JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEVELOPMENT STRATEGY INSTITUTE (DSI)
MINISTRY OF PLANNING AND INVESTMENT (MPI)
THE SOCIALIST REPUBLIC OF VIET NAM

THE STUDY ON THE INTEGRATED REGIONAL SOCIO-ECONOMIC DEVELOPMENT MASTER PLAN FOR THE KEY AREA OF THE CENTRAL REGION OF THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT
PRE F/S REPORT VOL.4

Hue-Da Nang Inter-city Highway Construction and Secondary Road Improvement Project

MARCH 1997

PACIFIC CONSULTANTS INTERNATIONAL
SANYU CONSULTANTS INC.
INTERNATIONAL DEVELOPMENT CENTER OF JAPAN

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The following foreign exchange rate is applied in the study:

US$ 1.00 = 11,000.00 Vietnamese Dong (as of October 1996)

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ABBREVIATIONS

ADB	Asian Development Bank
ASG	Assignment Group
B/C	Benefit Cost Ratio
BOT	Build, Operate and Transfer (formula)
DSI	Devlopment Strategy Institute
EIA	Environmental Impact Assessment
EPZ	Export Processing Zone
ESA	Equivalent Standard Axle
FIRR	Financial Internal Rate of Return
FTZ	Free Trade Zone
GDP	Gross Domestic Product
GMS	Greater Mekong Sub-Region
HDH	Hue - Da Nang Inter-city Highway Project
IBRD	International Bank for Reconstruction and Development (World Bank)
IEE	Initial Environmental Examination
IHCM	Indonesian Highway Capacity Manual
IPP	Individual power Producers
IRMS	Indonesian Integrated Road managemeent System
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature and Natural Resources
JICA	Japan International Cooperation Agency
MPI	Ministry of Planning and Investment
NIS	Network Information System (computer program)
NMV	Non-Motorized Vehicles
NPV	Net Present Value
NTSR	National Transportation Sector Review
PID	Privatized Infrastructure Development
SDR	Socio-Economic Development Region
TEDI	Transportat Engineering Design Inc.
TESI	Transport Development Strategy Institute
TPZ	Tourism Promotion Zone
TRANPLAN	Transportation Planning (computer program)
TSM	Transportation System Management
UNFPA	United Nations Population Fund
UNICEF	United Nations (International) Children's Fund

VOC	Vehicles Operating Cost
VPD	Vehicles per Day

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

This report presents road transport modeling techniques and methodologies as well as demand forecasts and feasibility reviews employed during the course of the Central Viet Nam Master Plan study.

1.1 OVERVIEW OF MODELING APPROACH

The modeling process can, in it's most basic sense, be summarized as consisting of four essential steps (Figure 1.1):

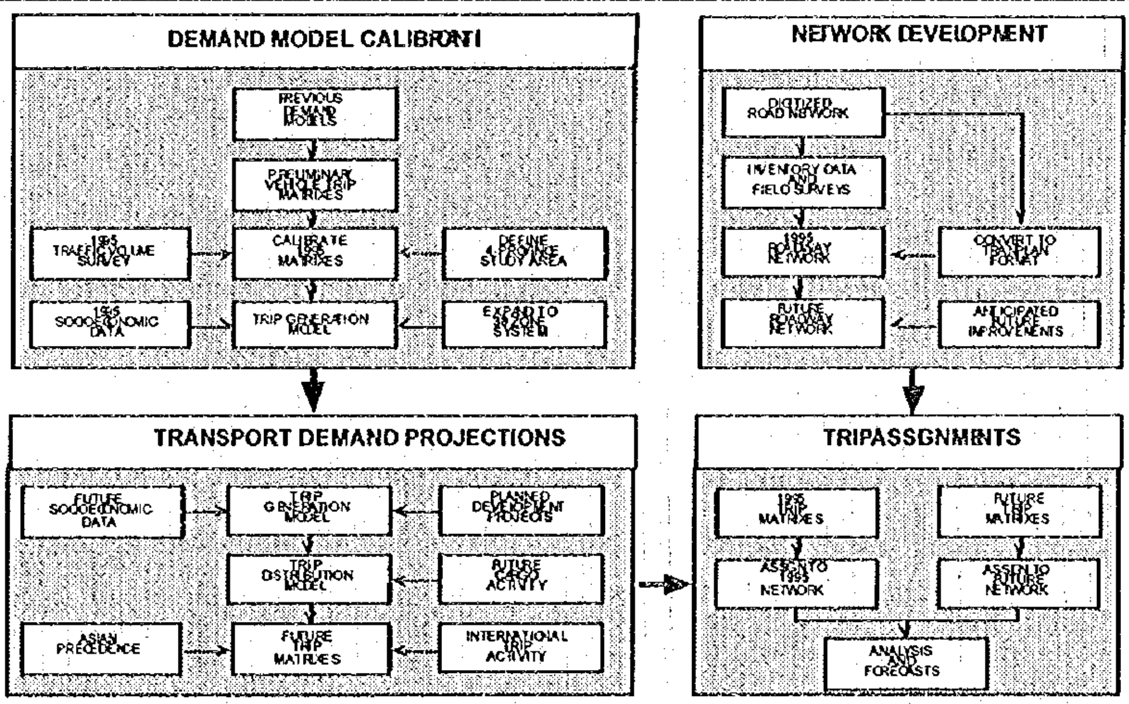


Figure 1.1
OVERVIEW OF ROAD TRANSPORT MODELING PROCESS

- Network development: road inventory data are assembled and a simulated year 1995 highway network is constructed. Inclusion of anticipated improvements such as upgrading of existing sections or construction of new segments leads to development of future (to year 2010) networks.
- Demand model calibration: vehicle trip matrixes are calibrated to 1995 conditions via information derived from the data collection program. Transport demand is linked with socio-economic data.

- Transport demand projections: future demand is correlated with landuse activity, regional development and traffic impacts of major new projects such as Dung Quat port.

- Trip assignments: Trips are loaded onto the base and future years networks, thus providing the basis for sufficiency analyses and projection of roadway utilization.

Execution of these tasks is complex, thus the capabilities of TRANPLAN/NIS software are employed during all steps of the modeling process[1]. Following sections of this chapter describe techniques and methodologies employed in building the transport model, as well as principal findings and conclusions of the simulation process. It is recognized that the estimation of future socioeconomic and transport activity is fraught with uncertainties given the on-going and anticipated continued massive restructuring of the Vietnamese economy, as well as changing political relationship with national neighbors. Transport activity will, correspondingly, be affected and thus innovative, yet practical, approaches to demand forecasting are required.

The transport model is therefore founded on two-tier technique which synthesizes "top down" and "bottom up" approaches:

- The top-down technique focuses on estimation of likely levels of national and regional development based on macro-economic and sociopolitical parameters which, in turn, are compared to indicators of historic transport evolution experienced by other Asian nations. Thus, a "likely" global scenario of the study area's future road transport demand can be developed.

- The bottom-up technique focuses on relative travel patterns experienced within each of the study area provinces. It is expected that sizable shifts in demand will occur as the economy continues to diversify as well as expand and mega-projects are realized. However, while some focused, capital-intensive improvements in road infrastructure are expected over the next two decades, existing locational aspects will largely remain as will those of cities, borders and natural terrain features. Thus, relative distribution patterns are, to reasonable degrees, expected to evolve from existing patterns. This lends credence to linking changes in internal (within the study area) trip demand with socioeconomic variables to include population, unit national income and mobility.

Extensive technical liaison was maintained throughout the modeling process. Numerous valuable comments were received from DSI counterpart staff and other governmental representatives regarding transport strategies and concepts, and likely resulting impacts upon forecasting procedures. In addition, other specialists of the Study Team conducted independent sectorial reviews, findings of which were cross-correlated with results of the road transport "top down" and "bottom up" techniques to ensure consistency of effort among all study participants.

1.2 AGGREGATIONS AND DEFINITIONS

Simulation techniques as used in this study rely on various terminologies. The following introductory descriptions are provided so that a more accurate and complete appreciation of transport modeling procedures may be obtained. Certain descriptions have been included in other sections of this report but are repeated here in order to make the presentation complete.

[1] TRANPLAN (Transportation Planning) and NIS (Network Information System) is an integrated set of computer programs offering, within a single package, comprehensive planning and forecasting capabilities for both highway and transit systems. TRANPLAN/NIS is proprietary software distributed by the Urban Analysis Group, Danville, California, USA and licensed for use by Pacific Consultants International.

- The four-province study area is subdivided into a series of analysis zones, the use of which implies that all movement to and from a zone can be adequately represented as starting or ending at a single point in the zone - the centroid. This point represents the zonal center of transport activity.

- The zone structure includes 32 internal zones (districts or combinations of districts), five external zones for trips between the study area and the rest of the nation, as well as one external zone representing the international border crossing with the Lao PDR. Thus, trips between all combinations of zones are contained in a matrix featuring 38 x 38 elements.

- Trip matrixes contain balanced daily travel demand, segregated by five vehicle types: passenger cars (sedan, van, jeep), buses, trucks, motorcycles and non-motorized vehicles (NMV).

- A trip is defined as a one way movement from an origin zone to a destination zone. The trip may be completed as a vehicular trip or as a "passenger car unit" (pcu). This stratification accepts that vehicle types exert differing impacts upon the traffic stream in which they operate. The pcu/vehicle equivalency is set at 1.0 for passenger cars, 2.5 for buses, 2.75 for trucks, 0.33 for motorcycles and 0.4 for NMV's.

- The trip matrix contains trips which cross a zone boundary. The zone structure adopted for the study area is designed to encompass as many "over the road" trips as possible, however, it must be recognized that some intra-zonal trips (such as those within Hue or Da Nang) are not included in trip matrixes.

1.3 STUDY AREA AND ZONE SYSTEM

The study area consists of four provinces: Quang Tri, Thua Thien - Hue, Quang Nam - Da Nang and Quang Ngai. However, transport simulation should, in order to properly fulfill its assigned role within the overall framework of the Master Plan study, be based on a more detailed system of analysis zones. This proved achievable via the adoption of a transport analysis zone system based on districts, or combinations of districts. In defining the zone system, several issues were considered:

- Any district containing a major city (or province capital) should be a separate zone.

- Any district in which major future development projects are planned should be a separate zone.

- Zones should be aggregatable to the province level of detail to foster the application of global control parameters.

- Populations of abutting zones should (particularly in coastal areas) be reasonable balanced as practical and possible.

- Zones should be so structured to ensure that a reasonable spread of traffic volume can be achieved on all parts of the simulated road network. This is particularly relevant in the mountainous areas, or where major geographical constraints are encountered.

- Zone structure should be conducive to the integration of new future road infrastructure.

The resulting system includes 32 internal zones, six being in Quang Tri province, seven in Thua Thien-Hue province, eleven in Quang Nam-Da Nang province, and eight in Quang Ngai province. The study area contained, in 1994, some 4.61 million persons, with highest concentrations found in zone 15 (Da Nang), followed by zones 8 (Hue) and 16 (Hoi An) (Table 1.1).

Additional external zones are created at locations where roads cross the study area boundary. These are:

ZONE NUMBER	LOCATION
33	Highway 1 (Binh Dinh Province)
34	Highway 24 (Kon Tum Province)
35	Highway 14 (Kon Tum Province)
36	Highway 9 (Lao PDR)
37	Highway 15 (Quang Binh Province)
38	Highway 1 (Quang Binh Province)

The adopted system therefore includes 32 internal zones and six external zones (Figure 1.2). Thus, the resultant 38 x 38 trip matrixes can contain journeys both of whose trip ends fall within the study area (internal-internal trip), one of whose trip ends falls within the study area (internal-external or external-internal trip), and trips without a trip - end in central Viet Nam (external-external trip).

1.4 REPORT STRUCTURE

The report is organized into a series of inter-related chapters:

- *Chapter 1* provides a general overview of the demand forecasting process.
- A summary of existing road transport conditions is presented in *Chapter 2*, to include status of the road system, traffic volume and vehicle ownership.
- Development of the simulated road network is discussed in *Chapter 3*.
- Projection of future demand, in the form of trip matrixes, as well as the underlying rationale is detailed in *Chapter 4*.
- *Chapter 5* focuses on sufficiency analysis of alternative road networks, perceived shortfalls and preferred courses of action. A series of priority improvement projects are presented.
- An approach to, and results of, economic viability reviews of priority projects is presented in *Chapter 6*.
- An initial environmental examination (IEE) of the priority projects is contained in *Chapter 7*.
- A preliminary implementation scheme is contained in *Chapter 8*, with a specific view towards private sector involvement in the financing of new road construction projects.

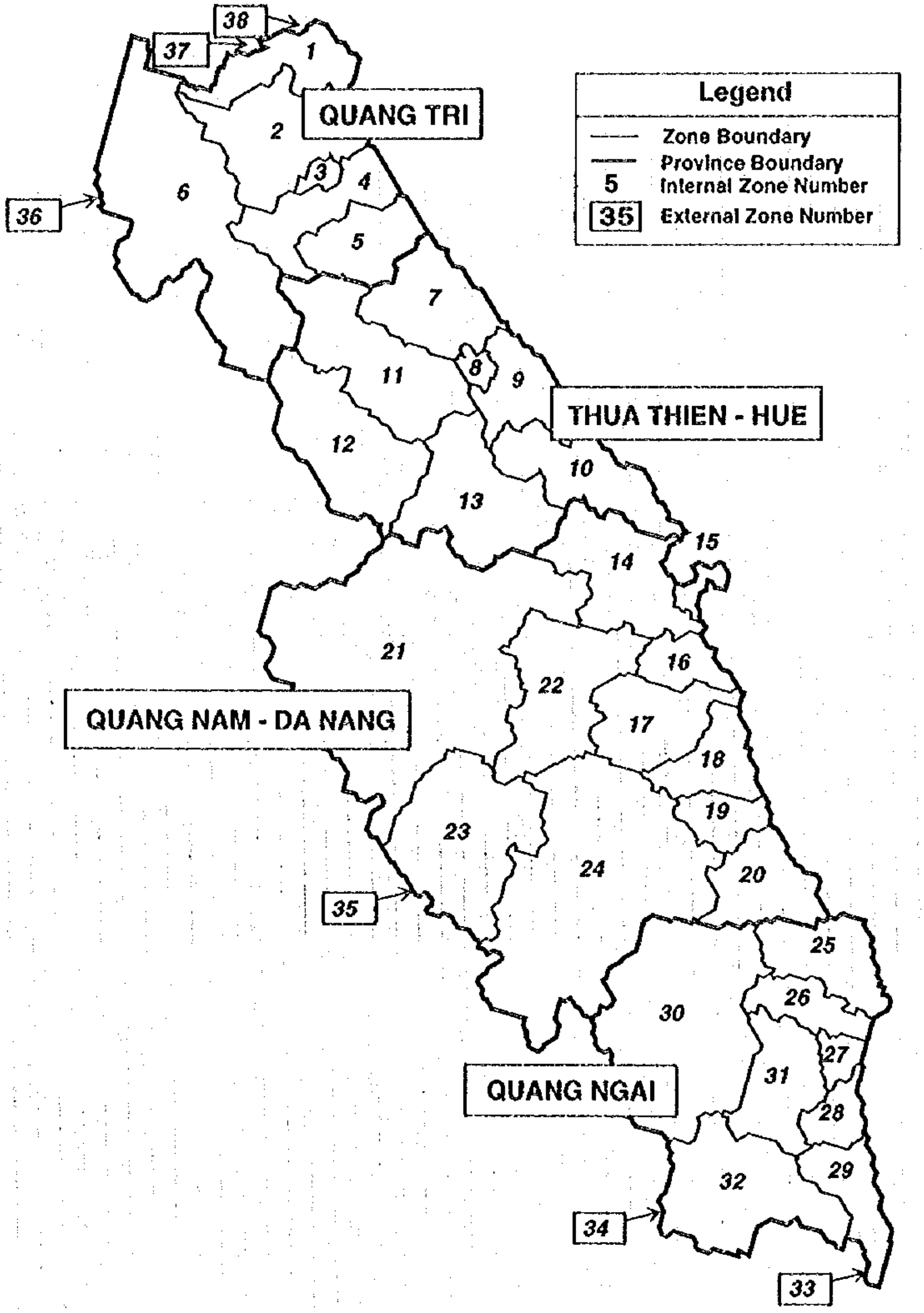
This report is one in a series produced within the framework of the current study. The interested reader is urged to consult these documents for additional detail regarding multi-sectorial topics upon which transport analyses are founded.

Table 1.1 STUDY AREA INTERNAL ZONING DIVISIONS

PROVINCE	ZONE NUMBER	DISTRICT NAMES	1994 POPULATION (1)	
			TOTAL (2)	URBAN
Quang Tri	1	Vinh Linh	84,246	10,956
	2	Gio Linh/Cam Lo	102,421	0
	3	Dong Ha	61,272	50,750
	4	Trieu Phong	102,925	0
	5	Quang Tri/Hai Lang	103,933	13,973
	6	Huong Hoa	59,433	6,856
Subtotal			514,230	82,535
Thua Thien - Hue	7	Phong Dien/Quang Bien/ Huong Tra (Part)	219,791	6,696
	8	Hue	276,366	222,815
	9	Phu Vang/Huong Thuy (Part)	215,673	10,101
	10	Phu Loc	140,244	10,697
	11	Huong Tra (Part)	61,711	744
	12	A Luoi	31,884	0
	13	Nam Dong/Houng Thuy (Part)	46,658	1,122
Subtotal			992,327	252,175
Quang Nam - Da Nang	14	Hoa Vang (Part)	146,877	16,272
	15	Da Nang/Hoa Vang (Part)	486,250	442,715
	16	Hoi An/Dien Ban	255,320	48,114
	17	Duy Xuyen/Que Son (Part)	167,621	19,908
	18	Thang Binh	171,763	20,833
	19	Tam Ky	158,040	50,829
	20	Nui Thanh	127,543	15,363
	21	Hien/Giang	44,123	7,764
	22	Dai Loc/Que Son (Part)	222,777	22,155
	23	Phuoc Son	16,292	6,184
	24	Hiep Duc/Tien Phuoc/Tra My	155,377	22,362
Subtotal			1,951,983	672,499
Quang Ngai	25	Binh Son	169,030	8,100
	26	Son Tinh	183,950	11,400
	27	Quang Ngai/Tu Nghia (Part)	187,605	72,275
	28	Mo Duc	138,950	9,400
	29	Duc Pho	139,400	8,300
	30	Tra Bong/Son Ha	99,460	0
	31	Tu Nghia (Part)/Nghia Hanh/ Minh Long	188,225	12,375
	32	Ba To	43,070	4,550
Subtotal			1,149,690	126,400
Total Study Area			4,608,230	1,133,609

(1) Source: General Statistical Office of Viet Nam
(2) Including urban population

Figure 1.2 Study Area and Zone System



CHAPTER 2

OVERVIEW OF EXISTING CONDITIONS

CHAPTER 2 OVERVIEW OF EXISTING CONDITIONS

This section sets forth the current status of road infrastructure within the study area, observed traffic volume and vehicle registration data.

2.1 ROAD SYSTEM

The Republic's 1994 road system aggregated to some 106,000 kilometers, of which about one-half consisted of roads classified as national, provincial or district facilities (Table 2.1).

Table 2.1 - 1994 National Road System - Republic of Viet Nam

Jurisdictional Classification	Extent	
	Kilometers	Percent
National Roads	10,805	10.2
Provincial Roads	15,295	14.5
District Roads	25,290	23.9
Village Roads	46,200	43.8
Urban Roads	2,570	2.4
Special Roads	5,450	5.2
Total	105,610	100.0

Source: Ministry of Transport

Nationwide road density totals 0.32 km/km^2, which is comparable to that of other Southeast Asian nations. Road densities for Thailand, Malaysia and Philippines total, for example, 0.20, 0.25 and 0.54 km/km^2, respectively. However, the condition of Viet Nam's road systems is sadly lacking with less than 10 percent of national, provincial and district roads being asphalted (Table 2.2).

Table 2.2 - 1994 Road Condition - Republic of Viet Nam

Jurisdictional Classification	Unit	Surface Treatment				
		Asphalt Concrete	Macadam Penetratio n	Gravel	Earth	Total
National	Km	3,305	3,600	1,400	2,500	10,805
	Percent	30.5	33.3	13.0	23.2	100.0
Provincial	Km	115	2,650	2,330	10,200	15,295
	Percent	0.8	17.3	15.2	66.7	100.0
District	Km	60	1,200	4,430	19,600	25,290
	Percent	0.2	4.8	17.5	77.5	100.0
Total	Km	3,480	7,450	8,160	32,300	51,390
	Percent	6.8	14.5	15.9	62.9	100.0

Source: Ministry of Transport

Within the study area, road infrastructure owned by the central government and the provinces, districts as well as communes aggregates to some 12,100 kilometers. Only 4.3 percent of that total consists of nationally owned and managed facilities (517 kilometers) and a further 15.9 percent nationally or provincially owned and managed by the provinces (1,927 kilometers). Almost 3,000 bridges exist in the study area, some one-third being under province control. Total length of all bridges is near 55 kilometers (Table 2.3).

About 88 percent of roads under national control are sealed, as are some 70 percent of roads under province control (roughly one-half being asphaltic concrete). Fully 75 percent of district managed roads, and 84 percent of commune managed roads, feature earth/gravel surfaces. All of nationally-managed bridges exceed a load capacity of 10 tons, but only some one-half of province-managed bridges satisfy the same criteria. Conversely, 42 percent of district-managed bridges, and 61 percent of commune-managed bridges, are restricted in weight to five tons (Table 2.4).

Travel within the study was, during January 1996, further complicated by a series of road closures (Figure 2.1). Highway 14 is permanently closed between Highway 14B and Province Highway 604 due to extensive bridge and roadbed failures. Highways 12, 24, 612 and 622 were blocked due to effects of recent flooding and/or efforts to repair this damage. Highways 14B and 604 were impassable for all but the largest vehicles due to road damage caused by heavily loaded trucks. Highway 609 is limited in use due to the bridge east of Highway 14B being restricted to only passenger cars and smaller vehicles. It is understood that other segments (such as Highway 14 in Quang Tri province) were only recently re-opened as a result of diligent repair efforts by provincial road authorities, including the installation of a number of temporary bridges.

2.2 TRAFFIC VOLUME

Up-to-date vehicle trip patterns in the study area were ascertained through a December, 1995 roadside count survey whose purposes are twofold:

- provide volume data at district and province boundaries to clarify 1995 traffic patterns; and,
- establish a basis for later calibration of interzonal demand matrixes developed as part of the road transport modeling process.

Twenty-nine locations (Figure 2.2 and Table 2.5) were designated for collecting either 24-hour (six locations) or 12-hour (23 locations) traffic counts. Traffic volume data at all locations were monitored by direction and by clock hour. Vehicles were classified according to nine categories:

- Motorized passenger vehicles
  - Passenger cars/vans/utilities
  - Small buses (less than 15 seats)
  - Large buses
- Motorized goods vehicles
  - Pick-up truck
  - Trucks with 2 axles
  - Trucks with 3 axles
  - Trucks with 4 and more axles
- Other vehicles
  - Bicycles/cyclos
  - Motorcycles

Table 2.3 1994 ROAD AND BRIDGE CONDITION
QUANG TRI, THUA THIEN-HUE, QUANG NAM - DANANG AND QUANG NGAI PROVINCES

HIGHWAY		ROAD SURFACE (KM)					NUMBER OF BRIDGES				BRIDGE LENGTH (M)
JURIS-DICTION	OWNER-SHIP	Asphalt Concrete	Mac'dn Pen'trn	Gravel	Earth	Total	5 Tons	5-10 Tns	>10 Tons	Total	
QUANG TRI PROVINCE (1)											
National	National	75	0	0	0	75				NA	NA
Province	Province	20	198	0	48	266	2	27	24	53	1,050
	National	166	33	0	0	199	1	5	60	66	1,602
	Subtotal	186	231	0	48	465	3	32	84	119	2,652
District	District	4	133	69	238	444	26	38	5	69	950
Commune	Commune	3	345	9	1,302	1,659	148	134	3	285	2,169
	District	0	0	0	0	0	0	0	0	0	0
	Subtotal	3	345	9	1,302	1,659	148	134	3	285	2,169
Total (2)		268	709	78	1,588	2,643	177	204	92	473	5,771
THUA THIEN - HUE PROVINCE (3)											
National	National	115	0	0	0	115	0	0	48	48	2,097
Province	Province	159	183	0	93	435	94	78	28	200	4,348
	National	80	48	0	9	137	3	18	24	45	1,234
	Subtotal	239	231	0	102	572	97	96	52	245	5,582
District	District	6	131	11	151	299	20	38	6	64	1,100
Commune	Commune	17	344	9	1,093	1,463	281	66	2	349	4,401
	District	0	30	10	85	125	28	19	3	50	757
	Subtotal	17	374	19	1,178	1,588	309	85	5	399	5,158
Total		377	736	30	1,431	2,574	426	219	111	756	13,937
QUANG NAM - DA NANG PROVINCE (4)											
National	National	167	0	0	62	229	0	0	359	359	13,678
Province	Province	148	199	0	229	576	0	36	74	110	2,367
	National	44	4	22	13	83	0	0	22	22	807
	Subtotal	192	203	22	242	659	0	36	96	132	3,174
District	District	130	45	58	920	1,153	98	155	32	285	4,077
Commune	Commune	0	101	0	1,100	1,201	29	97	4	130	2,429
	District	0	0	0	0	0	0	0	0	0	0
	Subtotal	0	101	0	1,100	1,201	29	97	4	130	2,429
Total		489	349	80	2,324	3,242	127	288	491	906	23,358
QUANG NGAI PROVINCE (5)											
National	National	98	0	0	0	98	0	0	53	53	2,468
Province	Province	37	81	24	22	164	0	15	52	67	1,230
	National	8	19	5	35	67	0	20	12	32	617
	Subtotal	45	100	29	57	231	0	35	64	99	1,847
District	District	13	190	26	432	661	167	68	84	319	3,727
Commune	Commune	2	266	14	2,385	2,667	218	105	13	336	3,770
	District	0	0	0	0	0	0	0	0	0	0
	Subtotal	2	266	14	2,385	2,667	218	105	13	336	3,770
Total		158	556	69	2,874	3,657	385	208	214	807	11,812
GRAND TOTAL											
National	National	455	0	0	62	517	0	0	460	460	18,243
Province	Province	364	661	24	392	1,441	96	156	178	430	8,995
	National	298	104	27	57	486	4	43	118	165	4,260
	Subtotal	662	765	51	449	1,927	100	199	296	595	13,255
District	District	153	499	164	1,741	2,557	311	299	127	737	9,854
Commune	Commune	22	1,056	32	5,880	6,990	676	402	22	1,100	12,769
	District	0	30	10	85	125	28	19	3	50	757
	Subtotal	22	1,086	42	5,965	7,115	704	421	25	1,150	13,526
Total		1,292	2,350	257	8,217	12,116	1,115	919	908	2,942	54,878

Source: Ministry of Transport and province authorities.

(1) Nationally owned roads include Highways 1, 9, 14 and 15. Eighteen numbered/lettered highways are owned by Quang Tri province.

(2) Excluding Highway 1 in Quang Tri province.

(3) Nationally owned roads include Highways 1, 14 and 49. Twenty-three numbered/lettered highways are owned by Thua Thien - Hue province.

(4) Nationally owned roads include Highways 1, 14 and 14B. Twenty-three numbered/lettered highways are owned by Quang Nam-Danang province.

(5) Nationally owned roads include Highways 1 and 24. Seven numbered/lettered highways are owned by Quang Ngai province.

Table 2.4 1994 ROAD AND BRIDGE CONDITION (PERCENT)
QUANG TRI, THUA THIEN-HUE, QUANG NAM - DA NANG AND QUANG NGAI PROVINCES

HIGHWAY		ROAD SURFACE					NUMBER OF BRIDGES			
JURIS-DICTION	OWNER-SHIP	Asphalt Concrete	Mac'dm Pen'trn	Gravel	Earth	Total	5 Tons	5-10 Tns	>10 Tons	Total
QUANG TRI PROVINCE										
National	National	100.0	0.0	0.0	0.0	100.0	•	•	•	•
Province	Province	7.5	74.4	0.0	18.0	100.0	3.8	50.9	45.3	100.0
	National	83.4	16.6	0.0	0.0	100.0	1.5	7.6	90.9	100.0
	Subtotal	40.0	49.7	0.0	10.3	100.0	2.5	26.9	70.6	100.0
District	District	0.9	30.0	15.5	53.6	100.0	37.7	55.1	7.2	100.0
Commune	Commune	0.2	20.8	0.5	78.5	100.0	51.9	47.0	1.1	100.0
	District	•	•	•	•	•	•	•	•	•
	Subtotal	0.2	20.8	0.5	78.5	100.0	51.9	47.0	1.1	100.0
Total		10.1	26.8	3.0	60.1	100.0	37.4	43.1	19.5	100.0
THUA THIEN - HUE PROVINCE										
National	National	100.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	100.0
Province	Province	36.6	42.1	0.0	21.4	100.0	47.0	39.0	14.0	100.0
	National	58.4	35.0	0.0	6.6	100.0	6.7	40.0	53.3	100.0
	Subtotal	41.8	40.4	0.0	17.8	100.0	39.6	39.2	21.2	100.0
District	District	2.0	43.8	3.7	50.5	100.0	31.3	59.4	9.4	100.0
Commune	Commune	1.2	23.5	0.6	74.7	100.0	80.5	18.9	0.6	100.0
	District	0.0	24.0	8.0	68.0	100.0	56.0	38.0	6.0	100.0
	Subtotal	1.1	23.6	1.2	74.2	100.0	77.4	21.3	1.3	100.0
Total		14.6	28.6	1.2	55.6	100.0	56.3	29.0	14.7	100.0
QUANG NAM - DA NANG PROVINCE										
National	National	72.9	0.0	0.0	27.1	100.0	0.0	0.0	100.0	100.0
Province	Province	25.7	34.5	0.0	39.8	100.0	0.0	32.7	67.3	100.0
	National	53.0	4.8	26.5	15.7	100.0	0.0	0.0	100.0	100.0
	Subtotal	29.1	30.8	3.3	36.7	100.0	0.0	27.3	72.7	100.0
District	District	11.3	3.9	5.0	79.8	100.0	34.4	54.4	11.2	100.0
Commune	Commune	0.0	8.4	0.0	91.6	100.0	22.3	74.6	3.1	100.0
	District	•	•	•	•	•	•	•	•	•
	Subtotal	0.0	8.4	0.0	91.6	100.0	22.3	74.6	3.1	100.0
Total		15.1	10.8	2.5	71.7	100.0	14.0	31.8	54.2	100.0
QUANG NGAI PROVINCE										
National	National	100.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0	100.0
Province	Province	22.6	49.4	14.6	13.4	100.0	0.0	22.4	77.6	100.0
	National	11.9	28.4	7.5	52.2	100.0	0.0	62.5	37.5	100.0
	Subtotal	19.5	43.3	12.6	24.7	100.0	0.0	35.4	64.6	100.0
District	District	2.0	28.7	3.9	65.4	100.0	52.4	21.3	26.3	100.0
Commune	Commune	0.1	10.0	0.5	89.4	100.0	64.9	31.3	3.9	100.0
	District	•	•	•	•	•	•	•	•	•
	Subtotal	0.1	10.0	0.5	89.4	100.0	64.9	31.3	3.9	100.0
Total		4.3	15.2	1.9	78.6	100.0	47.7	25.8	26.5	100.0
GRAND TOTAL										
National	National	88.0	0.0	0.0	12.0	100.0	0.0	0.0	100.0	100.0
Province	Province	25.3	45.9	1.7	27.2	100.0	22.3	36.3	41.4	100.0
	National	61.3	21.4	5.6	11.7	100.0	2.4	26.1	71.5	100.0
	Subtotal	34.4	39.7	2.6	23.3	100.0	16.8	33.4	49.7	100.0
District	District	6.0	19.5	6.4	68.1	100.0	42.2	40.6	17.2	100.0
Commune	Commune	0.3	15.1	0.5	84.1	100.0	61.5	36.5	2.0	100.0
	District	0.0	24.0	8.0	68.0	100.0	56.0	38.0	6.0	100.0
	Subtotal	0.3	15.3	0.6	83.8	100.0	61.2	36.6	2.2	100.0
Total		10.7	19.4	2.1	67.8	100.0	37.9	31.2	30.9	100.0

Figure 2.1 Road Passability (January 1996)

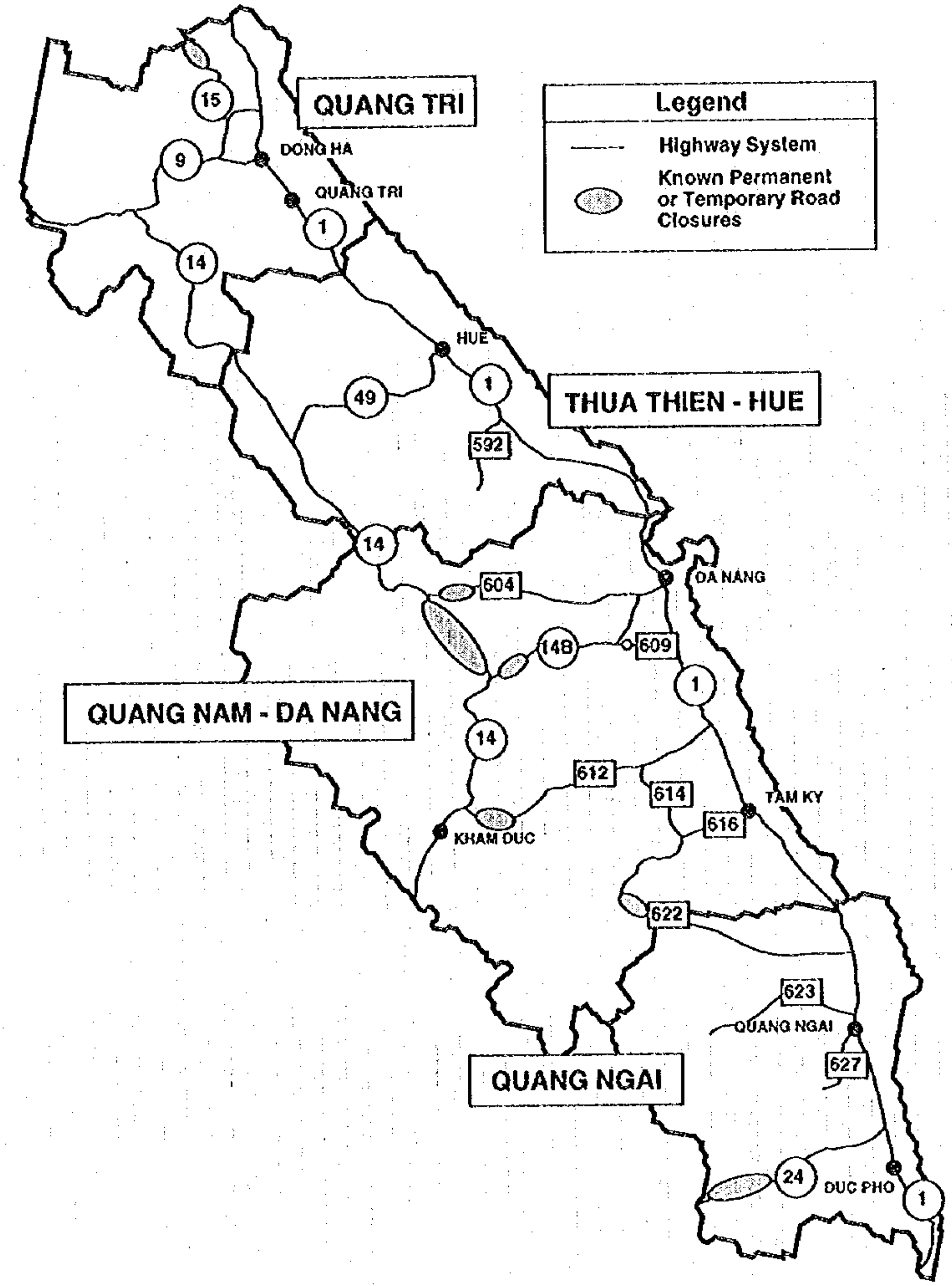


Figure 2.2 Study Area Traffic Count Locations

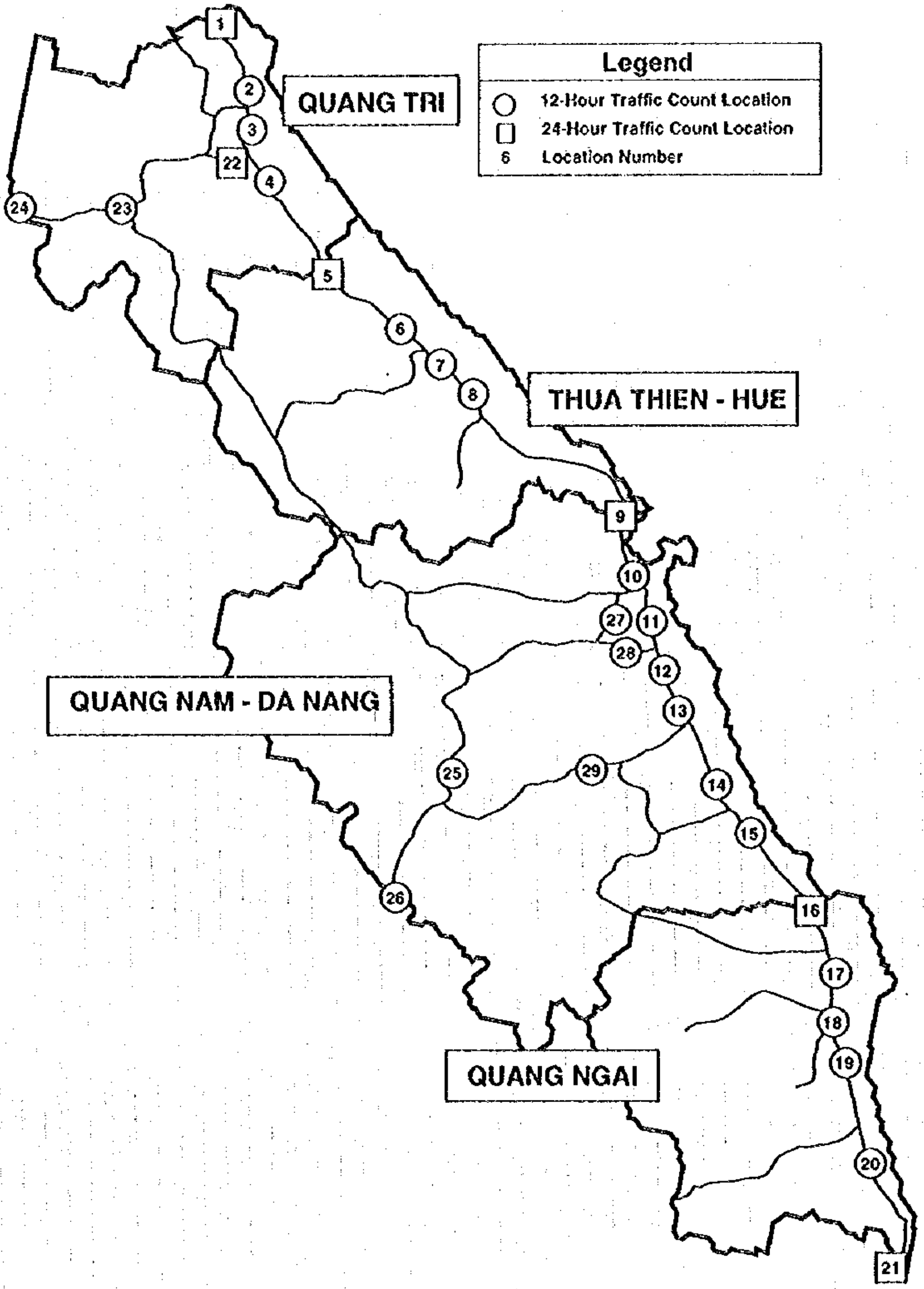


Table 2.5 LISTING OF ROADSIDE TRAFFIC COUNT LOCATIONS

HIGHWAY	SURVEY SITE (1)		TRAFFIC COUNT	
NUMBER	NMBR	BORDER OF	12 HRS	24 HRS
1	1	Quang Tri ~ Quang Binh Provinces		O
	2	Vinh Linh ~ Gio Linh Districts	O	
	3	Gio Linh ~ Dong Na Districts	O	
	4	Dong Ha ~ Trieu Phong Districts	O	
	5	Quang Tri ~ Thua Thien - Hue Provinces		O
	6	Huong Tra ~ Hue Districts	O	
	7	Hue ~ Huong Thuy Districts	O	
	8	Huong Thuy ~ Phu Loc Districts	O	
	9	Thua Thin - Hue ~ Quang Nam - Da Nang Provinces		O
	10	Hoa Vang ~ Da Nang Districts	O	
	11	Hoa Vang ~ Dien San Districts	O	
	12	Dien Ban ~ Duy Xuyen Districts	O	
	13	Que Son ~ Thang Binh Districts	O	
	14	Thang Binh ~ Tam Ky Districts	O	
	15	Tam Ky ~ Nui Thanh Districts	O	
	16	Quang Nam - Da Nang ~ Quang Ngai Provinces		O
	17	Binh Son ~ Son Thinh Districts	O	
	18	Son Tinh ~ Quang Ngai Districts	O	
	19	Tu Nghia ~ Mo Duc Districts	O	
	20	Mo Duc ~ Duc Pho Districts	O	
	21	Quang Ngai ~ Binh Dinh Provinces		O
9	22	Dong Ha ~ Cam Lo Districts		O
	23	Junction of Highways 9 and 14	O	
	24	East of Lao Bao Border Crossing	O	
14	23	Junction of Highways 9 and 14	O	
	25	Giang ~ Phuoc Son Districts	O	
	26	Quang Nam - Da Nang ~ Kon Tum Provinces	O	
14B	27	Hoa Vang ~ Dai Loc Districts	O	
609	28	Dien Ban ~ Dai Loc Districts	O	
612	29	West of Highway 614 Junction	O	

(1) Refer Figure 2.2 for locations

All data obtained from the roadside count survey were subjected to logic checks, coded in computerized spreadsheet format, and (in case of 12-hour counts) expanded to 24-hour status.

Traffic is, not surprisingly, heaviest along Highway 1. However, even these totals are modest: daily volumes for four-wheeled (or more) vehicles typically range from 1,500-2,500 vehicles, with highest volume (near 4,800 vehicles) recorded in vicinity of Da Nang. Two-wheeled vehicle activity was recorded as being lowest at the border of Thua Thien-Hue/Quang Nam-Da Nang provinces (Hai Van Pass) - a total of under 300 vpd, almost all being motorcycles. In contrast, over 28,000 daily two-wheeled vehicles were noted in vicinity of Da Nang (Table 2.6). Traffic volume along Highway 9 (the existing linkage to Lao PDR and Thailand) totals about 300 four-wheeled vehicles per day at the western extreme. Volumes along other roads are low, typically less than 200 vpd.

Table 2.6 DAILY 1995 TRAFFIC VOLUME
CENTRAL VIETNAM ROADWAY NETWORK

		MOTORIZED GOODS AND PASSENGER VEHICLES										OTHER VEHICLES			
			BUS (2)			TRUCK									
HIGHWAY NUMBER	SURVEY POINT(1)	CAR	Small	Large	Subtotal	Pick-up	2 Axles	3 Axles	4 Axles	Subtotal	Total	Bicycle Cyclo	Motor-cycle	Sub Total	GRAND TOTALS
1	1	130	49	240	289	27	590	103	9	729	1,148	821	501	1,322	2,470
	2	155	77	237	314	59	649	89	2	799	1,268	1,257	1,007	2,264	3,532
	3	233	102	213	315	103	741	112	2	958	1,506	2,371	1,960	4,331	5,837
	4	302	206	368	574	106	980	77	9	1,172	2,048	3,586	3,636	7,222	9,270
	5	155	147	217	364	62	619	129	8	818	1,337	1,106	795	1,901	3,238
	6	182	223	380	603	93	904	68	0	1,065	1,850	4,038	2,814	6,852	8,702
	7	519	363	468	831	54	1,066	107	2	1,229	2,579	6,618	5,159	11,777	14,356
	8	420	260	460	720	64	993	137	0	1,194	2,334	3,179	2,382	5,561	7,895
	9	175	121	272	393	8	553	96	20	677	1,245	11	281	292	1,537
	10	492	902	411	1,313	519	1,945	494	17	2,975	4,780	11,430	16,752	28,182	32,962
	11	349	782	388	1,170	152	1,177	108	11	1,448	2,967	2,633	4,082	6,715	9,682
	12	245	347	528	875	325	690	138	11	1,164	2,284	5,942	6,293	12,235	14,519
	13	179	124	548	672	80	609	172	15	876	1,727	2,450	3,792	6,242	7,969
	14	242	68	488	556	84	579	134	15	812	1,610	1,870	1,970	3,840	5,450
	15	157	127	619	746	114	597	134	11	856	1,759	4,439	3,174	7,613	9,372
	16	124	83	428	511	81	581	137	15	814	1,449	1,438	1,463	2,901	4,350
	17	155	149	313	462	51	782	268	57	1,158	1,775	4,200	2,217	6,417	8,192
	18	180	149	512	661	146	1,021	531	6	1,704	2,545	3,808	3,722	7,530	10,075
	19	321	54	378	432	153	616	248	2	1,019	1,772	3,664	4,782	8,446	10,218
	20	124	149	420	569	536	668	227	8	1,439	2,132	8,494	3,046	11,540	13,672
	21	107	82	414	496	43	638	140	3	824	1,427	430	978	1,408	2,835
9	22	131	40	57	97	66	430	35	14	545	773	3,204	3,210	6,414	7,187
	23	39	36	30	66	5	219	44	22	290	395	42	183	225	620
	24	46	11	15	26	11	266	28	30	335	407	241	2,852	3,093	3,500
14	23	2	5	3	8	0	5	18	0	23	33	32	90	122	155
	25	8	0	12	12	8	14	0	0	22	42	0	32	32	74
	26	3	0	0	0	0	0	19	0	19	22	0	22	22	44
14B	27	16	31	22	53	34	95	25	0	154	223	2,204	1,582	3,786	4,009
609	28	9	93	0	93	0	164	0	0	164	266	1,814	1,135	2,949	3,215
612	29	9	3	31	34	34	32	28	0	94	137	205	103	308	445

(1) Refer Figure 2 2 for site locations

(2) Small bus defined as having less than 15 seats.

The four-wheeled traffic stream tends to broadly consist of some 50-60 percent trucks, 20-30 percent buses, and on the order of 10-15 per cent passenger cars. The dominant form of truck is a 2-axle configuration, while the number of small buses (less than 15 seats) tends to exceed the more prevalent large buses only in vicinity of urban centers (Table 2.7).

Table 2.7 DAILY 1995 MODAL PATTERNS CENTRAL VIETNAM ROADWAY NETWORK

HIGHWAY NUMBER	SURVEY POINT(1)	MOTORIZED GOODS AND PASSENGER VEHICLES (PERCENT)										OTHER VEHICLES (PERCENT)		
			BUS (2)			TRUCK								
		CAR	Small	Large	Subtotal	Pick-up	2 Axles	3 Axles	4 Axles	Subtotal	Total	Bicycle Cyclo	Motor-cycle	Sub Total
1	1	11.3	4.3	20.9	25.2	2.4	51.4	9.0	0.8	63.5	100.0	62.1	37.9	100.0
	2	12.2	6.1	18.7	24.8	4.7	51.2	7.0	0.2	63.0	100.0	55.5	44.5	100.0
	3	15.5	6.8	14.1	20.9	6.8	49.2	7.4	0.1	63.6	100.0	54.7	45.3	100.0
	4	14.7	10.1	18.0	28.0	5.2	47.9	3.8	0.4	57.2	100.0	49.7	50.3	100.0
	5	11.6	11.0	16.2	27.2	4.6	46.3	9.6	0.6	61.2	100.0	58.2	41.8	100.0
	6	9.8	12.1	20.5	32.6	5.0	48.9	3.7	0.0	57.6	100.0	58.9	41.1	100.0
	7	20.1	14.1	18.1	32.2	2.1	41.3	4.1	0.1	47.7	100.0	56.2	43.8	100.0
	8	18.0	11.1	19.7	30.8	2.7	42.5	5.9	0.0	51.2	100.0	57.2	42.8	100.0
	9	14.1	9.7	21.8	31.6	0.6	44.4	7.7	1.6	54.4	100.0	3.8	96.2	100.0
	10	10.3	18.9	8.6	27.5	10.9	40.7	10.3	0.4	62.2	100.0	40.6	59.4	100.0
	11	11.8	26.4	13.1	39.4	5.1	39.7	3.6	0.4	48.8	100.0	39.2	60.8	100.0
	12	10.7	15.2	23.1	38.3	14.2	30.2	6.0	0.5	51.0	100.0	48.6	51.4	100.0
	13	10.4	7.2	31.7	38.9	4.6	35.3	10.0	0.9	50.7	100.0	39.3	60.7	100.0
	14	15.0	4.2	30.3	34.5	5.2	36.0	8.3	0.9	50.4	100.0	48.7	51.3	100.0
	15	8.9	7.2	35.2	42.4	6.5	33.9	7.6	0.6	48.7	100.0	58.3	41.7	100.0
	16	8.6	5.7	29.5	35.3	5.6	40.1	9.5	1.0	56.2	100.0	49.6	50.4	100.0
	17	8.7	8.4	17.6	26.0	2.9	44.1	15.1	3.2	65.2	100.0	65.5	34.5	100.0
	18	7.1	5.9	20.1	26.0	5.7	40.1	20.9	0.2	67.0	100.0	50.6	49.4	100.0
	19	18.1	3.0	21.3	24.4	8.6	34.8	14.0	0.1	57.5	100.0	43.4	56.6	100.0
	20	5.8	7.0	19.7	26.7	25.1	31.3	10.6	0.4	67.5	100.0	73.6	26.4	100.0
	21	7.5	5.7	29.0	34.8	3.0	44.7	9.8	0.2	57.7	100.0	30.5	69.5	100.0
9	22	16.9	5.2	7.4	12.5	8.5	55.6	4.5	1.8	70.5	100.0	50.0	50.0	100.0
	23	9.9	9.1	7.6	16.7	1.3	55.4	11.1	5.6	73.4	100.0	18.7	81.3	100.0
	24	11.3	2.7	3.7	6.4	2.7	65.4	6.9	7.4	82.3	100.0	7.8	92.2	100.0
14	23	6.1	15.2	9.1	24.2	0.0	15.2	54.5	0.0	69.7	100.0	26.2	73.8	100.0
	25	19.0	0.0	28.6	28.6	19.0	33.3	0.0	0.0	52.4	100.0	0.0	100.0	100.0
	26	13.6	0.0	0.0	0.0	0.0	0.0	86.4	0.0	86.4	100.0	0.0	100.0	100.0
14B	27	7.2	13.9	9.9	23.8	15.2	42.6	11.2	0.0	69.1	100.0	58.2	41.8	100.0
609	28	3.4	35.0	0.0	35.0	0.0	61.7	0.0	0.0	61.7	100.0	61.5	38.5	100.0
612	29	6.6	2.2	22.6	24.8	24.8	23.4	20.4	0.0	68.6	100.0	66.6	33.4	100.0

(1) Refer Figure 2.2 for site locations.
(2) Small bus defined as having less than 15 seats.

To provide an overview of temporal variation along Highway 1, data from 24-hour counts (excluding Hai Van Pass) were combined into a single composite site. Results indicate that passenger cars, motorcycles and bicycles/cyclos exhibit strong peaking patterns during daylight (work) hours. Bus activity is less peaked, although a morning surge is evident. Truck activity is, on the other hand, almost evenly spread throughout the 24-hour period. These patterns are reflected in modal peak hours: the passenger car peak hour totals, for example, 11.4 percent of daily volume. However, truck activity during any one hour never extends 5.6 percent of the daily total (Figure 2.3).

The conversion of vehicles to an equivalent number of passenger car units (pcu) reflects the fact that different types of vehicles, due to size and engine performance, exert differing impacts upon the traffic stream, particularly so under varying terrain conditions. Thus, a single 2-axle truck can be approximated as representing 2-3 (or more) pcu's. The application of pcu factors, coupled with observed vehicle type and temporal distributions, confirms the dominant role the truck plays in the current Highway 1 traffic stream. Trucks absorb, in terms of pcu's, some 40-50 percent of daytime road activity, a total which increases to 70-80 percent during late night and early morning hours (Figure 2.4).

Differences in survey classifications and site locations prevent a meaningful comparison between 1995 traffic data collected within the framework of the current study and data from previous years made available by the Ministry of Transport. However, analysis of MOT data within the study area provides some insight as to recent volume trends. An average of data obtained at 13 locations on Highway 1 within the study area suggests that, between 1993 and

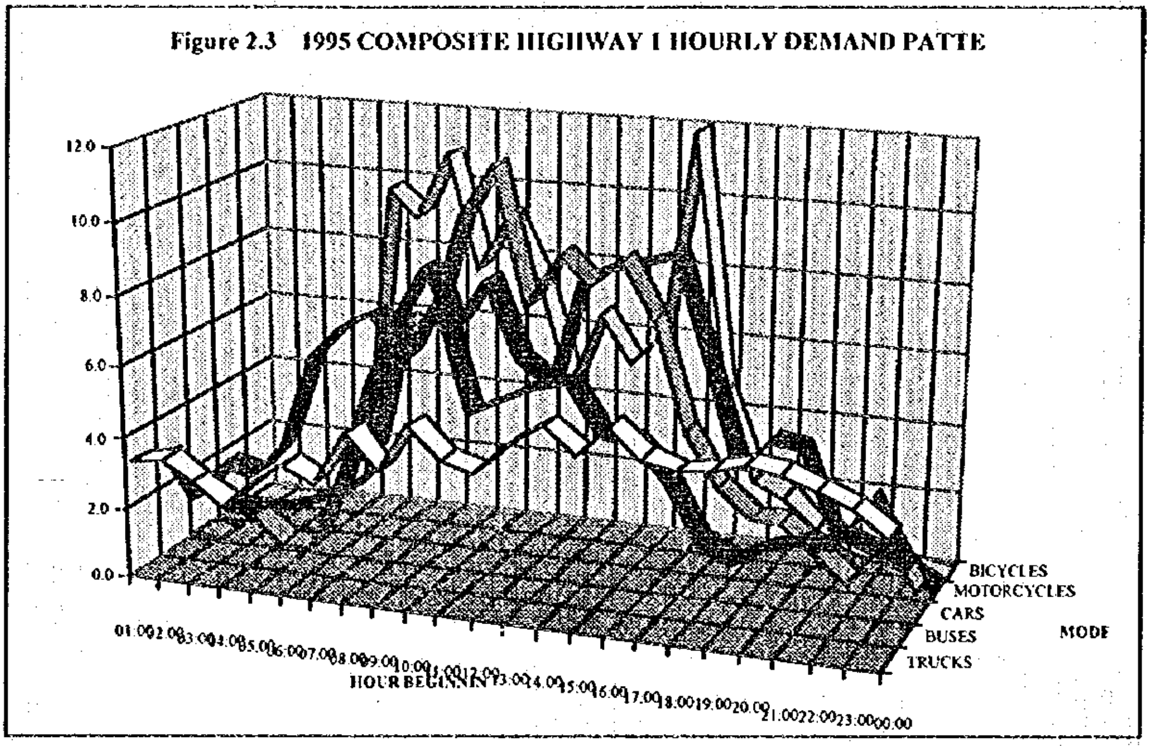


Figure 2.3 1995 COMPOSITE HIGHWAY 1 HOURLY DEMAND PATTE
12.0
10.0
8.0
6.0
4.0
2.0
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BICYCLES
MOTORCYCLES
CARS
BUSES
TRUCKS
MODE
HOUR BEGINNIN

Fig 2.3 & 2.4

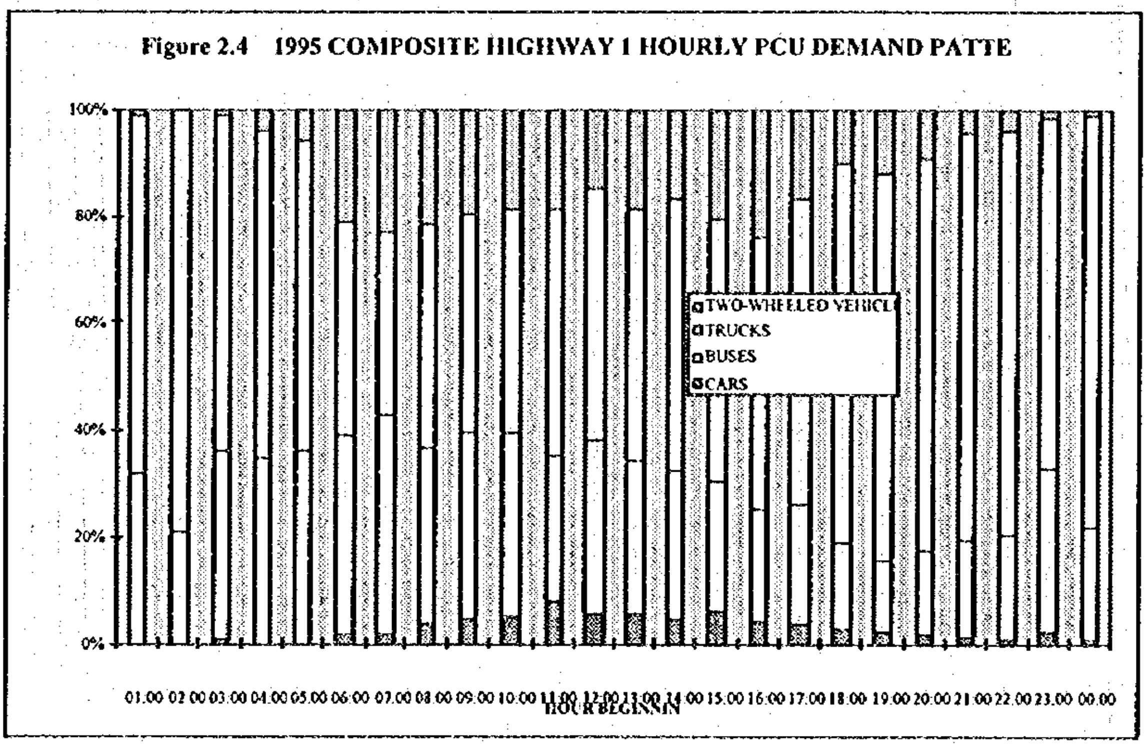


Figure 2.4 1995 COMPOSITE HIGHWAY 1 HOURLY PCU DEMAND PATTE
100%
80%
60%
40%
20%
0%
TWO-WHEELED VEHICL
TRUCKS
BUSES
CARS
01.00 02.00 03.00 04.00 05.00 06.00 07.00 08.00 09.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00 19.00 20.00 21.00 22.00 23.00 00.00
HOUR BEGINNIN

1994, car traffic dropped by five percent (the MOT "car" definition is not necessarily synonymous with that adopted by the current study), buses (20-60 seats) increased by 12 percent, trucks (> 3 tons) increased by three percent, and motorcycles increased by 11 percent.

Historic traffic flow data for the western-most segments of Highway 9 indicate that daily traffic has reduced from 703 vpd in 1992 to 570 vpd and 438 vpd in 1993 and 1994, respectively[1]. This drop has been identified with the collapse of Lao PDR-Eastern Europe trade, as well as the prohibition of forestry (logs) imports by the Government of Viet Nam. Data collected within the framework of the current study suggest that 1995 traffic flow may have stabilized near 300-350 vpd.

2.3 VEHICLE OWNERSHIP

Up-to-date vehicle registration statistics at the province level of detail are not, as yet, routinely available. Several sources were consequently utilized in order to gain an understanding of recent vehicle ownership patterns. These include the Transport Development Strategy Institute (TDSI) of the Ministry of Transport (1985 and 1991 data), the Ministry of Heavy Industries (1991 data)[2], and the General Statistics Office (1994 data)[3].

TDSI data suggest that the number of 1991 national registrations aggregated to about 103,700 vehicles, an increase of some one-fourth over the 82,000 vehicles shown as being registered in 1985 (Table 2.8).

Table 2.8 - Comparison of National 1985 and 1991 Vehicle Registrations

Vehicle Type	Number Registered		Annual Percent
	1985	1991	Change
Cars and Vans	13,662	21,000	7.4
Large Buses	9,891	25,520	17.9
Trucks	58,402	56,181	-0.6
Total	81,955	103,701	4.0

Source: TDSI

The bus category exhibited strong growth while the truck fleet appears to have declined in size. The overall average annual growth rate (four percent) is modest. However, questions persist as to the compatibility of these two data sets given that some changes in classification terminology as well as data collection techniques may have occurred in intermediate years.

A more detailed review of the 1991 TDSI data yields several interesting findings.

- The truck fleet consisted of some 56,000 units with a total capacity of 310,000 tons. Only 10-20 percent of the fleet was registered to private owners, the remainder to the central government (35 percent), DTCP (16 percent) and provincial government (23 percent). It is logical to surmise that the private ownership share has, since then, increased considerably. Many trucks were, in 1991, older than 10 years. A large majority were in the 5-7 ton class, and only some five to 10 percent had a load capacity of greater than seven tons. This is

[1] Source: Quang Tri Province People's Committee.

[2] "Demand Forecasts for the Vietnamese Automobile Market", Mitsubishi Corporation, July, 1992.

[3] Data developed by the GSO under contract to the Study Team, March, 1996.

consistent with findings of 1991 NTSR surveys[1] which established average truck loads of 4.2 tons (empty trucks included) and 6.7 tons (empty trucks excluded).

- The registered bus fleet consisted of 38,000 units with a total capacity of 635,000 seats. Almost one-third of that total was registered to private owners. However, registrations appear to include some 12,000 three-wheeled vehicles; eliminating this category leaves a total of about 26,000 "real" buses. Almost half of this fleet featured a capacity of less than 12 seats; the remaining half was almost equally divided between 12-36 seat units, and buses with more than 36 seats. About 45 percent of buses were over 10 years old, and slightly over five percent more than 20 years old.

- Data suggest that some 21,000 cars/vans were registered in 1991. Information is not available at the province level of detail, however, TDSI staff indicate that most of these vehicles were registered in either Hanoi or Ho Chi Minh City. Whether or not these vehicles actually operated in or near their place of registration is unknown.

While the TDSI data provide valuable insight to ownership patterns, discrepancies do unfortunately exist vis-à-vis information supported by the Ministry of Heavy Industries. This places 1991 national registrations nearer to 205,000 - or about twice the level suggested by the TDSI data. The reasons for this discrepancy are not known.

Discussions with GSO representatives regarding 1994 data (latest available year of record) confirm that an accurate accounting of vehicle registrations is still difficult due to several reasons.

- A cumbersome classification system is used which relies on ownership (not vehicle) parameters. Categories include state (province, national) and non-state registrations subdivided by entities such as enterprises, cooperatives, private and "100 percent foreign owned".

- Vehicle-type categories are very broad. For example, "motorized passenger cars of less than or equal to 14 seats" encompasses a wide variety of vehicles, among them sedans, vans and, presumably, mini-buses in commercial service.

- Base data is maintained (to varying degrees of accuracy) by each province, and is, with few exceptions, compiled manually.

- Vehicle registration is on a life-time basis. Thus, at present, inactive or scrapped vehicles still appear in vehicle registration records.

- Some elements of government do not provide vehicle data.

Nevertheless, available 1994 data still provide a valuable overview of Vietnamese vehicle ownership which, when linked with GDP, yields a relative comparison vi-à-vis her Asian neighbors.

GSO data suggest that the number of 1994 national car, bus and truck registrations aggregated to about 165,000 vehicles, an increase of some 50 percent over the 103,700 vehicles shown as being registered in 1991. The number of registered 1994 motorcycles exceeded 2.6 million (Table 2.9).

[1] "National Transport Sector review", by BCEOM Consultants, Paris, for Ministry of Transport and Communications, Government of Viet Nam, 1992.

Table 2.9 Comparison of National 1991 and 1994 Vehicle Registrations

Vehicle Type	Number Registered 1991	Number Registered 1994	Annual Percent Change
Cars and Vans	21,000	49,787	33.3
Large Buses	25,520	19,374	-8.8
Trucks	56,181	95,855	19.5
Total	103,701	165,016	16.7
Motorcycles	-	2,676,710	-

Sources: TDSI (1991) and GSO (1994)

Viet Nam is currently divided into eight socioeconomic development regions, in short, SDR 1 to SDR 8. Hanoi is located in SDR 3, and Ho Chi Minh City in SDR 7. The study area is partly located in SDR 4 (Quang Tri and Thua Thien-Hue Provinces) and partly in SDR 5 (Quang Nam-Da Nang and Quang Ngai Provinces). Earlier work[1] confirmed the dominance of SDR 7 and SDR 3 in terms of national GDP growth - 43.1 and 18.6 percent, respectively. A similar picture emerges in terms of vehicle registrations - some 50,000 cars, buses and trucks are registered in SDR 7 (4.53 vehicles per 1,000 persons) and some 43,000 cars, buses and trucks in SDR 3 (3.1 vehicles per 1,000 persons). These two totals represent about 56 percent of national registrations (Figure 2.5). SDR 3 and SDR 7 are even more dominant in terms of motorcycle registrations together accounting for 70 percent of the national total (Figure 2.6).

Registrations within the study area are, in an absolute sense, modest vi-à-vis national totals. However, unit rates (vehicles per 1000 persons) frequently meet or exceed national norms (Table 2.10).

Table 2.10 Study Area and National 1994 Vehicle Registration

Item	Location: Quang Tri	Thua Thien-Hue	Quang Nam-Da Nang	Quang Ngai	Nation
Registered Vehicles					
Cars and Vans	184	583	1,811	622	49,787
Large Buses	173	423	505	168	19,374
Trucks	889	1,333	1,964	862	95,855
Subtotal	1,246	2,339	4,280	1,652	165,016
Motorcycles	7,923	12,120	118,296	23,565	2,676,710
Vehicles per 1000 Persons					
Cars and Vans	0.34	0.59	0.93	0.53	0.69
Large Buses	0.32	0.42	0.26	0.14	0.27
Trucks	1.66	1.34	1.01	0.73	1.32
Subtotal	2.33	2.35	2.19	1.40	2.28
Motorcycles	14.81	12.18	60.58	19.99	36.92

Source: GSO (registered vehicles)

[1] "Progress Report II", The Study on the Integrated Regional Socio-economic Development Master Plan for the Key Area of the Central Region of the Socialist Republic of Viet Nam", prepared for Development Strategy Institute, Ministry of Planning and Investment, by Japan International Cooperation Agency, March, 1996.

Figure 2.5 1994 VEHICLE REGISTRATIONS BY DEVELOPMENT REGI(

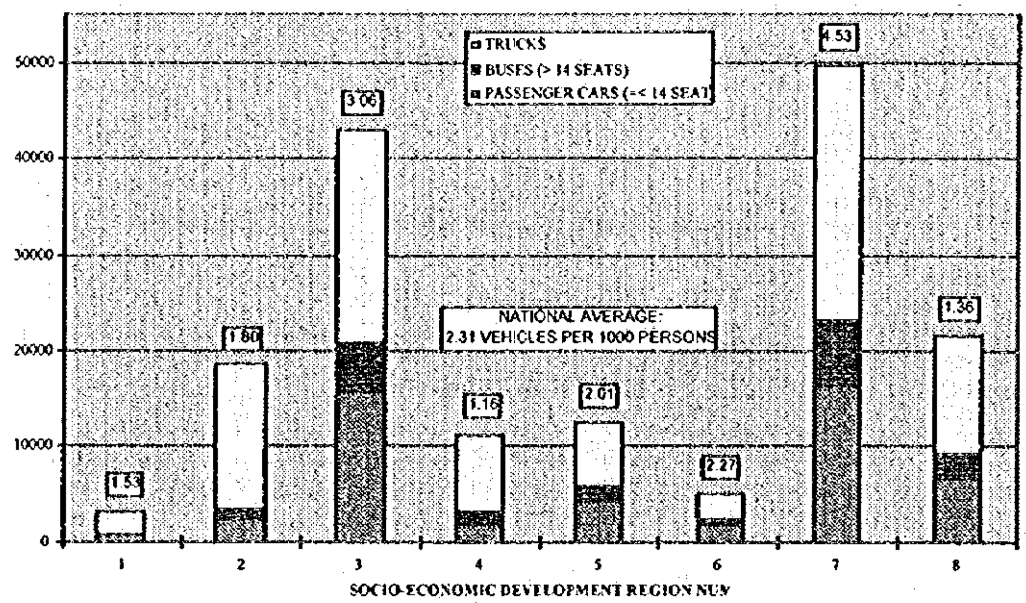
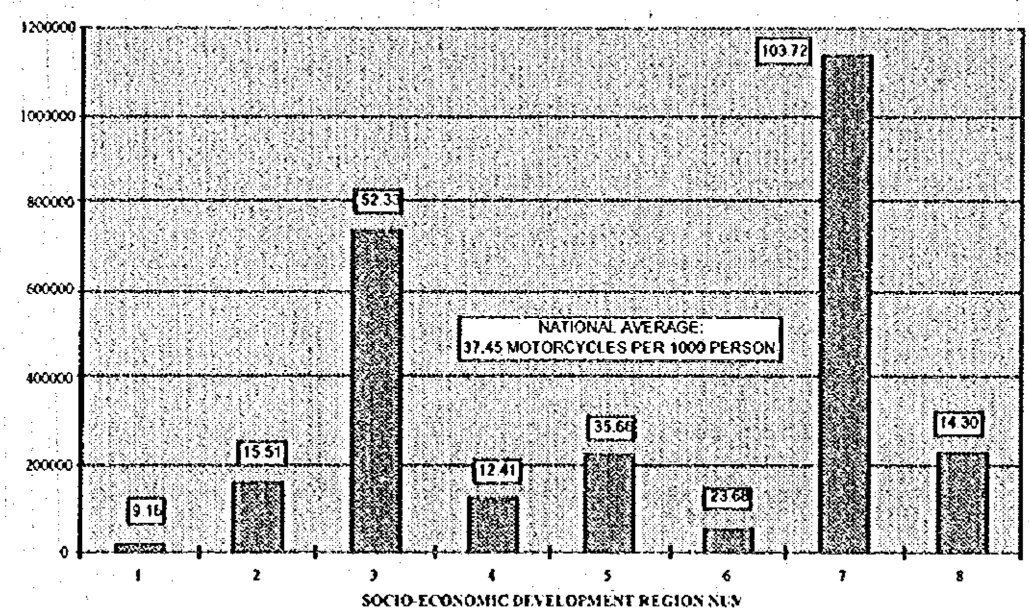


Fig. 2.5 & 2.6

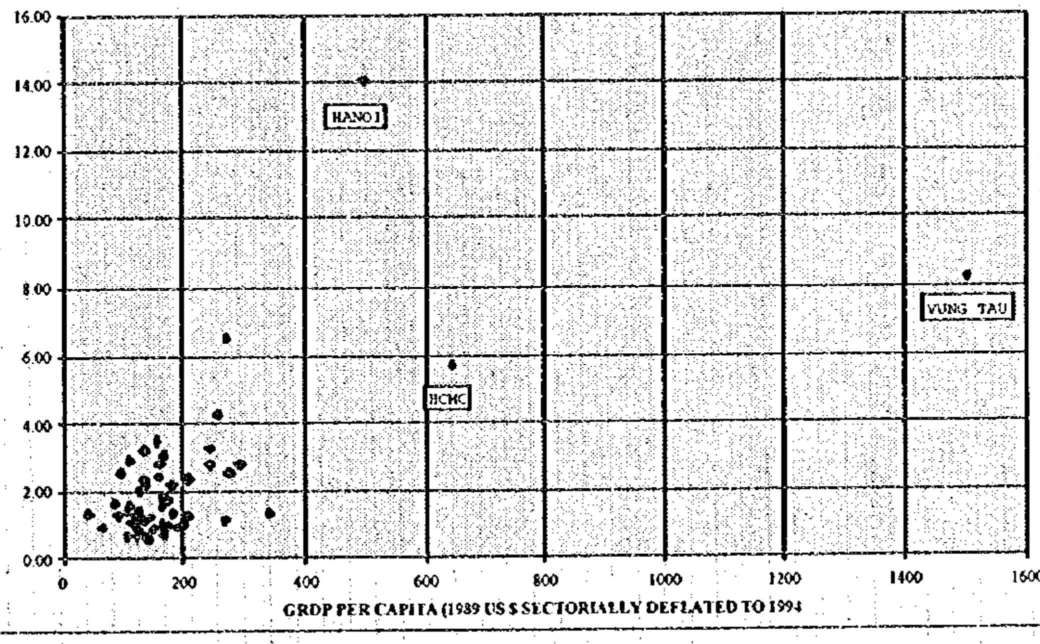
Figure 2.6 1994 MOTORCYCLE REGISTRATIONS BY DEVELOPMENT REGI(



Within the study area, highest registrations are observed in Quang Nam-Da Nang Province (particularly in the case of passenger cars and motorcycles) followed by Thua Thien-Hue Province. This pattern is consistent with that exhibited by other provinces of Viet Nam; that is, the vehicle ownership rate increases as unit wealth (GRDP per capita) increases (Figure 2.7). Only Hanoi appears over-represented in terms of vehicle ownership, possibly due to its role as the national capital and/or the fact that some vehicles may be registered in Hanoi but are operated in other parts of the country.

The vehicle ownership-income linkage exhibited by the Viet Nam data coincides with patterns exhibited by her Asian neighbors (refer Chapter 4). Thus, while the overall unit ownership rates in Viet Nam are modest, they are not unreasonable in light of the low national GDP per capita.

Figure 2.7 OVERVIEW OF 1994 NATIONAL VEHICLE OWNERSHIP PATTE



CHAPTER 3

ROAD NETWORK DEVELOPMENT

CHAPTER 3 ROAD NETWORK DEVELOPMENT

The road network is a computerized simulation of highways located within the study area. The network consists of numerous links (road segments) and nodes (intersection points), with each link being embedded with a unique set of indexes describing its operating capabilities. Two of the most important measures in this regard are speed and capacity.

There does not, at present, exist a manual in Viet Nam which quantitatively describes the interplay of speed, volume and capacity under local conditions. Sources external to Viet Nam must therefore be employed for this purpose. It is felt that link speed and capacity can adequately be developed based on recent findings of investigations financed by the World Bank (IBRD) and related to the performance of road systems in a Southeast Asian context[1]. This work has recently been further advanced under Asian Development Bank (ADB) funding through the release of an Indonesian Highway Capacity Manual (IHCM)[2]. It is judged that the application of these findings in a Vietnamese context is more appropriate than the more traditional American or Japanese highway capacity techniques. The use of a Vietnamese highway capacity manual is, of course, preferred once such a document is available and adopted on a uniform national scale.

A comparison of the IBRD and IHCM approaches identifies important points:

- The IBRD analysis focuses on two-lane roads and is thus a valuable tool particularly in the case of lower-order roads where roughness and road maintenance techniques are key factors in road performance. IBRD speed and capacity calculations are also sensitive to carriageway width, terrain and light/heavy vehicle mix.

- The IHCM comprehensively addresses all road types including two-lane arterial[3], multi-lane arterial (divided and undivided) as well as motorway (two lane and multi-lane). Capacity and speed can be fine-tuned via adjustment factors for lane width, shoulder width, terrain, vehicle type, and roadside friction. Roughness is not an adjustment variable, possibly since this is viewed as typically not being a dominant issue in the case of higher-order road operation.

The approach adopted by the current study is to utilize the strengths of both techniques in a unified and mutually complementary manner.

- Capacity and speed of two-lane roads are initially calculated via IBRD equations. Thus, free-flow speed is influenced by terrain, carriageway width, road roughness and light/heavy vehicle composition. Capacity, in turn, is based on terrain and carriageway width. As a second step, link capacities and speeds calculated using IBRD techniques are adjusted to expected IHCM norms. This is achieved by factoring link results by a ratio of IHCM and IBRD maximum speeds and capacities derived under ideal road conditions for flat, rolling or hilly terrain.

- Capacities and speeds of multi-lane arterials are calculated via IHCM techniques. Contributing parameters include vehicle type composition, lane width, road type, roadside friction and terrain.

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[1] "Road User Cost Model", for the Government of Indonesia, Ministry of Public Works, Directorate General of Highways, by Hoff & Overgaard, et al, May, 1992.

[2] "Consulting Services for Highway Capacity Manual-Phase 2; Interurban Highways", for Government of Indonesia, Directorate General of Highways, by SweRoad, et. al, June 1994 (draft report).

[3] Arterial designation, for purposes of the current study, includes any non-motorway road.

The IHCM concludes, in summary, that maximum two-lane arterial capacity can, ***under ideal conditions***, reach 3,100 pcu/hour per section, multi-lane arterial capacity 1,600-1,800 pcu/hour per lane, and multi-lane motorway capacity 2,200 pcu/hour per lane. Free-flow speed is shown as reaching 65-68 km/h, 72-78 km/h and near 90 km/h for light vehicles traveling on level two-lane arterials, multi-lane arterials and multi-lane motorways, respectively.

3.1 BASE YEAR NETWORK

The study area road system, including all national, province and district roads, totals some 5,000 kilometers. The level of detail to which the zone structure and highway network are built must be in balance; thus, not all existing roads need be included since zonal stratification extends only to the district level. Indeed, to provide linkage between all zones, a highway network embracing all nationally-owned, and principal province-owned roads, is adequate (Figure 3.1).

The base-year (1995) network was therefore built via three steps:

- Digitize, using the capabilities of AutoCad software, zone boundaries and relevant road network elements depicted on province-level maps. Within the study area, map scales varied between 1:200,000 and 1:300,000.
- Merge findings of 1995 field surveys with inventory data available from previous studies conducted within the study area.
- Calculate link parameters.

The TRANPLAN highway network simulation programs require following parameters for each link:

- A and B nodes, which are numeric values that identify the "from" and "to" ends of a link. Node locations are defined by their X and Y coordinates, which are derived from the digitizing process, and thus permit NIS displays of network content, performance and operation.
- Link distance defining the length of a link in kilometers.
- Free flow speed, which is defined as the safe speed at which a vehicle would travel on a link in the absence of other traffic. The average free flow speeds are calculated based on equations used in the IBRD and IHCM investigations, augmented by speed studies conducted throughout the study area.
- Link capacity is defined in terms of practical capacity and assignment capacity.
    * Practical capacity represents an absolute limit regarding the number of vehicles (pcu's) which can be accommodated on a given road section under realistic operating and terrain conditions.
    * Assignment capacity represents a trip-making threshold for modeling purposes at which alternative route choices (as possible) are likely. This is generally adopted as being synonymous with a Level of Service C/D and uninterrupted flow condition[1]. Assignment capacity, free flow speed and traffic loadings are integrated via speed-decay curves which dynamically decrease link attractiveness (speed) as the volume to capacity ratio (V/C) increases.

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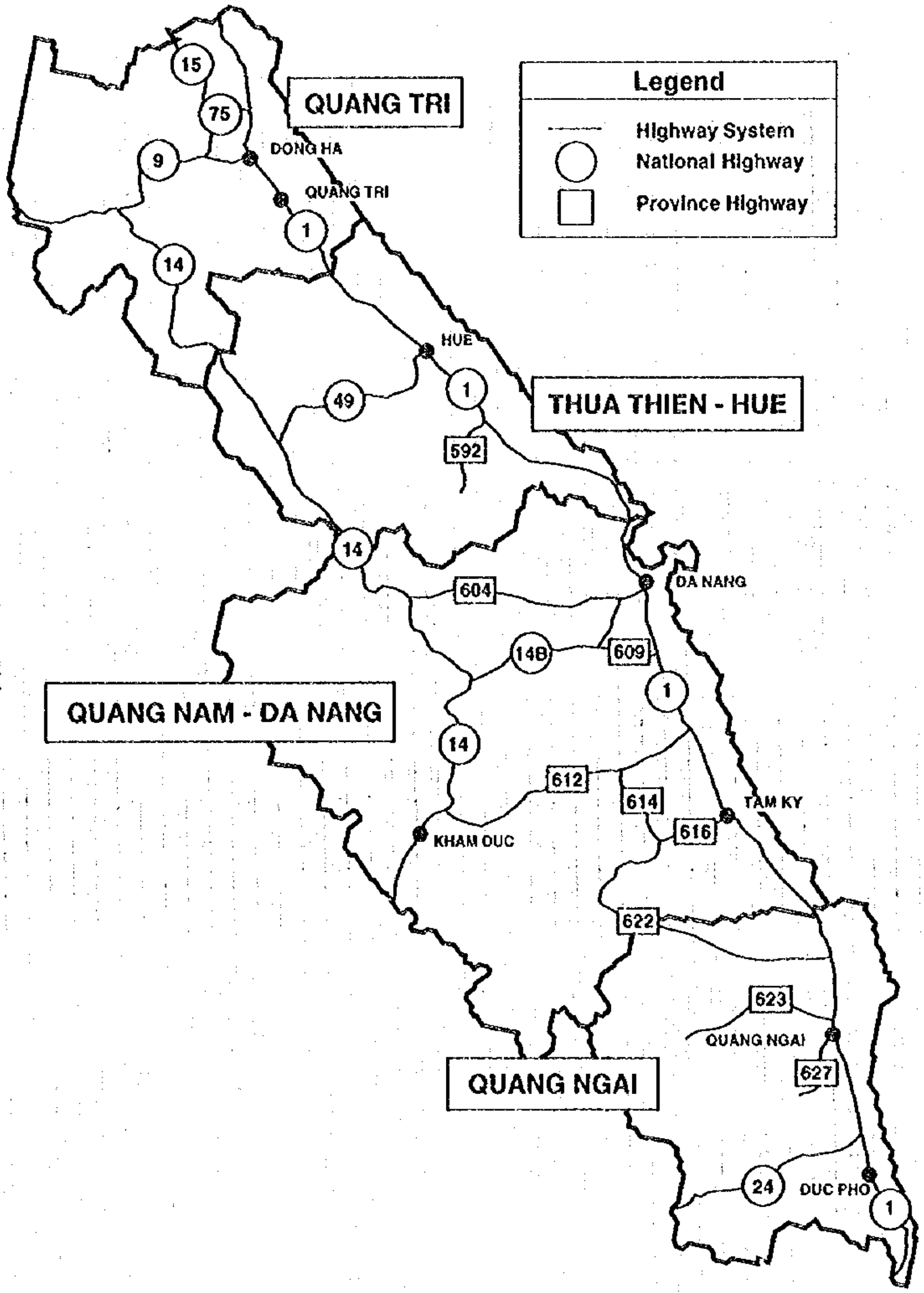
[1] Level of service as defined by the "Highway Capacity Manual, Special Report 209", Transportation Research Board, USA 1985 (with subsequent updates)

Figure 3.1 Study Area Highway Network



- Practical capacity is calculated in terms of hourly pcu's per lane or section, assignment capacity (about 80 percent of practical capacity) is generally expressed as daily link pcu's based on an 8.5 percent peak hour factor.

- Assignment group (ASG) code is used to identify links to which a common capacity restraint function is to be applied, that is, link speed is reduced by a pre-determined function as the link volume to capacity ratio increases. For TRANPLAN input, ASG codes were defined as follows:

  * Link type groupings are in accordance with facility type and/or facility width.

  * Free flow speed represents the V/C = 0.0 condition, while V/C = 1.0 simulates full utilization of assignment capacity.

  * A V/C of approximately 1.4 represents very congested flow prior to operational breakdown.

- Link group code is a numeric code which groups links with common characteristics for subsequent referencing, updating, and reporting. Identification of highway number and zone number is embedded in two link group codes.

The 1995 study area road network totals some 1,400 kilometers in length (Table 3.1):

- There are no multi-lane arterial roads within the study area. Only about 400 kilometers of the network would be considered of reasonable two-lane arterial standard in terms of width (ASG 4 and 5);

- About one-third of the road network is not paved;

- Surface condition (roughness) is poor throughout the network. Thus, free-flow speed does not exceed an average of 60 km/h for any of the ASG groupings.

- Speed decay functions mirror the IHCM speed-flow relationships and depict speed decreasing from free-flow status as the V/C ratio increases. The change is particularly pronounced for narrow roads due to numerous avoidance maneuvers between directional traffic streams, as well as between traffic streams and roadside activities.

These observations, when coupled with other factors such as poor maintenance, the presence of strong urban settlements and the magnitude of planned future developments, clearly confirms the need for upgrading road facilities in the study area.

3.2 PLANNED IMPROVEMENTS

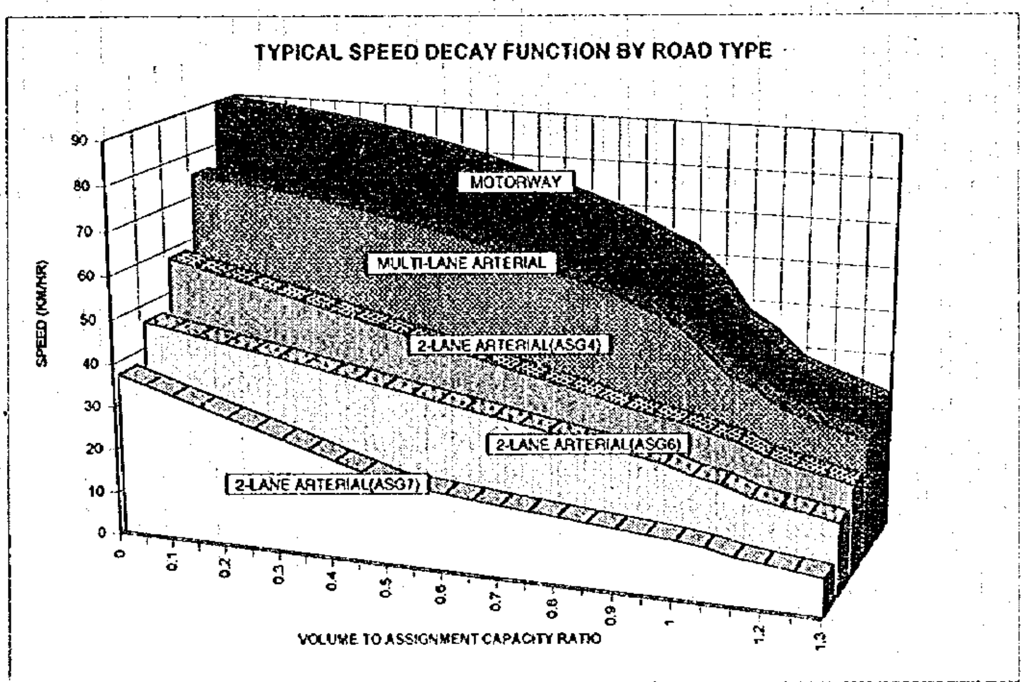
Over time, the base-year (1995) road network well change as improvements are implemented and, in general, roadside development expands and intensifies. The current study will nominate and evaluate certain road improvements; it is therefore necessary to formulate a common "future network" whose consistent operating criteria from the basis against which proposed improvements are tested.

Discussions with governmental and other entities have confirmed that numerous potentials for road improvements exist, but implementation schedules are uncertain since most will be funded via overseas sources. However, for modeling purposes, it is assumed that following road improvements will proceed regardless of any conclusions reached by the current study.

Table 3.1 STUDY AREA ROADWAY NETWORK PARAMETERS BY FACILITY TYPE

ASG CODE (1)	ROAD TYPE (2)			AVERAGE CONDITIONS (3)		
	CROSS SECTION	SURFACE	CARRIAGEWAY WIDTH (M)	LENGTH (KM)(4)	SPEED (KM/H)(5)	CAPACITY (PCU/DAY)(6)
1	Motorway	Paved	14	0	*	*
2	Six-lane Arterial	Paved	> 18	0	*	*
3	Four-lane Arterial	Paved	12 - 18	0	*	*
4	Two-lane Arterial	Paved	> 7.2	252.9	59.6	23,500
5		Paved	6.2 - 7.2	161.1	55.4	20,900
6		Paved	5.0 - 6.1	410.0	46.9	14,900
7		Paved	< 5.0	99.3	37.1	10,300
8	Two-lane Arterial	Unpaved	=> 5.0	358.6	34.6	12,300
9		Unpaved	< 5.0	137.5	29.0	8,100
TOTAL				1,419.4	44.6	15,500

(1) TRANPLAN designation to identify links to which a common capacity restraint is applied.
(2) The term "arterial" refers to a non-motorway facility, and should not be confused with functional classification.
(3) All averages are weighted by link length.
(4) Number of road kilometers.
(5) Free flow speed, or speed at which a vehicle would safely travel in the absence of other traffic.
(6) Two-way daily passenger car unit capacity per road section (assignment capacity).



- The Transport Engineering Design Inc. (TEDI) organization of the Ministry of Transport, Viet Nam, has recently completed a feasibility study for Highway 9. The recommendation is to upgrade Highway 9 over its entirety to a Class III (per TEDI criteria) road. This implies a paved carriageway width of seven meters plus flanking two-meter NMV (non-motorized vehicle) lanes in level terrain, and a carriageway width of six meters in mountainous terrain. The feasibility study includes an urban bypass to the north of Dong Ha (coinciding with the current alignment of Province Highway 71) linking with a 13.5 kilometer extension east of Highway 1 to Cua Viet port. Current plans call for completion of the Cua Viet port extension by late 1996/early 1997. In addition, extensive studies have been conducted throughout the Highway 9 corridor (Thailand-Lao PDR-Viet Nam) largely under the auspices of the ADB (refer section 4.3.2). Conclusions of these studies similarly point to Class III-type improvements. Given the important role of Highway 9 in the overall development of the Mekong Subregion, it is assumed that Highway 9 will, in the future network, appear as a Class III facility.

- Highway 1 within the study is now being studied by the IBRD and the ADB[1]. Final design is complete: the focus is to reseal, repair and reconstruct in the same alignment for the same number of lanes. No widening or urban bypasses are being contemplated. Minor bridges (< 20m) are to be replaced if needed, otherwise, rehabilitated. Major bridges are subject to a separate contract under administration of the Overseas Economic Cooperation Fund, Japan. Safety improvements (climbing lanes, emergency exit lanes) are included in the Hai Van pass area. It is understood that TEDI is currently also conducting feasibility studies for improving the Hai Van pass segment of Highway 1, although efforts are expected to focus only on improving curb radii, which in some cases are now as low as 40 meters. It is therefore assumed that Highway 1 will, in the future network, be upgraded in accordance with IBRD/ADB guidelines.

Both the Highway 1 and Highway 9 improvements provide NMV (bicycle) lanes in level terrain. It is therefore accepted, from a modeling perspective, that NMV flows will, in future, use NMV lanes along Highways 1 and 9. Thus, carriageway capacity is reserved for use by motorcycles, cars, buses and trucks.

In addition to these project-specific "committed" improvements, roadside development (land use) will increasingly impact the ability of arterial roads to operate up to their intended standard. Road performance involves the interplay of two different conditions (existing road, improved road). It must, however, be recognized that speed and capacity, like demand, are dynamic over time. Only operating parameters of a motorway will, for example, remain largely unchanged since that facility enjoys absolute control of access and roadside activity will not occur within the motorway's right-of-way. In the case of existing arterials, however, flanking land uses will, over time, modify as existing urbanization patterns expand and intensify, or new land uses are introduced thus altering what at present are essentially rural environments.

The assignment speed and capacity used in the modeling process, whose limits are calculated in accordance with ADB and IBRD-sponsored studies sensitive to Southeast Asian environments, can be viewed as corresponding to "rural highway under uninterrupted flow" conditions. But, given the temporal impact of increasing urbanization and intensifying land use patterns, road operations will gradually moderate to lower levels which can be described as "semi-interrupted conditions". This plateau could, depending on statutory and developmental policies, further degrade to "interrupted conditions", particularly so in highly developed areas and certainly following the introduction of traffic control devices.

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1 The ADB "Second Highway Improvement Project" addresses the Dong Ha-Nha Trang subsection. This includes all of Highway 1 within the study area except the segment north of Dong Ha which is included in the IBRD's Vinh-Dong Ha subsection. Tenders for improvement of the IBRD subsection were called during September, 1996.

For purposes of the current study, it is adopted that the calculated 1995 speed and capacity (uninterrupted conditions) will modify in future to near semi-interrupted status along all national highway segments in the coastal corridor. Comparison of the base year (1995) and resultant future-year network yields several observations (Table 3.2).

Table 3.2 Comparison of Principal Roadway Parameters Base Year and Committed Future Network

	Base Year (1995) Network			Committed Future Network		
ASG CODE(1)	Length (km)	Speed (km/h)	Capacity (pcu/day)	Length (km)	Speed (km/h)	Capacity (pcu/day)
1	0	*	*	0	*	*
2	0	*	*	0	*	*
3	0	*	*	0	*	*
4	252.9	59.6	23,500	252.9	52.3	21,100
5	161.1	55.4	20,900	178.3	50.0	18,500
6	410.0	46.9	14,900	392.8	46.7	14,900
7	99.3	37.1	10,300	99.3	37.1	10,300
8	358.6	34.6	12,300	358.6	34.6	12,300
9	137.5	29.0	8,100	137.5	29.0	8,100
Total	1,419.3	44.6	15,500	1,419.3	42.6	14,800

(1) Refer Table 3.1 for parameter definitions.

The upgrading of Highways 1 and 9 to full Class III standard has reduced the length of ASG 6 (paved arterial, 5.0-6.1 meters wide) roads and increased the overall length of ASG 7 (paved arterial, 6.2-7.2 meters wide) roads. However, the overall network free-flow speed as well as capacity have still decreased as a result of intensified roadside development.

CHAPTER 4

TRIP MATRIXES DEVELOPMENT

CHAPTER 4 TRIP MATRIXES DEVELOPMENT

Trip matrixes contain data as to vehicle trip or pcu trip interchanges between all zones within the study area. This section describes the development and content of base year (1995) and future year (2000, 2010) matrixes.

4.1 BASE YEAR ANALYSIS

Year 1995 trip matrixes were calibrated to observed traffic volumes, then linked with socio-economic parameters exhibited by each zone in the study area.

4.1.1 Calibration Procedures

Review of traffic count data made available by the MOT[1] revealed that, within the study area, traffic volumes are modest. Even along Highway 1, 1994 motorized vehicle volume (excluding motorcycles) rarely exceeded 2000 vehicles per day (vpd), and then only in vicinity of major urban centers such as Hue and Da Nang. Through trips, that is, between northern and southern Viet Nam, constitute a considerable component of this total. Recent roadside interview surveys[2] along Highway 1 confirm that, on a daily average, this demand axis totaled some 350 trucks, 120 buses, and 30 cars in 1995.

The derivation and calibration of 1995 vehicle trip matrixes was accomplished via a series of cascading work tasks.

Previous[3] modeling efforts based on roadside origin-destination surveys confirm that inter-zonal vehicle trips are strongly correlated with urban concentrations. Thus, as a "beginning point", internal trips (both trip ends within the study area) were synthesized by a simplified model of the form

$$T_{ij} = \frac{P_i P_j}{d_{ij}^{\,n}}$$

where, T_{ij} = propensity for trip interchange between zones i *and j*
$P_i P_j$ = population of zones i and j
d_{ij} = travel distance between zones i and j
n = exponent

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1 Mot conducts a nationwide revolving annual count program at some 60 locations along Highways 1, 10, 14 and 20.

2 "The Feasibility Studies on the Rehabilitation and Improvement of the Railways in Viet Nam", by Japan International Cooperation Agency, for Ministry of Transport and Communications, Government of Viet Nam, December, 1995 (Draft Final Report).

3 "National Transportation Sector Review", by BCEOM Consultants, Paris, for Ministry of Transport and Communication, Government of Viet Nam, 1992.

"The Master Plan Study on the Transport Development in the Northern Part of the Socialist Republic of Viet Nam", for Government of Viet Nam, Ministry of Transport and Communications, by Japan International Cooperation Agency, June 1994.

"Feasibility Study on the Highway Number 18 Improvement in Viet Nam", for Government of Viet Nam, Ministry of Transport, by Japan International Cooperation Agency, March, 1996.

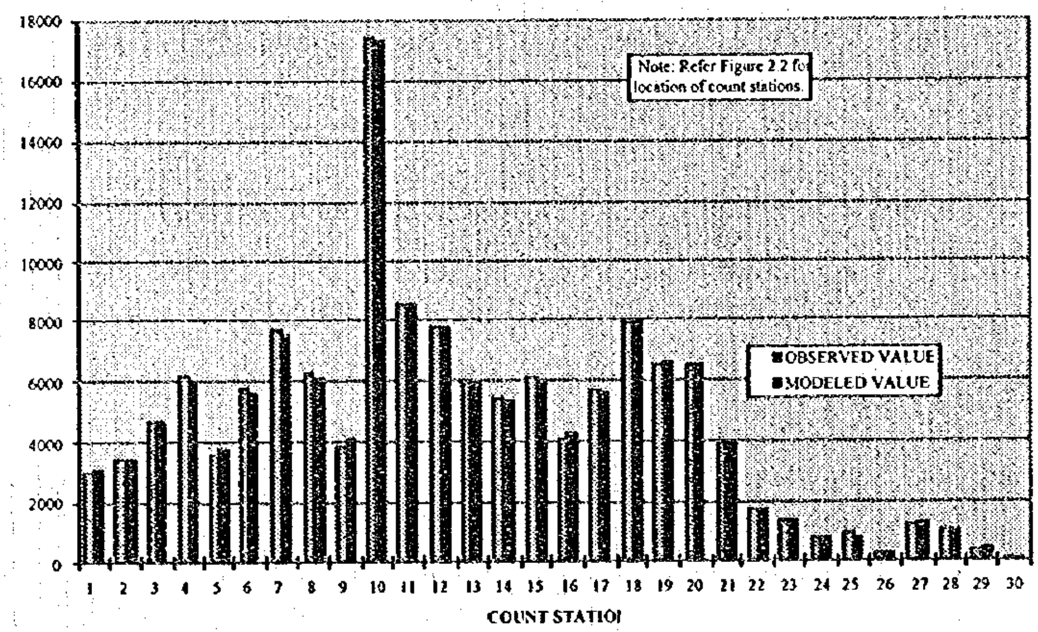
- The exponent was, based on results of the indicated recent modeling efforts, adopted as near 1.1 for cars, buses and trucks, and as 2.0 for motorcycles.

- The national rail study[1] developed, as part of its modeling effort, year 1994 inter-province trip matrixes for the entire nation. The matrixes were developed by mode and, in some cases, by commodity. External trip patterns for road passenger (car, bus) and road cargo (truck) could therefore be initially estimated for the study area by referencing these trip matrixes.

- Results of the 1995 traffic count program were used to develop a further preliminary matrix containing non-motorized vehicles (NMV). A simplified approach was adopted which assumes that, relative to other road modes, NMV (bicycle, cyclo) trips are of short distance. Thus, NMV volumes (all measured at zonal boundaries) were assumed to travel only between adjacent zones (centroids).

The resultant synthesized matrixes (passenger car, bus, truck, motorcycle, NMV) consequently contain reasonable relative demand patterns, however, absolute demand totals require calibration to ensure conformance with observed data. The synthesized matrixes were subsequently assigned onto the base-year highway network, and resultant link volumes compared to observed traffic data obtained via the 1995 volume count survey (refer Section 2.2). The content of each modal trip matrix was then iteratively adjusted using analogies available through TRANPLAN until assigned interzonal trip demand correlated closely with observed traffic volume. Results confirm that excellent correlation was achieved at all locations (Figure 4.1). It can therefore be stated with confidence that the calibrated 1995 vehicle trip matrixes are capable of accurately reproducing observed base-year road demand.

Figure 4.1 COMPARISON OF 1995 OBSERVED AND MODELED DEMAN



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[1] "The Feasibility Studies on the Rehabilitation and Improvement of the Railways in Viet Nam", op. cit.

4.1.2 Matrix Content

The calibrated 1995 matrixes contain some 15,200 four-wheeled vehicle trip ends, 56 percent of which are attributed to the truck mode. Not surprisingly, the Da Nang metropolitan area (zones 14 and 15) contains more than one-fourth of trip ends followed by Hue (7.4 percent) and Quang Ngai (6.1 percent). As expected, motorcycle and NMV activity far outnumbers other modes with a combined total of near 140,000 trips. While motorcycle trip ends tend to associate with urban center, NMV trip ends are much more evenly distributed throughout the study area (Table 4.1).

The orientation of vehicle trips is predominantly within respective provinces, particularly so in the case of cars and motorcycles. This confirms the strong transport linkages province capitals now enjoy with their economic hinterland, which typically encompasses adjacent districts (Table 4.2). If intra-province trips are removed from consideration, inter-province trips appear to exhibit three pronounced focii (Figure 4.2):

- Between adjacent provinces (particularly between Thua Thien-Hue and Quang Nam-Da Nang);
- Between provinces and Highway 1 at either the northern or the southern study area boundary; and,
- Through trips on Highway 1.

Other regions, such as the "southwest" (Highways 14 and 24 to/from Kon Tum province) are principally linked with adjacent provinces.

4.2 TRIP GENERATION MODEL

The trip generation process, that is, the propensity of any internal zone to generate trips in future, is particularly sensitive to "top down" and "bottom up" processes.

- The "bottom up" approach is based on a regression analysis which estimates trips based on zonal socioeconomic parameters; and,
- The "top down" approach provides realistic controls on future trip growth in the study area based on historic experiences of other Asian nations at a similar stage of development.

External trips, or those without or one trip end in the study area, are not only impacted by the socioeconomic evolution of the study area, but also by the national macro-economic framework as well as activities in other regions of Viet Nam. These trips are therefore correlated with broader aspects of national development.

4.2.1 "Bottom Up" Analysis

The formation of regression models was constrained by current socioeconomic data availability, very low levels of trip-making in 1995, as well as the reliability with which forecasts of district-level data can be prepared for future years. For these reasons, the process was restricted to using population as other promising future variables such as unit national income and employment are not routinely available at the district level of detail.

Table 4.1 SUMMARY OF YEAR 1995 ZONAL TRIP ENDS

ZONE (1)	NUMBER OF VEHICLE TRIP ENDS BY MODE (2)							PERCENT TRIP ENDS BY MODE						
NUMBER	PASS CAR	BUS	TRUCK	TOTAL	PERCENT	M'CYCLE	NMV	PASS CAR	BUS	TRUCK	TOTAL	M'CYCLE	NMV	TOTAL
1	18	12	24	54	0.4	467	1,054	33.3	22.2	44.4	100.0	30.7	69.3	100.0
2	40	87	87	214	1.4	551	1,579	18.7	40.7	40.7	100.0	25.9	74.1	100.0
3	175	46	305	526	3.5	2,403	3,730	33.3	8.7	58.0	100.0	39.2	60.8	100.0
4	18	62	29	109	0.7	403	2,006	16.5	56.9	26.6	100.0	16.7	83.3	100.0
5	70	81	137	288	1.9	1,318	1,364	24.3	28.1	47.6	100.0	49.1	50.9	100.0
6	44	30	80	154	1.0	148	785	28.6	19.5	51.9	100.0	15.9	84.1	100.0
7	117	132	63	312	2.1	1,170	2,576	37.5	42.3	20.2	100.0	31.2	68.8	100.0
8	327	253	544	1,124	7.4	4,430	6,233	29.1	22.5	48.4	100.0	41.5	58.5	100.0
9	89	145	55	289	1.9	1,436	4,903	30.8	50.2	19.0	100.0	22.7	77.3	100.0
10	38	93	37	168	1.1	761	2,000	22.6	55.4	22.0	100.0	27.6	72.4	100.0
11	11	55	110	176	1.2	597	951	6.3	31.3	62.5	100.0	38.6	61.4	100.0
12	24	49	110	183	1.2	248	182	13.1	26.8	60.1	100.0	57.7	42.3	100.0
13	12	50	106	168	1.1	300	400	7.1	29.8	63.1	100.0	42.9	57.1	100.0
14	89	422	1,036	1,547	10.2	8,136	5,733	5.8	27.3	67.0	100.0	58.7	41.3	100.0
15	269	634	1,732	2,635	17.4	11,144	8,260	10.2	24.1	65.7	100.0	57.4	42.6	100.0
16	49	291	283	623	4.1	1,467	5,199	7.9	46.7	45.4	100.0	22.0	78.0	100.0
17	46	155	100	301	2.0	1,551	4,203	15.3	51.5	33.2	100.0	27.0	73.0	100.0
18	57	135	76	268	1.8	1,060	2,166	21.3	50.4	28.4	100.0	32.9	67.1	100.0
19	110	128	166	404	2.7	1,515	3,560	27.2	31.7	41.1	100.0	29.9	70.1	100.0
20	113	154	74	341	2.3	1,367	2,942	33.1	45.2	21.7	100.0	31.7	68.3	100.0
21	3	7	13	23	0.2	221	451	13.0	30.4	56.5	100.0	32.9	67.1	100.0
22	23	62	87	172	1.1	1,179	2,412	13.4	36.0	50.6	100.0	32.8	67.2	100.0
23	20	55	93	168	1.1	258	212	11.9	32.7	55.4	100.0	54.9	45.1	100.0
24	20	78	148	246	1.6	400	554	8.1	31.7	60.2	100.0	41.9	58.1	100.0
25	105	67	151	323	2.1	818	3,930	32.5	20.7	46.7	100.0	17.2	82.8	100.0
26	54	88	208	350	2.3	803	5,518	15.4	25.1	59.4	100.0	12.7	87.3	100.0
27	216	85	621	922	6.1	3,672	4,139	23.4	9.2	67.4	100.0	47.0	53.0	100.0
28	75	88	278	441	2.9	1,170	6,487	17.0	20.0	63.0	100.0	15.3	84.7	100.0
29	20	65	320	405	2.7	1,100	4,463	4.9	16.0	79.0	100.0	19.8	80.2	100.0
30	11	50	100	161	1.1	300	400	6.8	31.1	62.1	100.0	42.9	57.1	100.0
31	16	51	101	168	1.1	303	400	9.5	30.4	60.1	100.0	43.1	56.9	100.0
32	20	45	94	159	1.1	255	421	12.6	28.3	59.1	100.0	37.7	62.3	100.0
33	53	246	412	711	4.7	488	212	7.5	34.6	57.9	100.0	69.7	30.3	100.0
34	11	30	58	99	0.7	45	18	11.1	30.3	58.6	100.0	71.4	28.6	100.0
35	10	10	50	70	0.5	55	12	14.3	14.3	71.4	100.0	82.1	17.9	100.0
36	12	10	134	156	1.0	27	0	7.7	6.4	85.9	100.0	100.0	0.0	100.0
37	12	20	49	81	0.5	148	248	14.8	24.7	60.5	100.0	37.4	62.6	100.0
38	66	146	376	588	3.9	248	415	11.2	24.8	63.9	100.0	37.4	62.6	100.0
TOTAL	2,463	4,217	8,447	15,127	100.0	51,962	90,118	16.3	27.9	55.8	100.0	36.6	63.4	100.0
NUMBER OF PCU TRIP ENDS BY MODE														
TOTAL	2,463	10,542	23,229	36,234	100.0	17,147	29,738	6.8	29.1	64.1	100.0	36.6	63.4	100.0

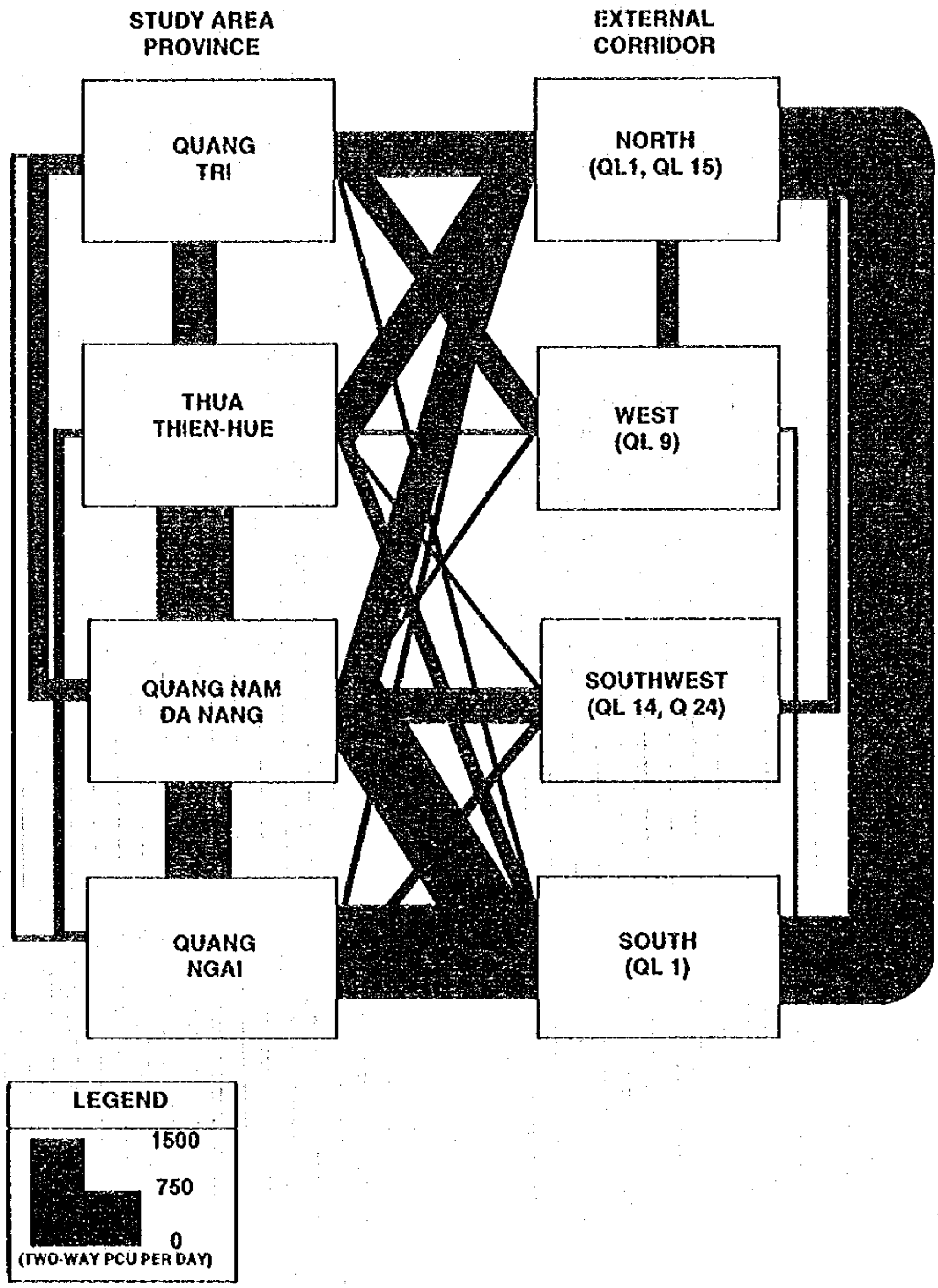
(1) Refer Figure 2.2 for zone system.
(2) Motorcycle and NMV (non-motorized vehicles) only include trips along major roads within the Study Area. Trips by all modes are those crossing a zone boundary.

Table 4.2 YEAR 1995 SIMPLIFIED TRIP MATRIXES
MOTORIZED VEHICLES

PASSENGER CAR										
ORIGIN/DESTN(1)		1	2	3	4	5	6	7	8	TOTAL
Quang Tri	1	298	22	18	1	0	0	3	23	365
Thua Thien - Hue	2	22	469	89	12	5	3	0	18	618
QN - Da Nang	3	18	92	637	27	6	5	1	13	799
Quang Ngai	4	2	14	25	436	30	8	0	2	517
South	5	0	5	6	29	0	0	1	12	53
Southwest	6	0	4	4	8	0	0	0	5	21
West	7	3	0	1	0	2	0	0	6	12
North	8	24	18	12	1	12	5	6	0	78
TOTAL		367	624	792	514	55	21	11	79	2,463
BUS										
ORIGIN/DESTN(1)		1	2	3	4	5	6	7	8	TOTAL
Quang Tri	1	266	17	11	0	9	0	5	10	318
Thua Thien - Hue	2	17	644	67	5	25	8	0	11	777
QN - Da Nang	3	12	67	1,873	45	71	8	1	44	2,121
Quang Ngai	4	0	5	46	396	74	7	0	11	539
South	5	8	24	71	77	0	0	0	66	246
Southwest	6	0	7	8	6	0	0	0	19	40
West	7	5	0	1	0	1	0	0	3	10
North	8	11	10	47	10	66	19	3	0	166
TOTAL		319	774	2,124	539	246	42	9	164	4,217
TRUCK										
ORIGIN/DESTN(1)		1	2	3	4	5	6	7	8	TOTAL
Quang Tri	1	462	53	29	4	8	0	58	48	662
Thua Thien - Hue	2	54	730	130	10	21	9	10	61	1,025
QN - Da Nang	3	30	129	3,302	45	123	74	16	89	3,808
Quang Ngai	4	4	11	46	1,694	94	14	0	10	1,873
South	5	8	21	124	93	0	0	4	162	412
Southwest	6	0	9	74	14	0	0	0	11	108
West	7	59	10	16	0	4	0	0	45	134
North	8	49	59	91	10	161	11	44	0	425
TOTAL		666	1,022	3,812	1,870	411	108	132	426	8,447
MOTORCYCLE										
ORIGIN/DESTN(1)		1	2	3	4	5	6	7	8	TOTAL
Quang Tri	1	4,532	325	58	3	0	0	27	345	5,290
Thua Thien - Hue	2	324	8,332	212	18	0	0	0	56	8,942
QN - Da Nang	3	63	212	27,278	620	55	70	0	0	28,298
Quang Ngai	4	6	21	626	7,305	432	31	0	0	8,421
South	5	0	0	55	433	0	0	0	0	488
Southwest	6	0	0	72	28	0	0	0	0	100
West	7	27	0	0	0	0	0	0	0	27
North	8	345	51	0	0	0	0	0	0	396
TOTAL		5,297	8,941	28,301	8,407	487	101	27	401	51,962

(1) Geographic definitions: "South" = Highway 1 at southern study area boundary; "Southwest" = Highways 24 and 14 at study area boundary; "West" = Highway 9 at study area boundary; "North" = Highways 1 and 15 at northern study area boundary.

Figure 4.2 1995 Inter-Province Road Transport Demand



A linear regression of the form

$$Y = a + bx_1 + cx_2 + \quad + nx_n$$

where		
	Y	= zonal vehicle trips
	a	= constant
	b,c ... n	= coefficients
	x_1, x_2 ... x_n	= zonal socioeconomic data

was therefore developed as a trip generation model using urban and rural population as independent variables. The equation coefficients are:

Mode	Constant	Urban Population	Rural Population	Correlation Coefficient (r)
Car	34.49	$6.76 * 10^{4}$	$9.10 * 10^{5}$	0.75
Bus	8.26	$1.20 * 10^{3}$	$5.35 * 10^{4}$	0.80
Truck	76.37	$2.95 * 10^{3}$	$2.73 * 10^{4}$	0.78
Motorcycle	312.71	$2.30 * 10^{2}$	$3.99 * 10^{3}$	0.80

Thus, the use of base and future zonal socioeconomic variables resulted in the calculation of a relative rate of growth vis-à-vis observed condition; that is,

$$T_F = T_B * \frac{T_{RF}}{T_{RB}}$$

where, for each zone,

T_F = Estimated future - year trips

T_B = Base - year trips

T_{RF} = Regression trip estimate derived from future socioeconomic variables

T_{RB} = Regression trip estimate derived from base - year socioeconomic variables

4.2.2 "Top Down" Analysis

The road mode has become increasingly dominant in Viet Nam in recent years. During 1994, some 66 percent of national cargo tons, and 82 percent of national passengers traveled via road modes (Table 4.3). The modal drift to road is not surprising, and has been a recurring feature of the transport fabric of Asian nations.

Table 4.3 OVERVIEW OF HISTORIC CARGO AND PASSENGER TRANSPORT DEMAND SOCIALIST REPUBLIC OF VIET NAM

YEAR	CARGO (THOUSAND TONS)						PASSENGERS (MILLION PERSONS)				
	RAIL	ROAD	INLAND WATERWAY	COASTAL WATERS	AIR	TOTAL (1)	RAIL	ROAD	INLAND WATERWAY	AIR	TOTAL (1)
VOLUME											
1980	3,509	25,913	11,610	1,259		42,291	33.8	370.5	43.2		447.5
1981	3,420	23,204	11,310	1,346		39,280	21.7	285.7	32.2		339.6
1982	3,235	22,626	11,896	1,476		39,233	18.7	299.1	37.5		355.3
1983	4,209	27,961	15,346	2,043		49,559	21.2	285.6	40.3		347.1
1984	4,146	29,985	14,693	2,499		51,323	23.7	339.3	42.7		405.7
1985	4,050	31,275	15,725	2,621		53,671	19.1	317.5	41.1		377.7
1986	4,137	31,485	16,354	2,581		54,557	21.1	327.3	39.3		387.7
1987	4,003	32,517	15,829	2,992		55,341	24.0	354.6	40.8		419.4
1988	3,930	31,258	15,362	3,415		53,965	17.8	360.6	40.3		418.7
1989	2,432	32,846	14,927	3,263		53,468	11.8	300.8	36.2		348.8
1990	2,341	31,765	16,295	3,484	4	53,885	10.4	271.5	43.6	0.5	325.5
1991	2,567	33,962	15,566	4,330	6	56,425	9.5	332.9	92.6	0.5	435.0
1992	2,774	40,120	16,894	5,105	10	64,893	8.7	388.7	92.5	0.9	489.9
1993	3,187	45,970	16,797	4,498	12	70,452	7.8	419.2	86.4	1.1	513.4
1994 (Est)	3,415	49,364	17,983	4,794		75,556	*	*	*		0
PERCENT											
1980	8.3	61.3	27.5	3.0		100.0	7.6	82.8	9.7		100.0
1981	8.7	59.1	28.8	3.4		100.0	6.4	84.1	9.5		100.0
1982	8.2	57.7	30.3	3.8		100.0	5.3	84.2	10.6		100.0
1983	8.5	56.4	31.0	4.1		100.0	6.1	82.3	11.6		100.0
1984	8.1	58.4	28.6	4.9		100.0	5.8	83.6	10.5		100.0
1985	7.5	58.3	29.3	4.9		100.0	5.1	84.1	10.9		100.0
1986	7.6	57.7	30.0	4.7		100.0	5.4	84.4	10.1		100.0
1987	7.2	58.8	28.6	5.4		100.0	5.7	84.5	9.7		100.0
1988	7.3	57.9	28.5	6.3		100.0	4.3	86.1	9.6		100.0
1989	4.5	61.4	27.9	6.1		100.0	3.4	86.2	10.4		100.0
1990	4.3	58.9	30.2	6.5		100.0	3.2	83.4	13.4		100.0
1991	4.5	60.2	27.6	7.7		100.0	2.2	76.5	21.3		100.0
1992	4.3	61.8	26.0	7.9		100.0	1.8	79.3	18.9		100.0
1993	4.5	65.3	23.8	6.4		100.0	1.5	81.7	16.8		100.0
1994 (Est)	4.5	65.3	23.8	6.3		100.0	*	*	*		*

(1) Excluding air

Source: "Statistical Yearbook 1994", Statistical Publishing House, Government of Viet Nam

In Viet Nam the modal evaluation of the road sector might have been even more accelerated if roads had been better and vehicles more suitable and/or plentiful. Once the vehicle fleet is renewed and enlarged, and the infrastructure improved, road freight and passenger operation should expand rapidly. Experience confirms that, at the "take-off" stages in developing economies, national wealth (GDP or GDP per capita) is closely linked with modal preferences. Three recent studies in Viet Nam have examined this issue in detail:

- The UN-sponsored "National Transportation Sector Review" (NTSR)[1] evaluated alternative year 2000 economic growth scenarios, and provided forecasts by major passenger modes and 15 commodity groupings.
- The IBRD-sponsored "Transport Sector Review"[2] estimated year 2000 modal shifts based on recent experiences of other Asian nations.
- The JICA-sponsored national rail improvement feasibility study[3] estimated (up to) year 2010 modal shares based on a detailed mode-split model sensitive to travel times, trip distances and journey costs. Forecasts reflect inter-province trips only, and assume an improved railway network.

Conclusions formulated by these studies permits the estimation of modal elasticities, that is, for a given change in GDP, what likely change in modal share can be expected. In summary, results are (Table 4.4):

Table 4.4 Relative Elasticities by Transport Mode to Year 2000

Source	Passenger Transport				Cargo Transport		
	Road	Rail	Inland Waterway	Air	Rail	Road	Inland Waterway
NTSR-1992	1.44-1.55	0.27-0.38	*	*	0.77-0.82	1.15-1.16	0.89-0.94
IBRD-1993	1.40-1.43	0.40-0.43	0.29-0.50	2.50-2.86	0.29-0.30	1.29-1.40	0.57-0.60
JICA-1995	1.18-1.40	0.55-0.62	*	1.15-1.33	0.45-0.49	0.80-0.88	0.68

While each study was conducted to unique requirements, and possibly focused on different goals, the underlying conclusions are consistent: The growth rate of road passengers is likely to exceed that of GDP by some 40-50 percent. With exception of the rail-oriented JICA study, road cargo growth is shown as exceeding GDP growth, but at a lesser rate than road passenger growth. The already prominent role of the road mode will therefore likely expand.

A further excellent surrogate for road traffic growth is expected relative change in vehicle ownership. This phenomenon is clearly illustrated by recent, observed experiences of other Asian nations. Vehicle ownership in Asia varies from amongst the lowest to near the highest in the world. This pattern is inexorably linked to national economic well-being that is, GDP per capita. In the lower income Asian nations, vehicle ownership is, relative to world norms, low: typically less than 30 - 50 cars, buses and trucks per 1,000 persons (Figure 4.3). Even Singapore and Hong Kong, whose average incomes are among the highest in Asia, exhibit modest ownership: some 100 - 200 vehicles per 1,000 persons. However, these data are clearly influenced by the unique geographic constraints associated with these island nations as well as local taxation policies. Australia and New Zealand, on the other hand, whose GDP per capita levels are reasonably similar to those of Singapore and Hong Kong, boast vehicle ownership some five to six times higher, exceeding even that of Japan, the highest - income nation in Asia.

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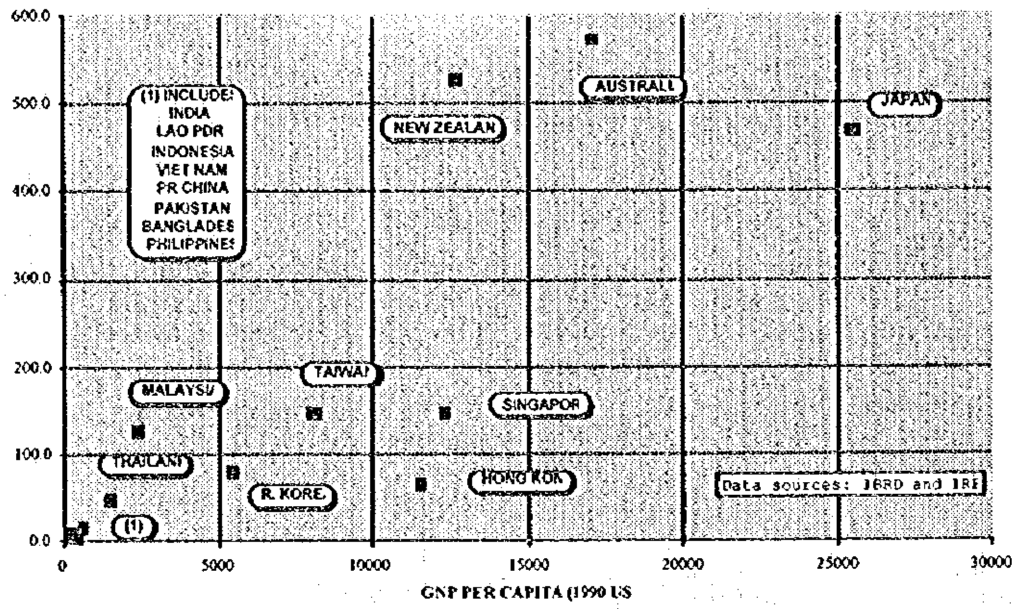
1 "National Transportation Sector Review", op.cit.

2 "Viet Nam Transport Sector Review", The World Bank, 1993

3 "The Feasibility Study on the Rehabilitation and Improvement of the Railways in Viet Nam", op. cit.

Figure 4.3 OVERVIEW OF VEHICLE OWNERSHIP (CARS, BUSES AND TI SELECT NATIONS - ASIAN REGION



The growth in passenger cars is, as suggested by recent Indonesian data, more rapid than that for buses and trucks. Among motorized vehicles, only motorcycle ownership growth exceeds that of passenger cars, although, as suggested by the Indonesian data, the number of motorcycles per 1,000 persons appears to "top off" as income reaches a level at which passenger car ownership becomes increasingly possible for the population, particularly so residents of "wealthier" major cities (Figure 4.4). This modal evolution is also evident when reviewing data from Delhi, India. At the lower income ranges, residents own no vehicles and must walk to meet travel needs. Gradually, as income increases, bicycles become more prevalent which, in turn, are slowly replaced by motorcycles as the preferred means of transport. Only at the higher income levels does the passenger car play a significant role in trip making (Figure 4.5).

Vehicle ownership in Viet Nam and the study area is, as discussed in Section 2.3, modest. However, as relative income (GDP/capita) increases, vehicle ownership is expected to intensify accordingly. A synthesis of existing vehicle ownership patterns, the socio-economic evolution specified in the macro-economic frame[1], and the vehicle ownership-income relationship exhibited by other Asian nations at similar stages of development suggests that reasonable growth rate for vehicle ownership in the study area are:

[1] "Interim Report", The Study on the Integrated Regional Socio-Economic Development Master Plan for the Key Area of the Central Region of the Socialist Republic of Viet Nam", for Ministry of Planning and Investment, by Japan International Cooperation Agency, July 1996

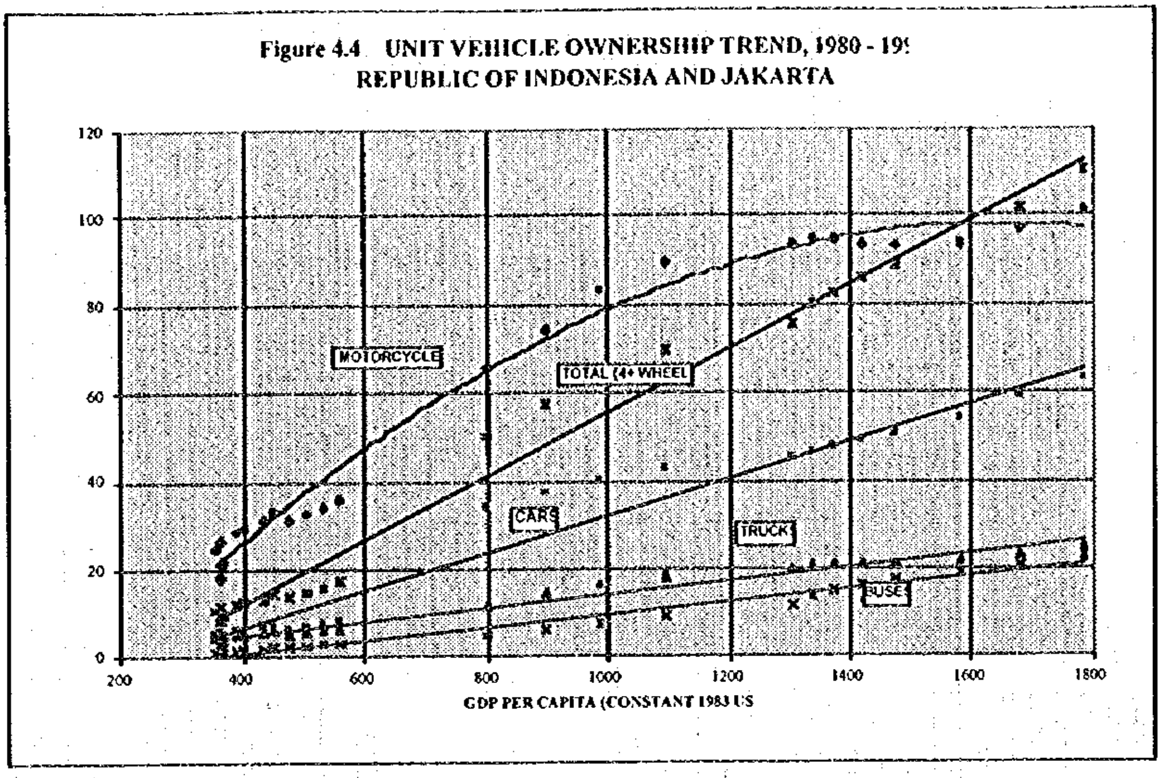


Figure 4.4 UNIT VEHICLE OWNERSHIP TREND, 1980 - 19
REPUBLIC OF INDONESIA AND JAKARTA
MOTORCYCLE
TOTAL (4+ WHEEL
CARS
TRUCK
BUSES
GDP PER CAPITA (CONSTANT 1983 US

Fig. 4.4 & 4.5

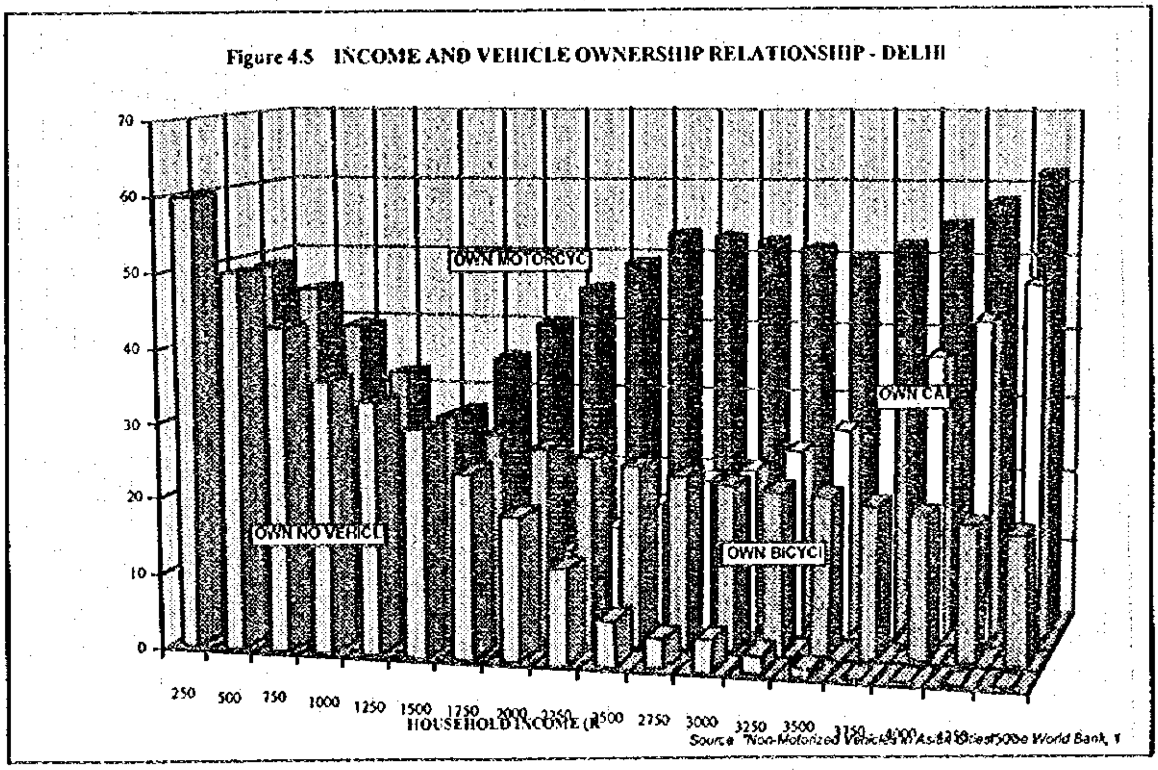


Figure 4.5 INCOME AND VEHICLE OWNERSHIP RELATIONSHIP - DELHI
OWN MOTORCYC
OWN CA
OWN NO VEHICL
OWN BICYC
HOUSEHOLD INCOME (R

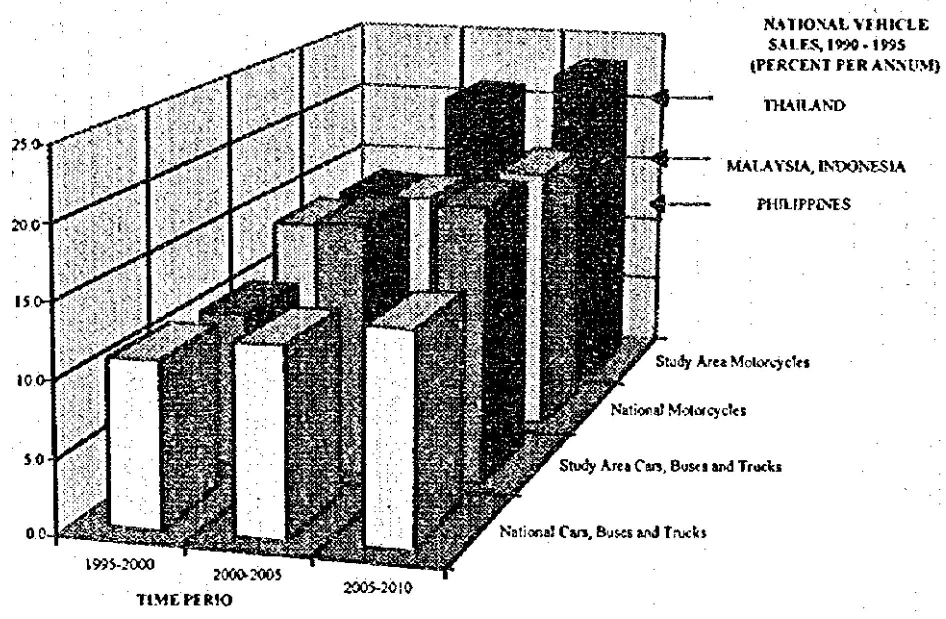
Mode	Average Annual Change (Percent)		
	1995 - 2000	2000 - 2005	2005 - 2010
Passenger Cars	11.1	17.8	19.0
Buses	10.3	17.7	20.4
Trucks	10.2	16.8	18.2
Motorcycles	13.2	21.0	23.1
NMV	-0.1	-3.3	-1.8

In other words, over the extent of the planning horizon, study area vehicle ownership (car, buses, trucks) is forecast to almost double every five years, more so in the case of motorcycles. A comparison of expected study area and national trends reveals that (Figure 4.6):

- Motorcycle ownership is anticipated to increase more rapidly than car, bus and truck ownership at both the national and study area levels.
- Growth in vehicle ownership in the study area is likely to lag national norms until the turn of the century, then accellerate ahead of national norms for the remaining decade of the planning horizon.

On a composite basis, the car, bus and truck ownership growth rate for the years 2005-2010 period (18.7 percent per annum) is shown as approaching the 20 percent average annual vehicle sales rate achieved by the Kingdom of Thailand over the years 1990-1995 period.

Figure 4.6 FORECAST VEHICLE OWNERSHIP GROWTH RATI



4.3 FUTURE DEMAND

The final compilation of future modal demand involves three components (a) internal trips spawned by socio-economic changes in the study area; (b) external trips with at least one trip end outside of the study area, and (c) impacts posed by mega-projects such as the Dung Quat development.

4.3.1 Internal Trips

Future year zonal trip ends for internal trips (both trip ends within the study area) were derived utilizing the trip generation model presented in the previous report section. The future element of the macro-economic frame[1] includes population forecasts which reflect future land-uses inherent to the proposed Master Plan framework. Total population is, in summary, expected to increase from 4.78 million persons in year 1995 to 6.48 million persons in year 2010 (36 percent increase). Urban population is, on the other hand, forecast to expand from 1.08 million persons in year 1995 to 2.15 million persons in year 2010 (100 percent increase). (Table 4.5)

Table 4.5 Forecast Study Area Population (Million)

Province	Year			
	1995	2000	2005	2010
Total Population				
Quang Tri	0.55	0.63	0.71	0.79
Thua Thien-Hue	1.04	1.17	1.30	1.43
Quang Nam-Da Nang	1.98	2.20	2.41	2.62
Quang Ngai	1.21	1.36	1.50	1.64
Total	4.78	5.36	5.92	6.48
Urban Population				
Quang Tri	0.09	0.12	0.17	0.24
Thua Thien-Hue	0.27	0.34	0.43	0.55
Quang Nam-Da Nang	0.61	0.70	0.85	1.09
Quang Ngai	0.11	0.13	0.19	0.27
Total	1.08	1.29	1.64	2.15

Source: Project macro-economic frame.

Population forecasts were initially entered, stratified by zone, into the "bottom-up" regression equations. This approximates a relative shift in trip making among study area zones based on changes in residential distributions as well as increased urbanization. Subsequently, "top down" controls based on Asian vehicle ownership-income relationships were applied at the province level to superimpose an absolute change on trip-making propensity based on forecast levels of vehicle ownership. This suggests that internal trips by cars, buses and trucks are likely to increase from 12,400 per day in year 1995 to almost 109,000 per day by year 2010 (Table 4.6).

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[1] Ibid.