URBAN TRAVEL CHARACTERISTICS AND TRANSPORT PLANNING IN REGIONAL CITIES OF NORTHERN THAILAND

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Abstract : The papers examines the urban travel characteristics and transport planning methods conducting in 4 regional cities of upper northern Thailand. The cities include Chaing Mai, Chiang Rai, Lam Pang and Lam Phun. The travel characteristics among cities are compared from the viewpoint of socio-economic characteristics of trip makers, trip generation and distribution characteristics. The comparative studies indicate similar patterns of travel characteristics that can used to describing travel behavior of the travelers in urban area of northern regional cities. The transport situation and planning approach employed to develop the transport master plan are also discussed.

1. INTRODUCTION

1.1 Transport Issues in Regional Cities of Thailand

The rapid economic growth and urban development of regional cities in Thailand during the Sixth National Development Plan (1990-1994) had effected the development of the infrastructures, viz., the urban streets and road network could not cope with the travel demand of the public and the increasing number of the vehicles. If it is without proper transport plans, there shall be detrimental to the economic, social and political sectors, the same as what of the other big cities.

Though, the traffic problem in the major regional cities is not so serious, but if it is without a preventive and corrective program, there shall be problems affecting the development of the cities in the near future. In order to have the problem resolution going systematically and the performances of traffic organization go coordinately, the Office of the Commission for the Management of Land Traffic (OCMLT) has aware of the importance that it ought to prepare a master plan for the management of the urban traffic and transport system of major regional cities in Thailand, focusing mainly on the short-term and medium-term improvement plans, in order to provide plans, remedy and prevention of the urban traffic and transport problems of those cities.

1.2 Transport Planning Projects for Northern Regional City

During 1994 to 1998, OCMLT has agreed to employ Chiangmai University to prepare master plans for traffic and transport system management in the city planning area of 4 cities of upper northern region of Thailand. The cities include Chiangmai, Chiangrai, Lampang and Lamphun. The projects started from Chiangmai in 1994 to Lamphun in 1998 respectively.

In this project, a conventional 4-step transport planning approach was adopted as a planning methodology for analyzing the proposed transport policies and plans. A series of comprehensive transport survey for each city has been conducted to examine the existing transport conditions and travel behavior of travelers in the study area. Travel behavior data is useful information used to building transport planning models including trip generation, trip distribution, modal split and traffic assignment.

The results from the studies provide useful information to describe urban travel characteristics and transport planning methods used in regional cities of northern Thailand. This information may be helpful for researchers who want to employ this data for statistical comparison either with other cities in Thailand or cities in other developing countries.

1.3 Objective of the Study

The primary objective of this study aims to present the lessons learned from conducting the transport planning projects of the regional cities, particularly in the specific view point of urban travel characteristics and application of transport planing methods. The study aims to present and discuss the following transport issues:

- Present the urban travel characteristics in northern regional cities of Thailand.
- Make comparative studies on urban travel behavior among cities.
- Discuss the transport planning approach and analysis methods used in preparation of transport master plan.

2. GENERAL CHARACTERISTICS OF THE STUDY AREAS

2.1 Area and Population

The study areas cover the city planning area of the city of Chiangmai, Chiangrai, Lampang and Lamphun as indicated by Figure 1. Area and population of the province, city planning and municipal areas illustrate by Table 1. Population growth was moderate in the 1990s for the provinces, averaging an estimated – 0.3 % per annum for Lamphun to 2.7 % per annum for Chiangrai during the 1990 to 1997 period.

2.2 Land Development and Transport System

The development pattern of urban land use of the 4 cities indicates similar trend. The land utilization appeared to be intermingled densely in the municipal area. The residences scattered around, the commercial area scattered along the main roads of the communities. The direction of expansion of the communities tends to go onto every direction.

Transport in urban area of northern regional cities relies almost entirely on public roads. The road network of currently developed area is essentially fixed. Transport system of people depends mainly on the private automobile with over-emphasis on private cars and motorcycles. Table 2 shows vehicle registration and vehicle ownership in the provincial areas during the year of study. Vehicle growth rate was high in the 1990s.

Public transport modes consist of minibuses or "Song Thaews" , conventional buses, tuk-tuk (three wheel motorized vehicles) and cycle rickshaws. Minibus is main public transport mode for all cities and share more than eighty percent of public transport passenger.

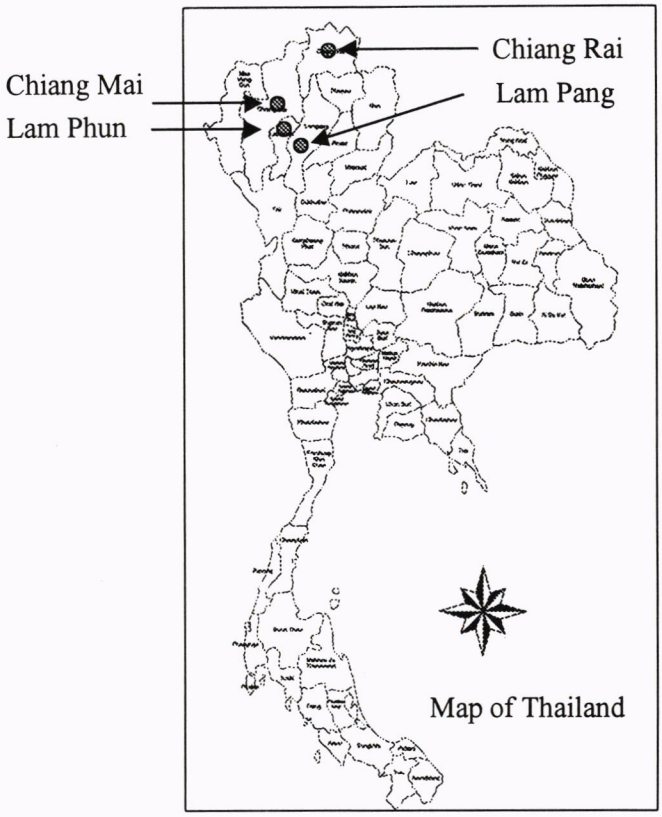

Figure 1 The study area

Table 1 Area and population in the base year of the study

Description	Chiang Mai	Chiang Rai	Lam Pang	Lam Phun
Year of Information	1994	1995	1996	1997
Area (km^2)				
• Provincial Area	20107	11678	12533	4505
• City Planning Area	429.2	152.5	92.0	58.0
• Municipal Area	56.8	60.8	22.1	6.0
Population (1000 persons)				
• Provincial Population	1,547.0	1,249.3	803.2	406.0
• City Planning Population	667.1	88.7	115.8	53.4
• Municipal Population	253.2	51.5	48.6	15.6
Population Density (persons/ km^2)				
• Provincial Area	77	107	64	90
• City Planning Area	1554	581	1258	920
• Municipal Area	4457	847	2199	2600

Table 2 Provincial vehicle registration and ownership

Description	Chiang Mai	Chiang Rai	Lam Pang	Lam Phun
Year of information	1994	1995	1996	1997
Vehicle registration (1000 vehicles)	544.2	282.6	245.4	162.4
• Passenger Car	51.1	15.3	11.8	7.5
• Pick-up	81.3	37.7	36.0	33.9
• Motorcycle	393.9	227.0	196.0	116.7
• Others	17.9	2.6	1.6	4.3
Vehicle growth rate (% per year)				
• Growth 1993-1996	7.7	12.5	5.1	6.0
Provincial vehicle ownership (vehicle/1000 population)	351	226	305	400
• Private Car Ownership	85	42	59	102
• Motorcycle Ownership	254	187	243	287

3. TRANSPORT SURVEY

3.1 Types of Data

In the preparation of the transport master plans for the study cities, the projects conducted the survey of traffic and transport system in particular study area which included both primary and secondary data to provide necessary database for analysis and evaluation of present traffic situation and future trends. The data was employed to build traffic and transport models for evaluation of the proposed plans and projects.

The primary data is the basic traffic and transport data that has been conducted in the field. The data includes travel demand , traffic volume, occupancy, travel time and delay on main roads, parking, physical of roads and intersection, road inventories and public transport service. For secondary data, the socio-economic data with related to the travel characteristics in the study area were collected, i.e., population, employment, student enrollment, government official, vehicle ownership, land use distribution, etc.

3.2 Travel Demand Survey

Travel characteristics and behavior of trip makers in the study area are the basic information for transport planning. The characteristics of traveler are commonly obtained from Original-Destination survey.

Travel demand and trip making characteristics of population in the study area were conducted by home interview survey. Roadside interview conducted to check in and out external trips from trip makers outside the study area. For the purpose of analysis and transport modeling, the study areas were divided into several traffic zones and the sample size of OD surveys was designated as indicated by Table 3.

Table 3 Sample size of data collection for travel demand survey

Description	Chiang Mai (1994)	Chiang Rai (1996)	Lam Pang (1997)	Lam Phun (1998)
Home interview survey				
• Total (internal) traffic zones	110	54	126	81
• Total number of households interviewed	3470	2504	1751	390
• % of total households	1.8 %	8.4 %	5 %	3 %
Roadside interview survey				
• Total (external) traffic zones	9	8	9	8
• Total number of surveyed stations	7	8	7	8
• Total number of persons interviewed	13,580	11,500	10,374	9,780
• % of interviewed vehicle at the stations	10 %	10 %	10 %	10%

3.3 Traffic Survey

Traffic characteristics are the essential information for understanding the existing traffic condition and transport problems in the study area. Traffic data was also used in the calibration of transport planning models. Therefore, traffic volume surveys were conducted to cover the whole area in order to be able to describe traffic condition in the study area.

Table 4 shows the number of the traffic count stations and other related traffic surveys. Traffic volume surveys are classified according to the purpose of use. Cordon-line and screen-line data are used to building and calibration of the transport models. Mid-link and turning volume data are mainly used to analyze traffic condition.

Table 4 List of traffic data to be collected

Description	Chiang Mai (1994)	Chiang Rai (1996)	Lam Pang (1997)	Lam Phun (1998)
Number of Traffic Count Stations				
• Cordonline count	8	8	8	8
• Screenline count	8	3	5	8
• Mid-link count	15	10	15	22
• Turning movement count	30	15	15	9
Other survey				
• Travel time survey (routes)	7	4	6	5
• Occupancy survey (stations)	5	3	5	3

4. ANALYSIS OF URBAN TRAVEL CHARACTERISTICS

4.1 Urban Travel Characteristics in Northern Regional Cities

The travel data from transport surveys were analyzed to examine urban travel characteristics of the people in the study areas and used in building the transport planning models. The model of trip generation, distribution, modal split and assignment were built based on travel characteristics of each particular city. Therefore, the travel characteristics used to describing urban travel behavior of travelers in the study areas can be classified according to the general characteristics for making trip as follows :

- characteristics relate to socio-economic of trip makers
- characteristics relate to generation of trip
- characteristics relate to distribution of trip

Analyzed urban travel characteristics of the people in the city planning area of Chiangmai, Chiangmai, Lampang and Lamphun illustrate in Table 5 to 7. The characteristics include socio-economic characteristics of trip makers, trip generation characteristics and trip distribution characteristics.

Household characteristics of trip makers influence trip-making behavior of household member. As shown in Table 5, general household characteristics used to describing trip-making behavior are household size, income, private vehicle, number of worker, number of student, etc.

Table 5 Socio-economic characteristics of trip makers

Description	Chiang Mai (1994)	Chiang Rai (1996)	Lam Pang (1997)	Lam Phun (1998)
Household Characteristics				
• Household size (persons)	3.38	3.55	3.31	3.67
• Household income (Baht/month)	9277	11730	10564	14370
• Private car per household	0.48	0.62	0.71	0.69
• Motorcycle per household	1.19	1.41	1.30	1.36
• Total trips per household	6.62	6.0	5.80	5.83
• Worker per household	1.94	1.85	1.72	2.18
• Student per household	0.81	0.78	0.72	0.89
Vehicle ownership in city planning area (vehicle/1000 population)	469	530	609	531
• Private car ownership	126	149	217	181
• Motorcycle ownership	343	381	391	350

Note : 1 US$ ~ 38 Baht (Jan.1998 exchange rate)

The number of trip generated by individual illustrates generation characteristics of trip makers. Trip generation characteristics can be expressed in term of trip rate (trip per person). The surveys indicate that person trip rate in the study areas varies by occupation, income and ages of trip makers. Table 6 presents person trip rate per day for each group.

The pattern of origin and destination of trip explains trip distribution characteristics of travelers. The travel data from the surveys can be classified by the distribution of trip according to purpose, time of day and mode of travel of trip makers. These characteristics are compared as indicated by Table 7. The distribution of vehicle trips in road network exhibits by Table 8.

Table 6 Trip generation characteristics in city planning area

Description	Chiang Mai (1994)	Chiang Rai (1996)	Lam Pang (1997)	Lam Phun (1998)
Total travel demand (1000 person-trips/day)	1589	250	286	158
• Trips in study area (internal)	1329	182	204	73
• Trips in and out the study area (external)	260	68	82	86
• Average daily trip rate(trip/person/day)	1.96	1.76	1.75	1.53
Trip rate by occupation (trip/person/day)				
• Student	NA	1.80	1.95	1.62
• No Job	NA	0.75	0.63	0.56
• Government Service	2.03	2.63	2.74	2.33
• Private	1.80	2.25	2.48	1.82
• Labor	1.35	1.80	1.75	1.75
• Agricultural	0.76	1.50	1.16	0.80
• Retired	NA	1.50	1.36	1.44
Trip rate by monthly income group (trip/person/day)				
• < 2000 Baht	NA	1.40	1.33	1.11
• 2000-10000 Baht	NA	2.13	2.09	1.84
• 10000-20000 Baht	NA	2.49	2.50	2.07
• > 20000 Baht	NA	2.35	2.21	2.04
Trip rate by age group (trips/person/day)				
• < 10 yr.	0.56	1.00	0.96	1.03
• 11-20 yr.	1.63	2.05	2.11	1.74
• 21-30 yr.	1.46	1.95	2.06	1.74
• 31-40 yr.	1.41	2.18	2.23	2.06
• 41-50 yr.	1.20	1.80	1.85	1.60
• 51-60 yr.	0.68	1.45	1.40	1.29
• > 60 yr.	0.28	0.70	0.68	0.59

Note : NA = not available or inadequate data for analysis

Table 7 Trip distribution characteristics in city planning area

Description	Chiang Mai (1994)	Chiang Rai (1996)	Lam Pang (1997)	Lam Phun (1998)
Trip distribution by purposes(%)				
• Home-Based Work (HBW)	42	37	30	38
• Home-Based School (HBS)	27	21	21	25
• Home-Based Others (HBO)	24	35	30	31
• Non-Home Based (NHB)	7	7	19	6
Trip distribution by time of day (%)				
• Morning peak (06 AM-09AM)	42	37	39	37
• Day time off peak (09 AM –15 PM)	14	21	17	27
• Afternoon peak (15 PM –18 PM)	36	35	35	29
• Night time (18 PM – 06AM)	9	7	9	6
Trip distribution by motorized-mode (%)				
• Private car	32.4	29.7	34.5	38.6
• Motorcycle	55.1	60.0	55.4	50.1
• Song Thaew (mini-bus)	9.6	5.4	6.1	4.9
• Bus	1.8	0.8	0.8	0.7
• Others	1.1	4.1	3.2	5.7

Table 8 Traffic distribution in existing road network

Description	Chiang Mai (1994)	Chiang Rai (1996)	Lam Pang (1997)	Lam Phun (1998)
Traffic composition in Municipal Area (%)				
• Passenger cars	32	39	45	50
• Motorcycle	61	54	47	40
• Song Thaew (mini-bus)	5	4	6	5
• Buses	-	-	-	-
• Others	2	3	2	5
Average vehicle occupancy in municipal area (persons/vehicle)				
• Motorcycle	1.36	1.40	1.37	1.60
• Car	1.52	1.63	1.72	1.94
• Pick-up	1.76	1.81	1.89	1.74
• Buses	10.22	-	22.42	17.25
• Song Thaew (mini-bus)	3.16	4.10	5.64	4.27

4.2 Comparative Studies

It was found that many travel characteristic indicators as shown by Table 5 to 8 tend to have similar pattern and trend. Further analysis is to identify typical characteristics that applicable to represent travel behavior of people in the northern cities. The simple analysis was done by examining the deviation range of indicators as illustrated by Table 9 to11. The analysis was based on the following equations:

$$Y^m = \frac{\left(x_i^m - X^m\right)*100}{X^m} \quad \text{.....(1)}$$

$$D^m = \frac{\left(X^m - s^m\right)*100}{X^m} \quad \text{.....(2)}$$

$$W^m = \sum_j D^m P_j^m \quad \text{.....(3)}$$

where

X^m = mean value of the characteristics m of 4 cities

x_i^m = mean value of the characteristics m of city i

s^m = standard deviation of the characteristics m

p_j^m = proportion (share) of the element j of characteristics m

i = the city of Chiangmai, Chiangrai, Lampang and Lamphun

Y^m = percent different from mean of the characteristics m

D^m = percent deviation from mean value of the characteristics m

W^m = weighted percent deviation from mean value of the characteristics m

Y^m figures describe range of the different of average value for each city and mean value of the 4 cities. D^m figures show the deviation from mean of the average value. Where W^m ,which represent in term of weighted average deviation, help to identify typical urban travel characteristics.

The main purpose of having urban travel characteristics data is to build transport planning models. The model for strategic planning level for these studies are expected to have performance of forecasting which error of prediction should not more than 20 percent. Based on this figure, the evaluation criteria to identify typical urban travel characteristics for the 4 study areas was setup. Therefore, the indicators that percent weighted deviation from average value less than 15 percent can consider to be typical urban travel characteristics represented the cities of upper northern region.

The summary of average weighted percent deviation from mean for all characteristics described in Table 12. The figures show that most of characteristics, except the characteristics that largely depend on income level, tend to have similar characteristics which can represent urban travel characteristics of northern regional cities.

Table 9 : Percent different from average value for socio-economic characteristics

Characteristics Group	Mean Value (X^m)	Std. Dev. (s^m).	% different from mean(Y^m)			
			Chiang Mai	Chiang Rai	Lam Pang	Lam Phun
Household characteristics						
• Household size	3.48	0.183	-2.8	2.1	-4.8	5.5
• Household income	11485	1950	-19.2	2.1	-8.0	25.1
• Private car per household	0.63	0.047	-23.2	-0.8	13.6	10.4
• Motorcycle per household	1.32	0.055	-9.5	7.2	-1.1	3.4
• Total trips per household	6.06	0.108	9.2	-1.0	-4.3	-3.8
• Worker per household	1.92	0.237	0.9	-3.8	-10.5	13.4
• Student per household	0.80	0.086	1.3	-2.5	-10.0	11.3

Table 10 : Percent different from average value for trip generation rate characteristics

Characteristics Group	Share (p^m_j) %	Mean trip rate (X^m)	Std. Dev. (s^m).	% different from mean(Y^m)			
				Chiang Mai	Chiang Rai	Lam Pang	Lam Phun
Trip generation rate by occupation	100.0						
• Student	24.7	1.79	0.165	-	0.6	8.9	-9.5
• No Job	19.0	0.65	0.096	-	16.0	-2.6	13.4
• Government Service	12.7	2.43	0.212	-16.5	8.1	12.6	-4.2
• Private	8.3	2.08	0.335	-13.8	7.8	18.8	-12.8
• Labor	11.4	1.66	0.029	-18.8	8.3	5.3	5.3
• Agricultural	2.1	1.05	0.350	-28.0	42.2	10.0	-24.2
• Retired	1.0	1.43	0.070	-	4.7	-5.1	0.5
• Others	17.8	-		-	-	-	-
Trip generation rate by monthly income group	100.0						
• < 2000 Baht	48.7	1.28	0.151	-	9.4	3.9	-13.3
• 2000-10000 Baht	43.9	2.02	0.157	-	5.4	3.5	-8.9
• 10000-20000 Baht	5.8	2.35	0.245	-	5.8	6.2	-12.0
• > 20000 Baht	1.6	2.20	0.155	-	6.8	0.5	-7.3
Trip generation rate by age group	100.0						
• < 10 yr.	13.3	0.89	0.035	-36.9	12.7	8.2	16.1
• 11-20 yr.	16.4	1.88	0.199	-13.4	8.9	12.1	-7.6
• 21-30 yr.	17.4	1.80	0.163	-19.0	8.2	14.3	-3.5
• 31-40 yr.	20.5	1.97	0.087	-28.4	10.7	13.2	4.6
• 41-50 yr.	14.8	1.61	0.132	-25.6	11.6	14.7	-0.8
• 51-60 yr.	9.7	1.20	0.082	-43.6	20.3	16.2	7.1
• > 60 yr.	7.9	0.56	0.059	-50.2	24.4	20.9	4.9

Table 11 : Percent different from average value for trip distribution characteristics

Characteristics Group	Mean (X^m) %	Std. Dev. (s^m).	% different from mean(Y^m)			
			Chiang Mai	Chiang Rai	Lam Pang	Lam Phun
By trip making purposes	100.0					
• Home-Based Work (HBW)	36.7	4.992	8.4	-4.5	0.6	4.5
• Home-Based School (HBS)	23.5	3.000	-29.1	6.3	-13.9	36.7
• Home-Based Others (HBO)	30.0	4.546	6.7	3.7	3.7	-14.1
• Non-Home Based (NHB)	9.8	6.185	16.1	-9.7	16.1	-22.6
By time of day	100.0					
• Morning peak (06-09)	38.8	4.203	12.0	-14.7	4.0	-1.3
• Day time off peak (09-15)	19.8	5.598	-26.3	-5.3	-10.5	42.1
• Afternoon peak (15 –18)	33.7	3.367	5.9	5.9	2.9	-14.7
• Night time (18–06)	7.7	2.449	28.6	-42.9	28.6	-14.3
By motorized-mode	100.0					
• Private car	33.8	3.755	-4.1	-12.1	2.1	14.2
• Motorcycle	55.1	4.045	-0.1	8.8	0.5	-9.2
• Song Thaew (mini-bus)	6.5	2.124	47.7	-16.9	-6.2	-24.6
• Bus	1.1	0.519	75.6	22.0	-22.0	-31.7
• Others	3.5	1.919	-68.8	16.3	-9.2	61.7

Table 12 : Summary average weighted percent deviation from mean for all characteristics

Characteristics Group	Average deviation From mean value %
Household Characteristics (D^m)	
• Household size	5.27
• Household income	16.98
• Private car per household	7.56
• Motorcycle per household	4.19
• Total trips per household	1.78
• Worker per household	12.33
• Student per household	10.78
Trip generation characteristics (weighted value, W^m)	
• Trip rate by occupation	8.48
• Trip rate by income group	9.88
• Trip rate by age group	7.44
Trip distribution characteristics (weighted value, W^m)	
• Trip distribution by purpose	13.50
• Trip distribution by time of day	15.61
• Trip distribution by mode	12.36

5. TRANSPORT PLANNING AND ANALYSIS

The following sections summarize transport planning method and analysis techniques used in preparation of the master plan for the management of the urban traffic and transport system in the city of Chiangmai, Chiangrai, Lampang and Lamphun.

5.1 Planning Procedure

The preparation of the master plan for the management of the urban traffic and transport system in the study areas comprises steps of procedure as follows:

- Review of the recent studies, the work programs/projects and the responsibility of the traffic related agencies.
- Survey and analysis of transport and traffic data.
- Development of transport models.
- Analysis of traffic and transport problems and forecasting future trend.
- Preparation of the master plan for the management of the urban traffic and transport system
- Preparation of details of the project and set priority of the projects and the investment plan.

5.2 Transport Problem Issues

The transport problems in the northern regional cities, in general, have similar issues but different in level of seriousness. The level of congestion is highest from Chiangmai to Lampang, Chaingrai and Lamphun respectively. The general characteristics of problems involving urban traffic and transport in the study areas summarize by Table 13.

It was found that the road network of all study cities in general is not adequate. The road space share less than 10 % of total area. There exist physical problems at points in the road network that prevent traffic from efficient use of the network. For public transport, it was found that the supply is low, the services does not well cover the area desired by population, low quality of service and lack of popularity among trip makers.

Table 13 Summary on issues of transport problem in the city of northern region

Problem issues	Problem Characteristics
1. Road network and land use	• Lack of appropriate road network • Lack of efficient management of the road space • Uncoordinated use of land and road network development
2. Traffic control	• Parking problems • Lack of efficient traffic control equipment
3. Public transport system	• Lack of main public transit system • Condition and quality of service are not to good standard • High proportion use of private vehicle
4. Safety	• High accident rate • Defects of control and engineering design • Carelessness of driver
5. Traffic discipline	• Discipline problems of road users

5.3 Transport Analysis

The importance goals for planning of urban traffic and transport system are to seek for transport system and engineering measures that shall help traffic on transport network in present and in future to be acceptable under the designated conditions. Approach of analysis to find appropriate policy and development plan arrange in steps summarized as follows:

- Building transport model to represent travel behavior on interesting highway network.
- Forecasting the travel demand in the target-year.
- Taking the behavior and forecasted travel demand into consideration to find policies and measures that it can accommodate the predicted travel demand with acceptable traffic condition.
- Taking proposed plan and measures to be analyzed to find the feasibility and appropriateness using the traffic model.
- Select the best plan and measure.

A conventional 4-step transport planning approach was used as a methodology for building transport planning models. The models consist of 4 sub-models that are trip generation model, trip distribution model, modal split model and traffic assignment model. The models have been built for applying at the level of strategic planning analysis. Table 14 illustrates the selected techniques in formulating the transport models. The selection of modeling technique was based on availability of planning data, type of transport policy and plan to be analyzed , availability of transport software and limited time duration to conduct the projects.

Table 14 Selected techniques in formulating the transport models

Description	Chiang Mai	Chiang Rai	Lam Pang	Lam Phun
Trip Generation Model	Linear Regression	Linear Regression	Category Analysis	Category Analysis
Trip Distribution Model	Fratar Growth	Fratar Growth	Gravity Model	Gravity Model
Modal Split Model	Multinomial Logit	Trip End Modal split	Trip End Modal split	Trip End Modal split
Traffic Assignment Model	Capacity Restraint	Capacity Restraint	Capacity Restraint	Capacity Restraint
Computer programs used to building models	TRAN-PLAN	TRAN-PLAN	TRIPS	TRIPS

Building the transport model of Chiangmai was set-up as a pilot case study for other cities. TRANPLAN program was suggested to used as transport planning tool in building models. The formulation techniques used to building transport planning models for Chiangmai are summarized as following.

- Multiple linear regression was used to formulating trip generation model. The trip generation model comprises of trip production and attraction equations for

4 type of trip purposes which are home-based work (HBW), home-based school (HBS), home-based others (HBO) and non-home-based (NHB).

- Growth factor method is a simple technique that widely used in trip distribution process. Data preparation and computation processes are less complicated compared to synthesis method such as Gravity model. Therefore, Fratar growth factor method was selected for a case of Chiangmai.
- The analysis of proposed transport plans of Chiangmai involve the consideration for new mass transit system such Light Rail Transit (LRT). In order to take into account a new mode of transport (LRT), Multinomial Logit model was applied for building modal split model. There are 5 types of vehicle considered in the modal split model, i.e., cars, motorcycles, buses, song-thaews and LRT,
- For traffic assignment model, conventional technique of capacity restraint was applied. The method of equilibrium assignment was adopted in computation process.

For a case of Chiangrai, the study employed similar techniques as of Chiangmai in building transport planning models. There was only some modification on modal split model. Instead of using Multinomial Logit model, trip end modal split model was adopted for estimating number of trip using public and private transport mode. Trip end modal split is more simply and convenient to apply than Logit model. It has been recognized that trip end modal split model is applicable where the public transport share is small. In Chiangrai, existing public transport usage shared only 6 % of total trip and only song-thaew was available for service.

For a case of Lampang, there were improvements in building transport planning models and transport data collection. More information of travel behavior of trip maker was obtained from OD survey. Therefore, category analysis (or cross-classification analysis) was adopted in formulating trip generation model of Lampang. Trip generation and attraction were classified by 4 household types of 3 modes and 4 purposes. Improvement on trip distribution process was to apply Gravity model method. For trip end modal split model and capacity restraint assignment model still appropriate for applying in case of Lampang. In this study OCMLT suggested to employ TRIPS program for building transport planning models.

For a case of Lamphun, the study employed similar techniques as of Lampang in building transport planning models.

5.4 Transport Plans

The goals of traffic and transport master plan for the 4 cities aim to achieve the following conditions :

- To have a movement of vehicles and pedestrians at both present and future year be safe, efficient and convenient with good speed.
- To provide short, medium and long term measures in order to cope with traffic situation in present and future year
- For short term measures, travel speed and safety should improve by 20 %

It is not possible to achieve the goals mentioned above by means of implementing any one measure. There must be a set of plan that complementary each other's for remedial actions

during each time frame. The selection of appropriate set of plan is done systematically. The process consists of selecting measures that seem to be applicable for the type of problem encountered and testing for their level of merit by using transport planning models. The models analyze the traffic condition and then compare to that of the goals. If the goal is achieved, the set of measures is accepted as master plan, otherwise another measure is then included and the steps repeat.

Resulting from the analysis, the short-term and medium-term plans have been proposed. The short-term plan is the investment plan that aims to resolve traffic problems presently encountered, with purposes to improve existing traffic system and travel environment within period of operational time of 1-5 years. The short-term plans emphasis on the improvement of the traffic management system and safety.

The medium/long-term plans are investment plans aiming to develop traffic system and transport to be able to accommodate the travel demand in the next 5-10 years without creating any traffic problem. They are plans that require great amount of budget and length of time for implementation. The goals of these work programs stressed on development road network and public transport appropriately and adequate to the travel demand in the future.

In summary, the plans or measures proposed to prevent and correct transport problems in the study areas [detailed in reference 1,2,3] can be categorized into the following programs.

- Improve traffic management and control system
- Improve road safety and travel environment
- Improve road network
- Improve public transport system
- Improve traffic discipline of road user

6. CONCLUDING REMARKS

This study presents fact of travel characteristics in the 4 regional cities of northern Thailand. The analysis is based on travel data obtained from comprehensive transport survey. The following typical travel characteristics can be used to describing travel behavior of northern regional cities:

- Household characteristics denote socio-economic characteristics of trip-makers. The characteristics include household size, motorcycle ownership, number of worker and student in household, and total trip per household.
- Trip rate by occupation, income and age groups indicate similar pattern in trip generation characteristics.
- Trip distribution by purpose, time and mode testify comparable trip distribution characteristics.

This study also discusses the transport planning method applying in preparation of transport master plan in the study cities. The following points should be emphasized to indicate transport situation and planning approach described in this study.

- There is similarity in transport problems. High private automobile use with low supply in public transport profound in all cities.

- Comprehensive travel demand and traffic surveys are important to provide planning data for further analysis and building transport planning models.
- Conventional 4-steps planning approach is well applicable for building transport planning models. The models are essential for estimating future travel demand and evaluating transport measures.
- Transport measures that complementary each other can be an appropriate set of transport plan for implementation.

Finally, the information on urban travel characteristics and transport planning method discussed in this paper may be useful for statistical comparison for researchers in other developing cities.

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