges and further*
- *the need for the Urban Circumferential Road to achieve an overall decrease of the travel times in Cebu City and not only on some parts of Cebu Highway*

With regard to land use the following strategies were formulated

- *to include more the surrounding municipalities and cities in Metropolitan Cebu in catching the rapid urban growth, especially the 3 northern located Municipalities of Consolacion, Compostela and Liloan*
- *a fully development of the North Reclamation Area because of its strategic location, existing infrastructure facilities, neighbourhood of existing commercial activies and other normative factors*

The proposed extension, the already existing highway and the new Coastal Highway can link the new developed areas on the North Reclamation Area and the northern part of Metropolitan Cebu and at the same time provide direct access to the southern parts of Metropolitan Cebu. The described strategies and the exact locations for the future commercial and dwelling areas are visualized more precisely on figure 8.10. On the map also the best opportunities for new dwelling areas are visualized. It is mostly in the westerns parts of Cebu City that the best possible options can be found for new dwelling areas, which is also the case for the rest of the cities and municipalities in Metropolitan Cebu.

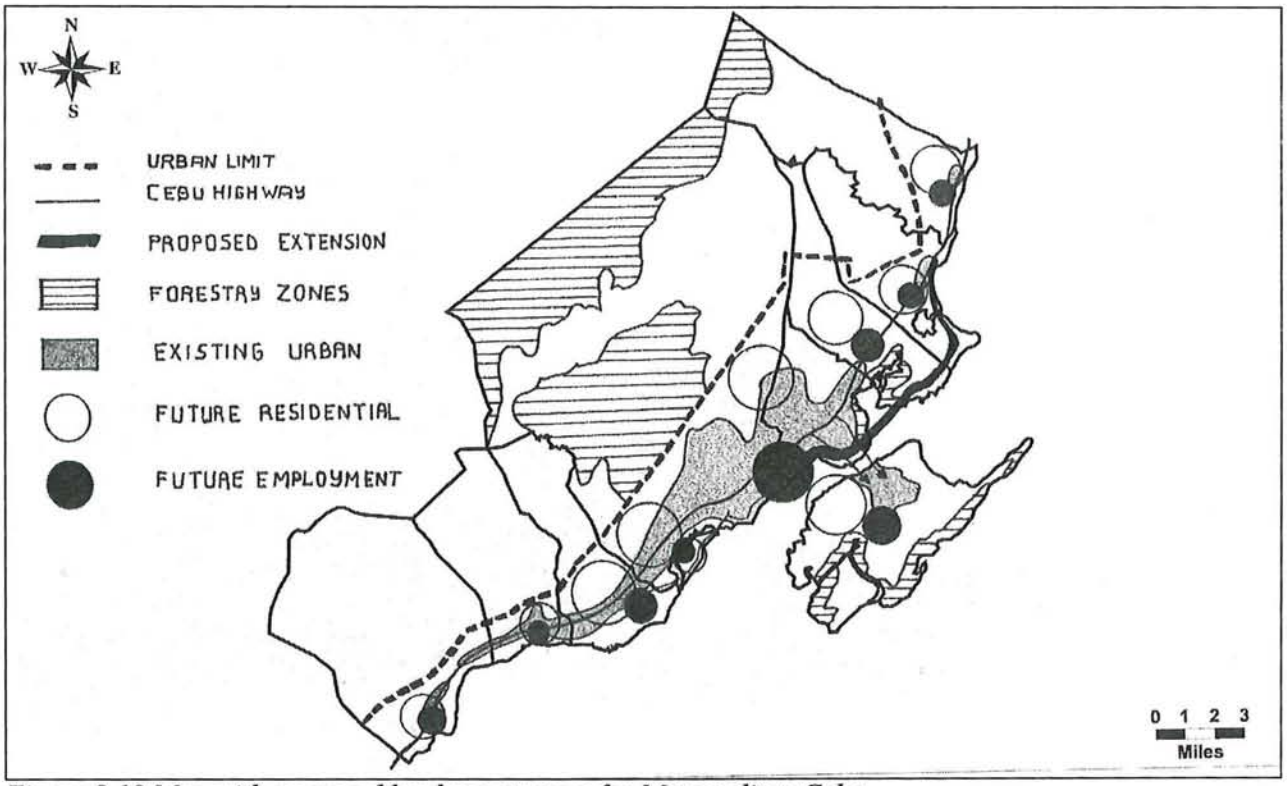


Figure 8.10 Map with proposed land use strategy for Metropolitan Cebu

The proposed strategies that have been described in this chapter need to be translated into the designed transportation model so they can be evaluated on their effects.
In the following chapter the proposed strategies will be worked out in TransCAD on the basis of 2 scenarios that describe

- the situation for which the northern part of Metropolitan Cebu and the North Reclamation Area have new employment numbers and the proposed new infrastructure (in this case only the proposed extension)
- the situation for which the northern part of Metropolitan Cebu and the North Reclamation Area have new employment numbers and the proposed new infrastructure (in this case the proposed extension and the urban circumferential road).

9 TRAFFIC ASSIGNMENT FOR THE PROPOSED STRATEGIES

9.1 Introduction

The strategies formulated in the previous sections can be translated into new input for the model that was made for Metropolitan Cebu. In this chapter a new traffic assignment will be performed for the proposed strategies. This will happen on the basis of two planning scenarios.

- Scenario 4 describes the situation in Metropolitan Cebu for which the North Reclamation Area, the South Reclamation Area and the northern municipalities have new/adapted demographic characteristics for the future year 2010, and for which the proposed extension is implemented.
- Scenario 5 describes the situation in Metropolitan Cebu for which the North Reclamation Area, the South Reclamation Area and the northern municipalities have new/adapted demographic characteristics for the future year 2010, and for which the proposed extension and the urban circumferential road are implemented.

In this way TransCAD will provide new results that can be used for the evaluation of the formulated land use and transportation strategies. The calculation will not have the same structure as previous calculations. The final results will directly be presented and the results obtained halfway, such as the trip generation and distribution, will be omitted to keep the total survey.

ZONES

ID	District_ID	population	employment	work_pop
36	1	24678	21770	14807
38	2	74338	15121	44603
34	3	151899	60566	91139
32	4	64396	13542	38638
40	5	64660	79204	38796
28	6	114581	8933	68749
30	7	81767	14107	49060
42	8	102226	54956	61336
45	9	382850	160410	229710
18	10	238587	69842	143152
57	11	251238	118150	150743
47	12	0	0	0

Figure 9.1 Previously used demographic input for the base year 2000

ZONES

ID	District_ID	population	employment	work_pop
36	1	32461	21770	19477
38	2	97754	15121	58652
34	3	199747	60566	119848
32	4	84681	13542	50809
40	5	85028	79204	51017
28	6	150674	8933	90404
30	7	107524	14107	64514
42	8	134427	54956	80656
45	9	436021	196103	261613
18	10	322279	90795	193367
57	11	379524	153596	227714
47	12	0	100000	0

Figure 9.2 Previously used demographic input for the future year 2010

The demographic information that was used as input for the model in chapter 5 is shown again in these two figures. For the traffic assignment for the proposed strategies these numbers need to be changed into new values that will represent the in the previous chapter described proposed situation. The South Reclamation Area is designed to house 100 000 new employees. However, it was suggested that the South Reclamation Area also can be utilized for new dwelling areas instead of only new commercial areas. In order to achieve this the previously forecasted and used population and employment numbers need to be redistributed over the traffic zones, giving the South Reclamation Area (i.e. traffic zone 12), the North Reclamation Area (i.e. traffic zone 5) and the northern impact area (i.e. traffic zone 9) a new population and employment number.

Based on the proposed strategies the following redistribution of the future year numbers will be applied:

- 50 000 of the 100 000 planned jobs on the South Reclamation Area (i.e. traffic zone 12) will be assigned to the North Reclamation Area (i.e. traffic zone 5)
- 25 000 of the 100 000 planned jobs on the South Reclamation Area (i.e. traffic zone 12) will be assigned the northern impact area (i.e. traffic zone 9)
- 75 000 of the total increase of Cebu Cities population will be assigned to the South Reclamation Area (i.e. traffic zone 12). In order to achieve this a proportional adaptation of the population numbers for each traffic zone in Cebu City is required. After all, the sums of the previously forecasted and new assigned values have to stay the same

Other combinations of the applied redistribution, that also comply with the proposed strategies are as well possible. It is important to keep in mind that in practice it is not possible to make long term plans that exactly can result in these numbers. This because of the many variables and uncertentaties that are involved in planning. In this perspective the model must be seen as only a tool that can help found a proposed approach with regard to land use and transportation.

The following figure contains the new demographic information that will function as the new input for the model.

ZONES

ID	District_ID	population	employment	work_pop
36	1	27461	21770	16477
38	2	87754	15121	52652
34	3	189747	60566	113848
32	4	74681	13542	44809
40	5	75028	129204	45017
28	6	140674	8933	84404
30	7	97524	14107	58514
42	8	124427	54956	74656
45	9	436021	221103	261613
18	10	322279	90795	193367
57	11	379524	153596	227714
47	12	75000	25000	45000

Figure 9.3 Demographic input based on the proposed approach with regard to land use

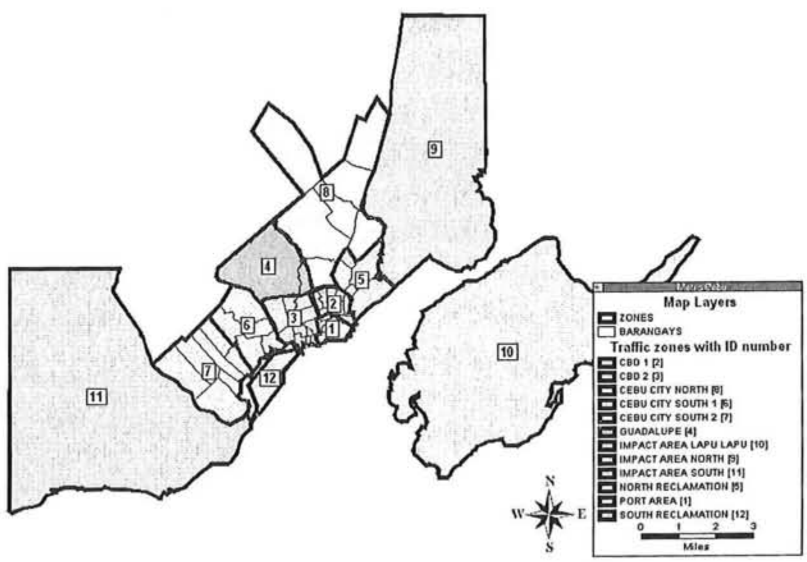


Figure 9.4 Zoning map of Metropolitan Cebu

In chapter 8 a formulation was given of some measurements with regard to traffic management concerning the PUJ's. The assumption will be made here that the average speed that previously was assigned to the road links can increase with 5 km/h if the formulated measurements are implemented. For the average speed on the roads and the connectors a value of 20 km/h is estimated. The roads in the outskirts of Cebu City will be given a speed of 35 km/h.

The previously assigned values for the capacities and impedance on the road links will remain the same (see also section 7.1).

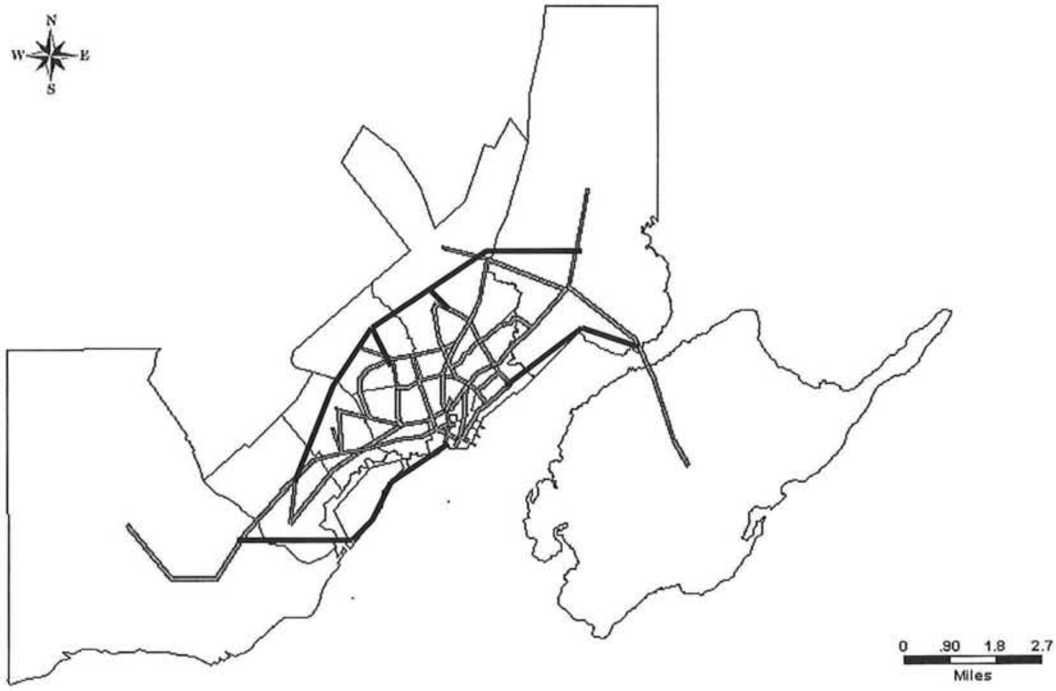


Figure 9.5 Complete future road network for the study area Cebu City

Figure 9.5 shows the complete future road network on which the traffic flows will be calculated. For understanding the effects of the proposed extension and the urban circumferential road it is necessary to perform a traffic assignment for which only the proposed extension is included (scenario 4) and one for which also the urban circumferential road is included (scenario 5). These traffic assignments will be performed in the following section, so that in section 9.3 the results can be compared and conclusions can be drawn about the effects.

9.2 Traffic assignment

9.2.1 Traffic assignment scenario 4

Scenario 4 describes a future year (2010) situation with the proposed extension. The extra link will be assigned an average speed of 50 km/h and a maximum total capacity of 4000 vehicles per hour.

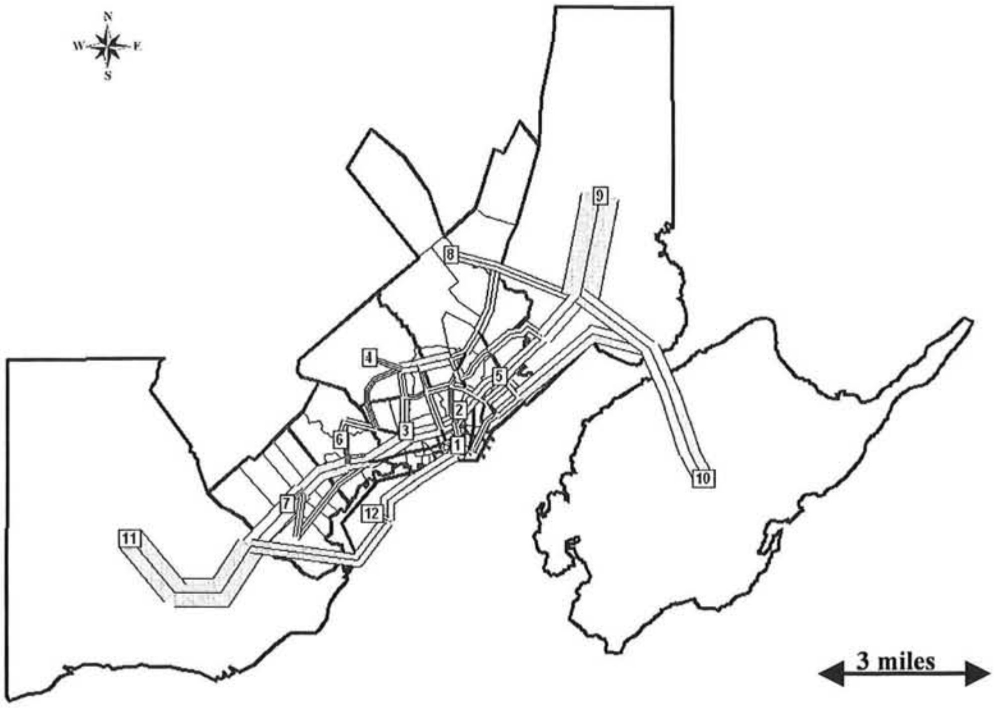


Figure 9.6 Traffic assignment for scenario 4 (2010)

figures for every user over entire network	scenario 4
average free-flow travel time [min.]	42
average congested travel time [min.]	138
average travel distance [km]	12.3

Table 9.1 Travel times and distance for the scenario 4 traffic assignment

average congested travel times between mentioned traffic zones for every user		scenario 4
traffic zone A	**traffic zone B**	**[min.]**
8	7	94
5	7	109
8	1	54

Table 9.2 Travel times for the scenario 4 traffic assignment

9.2.2 Traffic assignment scenario 5

Scenario 5 describes a proposed future year (2010) situation with both the proposed extension and the urban circumferential road. The average speed that is assigned to the circumferential road is 20 km/h because of its location in the mountainous area of Cebu City. The capacity is 2000 vehicles per hour. As calculated for this traffic assignment the urban circumferential road isn't utilized for new commercial and dwelling areas.

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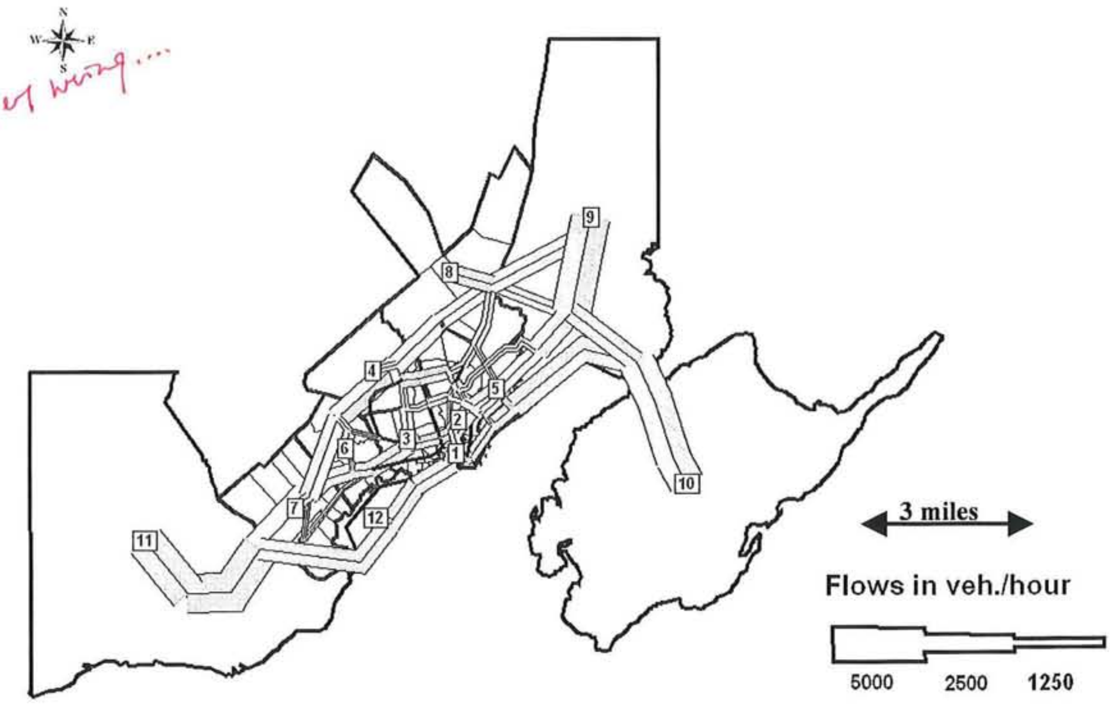

Figure 9.7 Traffic assignment for scenario 5 (2010)

figures for every user over entire network	scenario 5
average free-flow travel time [min.]	41
average congested travel time [min.]	118
average travel distance [km]	12

Table 9.3 Travel times and distance for the scenario 5 traffic assignment

average congested travel times between mentioned traffic zones for every user		scenario 5
traffic zone A	**traffic zone B**	**[min.]**
8	7	73
5	7	90
8	1	52

Table 9.4 Travel times for the scenario 5 traffic assignment

9.3 Analysis of the results

9.3.1 Introduction

The steps described in the classical four-stage transportation model have now been completed for 5 planning scenarios. For scenario 4 and 5 the output of the traffic assignment can be found in the appendices 16 through 21.
The visualized results show that the proposed extension and the urban circumferential road will process a major part of the extra-generated traffic. In this respect it can be concluded that the transportation model has proven the benefit and the need of these extra infrastructure measurements. The surrounding municipalities and cities generated the major part of the traffic in the study area Cebu City. The proposed extension and the urban circumferential road provide direct access to the impact areas; so they provide the possibility of diverting these large traffic movements and thus keeping the crowded CBD areas from getting overloaded more. The exact way for which these effects are utilized will be studied on the basis of the calculated characteristics travel time and distance in the next subsection.

9.3.2 Comparison of the five scenarios

In the following tables all the five planning scenarios are compared for the characteristics travel time and travel distance. The effects of the proposed strategies can be derived by comparing the characteristics for scenario 4 and 5 with the base year.

figures for every user over entire network	**scenario 1 (base year)**	**scenario 2 (zero alternative)**	**scenario 3 (future year)**	**scenario 4 (proposed strategy)**	**scenario 5 (complete proposed strategy)**
Average free-flow travel time [min.]	55	56	49	42	41
Average congested travel time [min.]	110	328	150	138	118
Average travel distance [km.]	12.1	12.3	12.5	12.3	12

Table 9.5 Overview travel times and distance over the entire network in Metropolitan Cebu compared for the five scenarios

average congested travel times between mentioned traffic zones for every user		**scenario 1 (base year)**	**scenario 2 (zero alternative)**	**scenario 3 (future year)**	**scenario 4 (proposed strategy)**	**scenario 5 (complete proposed strategy)**
traffic zone A	**traffic zone B**	**[min.]**	**[min.]**	**[min.]**	**[min.]**	**[min.]**
8	7	124	238	135	94	73
5	7	97	194	92	109	90
8	1	61	78	82	54	52
3	2	34	53	49	34	33
6	2	74	174	79	46	35

Table 9.6 Overview travel times along the most important routes in Cebu City compared for the five scenarios

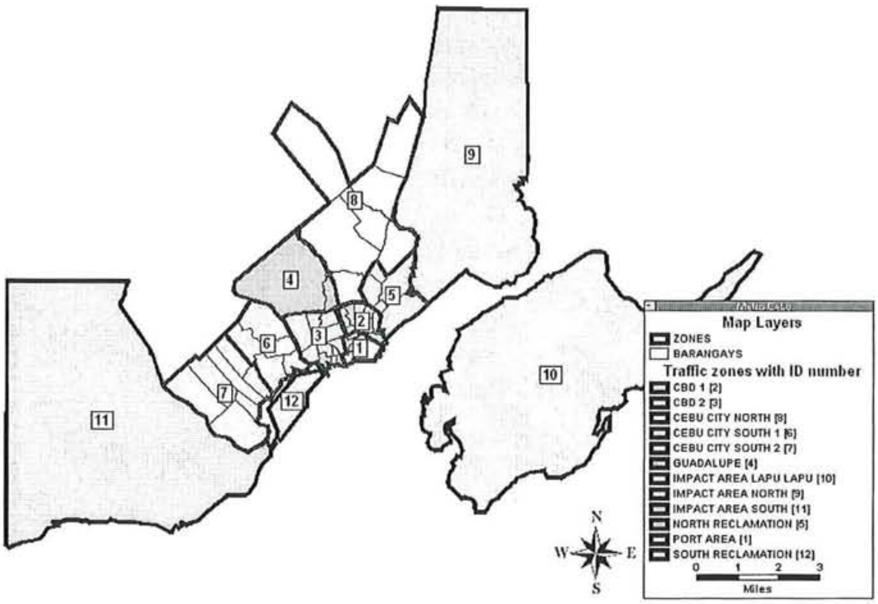

Figure 9.8 Zoning map of Metropolitan Cebu

9.3.3 Conclusions

The average congested travel time over the entire network in Metropolitan Cebu decreases from 150 minutes for scenario 3 to 118 minutes for scenario 5. If compared with the base year traffic assignment an increase of only 8 minutes can be derived from table 9.5. The average congested travel times are calculated for the entire network in Metropolitan Cebu; also the connectors and the road links on the impact areas are included. However, for the major part of the calculated travel times between the traffic zones in the study area Cebu City a decrease can be noticed if compared with the base year situation (see also appendix 7 and 19). The travel times show a considerable decrease (thus also in east-west direction) for the interzonaal trips if the proposed extension and/or the urban circumferential road are implemented. In the appendices 16 and 19 the travel times between the 12 traffic zones for the scenario 4 and 5 traffic assignment can be found.

Table 9.5 shows that for scenario 5 it takes approximately three times the effort for a commuter to travel in the peak hour (the average free-flow travel time is 41 minutes and the average congested travel time is 118 minutes); for the base year situation it takes a commuter two times the effort. This indicates that if the proposed strategies are implemented a commuter can improve his or her situation more if the choice is made to travel outside the peak hour.

On the basis of the calculated traffic flows that can be found in the appendices an average traffic flow is calculated on Cebu Highway for all the five scenarios and represented in the following table.

	scenario 1 [veh./h]	scenario 2 [veh./h]	scenario 3 [veh./h]	scenario 4 [veh./h]	scenario 5 [veh./h]
average traffic flow on Cebu Highway	3500	4363	3506	3223	2517

Figure 9.7 Overview average traffic flow on Cebu Highway for the five planning scenarios

The following conclusions can be drawn:

- *The proposed extension and the urban circumferential road both contribute to a relieve of the congested Cebu Highway if compared with the base year situation. For the scenario 5 traffic assignment the average traffic flow on Cebu Highway decreases with 30% if compared with the base year traffic assignment.*
- *The urban circumferential road also contributes to a decrease of the travel times in the east-west direction.*
- *The proposed extension and the urban circumferential road both contribute to a decrease of the inter- and intrazonaal trip travel time (see also the travel time matrices in the appendices 7,16 and 19).*
- *In this respect the infrastructure measurements and proposed land use strategies contribute to an improved accessibility of the CBD areas of Cebu City.*

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9.4 Evaluation of the model

In order to obtain results that can be used for comparing the planned and proposed land use and transportation strategies it was necessary to make some assumptions and estimations during the process of the modeling work. Some assumptions and estimations were more or less intuitive while others were based on what is commonly accepted. The choice for the right values for the used quantities such as growth percentages, speed and capacity has a great influence on the results of the designed model. However, when using the results for the purpose of comparing several planning scenarios the used assumptions don't influence the conclusions much, that is if the assumptions are made under the same conditions and consistently. Comparisons were made on the basis of among others the calculated travel times, which will only differ with an unknown factor if one or more assumptions is resp. are not reliable.

Still the application and possibilities of the used transportation model can be expanded respectively increased if assumptions and estimations are avoided as much as possible and replaced by '100% reliable statements'. For example the in availability of detailed demographic information has imposed important restrictions on the applied space of time of 10 years. The greater the used space of time the less reliable is the output of the transportation model.

Cebu City has been chosen as the study area because of the traffic problems that this city is suffering from. A different approach is one for which also Mandaue City is included because this City is also suffering from the same problems. However, this City has it's own GIS office and the collection of for example important data with regard to the road network takes place independently from Cebu City. In the previous chapter it was mentioned in the planning constraints that it was required to make the surrounding cities and municipalities integral to Cebu City for understanding the problems in Cebu City. In this respect it is recommended to follow the same approach in the process of obtaining and processing important information with regard to the network and the demographic information.

The results of the tip distribution and thus the traffic assignment are calculated on the basis of a shortest path matrix based on distance. So the largest trips are assigned to routes that provide the shortest travel distance. However, travel choice behaviour is dependent from all kinds of factors besides travel distance. Figure 9.9 shows a shortest path between traffic zone 8 and 7. In practice however most PUJ's make use of the route along Osmena Boulevard (2) (see also appendix 2).

The model can be optimised if the route choice behaviour of the Jeepneys is included. Road links that are part of a shortest route should be given a higher value of the impedance if they are not used by the Jeepneys. In this respect it is recommended to map the number of PUJ's and their routes.

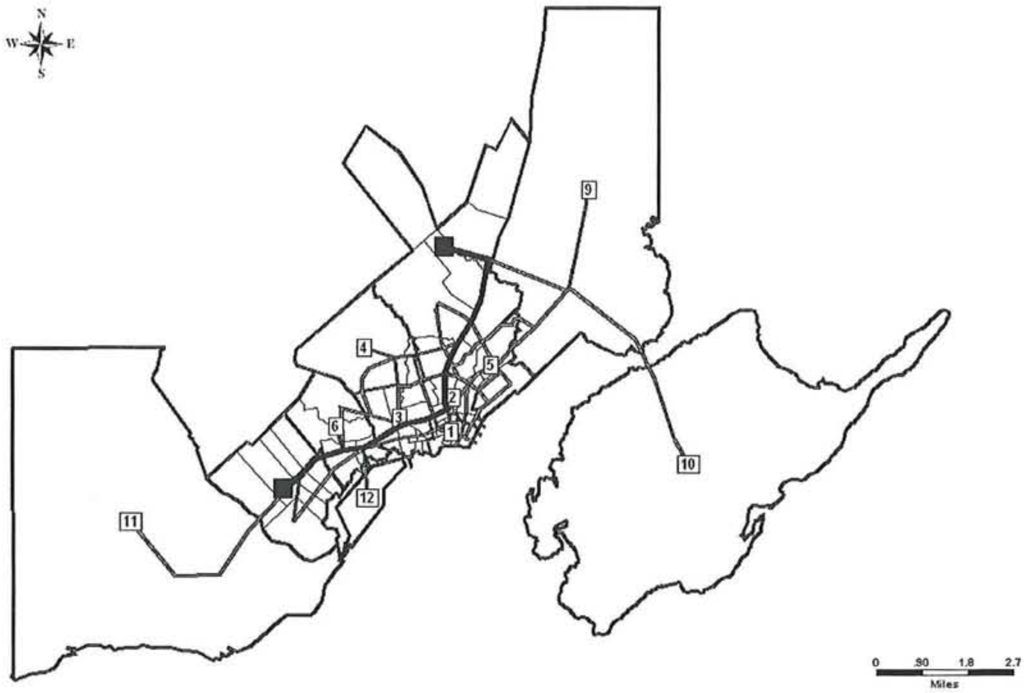

Figure 9.9 Shortest path between traffic zone 8 and 7

In section 9.1 new values for the demographic characteristics employment and population have been assigned to the most traffic zones. Subsequently the traffic assignment has been performed for 2 planning scenarios. The results of the scenario 5 traffic assignment in travel times between the traffic zones are presented in appendix 19. The major part of the new calculated travel times shows a considerable decrease if compared with the base year travel times that are presented in appendix 7. However, for the travel times listed in the columns 5 and 9 in appendix 19 this not the case. In practice it is not as easy as in a transportation model to assign a new employment number to an area and to expect that the proposed situation will be realized. For example only practice will show whether the South Reclamation Area will house the planned number of 100 000 employees or whether the North Reclamation Area will house the proposed 50 000 extra employees. In this respect it can be concluded that the proposed planning will result in an overall decrease of the travel times in the study area Cebu City, although the assigned numbers perhaps need more 'fine-tuning' for obtaining travel times that are lower in the colums 5 and 9.

10 GENERAL CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

The application of the transportation model has proven its benefit in studying the effects of spatial and infrastructure planning. Besides the impact on the daily traffic movements the transportation model has also provided the possibility of putting in order the diversity and complexity of information. The base year and future year demographic characteristics were visualized orderly on the basis of the schematic map of Metropolitan Cebu that was made in TransCAD. In this respect the application of the designed transportation model has provided important information concerning the present and future spatial developments in Metropolitan Cebu. These spatial developments are together with the realization of new infrastructure determinative for the growth or reduction in the travel demand. The designed transportation model has been used for studying the effects of new infrastructure (i.e. the coastal highway, a proposed extension and a recommendation for the realization of the urban circumferential road), so that eventually a systematic classification of the major road network could be obtained that contributes to an improved accessibility of the CBD areas of Metropolitan Cebu. This was also the case for the formulated land use strategies that were mainly focussing on the creation of new oppurtunities for dwelling and commercial areas on the two reclamation areas and the northern parts of Metropolitan Cebu. In this respect it can be concluded that the designed transportation model has successfully helped in achieving the goals and objectives of this study.

More concretely, the output of the designed transportation model has lead to the following conclusions:

- *The results of the trip distribution show that the major part of the trips that is made every day originates in the northern parts of Metropolitan Cebu; for the base year (2000) a total number of person trips of 370 000 was calculated from which 100 000 are made between the northern impact area and the study area Cebu City. The realization of the South Reclamation Area will attract every day more than 50% of the total increase in the total number of person trips in the future year (2010). These results have lead to the formulation of a land use strategy that describes the development of the North Reclamation Area and the northern parts of Metropolitan Cebu .It was also proposed to reconsider a change of the function of the South Reclamation Area into an area that is also suitable for the development of new dwelling areas instead of only commercial areas.*

- *The results of the traffic assignments have shown that Cebu Highway has to process high traffic flows and that the realization of the South Coastal Highway will contribute to a relieve of the traffic flows on some parts of Cebu Highway. The calculated average traffic flow on Cebu Highway for the base year is approximately the same as in the future year traffic assignment (i.e. 3500 vehicles/hour). However, the coastal highway doesn't lead to an overall decrease of the travel times in the study area Cebu City. Especially in east-west direction an increase of the travel times can be observed. These results have lead to the formulation of a transportation strategy that describes an extension towards the northern parts of Metropolitan Cebu for a further relief of Cebu Highway and a recommendation for the realization of the planned urban circumferential road for decreasing the overall travel times.*

- *The results of the traffic assignments for the proposed strategies show that an overall decrease of the inter-and intrazonaal trip travel times can be reached by pointing out strategic locations for new commercial and dwelling areas and by the realization of the proposed new infrastructure.*
  In this respect the proposed land use and transportation strategies contribute to an improved accessibility of the CBD areas in the study area Cebu City.

- *The results of the traffic assignment for the proposed strategies and thus the travel times between the traffic zones can be further optimised by 'fine tuning' the new values for the demographic characteristics that have been assigned to the traffic zones.*

10.2 Recommendations

The designed transportation model has proven the benefits of the proposed land use and transportation strategies. In this respect it is strongly recommended to study the effects of a reconsideration of the North and South Reclamation Area's destination and the proposed infrastructure measurements.

In section 9.4 already a few recommendations were made with regard to the possibilities of optimizing the results of the model. In Metropolitan Cebu several independent agencies are active in collecting and processing information such as the National Statistics Office, the National Economic Development Authority and the GIS office. In cases of need of certain information these agencies need to be adressed seperately. However, a transportation model of the Metropolitan in TransCAD provides the possibility of storing a lot of varying information and even processing this information and obtaining new information. In this respect it is strongly recommended to describe the Metropolitan in a transportation model. The possibilities in a transportation model made in TransCAD are almost infinite. New obtained information with regard to certain spatial developments can be added to the model very easily and studied on the effects on the traffic movements in the Metropolitan. A transportation model can be adapted easily to social developments. The implementing time of a certain infrastructure measurements such as the light rail (see also subsection 3.4.3) and the urban circumferential road may take several years. During this time the circumstances for which the infrastructure measurement is designed may become completely different. In a quikly changing Metropolitan such as Cebu the application of a transportation model can be considered as a very cheap way to study the effects of a certain infrastructure measurement under new adapted circumstances.

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APPENDICES

1. Newspaper article Cebu City

2. Road map of the southern part of Cebu City

3. Road map of the northern part of Cebu City

4. Photos of roads in Cebu City

5. Construction photos of the South Reclamation Area and the Coastal Highway

6. Newspaper article concerning predicted economic growth in the Philippines

7. Congested travel times between the centroids of the 12 zones for the base year traffic assignment (scenario 1)

8. Road map with ID numbers for the base year traffic assignment (scenario 1)

9. Output for the base year traffic assignment with the matching ID numbers (scenario 1)

10. Congested travel times between the 12 traffic zones for the zero alternative traffic assignment (scenario 2)

11. Road map with ID numbers for the zero alternative traffic assignment (scenario 2)

12. Output for the zero alternative traffic assignment with the matching ID numbers (scenario 2)

13. Congested travel times between the 12 traffic zones for the future year traffic assignment (scenario 3)

14. Road map with ID numbers for the future year traffic assignment (scenario 3)

15. Output for the future year traffic assignment with the matching ID numbers (scenario 3)

16. Congested travel times between the 12 traffic zones for the scenario 4 traffic assignment

17. Road map with ID numbers for the scenario 4 traffic assignment

18. Output for the scenario 4 traffic assignment with the matching ID numbers

19. Congested travel times between the 12 traffic zones for the scenario 5 traffic assignment

20. Road map with ID numbers for the scenario 5 traffic assignment

21. Output for the scenario 5 traffic assignment with the matching ID numbers

APPENDIX 1 Newspaper article Cebu City

Cebu city slides to 22nd in list of 'Best Cities'

Davao inches up to 19; Manila dips to 25

CEBU city slipped from 19th to 22nd this year in Asiaweek magazine's yearly survey of Asia's 40 most livable cities.

Fukuoka city of Japan remained on top, followed by Tokyo, then Singapore.

Davao city outpaced Cebu again and moved one rank higher from 18th last year. Manila slid to 25th from 22nd in 1999.

Former mayor Tomas Osmeña blamed the decline of the city's economic climate on Mayor Alvin Garcia.

In 1996, Cebu city ranked eighth in the six-month survey during the Garcia administration. It also fared well as one of the least dusty cities in Asia.

However, the city failed to climb back to the top 10 when it dropped to 13th place in 1997 and to 14th in 1998.

Although there was no absolute yardstick, the cities were graded based on 26 indicators in the magazine's latest quality of life index.

ASIAWEEK SURVEY. *The magazine's latest quality of life index in key cities in Asia includes average income, peace and order, jobs, leisure, environment and sanitation, transportation, education, public transport, housing and health care.*

The index includes average income, peace and order, economic opportunity, leisure, environment and sanitation, transportation, education, public transport, housing and health care.

In its fifth year, the Hong Kong-based magazine's yearly survey used similar indicators with those adopted since 1996 except for the number of mobile phones and Internet use.

The last two indicators were used to determine how the cities increased their role in modern life for the new millennium.

The survey, though, did not provide adequate data as to how the cities fared in some criteria like the unemployment rate, ratio of house price to income, number of phones per 1,000 people and the number of dust particles in the air.

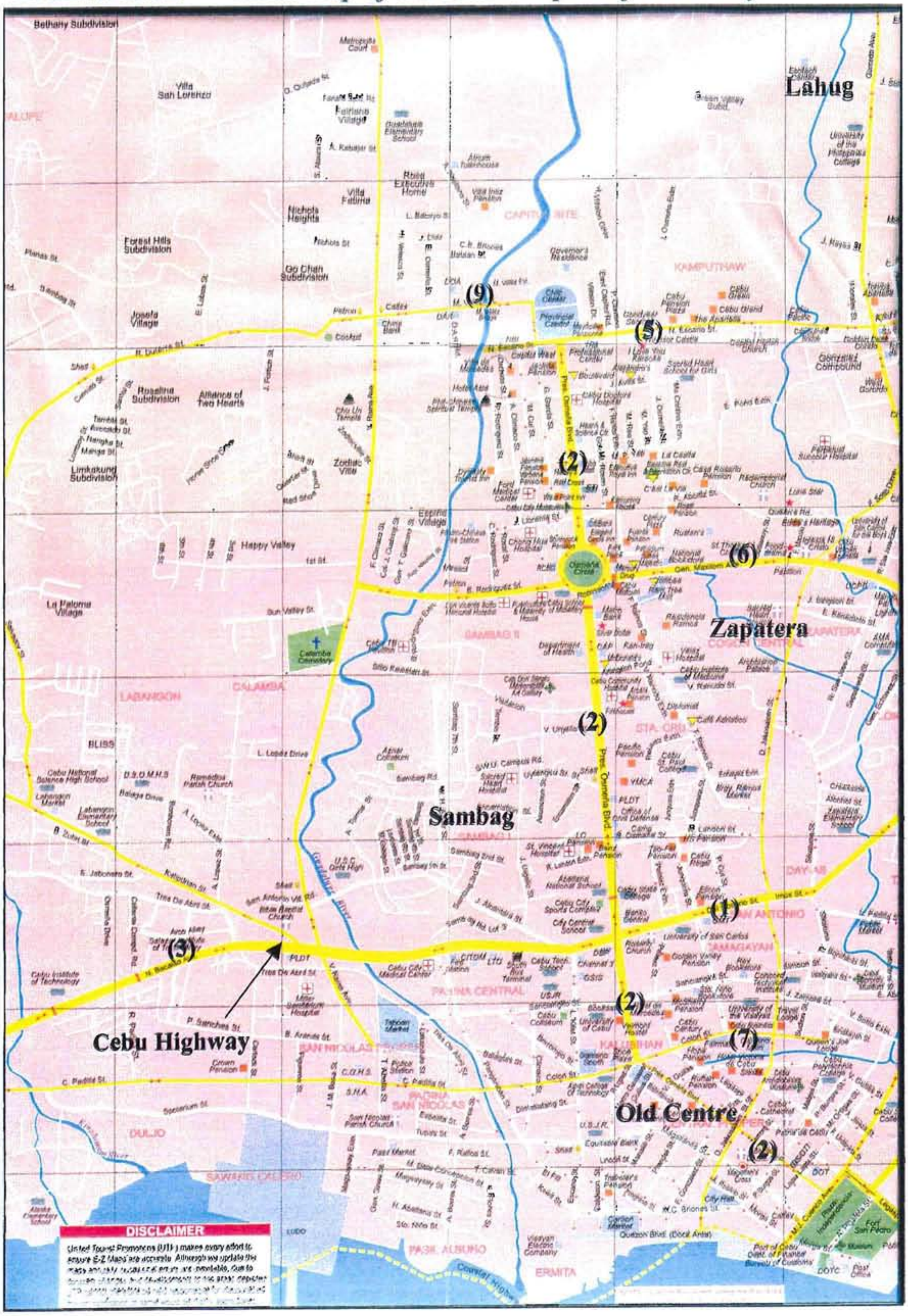
Last year, Cebu city scored high in the least dusty cities but the survey results did not state any for indicator this year. The same goes for average income, housing, Gross Domestic Product growth, traffic and the number of mobile phones and Internet use.

No details or figures were provided on Cebu city's chart as shown by the magazine's issue for the 2nd week of December.

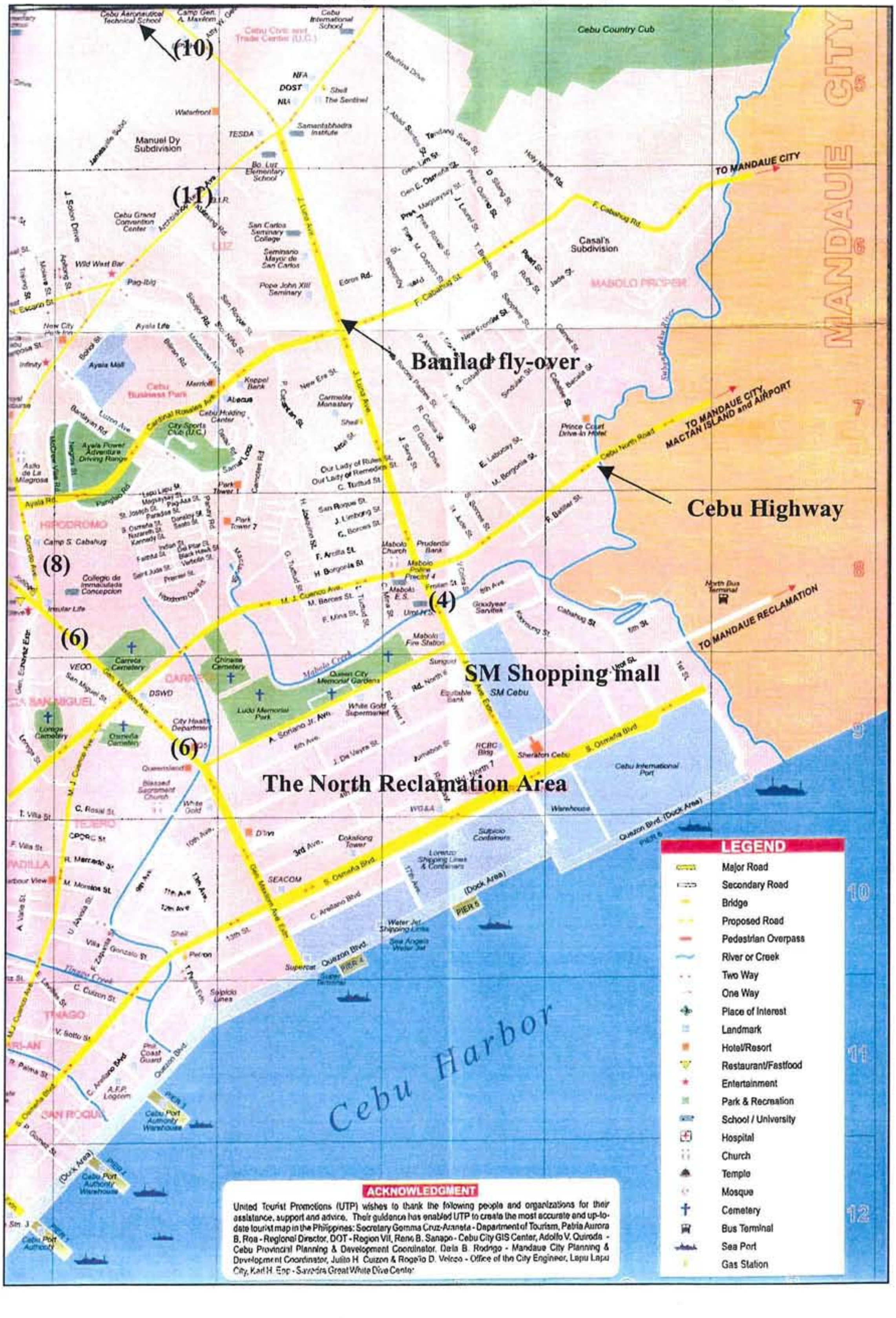
The city, however, ranked third on the number of TV sets and sixth on the number of hospitals beds per 1,000 people.

"The poor infrastructure development, poor peace and order and sanitation management has made Cebu unattractive to the foreign market. Davao has now outpaced Cebu as the number one most livable city in the country," Osmeña lamented. GRA/ With JBN

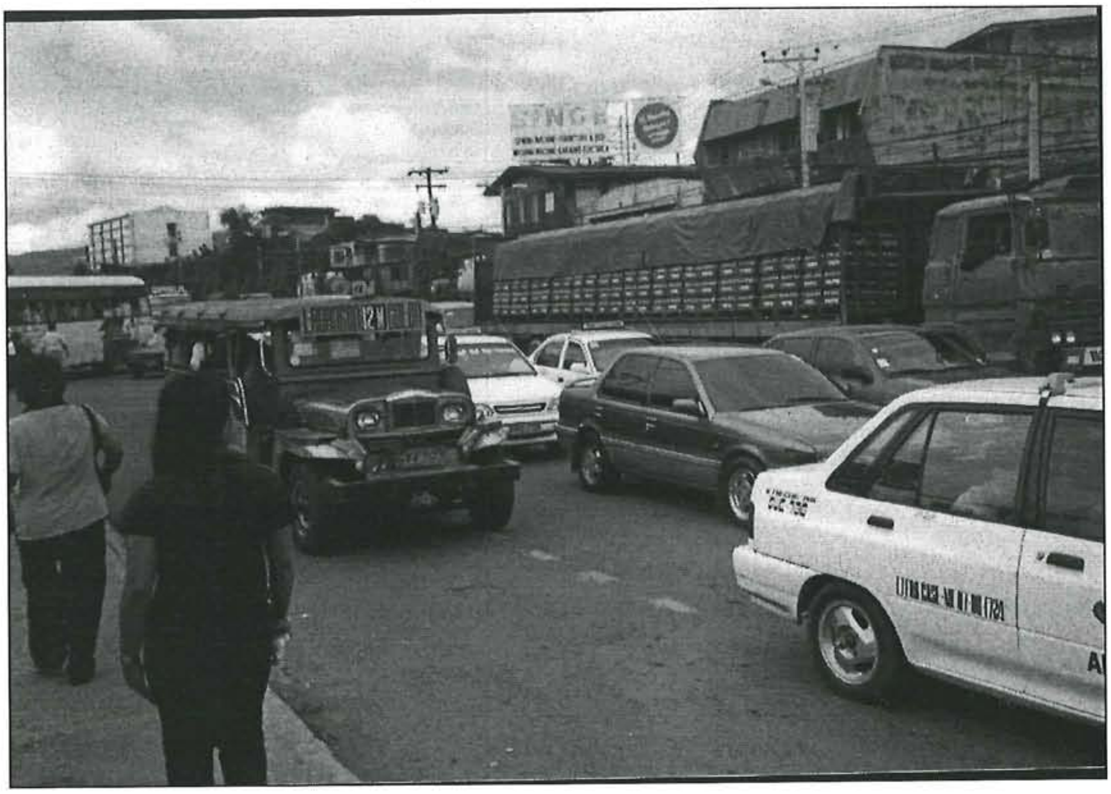
APPENDIX 2 *Road map of the southern part of Cebu City*

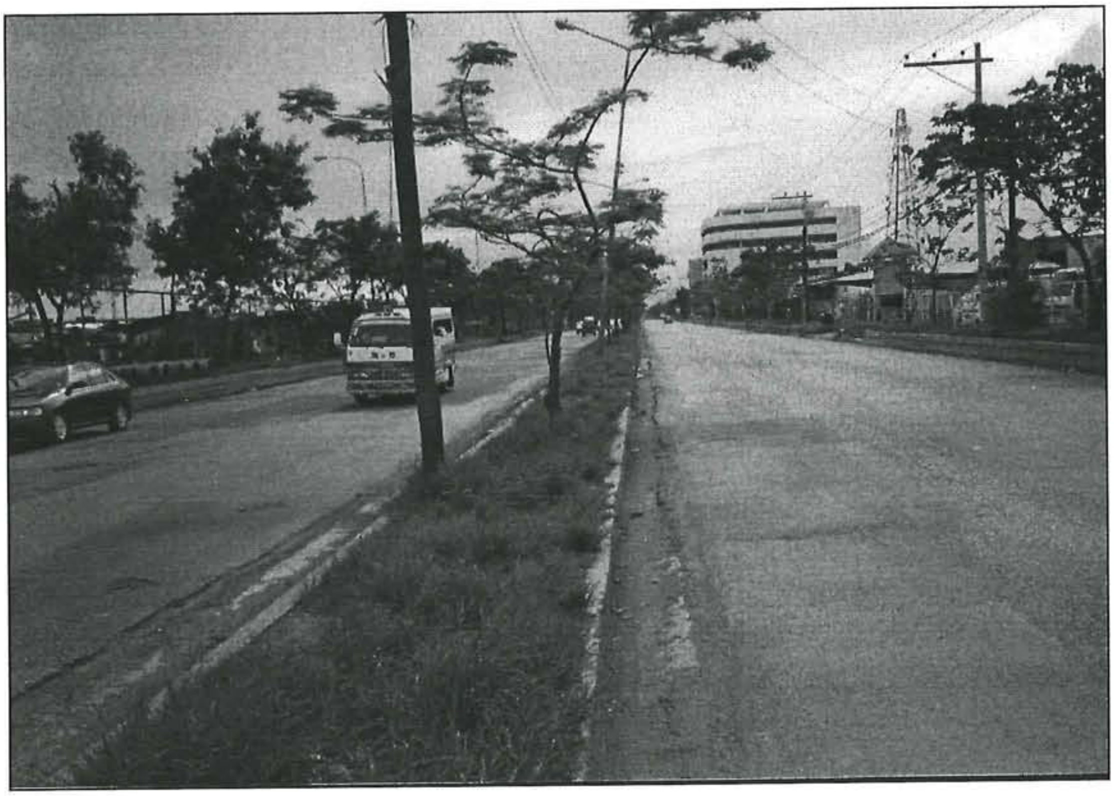


APPENDIX 3 Road map of the northern part of Cebu City

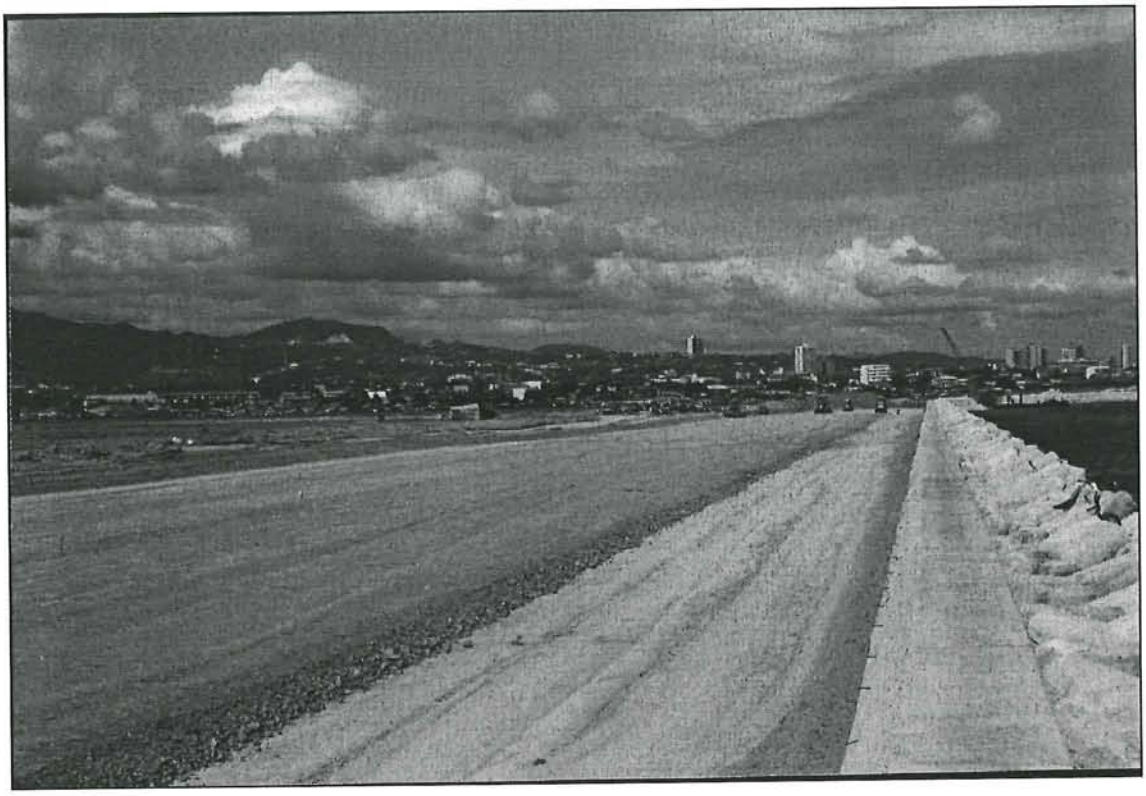


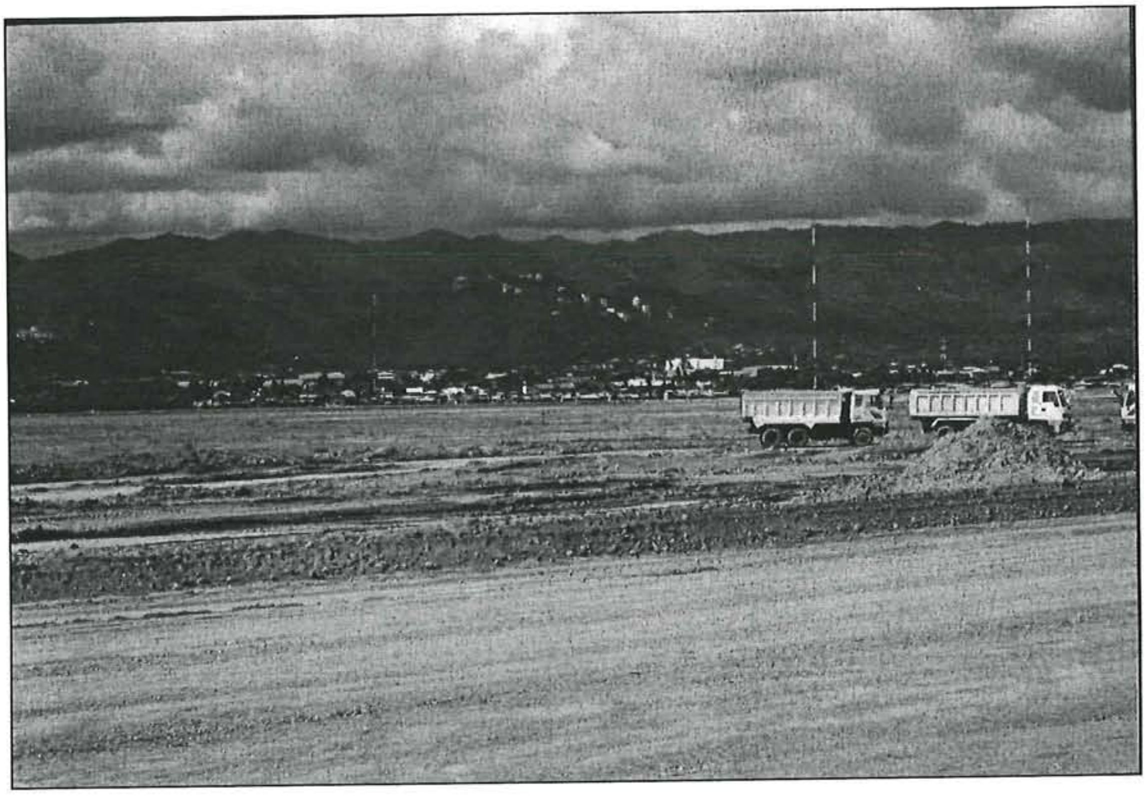
APPENDIX 4 Photos of roads in Cebu City





APPENDIX 5 Construction photos of the South Reclamation Area and the Coastal Highway





APPENDIX 6 *Newspaper article concerning predicted economic growth in the Philippines*

Economic recovery in 2-5 yrs. — Romulo

MANILA—The economy could take two to five years to get back on strong footing, said Finance Secretary-designate Alberto Romulo, President Gloria Macapagal-Arroyo's first appointment to the Cabinet.

Amid eroding investor confidence and political uncertainty, the economy has been hit by high interest rates, inflation and unemployment, weak currency and stocks and a huge budget deficit in the past year.

"It will take a minimum of two years to get back on our feet. Some are even more unkind, they say it will take five years or even more," Romulo said.

Foreign investors first started packing up in January last year after Estrada allegedly intervened to save a business crony from being investigated in the country's largest insider trading scandal.

The peso has since hit historic lows. The Philippine stock market is among the worst, if not the poorest performer, in Southeast Asia, with trading volumes slashed by more than half from a year ago.

But Philippine stocks and the country's battered currency are expected to perk up with the installation of a "business-friendly" government led by Arroyo, a US-trained economist, although analysts cautioned against over-exuberance.

Last Friday, the peso recovered dramatically to a high of P47 to the dollar from the previous day's close of P54.79, as news of mass defections to the anti-Estrada camp hit the market at the end of trading.

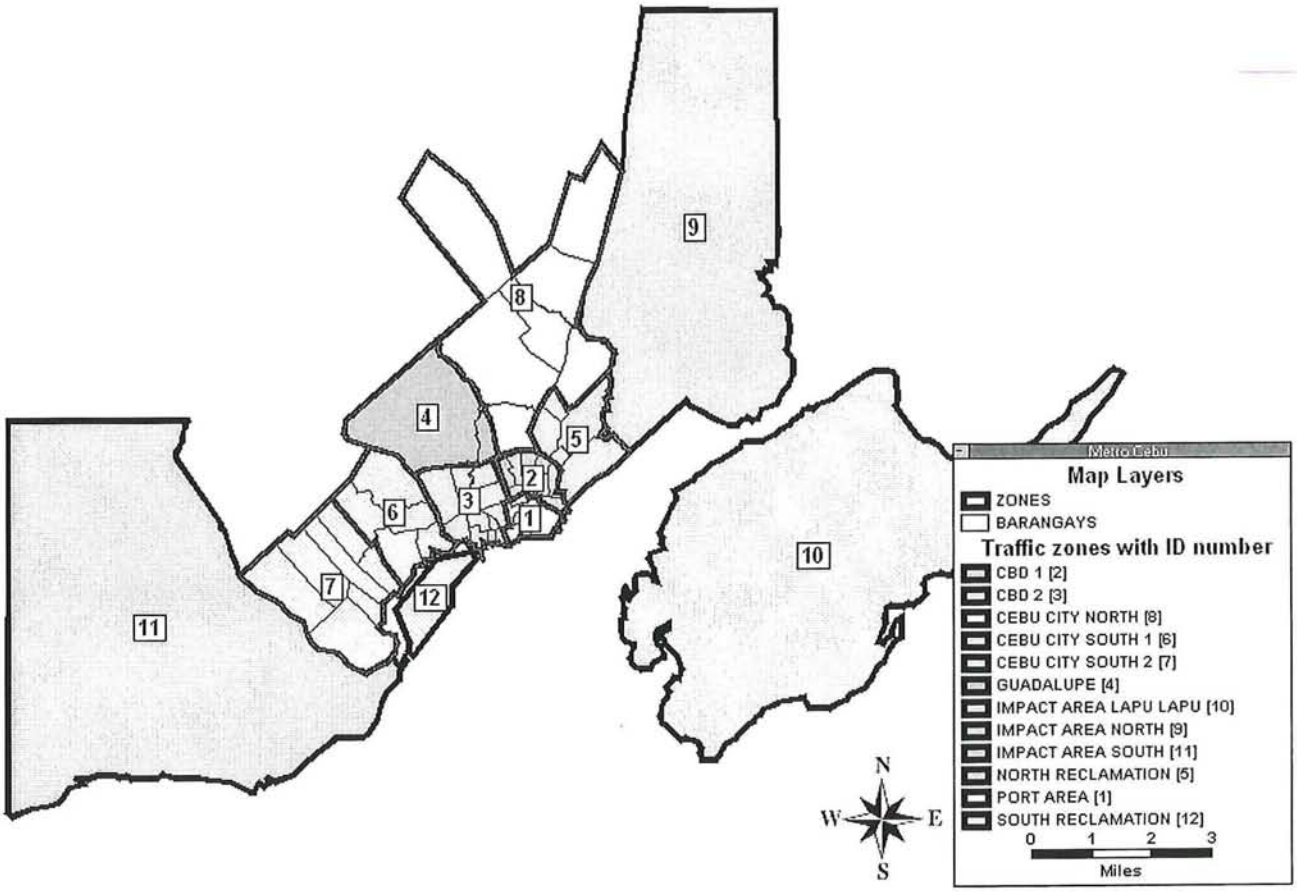
Estrada was ousted on Saturday after the Supreme Court declared the presidency vacant.

▶ROMULO, 31

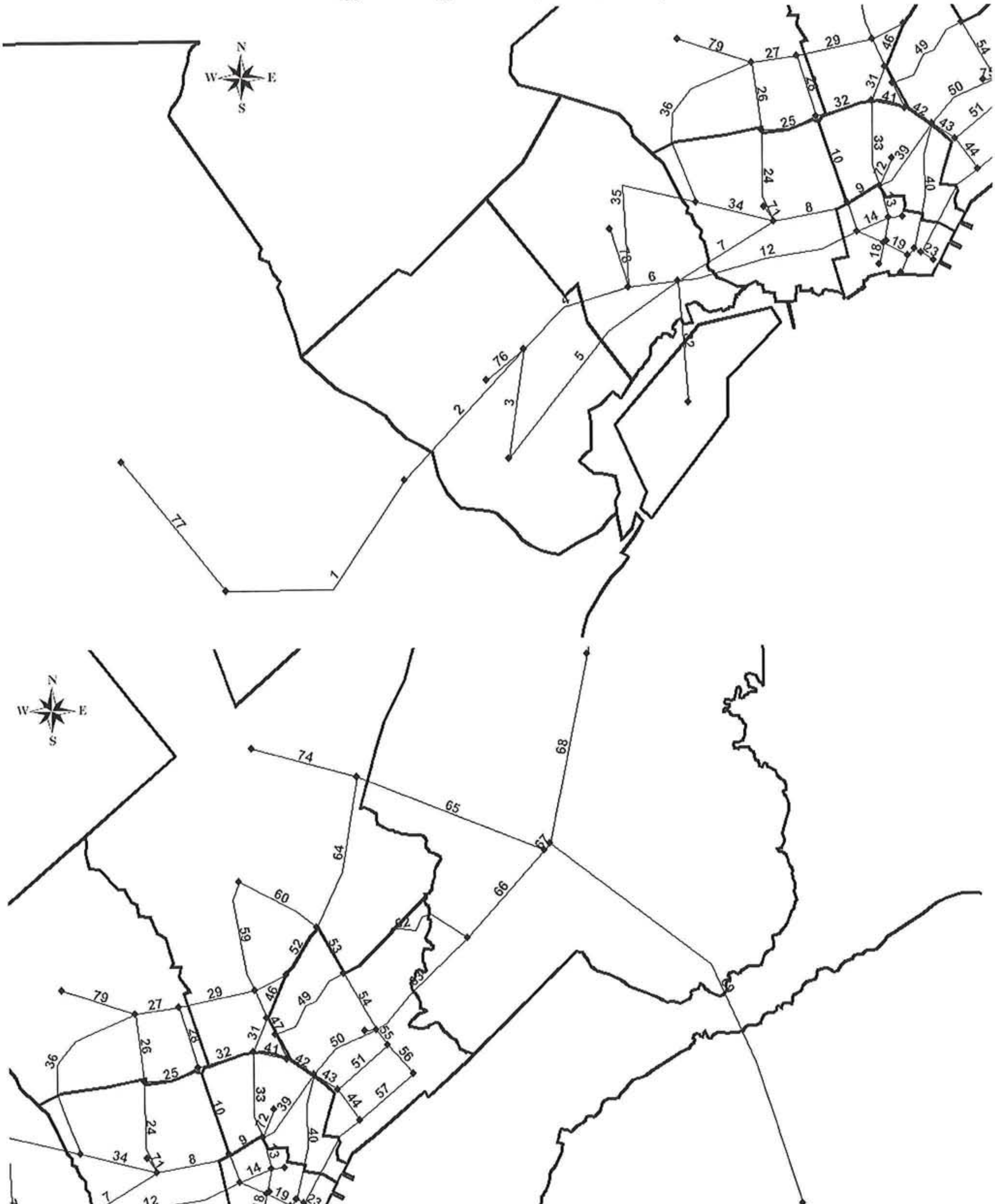
APPENDIX 7 Congested travel times between the centroids of the 12 zones for the base year traffic assignment (scenario 1)

Congested travel times for the base year

	1	2	3	4	5	6	7	8	9	10	11	12
1	0	10	30	29	37	49	54	73	87	69	104	0
2	11	0	34	32	40	57	63	72	89	71	112	0
3	32	33	0	37	65	53	59	95	115	96	108	0
4	35	34	38	0	45	56	64	72	92	74	113	0
5	20	18	44	23	0	67	73	55	68	49	122	0
6	87	91	88	92	123	0	24	153	173	154	73	0
7	86	90	87	90	121	15	0	151	171	152	57	0
8	48	45	69	43	47	90	98	0	72	54	147	0
9	82	81	107	82	80	129	135	91	0	76	185	0
10	75	74	100	75	73	122	129	84	88	0	178	0
11	123	128	124	128	159	53	45	189	209	190	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0



APPENDIX 8 Road map with ID numbers for the base year traffic assignment (scenario 1)



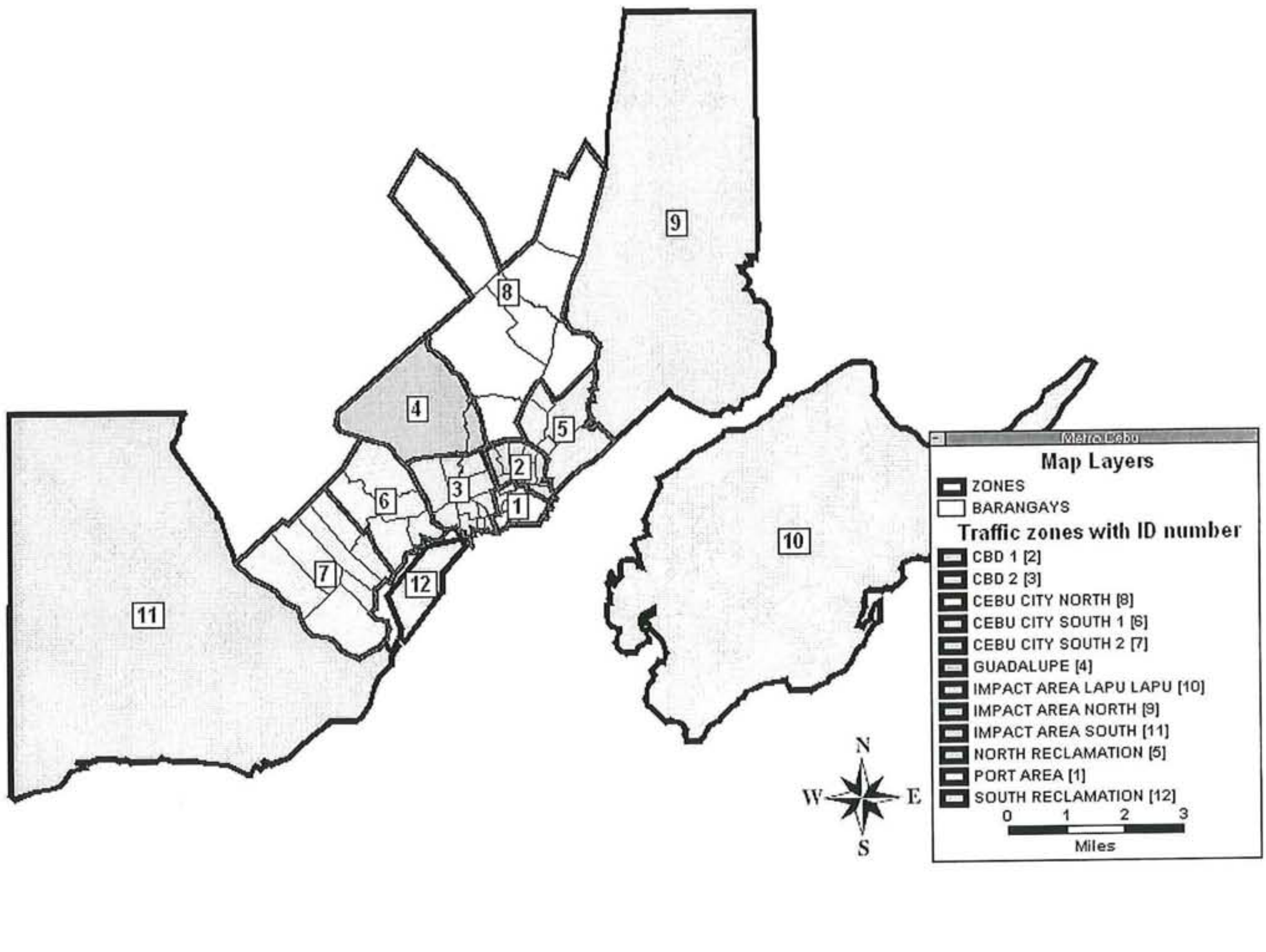
APPENDIX 9 Output for the base year traffic assignment with the matching ID numbers (scenario 1)

ID	AB FLOW	BA FLOW	TOT FLOW	MAX VOC
1	2412	2854	5265	1.4268
2	2412	2854	5265	1.4268
3	1060	762	1822	1.0602
4	1871	2167	4037	1.0834
5	1060	762	1822	2.1204
6	1635	1334	2969	3.2707
7	1802	1661	3463	0.9012
8	1767	1415	3181	0.8833
9	1444	1380	2823	1.4435
10	298	529	827	0.2647
11	379	323	701	0.1893
12	893	434	1328	0.8933
13	172	80	252	0.3431
14	23	41	64	0.0812
15	690	158	848	1.3801
16	57	131	188	0.2619
17	0	0	0	0.0000
18	0	0	0	0.0000
19	557	240	797	1.1140
20	0	0	0	0.0000
21	557	240	797	1.1140
22	557	240	797	1.1140
23	0	0	0	0.0000
24	1031	933	1964	1.0309
25	982	838	1820	0.9820
26	115	69	184	0.2293
27	770	551	1322	1.5407
28	334	643	977	0.3216
29	1382	854	2236	0.6911
30	804	454	1259	0.8044
31	922	828	1750	0.9215
32	807	873	1680	1.7463
33	272	468	740	0.9361
34	179	492	671	0.9842
35	654	941	1595	1.8813
36	475	449	923	0.9497
38	557	240	797	0.5570
39	1359	1234	2593	1.3590
40	0	0	0	0.0000
41	495	139	634	0.4948
42	652	175	827	0.6519
43	331	28	359	0.3310
44	0	0	0	0.0000
45	578	400	977	0.5777
46	532	583	1115	0.5833
47	1035	829	1864	1.0347
48	198	77	275	0.1980
49	878	793	1670	0.8776
50	1680	1381	3061	1.6800
51	331	28	359	0.3310
52	1161	932	2093	1.1610
53	266	166	432	0.2656
54	333	112	445	0.3329
55	268	888	1156	0.4440
56	240	557	797	0.2785
57	557	240	797	0.2785
59	0	0	0	0.0000
60	0	0	0	0.0000
62	955	991	1946	0.9912
63	1921	2073	3994	2.0732
64	1196	1066	2262	1.1959
65	1104	1321	2425	1.3207
66	3064	2876	5940	1.5322
67	3915	4320	8236	2.1602
68	3874	3675	7549	1.9368
69	1687	2290	3977	1.1452
71	1326	1321	2647	2.6517
72	349	697	1046	0.6971
73	518	229	747	0.5178
74	1237	891	2128	1.2372
75	1840	548	2387	1.8398
76	321	766	1087	0.7656
77	2854	2412	5265	1.4268
78	199	1083	1283	1.0834
79	313	604	917	0.6039
83	1687	2290	3977	1.1452
81	3874	3675	7549	1.9368
82	0	0	0	0.0000

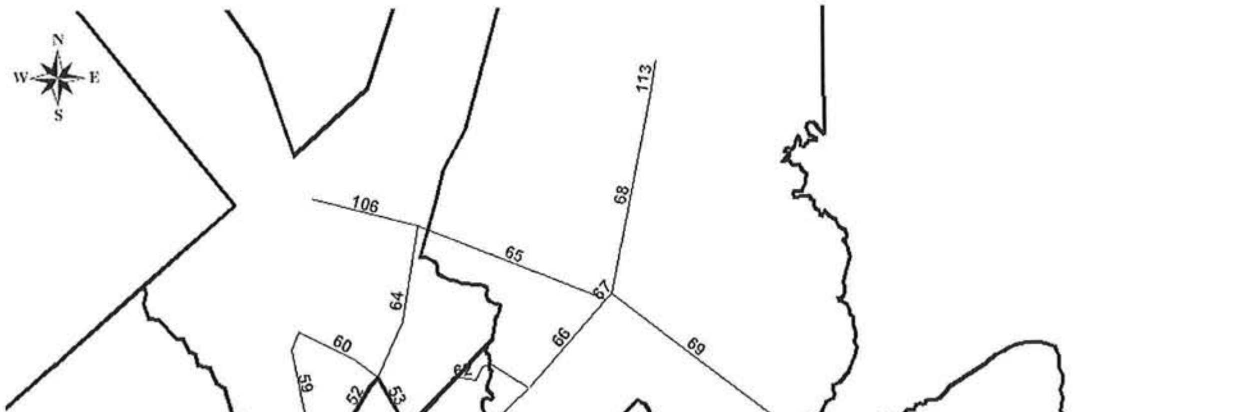
APPENDIX 10 Congested travel times between the 12 traffic zones for the zero alternative traffic assignment (scenario 2)

Congested travel times for the zero alternative

	1	2	3	4	5	6	7	8	9	10	11	12
1	0	10	31	29	37	75	85	80	135	79	171	1055
2	15	0	40	37	43	87	96	84	142	85	182	1066
3	63	65	0	66	96	107	117	133	195	138	202	1086
4	35	35	40	0	45	87	97	80	141	85	183	1066
5	21	20	48	24	0	95	105	61	116	60	191	1074
6	263	267	262	268	298	0	47	336	397	341	133	1257
7	249	252	248	253	284	23	0	321	382	326	97	1242
8	76	73	99	70	73	145	155	0	140	84	241	1125
9	111	110	139	111	108	185	195	115	0	100	281	1165
10	104	102	131	104	100	177	187	107	148	0	273	1157
11	325	328	324	329	360	99	88	397	458	402	0	1318
12	42	45	41	46	77	55	65	114	175	119	151	0



APPENDIX 11 Road map with ID numbers for the zero alternative traffic assignment (scenario 2)



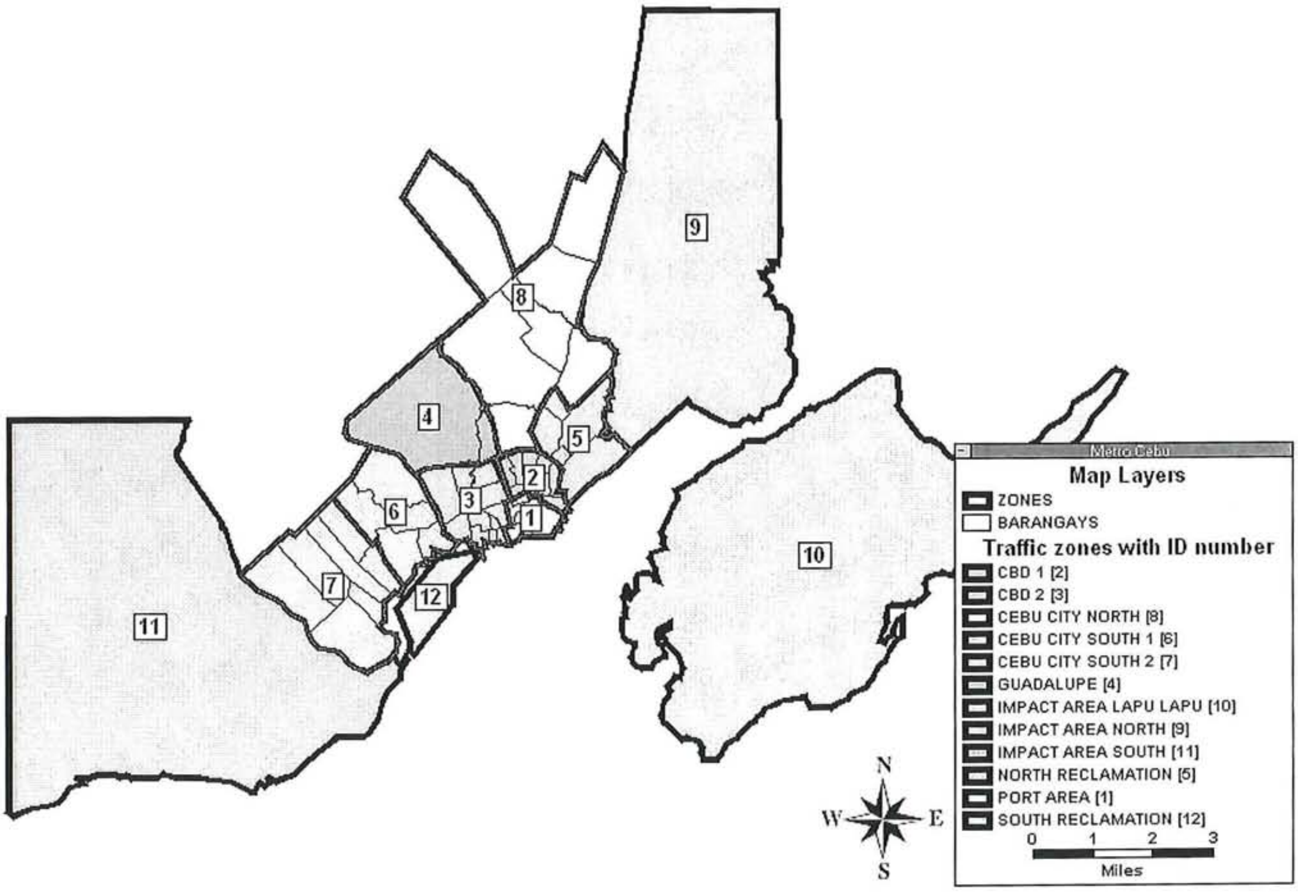
APPENDIX 12 Output for the zero alternative traffic assignment with the matching ID numbers (scenario 2)

ID	AB FLOW	BA FLOW	TOT FLOW	MAX VOC
1	3643	3702	7345	1.8508
2	3643	3702	7345	1.8508
3	1465	916	2381	2.9299
4	2899	2814	5714	1.4497
5	1465	916	2381	2.9299
6	2384	1573	3957	4.7676
7	2034	2851	4885	1.4253
8	2080	2023	4103	1.0401
9	1544	1554	3098	1.5544
10	1022	905	1927	0.5110
11	857	671	1528	0.4284
12	1063	1297	2360	1.2971
13	394	115	510	0.7884
14	43	256	299	0.5116
15	698	533	1231	1.3958
16	72	138	211	0.2768
17	0	0	0	0.0000
18	0	0	0	0.0000
19	556	538	1094	1.1112
20	0	0	0	0.0000
21	556	538	1094	1.1112
22	556	538	1094	1.1112
23	0	0	0	0.0000
24	1209	1217	2426	1.2169
25	524	110	635	0.5243
26	1108	687	1795	1.1081
27	1739	1577	3315	1.7386
28	206	453	659	0.2265
29	2121	1712	3834	1.0607
30	1203	1000	2204	1.2033
31	905	662	1567	0.9054
32	873	923	1796	1.8452
33	410	565	974	1.1293
34	328	737	1065	1.4739
35	930	1436	2366	2.8712
36	602	699	1300	1.3973
38	556	538	1094	0.5556
39	1473	1343	2816	1.4727
40	0	0	0	0.0000
41	788	340	1128	0.7880
42	859	352	1211	0.8590
43	860	330	1189	0.8597
44	515	225	741	0.2576
45	900	712	1612	0.9000
46	725	599	1323	0.7245
47	1252	1167	2419	1.2521
48	302	242	544	0.3020
49	1181	1156	2337	1.1811
50	1472	1365	2837	1.4720
51	1085	845	1930	1.0851
52	1499	1436	2935	1.4986
53	446	296	742	0.4459
54	481	161	642	0.4811
55	868	1415	2283	0.7076
56	23	330	353	0.1651
57	330	23	353	0.1651
59	18	0	18	0.0182
60	18	0	18	0.0182
62	1370	1515	2885	1.5149
63	2195	2313	4508	2.3128
64	1489	1558	3047	1.5580
65	1534	1637	3171	1.6370
66	3828	3565	7393	1.9139
67	4961	5326	10287	2.6631
68	4726	4186	8912	2.3629
69	2188	3094	5282	1.5469
100	2188	3094	5282	1.5469
101	1322	1780	3102	3.5598
102	348	922	1269	1.8432
103	517	304	820	1.0331
104	1231	1197	2428	2.4616
106	321	1013	1334	2.0262
107	3702	3643	7345	1.8508
108	199	1430	1629	2.8601
109	312	798	1110	1.5969
110	2188	3094	5282	1.5469
111	4726	4186	8912	2.3629
112	2410	0	2410	2.4100
105	1834	741	2575	3.6671

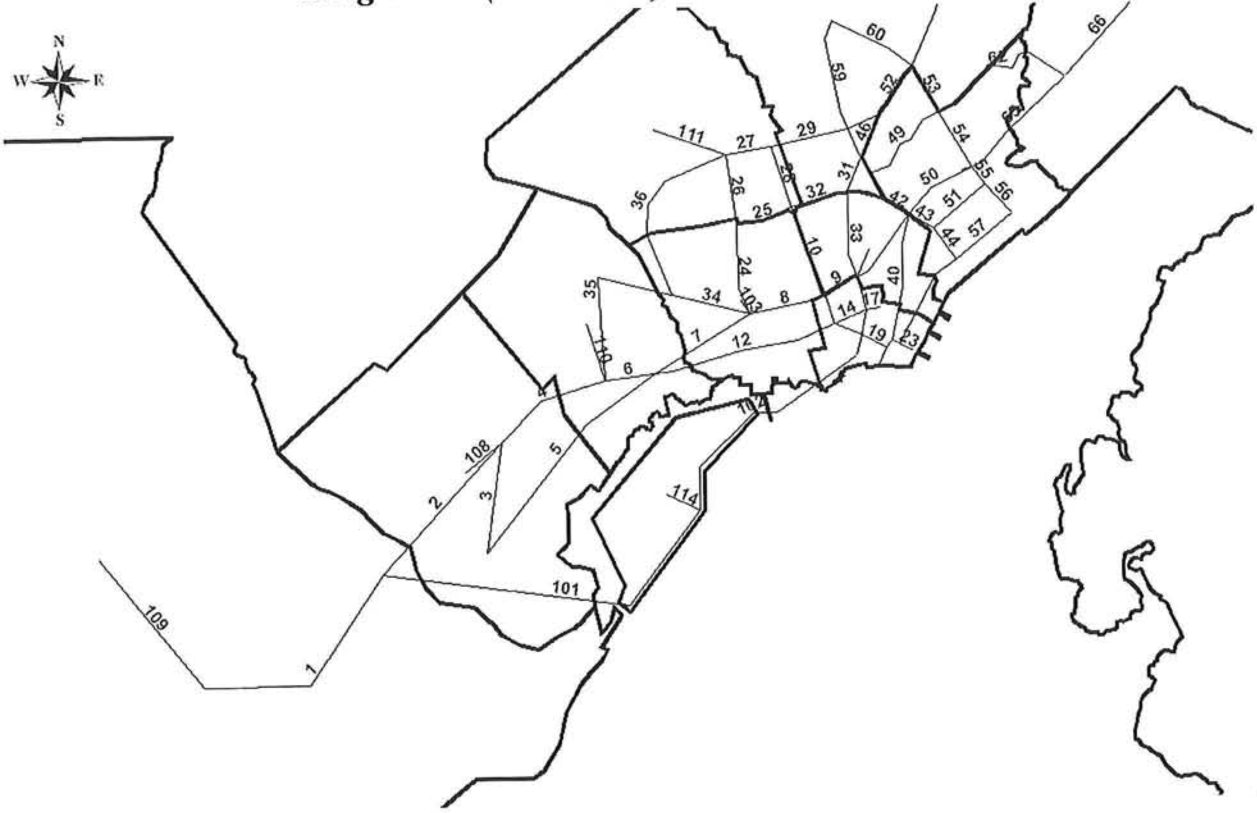
APPENDIX 13 *Congested travel times between the 12 traffic zones for the future year traffic assignment (scenario 3)*

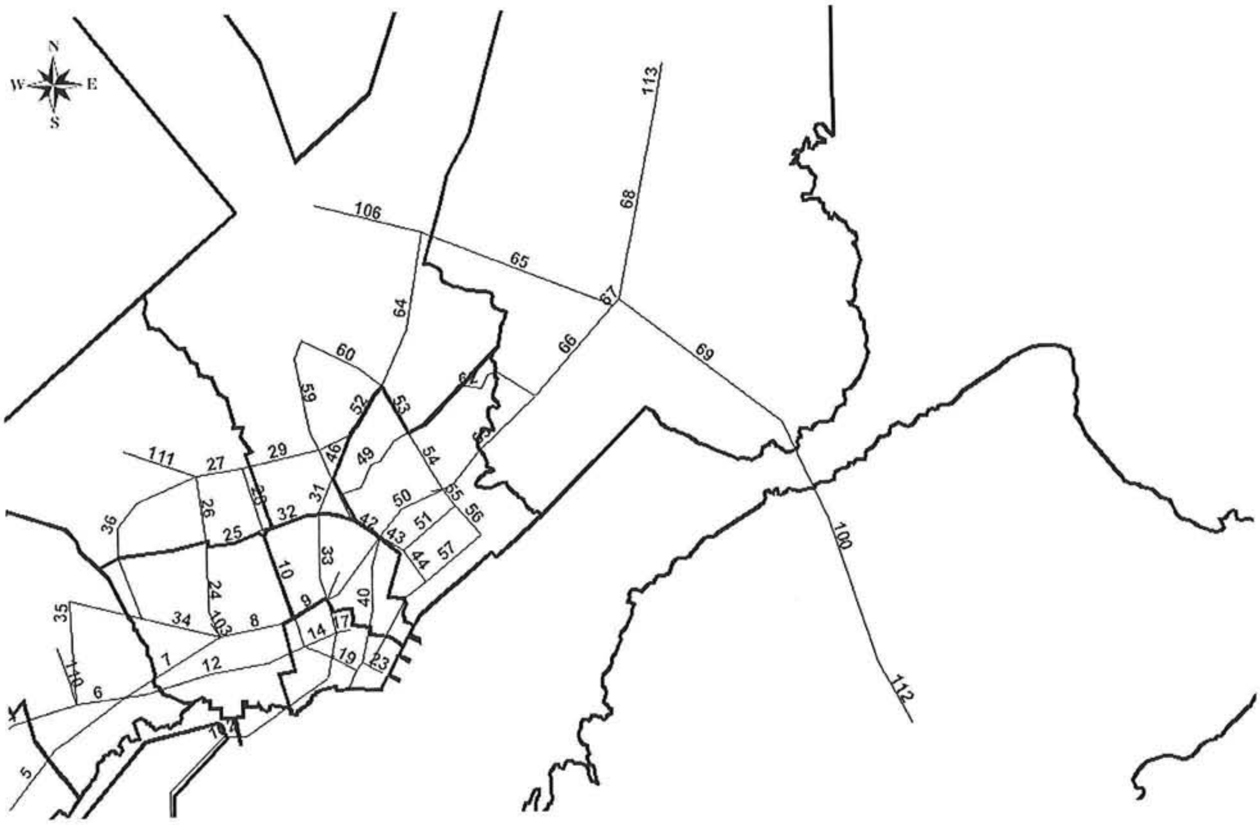
Congested travel times for the future year

	1	2	3	4	5	6	7	8	9	10	11	12
1	0	13	30	27	45	61	65	83	146	90	146	66
2	20	0	37	34	44	70	77	82	145	88	164	85
3	61	61	0	65	93	93	100	129	194	138	187	122
4	33	34	39	0	44	69	78	76	142	85	165	98
5	28	19	45	22	0	77	84	59	119	63	171	93
6	81	87	85	90	119	0	47	155	219	163	134	68
7	62	68	66	71	100	19	0	136	200	144	98	33
8	81	72	96	69	74	126	135	0	137	81	222	146
9	119	111	136	110	109	167	176	113	0	100	263	184
10	112	103	128	102	101	159	168	106	148	0	255	176
11	125	137	135	140	169	87	80	205	269	213	0	84
12	43	55	69	70	87	21	14	125	189	132	82	0



APPENDIX 14 *Road map with ID numbers for the future year traffic assignment (scenario 3)*





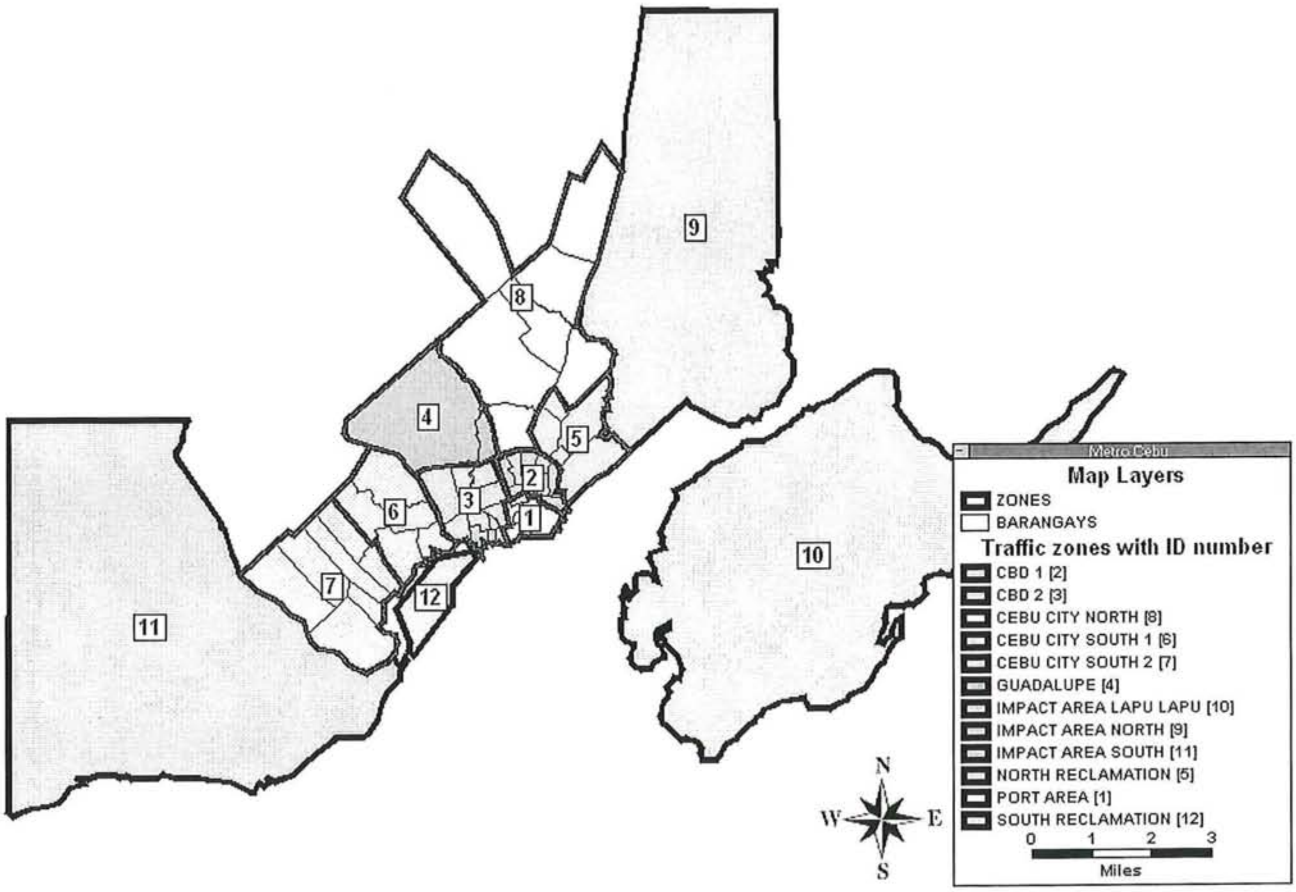
APPENDIX 15 Output for the future year traffic assignment with the matching ID numbers (scenario 3)

ID	AB_FLOW	BA_FLOW	TOT_FLOW	MAX_VOC
1	3643	3702	7345	1.8508
2	1543	3806	5349	1.9029
3	730	828	1557	1.6551
4	1249	2721	3970	1.3606
5	730	828	1557	1.6551
6	1345	1517	2862	3.0341
7	1950	1962	3912	0.9809
8	1677	1372	3049	0.8385
9	1081	1219	2300	1.2191
10	759	595	1354	0.3794
11	725	118	843	0.3625
12	124	383	507	0.3828
13	773	694	1467	1.5458
14	0	0	0	0.0000
15	522	174	696	1.0448
16	694	773	1467	1.5458
17	0	0	0	0.0000
18	1822	1616	3438	3.6431
19	954	945	1900	1.9083
20	0	0	0	0.0000
21	954	945	1900	1.9083
22	854	813	1667	1.7078
23	0	0	0	0.0000
24	1143	1131	2273	1.1428
25	367	92	459	0.3671
26	1039	776	1815	1.0390
27	1700	1417	3116	1.6998
28	136	149	285	0.0746
29	1707	1411	3118	0.8535
30	481	207	689	0.4814
31	848	825	1673	0.8480
32	731	830	1561	1.6604
33	470	622	1092	1.2432
34	347	218	565	0.6947
35	798	729	1527	1.5962
36	459	519	977	1.0372
38	854	813	1667	0.8539
39	1488	1283	2771	1.4879
40	100	132	233	0.1324
41	617	344	961	0.6171
42	660	393	1054	0.6603
43	799	460	1259	0.7990
44	393	339	731	0.1964
45	1226	1204	2429	1.2256
46	105	117	222	0.1170
47	1190	950	2140	1.1898
48	150	156	306	0.1563
49	1147	900	2047	1.1466
50	1449	1349	2798	1.4495
51	1138	852	1990	1.1375
52	1343	1309	2651	1.3425
53	360	234	594	0.3599
54	866	345	1210	0.8658
55	1273	1653	2926	0.8265
56	420	515	936	0.2577
57	515	420	936	0.2577
59	0	0	0	0.0000
60	0	0	0	0.0000
62	1373	1522	2894	1.5217
63	2225	2315	4540	2.3153
64	1515	1608	3123	1.6078
65	1497	1623	3119	1.6229
66	3837	3598	7435	1.9185
67	4964	5329	10293	2.6646
68	4726	4186	8912	2.3629
69	2188	3094	5282	1.5469
100	2188	3094	5282	1.5469
101	2974	769	3743	1.4868
102	1616	1822	3438	0.9108
103	1321	1779	3100	3.5578
104	348	922	1269	1.8432
105	517	304	820	1.0332
106	1231	1197	2428	2.4617
107	1834	741	2575	3.6672
108	321	1013	1334	2.0258
109	3702	3643	7345	1.8508
110	199	1430	1628	2.8596
111	312	798	1110	1.5968
112	2188	3094	5282	1.5469
113	4726	4186	8912	2.3629
114	2410	0	2410	1.2050

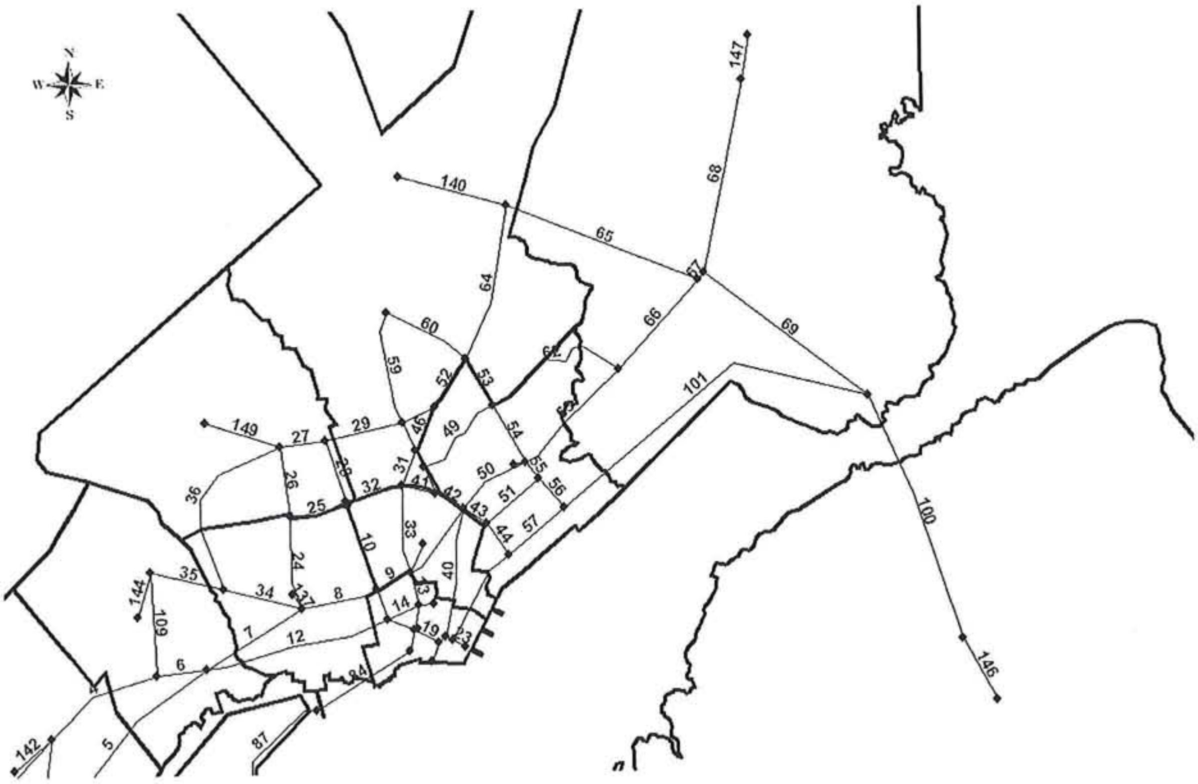
APPENDIX 16 Congested travel times between the 12 traffic zones for the scenario 4 traffic assignment

Congested travel times for scenario 4

	1	2	3	4	5	6	7	8	9	10	11	12
1	0	11	23	20	114	25	37	60	156	58	98	28
2	13	0	26	23	110	28	43	59	153	54	111	40
3	40	41	0	43	144	42	57	89	186	88	126	67
4	23	24	27	0	109	27	45	54	150	54	114	50
5	20	14	32	15	0	35	50	42	131	34	117	47
6	62	63	62	65	166	0	35	111	208	110	104	46
7	59	65	63	67	168	21	0	113	210	112	76	18
8	47	41	58	38	119	58	75	0	146	56	144	74
9	85	79	97	78	154	98	115	88	0	85	183	112
10	65	60	78	61	135	81	96	79	164	0	163	92
11	121	127	125	129	230	83	69	175	272	174	0	69
12	53	63	70	72	166	27	14	112	209	110	72	0



APPENDIX 17 Road map with ID numbers for the scenario 4 traffic assignment



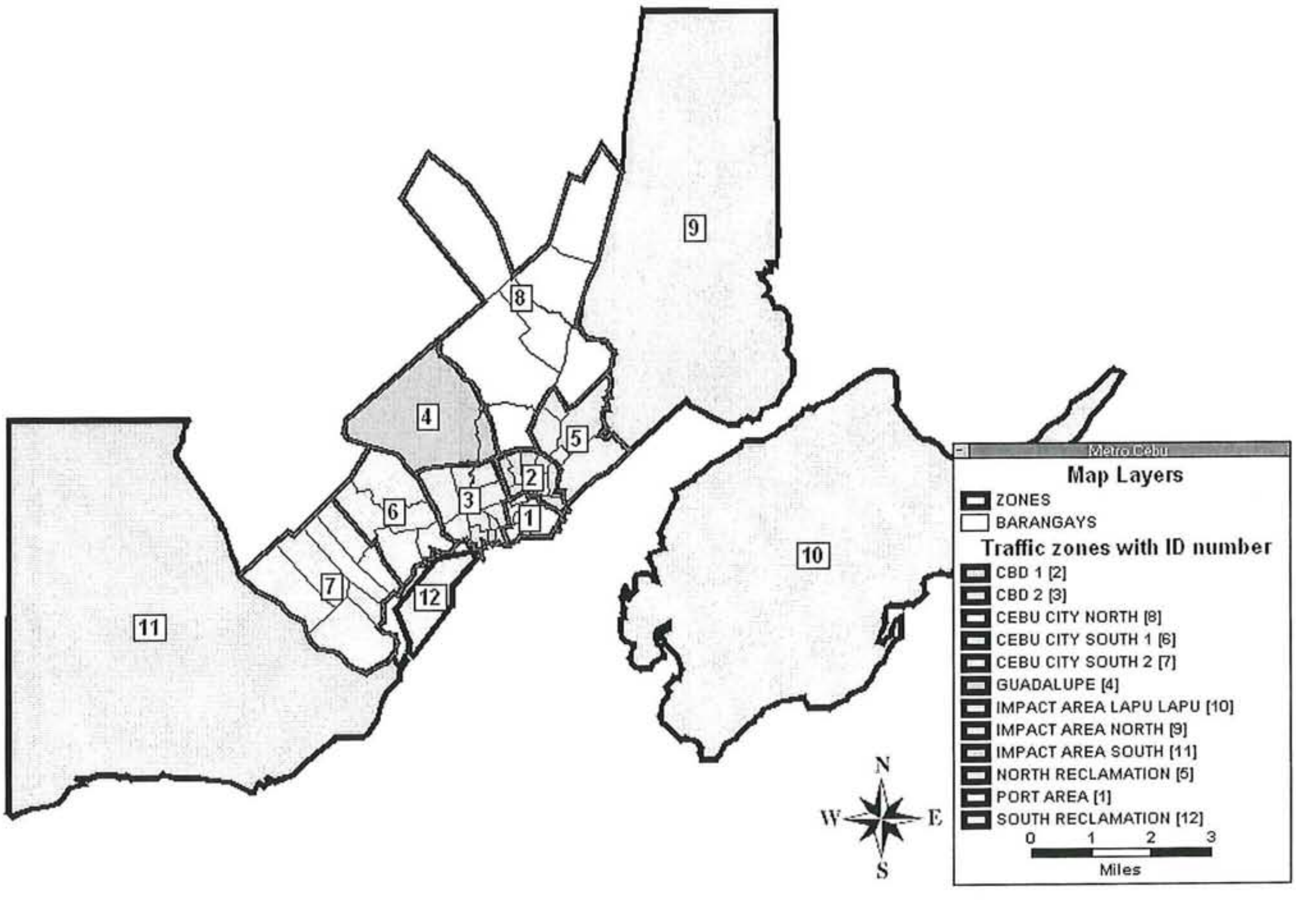
APPENDIX 18 Output for the scenario 4 traffic assignment with the matching ID numbers

ID	AB_FLOW	BA_FLOW	TOT_FLOW	MAX_VOC
1	3643	3702	7345	1.8508
2	2363	2628	4991	1.3139
3	923	579	1501	1.8453
4	1854	1867	3721	0.9334
5	923	579	1501	1.8453
6	1579	1272	2851	3.1583
7	2034	1832	3866	1.0171
8	2032	1286	3318	1.0161
9	1236	864	2100	1.2355
10	474	1132	1606	0.5662
11	211	494	705	0.2470
12	468	19	486	0.4676
13	745	758	1504	1.5168
14	0	0	0	0.0000
15	512	347	859	1.0241
16	758	745	1504	1.5168
17	0	0	0	0.0000
18	1523	1847	3370	3.6940
19	1114	899	2014	2.2290
20	0	0	0	0.0000
21	1114	899	2014	2.2290
22	991	865	1856	1.9828
23	0	0	0	0.0000
24	1237	979	2216	1.2369
25	650	250	900	0.6503
26	730	587	1317	0.7299
27	1585	962	2547	1.5854
28	70	819	889	0.4095
29	2283	910	3192	1.1413
30	1081	356	1437	1.0808
31	525	353	878	0.5252
32	661	971	1633	1.9426
33	250	703	953	1.4062
34	77	516	593	1.0322
35	299	1114	1413	2.2281
36	222	598	820	1.1959
38	991	865	1856	0.9914
39	1644	1235	2879	1.6443
40	123	34	157	0.1231
41	1314	379	1692	1.3137
42	1499	470	1969	1.4993
43	1645	782	2426	1.6448
44	457	138	595	0.2285
45	1202	554	1756	1.2018
46	160	114	274	0.1600
47	1318	719	2037	1.3178
48	186	91	277	0.1856
49	1132	628	1760	1.1322
50	1622	958	2580	1.6218
51	1221	676	1898	1.2213
52	1316	714	2030	1.3157
53	389	62	451	0.3892
54	543	96	639	0.5426
55	258	1398	1655	0.6988
56	804	1399	2204	0.6997
57	1415	970	2385	0.7075
59	0	0	0	0.0000
60	0	0	0	0.0000
62	1138	752	1890	1.1378
63	1277	1421	2699	1.4211
64	1152	877	2030	1.1523
65	1049	904	1953	1.0492
66	2174	2415	4589	1.2076
67	3465	3078	6542	1.7323
68	5328	4186	9514	2.6641
69	1449	2205	3654	1.1025
84	1847	1523	3370	0.9235
86	1841	1635	3476	0.9207
87	1847	1523	3370	0.9235
101	1983	2133	4117	1.0667
109	718	399	1117	1.4367
111	350	828	1177	1.6551
112	518	257	775	1.0359
114	3008	615	3623	6.0164
118	314	704	1018	1.4086
137	1329	1691	3021	3.3828
140	1240	1110	2349	2.4791
142	323	919	1241	1.8375
143	3702	3643	7345	1.8508
146	2188	3094	5282	1.5469
146	2188	3094	5282	1.5469
147	5328	4186	9514	2.6641
148	602	720	1322	0.3600
149	200	1335	1535	2.6699

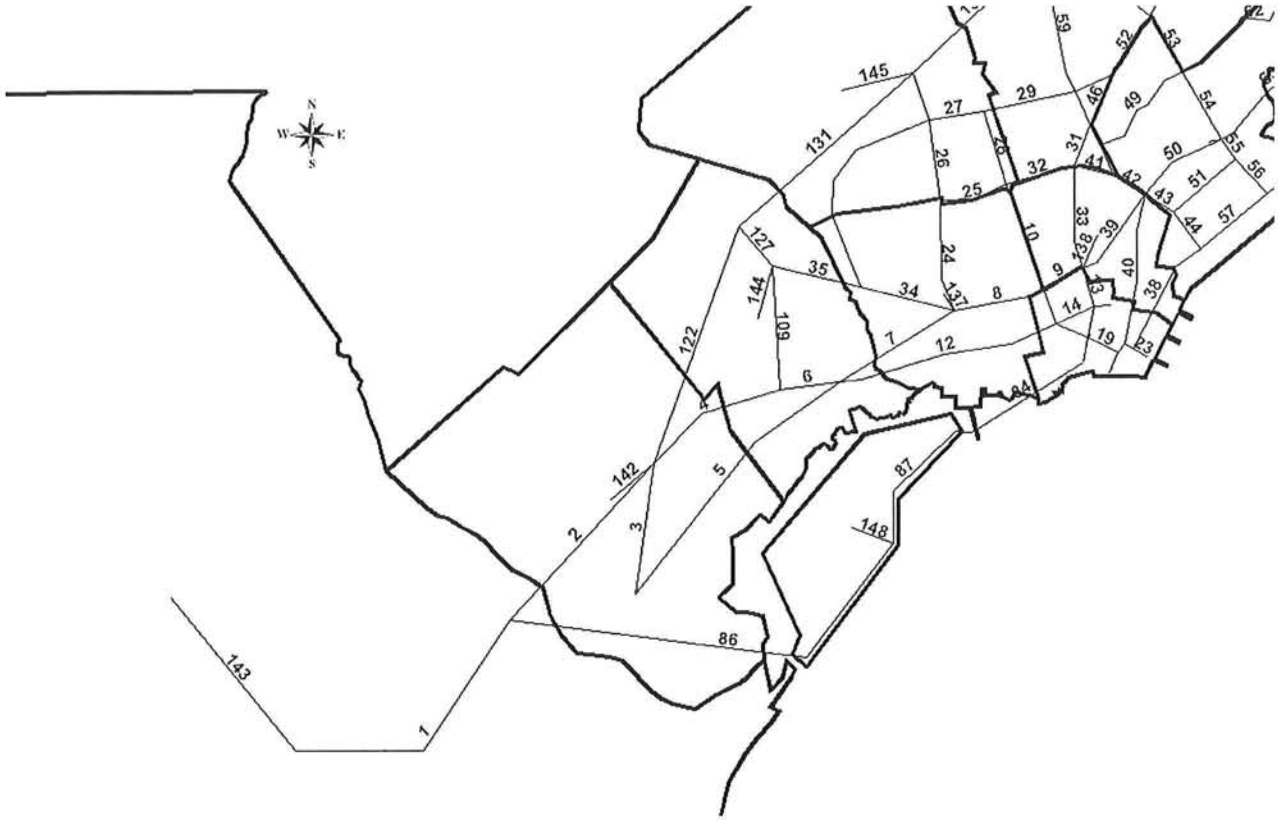
APPENDIX 19 Congested travel times between the 12 traffic zones for the scenario 5 traffic assignment

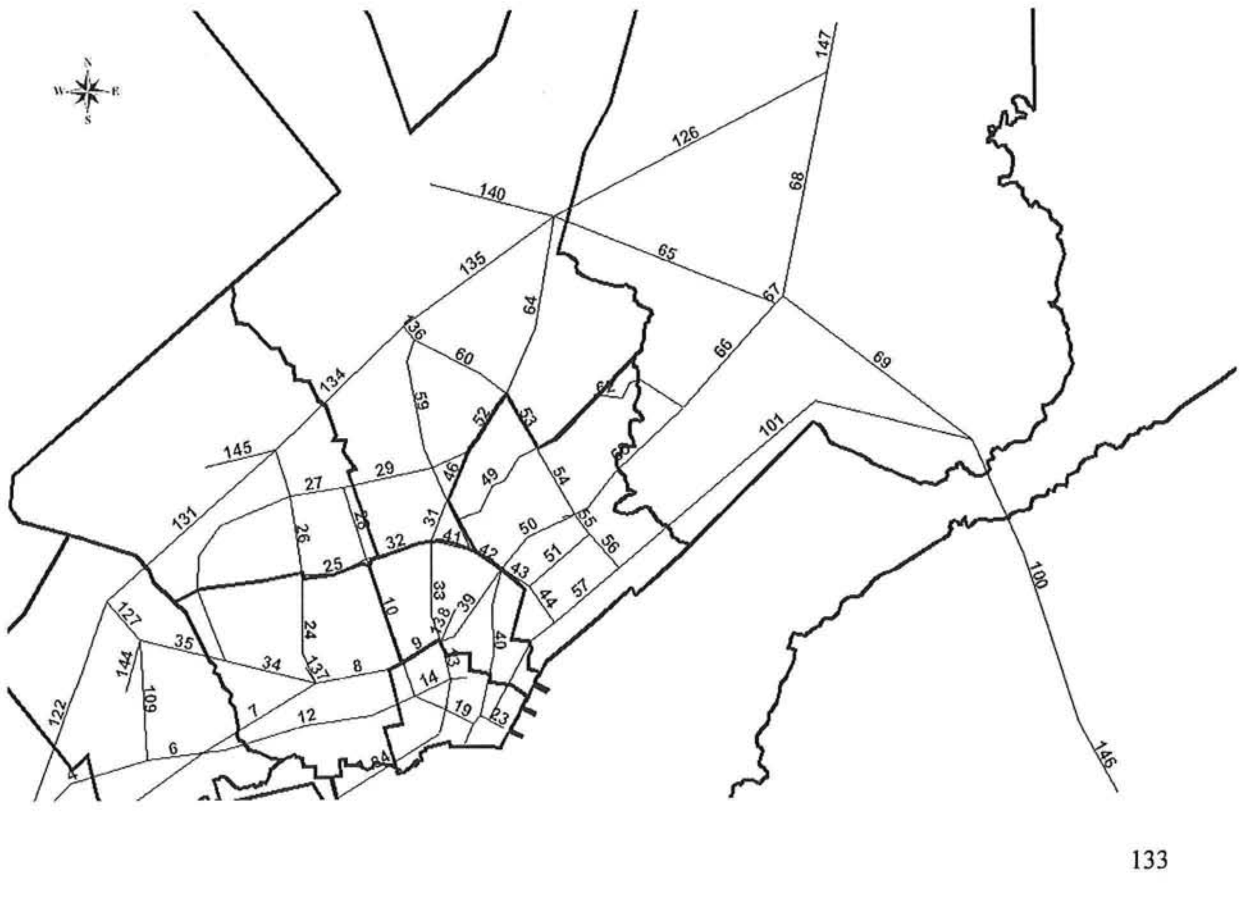
Congested travel times for scenario 5

	1	2	3	4	5	6	7	8	9	10	11	12
1	0	10	22	20	109	25	28	57	126	51	90	20
2	13	0	25	23	107	28	33	54	125	51	102	32
3	39	40	0	43	139	42	47	86	157	83	116	58
4	24	24	27	0	108	19	31	51	123	52	100	41
5	18	13	31	15	0	28	39	41	106	33	107	37
6	40	41	40	39	140	0	30	83	155	84	99	41
7	37	41	40	39	140	19	0	83	155	84	76	17
8	46	41	56	38	119	51	63	0	121	55	131	65
9	73	68	86	68	144	81	93	79	0	76	162	92
10	62	59	77	61	135	74	84	78	140	0	152	81
11	93	103	103	102	202	82	70	146	218	144	0	69
12	26	35	47	45	134	26	14	82	152	76	72	0



APPENDIX 20 Road map with ID numbers for the scenario 5 traffic assignment





APPENDIX 21 Output for the scenario 5 traffic assignment with the matching ID numbers

ID	AB_FLOW	BA_FLOW	TOT_FLOW	MAX_VOC
1	3643	3702	7345	1.8508
2	2583	2651	5234	1.3257
3	420	45	465	0.8402
4	1395	1117	2511	0.6973
5	420	45	465	0.8402
6	1159	787	1945	2.3173
7	1365	814	2179	0.6825
8	1182	580	1762	0.5909
9	955	582	1537	0.9545
10	56	227	283	0.1137
11	182	124	305	0.0908
12	214	18	232	0.2138
13	708	689	1397	1.4157
14	0	0	0	0.0000
15	395	142	537	0.7906
16	689	708	1397	1.4157
17	0	0	0	0.0000
18	1356	1484	2840	2.9679
19	921	782	1702	1.8414
20	0	0	0	0.0000
21	921	782	1702	1.8414
22	827	778	1605	1.6546
23	0	0	0	0.0000
24	1134	591	1724	1.1337
25	578	339	917	0.5782
26	255	559	814	0.5590
27	1624	518	2143	1.6244
28	99	25	125	0.0497
29	1530	498	2027	0.7648
30	837	308	1145	0.8365
31	269	408	677	0.4079
32	376	861	1237	1.7226
33	99	545	643	1.0891
34	29	260	289	0.5200
35	29	578	607	1.1560
36	0	318	318	0.6360
38	827	778	1605	0.8273
39	1457	1072	2529	1.4571
40	93	4	97	0.0934
41	988	196	1184	0.9884
42	1377	493	1870	1.3765
43	1415	644	2059	1.4147
44	477	109	587	0.2387
45	694	200	894	0.6941
46	95	143	238	0.1425
47	1085	466	1551	1.0853
48	388	297	686	0.3882
49	697	168	866	0.6972
50	1512	924	2437	1.5123
51	974	572	1546	0.9742
52	837	295	1132	0.8366
53	464	86	550	0.4636
54	378	73	451	0.3783
55	178	1455	1633	0.7275
56	391	1266	1657	0.6329
57	1268	850	2118	0.6339
59	11	1	12	0.0106
60	146	4	150	0.1459
62	782	182	965	0.7825
63	1148	1372	2520	1.3715
64	884	578	1461	0.8836
65	794	815	1608	0.8145
66	1554	1931	3485	0.9655
67	2721	2364	5085	1.3603
68	3846	3041	6887	1.9230
69	1213	1662	2874	0.8308
84	1484	1356	2840	0.7420
86	1440	1430	2871	0.7202
87	1484	1356	2840	0.7420
100	2188	3094	5282	1.5469
101	1457	1914	3370	0.9568
109	330	236	566	0.6599
122	1278	1403	2681	1.4030
126	1482	1145	2627	1.4822
127	771	279	1049	0.7706
131	1827	1461	3288	1.8275
133	1329	845	2174	1.3289
134	1414	1141	2555	1.4141
135	1282	1141	2423	1.2817
136	147	15	162	0.1470
137	1328	1690	3019	3.3805
138	349	827	1177	1.6548
139	518	257	775	1.0358
140	1243	1113	2356	2.4860
141	3007	614	3621	6.0145
142	323	919	1241	1.8377
143	3702	3643	7345	1.8508
144	200	1335	1535	2.6702
145	314	705	1019	1.4097
146	2188	3094	5282	1.5469
147	5328	4186	9514	2.6641
148	602	720	1322	0.3600