7.4 Enhanced Traffic Management

7.4.1 General

In the present urban transportation system of Managua, there are a variety of problems as analyzed in previous chapters. Fortunately, however, the magnitude and seriousness of the problems are not so outstanding yet as are seen in many other large cities of the world. This is not only because of the smaller scale of economic activities in Managua but because of the relatively high level of infrastructure stock and well disciplined behavior of Government and citizen.

Nevertheless, it is foreseen that the traffic situation will soon be serious as economy grows and people's discipline may be eroded if well planned actions are not taken. It is the time now for the Government to launch new actions to prevent such degradation. The preventive planning, however, is difficult to be implemented due to the lack of financial resources which is supposed to remain at least a few more years. Under these circumstances, the role of traffic management is very important since it basically intends to make maximum use of the existing infrastructure without large-scale capital investment. The outline of the proposed actions is as follows:

I. Immediate Actions

1. Improve existing facilities such as malfunctioning signals.
2. Concentrate on effective and less expensive measures for enhancing traffic safety.
3. Strengthen institutional capacity on planning, administration and enforcement.
4. Cultivate people's consciousness towards the need of traffic management (particularly to control private cars), and raise the rate of fuel consumption tax.

II. Short-Term Actions

1. Concentrate on effective and less expensive measures for improving quality of transportation.
2. Upgrade existing facilities with a strong emphasis on improving public transportation.
3. Strengthen parking control and improve walking condition for pedestrians.
4. Designate public transportation priority area and start controlling private traffic.
5. Raise car prices by increasing import duties.
6. Identify recommendable truck routes.

III. Medium-Term Actions

1. Upgrade and modernize traffic control facilities in response to increasing traffic and enhanced public transportation system.
2. Expand traffic management to cover newly urbanized areas.
3. Improve traffic management area-wide in relation to secondary roads.
4. Designate more public transportation priority areas.

IV. Long-Term Actions

1. Upgrade heavily trafficked intersections according to the hierarchy of roads (flyover, interchange, etc.).
2. Develop pedestrian/bicycle paths in major touristic, cultural and recreational areas.
3. Conduct studies on possible pricing measures (TDM) to improve traffic situation and to raise fund for enhancing transportation system.
4. Designate truck routes.

7.4.2 Intersection Improvement

(1) Guidelines

A. Type of Intersection

Type of intersection is basically determined by traffic volume, which, however, changes according to economic growth, urbanization and current traffic control measures. In this Study, the type of intersections in Managua is determined based on the functional hierarchy of roads as presented in Table 7.4.1.

Table 7.4.1
Desirable Type of Intersection

Road Hierarchy	Travesía	Primary Distributor	Primary Collector	Secondary Connector	Local Road
Travesía	IC	GS	GS	NA	NA
Primary Distributor	--	SI (GS/RA)	SI (RA)	SI	SI
Primary Collector	--	--	SI	SI	SI
Secondary Collector	--	--	--	SI	AG
Local Road (calle)	--	--	--	--	AG

Note:
IC = Interchange
SI = Signalization
AG = At Grade
GS = Grade Separation
RA = Roundabout
NA = No Access

B. Signalization vs. Roundabout

At present, five (5) roundabouts are existing in Managua and some more are planned for implementation. However, the construction of roundabouts needs careful investigation. Table 7.4.2 compares signalization and roundabouts.

Table 7.4.2
Comparison of Signalization and Roundabouts

	Signalization	Roundabout
Capacity	• Relatively large.	• Relatively small.
Delay Time	• Large loss time due to compulsory stops when traffic volume is low. • Relatively equalized delay time by direction when traffic volume is large.	• Small delay time when traffic volume is low. • When traffic volume is large, delay time may extremely differ by direction.
Coordinated or Area Control	• Easy to apply (improvement/upgrading necessary)	• Difficult to apply
Durability	• Subject to maintenance and electricity supply	• High
Safety of Pedestrian Crossing	• Easy to secure	• Difficult
Land Space	• Small	• Large (but easy to convert to grade separation)
Landscaping		• Can be monumental or focul point

The comparison of signalization and roundabouts is further discussed in Appendix 5. At present in Managua where traffic demand is not yet high and electricity suppy is unstable, roundabouts are attractive as compared to signalization. However, signalization is, in general, considered more desirable in the long run taking into account its capacity, flexibility (adjustability) and applicability of control technology. In conclusion, the construction of roundabouts may be considered in the location that satisfies the following conditions:

- Land space available
- Relatively small traffic demand
- Land use not too dense
- Rather independent from other intersections

In this Study, new roundabouts are proposed in relation to the Public Transportation Corridor.

C. Effect of Coordinated/Area Control

Compared to the conventional pre-timed signal, modern signal is efficient with the dynamic mechanism which changes signal phases according to the monitored traffic volume. Moreover, if it is coordinated in consistency with the adjacent signals on the same road or in the same area, the total efficiency will be largely improved. The following calculation is hypothetical, but represents the typical situation in Managua.

Economic Benefit of Coordinated Control of Five (5) Consecutive Signals Independently Controlled

- Road : 4- lane segregated road (2 lanes x 2 directions)
- Traffic Volume : 30,000 vehicle/day for both directions
- Average Green Time : 60 seconds (cycle time 100 seconds)
- Total Delay Time :

20 sec. x 5 signals x 30,000 x 310 days
= 930 million sec.
= 258 thousand hours

- Total Delay Time when coordinated:

258 thousand hours x 0.4 (assuming 2 stops on average)
= 103 thousand hours

- Total Annual Time Savings (assuming C$13/vehicle-hour)

(258-103) thousand hours x C$13
= C$2.0 million (per year)

As such, the economic benefit of coordinated control is so large that initial investment could be recovered in the first year of operation. This should be implemented as soon as the financial resources become available.

(2) Planning

A. <u>Intersection Improvement and Development</u>

Figure 7.4.1 presents the Master Plan for intersection improvement and development. This proposal includes the following components:

- Improvement of Existing Signals

  There are at present 58 signalized intersections in Managua. These signals are pre-timed, and their fixed phasing has not been adjusted to the increasing traffic in most cases as analyzed in Appendix 5. In addition, some of them are considered to be already saturated even after adjustment of phasing. In this case, they have to be improved also by minor geometrical modification.

  In general, minor intersection improvement including the adjustment of phasing brings about a large economic benefit due to its small cost. The following is recommended as an immediate action:

  1. Traffic count survey at 58 signalized intersections (by direction, by vehicle type, 3 days, peak hour).
  2. Intersections analysis.
  3. Adjustment of phasing.
  4. Minor geometrical improvement for critical intersections.

- Signalization

  A total of 259 intersections should be signalized by 2018. Although this includes 58 existing signals, all the signals are assumed to be modernized (e.g. actuated or semi-actuaded).

- Grade Separation

  10 intersections should be grade-separated in relation to the proposed Travesía. In addition, 6 intersections of Primary Distributors where traffic volume will exceed its capacity should be grade separated. This does not include the grade separation of busway proposed in relation to Public Transportation Corridor.

- Roundabout

  In addition to the existing 5 roundabouts, new 5 roundabouts are proposed on Carretera Norte and Pista Sabana Grande in relation to the proposed Public Transportation Corridor. When traffic volume increases, additional signals may become necessary in these intersections.

- Coordinated Control of Signals

  4 road sections that have a series of traffic signals in a short distance are proposed to have a coordinated control of the signals.

B. <u>Phasing of Plans</u>

- Table 7.4.3 shows the quantity of the proposed projects by planning period. Figure 7.4.2 presents graphically the phasing of the proposal. This is determined according to the road development Master Plan.

Figure 7.4.1 Master Plan of Intersection Improvement and Development

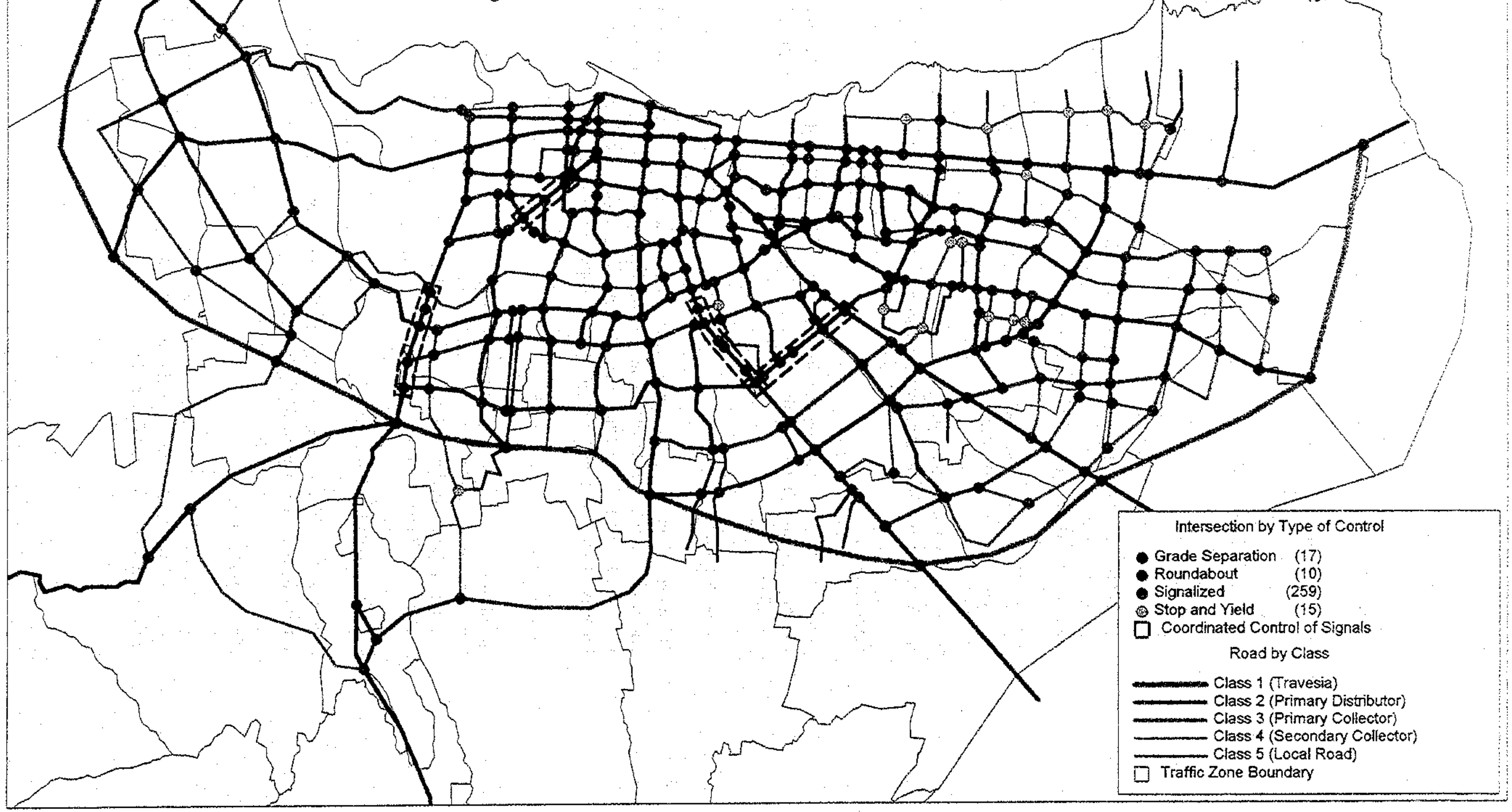


Figure 7.4.2 Phasing of Intersection Improvement and Development

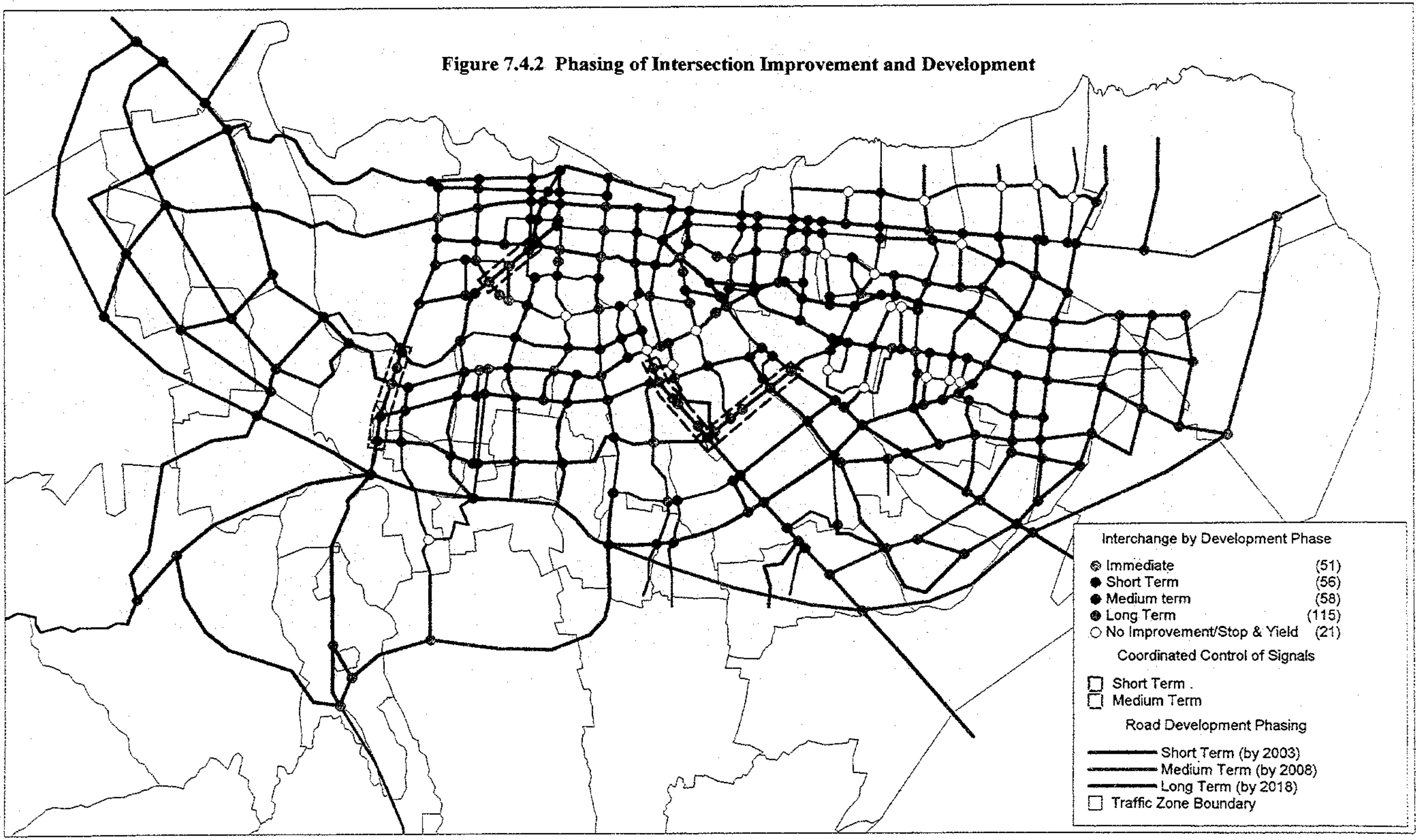


Table 7.4.3
No. of Projects by Planning Period

	Immediate	Short	Medium	Long	Total
Improvement*	58	0	0	0	58
Grade Separation**	0	2	6	8	16
Roundabout***	0	2	1	2	5
Signalization****	0	107	51	105	263
Coordinated Control of Signals	0	3	1	0	4

Note: * Improvement of existing signals, including traffic count survey, analysis, minor geometrical improvement, etc.
** Including one existing signalized intersection in each of the planning phase.
*** Including existing signalized intersections, two in Short-term, one each in Medium and Long-Term.
**** Short-term includes upgrading of 51 existing signals.

- As a result, the number of intersections by type of control will be as shown in Table 7.4.4.

Table 7.4.4
No. of Intersections by Type of Control

	Existing	2003	2008	2018
Grade Separation	1	3	9	17
Roundabout	5	7	8	10
Signalization	58	107	156	259

C. Project Cost

- Table 7.4.5 shows the estimated cost of the proposed projects by planning period. The total cost is about US$70.1 million. Short-Term shares about 25%, Medium-Term about 34% and Long-Term about 40%.

7.4.3 Development of Space for Pedestrians and Bicycles

This section proposes the development of space for pedestrians and bicycles from the following viewpoints:

1. Improvement of traffic safety for pedestrians.
2. Promotion of walking and bicycle use for recreational purposes.

A. Improvement of Traffic Safety for Pedestrians

- The safety condition for pedestrians will be largely improved by the following measures proposed earlier:

  - Road construction and widening, particularly of bottleneck sections.
  - Development of Public Transportation Corridor including pedestrian crossing, pedestrian bridge and pedestrian priority signal.
  - New feeder public transportation service that reduces walking distance.
  - Improvement of bus terminal.
  - Intersection improvement.

- Here, as an immediate action, development of pedestrian crossing with signal installation is proposed in the following critical places:

  - Bo. Las Piedrecitas
  - Mercado Ivan Montenegro (Mercado San Miguel)
  - Las Mercedes (Carretera Norte)

Table 7.4.5 Estimated Cost for Intersection Improvement and Development

	No. of	No. of Lanes		Unit Cost	No. of Intersections				Cost (000 US$)				
	Legs	Main	Cross	(000 US$)	Immed.	Short	ediu	Long	Immediat	Short	Medium	Long	Total
1. Improvement *				1.0	58				58	0	0	0	58
2. Grade Separation **	3	6	6	3,109.2		1			0	3,109	0	0	3,109
		6	4	3,103.8			1		0	0	3,104	0	3,104
		4	4	2,143.8				4	0	0	0	8,575	8,575
	4	6	6	3,153.4		1	1		0	3,153	3,153	0	6,307
		6	4	3,140.4			4	2	0	0	12,562	6,281	18,842
		4	4	2,180.4				2	0	0	0	4,361	4,361
	Sub-Total				0	2	6	8	0	6,263	18,819	19,217	44,298
3. Roundabout ***		14		750.0				1	0	0	0	750	750
		18		950.0				1	0	0	0	950	950
		20		1,050.0		1			0	1,050	0	0	1,050
		22		1,150.0		1	1		0	1,150	1,150	0	2,300
	Sub-Total				0	2	1	2	0	2,200	1,150	1,700	5,050
4. Signalization ****													
a. Incl. geometric improvement	3	4	4	93.7		4			0	375	0	0	375
		4	2	75.0		6	1		0	450	75	0	525
	4	4	4	138.1		6			0	829	0	0	829
		4	2	94.2		3			0	283	0	0	283
b. Signal system only	3	6	6	73.9				1	0	0	0	74	74
		6	4	73.9		16	3	5	0	1,182	222	370	1,774
		6	2	56.6		5	9	7	0	283	509	396	1,189
		4	4	71.7		5	3	11	0	359	215	789	1,362
		4	2	56.8		10	7	25	0	568	398	1,420	2,386
		2	2	46.9				10	0	0	0	469	469
	4	6	6	106.2		8	5		0	850	531	0	1,381
		6	4	104.0		21	4	1	0	2,184	416	104	2,704
		6	2	69.0		6	8		0	414	552	0	966
		4	4	101.0		9	9	22	0	909	909	2,222	4,040
		4	2	69.0		8	2	19	0	552	138	1,311	2,001
		2	2	54.4				4	0	0	0	218	218
	Sub-Total				0	107	51	105	0	9,237	3,965	7,372	20,573
5. Coordinated Control of Signals (additional cost only)				8.0		15	4	1	0	120	32	8	160
				Total Cost					58	17,819	23,966	28,297	70,139

Note: * Improvement of existing signals, including traffic count survey, analysis, minor geometrical improvement, etc.

** Including one existing signalized intersection in each of the planning phase.

*** Including existing signalized intersections, two in Short-term, one each in Medium and Long-term.

**** Short-term includes upgrading of 51 existing signals.

The cost of the projects above will be about US$0.15 million.

B. Promotion of Walking and Bicycle Use

- It is important for Managua to cultivate people's habit to walk more and to use bicycles more for people's health and recreation.

- Figure 7.4.3 shows the proposed bicycle road and pedestrian path for recreational purposes. The bicycle road of about 40 km connects vista points, lakes, major cultural and recreational zones and universities, while pedestrian path of about 5 km is proposed along the shore of Managua Lake and the North-South axis between the old CBD and university area through Tiscapa.

- This plan is proposed as a Long-Term action because the shoreline of Managua Lake and waterways in the built-up area need to be cleaned and the roads be widened. The total cost will be the order of US$10 million including landscaping and street furnitures.

7.4.4 Transportation Demand Management (TDM)

1) Necessity of TDM

Many large cities in the world suffer from traffic congestion. As the "vicious circle" in Figure 7.4.4 indicates, traffic congestion is a difficult problem to solve. The vicious circle shows that with traffic congestion bus and other road-based mass transit become slow and unreliable, providing users with an incentive to switch to private vehicles in order to obtain higher levels of service. These results in the fares for mass transit becoming higher to make up for lost revenue, which lowers the level of service of public transit even more and produces a greater shift in ridership to modes of private transportation.

Figure 7.4.4
Vicious Circle of Traffic Congestion

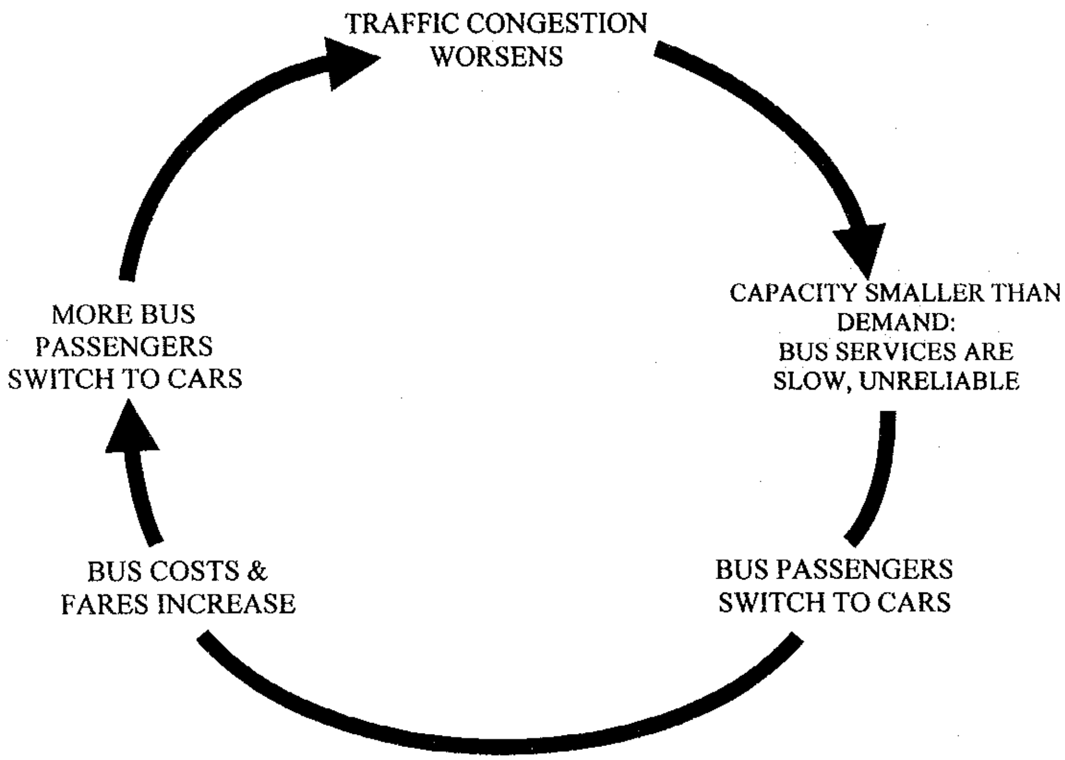
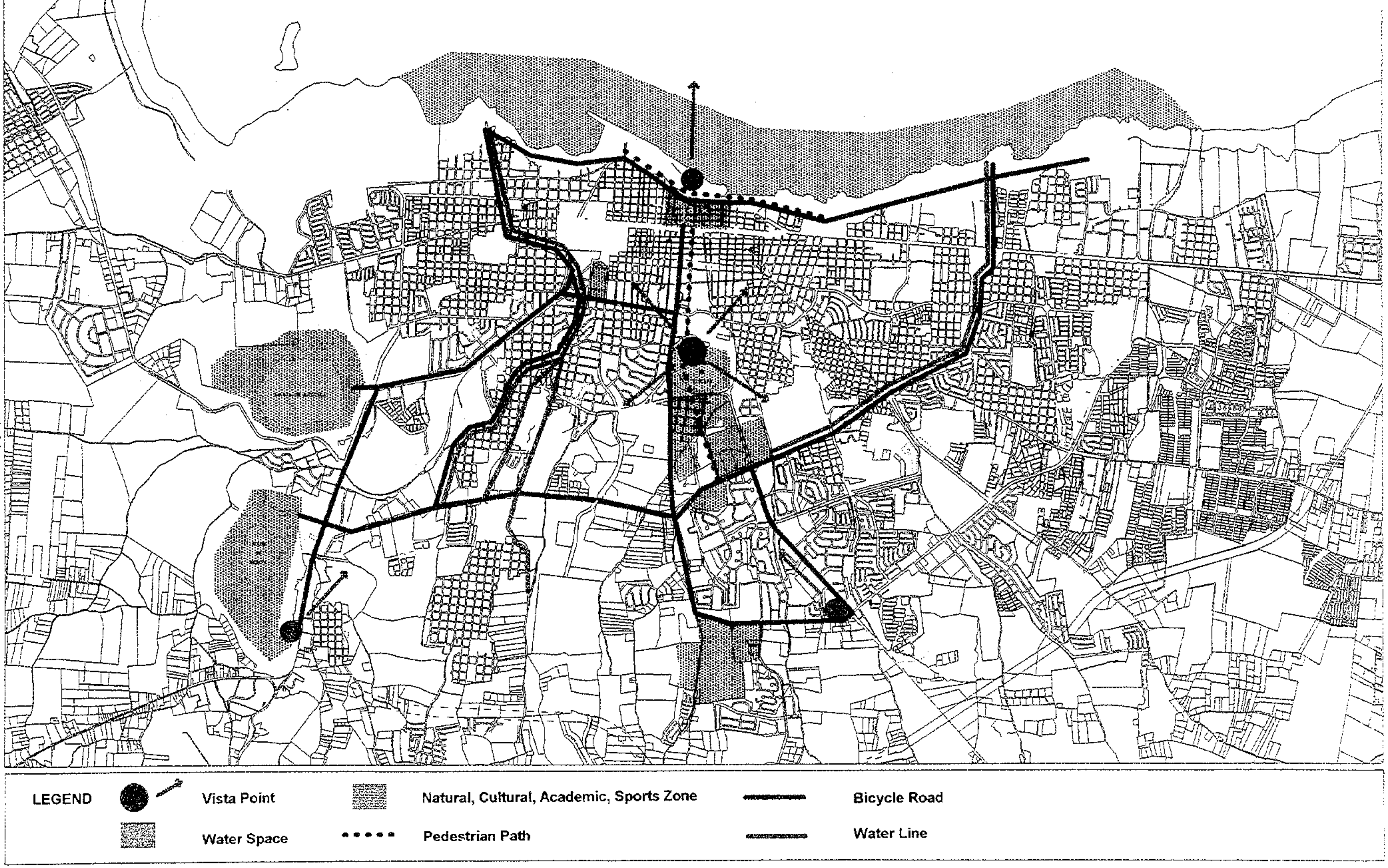


Figure 7.4.3 Proposed Bicycle Road and Pedestrian Path



Conventionally, the method for reducing road traffic congestion has been to increase network capacity by constructing new roads. However, the provision of infrastructure has failed to keep pace with the ever-increasing road traffic demand. In other words, it has been shown throughout the world that it is difficult, if not impossible, to solve traffic congestion from the supply side alone. Therefore, more attention has been given to managing traffic demand via the application of traffic demand management (i.e, TDM) techniques (e.g, as shown in Table 7.4.6).

The major objectives of TDM techniques are to use road space more efficiently and to promote modal balance in order to alleviate traffic congestion and thereby reduce travel time (i.e. improve the level of service of roads). There is another reason that makes TDM measures more attractive. That is the possibility to obtain revenue which can be invested into transportation infrastructure to provide better service for road users.

2) Application Opportunities of TDM Measures in Managua

A. Public Transportation Priority Area

- This is proposed with an intention to prioritize public transportation by controlling the movement of private vehicles. This is particularly important in bus terminal areas. Since existing bus terminals are mostly located in market areas and new public bus terminals are proposed in connection with market development, Public Transportation Priority Area has the following effects:

Table 7.4.6
TDM Techniques

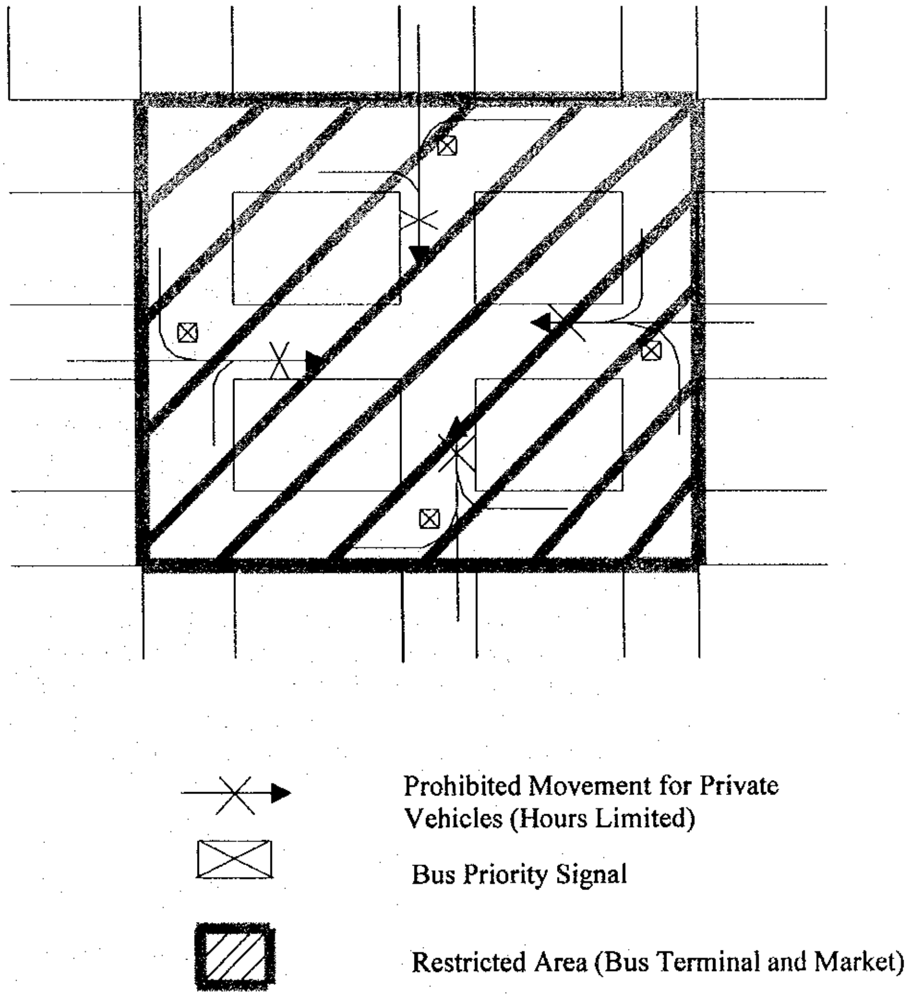
Technique	Description	Cities/Countries Where Implemented
Traffic restrictions for residential areas	On-street parking controls, street closures, road humps, elimination of curbs, etc, are used to improve the residential environment.	Copenhagen, Netherlands, (Harlem, Delft, Enschedes, Sweden (Vasteras)
License-plate numbering system	Vehicles with odd-numbered plates are not permitted to enter controlled areas on odd-numbered working days and vehicles with even-numbered plates are not permitted to enter on even-numbered days.	Nigeria (Lagos), Seoul, Greece (Athens)
Planned congestion	Capacity restrictions and time delays using traffic signals are applied to achieve planned congestion.	Nagoya, Nottingham, Ottawa – Carleton
Traffic cell system	Division of an urban area into zones which are only mutually accessible by public transport or by a circuitous route. Pedestrian streets are used to prevent vehicular traffic from passing through an area.	Gothenburn, Besancon, Dijon, Nottingham, Gronigen, Delft, Geneva, Nagoya, Bremen, Ottawa
Auto-restricted zone in CBD	Zones where automobiles are totally eliminated; a new circulation system for buses, pedestrians, taxis, and delivery trucks with priority given to buses.	Boston
Area-licensing/congestion charging	Vehicles are charged for entering a congested area during peak periods, excluding public and emergency vehicles.	Singapore
Vehicle ownership restraints	Vehicle ownership is inhibited by high import taxes, purchase taxes, vehicle registration fees, and annual licensing fees.	Hong Kong, Seoul
User taxes	Vehicle use is restrained through user taxes imposed on fuel, tires, spare parts, etc., thus adding to the operating cost in relation to the distance traveled.	Seoul
Cordon toll gates	Toll gates installed at cordons around a controlled area.	Bristol, Bergen
Tolls placed at particular facilities to control movement	Toll gates are placed at particular facilities, like tunnels and bridges, to control movement.	New York, Southampton, Seoul, Hong Kong.
Pedestrian streets	Selected streets are closed to vehicles to promote pedestrian use and safety and a pleasant environment.	UK (London, Nottingham, Glasgow, Norwich, Liverpool, Leeds, Durham coventry), Germany (Mainz, Munich Stovede, Essen, Stuttgart, Cologne Dusseldorf, Hanover, Frankfurt), France (Paris, Besancon), USA (Boston, Minneapolis, Madison, Minnesota, California), Netherlands (Hague, Gronigen), Copenhagen, Brussels, Ottawa, Tokyo, Rome, Geneva, Vienna, Gothenburg.
Pedestrian street	Pedestrians and buses share road space to reduce traffic congestion and to promote a pleasant environment.	Germany (Trier), UK (Derby, London, Leeds).

Source: H.C. Park, "Traffic Demand Management: Some Possible Techniques for Bangkok", Master's Thesis, Asian Institute of Technology (AIT), 1989, adapted.

1. Improvement of traffic congestion around bus terminals and markets
2. Improvement of shopping environment

- The concept of this proposal is shown in Figure 7.4.5. When the restriction is implemented in consistency with the renovation or development of bus terminals and markets, the area will become a "transit mall" which has been successfully implemented in various cities of the world. In addition, the time of restriction must be limited not to hinder the activities of cargo loading/unloading, delivery, etc. (e.g. 7:00-19:00).

Figure 7.4.5
Concept of Public Transportation Priority Area



- The proposed areas are shown in Figure 7.4.6. The cost of this project is estimated at US$ 2.2 million for 11 areas (US$0.2 million per area assuming 4 additional signals and installation of traffic signs).

Short-Term	Mercado Oriental	US$0.2 million
Medium-Term	Mercado Ciudad Sandino	0.2
	Mercado Boer	0.2
	Mercado San Judas	0.2
	Mercado Virgen de Candelaria	0.2
	Mercado Roberto Huembes	0.2
	Mercado Mayoreo	0.2
	Mercado San Miguel	0.2
	Sub-Total	1.4
Long-Term	Villa Flor	0.2
	Sabana Grande	0.2
	Ciudad Satélite Asososca	0.2
	Sub-Total	0.6

B. On-Road Parking Banned Area

- On-road parking is already prohibited on major roads in Managua. However, the restriction is not always followed as revealed by the road inventory survey conducted in this Study.

- On-Road Parking Banned Area intends to strengthen this restriction on the designated Public Transportation Corridors. Continuous monitoring and strict enforcement are necessary.

C. Tax Increase on Fuel Consumption

- To raise the tax rate on fuel consumption is a TDM measure that discourages the usage of vehicles. At present, this is proposed by MTI (supported by WB, IDB and other international organizations) in order to create the Road Maintenance Fund (Fondo de Mantenimiento Vial). The primary objective of this fund is to secure the financial resources for the maintenance of national road network of which cost is enormous.

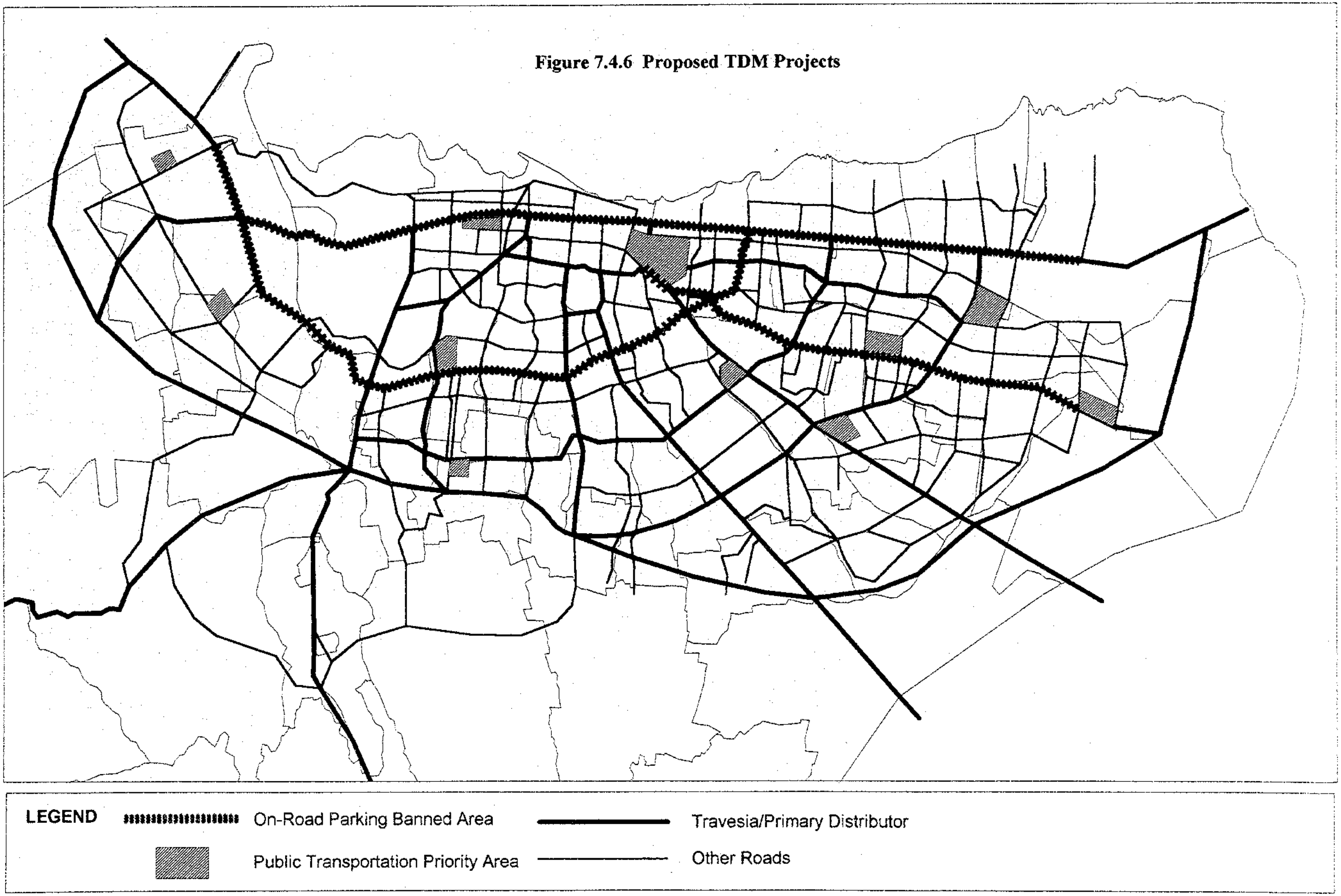
- Revenue potential of this TDM measure is estimated at about US$10 million in 1998 and US$40 million in 2018 assuming a rate increase of 10%.

- This Study also supports this proposal due to the following reasons:

  1. In principle, the cost of road maintenance should be shouldered by beneficiaries. The benefit of road users who use the maintained roads is much larger than what they pay.
  2. Although the rate increase of fuel consumption tax pushes up the cost of cargo and public transportation slightly, the impact will be larger for private car users who pay the cost out of their pockets.
  3. Government budget is extremely insufficient to cover the needs for road maintenance.

- The only problem of this proposal for Managua is that the fuel consumption tax is a national tax and that the allocation of the fund to Managua is not guaranteed. The fact that the share of Managua in fuel consumption is large (mostly by light vehicles

Figure 7.4.6 Proposed TDM Projects



which damage the road less) should be reasonably taken into account in allocating the fund.

D. Tax Increase on Vehicle Import

- The primary objective of this rate increase of vehicle import duty is to discourage the vehicle ownership as well as to raise public funds.

- As pointed out in Section 6.2, the price of vehicles in Managua is considerably low compared to the international level. The Study proposes to raise the current import duty on cars so that the retail price goes up by 20%. This is a level comparable to Mexico City as of 1998 which is still lower than many other countries.

- The revenue potential of this TDM measure is large; about US$30 million in 1998 and US$120 million in 2018 (see Section 6.2). Although this is a national tax, a considerable percentage (e.g. 1/4 ~ 1/3) should be allocated for Managua's transportation infrastructure since the major part of this revenue comes from Managua.

- This TDM measure also has a large impact on Managua's transportation and traffic situation. Based on the sensitivity test using the modal split model and traffic assignment model, the following effects were observed as compared to the base case (without toll road and Public Transportation Corridor, see Table 7.2.5):

1. Car Ownership

   2003: 4.1% less
   2008: 4.9% less
   2018: 7.5% less

2. Public Modal Share

   2003: 3.0% up
   2008: 3.3% up
   2018: 5.2% up

3. Average Volume/Capacity Ratio

   2003: 0.06 down
   2008: 0.06 down
   2018: 0.08 down

4. Average Travel Speed

   2003: 1.4 km/h up
   2008: 1.4 km/h up
   2018: 2.7 km/h up

E. Road Pricing

- Road pricing (or congestion charging) has been successfully implemented in some cities in the world such as Singapore, Oslo and Tronheim. At the same time, however, the proposal for road pricing has been rejected in some cities like Hong Kong and London and most of other cities are of wait-and-see attitude.

- The problem inherent to road pricing is the difficulty to reach a social consensus particularly in relation to the revenue created by road pricing. Political decision is usually made by car owners, and they don't like to be taken of money and are afraid of objections raised by car-owning society. Finance officers of the government want to incorporate the revenue from road pricing into the general budget while the proponents of road pricing always intend to earmark the revenue for transportation infrastructure.

- At the end of the Study, the JICA Study Team is not yet convinced whether road pricing works effectively in Managua and whether the proposal could be accepted politically and socially. However, the following can be pointed out:

1. Road pricing must be proposed in relation to the improvement of public transportation system (i.e. within Public Transportation Corridor).
2. The effect of alleviating traffic congestion will be remarkable on the target road.
3. The revenue potential from road pricing can be large enough to cover most of the cost of the proposed projects.
4. Road pricing, if implemented, will use initially a licensing system that issues a sticker to be pasted to the windshield of vehicle. The sticker should be able to be purchased in various places in Managua (e.g. post offices, banks, supermarkets, etc.) and should be payable together with the Road User Tax (Rodamiento) to ALMA in case of yearly license. Restricted time of the day, charging rate, etc. must be studied carefully before implementation.
5. Based on the traffic assignments conducted for several road pricing scenarios, it seems that road pricing is inappropriate before the long-term period because the traffic demand on priced roads is easily charged off at a low charging rate (i.e. revenue is small) in the short and medium-term (i.e. time value is low) and the traffic distribution is distorted causing a considerable amount of economic disbenefit. However, even in the short and medium-term, this TDM measure could be applied in a relatively short section of road if the necessity is clearly identified.

- In conclusion, it is recommended to conduct a study on road pricing in the long-term.

7.4.5 Determination of Truck Routes

- The most serious problem in relation to trucks is the damage to roads caused by trucks. According to the Study on "Administration and Implementation of Effective Control on Weight and Size of Vehicles" (Administración e Implementación del Efectivo Control de Pesos y Dimensiones de Vehículos Automotores), June 1998, MTI, one medium truck (rear axle of 8.5 ton) and one heavy truck (gross vehicle weight of 40 ton) are equivalent to 5,000 and 9,600 cars, respectively. Moreover, if a truck is overloaded, the damage to roads increases exponentially as shown in Table 7.4.7.

Table 7.4.7
Increase of Damage on Pavement of Roads due to Overloading

% Overloading	% Damage Increase
10	45
20	105
30	185
40	285

Source: MTI

- Although there is no weighing station in Managua, two weighing stations are installed near Managua; one in Chilamatillo in the north-east of Managua and the other in Mateare in the north-west of Managua. Based on the field survey conducted for the above mentioned study, the percentage of overloaded trucks was 17% in Chilamatillo and 11% in Mateare. Although there is no data inside Managua, it is not difficult to imagine that many trucks are running in Managua causing serious damages on roads.

- To prevent the damage on roads caused by trucks, there are two approaches:

  - Stricter enforcement.
  - Designation of truck routes.

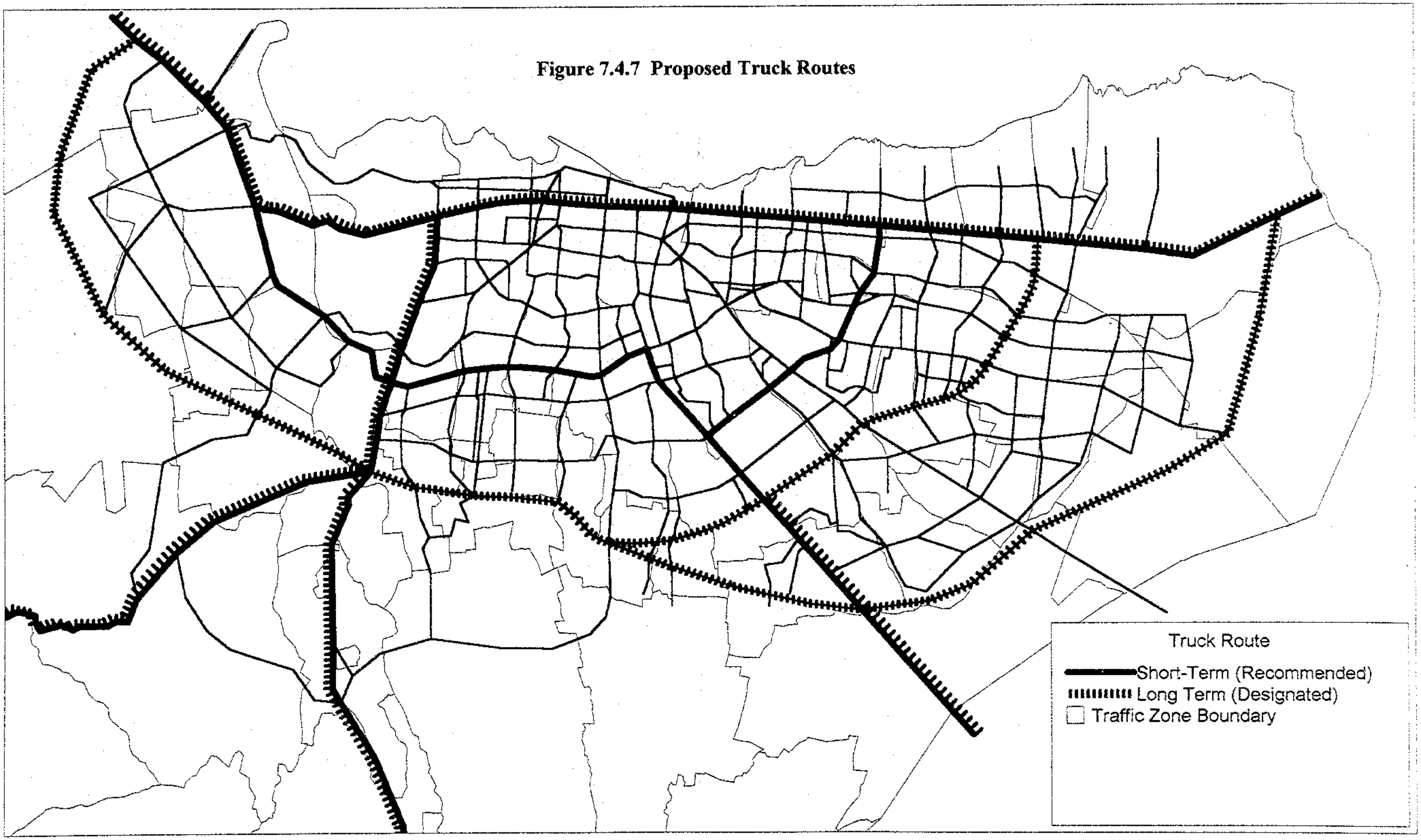
1. Stricter Enforcement

- According to the above mentioned study, only less than 1/10 of overloaded trucks were detected and recorded by the weighing stations in Chilamatillo and Mateare operated my MTI. A number of countermeasures are already proposed to improve this situation such as replacement of obsolete equipment and improvement of working conditions.
- However, drastic change will hardly happen unless MTI is authorized to unload the overload at weighing station and deposit it until due procedure is taken.

2. Designation of truck routes

- Most of the trucks running in and around Managua have origin or destination in Managua. Hence, strict restriction of truck routes is considered unrealistic at present.
- In the medium to long-term, however, it becomes desirable to designate truck routes in stricter sense because the trucking industry also needs to be rationalized by establishing private or public cargo terminals.
- The Study proposes the truck routes as shown in Figure 7.4.7. The pavement structure of the roads recommended or designated as the truck routes needs to be strengthened in conjunction with the proposed improvement or construction.

Figure 7.4.7 Proposed Truck Routes



8. Project Evaluation

8. PROJECT EVALUATION

8.1 Project Packages

8.1.1 Road Development Projects

- Figures 8.1.1 and 8.1.2 show the proposed road development project for widening and new construction, respectively. These projects have been identified considering the following:

    - Project type (widening or new construction).
    - Phasing (short-term, medium-term or long-term).
    - Continuity of road sections.

    Each project is summarized in Table 8.1.1. There are a total of 104 projects (34 widening projects and 70 new construction projects).

- In order to conduct economic, financial and environmental evaluation, however, the number of projects is too numerous. Thus, the projects were further aggregated into project packages as shown in Table 8.1.2. Out of 22 packages, 11 packages stand for major road projects while the remaining 11 packages are for other smaller road projects summarized by area and phasing.

8.1.2 Public Transportation Projects

- The proposed projects in relation to public transportation are summarized as shown in Table 8.1.3. Among the listed project packages, the two (2) Public Transportation Corridor project packages are quantitatively evaluated economically and financially. The six (6) public bus terminal project packages are roughly evaluated financially in an indicative manner. IEE (Initial Environmental Examination) covers both project packages. However, the proposed low-cost project packages such as "Rerouting" are excluded from the evaluation due to their "software" features.

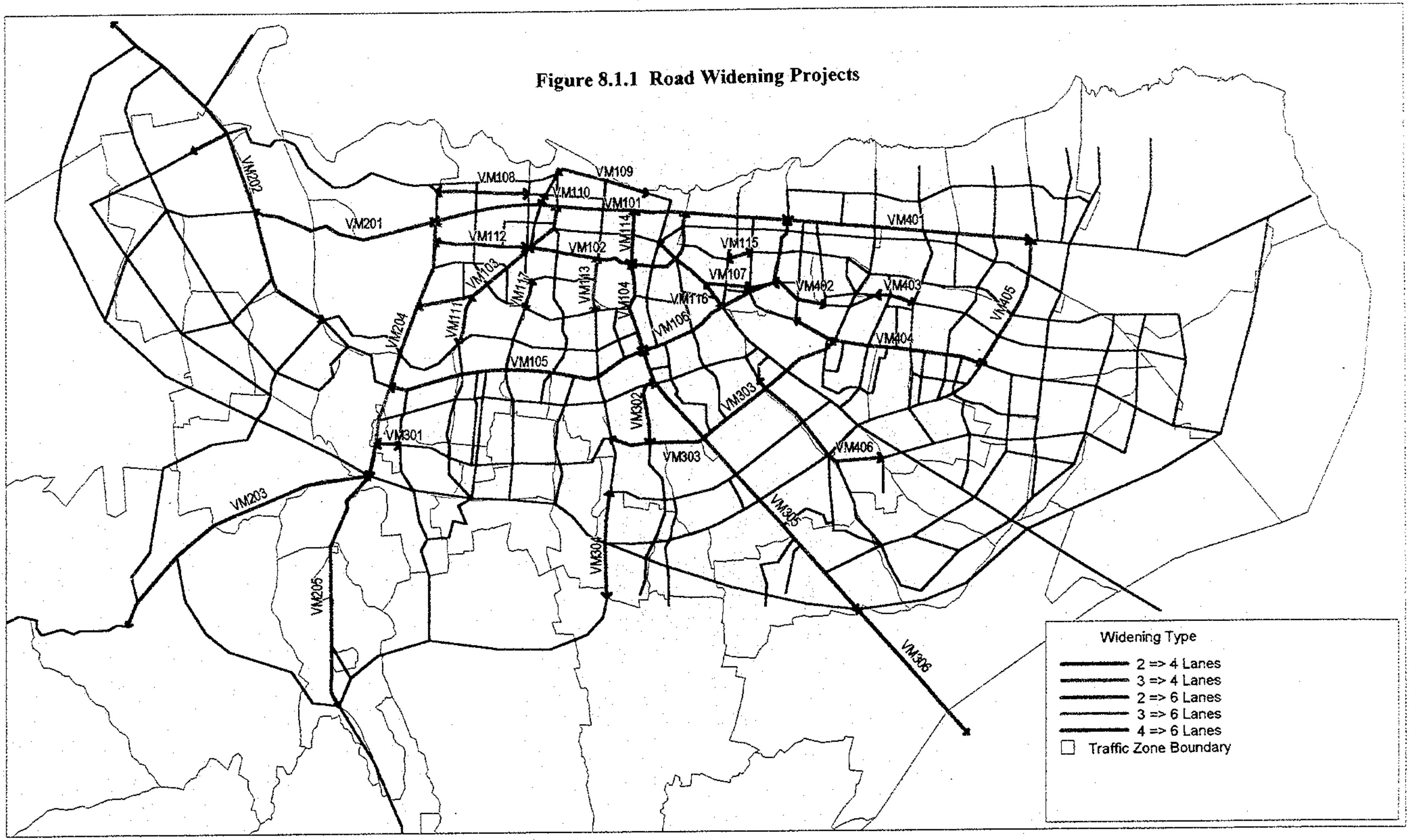


Figure 8.1.1 Road Widening Projects

Figure 8.1.2 New Road Construction Projects

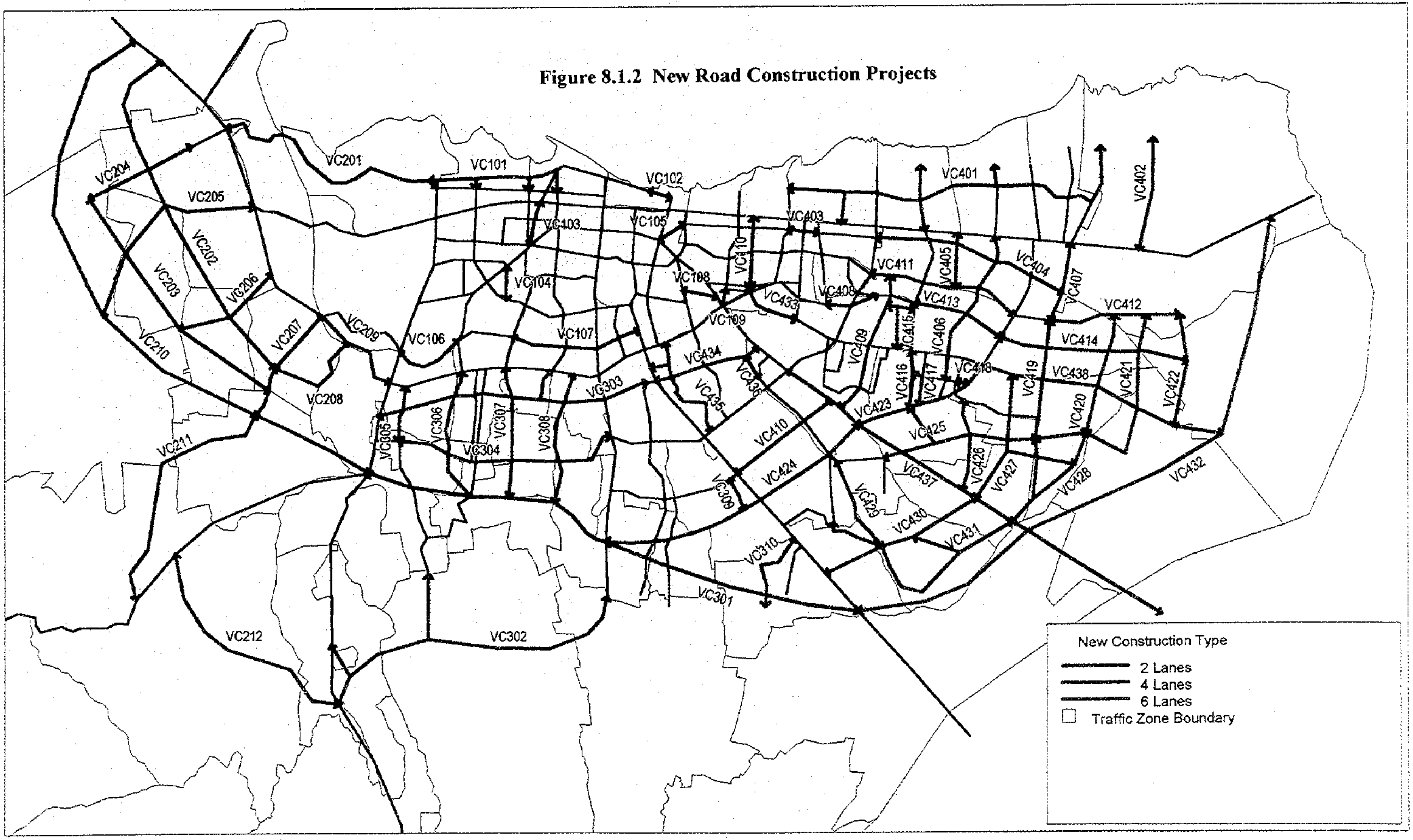


Table 8.1.1 Road Development Projects Summary

PROJECT	PHASE 1=Short 2=Medium 3=Long	PROJECT TYPE	NO. OF LANES (Predominant Type Only)
VM101	1	Widening	4=>6
VM102	1	Widening	4=>6
VM103	3	Widening	4=>6
VM104	1	Widening	4=>6
VM105	2	Widening	4=>6
VM106	2	Widening	4=>6
VM107	1	Widening	2=>6
VM108	3	Widening	2=>4
VM109	1	Widening	2=>4
VM110	1	Widening	2=>4
VM111	3	Widening	2=>4
VM112	3	Widening	2=>4
VM113	2	Widening	3=>4
VM114	1	Widening	2=>4
VM115	2	Widening	2=>4
VM116	1	Widening	2=>4
VM117	2	Widening	2=>4
VM201	1	Widening	4=>6
VM202	2	Widening	2=>4
VM203	3	Widening	2=>4
VM204	2	Widening	4=>6
VM205	3	Widening	2=>4
VM301	1	Widening	2=>4
VM302	2	Widening	2=>4
VM303	2	Widening	4=>6
VM304	1	Widening	2=>4
VM305	2	Widening	2=>6
VM306	3	Widening	2=>4
VM401	1	Widening	4=>6
VM402	1	Widening	2=>4
VM403	1	Widening	2=>4
VM404	2	Widening	4=>6
VM405	3	Widening	2=>4
VM406	3	Widening	2=>4
VC101	2	New Const.	2
VC102	2	New Const.	4
VC103	1	New Const.	4
VC104	2	New Const.	4
VC105	1	New Const.	4
VC106	3	New Const.	2
VC107	2	New Const.	2
VC108	2	New Const.	2
VC109	1	New Const.	4
VC110	3	New Const.	2
VC201	2	New Const.	4
VC202	2	New Const.	4
VC203	3	New Const.	2
VC204	2	New Const.	4
VC205	3	New Const.	4
VC206	3	New Const.	2
VC207	3	New Const.	4
VC208	2	New Const.	2
VC209	1	New Const.	4
VC210	3	New Const.	4
VC211	3	New Const.	2
VC212	3	New Const.	2
VC301	2	New Const.	6
VC302	3	New Const.	4
VC303	3	New Const.	4
VC304	1	New Const.	4
VC305	2	New Const.	2
VC306	2	New Const.	4
VC307	3	New Const.	4
VC308	2	New Const.	4
VC309	3	New Const.	2
VC310	3	New Const.	2
VC401	3	New Const.	2
VC402	3	New Const.	2
VC403	2	New Const.	2
VC404	2	New Const.	2
VC405	3	New Const.	2
VC406	2	New Const.	2
VC407	3	New Const.	2
VC408	1	New Const.	4
VC409	2	New Const.	2
VC410	3	New Const.	2
VC411	3	New Const.	4
VC412	3	New Const.	4
VC413	3	New Const.	4
VC414	3	New Const.	2
VC415	3	New Const.	2
VC416	2	New Const.	4
VC417	3	New Const.	2
VC418	3	New Const.	2
VC419	3	New Const.	4
VC420	3	New Const.	4
VC421	3	New Const.	2
VC422	3	New Const.	2
VC423	1	New Const.	4
VC424	1	New Const.	4
VC425	3	New Const.	4
VC426	3	New Const.	2
VC427	3	New Const.	2
VC428	3	New Const.	2
VC429	3	New Const.	4
VC430	3	New Const.	4
VC431	3	New Const.	2
VC432	3	New Const.	4
VC433	1	New Const.	6
VC434	3	New Const.	4
VC435	3	New Const.	2
VC436	3	New Const.	4
VC437	3	New Const.	4
VC438	3	New Const.	4

Table 8.1.2
Road Project Package

No.	Project Package Name	Related Project Components					Evaluation		
							Economic	Financial	Environmenttal
1	Carretera Norte	VM101	VM201	VM401	VC205		◎		○
2	Travesia (Toll Road)	VC210	VC301	VC432			◎	◎	○
3	Pista Juan Pablo II	VM105	VM106				◎		○
4	Carretera Sur	VM204	VM205				◎		○
5	Pista Portezuelo	VM301	VM303	VC304			◎		○
6	Pista Rural de Circunvalación	VM405	VC423	VC424			◎		○
7	Pista Sabanagrande	VM107	VM404	VC433	VC438		◎		○
8	AV. Rubén Dario-Carretera a Masaya	VM104	VM114	VM305	VM306		◎		○
9	Carretera Nueva a León	VM202	VC209				◎		○
10	Carretera Vieja a León	VM203					◎		○
11	Pista alterna a Masaya	VC437					◎		○
12	Central Road Package (Short - Term)	VM102 VC105	VM109 VC109	VM110	VM116	VC103	◎		○
13	Central Road Package (Medium - Term)	VM113 VC104	VM115 VC107	VM117 VC108	VC101	VC102	◎		○
14	Central Road Package (Long - Term)	VM103 VC110	VM108	VM111	VM112	VC106	◎		○
15	Western Road Package (Medium - Term)	VC201	VC202	VC204	VC208		◎		○
16	Western Road Package (Long - Term)	VC203	VC206	VC207	VC211	VC212	◎		○
17	Southern Road Package (Short - Term)	VM304					◎		○
18	ern Road Package (Medium - Term)	VM302	VC305	VC306	VC308		◎		○
19	Southern Road Package (Long - Term)	VC302	VC303	VC307	VC309	VC310	◎		○
20	Eastern Road Package (Short - Term)	VM402	VM403	VC408			◎		○
21	Eastern Road Package (Medium - Term)	VC403	VC404	VC406	VC409	VC416	◎		○
22	Eastern Road Package (Long - Term)	VM406 VC410 VC415 VC421 VC428 VC435	VC401 VC411 VC417 VC422 VC429 VC436	VC402 VC412 VC418 VC425 VC430	VC405 VC413 VC419 VC426 VC431	VC407 VC414 VC420 VC427 VC434	◎		○
23	Maintenance of Road								

Note: ○ stand for initial evaluation only

Table 8.1.3
Public Transportation Project Package

Package No./ Project Package Name	Phase: 0= Immediate 1= Short 2= Medium 3= Long	Evaluation		
		Economic	Financial	Environmental
1. Public Transportation Corridor: Carretera Norte	1	◎	◎	○
2. Public Transportation Corridor: J. Pablo/S.Grande	2	◎	◎	○
3. Security Enhancement	0			
4. Rerouting	0, 1, 2, 3			
5. Fare Adjustment	0, 1, 2, 3			
6. Introduction of New Service	0, 1			
7. Public Bus Terminal: Mercado Oriental	1		○	○
8. Public Bus Terminal: Mercado San Judas	2		○	○
9. Public Bus Terminal: Mercado Virgen de Candelaria	2		○	○
10. Public Bus Terminal: Villa Flor	3		○	○
11. Public Bus Terminal: Sabana Grande	3		○	○
12. Public Bus Terminal: Ciudad Satélite Asososca	3		○	○

Note: (○) stands for indicative or initial evaluation only.

8.1.3 Traffic Management Projects

- The proposed projects in relation to traffic management are listed in Table 8.1.4.

Table 8.1.4
Traffic Management Project Packages

Package No./ Project Package Name	Phase: 0= Immediate 1= Short 2= Medium 3= Long	Evaluation		
		Economic	Financial	Environmental
1. Improvement of Existing Signals	0			
2. Signalization and Coordinated Control (Short-Term)	1	○		
3. Signalization and Coordinated Control (Medium-Term)	2	○		
4. Signalization (Long-Term)	3	○		
5. Grade Separation (Short-Term)	1			
6. Grade Separation (Medium-Term)	2			
7. Grade Separation (Long-Term)	3			
8. Roundabout Const. (Short-Term)	1			
9. Roundabout Const. (Medium-Term)	2			
10. Roundabout Const. (Long-Term)	3			
11. Pedestrian Crossing	0			
12. Bicycle Road and Pedestrian Path	3			
13. Public Transportation Priority Area	1, 2, 3			
14. On-Road Parking Banned Area	1, 2			
15. Increase of Fuel Consumption Tax	0		○	
16. Increase of Vehicle Import Duty	1		○	
17. Designation of Truck Routes	1, 2, 3			

Note: (○) Stands for indicative evaluation or hypothetical analysis only.

8.2 Economic Evaluation

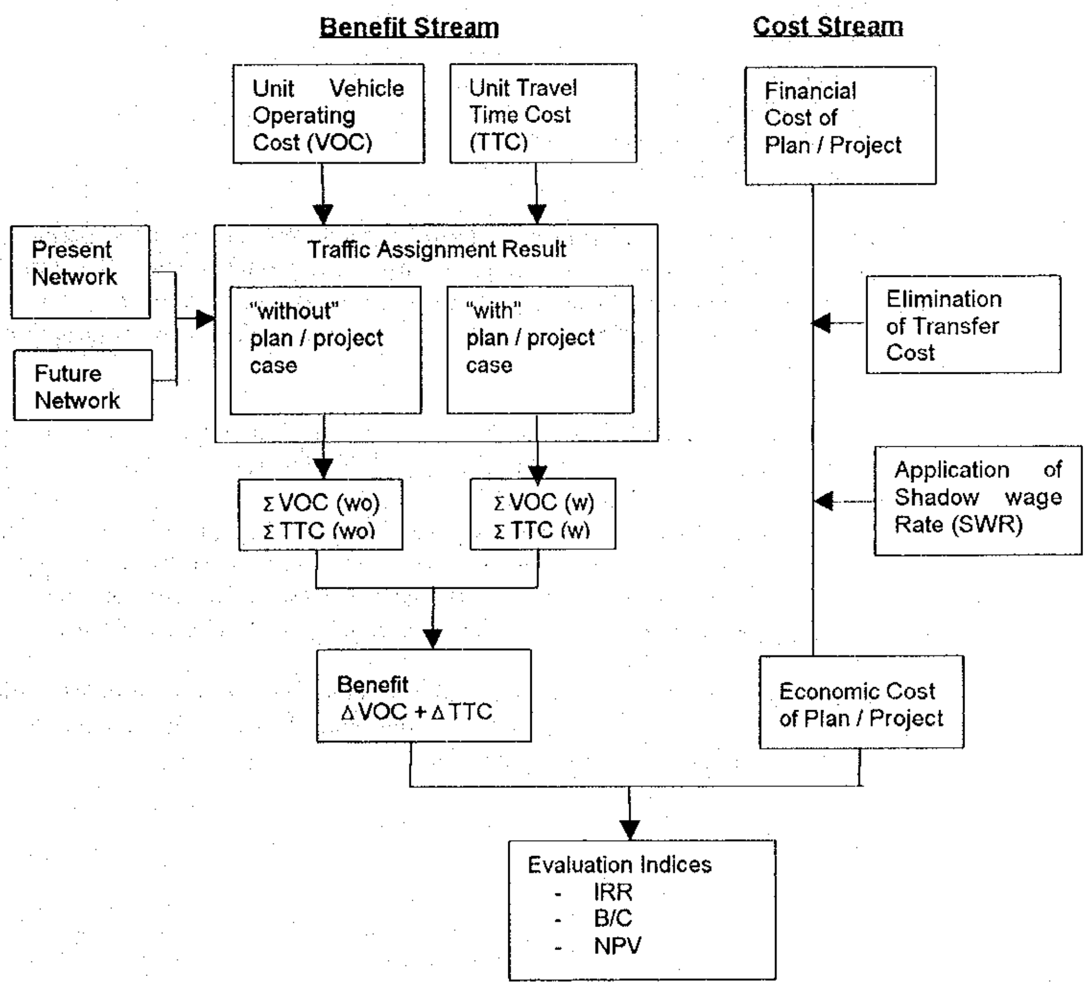
8.2.1 Approach and Assumptions

Proposed Master Plan and its component projects are evaluated from the economic viewpoint, following a normative cost-benefit analysis. To measure and compare cost and benefit of a project or a project package in economic price, the procedure shown in Figure 8.2.1 was taken.

Economic cost is a monetary expression of goods and services to be really consumed for a project implementation. Then, all the transfer costs (tax and subsidy) are deducted from the cost estimated in market price. In addition, shadow wage rates (SWRs) are applied to labor costs included in the project cost. The same process is taken to estimate the unit cost of vehicle operation which is used to estimate economic benefits, by excluding all taxes and applying the SWRs to labor cost of mechanics and crews.

The implementation program shown in the chapter 9 is preconditioned to identify the year when the project cost is generated and the benefit starts to accrue. Therefore, the evaluation results are affected by a change of the implementation program.

Figure 8.2.1
Work-Flow of Plan / Project Evaluation



1) Economic Benefit

Economic benefit is defined as the saved amount in travel costs caused by a project. Travel costs consist of two components, vehicle operating cost(VOC) and travel time cost(TTC). These are the benefits most direct and comparatively easy to quantify. It is obvious that other benefits of a transportation project exist in addition to those direct benefits, such as safety improvement and acceleration of urban development as well as mitigation of traffic congestion. In this Master Plan, however, those kinds of benefits difficult to measure were neglected to exclude an arbitrary evaluation.

Benefit of a project is measured through so-called "with" and "without" comparison. Using the results of traffic assignment to a network with the project in question and also to the same network but without the project, total VOC and TTC of each cases are calculated. And then, the benefit is obtained as the difference between "with" and "without" cases.

(1) Vehicle Operating Cost

In order to calculate the total VOC in a network, unit VOC (vehicle operating cost per kilometer and per hour by type of vehicle) is worked out (see Appendix 8). Vehicles are classified into five types: car/jeep, microbus, bus(standard sized bus), light truck and medium/heavy truck. VOC is composed of the following cost items:

a. Fuel cost
b. Oil cost
c. Tyre cost
d. Maintenance cost
e. Depreciation cost
f. Capital opportunity cost (interest)
g. Crew and overhead cost

In Nicaragua, the Ministry of Transport and Infrastructure(MTI) has been periodically updating VOC data in order to use an input to the HDM Model which is developed by IBRD for the appraisal of highway development and maintenance projects. The VOC estimates in this Master Plan Study depend on the basic information and assumptions of the MTI's data.

The HDM Model is mostly applied, however, to inter-municipal or inter-regional highway projects and then a key factor affecting VOC is surface conditions of a road, especially in terms of roughness. On the other hand, unit VOCs in need are those applicable to urban road which are mostly paved and then, key factor is not roughness but operating speed. Therefore, unit VOC of each component from (a) to (e) is expressed as a function of operating (travel) speed. A part of item (e) and the others (item (f) and (g)) are not directly affected by operating speed but by travel time.

The unit VOC are estimated on selected models which represent each type of vehicles in Managua.They are shown in Table 8.2.1 together with their price and annual average usage which refer to the MTI's HDM input data.

Table 8.2.1
Characteristics of Representative Vehicle

		Car/Taxi	Microbus	Large Bus	L.Truck	M.truck
1	Representative Model	Nissan Ford Mitsubishi Toyota LADA	Hyndai Toyota Kia International	International Frigtliner Mercedes B.	Hyndai Isuzu Toyota Mac	Mercedes B. Isuzu
2	Price (US$) (1) Financial (2) Economic	 15,870 11,720	 22,595 15,280	 78,380 67,223	 22,595 15,280	 58,340 49,242
3	No. of Tires	4	4	6	4	6
4	Main Fuel Type	Gasoline	Gasoline	Diesel	Gasoline	Diesel
5	Annual Operation (km/year)	25000	70000	70000	35000	35000
6	Average Speed (km/hour)	35	25	25	30	30
8	annual operation hours (hours/year)	714	2800	2800	1167	1167

Table 8.2.2 and Figure 8.2.2 show the resultant estimates of the unit VOC by type of vehicles. The most economical speed is in the range of 40 to 50 kilometers per hour and the economic cost is 20% to 25% lower than financial cost in all vehicle type.

To calculate total VOC in a network, firstly, operating speed of each link (road section) is obtained from a traffic assignment result and then, total distance-related cost is calculated by summing up the cost in each link (unit cost x link length x traffic volume) and lastly time-related cost (unit cost x total vehicle-hours) is added to the distance-related cost.

Table 8.2.2
Vehicle Operating Cost by Type of Vehicle

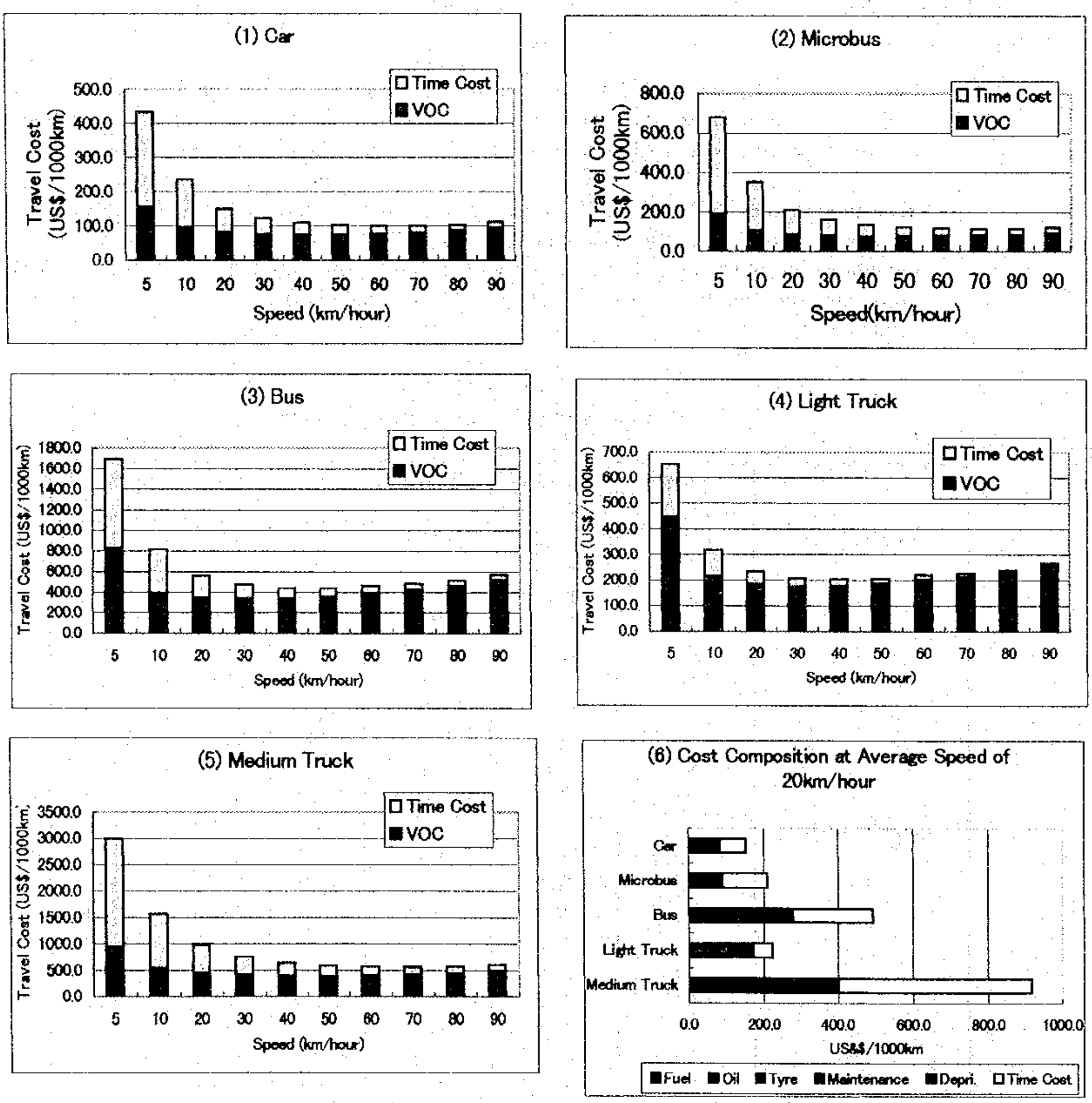
(1) VOC subject to Use (US$/1000Km)

	Speed (Km/hour)	Pass. Car & Taxi	Microbus	Bus	Light Truck	Medium Truck
Financial Cost	5	182.2	232.8	608.2	421.4	903.0
	10	142.8	171.9	506.1	324.4	717.3
	20	118.6	139.5	443.8	273.7	599.7
	30	111.2	127.4	437.8	259.0	534.8
	40	108.1	118.4	446.2	264.7	508.2
	50	108.1	118.8	479.9	278.1	506.1
	60	110.2	119.1	511.0	288.8	507.2
	70	114.1	121.6	548.6	299.2	522.0
	80	124.5	131.9	627.6	334.4	582.5
	90	139.2	148.0	727.5	382.8	670.2
Economic Cost	5	154.3	188.9	824.5	444.4	939.0
	10	95.4	105.7	385.7	213.7	531.7
	20	80.8	87.0	341.8	183.7	450.5
	30	76.0	80.2	332.5	174.0	404.1
	40	73.8	74.3	332.4	176.5	381.3
	50	73.9	74.7	352.7	185.9	377.3
	60	77.2	77.2	389.9	201.6	390.8
	70	80.2	79.4	419.3	211.3	404.5
	80	85.4	83.8	455.7	226.4	433.8
	90	94.6	93.0	518.6	255.5	491.2

(2) VOC subject to Time (US$/Hour)

	Pass. Car & Taxi	Microbus	Bus	Light Truck	Medium Truck
Financial Cost					
Depreciation	0.681	0.202	0.577	0.371	1.030
Capital Opportunity Cost	1.476	0.438	1.953	1.294	3.484
Crew and Overhead Cost	-	2.229	2.229	-	8.023
Total	2.157	2.868	4.759	1.665	12.537
Economic Cost					
Depreciation	0.501	0.136	0.495	0.248	0.869
Capital Opportunity Cost	0.892	0.295	1.814	0.790	2.202
Crew and Overhead Cost	-	2.006	2.006	-	7.221
Total	1.393	2.437	4.315	1.037	10.291

Figure 8.2.2
VOC and TTC by Operation Speed



(2) Travel Time Cost

Travel time of car users and bus passengers is converted to money term using unit time value. Their time values are estimated based on their income which reflects their productivity. According to the data of our home interview person trip survey, monthly household income is US$ 134 for non-car owning families and US$ 374 for car owning families in average as of March in1998. Average household size is 5.43 persons (aged 5 years and older) and 1.86 persons out of them are income earners. Assuming monthly working hours of 160 hours, the value of one hour at work is estimated at US$ o.45 for non-car owner (i.e. public transport passenger) and US$ 1.26 for car owner (i.e. car user).

The time value of a person is converted to the time value per vehicle, using data of average occupancy and trip purpose composition as shown in Table 8.2.3. Average occupancy of a car is 1.96 persons and of a bus, 29.4 persons. All trips with "business" purpose are regarded as productive activities and then time spent for a "business" trip is given the said value. The share of "business" trip is 8%. "To work" trips (with a share of 45%) and "to home" trips from work are assumed to have a half of the time value at work while other trips have no time value.

Time value will change by year. The higher people's productivity rises, the larger the time value becomes. Then, it may be reasonable to assume the time value will rise at the same rate as GRDP per capita growth. As assumed in Chapter 4, GRDP per capita index (year 1998=100) will grow to 115 in 2003, 132 in 2008 and 185 in 2018.

Total TTC is estimated by multiplying these unit time value to aggregate passenger-hours by mode calculated from assigned traffic in a network.

Table 8.2.3
Travel Time Value per Vehicle

(US$ /Vehicle-hour)

Year	Time value at work		Time value on trip	
	Private Mode	Public Mode	Private Mode	Public Mode
1998	2.47	13.28	1.31	7.04
2003	3.84	15.28	2.04	8.10
2008	3.26	17.52	1.73	9.29
2018	4.57	24.56	2.42	13.02

2) Economic Project Cost

Project costs estimated in Chapter 7 are financial cost estimated in market price and they are converted into economic cost, taking the following process:

a. Construction cost is broken down into three cost items: material cost, equipment cost and labor cost. The cost composition by item is assumed 45% for material, 30% for equipment and 25% for labor cost.

b. Out of material and equipment cost, import duties and value added tax are deducted. The tax rate is in the range of 15 to 25%. Assumed average rate is 15% for material and 22% for equipment.

c. Assuming 80% of labor cost is for unskilled laborers, a shadow wage rate (SWR) is applied. According to a statistic of The Ministry of Labor, unemployment rate in construction sector is 12.2% in Managua. Under such situation, the SWG is estimated at 65% by the Haveman's formula:

SWG = (Wage rate in market) x (1.25 – Unemployment Rate / 0.2)
= (Wage Rate in market) x 0.65

Table 8.2.4 shows economic cost of the proposed projects in the Master Plan. Economic Cost of construction corresponds 80% of financial cost. No modification is made for land cost. Total economic cost is US$ 400 million while total financial cost is US$ 481 million.

3) Evaluation Indicators

Economic cost and benefit are compared through discount cash flow analysis. The discount rate is 12% which is widely used in Nicaragua as an economic interest rate. The same rate is used in estimation of capital opportunity cost of VOC. As evaluation indicators, internal rate of return (IRR), benefit/cost ratio (B/C) and net present value (NPV) are calculated.

Pro-forma cash flow of a project to evaluate is prepared for the period of 1999 to 2018. Although a physical life of a infrastructure project is 50 to 60 years long, economic life is assumes 25 years, taking future rapid urban growth in consideration. Then, every investment is not completely depreciated within the planning period until 2018. Therefore, residual value of each project in 2019 is calculated and added in the benefit stream.

Table 8.2.4
Financial and Economic Cost Project Package

(US$ 1,000)

Package	Financial Cost			Economic Cost
	Construction	ROW	Total	
I Road Project Package				
1 Carretera Norte	17,348	3260	20,608	17,138
2 Travesia	37,628	10536	48,164	40,638
3 Pista Juan Pablo II	8,904	2536	11,440	9,659
4 Carretera Sur	7,460	2471	9,931	8,439
5 Pista Portezuelo	8,872	2276	11,148	9,374
6 Pista Rural de Circunvalacion	10,151	3456	13,607	11,577
7 Pista Sabana Grande	10,891	3430	14,321	12,143
8 Ave. Ruben Dario-Carretera a Masaya	9,575	1770	11,345	9,430
9 Carretera Nueva a Leon	7,536	721	8,257	6,750
10 Carretera Vieja a Leon	3,984	591	4,575	3,778
11 Pista Alterna a Masaya	8,678	2094	10,772	9,036
12 Central Road Package (Short-Term)	6,248	6485	12,733	11,483
13 Central Road Package (Mediun-Term)	5,757	7021	12,778	11,627
14 Central Road Package (Long-Term)	6,706	3320	10,026	8,685
15 Western Road Package (Medium-Term)	12,862	2477	15,339	12,767
16 Western Road Package (Long-Term)	8,750	1636	10,386	8,636
17 Southern Road Package (Short-Term)	1,294	257	1,551	1,292
18 Southern Road Package (Medium-Term)	5,695	2036	7,731	6,592
19 Southern Road Package (Long-Term)	13,663	3774	17,437	14,704
20 Eastern Road Package (Short-Term)	1,943	444	2,387	1,998
21 Eastern Road Package (Medium-Term)	5,102	1858	6,960	5,940
22 Eastern Road Package (Long-Term)	42,416	10336	52,752	44,269
23 Road Maintenance	40,542	0	40,542	32,434
Subtotal	282,005	72785	354,790	298,389
II Public Transportation				
1 Public Transportation Corridor: Carretera Norte	14,358	0	14,358	11,486
2 Public Transportation Corridor: J.Pablo/Sabana Grande	16,123	0	16,123	12,898
3 Security Enhancement	8,000	0	8,000	6,400
4 Rerouting	0	0	0	0
5 Fare Adjustment	0	0	0	0
6 Introduction of New Service	0	0	0	0
7 Public Bus Terminal: Mercado Oriental	1,500	0	1,500	1,200
8 Public Bus Terminal: Mercado San Judas	750	100	850	700
9 Public Bus Terminal: Mercado Virgen de Candelaria	750	100	850	700
10 Public Bus Terminal: Villa Flor	750	50	800	650
11 Public Bus Terminal: Sabana Grande	750	50	800	650
12 Public Bus Terminal: Ciudad Satelite Asososca	750	50	800	650
Subtotal	43,731	350	44,081	35,335
III Traffic Management				
1 Improvement of Existing Signals	58	0	58	46
2 Signalization and Coordinated Control (Short-Term)	9,357	0	9,357	7,486
3 Signalization and Coordinated Control (Medium-Term)	3,997	0	3,997	3,198
4 Signalization (Long-Term)	7,380	0	7,380	5,904
5 Grade Separation (Short-Term)	6,263	0	6,263	5,010
6 Grade Separation (Medium-Term)	18,819	0	18,819	15,055
7 Grade Separation (Long-Term)	19,217	0	19,217	15,374
8 Roundabout Construction (Short-Term)	2,200	0	2,200	1,760
9 Roundabout Construction (Medium-Term)	1,150	0	1,150	920
10 Roundabout Construction (Long-Term)	1,700	0	1,700	1,360
11 Pedestrian Crossing	150	0	150	120
12 Bicycle Road and Pedestrian Path	10,000	0	10,000	8,000
13 Public Transportation Priority Area	2,200	0	2,200	1,760
14 On-Road Parking Banned Area	0	0	0	0
15 Increase of Fuel Consumption Tax	0	0	0	0
16 Increase of Vehicle Import Duty	0	0	0	0
17 Designation of Truck Routes	0	0	0	0
Subtotal	82,491	0	82,491	65,993
Grand Total	408,227	73,135	481,362	399,717

8.2.2 Evaluation of Entire Master Plan

Proposed Master Plan is evaluated as a whole by comparing "Do nothing" case and the case where all the component project is implemented according to the schedule proposed in Chapter 9. Traffic assignment is done for each and year by year from 1998 to 2018.

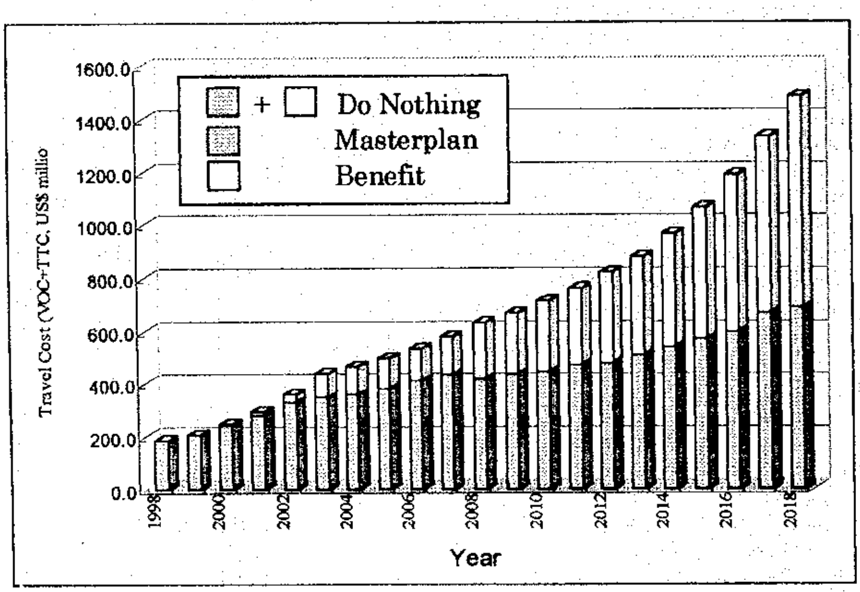
1) Economic Benefit

Total VOC and TTC is estimated as shown in Table 8.2.5. Under "Do nothing" case, total TTC will drastically increase in the Master Plan period by 16.2 times, while TTC increases by 5.8times. Total travel cost increase is 8.0 times. In the same period, the number of trips will increase 2.2 times.

On the other hand, in the "Master Plan" case, cost increase is mitigated down to 5.9 times of TTC, 3.1 times of VOC and 3.7 times of the total. Although the effect of cost saving by the Master Plan is remarkable, the travel cost increase is still higher than the trip increase. This means one tip in 2018 will cost 1.5 times (3.7 / 2.2) higher than in present.

The difference of the travel cost in two cases is economic benefit brought about by the Master Plan. The benefit amount will increase rapidly, especially in the last 5 years of the planning period, reaching almost US$ 800 million in 2018. (Figure 8.2.3)

Figure 8.2.3
Trend of Total Travel Cost and Economic Benefit



2) Evaluation

This benefit is compared with the economic cost of the Master Plan as shown in Table 8.2.6. IRR is extraordinarily high at 97%. There are two reasons of such a high rate. One is due to the base of comparison, "Do nothing" case. It is not of reality to assume no effort be done at all to improve transport system for coming 20 years. If it should happen, however, future traffic conditions would be horrible and urban functions would be paralyzed. This high IRR suggests that.

The other reason is in the nature of IRR itself. IRR is an indicator to evaluate an ordinary project which requires an initial investment in the first stage and after implementation, accrues a return. In the case of Master Plan, however, investment will continuously last throughout the planning period simultaneously together with benefit, under which conditions, IRR becomes unstable. In the cash flow in Table 8.2.6, annual costs are mostly offset by the same year benefit and negative cash flow appears only in the first few years. Thus, IRR is not an appropriate evaluator for a Master Plan.

Nevertheless, B/C ratio and NPV of the Master Plan are also very high, which assures high economic returns. NPV reaches almost one billion US dollars. In other word, Managua would lose one billion US dollars during 20 years, without any investment in urban transportation sector.

Table 8.2.7 shows a result of sensitivity analysis, changing cost and benefit. Even in case of cost increase by 50% and at the same time benefit decrease by 50%, IRR is 37%, high enough to make the Master Plan economically justifiable.

Table 8.2.5
Annual Economic Benefit of Entire Master Plan

(Million US$)

Year	"Do nothing " Case			"Master Plan " Case			Economic Benefit		
	VOC	TTC	Total	VOC	TTC	Total	VOC	TTC	Total
1998	144.4	40.7	185.1	144.4	40.7	185.1	0.0	0.0	0.0
1999	156.9	47.6	204.5	155.2	47.0	202.2	1.7	0.6	2.3
2000	184.0	60.1	244.1	180.2	58.6	238.8	3.8	1.5	5.3
2001	217.4	76.9	294.3	206.6	70.7	277.3	10.8	6.2	17.0
2002	259.6	99.3	358.9	239.2	87.2	326.4	20.4	12.1	32.5
2003	310.6	124.9	435.5	256.6	90.4	347.0	54.0	34.5	88.5
2004	325.6	136.4	462.0	265.1	96.5	361.6	60.5	39.9	100.4
2005	343.7	150.2	493.9	277.3	105.3	382.6	66.4	44.9	111.3
2006	364.9	166.6	531.5	295.8	116.6	412.4	69.1	50.0	119.1
2007	389.4	185.9	575.3	307.6	124.3	431.9	81.8	61.6	143.4
2008	418.8	208.7	627.5	300.4	115.3	415.7	118.4	93.4	211.8
2009	437.6	227.7	665.3	307.7	123.0	430.7	129.9	104.7	234.6
2010	462.0	251.3	713.3	314.4	130.6	445.0	147.6	120.7	268.3
2011	484.4	274.6	759.0	329.1	139.6	468.7	155.3	135.0	290.3
2012	514.6	305.4	820.0	331.3	143.2	474.5	183.3	162.2	345.5
2013	542.8	337.2	880.0	348.2	157.6	505.8	194.6	179.6	374.2
2014	584.0	380.1	964.1	364.1	169.6	533.7	219.9	210.5	430.4
2015	631.7	431.5	1063.2	383.1	185.3	568.4	248.6	246.2	494.8
2016	694.0	495.9	1189.9	394.2	198.0	592.2	299.8	297.9	597.7
2017	762.9	571.1	1334.0	432.7	232.4	665.1	330.2	338.7	668.9
2018	832.4	651.0	1483.4	446.9	240.7	687.6	385.5	410.3	795.8

Table 8.2.6
Benefit/Cost Flow of Proposed Masterplan

(Mill.US$)

Year	Economic Cost	Economic Benefit	Net Cash Flow	Discounted Cash Flow(at 12%) Cost	Benefit	Net
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	12.0	2.3	-9.7	10.8	2.1	-8.7
2000	12.3	5.3	-7.0	9.8	4.2	-5.6
2001	13.3	17.0	3.7	9.5	12.1	2.6
2002	20.3	32.5	12.2	12.9	20.7	7.7
2003	21.8	88.5	66.7	12.4	50.2	37.9
2004	23.5	100.4	76.9	11.9	50.9	39.0
2005	23.1	111.3	88.2	10.4	50.3	39.9
2006	23.7	119.1	95.4	9.6	48.1	38.5
2007	26.3	143.4	117.1	9.5	51.7	42.2
2008	24.7	211.8	187.1	8.0	68.2	60.2
2009	21.5	234.6	213.1	6.2	67.4	61.2
2010	16.9	268.3	251.4	4.3	68.9	64.5
2011	19.7	290.3	270.6	4.5	66.5	62.0
2012	18.6	345.5	326.9	3.8	70.7	66.9
2013	20.7	374.2	353.5	3.8	68.4	64.6
2014	18.7	430.4	411.7	3.1	70.2	67.2
2015	21.8	494.8	473.0	3.2	72.1	68.9
2016	22.4	597.7	575.3	2.9	77.7	74.8
2017	19.4	668.9	649.5	2.3	77.7	75.4
2018	18.8	795.8	777.0	2.0	82.5	80.5
Residual		271.0	271.0	0.0	25.1	28.1
Total	399.7	5,603.1	5,203.4	140.7	1,105.6	967.9

B/C	-	8.3
NPV	(Mill. US$)	974.7
IRR	%	97.3%

Table 8.2.7
Sensitivity of IRR to Cost and Benefit Change

(%)

Case		Cost 0% (Base Case)	20% up	50% up
Benefit	0% (Base Case)	97.3	82.8	68.1
	20 % less	79.9	68.1	55.9
	50 % less	52.9	45.0	36.8

Additionally, sensitivity analyses are made for two hypothetical cases. One is to assume that all the investment of US$ 400 million were made in one year of 1998. The resultant IRR is 21.8 % even in this case. The other is to neglect travel time cost, which results in 63% of IRR. This means that even VOC savings alone can prove the viability of the Master Plans

8.2.3 Road Project Package

1) Evaluation of Entire Road Projects

In the same way as the Master Plan evaluation, all the road projects including new construction and improvement are evaluated regarding them as one package. Estimated benefit is summarized in Table 8.2.8. Economic benefit is about 10 % lower than that of the entire Master Plan case stated in the previous section. This is because no modal shift is considered here, while public transportation corridor project assumes a certain demand shift from private mode to public mode due to improved bus service.

IRR is almost 100% due to the same reason explained in the previous section. Negative cash flow appears only in the first two years because in other years, cost is cancelled by overwhelming benefit (Table 8.2.9).

Even if all the investment should be implemented in 1998, the IRR would be 25.1% under the same benefit flow. The result of this hypothetical case also shows very high economic viability of the road project packages as a whole.

Table 8.2.8
Annual Economic Benefit of Entire Road Project Package

(Million US$)

Year	"Do nothing " Case			With all Road Project			Economic Benefit		
	VOC	TTC	Total	VOC	TTC	Total	VOC	TTC	Total
1998	144.4	40.7	185.1	144.4	40.7	185.1	0.0	0.0	0.0
1999	156.9	47.6	204.5	156.9	47.6	204.5	0.0	0.0	0.0
2000	184.0	60.1	244.1	184.0	60.1	244.1	0.0	0.0	0.0
2001	217.4	76.9	294.3	211.8	72.9	284.7	5.6	4.0	9.6
2002	259.6	99.3	358.9	247.4	90.9	338.3	12.2	8.4	20.6
2003	310.6	124.9	435.5	265.7	94.2	359.9	44.9	30.7	75.6
2004	325.6	136.4	462.0	276.3	101.4	377.7	49.3	35.0	84.3
2005	343.7	150.2	493.9	292.2	112.2	404.4	51.5	38.0	89.5
2006	364.9	166.6	531.5	299.0	111.1	410.1	65.9	55.5	121.4
2007	389.4	185.9	575.3	314.0	120.1	434.1	75.4	65.8	141.2
2008	418.8	208.7	627.5	309.7	114.9	424.6	109.1	93.8	202.9
2009	437.6	227.7	665.3	322.6	125.1	447.7	115.0	102.6	217.6
2010	462.0	251.3	713.3	330.7	133.0	463.7	131.3	118.3	249.6
2011	484.4	274.6	759.0	342.5	136.9	479.4	141.9	137.7	279.6
2012	514.6	305.4	820.0	357.5	147.2	504.7	157.1	158.2	315.3
2013	542.8	337.2	880.0	378.2	163.9	542.1	164.6	173.3	337.9
2014	584.0	380.1	964.1	393.2	172.9	566.1	190.8	207.2	398.0
2015	631.7	431.5	1063.2	413.9	188.8	602.7	217.8	242.7	460.5
2016	694.0	495.9	1189.9	429.3	201.5	630.8	264.7	294.4	559.1
2017	762.9	571.1	1334.0	475.2	238.3	713.5	287.7	332.8	620.5
2018	832.4	651.0	1483.4	495.0	253.7	748.7	337.4	397.3	734.7

Table 8.2.9
Benefit/Cost Flow of Proposed Masterplan

(Mill.US$)

Year	Economic Cost	Economic Benefit	Net Cash Flow	Discounted Cash Flow (12%)		
				Cost	Benefit	Net
1998	0.0	0.0	0.0	0.0	0.0	0.0
1999	6.7	0.0	(6.7)	6.0	0.0	-6.0
2000	7.2	0.0	(7.2)	5.7	0.0	-5.7
2001	8.1	9.6	1.5	5.8	6.8	1.1
2002	14.5	20.6	6.1	9.2	13.1	3.9
2003	15.9	75.6	59.7	9.0	42.9	33.9
2004	16.1	84.3	68.2	8.1	42.7	34.6
2005	15.6	89.5	73.9	7.1	40.5	33.4
2006	16.2	121.4	105.2	6.5	49.0	42.5
2007	17.9	141.2	123.3	6.5	50.9	44.5
2008	16.3	202.9	186.6	5.3	65.3	60.1
2009	15.4	217.6	202.2	4.4	62.6	58.1
2010	10.7	249.6	238.9	2.7	64.1	61.3
2011	13.4	279.6	266.2	3.1	64.1	61.0
2012	12.2	315.3	303.1	2.5	64.5	62.0
2013	14.3	337.9	323.6	2.6	61.7	59.1
2014	12.2	398.0	385.8	2.0	64.9	62.9
2015	15.2	460.5	445.3	2.2	67.1	64.9
2016	14.8	559.1	544.3	1.9	72.7	70.8
2017	12.0	620.5	608.5	1.4	72.0	70.7
2018	11.5	734.7	723.2	1.2	76.2	75.0
Residual		241.0	241.0	0.0	22.3	22.3
Total	266.0	5,158.9	4,892.9	93.2	1,003.5	910.3

B/C	-	10.8
NPV	(Mill. US$)	910.3
IRR	%	99.9

2) Project Package

One hundred and four road projects are combined according to their function or to their location into 22 road project packages. Each package is evaluated individually. The results are shown in Table 8.2.10. The relation between IRR and NPV is illustrated in Figure 8.2.4

If dividing the graph area into four regions with two lines of IRR=20% and NPV=US$ 20 million, road packages can be classified into four groups. More than half of packages belong to the group of high IRR and moderate NPV. Packages with high IRR and large NPV in the first quadrant are 1, 2, 5, 6, 7, 8, 15 and 22. Among them, the project with the highest IRR is package 7 (Pista Sabana Grande) and the package with the largest NPV is package 2 (Travesia).

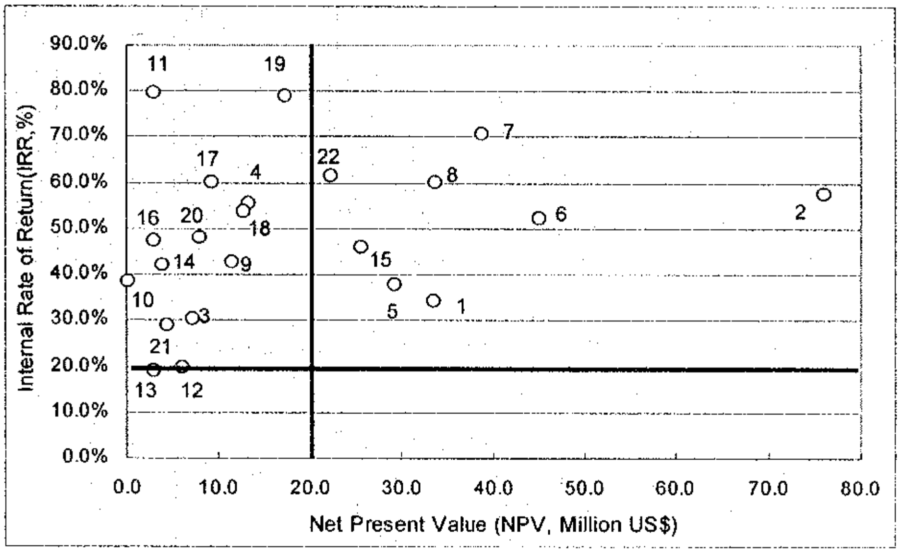
Table 8.2.10
Economic Evaluation of Road Project Package

(US$ million)

No	Project Package Name	Financial Cost	Economic Cost	Bebefit in 2018	Evaluation Indicators		
					Net Present Value	IRR %	Benefit/ Cost ratio
1	Carretera Norte	20.6	17.1	28.5	33.5	34.4	4.4
2	Travesia	48.2	40.6	92.9	76.0	57.6	7.0
3	Pista Juan Pablo II	11.4	9.7	7.5	7.2	30.3	2.9
4	Carretera Sur	9.9	8.4	20.4	13.2	55.8	6.4
5	Pista Portezuelo	11.1	9.4	19.4	29.3	37.9	5.9
6	Pista Rural de Circunvalacion	13.6	11.6	19.5	45.0	52.4	6.6
7	Pista Sabana Grande	14.3	12.1	21.1	38.8	70.9	9.6
8	AV.Ruben Dario - Carretera a Masaya	11.3	9.4	41.9	33.6	60.3	10.4
9	Carretera Nueva a Leon	8.3	6.7	12	11.3	42.8	5.0
10	Carretera Vieja a Leon	4.6	3.8	2.1	0.1	38.7	1.3
11	Pista Alterna a Masaya	10.8	9.0	21.1	3.0	79.8	3.5
12	Central Road Package (Short-Term)	12.7	11.5	5.9	6.1	19.7	1.9
13	Central Road Package (Medium-Term)	12.8	11.6	3.6	2.9	19.1	1.6
14	Central Road Package (Long-Term)	10.0	8.7	6.6	3.9	42.2	3.1
15	Western Road Package (Medium-Term)	15.3	12.8	24.8	25.6	46.2	5.7
16	Western Road Package (Long-Term)	10.4	8.6	8.1	2.9	47.3	3.2
17	Southern Road Package (Short-Term)	1.6	1.3	6.6	9.2	60.1	13.5
18	Southern Road Package (Medium-Term)	7.7	6.6	11.3	12.7	54.0	6.1
19	Southern Road Package (Long-Term)	17.4	14.7	39.4	17.3	78.9	7.1
20	Eastern Road Package (Short-Term)	2.4	2.0	4.8	7.9	48.0	7.7
21	Eastern Road Package (MediumTerm)	7.0	5.9	2.5	4.4	28.9	2.8
22	Eastern Road Package (Long-Term)	52.8	44.3	60	22.2	61.7	3.9

Figure 8.2.4

IRR and NPV of Road Project Package



8.2.4 Travesia Toll Road Project

In the previous section, Travesia is treated as an urban expressway with access control but free of charge. Here, influence of charging toll on Travesia to economic IRR is analyzed. If toll rate is US$ 1.00 / use (about 10 C$ / use), cash flow is as shown in Table 8.2.11. Although the IRR value falls down to less than half of that in the case of no charge, it is 23%, still high enough to judge the project economically feasible..

Table 8.2.12 shows IRR values under various toll rates from zero to US 2.00$. In most cases, the higher the rate of charge, the lower the economic IRR, because traffic assignment result is an approximation of system optimum where total impedance is minimum and toll charge will distort the optimum solution. As the table shows, the project implies high IRR of 58% at no toll and the IRR fall down to 23% at US$ 1.00 , 16% at US$ 1.60. The elasticity of IRR to toll rate is rather high. Therefore, if the project is implemented as a toll road, careful attention is needed not to sacrifice the economic benefit too much.

Table 8.2.11
Economic Cost and Benefit of Travesia Toll Road Project

(mill. US$)

Year	Project Cost		Benefit (Toll=1 US$)	Economic Cash Flow	Discounted Cash Flow (at 12%)
	Financial	Economic			
1999	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00
2001	0.00	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.00	0.00
2004	8.37	7.56	0.00	-7.56	-3.83
2005	4.03	3.22	0.00	-3.22	-1.46
2006	4.03	3.22	0.00	-3.22	-1.30
2007	0.00	0.00	0.72	0.72	0.26
2008	0.00	0.00	0.90	0.90	0.29
2009	7.41	6.55	1.44	-5.11	-1.47
2010	4.29	3.43	2.30	-1.13	-0.29
2011	4.29	3.43	3.69	0.26	0.06
2012	7.30	6.46	5.90	-0.56	-0.11
2013	4.23	3.38	9.44	6.06	1.11
2014	4.23	3.38	16.04	12.66	2.07
2015	0.00	0.00	30.61	30.61	4.46
2016	0.00	0.00	32.22	32.22	4.19
2017	0.00	0.00	33.92	33.92	3.94
2018	0.00	0.00	35.70	35.70	3.70
Residual	-	-29.09	0.00	29.09	2.69
Total	48.17	11.55	172.87	161.32	14.30

Table 8.2.12
Economic Evaluation of Travesia Toll Road Project

Toll Rate (US$)	IRR %	NPV (mill.US$)	B/C -
0.0	57.6	75.35	6.97
0.2	45.2	53.10	5.20
0.4	37.7	39.30	4.11
0.6	32.1	28.97	3.29
0.8	26.7	20.06	2.59
1.0	23.2	14.30	2.13
1.2	19.5	9.25	1.73
1.4	18.3	7.42	1.59
1.6	16.1	4.54	1.36
1.8	13.9	1.98	1.16
2.0	11.9	-0.08	0.99

8.2.5 Public Transportation Corridor Project

Public Transportation Corridor projects compose two packages; one is the project along Carretera Pan-Americana Norte and the other includes two components along Pista Juan Pablo II and Pista Sabana Garande. Those packages are evaluated individually and also together. The result is shown in Table 8.2.13 and Table 8.2.14.

This kind of projects does not require huge amount of investment for infrastructure development, while it can sometime generate significant economic return. The recommended packages imply extreme IRR as high as 86% of package 1 and 66% of Package 2. If combining two into one, IRR will be 89% which is higher than either of them alone. This suggests their multiplier effect, affecting each other advantageously.

In this economic analysis, no user charge is considered. Financial analysis of these packages stated in the next section will assume minimal charges on buses operated on the busways. Charging on transportation facilities will more or less sacrifice its economic return. In this case, however, no analysis on the trade-off relation of economic and financial IRR will be needed because economic IRR is too high while charging rate is minimal.

Table 8.2.13
Economic Cost and Benefit of Public Transport Corridor Project

(Million US$)

Year	Economic Cost			Economic Benefit			Net Cash Flow		
	"1" & "2"	"1" only	"2" only	"1" & "2"	"1" only	"2" only	"1" & "2"	"1" only	"2" only
1999	0.92	0.92	0.00	0.00	0.00	0.00	-0.92	-0.92	0.00
2000	0.92	0.92	0.00	0.00	0.00	0.00	-0.92	-0.92	0.00
2001	0.92	0.92	0.00	0.00	0.00	0.00	-0.92	-0.92	0.00
2002	0.92	0.92	0.00	4.00	4.00	0.00	3.08	3.08	0.00
2003	0.92	0.92	0.00	8.00	8.00	0.00	7.08	7.08	0.00
2004	1.76	0.36	1.40	7.28	7.28	0.00	5.52	6.92	-1.40
2005	1.76	0.36	1.40	6.56	6.56	0.00	4.80	6.20	-1.40
2006	1.76	0.36	1.40	5.84	5.84	0.00	4.08	5.48	-1.40
2007	1.76	0.36	1.40	17.91	5.12	2.45	16.15	4.76	1.05
2008	1.76	0.36	1.40	19.90	4.40	4.90	18.14	4.04	3.50
2009	1.10	0.51	0.59	23.95	5.80	6.41	22.85	5.29	5.82
2010	1.10	0.51	0.59	28.83	7.64	8.38	27.73	7.13	7.79
2011	1.10	0.51	0.59	34.69	10.06	10.95	33.59	9.55	10.36
2012	1.10	0.51	0.59	41.75	13.25	14.32	40.66	12.75	13.73
2013	1.10	0.51	0.59	50.25	17.46	18.73	49.15	16.95	18.14
2014	1.10	0.51	0.59	60.48	23.00	24.49	59.38	22.50	23.90
2015	1.10	0.51	0.59	72.79	30.31	32.03	71.69	29.80	31.43
2016	1.10	0.51	0.59	87.61	39.93	41.88	86.51	39.42	41.29
2017	1.10	0.51	0.59	105.44	52.60	54.76	104.34	52.10	54.17
2018	1.10	0.51	0.59	126.90	69.30	71.60	125.80	68.79	71.01
Residual	-14.1	-6.1	-8.0				14.08	6.12	7.96
Total	10.31	5.37	4.93	702.18	310.55	290.90	691.88	305.18	285.96

Table 8.2.14
Economic Evaluation of Public Transport Corridor Project

Indicator	Unit	Packages		
		"1" & "2"	"1" only	"2" only
NPV	mill.US$	118.57	53.43	40.01
B/C	-	16.6	13.1	13.5
IRR	%	88.9	86.2	66.1

Table 8.2.15 shows the result of economic evaluation for the construction project of the Public Transportation Corridor on Carretera Norte (package 1) combined with the road widening project which are proposed as a short-term project. When coupled with the road widening component, the EIRR of the Public Transportation Corridor on Carretera Norte decreases from 86% to 52%. This is, however, still very high, and is certainly feasible economically.

Table 8.2.15
Economic Evaluation for Public Transportation Corridor and Road Widening of Carretera Norte

Year	Cost (Million US$)			Benefit (Million US$)			Cash Flow	Discounted Cash Flow	
	Road Widening	PTC	Total	Road Widening	PTC	Total		Cost	Benefit
1999	0.00	0.92	0.92	0.00	0.00	0.00	(0.92)	0.82	0.00
2000	3.53	0.92	4.45	0.00	0.00	0.00	(4.45)	3.55	0.00
2001	1.67	0.92	2.59	0.00	0.00	0.00	(2.59)	1.84	0.00
2002	4.92	0.92	5.84	0.00	4.00	4.00	(1.84)	3.71	2.54
2003	2.72	0.92	3.64	0.00	8.00	8.00	4.36	2.06	4.54
2004	0.00	0.36	0.36	3.60	7.28	10.88	10.52	0.18	5.51
2005	0.00	0.36	0.36	5.10	6.56	11.66	11.30	0.16	5.27
2006	0.00	0.36	0.36	6.60	5.84	12.44	12.08	0.15	5.02
2007	0.00	0.36	0.36	8.10	5.12	13.22	12.86	0.13	4.77
2008	0.00	0.36	0.36	9.60	4.40	14.00	13.64	0.12	4.51
2009	2.58	0.51	3.09	9.60	5.80	15.40	12.31	0.89	4.43
2010	1.73	0.51	2.22	9.60	7.64	17.24	15.01	0.57	4.42
2011	0.00	0.51	0.51	1363	10.06	23.69	23.19	0.12	5.43
2012	0.00	0.51	0.51	15.15	13.25	28.40	27.89	0.10	5.81
2013	0.00	0.51	0.51	16.83	17.46	34.29	33.78	0.09	6.26
2014	0.00	0.51	0.51	18.70	23.00	41.70	41.20	0.08	6.80
2015	0.00	0.51	0.51	20.78	30.31	51.08	50.58	0.07	7.44
2016	0.00	0.51	0.51	23.09	39.93	63.01	62.51	0.07	8.19
2017	0.00	0.51	0.51	25.65	52.60	78.25	77.75	0.06	9.09
2018	0.00	0.51	0.51	28.50	69.30	97.80	97.29	0.05	10.14
Residual	-8.64	-6.12	-14.76			0.00	14.76	-1.37	0.00
Total	8.50	5.37	13.87	214.52	310.55	525.07	511.20	13.47	100.18

Note) PTC: Public Transportation Corridor

EIRR=	51.6%
NPV=	86.7
B/C=	7.4

8.3 Financial Evaluation

8.3.1 Travesia Project (Roll Road)

- Table 8.3.1 shows the traffic volume and revenue of Travesia Project estimated by traffic assignment. This exercise assumes the following:
  - Double toll for bus compared to passenger car (i.e. the same rate per PCU)
  - 310 operating days per year

Table 8.3.1 Traffic Volume and Revenue of Travesía Project by Toll Rate

Toll Rate (US$)	2008				2018			
	Patronage (1000pcu/day)			Total Revenue (Million US$/Yr)	Patronage (1000pcu/day)			Total Revenue (Million US$/Year)
	Private	Public	Total		Private	Public	Total	
0	100.2	5.2	105.4	0.00	144.8	11.2	156.0	0.00
0.2	39.7	1.7	41.4	2.57	134.2	10.1	144.3	8.95
0.4	16.5	0.6	17.1	2.12	111.3	5.7	117.0	14.51
0.6	7.7	0.3	8.0	1.49	88.8	4.4	93.2	17.34
0.8	3.7	0.2	3.9	0.97	71.4	3.6	75.0	18.60
1.0	1.7	0.1	1.8	0.56	56.8	3.0	59.8	18.54
1.2	1.0	0.0	1.0	0.37	47.2	2.6	49.8	18.53
1.4	-	-	-	-	40.4	2.4	42.8	18.58
1.6	-	-	-	-	33.7	2.1	35.8	17.76
1.8	-	-	-	-	28.8	2.0	30.8	17.19
2.0	-	-	-	-	24.9	1.8	26.7	16.55

- In 2008, the traffic demand is easily tolled off from Travesia at a very low charging rate. This is due to the low time value of passengers and the comparatively low congestion of the alternative roads. In contrast, the traffic demand is not tolled off at a relatively high toll rate in 2018. At a toll level of US$0.8, about ½ of the potential demand is still on Travesía, and about ⅓ at a toll level of US$1.0. The maximum revenue can be attained at a toll level of US$0.8 ~ 1.2. Within this range, the revenue remains almost constant. The revenue from bus is only 5% of the total revenue. The impact of bus on the financial viability is small.

- Table 8.3.2 shows the cost and revenue flow of the project, assuming a toll rate of US$0.2 in 2006 (assumed opening year) and US$1.0 in 2018, and gradual increase of the toll in the intermediate years. This assumption brings about the highest financial feasibility at a financial IRR of 16.5%. Due to the deficit in cashflow up to 2014, however, operation of the toll road solely by the private sector will be difficult. Some subsidy measures by the Government will be necessary.

Table 8.3.2 Cost and Revenue of Travesía Toll Road Project

(US$ 000)

Year	Financial Project Cost				Revenue	Net CashFlow	Discounted Cash Flow (at 12%)
	Construction Cost	ROW Cost	Operating Cost	Total			
1999	0	0		0	0	0	0
2000	0	0		0	0	0	0
2001	0	0		0	0	0	0
2002	0	0		0	0	0	0
2003	0	0		0	0	0	0
2004	4,027	4,341		8,368	0	-8,368	-4,239
2005	4,027	0		4,027	0	-4,027	-1,822
2006	4,027	0	33	4,060	1,100	-2,960	-1,195
2007	0	0	66	66	2,200	2,134	770
2008	0	0	73	73	2,445	2,371	763
2009	4,289	3,120	88	7,497	2,933	-4,564	-1,312
2010	4,289	0	106	4,395	3,520	-874	-224
2011	4,289	0	127	4,416	4,224	-192	-44
2012	4,227	3,075	215	7,517	7,181	-336	-69
2013	4,227	0	237	4,464	7,899	3,435	628
2014	4,227	0	261	4,488	8,689	4,202	685
2015	0	0	386	386	12,871	12,485	1,818
2016	0	0	429	429	14,301	13,872	1,804
2017	0	0	477	477	15,890	15,413	1,790
2018	0	0	530	530	17,655	17,126	1,775
Residual	-				35,229	35,229	3,261
Total	37,629	10,536	3,027	51,192	136,138	84,946	4,388

Note: Toll rate in 2006 and 2018 is US$0.2 and 1.0 respectively

- Table 8.3.3 presents the results of financial evaluation of the Project assuming a partial opening of Travesia in 2006 for the section between Carretera Sur and Carretera a Masaya at a toll rate of US$0.2. This exercise intends to test the financial viability for various toll levels of 2018. The financial viability is the highest for the 2018 toll rate of US$1.0 to 1.2.

Table 8.3.3 Financial Evaluation of Travesía Toll Road Project

Toll Rate in 2018 (US$)	IRR %	Net Present Value (US$ 000)	Benefit/Cost Ratio
0.2	11.5	429	1.01
0.4	13.2	2,826	1.08
0.6	14.3	3,930	1.13
0.8	16.4	4,312	1.27
1.0	16.5	4,388	1.28
1.2	16.5	4,392	1.29
1.4	16.4	4,303	1.28
1.6	16.3	4,085	1.27
1.8	16.1	3,864	1.25
2.0	14.2	3,619	1.12

Note: Toll rate in 2006: US$0.2/pcu.

- Table 8.3.4 shows the results of sensitivity tests. Even if revenue or cost moves to the negative direction by about 20%, the financial viability will be maintained.

Table 8.3.4 Sensitivity of Financial IRR of Travesía Toll Road Project to Cost and Revenue Change

Revenue Change	Cost Change			
	Base Case (%)	10% up	20% up	30% up
Base Case	16.5	14.8	13.2	11.8
10%	14.9	13.3	11.7	10.4
20%	13.3	11.7	10.2	8.9
30%	11.6	10.1	8.6	7.3

8.3.2 Public Transportation Corridor

- Table 8.3.5 shows the results of traffic assignments conducted in order to evaluate the effect of the proposed Public Transportation Corridors.

Table 8.3.5 Results of Traffic Assignment

	1998	2003	2008	2018
1. Bus PCU-Kms on Entire Road Network (000/day)	377	560	631	966
2. Bus PCU-Kms on Public Transportation Corridor (000/day)	-	117	208	289
• Carretera Norte	-	117	68	116
• Pista Juan Pablo II	-	-	80	93
• Pista Sabana Grande	-	-	60	80
3. Bus PCUs on Public Transportation Corridor (000/day)	-	25	60	71
• Carretera Norte	-	25	17	23
• Pista Juan Pablo II	-	-	23	24
• Pista Sabana Grande	-	-	20	24

- The average trip length of buses plying on the Public Transportation Corridor is 4.8 km in 2003, 3.4 km in 2008 and 4.1 km in 2018 (Public Transportation Corridor section only). It is observed that most buses use the Corridor for a part of their routes.

- The number of bus units operating in Managua at present is 930. Thus, average vehicle-kms per day is calculated at 203 km/bus based on the result of traffic assignment (1 bus = 2 PCUs). This is a figure very close to the actual data obtained from the field survey (190 km/bus).

- The number of bus units which are likely to use the Public Transportation Corridors was estimated on the following assumptions:

  1. Number of bus units increases in proportion to PCU-kms.

  2. The buses running on the Corridor use it for 50% of their routes.

- The result is presented in Table 8.3.6

Table 8.3.6 No. of Bus Units on Public Transportation Corridor

	2003	2008	2018
Carretera Norte	576	338	572
Pista Juan Pablo II	-	392	463
Pista Sabana Grande	-	294	394
Total	576	1,024	1,426

- The charge to use the Public Transportation Corridor was assumed to be C$75 per day per bus. This is corresponding to C$0.10 per passenger assuming the present operational level, i.e. 750 passengers per day per bus.

- Then the revenue from the operation of Public Transportation Corridors can be estimated as presented in Table 8.3.7.

Table 8.3.7 Estimated Revenue from the Proposed Public Transportation Corridors

(US$ million/year)

	2003	2008	2018
Carretera Norte	1.28	0.75	1.23
Pista Juan Pablo II	-	0.87	1.02
Pista Sabana Grande	-	0.65	0.87
Total	1.28	2.27	3.12

Note: 310 operating days/year.

- Table 8.3.8 presents the result of financial analysis on the proposed Public Transportation Corridors. This assumes a revenue increase in proportion to the growth of public transportation demand and an annual operating cost of 3% of revenue. When Package 2 opens, the revenue of Package 1 decreases considerably due to the diversion of demand.

- In conclusion, the financial viability is not so high as for the private sector to implement the Project without public support. This is mainly due to the long lasting investment which amounts to almost one half of the estimated annual revenue. Considering, however, the financial IRR of about 10-11% in real terms, a commercial loan of up to 20% interest rate can be mobilized. The following arrangement is desirable.

  1. Government finance for initial investment (Economic benefic is huge).
  2. Operation and repayment by a public or semi-public organization newly established.
  3. Operation by one organization for both Package 1 and 2 (Interaction of two packages is strong).

- Table 8.3.9 shows the results of sensitivity test on the change of charging rate. If the charge can be raised to C$100/day/bus from the assumed C$75/day/bus, the project becomes highly feasible.

Table 8.3.8 Financial Analysis of Public Transportation Corridor Project

(US$ 1000)

Year	Package 1 (Carretera Norte)				Package 2 (Pista J.Pablo II/Sabanagrande)				Package 1 and 2			
	Cost		Revenue	Net Cash Flow	Cost		Revenue	Net Cash Flow	Cost		Revenue	Net Cash Flow
	Invest-ment	Opera-tion			Invest-ment	Opera-tion			Invest ment	Opera tion		
1999	1150			-1150					1150	0	0	-1150
2000	1150			-1150					1150	0	0	-1150
2001	1150			-1150					1150	0	0	-1150
2002	1150	31	1024	-157					1150	31	1024	-157
2003	1150	38	1280	92					1150	38	1280	92
2004	455	40	1318	824	1746			-1746	2201	40	1318	-922
2005	455	41	1358	862	1746			-1746	2201	41	1358	-884
2006	455	42	1399	902	1746			-1746	2201	42	1399	-844
2007	455	32	1061	574	1746	61	760	-1047	2201	93	1821	-473
2008	455	23	750	273	1746	122	1520	-348	2201	144	2270	-75
2009	634	24	788	130	739	124	1553	690	1373	148	2342	821
2010	634	25	828	169	739	127	1588	722	1373	152	2416	891
2011	634	26	870	210	739	130	1623	754	1373	156	2493	964
2012	634	27	914	253	739	133	1658	787	1373	160	2573	1039
2013	634	29	960	298	739	136	1695	820	1373	164	2655	1118
2014	634	30	1009	345	739	139	1732	855	1373	169	2741	1200
2015	634	32	1060	395	739	142	1770	890	1373	173	2831	1284
2016	634	33	1114	447	739	145	1809	926	1373	178	2924	1372
2017	634	35	1171	502	739	148	1849	962	1373	183	3020	1464
2018	634	37	1230	559	739	151	1890	1000	1373	188	3120	1559
Residual			7,031	7,031			9,743	9,743	0	0	16,774	16,774
Total	14,365	544	18,135	3,226	16,120	1,556	19,449	1,773	30485	2,100	37,583	4,998
NPV				-820				-1,397				-2,217
B/C				0.87				0.73				0.81
IRR				11.3%				9.9%				10.6%

Table 8.3.9 Sensitivity of Financial IRR of Public Transportation Corridor Project to Charging Rate

(%)

Rate (C$/day/unit)	Package 1 Carretera Norte	Package 2 Pista J.Pablo II / Sabanagrande	Package 1 & 2
50	4.6	4.8	4.7
60	7.2	6.9	7.0
70	10.0	8.9	9.4
75*	11.3	9.9	10.6
80	12.7	10.9	11.9
90	15.5	12.9	14.3
100	18.3	14.8	16.8

*Recommended Rate

8.3.3 Public Transportation Terminal

- This section intends to conduct an indicative financial evaluation for a typical case of the construction of public transportation terminal. Also, for the proposed Public Transportation Priority Area, its financial viability is implicitly studied in the sensitivity test by including its cost in that of terminal project.

- The revenue of a typical terminal of 1 ha was estimated at US$0.23 million annually assumming the following.

Terminal charge	C$5/departure (average)
No. of berths	30
No. of departures/berth/day	50
No. of operating days/year	310

- The cost of construction of a typical terminal of 1 ha is US$0.75 million. This cost may increase to US$0.85 million if land acquisition cost is included, and further to US$1.05 million if the cost of Public Transportation Priority Area is added.

- Table 8.3.10 shows the result of financial analysis of the project which assumes a constant revenue and an operating cost of 5% of the revenue. No residual value was taken into account.

Table 8.3.10 Evaluation of Public Transportation Terminal Project

(000 US$)

Year	Cost			Revenue	Net Cash Flow	Discount Cash Flow (12%)
	Investment	Operating	Total			
1999	350.0		350.0		-350.0	-312.5
2000	400.0		400.0		-400.0	-318.9
2001		11.5	11.5	230.0	218.5	155.5
2002		11.5	11.5	230.0	218.5	138.9
2003		11.5	11.5	230.0	218.5	124.0
2004		11.5	11.5	230.0	218.5	110.7
2005		11.5	11.5	230.0	218.5	98.8
2006		11.5	11.5	230.0	218.5	88.2
2007		11.5	11.5	230.0	218.5	78.8
2008		11.5	11.5	230.0	218.5	70.4
2009		11.5	11.5	230.0	218.5	62.8
2010		11.5	11.5	230.0	218.5	56.1
2011		11.5	11.5	230.0	218.5	50.1
2012		11.5	11.5	230.0	218.5	44.7
2013		11.5	11.5	230.0	218.5	39.9
2014		11.5	11.5	230.0	218.5	35.6
2015		11.5	11.5	230.0	218.5	31.8
2016		11.5	11.5	230.0	218.5	28.4
2017		11.5	11.5	230.0	218.5	25.4
2018		11.5	11.5	230.0	218.5	22.7
Total	750.0	207.0	957.0	4140.0	3183.0	631.4

IRR	25.6%
NPV	631.4
B/C	1.9

- The project is proven highly feasible financially. Even if the cost increases by 30% and the revenue decreases by 30%, the project is still financially feasible as shown by the sensitivity test shown in Table 8.3.11. The project is suitable for the private sector to take the initiative.

Table 8.3.11 Sensitivity of Financial IRR of Public Transportation Terminal Project

(%)

Revenue Change	Cost Change			
	Base Case	10% up	20% up	30% up
Base Case	25.6	23.3	21.4	19.7
10% less	23.1	21.0	19.2	17.6
20% less	20.5	18.6	16.9	15.5
30% less	17.8	16.1	14.5	13.2