Chapter 4

ROUTE SELECTION

4.1 Introduction

The decision making process for route selection is under 4 constrains which are the estimated demand of each route, size of investment, needs of passengers, and law and regulation.

Size of the estimated demand for each route is the key decision factor in route selection as demand is the key to survival of the project. When comparing the 4 constrains, demand is the most important factor in route selection. The demand can be estimated through many different processes. In this thesis, the classic four-step model or sequential is chosen as the key model for demand estimation.

Size of investment is the second most important factor of the 4 constrains. If the estimated demand was so high but at the same time the size of investment is huge, so huge that it would be very difficult to get a return. Therefore when considering the size of estimated demand of each route, at the same time, the size of investment should also be taken into consideration. The factor that often affects the size of investment is the length of the route.

The third constrain, the needs of passengers, must be included into decision process. The needs of passengers must be considered if the bus operation would have successful future. The more needs are supplied, the better chance the project would survive. The factor that have the affect on this constrain, route selection wise, is the need to travel. The need to travel of passengers includes the origin and destination of a trip. Therefore, land used is the key factor when considering the need to travel of passengers.

The final constrain is the law and regulation. After all, if the law does not allow the bus to operate on those roads the selected route passes through, the operation could not be established. Therefore, law and regulation play an important in route selection. However, the 33 routes that the route selection process is selecting from is already considered the law and regulation, therefore all the roads lies on those 33 routes are operational.

After the 4 constrain is all considered, then the decision could be made to which route would be the most suitable route for the bus operation.

The decision making process on route selection is presented in **Figure 4.1** on the following page.

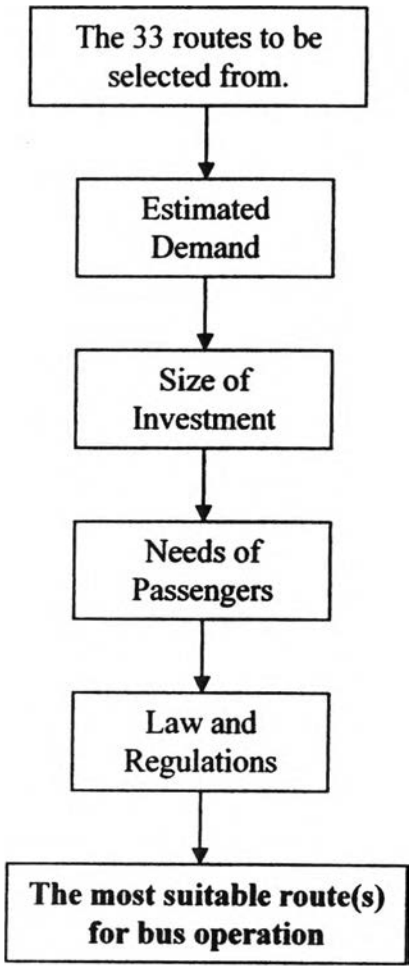

Figure 4.1: Decision making process on route selection

4.2 The routes

The research on public transportation system management in Chiang Mai municipal area by Saowapol and Therarattanaket (2004) has set up 33 routes. The routes cover the entire municipal area and parts of 3 other districts. The routes were originally design for the purpose of running minibuses on fixed-route and fixed-schedule. Although the routes are designed for the use of minibus, the method of route formation was the same as designing the routes for other public transportation means.

These 33 routes were formed by Manual Approach where the experience and knowledge of experts is the key in route design. While the judgment of these experts is based on mainly their knowledge and experience, some quantitative indicators are also included in designing process. The mixed route network, radial-circumferential, is the pattern used for these 33 routes since the road network in the study area is radial network but to increase the coverage feeder routes (Soi or side road routes) are added.

The 33 routes can be divided into three categories according to the type of route. The first type is the main routes, the second type is the sub-routes, and finally the third type is the feeder routes (Soi or side-road routes), with total distance of 470 kilometers (two ways).

There are 13 different routes in the first category, the main routes, which cover mainly the crowded city. They also provide connections of suburbs and the city with the center at Waroros Market.

The Sub Routes has 7 different routes, provide the connection for the two sides of Ping River. They also connect to three main transport stations which are the airport, the train station and the inter-city bus station.

For the feeder routes, there are 13 different routes which provide connection for small communities to the main and sub routes.

The four figures below show the maps for each type of route, as well as a map which shows all three different types of route together.

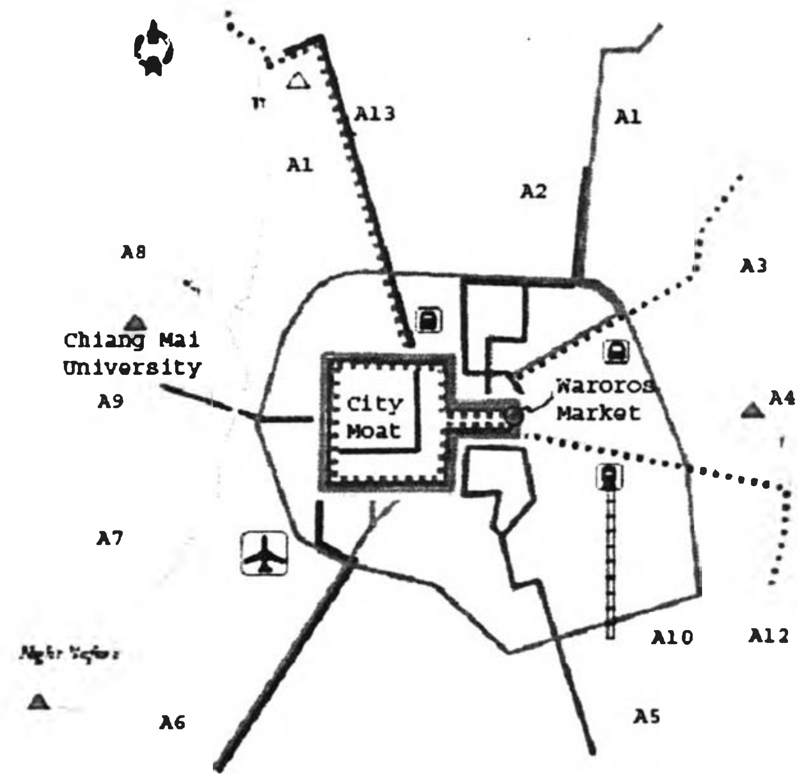

Figure 4.2: Main Routes

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

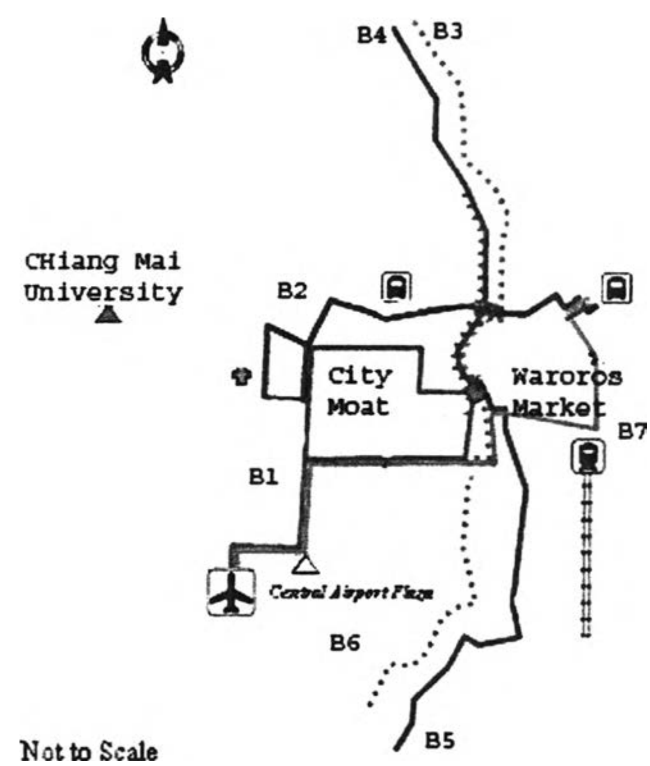

Figure 4.3: Sub Routes

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

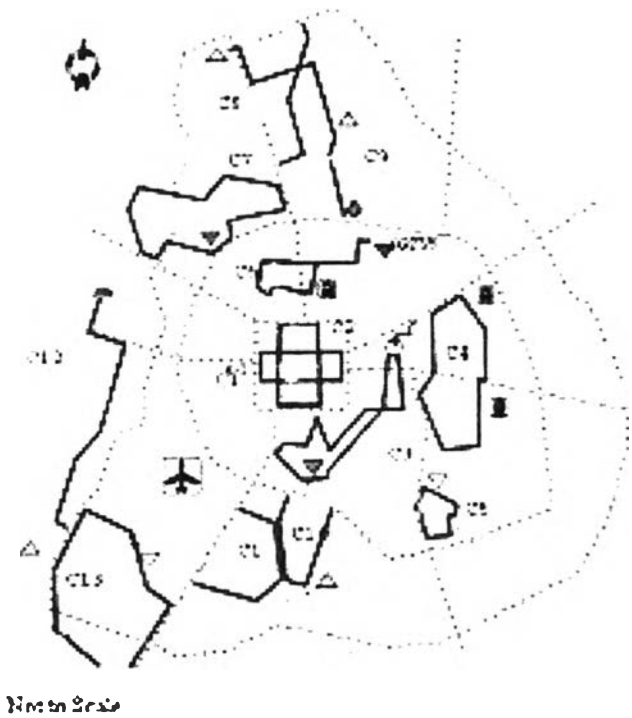

Figure 4.4: Feeder Routes

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

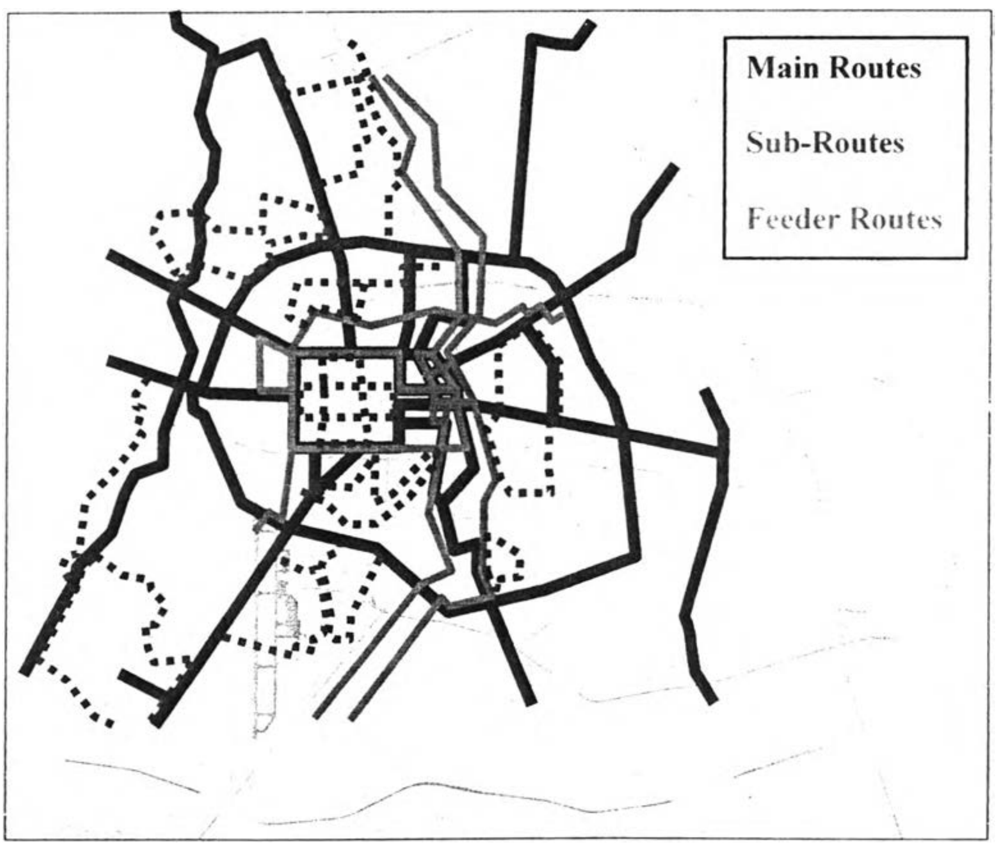

Figure 4.5: Routes

Source: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

With the 33 routes are designed for minibuses, some adjustments are needed for them to be suitable to be used as a bus route. The interview with Mr. Kongdech Therarattanaket, an ITSC Chiang Mai University researcher and the member of public transportation system management in Chiang Mai municipal area research team, suggested that the adjustment for the routes to be suitable for the buses, the feeder routes must be eliminated. The main routes and sub-routes are situated on 2 lane and 4 lane roads, while the feeder routes are mostly situated on 1 lane roads. The buses, if used on a 1 lane road, can create traffic blockage which would worsen the traffic congestion instead of improving. Therefore, from all 33 original routes, only 20 routes, 13 main routes and 7 sub-routes, are suitable for the purpose of this thesis.

4.3 Demand estimation

The bus route(s) that is suitable for co-investment must have the suitable road width. From the previous paragraph, the routes with unsuitable road width are eliminated. On the following paragraphs, the demand of each of the 20 routes is estimated.

Demand estimation method called Sequential Model or the Four-step model is applied to each routes. The four steps are Trip Generation, Trip Distribution, Modal Split, and Trip Assignment. The outcome of the Sequential Model is the estimated user demand for each route. The route(s) with the highest estimated demand is likely to be selected as the route for co-investment. However, there are other factors involve in the selection process such as size of investment, needs of passengers, and law and regulation

4.3.1 Trip generation

Trip generation is the process that estimates trip production and trip attraction of each area. Trip is generated solely from the need to travel not the benefits of the trip itself. Therefore the purpose of each trip is commonly used to categorize trip generation. However, trip can be categorized by other ways, for example, by person type, and by time of day.

Time of day was used to categorize trip generation in each area in the research of Saowapol and Therarattanaket (2004). The area of trip generation is classified by the name of the street. The study collected the primary data from 22 spots which covered the main and sub routes entirely. The time of collection was from 6 am to 6 pm, on weekdays. The average trip per day of each road is shown in **Table 4.1** below:

Street	Amount of Traffic (vehicle per day)
Suthep	45,632
Huaykeaw	44,665
Chotana	53,533
Rattanakosin	35,718
Wang Singh Kam	21,508
Faham	23,873
Keawnawarat	34,655
Charernmaung	44,894
Chiang Mai-Lamphun	43,423
Charernprates	15,539
Changklan	35,285
Taphae	53,639
Changmoi	24,786
Chiang Mai-Lampang	71,779
Mahidol	70,326
700th Stadium	27,731
Bunreungrit	59,246
Arag	25,644
Maninoparat	53,580
Mulmaung	61,775
Sriphum	35,839
Changloh	46,501
Prapokloa	24,294
Rachadamnern	15,529

Table 4.1: Average Amount of Traffic in Chiang Mai Municipal Area

Sourec: **Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University**

The **following 4 graphs** shows the average trip generation by hour of the 4 roads that represent the inner ring roads, the inner city roads, the city roads, and the city moat roads.

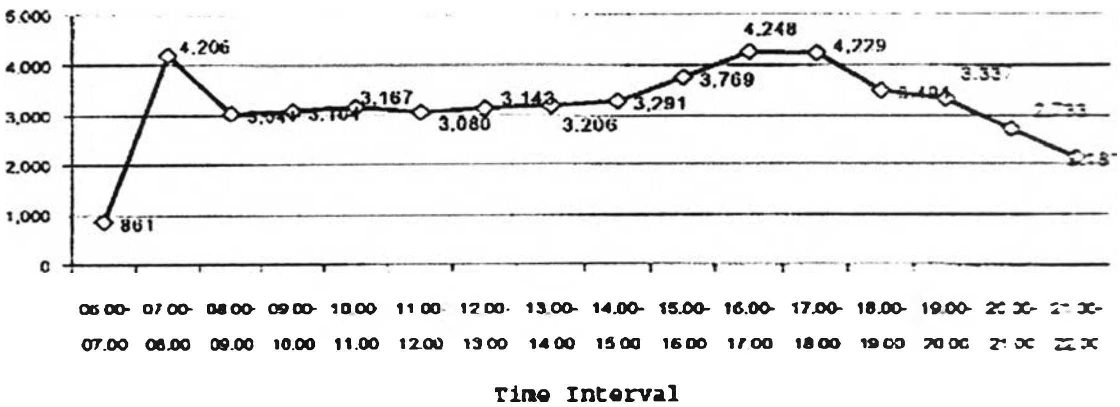

Figure 4.6: Amount of Traffic of Each Hour on Tapae Road

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

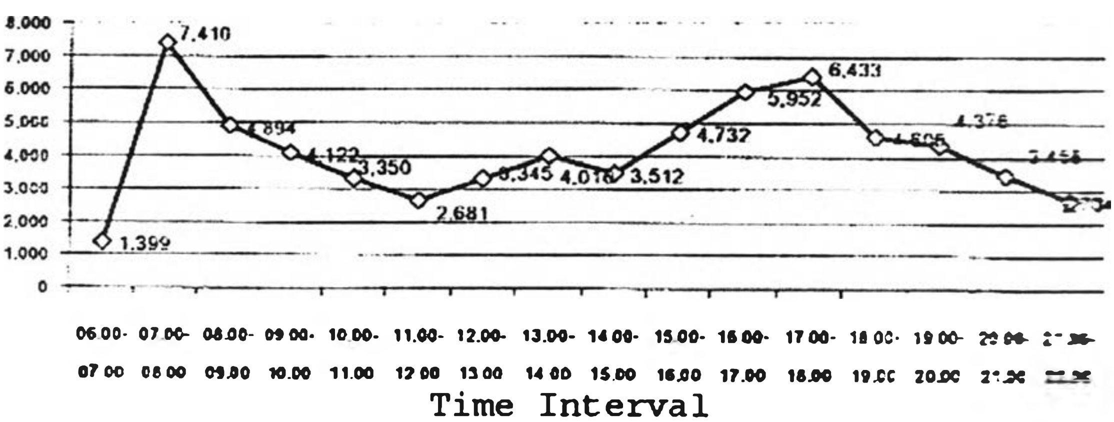

Figure 4.7: Amount of Traffic of Each Hour on Mahidol Road

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

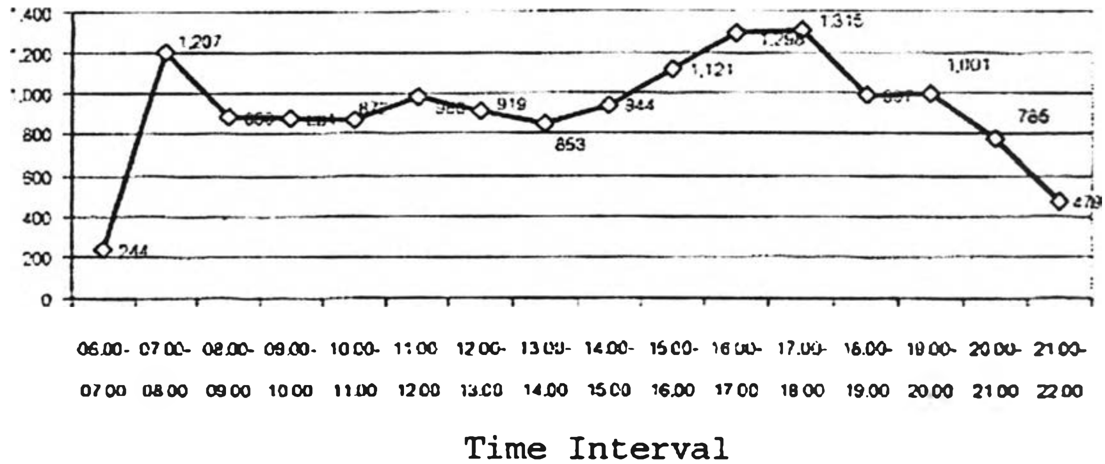

Figure 4.8: Amount of Traffic of Each Hour on Rachadamnern Road

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

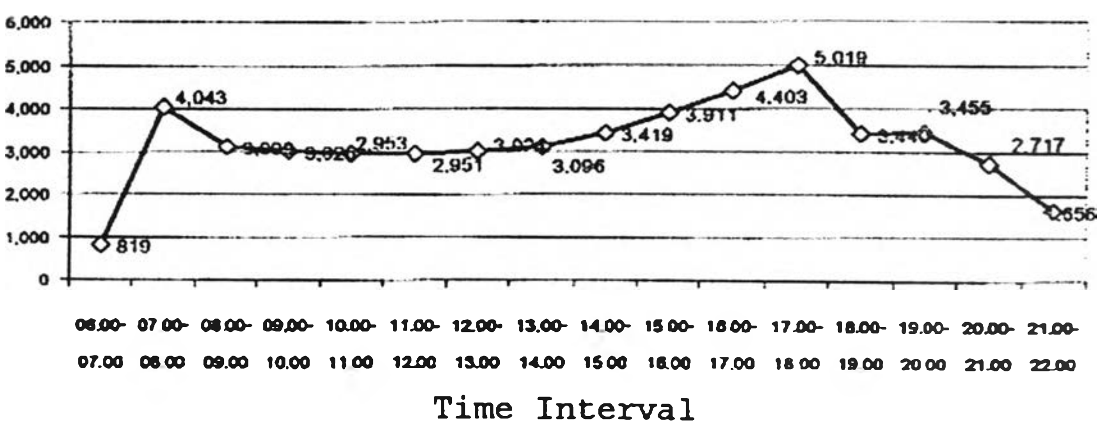

Figure 4.9: Amount of Traffic of Each Hour on Maninoparat Road

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

4.3.2 Trip distribution

In this second step of the demand estimation, trip distribution is to pair the trip-production to trip-attraction to generate the total number of trip among each of the study area.

The study of Saowapol and Therarattanaket (2004), shows that, at present, public transportation passengers are those who have no other choice of transportation. These people rely on minibus as the main mean of public transportation. Also, it shows the needs of current minibus users for fixed-route and fixed-schedule public transportation system. Therefore to be precise on demand estimation, the data used in trip distribution can be the data from those trips generated by minibus since the minibus users are the people who are most likely to be the bus passengers in the future.

Based on the research of Saowapol and Therarattanaket (2004), the area of study is divided into 17 zones as in **Figure 4.10.** The study concluded that most trips are generated and attracted by zone1, the inner city area, with average of 36,840 trips per day which equivalent to 15.6% of all trip generated in area of study. The second highest zone was zone 2, Waroros Market area, with average of 22,924 trips per day which equivalent to 9.7%. Zone 7, Chiang Mai University and Suandok Hospital area, was the third highest zone, with average 19,884 trips per day which equivalent to 8.4%. The primary data of average trip generation of each zone is presented in **Table 4.2** below.

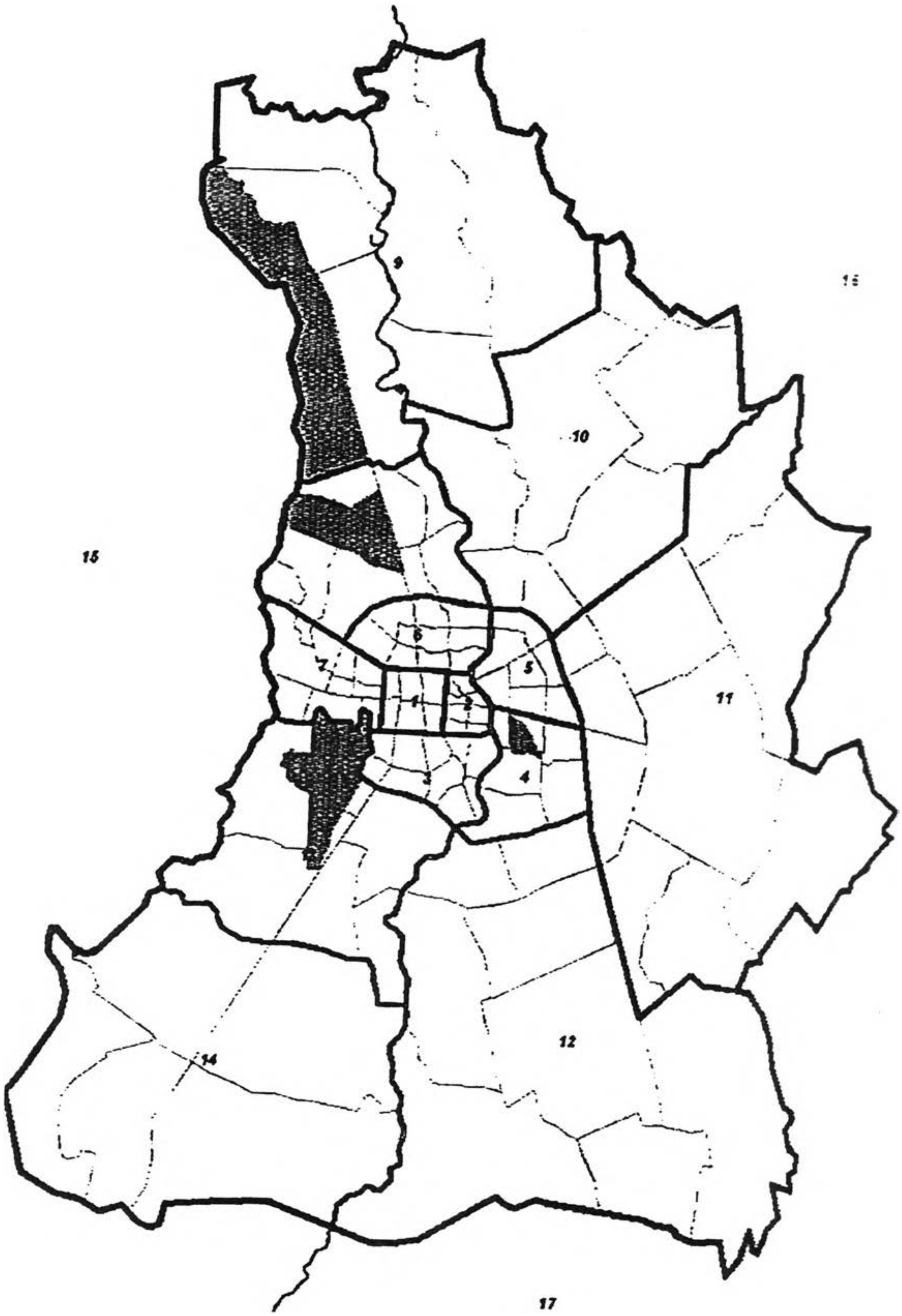

Figure 4.10: The Zone

Source: Public Transportation Planning, Saowapol and Therarattanakket (2003), ITSC Chiang Mai University

Origin District	Destination District																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	TOTAL
1	2289	2675	1086	334	578	1500	1566	482	328	247	116	58	1529	689	0	36	681	14194
2	2512	790	1291	425	449	1203	754	145	311	907	453	834	292	68	16	198	847	11495
3	2317	1141	2097	528	145	624	1224	93	85	127	181	170	128	50	0	0	70	8980
4	1452	563	528	1833	503	347	98	93	159	237	362	649	539	20	36	36	801	8256
5	589	529	357	961	344	335	505	179	99	594	323	229	86	0	218	109	17	5474
6	1906	1129	674	347	283	1628	482	420	475	542	79	68	158	149	1171	97	728	10336
7	6273	855	1272	147	447	284	693	170	92	218	76	16	703	0	0	0	597	11843
8	1219	125	69	93	203	386	205	486	463	45	108	81	0	34	255	73	36	3881
9	304	246	56	182	100	386	132	373	2705	560	62	0	62	0	1022	71	50	6311
10	328	858	127	228	485	401	265	39	560	682	220	23	47	0	40	86	100	4489
11	169	455	159	362	293	79	112	108	62	220	1132	158	54	0	0	114	31	3508
12	74	503	116	646	245	26	32	48	36	23	216	3905	51	92	100	72	788	6973
13	1312	292	209	68	458	0	772	0	62	47	77	51	738	445	0	36	186	4753
14	298	56	50	0	0	163	108	34	0	0	0	72	14	2768	0	0	269	3832
15	324	198	73	109	0	1099	291	772	1250	50	22	100	250	50	50	50	650	5338
16	161	109	72	72	436	315	290	72	200	71	186	194	73	50	50	0	100	2451
17	1119	905	106	145	178	615	512	181	150	64	109	525	490	39	250	300	0	5688
	22646	11429	8342	6480	5147	9391	8041	3695	7037	4634	3722	7133	5214	4454	3208	1278	5951	117802

Table 4.2: Trip Assignment for Each Zone

Source: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

4.3.3 Modal split

The purpose of modal split is to determine the percentage of trips using each of the transportation modes available. Stated in previous part that, from the study, transit riders can be considered as captive riders who have no other option of transportation. According to Meyer and Miller (2001), this is the case that happens to most of the developing countries where the people who can afford an automobile would get one and cease to use transit. By this assumption, the suitable model to be used in modal split is Trip-End model. The data needed for calibration or prediction are such as auto ownership, income, distance from central business district (CBD), household size, and etc.

ITSC Chiang Mai University has conducted as interview on 352 travelers with 59.9% were female and 40.1% were male. The result from the interview shows that the average number of people per household was 4.2 where 2.4 people were in working age and 1.3 people were students. The average number of car per household was 1.2 and average number of motorcycle per household was 1.7. **Table 4.3** below shows the number of travelers in each modes of transportation according to the purpose of the trip.

Purpose of a Trip	Mean of Transportation		Total
	Personal Transport	Public Transport	
Home Base Work (HBW)	77	46	123
Home Base School (HBS)	80	50	130
Non-Home Base (NHB)	70	29	99
Total	227	125	352

Table 4.3: Selected Mean of Transport

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

Conclusion drawn from **Table 4.3** are:

Selected Mode of Transportation: 64.5% chose to travel by personal vehicle where another 35.5% traveled by means of public transport. Further investigation found personal vehicle can be grouped into motorcycle with 64.3%, car 21.6%, and 14.1% for pick-up truck. For public transit, 73.6% of travelers used minibus, 14.4% used school bus, and 12% for others.

Time and Expenses: For personal vehicle the average time spend for one trip is 21.7 minutes and it cost, on average, 25.3 Baht per trip. For public transit, passengers spend on average 25.8 Baht per trip and it takes 16.2 minutes per trip on average. The average expense per trip for both travelers is suspected to be much higher due to the oil price crisis in the year 2005.

4.3.4 Trip assignment

The final step for demand estimation, Trip Assignment, is the assignment of predicted flow of each mode to actual routes through given mode's network.

The study of Saowapol and Therarattanaket (2004), has estimated the demands for each of the 33 original routes with the aid of computer program. The steps for demand prediction of the computer program is very much similar to the four-step model where first the transit network must be created, then input the trip matrix, and finally the program would assigned the flow to the transit network created. The demand estimation for each road on the 20 selected routes of the 2 researchers is presented in **Table 4.4** below:

Street	Estimated Demand (person per day)
Suthep	24,495
Huaykeaw	10,858
Chotana	9,859
Rattanakosin	9,074
Wang Singh Kam	13,508
Faham	17,301
Keawnawarat	9,135
Charernmaung	3,457
Chiang Mai-Lampoon	6,855
Charernprates	1,778
Changklan	2,208
Taphae	2,249
Changmoi	1,664
Chiang Mai-Lampang	739
Mahidol	1,258
700th Stadium	427
Bunreungrit	9,685
Arag	5,725
Maninoparat	8,975
Mulmaung	17,102
Sriphum	8,106
Changloh	8,496
Prapokloa	5,543
Rachadamnern	3,365
Chiang Mai-Mae Rim	7,108
Chiang Mai-Mae Jo	1,983
Chiang Mai- Doi Saked	6,021
Chiang Mai-Samkampang	3,569
Chiang Mai-Oonluay	2,465
Chiang Mai-Lampoon (Middle ring section)	1,098
Chiang Mai-Lampang	568
Chiang Mai- Hang Dong	8,723

Table 4.4: Estimated Demand for Each Road

Sourec: Public Transportation Planning, Saowapol and Therarattanaket (2003), ITSC Chiang Mai University

The outcome from the study of Saowapol and Therarattanaket (2004) presented above is actually the demand estimation for the minibuses on the 20 selected routes since all input data were based on the minibus primary data. However, it is perfectly substitutable for predicting the demand of bus transit. In depth discussion on this topic is presented in the conclusion.

4.4 Size of investment

Demand is the key factor in route selection for the bus to operate. If one route had significantly higher demand than others, then that route would be chosen without considering other factors. However, as stated earlier there are other factors in determining the suitable route for co-investment. Those factors are size of investment, passenger's needs, and laws and regulations.

Size of investment is the second most important decision factor in route selection. It should be considered when there is no significant high demand present. The size of investment is directly related to the length of the route. The longer the route means the higher the number of the bus needed since the time to complete the trip is longer, hence the higher number of drivers and hostesses. The length of the route also has many other significant impacts on several factors that directly related to the size of investment such as the fuel cost, the maintenance cost, and the road condition improvement cost. It can be concluded that the longer the route the bigger the size of investment. In this case route 9 is selected considering the size of investment comparing to the route that has same level of demand. The result from the study of Saowapol and THerarattanaket (2004) shows that route 9 and route 8 are the two routes with the first and the second highest demand potential. However, the demand potential of these routes would be meaningless if their lengths are so long. Therefore the length of the route and its demand potential should be considered together. The following Table 4.5 shows the amount of potential demand per kilometer of each of the 20 routes.

The result from Table 4.5 shows that route 9 has the highest number of passengers per kilometer. Therefore when considering the demand potential and the size of investment, route 9 is still the most attractive choice.

Route Main Route	Estimated Demand	Length (Km)	Number of passenger per Kilometer
1	30679	26	1180
2	13726	14	980
3	9135	13	703
4	4196	13	323
5	13090	21	623
6	56448	20	2822
7	427	38	11
8	64364	13	4951
9	78001	14	5572
10	8852	21	422
11	26436	26	1017
12	4196	20	210
13	47393	35	1354
Sub Route			
1	22573	12	1881
2	53562	14	3826
3	22951	15	1530
4	17301	14	1236
5	3457	26	133
6	5665	14	405
7	13731	19	723

Table 4.5: Number of passenger per kilometer

4.5 <u>The needs of passengers</u>

Another factor to be considered in route selection is the passenger's needs. The needs of passengers such as the waiting time interval, the type of transportation they prefer, and the acceptable fare for the passenger should all be included when setting up a public transportation. However, the needs of passenger that related to the route selection process are the needs to travel. The needs to travel are the origin they are traveling from and the destination they wanted to be. The active points such as business district, malls, markets, schools, universities, and hospitals are the places that people would travel to and from. Route 9 passes through Chiang Mai's 2 important business districts, Waroros Market and Suthep Road. Waroros Market provides the connection for the people from the inner city to the suburb. Along Suthep road, there are several key active points such as Suandok Hospital, the provincial hospital, and Chiang Mai University. As stated earlier, the key passengers who are likely to use public transport are students and working class people. Chiang Mai University is the biggest educational center in the city, and also along Suthep road there are numbers of offices located. Therefore Route 9 would be able to satisfy the needs of most transit passengers in the city.

4.6 Law and regulation

The final factor to be considered in route selection is the law and regulation. The most important factor to be considered is whether the selected road for the operation would be suitable or not. The road for the bus to be operated on should be at least two lanes road, otherwise the operation would create traffic blockage and worsen the traffic condition instead of improving. Considering Route 9, all the roads along the route are two lane roads. The bus operation on route 9 would not worsen the current traffic condition.

4.7 Conclusion

Demand is the key decision factor in route(s) determination for co-investment, however, apart from demand there are other decision factors in case of a tie such as land use and route length.

Demand can be estimated through many demand estimation and analysis models, one commonly used model is the classic four-step model. The inputs of the four-step models are transportation and traffic information of the study area, behavior of travelers, and available modes of transportation. The outcome of the model is the prediction of demand for the studied mode of transportation.

In this chapter, the prediction from the model is actually the estimated demand for minibuses along the selected 20 routes. However, it is perfectly substitutable for demand estimation of bus transit. The five reasons that support this claim are represented below:

1. The research of ITSC by Saowapol and Therarattanaket (2004) shows that the users of public transportation have no access other means of transportation. They depend solely on public transportation. Meyer and Miller (2001) states that in most developing countries, vast majority of transit riders cannot afford an automobile. One that can afford to own an automobile does so and then ceases the use of public transport. This is actually the case that happen in Chiang Mai as the level of public transportation services are low.
2. The ITSC recommends further that in the future buses should be used as a replacement of minibuses due to the greater rate of efficiency.
3. The result from series of interviews from transit users has strengthened the claim. Approximately 80% of transit users are regular minibus passengers. On further investigation on the needs of these passengers shows that 38% of them demand for a fixed-route type of public transit and another 33% demand for microbus. Furthermore, 46% of the transit passenger also felt that the suitable price should be between 10-15 Baht per trip which leads to the next reason.

4. The price for the bus under co-investment manner in this thesis is a fixed rate at 15 Baht per trip. Further detail on price determination is discussed in chapter 5.
5. Finally, the data on Chiang Mai traffic, traveler characteristics and behaviors, and mode selection are conduct on the sample that represents the whole population in the study area. Therefore this data is already qualified to be used in bus transit demand estimation.

The result from the study of Saowapol and Therarattanaket (2004) shows estimated demand by the name of the street as in **Table 4.4**. The estimated demands are then rearranged to give the total demand of each route as shown in **Table 4.6** below:

Route	Estimated Demand
Main Route	
1	30679
2	13726
3	9135
4	4196
5	13090
6	56448
7	427
8	64364
9	78001
10	8852
11	26436
12	4196
13	47393
Sub Route	
1	22573
2	53562
3	22951
4	17301
5	3457
6	5665
7	13731

Table 4.6: Estimated Demand of The 20 Routes

The estimated demand shows that Main Route 9 and Main Route 8 have the highest and the second highest estimated demand accordingly. The estimated demands of these routes do not show significant different. Therefore, to decide which of the two to be selected for co-investment the other three constrains must be carefully considered. For the size of investment, the length of the routes is almost equal with about 15 kilometers. However, after considering the size of investment by looking at the figure of passenger per kilometer, route 9 has over 600 passengers more than route 8. Considering the next constrain, needs of passengers where the main factor is the use of land. The routes are sharing part of their route where only different in the routes is Route 8 uses Huaykeaw Road to reach Chiang Mai University while Route 9 uses Suthep. The land use shows that Route 9 passes through 2 more active points that Route 8 which are Suandok Hospital and Tonpayom Market. Along Suthep road there are numbers of government departments and also Suthep road passes through business area. For the final factor, the 20 base routes that the co0investment route is selected from are all pass the law and regulation qualification.

From all the factors of estimated demand, length of the route, and the land use, Route 9 shows significant potential. Therefore, the Main Route 9 is selected as the route for co-investment.