

SIMPLIFIED PHYSICAL DISTRIBUTION SURVEY FOR ENVIRONMENTAL IMPACT ASSESSMENT IN BANGKOK

Hitoshi IEDA

Professor
Dept. of Civil Eng.,
The University of Tokyo
7-3-1, Hongo, Bunkyo, Tokyo, 113-8656,
Japan
Fax: +81-3-5841-8506
E-mail: ieda@trip.t.u-tokyo.ac.jp

Kazushi SANO

Associate Professor
Dept. of Civil and Environmental Eng.,
Nagaoka University of Technology,
1603-1, Fukazawa, Nagaoka, Niigata,
940-2188, Japan
Fax: +81-258-47-9600
E-mail: sano@vos.nagaokaut.ac.jp

Viroat SRISURAPANON

Assistant Professor
Division of Civil Eng.,
King Mongkut's University of Technology
Thonburi.
Suksawads 48, Bangmod, Toongkru, Bangkok,
10140, Thailand
Fax: +66-2-427-9063
E-mail: iviranon@cc.kmutt.ac.th

Atsushi FUKUDA

Lecturer
Dept. of Transportation Eng.,
Nihon University
7-24-1 Narashinodai, Funabashi, Chiba,
274-8501 Japan
Fax: +81-47-469-5355
E-mail: fukuda@trpt.cst.nihon-u.ac.jp

Kiyoshi TAKAHASHI

Associate Professor
School of Civil Eng.,
Asian Institute of Technology (Univ. of Tokyo)
P.O. Box 4, klong Luang, Pathumthani 12120,
Thailand
Fax: +66-2-524-5509
E-mail: takahasi@ait.ac.th

Abstract: The exhaust fumes from automobile in developing country has currently been serious problem accordance with the rapid economical growth. Especially, the truck transport used to discharge the exhaust so that it is quite necessary to estimate the total truck mileage to evaluate the policy on physical distribution system, however, it has not been observed in developing countries so that the survey is quite necessary.

Thus, in this study, we conducted the survey to clarify the physical distribution in Bangkok as the one of practical case in developing country. Applying the result from the survey, the amount of the exhaust fumes was estimated.

1. INTRODUCTION

"Sustainable Cities" takes the world-wide concern in this time of global-environment. Transportation is doubtlessly one of the expected sector to contribute to the issue, since it occupies approximately 30% of the whole energy consumption in cities. Physical distribution and freight transport have been, however, comparatively disregarded than passenger transport because of their complicated and difficult dynamism in spite of their equivalent outcome on cities. Appropriate policies for passenger transport for "Sustainable Cities" are already devised, e.g. TDM and TOD, in European and American cities. Similarly in physical distribution, likely initiatives are also prepared and introduced in many cities e.g.,

- 1) distribution policies such as the establishment of suitable hierarchical freight transport system and transport-collaboration schemes to improve loading and traffic efficiency;
- 2) freight infrastructure policies such as allocation of truck terminals and distribution centers;
- 3) freight traffic policies such as truck-routes and truck-time to control time-and-place dependent traffic load on city centers; and
- 4) policies of loading/unloading facilities to avoid traffic confusions 1), 2).

Although the environmental and traffic situation in cities in developed countries has been, and most probably will be, more or less improved through the upper mentioned measures, that in developing countries is not yet enough taken care of up to now. Transportation especially physical distribution in large conurbations in developing countries in Asia such as Bangkok, Manila, Jakarta, Shanghai, etc., will surely become more and more important due to their rapid economic growth. Data of physical distribution which enables the estimation of traffic and environmental load of physical distribution and the assessment of related policies are, however, extremely limited in developing countries much more than that of passenger transport are. This is one of the reason why few research works have been done in this field.

The authors tried to carry out an original physical distribution survey in Bangkok Metropolitan Area in 1998 and in 1999 which seems minimally required for the upper mentioned estimation and assessment, and shows the outline of the survey and the interim results acquired from it. Firstly in Chapter 2 the whole logical structure of the survey and analysis is introduced, and in Chapter 3 and 4 results of both macroscopic and microscopic results are pointed out. Finally in Chapter 5 the traffic and environmental loads are estimated and discussed through the upper mentioned data analysis.

2. WHOLE STRUCTURE OF SURVEY AND ANALYSIS IN BANGKOK METROPOLITAN AREA (BMA)

Since the physical distribution at metropolises used to be involved, it is quite necessary to grasp it macroscopically. The physical distribution survey will cost a great deal. In fact, the comprehensive survey to investigate the physical distribution has never been carried out in Bangkok. So we must need the simple tool which we can collect freight data and analysis the freight transport mechanism in developing countries.

In the purpose of this survey is develop the prototype model which investigate the freight transport in Bangkok under the limited availability of data. Overall structure of the survey in BMA is shown in Figure 1.

The following are the major points examined in this structure.

- (1) Official statistic collection means a basic survey. Survey items are Population, Land use, Traffic counting data, Environmental data and so on. These data are all published
- (2) In general interview-survey to public sectors and private sectors, we get several focus points of freight transport policy and freight transport behavior.
- (3) Interview-survey on sample-firms in distribution centers and commercial markets is a very important part in this survey. The number of sample trucks collected were 150 in the distribution center 180 commercial markets, about 330 in total.

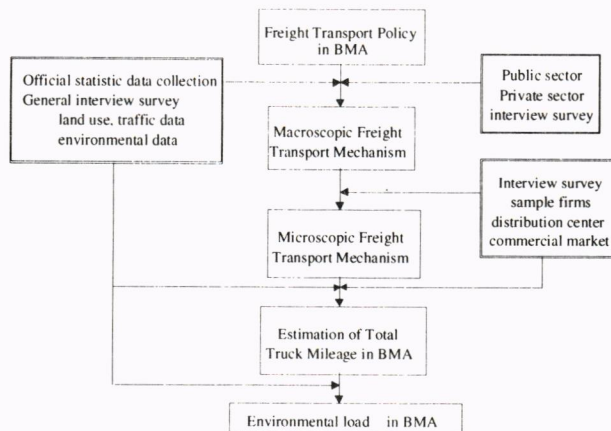


Figure 1 Structure of survey and analysis in this study

Simplified Physical Distribution Survey for Environmental Impact Assessment in Bangkok

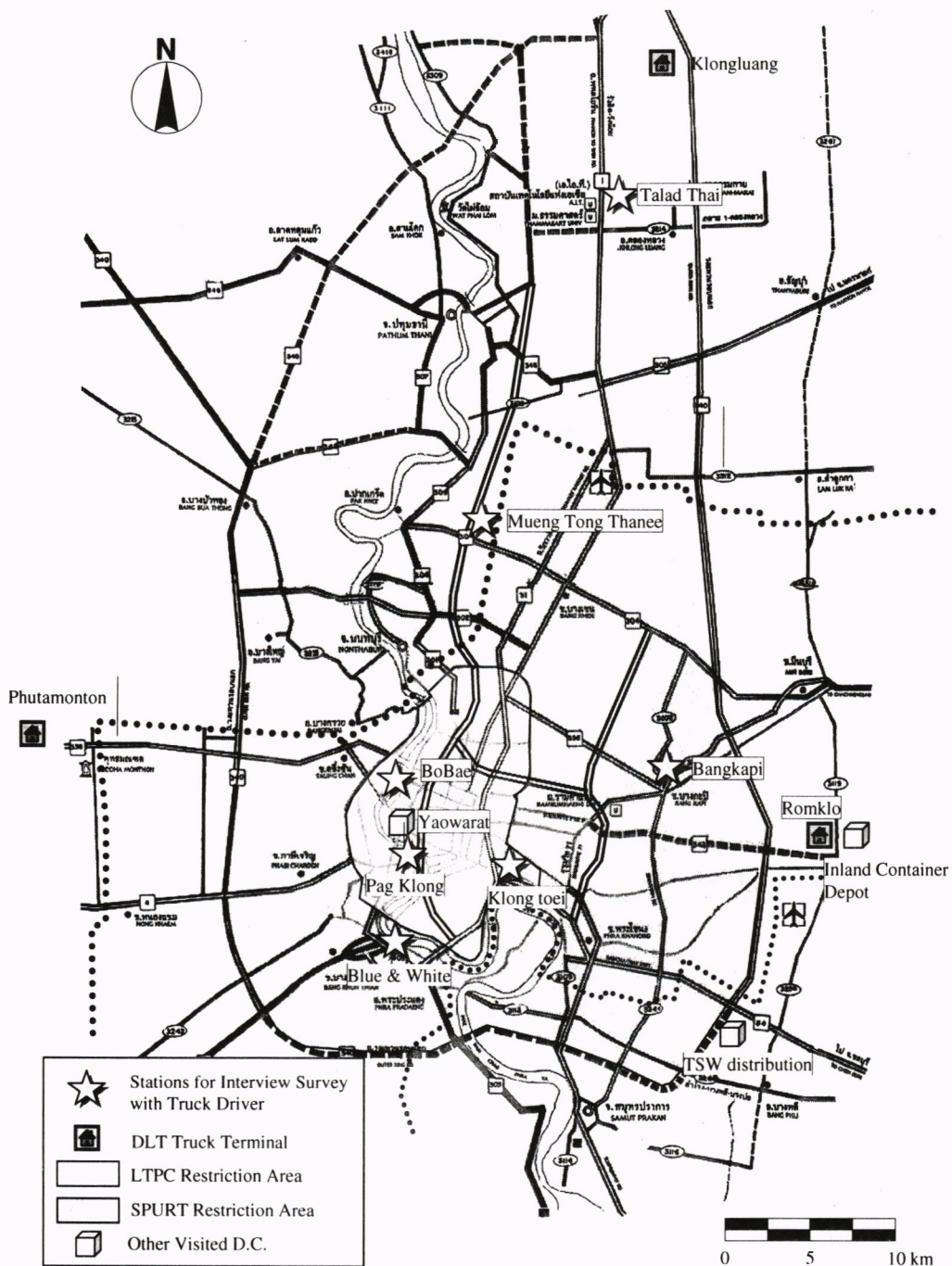


Fig.2 Fundamental strategy regarding truck transport and our survey stations

3. MACROSCOPIC SURVEY AND THE RESULTS IN BMA

(1) Inter-regional distribution.

The inter-regional distribution system in Thailand has been quite simple. Since Bangkok has not been only a capital city of Thailand but also the center of Thai economy and the gateway of import-export trade in this region, the most of inter-regional commodity has been originated or attracted at Bangkok.

Presently more than 90% of the total truck fleets are held by around 200,000 small private operators which have less than 5 trucks. Most of them have located in Bangkok and used to transport groceries and miscellaneous goods between Bangkok and local regions. Staple products and natural resources such as rice, oil, etc. have been transported by the National Enterprise Transporter, ETO between main ports and local regions. So far, the freight movement between local regions are unobserved but it would be rather small.

The Department of Land Transport (DLT) used to conduct the station interview survey at the corridor-line of BMA on the main national highway regularly. Accordance with this result, majority of incoming cargoes in ton-kilometers are construction material such as sand, exported agricultural products such as rice and household consumption goods, while the out going cargoes are manufactured goods and imported goods such as steel and animal feeds as shown in Table 1. The amount of commodity coming in and out Bangkok were over 65 million ton/year and 20 million ton/year in 1995.

Incoming agricultural cargoes used to be sent to warehouses or depots to export or reprocess. Some of them are distributed for local consumption also. Outgoing cargoes are 1) truck load cargoes such as fuel, cement, some manufactured goods, 2) break bulk cargoes such as consumer goods which are sent from big factories in Bangkok to provincial depots or wholesalers and 3) consolidated cargoes whereas cargoes will be collected by transport operators from different consignors and put into a truckload carried to the same destinations.

Table 1 Incoming cargoes and outgoing cargoes in BMA

COMMODITY	IN			OUT		
	VOLUMES (Ton)	TRIP (Trip)	VOLUMES (Ton - Km.)	VOLUMES (Ton)	TRIP (Trip)	VOLUMES (Ton - Km.)
1. RICE	3,699,628	280,121	1,038,109,273	566,928	49,173	146,421,299
2. SUND & GRAVEL	42,377,224	2,978,667	4,047,197,083	359,889	38,048	30,965,593
3. CEMENT & PRODUCTS	5,684,141	354,682	627,675,718	2,301,770	152,919	728,041,797
4. STEEL	795,873	65,141	142,343,444	1,638,283	158,119	622,529,755
5. OTHER CONSTRUCTION	718,861	92,975	99,925,813	474,489	50,266	142,052,325
6. TIMBER	1,260,880	120,975	686,417,996	821,331	72,621	225,055,525
7. FIREWOOD	233,412	24,631	69,757,068	100,006	15,053	9,173,927
8. PERTOLEUM PRODUCTS	414,729	31,385	47,581,216	3,306,246	242,433	881,256,452
9. MINERALS	318,278	15,509	107,653,885	390,092	24,180	56,833,071
10. VEGETABLE & FRUIT	713,105	139,231	274,111,279	378,402	63,766	119,410,271
11. TAPIOCA	1,275,030	76,824	355,877,436	182,499	10,857	20,558,160
12. MAIZE	322,620	28,279	109,781,100	50,187	4,743	4,625,370
13. SUGAR	1,392,652	100,276	311,480,686	216,259	17,514	51,822,305
14. BEANS	51,919	4,926	21,498,395	10,950	456	7,610,250
15. JUTE & PRODUCTS	21,532	4,104	4,028,948	19,162	1,824	4,195,625
16. BEVERAGES	444,930	63,595	47,726,720	1,211,422	138,047	293,746,516
17. PROCESSED FOODS	998,263	113,867	260,402,717	338,804	62,309	113,993,416
18. ANIMALS	219,996	76,825	33,798,854	58,120	22,895	17,973,347
19. FISH	334,242	54,104	175,964,854	196,085	38,498	70,271,060
20. FERTI & ANIMAL FEEDS	660,640	72,716	155,505,732	2,431,883	236,859	939,649,882
21. PERSONAL EFFECTS	878,548	106,843	164,234,086	869,517	139,321	233,607,030
22. OTHER MANUFACTURES	685,459	122,627	142,542,859	2,892,880	334,773	1,265,916,774
23. ALL OTHERS	1,910,852	190,608	432,979,620	1,453,688	176,640	315,053,092
TOTAL	65,412,814	5,118,911	9,356,594,782	20,268,892	2,051,314	6,300,762,842

Source: DLT

The inter-regional distribution system in Thailand is, however, just under the innovation. The change on the social condition, such as opening of the outer ring road, other arterial highways and new port, relocation of a container depot and a distribution center from CBD to outskirts, and introduction of truck ban system, lets the inter-regional distribution system reformed itself. According to this changing, a heavy truck is avoided at least from the area surrounded by the middle ring road and its air pollution has been decreased currently so that we are not pay much attention to investigate the inter-regional distribution.

(2) intra-regional distribution in Bangkok

More than 8.9 million of population live in 7,758 quare kilometer of Bangkok Metropolitan Region so that the intra-regional distribution also made to use a lot of truck fleet, especially a pickup truck and a van to deliver the commodity. However, a survey has been scarcely done to investigate the intra-regional distribution in Bangkok. Thus, the outline of distribution can be only known from the interview survey and depicted as shown in Figure 3.

- In Bangkok, most of a factory deliver its products directly to a department store (R1), supermarket (R2) and retail shop (R3). So, one truck stops several places a day.
- In the case of groceries, a farmer or a broker send it to a large market (M1). This type of market was launched by the government and become very popular for retail shopper to purchase groceries.
- Some farmer come small market (M3) to sell the groceries directory also. This is traditional type of market located in almost every subdistrict.
- Some broker delivers groceries between a distribution center and/or a market to a department store, supermarket, etc.
- Staple products and natural resources are handled by ETO mainly originated/ terminated at Bangkok port (P)

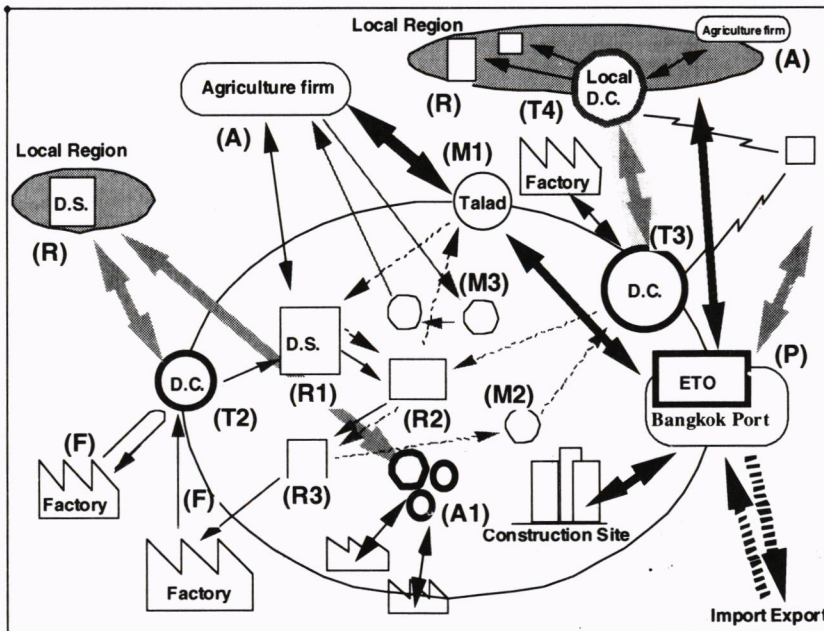


Figure 3 Concept of physical distribution system in BMA

For all delivery mentioned above, pickup truck or van are preferable than a truck because a large size truck is really inconvenient to find parking/loading space on the road side. Also, many streets in Bangkok are very narrow so that this does not allow a large size truck to access to destination. Also, a truck can not drive during the peak period because the truck ban system has been applied in Bangkok to alleviate traffic congestion.

The metrical evidence that pickup truck or van is very preferable in Bangkok is only the number of registered vehicle. During last decade, the number of registered vehicle excluding motorcycle in BMA has been increased from 1 million to 2 million, with unremitting annual growth of 10 percent. The portion of van and pickup truck corresponds to 20 percent of whole registered vehicle. This is more than four times of trucks as shown in Table 2.

Table 2 Number of Vehicles Registered in Bangkok for the Year 1997 (unit: vehicle)

Type of Vehicle	Total		Sector				
	1996	1997	1	2	3	4	5
Van & Pick Up*	462,803	552,835	71,959	59,850	82,180	16,270	322,576
Truck	110,454	98,234	22,416	20,717	20,827	5,246	41,248

Remarks;

*some are used as commercial vehicles

1 Bangkhun-tiean, Bangbon, Jomthong, Thonburi, Klongsan, Ratburana, Toongkru, Bangkor-learn, Yannawa, Sathorn

2 Talingchun, Bangplad, Bangkoknoi, Bangkokyai, Phasi-ja-reon, Nongkham, Pranakhon

3 Prakanong, Prawes, Suanlaung, Klongtoey, Wattana

4 Meanburi, Nongjog, Ladkrabang, Beungkum, Sapansoong, Kunnayao

5 Dusit, Pomprab, Sumpantawong, Bangrak, Bangkean, Bangkokapi, Pathumwan, Payathai, Ratchatewee, Bangsue, Jatujak, Donmeung, Ladprao, Huaw-kuang

(3) Policy regarding distribution system in BMA

Truck Ban has been induced by traffic control police, so as to avoid traffic congestion during morning and afternoon commuting period. Under truck ban system, a truck which has more than 4 wheels can not enter the BMA as below.

Table 3 Regulated Time under Truck Ban System

Type of Truck	Regulated Period
4 wheels and 6 wheels	6-9 and 16-20
more than 10 wheels including trailer	6-10 and 15-21
heavy truck carried gasoline, diesel, gas or long piles	6-22

Remarks: This was summarized by authors

Though the purpose of this truck ban system is not to improve the distribution system, it has made a transporter and a warehouse company move their distribution center, depot and warehouse out from the city center to the suburbs.

Another policy is an introduction of three truck terminals by DLT as follows;

- North 32 km from CBD along Highway Route No. 1 and the outer ring road.
- East Near inland container depot on Highway. No. 3119 and 3256
- West 20 km from CBD along Highway. No. 338

So far, a transporter used to collect cargoes from customers to his shop house, sort and consolidate their cargoes in front of the office and deliver to the destinations by contracted trucks or by their own trucks. Loading and unloading of cargoes using road spaces and footpaths have created traffic jam and made heavy trucks come into CBD just for loading/unloading cargoes. The role of new truck terminals would avoid the concentration of heavy truck traffic in CBD as well as improve the efficiency of the physical distribution.

4. MICROSCOPIC SURVEY AND THE RESULTS IN BMA

(1) Outline of the survey

a) Objectives

The purpose of this survey is to investigate microscopic characteristics of physical distribution and freight transport system in Bangkok. But there is no data which show the characteristics of the movement of goods and trucks, we can't estimate freight transport system in Bangkok. So we carried out microscopic survey on sample-firms about physical distribution and freight transport system, we would like to get the freight transport data to estimate the freight traffic load, the environmental load and its social cost in BMA.

b) Interview-survey points and method

Interview survey points of location are shown in Figure 2. They consist of one distribution center and four commercial markets in BMA. Interview survey point of distribution center (company name; Blue and White Trans Logistic Co. Ltd.) is middle scale (about 10 trucks ownership , about 1300 m² warehouse area) of logistic company, and this company has another three centers which is as same as this survey point in BMA. Survey points of commercial markets consist of different scales (Talad Thai, large scale; Mueng Tong Thaneer, middle scale; Bangkapi and BoBae, small scale).

Interview survey was carried out only for sampled truck (random interview-survey on sample-firms) in/out survey points and their drivers were questioned on several items such goods types others. The number of sample trucks collected were 150 within the distribution center and 183 in commercial markets, 333 in total. The interview survey was conducted in January 3 to 10 in 1999.

c) Items of questionnaire

The questionnaire was composed of three parts;

- Outline of the companies
- Commodity data (Goods type, Amount of goods, etc.)
- Truck used data (trip distance, etc.)

The type of trucks is classified by the number of wheels, such as 4 wheels, 6 wheels, 10 wheels and 1 ton pick-up truck. The type of goods is classified by Rice, Food, Processed Foods, Manufacture, Cloths and Others.

(2) Characteristics of the movement of goods

The outline of the distribution center and commercial markets are shown in Table 4. In Survey point of distribution center, as for main goods in this survey, others (including miscellaneous goods) has the biggest share (59.8%) , followed by manufacture (24.5%), clothes (12.6%). In the case of truck type, the pick up truck has the biggest share 72.0 %.

On the other hand , in the characteristics of the commercial markets, there is no clear pattern in the type of goods and trucks observed from the survey results, partly because the number of samples is small. Yet, it is noted that the share of pick up truck are rather irrespective of goods type.

Table 4 Stations for Interview Survey with Truck Drivers

Place	Scale	Main Goods	Location		Samples	
			LTPC R.A.	SPURT R.A.		
distribution center	Blue & White	Middle	others 59.8%, manufacture 24.5%	OUT	IN	150
commercial markets	Talad Thai	Large	food 72.8%, others 24.3%	OUT	OUT	73
	Mueng Tong Thaneer	Middle	others 57.9%, manufacture 24.8%	OUT	IN	32
	Bangkapi	Small	others 57.9%, food 26.9%	OUT	IN	30
	BoBae	Small	clothes 43.6%, others 43.6%	IN	IN	48

Among survey samples, the ratio of pick up truck was dominant on every survey points although slight fluctuation in its absolute level can be seen. This truck occupies about 80 % of all truck volume on almost survey points (Figure 4). As shown in Figure 5, the ratio of pick up truck has the biggest share on every type of goods. This means that there are almost survey points inside trucks restriction area (LTPC Restriction Area and SPURT Restriction Area) in central Bangkok.

Daily average trip length and number of destination per day by goods item are shown in Table 5 and characteristics are well summarized in this table.

Its average trip length is 114.3 km/ day, as shown in this table, there was clear difference in average trip length corresponding to goods type. In this survey, the average length is 137.6 km for process food, followed by manufacture (123.4 km), clothes (114.4 km). On the other hand, food (including fresh food) shows the shortest trip length (103.3 km). As for the number of destination points , it can be said that, they have the same tendency.

Survey points of commodity transport by types of truck can be summarized as follows:

- 1) Pick-up truck are the major means of transportation for any commodities
- 2) Its average trip length is 114.3 km/ day, as shown in this Table, there was clear difference in average trip length corresponding to goods type.
- 3) The average number of destination points is 4.2 points, maximum number is 5.8 for Rice, minimum number is 2.9 for Food.

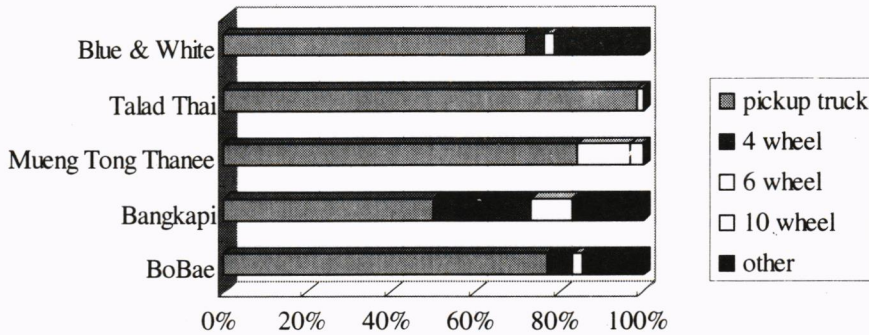


Figure 4 Share of truck type in survey points

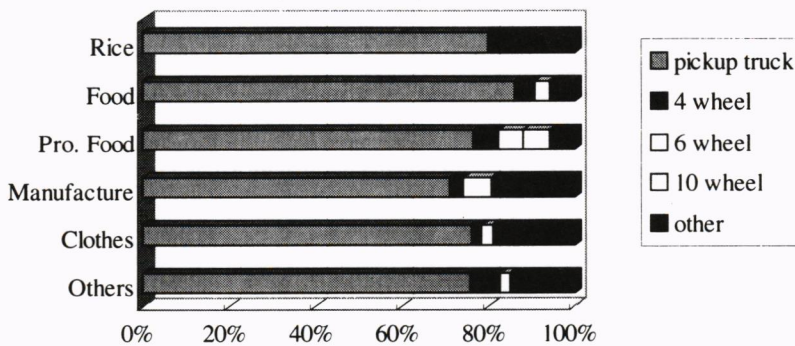


Figure 5 Share of truck type in Goods

(3) Characteristics of the movement of pick-up trucks

Although a number of researches have been carried out into the movement of goods and trucks in BMA, little is known about the movement of 1 ton pick up truck in the restriction area of BMA. Almost interview survey points are selected to represent restriction area points in central Bangkok. Thus, it is understood that the results of this interview survey should reveal the movement of goods and movement of trucks in restriction area behind such distribution characteristics in general with the focus on 1 ton pick up truck in BMA.

In company type, among surveyed pick up trucks were composed of three types, factory (40.5%), wholesaler (27.8%), retailer (25.1%). Nearly all the drivers, about 80% in this survey, does not have assistants in their trucks. As for main goods, others (including miscellaneous goods) has the biggest share (35.1%), followed by food (29.0%), manufacture (17.0%), clothes (12.4%). (Figure 6). It means that pick up trucks play an important part in physical distribution and freight transport system in central Bangkok. Because in restriction area only pick up trucks are free in freight activities. As shown in Table 6, its average trip length is 112.8 km, there was clear difference in average length according to goods types. On the other hand, the question "how many distributions do you go around per day?", the answers is very wide range from 1 place to over 15 places. The average number of around points is 3.9 points in this survey.

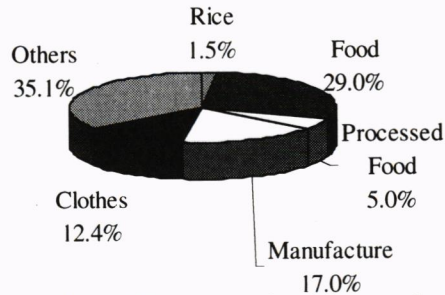


Figure 6 Rate of Goods type in pickup truck

Table 5 Average of movement in total truck

	avg. trip length (per day) (km)	destinations number (per day) (points)
Rice	110.0	5.8
Food	103.3	2.9
Processed Food	137.6	5.6
Manufacture	123.4	4.8
Clothes	114.4	3.6
Others	114.2	4.7
total avg.	114.3	4.2

Table 6 Average of movement in pickup truck

	avg. trip length (per day) (km)	destinations number (per day) (points)
Rice	117.5	5.0
Food	99.0	2.3
Processed Food	151.5	5.8
Manufacture	119.0	4.6
Clothes	108.3	3.7
Others	116.8	4.6
total avg.	112.8	3.9

5. ESTIMATION OF TOTAL TRUCK MILEAGE

In developing countries, there are few nationwide data which can be used for expanding the sample data. In Thailand, Department of Land Transport sums up the number of the registered cars and trucks every year, and this data is suitable for this purpose. We try to estimate the total truck mileage as follows

- Sample running truck survey about their age and truck mileage, which was already introduced in chapter 3.
- Estimation of truck mileage according to their types and areas

(1) Data for estimation

We use two kinds of data in order to estimate total truck mileage. One is an interview survey at truck terminals, and the other is the registered truck data collected by the Department of Land Transport in Thailand. As the behavior of trucks is much different with their size, we should analyze the data according to size separately. However, the number of the samples isn't enough, we deal with all data as one truck size after this.

The distribution of the truck age is shown in Figure 7, that of truck mileage is also shown in Figure 8. It is calculated that the average truck mileage in Bangkok is 36 thousand kilometer a year.

(2) Estimation of total truck mileage and exhaust gas

We assume that the number of trucks running in Bangkok is 663,289 which is the number of the registered in 1997. Thus total truck mileage in Bangkok is 2.39×10^{10} km, which is the product of 663,289 trucks and 36 thousand kilometer.

Though there are many kinds of exhaust gas, we deal with NO_x as a typical one. Exhaust coefficient of NO_x depends on speed, so we use the existing data about running speed of the trucks in Bangkok. Table 7 shows average speed, vehicle-kilometers, and exhaust coefficient of the average speed at each area. Figure 9 shows the relations between the speed and the exhaust coefficient of NO_x of trucks and pick-up trucks.

The number of trucks registered in 1997 is 110,454 and that of pick-up trucks is 552,835. When we assume that the ratio of the number of the trucks to that of the pick-up trucks are same among these areas, we can calculate the exhaust NO_x gas by each area and truck type. Thus total exhaust NO_x gas by cargo trucks in Bangkok is 4.59×10^7 kg a year, which is the sum total of the products of the total truck mileage and the coefficient of each area and truck type. Generally speaking, the average speed during a peak hour is different from that during a day. However the traffic congestion in Bangkok is so sever all day long that we could use the average speed during a peak hour instead of that during a day.

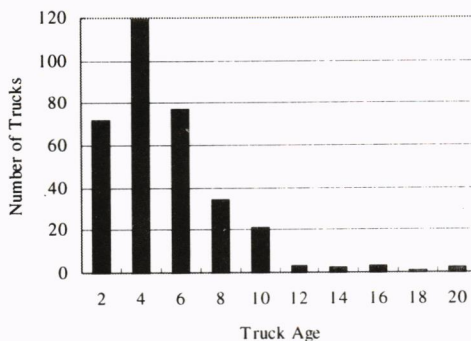


Figure 7 Distribution of truck age

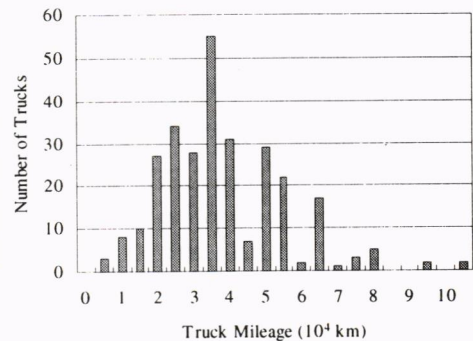


Figure 8 Distribution of truck mileage

Table 7 1994 Base Year-average speed and vehicle kilometers during rush hours

Area	Average speed v [km/h]	Vehicle-kilometers during peak hour	Share	Exhaust coefficient of a truck at speed v	Exhaust coefficient of a pick-up truck at speed v
Inner core areas	10.8	76.1	0.017	7.03	2.16
Inner areas	19.2	314.3	0.072	5.24	1.65
	20.5	1102.4	0.252	5.03	1.59
Middle areas	27.6	2606.6	0.595	4.11	1.32
Outer areas	37.7	249.2	0.057	3.30	1.14
Express way	22.8	32.3	0.007	4.70	1.49
Total	25.5	4380.9	1.000		

Source: Boontharawara, N., et al. (1994)

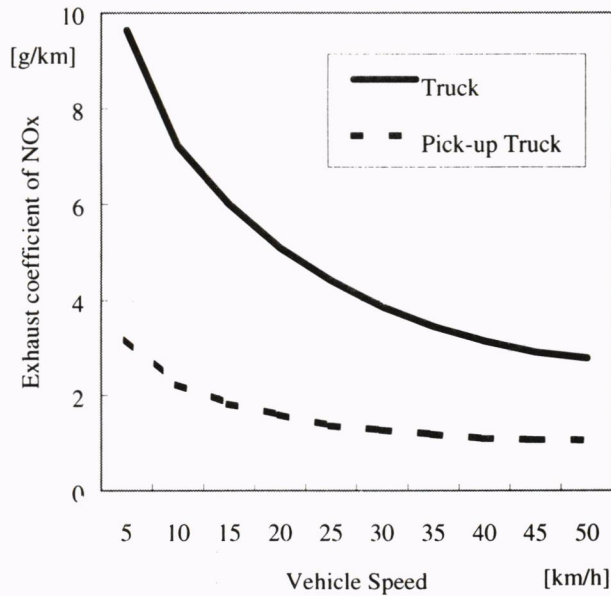


Figure 9 Exhaust coefficient of NOx

6. CONCLUSION

In this study, we could grasp the overall system of physical distribution, especially the intra-regional distribution in BMA which has never been analyzed metrically. From the interview survey at 6 places, we could found Boontharawara, N., et al. (1994) that average of pickup truck movement was more than 112 km/day and average of stopping destination was around 4 places. Using this figures and general statistics, we could estimated NOx gas discharged from cargo trucks in Bangkok.

ACKNOWLEDGMENT

The authors would like to acknowledge Mr. Silpachai Jarukasemratana of DLT and Mr. Sunyawit Sethapokin of Trans Logistics Co. Ltd. providing valuable information.

REFERENCES

a) Journal paper

Boontharawara, N., et al. (1994) Traffic Crisis and Air Pollution in Bangkok. **TEI Quarterly Environment Journal**, Vol. 2, No. 3, 4-37

Hanson, M.E. and Lopes, R. W. (1992) Methodology for Evaluating Urban Transportation Energy-Environment Strategies: Case Study for Bangkok, **Transportation Research Record** 1372, 53-61

b) Other documents

National Statistical Office (1990-97) Statistical Yearbook Thailand.

Japan International Cooperation Agency (1992) Interim Report of The Study on Greater Bangkok Truck Terminal in the Kingdom of Thailand.

Department of Land Transport (1995) Report on Survey for Quantity of Road Transportation in 1995.