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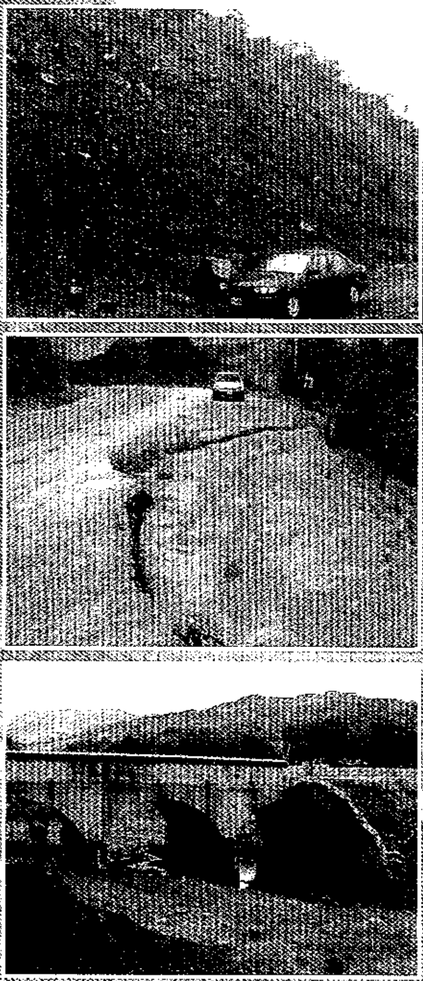
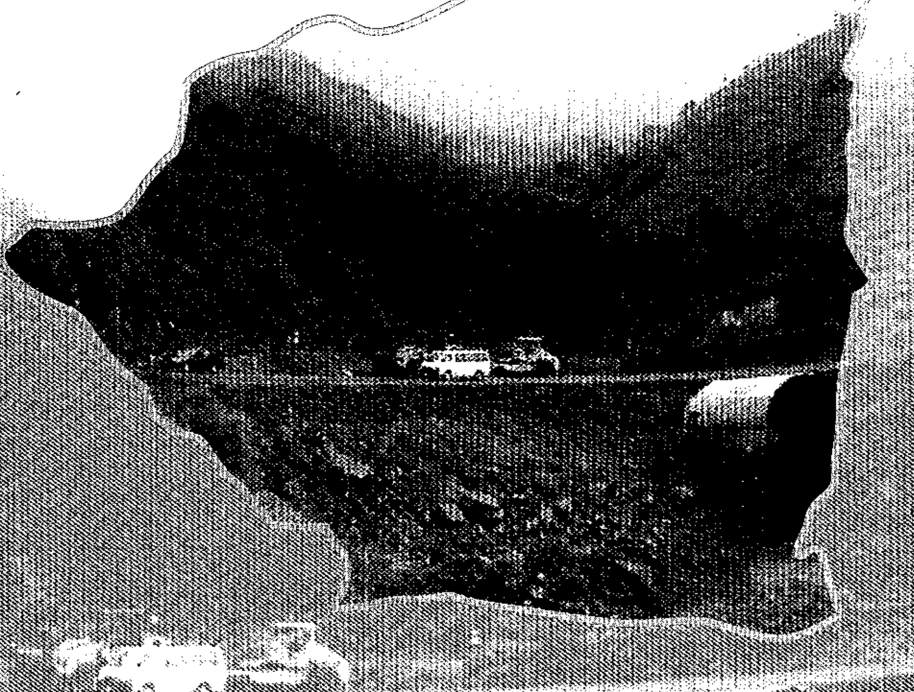
No. 12

JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

MINISTRY OF TRANSPORT AND
INFRASTRUCTURE
REPUBLIC OF NICARAGUA

THE STUDY ON VULNERABILITY REDUCTION FOR MAJOR ROADS IN THE REPUBLIC OF NICARAGUA





FINAL REPORT

Volume 2 of 5

MAIN TEXT

January 2003

Oriental Consultants Company Limited

Japan Engineering Consultants Company Limited

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COOPERATION AGENCY (JICA)

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PREFACE

In response to a request from the Government of the Republic of Nicaragua, the Government of Japan decided to conduct the Study on Vulnerability Reduction for Major Roads in the Republic of Nicaragua and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Keigo Konno of Oriental Consultants Co., Ltd. and consist of Oriental Consultants Co., Ltd. and Japan Engineering Consultants Co., Ltd. to Nicaragua, three times between January 2002 and January 2003.

In addition, JICA set up an advisory committee consist of Mr.Tetsuo Hirose, Chief of Maintenance Planning Division, Maintenance and Facility Department, Hanshin Expressway Public Corporation and Mr. Yoshifumi Nagata, Chief of Public Relations Division, General Affairs Department, Metropolitan Expressway Public Corporation between January 2002 and January 2003, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Nicaragua and conducted the field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Nicaragua for their close cooperation extended to the team.

January 2003

Takao Kawakami
President
Japan International Cooperation Agency

Letter of Transmittal

January 2003

Mr. Takao Kawakami
President
Japan International Cooperation Agency

Dear Sir,

We are pleased to submit to you the final report on The Study on The Vulnerability Reduction for Major Roads in The Republic of Nicaragua.

This study was conducted by Oriental Consultants Company Limited and Japan Engineering Consultants Company Limited, under a contract to Japan International Cooperation Agency (JICA), during the period from January 2002 to January 2003. In conducting the study, we examined the feasibility and rationale of road disaster measures with due consideration to the present status of Nicaragua's roads and formulated the most appropriate project incorporating the results of the examination.

We wish to take this opportunity to express our sincere gratitude to the concerned officials of JICA, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, Hanshin Expressway Public Corporation, and Metropolitan Expressway Public Corporation. In addition, we wish to deep thank the Ministry of Transport and Infrastructure, the JICA Nicaragua office and the Embassy of Japan in the Republic of Nicaragua for their cooperation and assistance to the study team during its stay in Nicaragua.

Finally, we hope that this report will contribute to the further promotion of the project.

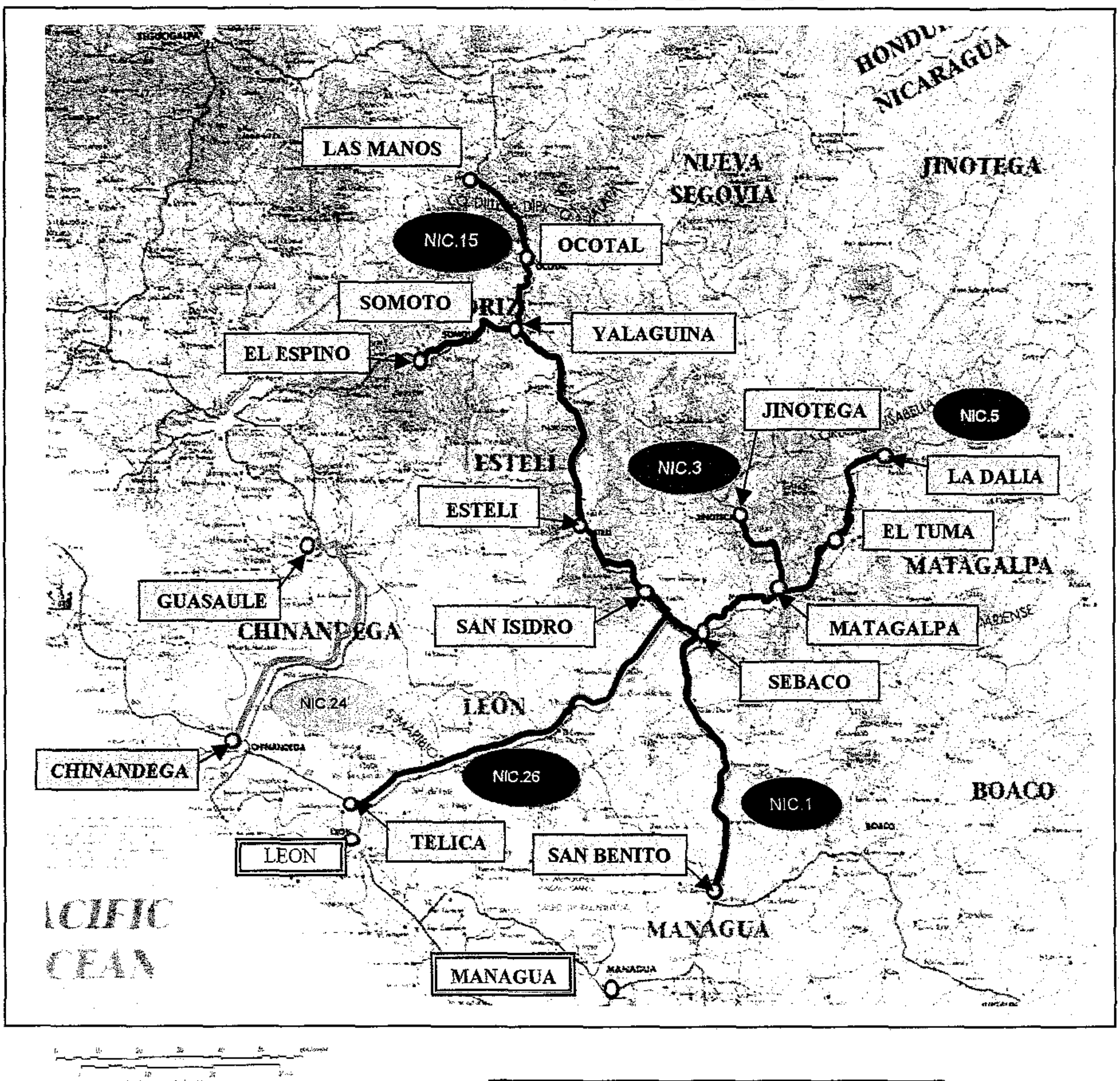
Very truly yours,

今野啓悟

Keigo Konno, Team Leader
The Study on Vulnerability Reduction
for Major Roads in the Republic of Nicaragua,
Oriental Consultants Company Limited

LOCATION MAP

THE STUDY ON VULNERABILITY REDUCTION FOR MAJOR ROADS IN THE REPUBLIC OF NICARAGUA



Legend

NIC. 1 El Espino～San Benito
NIC. 3 Sebaco～Jinotega
NIC.5 Matagalpa～La Dalia
NIC.15 Yalagüina～Las Manos
NIC.24 Chinandega～Guasaule
NIC.26 Telica～San Isidro

Route No. NIC.26

Project Summary

1. Country	Republic of Nicaragua
2. Name of Study	The Study on Vulnerability Reduction for Major Roads in The Republic of Nicaragua
3. Counterpart Agency	Ministry of Transport and Infrastructure (MTI)
4. Objective of Study	-To identify disaster critical spots of vulnerable spots on the major roads, and to conduct a Feasibility Study of disaster prevention spots due to the emergent countermeasures. -To prepare a disaster prevention plan and a manual for road vulnerability reduction.

1. Study Roads: There are 6 roads on NIC1,NIC3,NIC5,NIC15,NIC24 and NIC26 within major roads in Nicaragua.

2. Plan Policy of Road Disaster Prevention

1) Whole Policy of the Project: Problems dissolution of vulnerability spots (Unstable cut/ embankment slopes, Bridge foundation scouring), Strengthening of maintenance system in MTI, Environmental safeguard of roadsides located in disaster critical spots, Enhancement of the PRSP and the BHN,
2) Planning of vulnerability reduction: Inspection methods of Vulnerability spots, Evaluation methods of Inspection, *Identification methods of disaster potential spots/ critical spots/ prevention spots,*
3) Planning of disaster prevention countermeasures: Planning of local machines/ materials, Planning of countermeasure types,
4) Road maintenance plan: Strengthening of maintenance division in MTI, Efficiency road maintenance work (Establishment of rural offices, Management of efficiency relative data), Establishment/management of Database for the maintenance work.

3. Project Cost

Package No.	Sub Package	Site No.	ID No.	Road	Cost (US$)
1	1a	2	N001A280	Nc1	12,339
		3	Junquillal	Nc1	51,825
		4	San Nicolas	Nc1	30,849
		6	San Ramon	Nc1	11,105
		7	N001A240	Nc1	32,082
		8	N001B230	Nc1	7,404
		12	N001B150	Nc1	33,316
	Cost				178,921
	1b	24	N003B400	Nc3	49,358
		27	N003B320	Nc3	294,912
	Cost				344,269
	1c	51	N026A160	Nc26	16,041
		52	San Juan de Dios	Nc26	6,170
		54	Papalon	Nc26	62,931
	Cost				85,142
Package 1 Cost					608,333

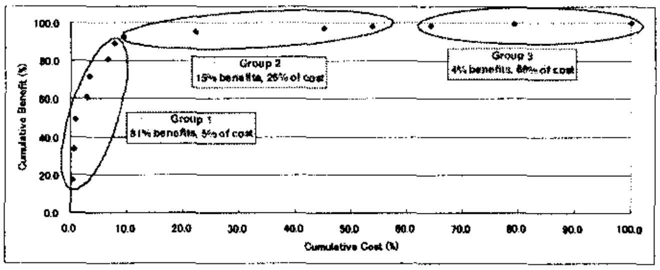
Package No.	Sub Package	Site No.	ID No.	Road	Cost (US$)
2	2a	1	N001A290	Nc1	413,370
	Cost				413,370
	2b	25	N003B370	Nc3	215,940
		26	El Guayacan	Nc3	1,701,604
		30	N003E170	Nc3	382,521
	Cost				2,300,064
	2c	35	N005A010	Nc5	480,003
	Cost				480,003
	2d	45	La Bandanita	Nc26	38,252
		55	Solis	Nc26	81,440
	Cost				119,692
Package 2 Cost					3,313,129

Package No.	Sub Package	Site No.	ID No.	Road	Cost (US$)
3	3a	5	Las Chorillas	Nc1	233,215
		11	N001B170	Nc1	1,961,965
		13	N001B120	Nc1	1,004,427
		18	Rio Inali	Nc1	1,021,702
		19	Rio Tapacal	Nc1	347,971
	Cost				4,569,280
	3b	29	N003C230	Nc3	404,732
		32	N003C150	Nc3	1,132,757
		33	N003C140	Nc3	924,221
	Cost				2,461,711
	3c	44	N026A060	Nc26	389,925
		49	N026B140	Nc26	1,115,482
		50	N026A150	Nc26	259,127
	Cost				1,764,534
Package 3 Cost					8,795,526
Grand Total					12,716,988

30 disaster prevention spots are divided into 3 groups. Those groups provide the basis for prioritising investment, and creating work packages.

4. Benefit by Project Execution

The creation of prioritised packages of work that maximise benefits, whilst minimising costs. **Priority Group 1** account for 66% of total benefits and 12% of total costs. **Priority Group 2** make up 24% and 31% of the total benefits and costs, respectively. As for **Priority Group 3**, it accounts for 10% of the total benefits and 57% of the total cost.



5. Implementation Programme and Recommendation

1) Project Packaging

- Group 1 (construction period: 2 years): NIC1 (7 spots), NIC3 (2 spots), NIC26 (3 spots) = Total 12 spots
- Group 2 (construction period: 2 years): NIC1(1 spot), NIC3 (3 spot), NIC5 (1 spot), NIC26 (2spots) = Total 7 spots
- Group 3 (construction period: 2 years): NIC1 (5 spots), NIC3 (3 spots), NIC26(3 spots) = Total 11 spots

2) Conclusion and Recommendation

①Conclusion

- **Early execution of the disaster prevention spots:** The disaster prevention works should be executed as early as possible in order to protect the safety of road users and the stability of traffic movement and economy.

②Recommendation

- ***Execution of screening, emergency/ routine/ periodic inspection survey:*** *The screening and inspection surveys should* be carried out for not only the objective roads but also other major roads and the rural roads.
- **Strengthening of maintenance division in MTI:** In order to carry out sustainable maintenance works, the division of road maintenance of the general division of roads in MTI should be strengthened.
- **Establishment of regional offices:** In order to get information of disaster quickly, regional offices should be established at main towns on major roads.
- **Secure the special budget for road disasters:** In order to safeguard road safety and economic development to the road users, MTI should itself secure a special budget for road disasters.

List of Abbreviations
(In alphabetical order)

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
AHP	:	Analytic Hierarchy Process
ASTM		American Society for Testing and Materials
B/C	:	Benefit to Cost ratio
BH		Boring Hole
BHN	:	Basic Human Needs
BIT		Central American Development Bank
DID		Densely Inhabitant District
EIA	:	Environmental Impact Assessment
GDP	:	Gross Domestic Product
GRN	:	The Government of Republic of Nicaragua
ID		Identification
IDF	:	Rainfall Intensity Duration Frequency
IEE	:	Initial Environmental Examination
INETER	:	Institution of National Territorial Study
IRR	:	Internal Rate of Return
JICA		Japan International Cooperation Agency
MARENA	:	The Ministry of Natural Resources and Environment
MTI	:	The Ministry of Transport and Infrastructure
OD	:	Origin and Destination
PRSP	:	Poverty Reduction Strategy paper
QV	:	Volume capacity
ROW	:	Right of Way
STRADA		System for Traffic Demand Analysis
VAT		Value Added Tax
VOC	:	Vehicle Operation Cost
WB		World Bank
pcu	:	Passenger Car Unit
	:	

The following foreign exchange rate is applied in the study :

1 US dollar = 14.40 Cordovas = 125.00 Japanese Yen (October 2002), or

1 Cordovas = 8.68 Japanese Yen

Summary of the Study

1. Background of the Study

Nicaragua is the frequent occurrence country of natural disaster and it influences recurs the undesirable progress of the recovery of infrastructures. Especially, about 1,500 km of the paved roads and about 6,000 km of unpaved roads were disrupted by the hurricane "Mitch" occurred in October 1998 and also as for the bridge, complete collapse on 22 bridges and partial destruction on 46 bridges suffered. In such situation, the Government of Republic of Nicaragua (hereinafter referred to as the "GRN") was established the National Transportation Plan (hereinafter referred to as the "NTP") including the improvement of the road network in February 2001. However the disaster prevention plan was not established in the NTP clearly, and the reliability of the traffic is in low condition such as the case of the bad weather.

The GRN requested assistance of the Japanese Government to implement the Study on Vulnerability Reduction for Major Roads in the Republic of Nicaragua (hereinafter referred to as the "Study"). In response to this request from the GRN, the Government of Japan has decided to carry out a study to identify disaster critical spots and execute a Feasibility Study for the Study.

Therefore, the ultimate goal of this Study is to assist the GRN in prioritising and recommending those road disaster prevention projects that are to identify disaster critical spots, to execute a Feasibility Study for urgent disaster prevention spots, to prepare the road disaster prevention plan and the manuals. The area of the Study shall cover the following Project Roads within major roads in the Republic of Nicaragua;

1) El Espino - San Benito (NIC. 1)
2) Sebaco - Jinotega (NIC. 3)
3) Matagalpa – Da Lida (NIC. 5)
4) Yalaguina - La Dalia (NIC. 15)
5) Chinandega - Guasaule (NIC. 24)
6) Telica - San Isidro (NIC. 26)

2. Study Approach

The major focus of the Study is to identify disaster critical spots, to identify disaster prevention spots for a Feasibility Study, and the to examine the technical, environmental and economic validity of this project in the Feasibility Study.

1) To collect and analyze the background and situation of the natural and environment conditions and the development plan, and to examine the relation to the road disasters.
2) To carry out the site investigations regarding the spots of disaster potential cut/ embankment slope damages and bridge foundation scouring, and to select disaster potential spots for disaster prevention, furthermore to identify high potential disaster critical spots.
3) To evaluate stability level, to forecast traffic demand, to assess environment, to examine technically for the Feasibility Study (target year: 2020).
4) To examine countermeasures for identified disaster prevention spots and to confirm the validity of environment, economic and countermeasures for disaster spots.
5) To prepare the disaster prevention manuals for maintenance work.

I. Identification of Study Spots

1) Review of the natural condition, related development plans, socio-economic data.
2) Examine of the assessment ways for road disaster spots.
3) Identify of the disaster potential spots and disaster critical spots by site survey.
4) Examine of countermeasures and estimate of rough construction costs.
5) Investigate of natural conditions and initial environmental examination.
6) Analysis of socio-economic framework.
7) Forecast of future traffic demand.
8) Identify of disaster prevention spots.

II. Feasibility Study

1) Arrange of the design standards.
2) Detailed examine of countermeasures.
3) Construction plan and construction cost estimate.
4) Assess of environmental impact.
5) Project evaluation.
6) Implementation programme.
7) Management and operations system.
8) Conclusion and recommendation

3. Topography and Geology of Study Area

The topographical characteristic of Nicaragua is divided into three areas:

- Pacific plains area (including the volcanic mountain range area);
- Central mountains range area;
- Atlantic coast plains area.

The land of the Pacific plains area is very fertile, being covered by weathered volcanic ash soil or alluvium. The Nicaraguan rift valley is laid between volcanic mountain range and central mountains range in this area and is mainly subsidence land. It contains two large lakes (Lake Managua and Lake Nicaragua). A volcanic mountain range is laid in middle of the Pacific plains area and running parallel with coast.

The main rocks of volcanic lava distributed in the Study area are basaltic, andesite-basalt, andesite, rhyolite and other lava, with such effusive rocks as tuffbreccia, dacitic agglomerate of the Palaeocene Period, and lavas of quarts-andesite, pyroclastic rock, and welded tuff belonging to the Eocene Period. They are widely distributed along NIC.1, NIC.3, and NIC.26. These lava flows display erosion in combination with tuffs. The Mesa Plateau is composed of lava on top, with tuffs underneath, which, when weathered make a sharp slope. NIC.1 displays this topography a good deal. Along NIC.24, the volcanic rocks of the Quaternary Era are recognizable by the white Pleistocene tuffs, agglomerate, tuffs with pumice, andesite-quartz/andesite, and ryyolite. Relatively new un-cemented volcanic ash covers them

4. Factors of Environmental Impact

The Study projects are not assessed as the objective project shown in the environmental impact assessment in Nicaragua. However, all of projects need the permission of the Ministry of Natural Resources and Environment (hereinafter referred to as the "MARENA") in spite of the scale of projects. Furthermore in order to apply the permission for projects, a private company and a public agency must procedure respectively under Nicaragua law. Ten items have been selected to evaluate negative impacts: resettlement, economic activity, traffic and public facilities, waste, groundwater, lakes and rivers, fauna and flora, landscape, water pollution, and noise and vibration.

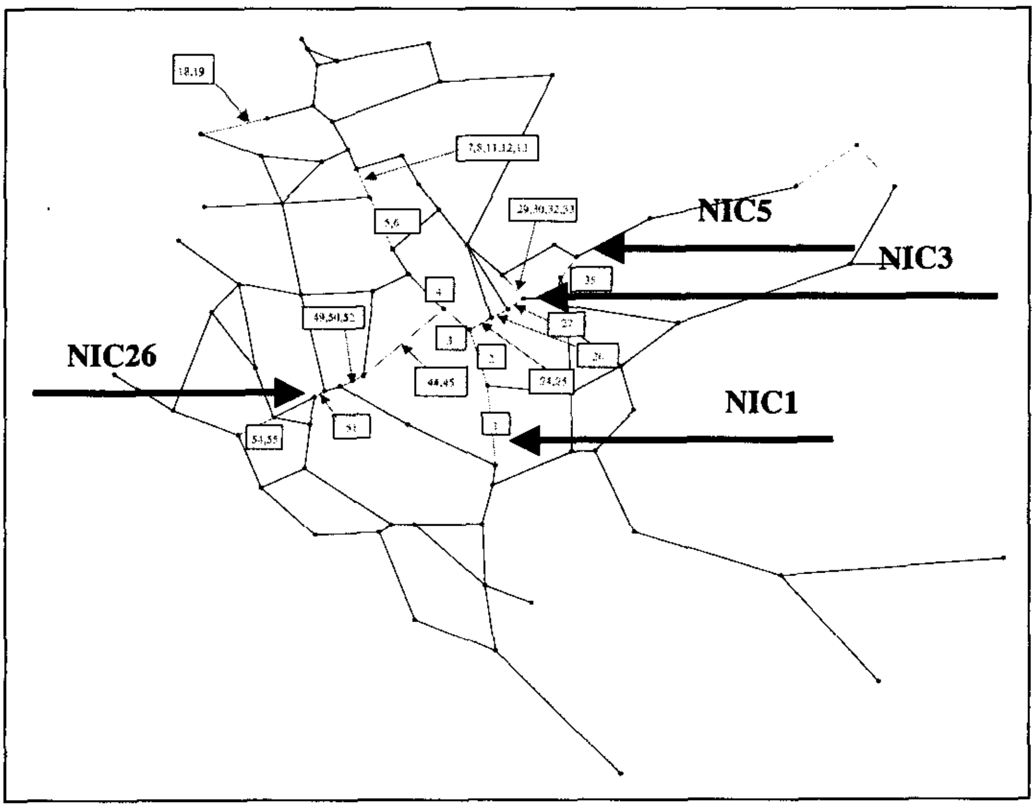
5. Identification of Disaster Prevention Spots

The disaster critical spots identified in Chapter 6 of the Study require urgent, temporary or permanent countermeasures so that they can be transformed into disaster prevention spots. These spots are identified using various factors. It is difficult to designate a point a disaster critical spot based on economics only, since there are some spots where there are low traffic volumes. Therefore, when evaluating roads and road sections for disaster criticality, a broader approach that incorporates level of stability, traffic volume, environmental impacts, development potential, natural conditions, benefits, required level of restoration, should be considered.

The evaluation score of a disaster critical spot differs depending on the scale of a disaster. Moreover, note that it is very difficult to identify disaster prevention spots in terms of cost only. Therefore, it is necessary to create an evaluation index to assess overall importance. Therefore, in this Study, the selection of disaster prevention spots is carried out using the Analytic Hierarchy Process (hereafter referred to as "AHP"). AHP is a multi-criteria decision-making technique that assigns numerical values (or weights) to various types of evaluation criteria. AHP was applied to select 30 disaster prevention spots for urgent spots and basis of disaster prevention in Nicaraguan country from the 55 disaster critical spots.

6. Proposed Project and Implementation Schedule

Locations of vulnerable spots are shown in the below figure.



Disaster prevention works are shown in the below figures.

NIC.1 Countermeasures for Slope Failure

No.	ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
1	N001A290	R.F	Removal + Prevention net + Drainage	T	m^2	23,286	335
2	N001A280	R.F	Horizontal drainage	P	m	100	10
7	N001A240	R.F	Removal + Prevention net	T	m^2	950	26
8	N001B230	R.C	Removal + Prevention net	T	m^2	228	6
11	N001B170	R.C	Recutting + Drainage	P	m^3	36,028	1,590
12	N001B150	R.C	Recutting + Shotcrete + Drainage	P	m^2	252	27
13	N001B120	R.C	Recutting + Drainage	P	m^3	10,655	814
Total							2,808

Note) R.F: Rock fall; R.C: Rock collapsing; P: Permanent countermeasure; T: Temporary countermeasure

NIC.1 Countermeasures for Bridge Foundation Scouring

No.	ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
3	Junquillal	Bridge	Gabion mat	T	m^3	435	42
4	San Nicolas	Bridge	Gabion mat	T	m^3	114	25
5	Las Chanillas	Bridge	Concrete block	T	m^3	288	189
6	San Ramon	Bridge	Gabion mat	T	m^3	86	9
18	Inali	Bridge	Gabion mat Revetment +Stone masonry	T	m^3 m^2	1,138 1,758	828
19	Tapacali	Bridge	Gabion mat Revetment	T	m^3 m^2	238 640	282
Total							1,375

Note) Bridge: Scouring of foundation; T: Temporary countermeasure

NIC.3 Countermeasures for Slope Failure

No.	ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
24	N003B400	R.C	Recutting + Drainage	P	m^3	290	40
25	N003B370	R.C	Recutting + Drainage	P	m^3	1,676	175
27	N003B320	R.C	T-shaped retaining wall +Refilling+ Vegetation+ Drainage	P	m^3	3,168	239
29	N003C230	S.S + R.C	Recutting + Cribwork + Vegetation+ Drainage Embankment + Vegetation + Drainage	P	m^2 m^3	638 4,934	328
30	N003E170	D.F + R.C	Concrete dam + Box culvert Recutting + Drainage	P	m m^3	20 2,670	310
32	N003C150	S.S + R.C	Recutting + Drainage Embankment +Vegetation+ Drainage	P	m^3	9,221 16,076	918
33	N003C140	S.S + R.C	Recutting +Horizontal drainage + Drainage Embankment +T-shaped retaining wall + Vegetation + Drainage	P	m^3	5,408 3,176	749
Total							2,759

Note) R.C: Rock collapsing; S.S: Slope Slide; D.F: Debris flow; P: Permanent countermeasure

NIC.3 Countermeasures for Bridge Foundation Scouring

No.	ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
26	El Guayacan	Bridge	New bridge construction	P	m^2	500	1,379

Note) Bridge: Scouring of foundation; P: Permanent countermeasure

NIC.5 Countermeasures for Slope Failure

No.	ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
35	N005A010	R.F	Recutting + Drainage	P	m^3	10,760	389

Note) R.F: Rock fall; P: Permanent countermeasure

NIC.26 Countermeasures for Slope Failure

No.	ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
44	N026A060	R.F	Recutting + Shotcrete + Drainage	P	m^2	3,604	316
33	N026A140	R.C	Recutting + Horizontal drainage + Drainage	P	m^3	11,495	904
50	N026A150	R.F	Recutting +Drainage	P	m^3	2,113	210
49	N026B160	R.C	Removal + Prevention net +Drainage	T	m^2	1,568	13
Total							1,443

Note) R.F: Rock fall; R.C: Rock collapsing; P: Permanent countermeasure; T: Temporary countermeasure

NIC.26 Countermeasures for Bridge Foundation Scouring

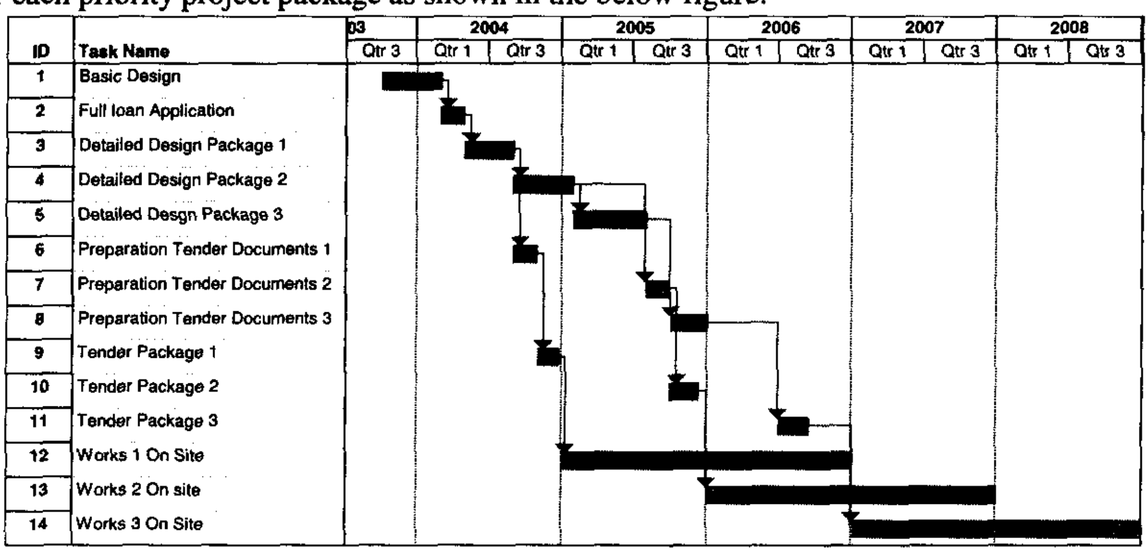
No.	ID. No	Type of Disaster	Type of Countermeasure		Unit	Qty	Cost (US$1000)
55	Solis	Bridge	Stone riprap with mortar Gabion mat	T	m^3	72 546	66
54	Papalon	Bridge	Stone riprap with mortar Gabion mat	T	m^3	50 408	51
52	San Juan de Dios	Bridge	Gabion mat	T	m^3	115	5
45	La Banderita	Bridge	Stone riprap wall Gabion mat	T	m^2 m^3	162 375	31
Total							153

Note) Bridge: Scouring of foundation; P: Permanent countermeasure

Total Construction Cost by Route (Direct Cost)

Objective Route	Cost (US$1000)		
	Slope	Bridge	Total
NIC.1	2,808	1,375	4,183
NIC.3	2,759	1,379	4,138
NIC.5	389	0	389
NIC.26	1,443	153	1,596
Total	7,399	2,907	10,306

The implementation schedule was set up taking account of the construction period estimated for each priority project package as shown in the below figure.



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INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Republic of Nicaragua, which has 129,541 square kilometers in area, 5 million population, is located in the center of the Central America, the agriculture and stock farming are key industries in the country. Since the 1990's after the civil war termination of the 1980's, the democratization and the reconstruction of the domestic economy has been promoted by the Government of Republic of Nicaragua (hereinafter referred to as "GRN"). However, there are many subjects that the Nicaragua is having a voluminous foreign debt and should solve increase of unemployment rate, poverty layers etc. Therefore the GRN has been setting the improvement of infrastructure as the urgent subject for the recovery of domestic economy.

On the other hand, Nicaragua is also the frequent occurrence country of natural disaster and it influences recurs the undesirable progress of the recovery of infrastructures. Especially, about 1,500 km of the paved roads and about 6,000 km of unpaved roads were disrupted by the hurricane "Mitch" occurred in October, 1998 and also as for the bridge, complete collapse on 22 bridges and partial destruction on 46 bridges suffered.

In such situation, the GRN was established the National Transportation Plan including the improvement of the road network in February, 2002. The main major road network will become the important lifeline in case of emergency, and establishment of the sufficient antidisaster plan is necessary.

However the disaster prevention plans was not established in the National Transportation Plan clearly, and the reliability of the traffic is in low condition such as at the case of the bad weather.

Therefore, the ultimate goal of this study is to assist the GRN in prioritizing and recommending vulnerability reduction plans that are crucial for the economic development of the country.

1.2 Objectives of the Study

The objectives of the Study are as follows ;

1) To formulate a reduction plan of road vulnerability for the major roads in the Republic of Nicaragua,

2) To prepare detailed countermeasures for the high priority roads,
3) To prepare a manual for road vulnerability reduction, and
4) To pursue technology transfer to the counterpart personnel in the course of the Study.

Objective disasters in the Study shall be those related to roads such as slope failure, rock fall, land slide, debris flow and scouring around bridge foundation.

1.3 Study Area

The area of the Study shall cover the following Project Roads within major roads in the Republic of Nicaragua.

i) El Espino - San Benito (NIC. 1)
ii) Sebaco - Jinotega (NIC. 3)
iii) Matagalpa – Da Lida (NIC. 5)
iv) Yalaguina - Las Manos (NIC. 15)
v) Chinandega - Guasaule (NIC. 24)
vi) Telica - San Isidro (NIC. 26)

1.4 Workflow of the Study

The workflow of the Study is shown in Figure 1.4.1.

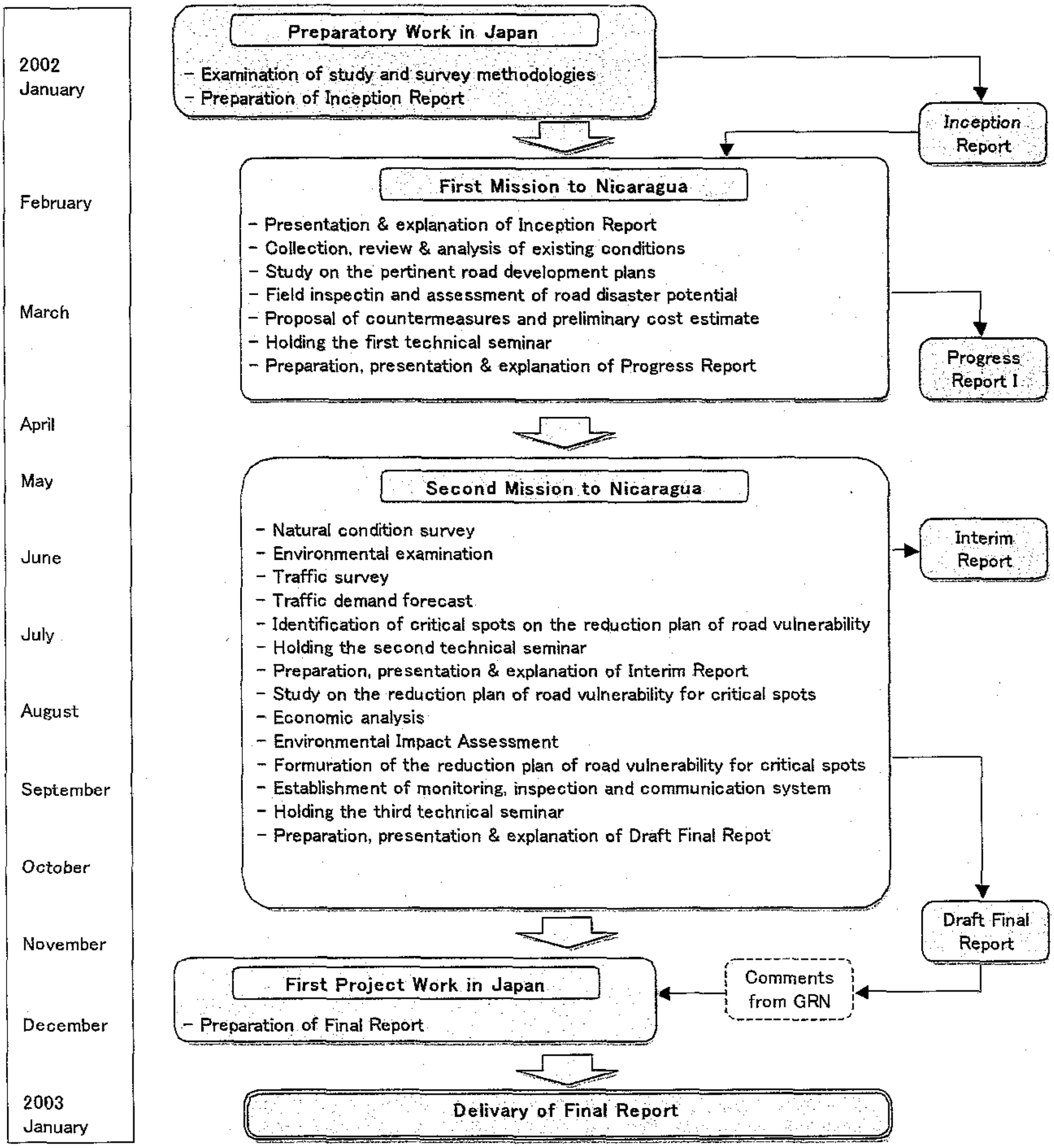


Figure 1.4.1 Study Workflow

PART A

IDENTIFICATION OF STUDY SPOTS

CHAPTER 2

PRESENT SITUATION ON STUDY AREA

CHAPTER 2 PRESENT SITUATION OF STUDY AREA

2.1 Natural Conditions

2.1.1 Topography

The Republic of Nicaragua is located in the middle of Central America (10.45- 15.05 degrees of North latitude, 83.11-87.42 degrees of West longitude) South of Honduras and North of Costa Rica. Its area is 120,349 km^2.

The topographical characteristic of Nicaragua is divided into three areas :

- Pacific plains area (including the volcanic mountain range area);
- Central mountains range area;
- Atlantic coast plains area.

The Pacific plains area runs around 350km along the coast from Gulf Fonseca in a North-West to South-East direction, around 70 to 100km wide. The land is very fertile, being covered by weathered volcanic ash soil or alluvium. The Nicaraguan rift valley is laid between volcanic mountain range and central mountains range in this area and is mainly subsidence land. It contains two large lakes (Lake Managua and Lake Nicaragua). A volcanic mountain range is laid in middle of the Pacific plains area and running parallel with coast. The Maribios volcanic mountain range occupies the North-East side of the area. The major volcanos are Consiguina, San Cristobal, Casita, Telica, and Momotombo. There is a gap in the range at Managua, and this lead to Masaya, Mombacho, Mt.Conception and Maderas.

The central mountains range area consists of three Cordillera (Isabelia, Dariense and Chontalena) that radiate in all directions, with a large basin and mountain table less than 1, 500m high. Mt. Mogoton, the highest mountain in Nicaragua (2,107m), is located on the border of Honduras. This area decreases in altitude and falls to reach alluvial plains in the Western lowlands.

The Atlantic coast plains area is typically 100m high, and around 150km wide. The West part of this area is called "Costa de Misquitos ". This area has many major rivers (Segovia, San Juan, Coco, Laguun de Perlas, Grande and Wawa). The South portion of this area is tropical and humid marshland.

The study area the roads NIC.1, NIC.3, NIC.5 and NIC.15 are located in the central mountains range area. NIC.24 and NIC.26 are located in the Pacific plains area.

2.1.2 Geology

1) Geology

The oldest bed rock of Nicaragua is considered to be the metamorphic rock and granite etc. as stretched toward North-East/South-West along the border with Honduras judging from the geological and topographical distribution of Nicaragua. They develop less than 10% of the whole area but it is presumed that they were subject to repeated complicated tectonic movement and continued upheaval movement even after quaternary era thereby CoCo River slid into South-West direction. And Quizuli River and Achuapa River flow South-East crossing for long the diluvium terrace and alluvial fan as distributed widely along the said CoCo River. Meantime, a structure line is predicted around some 3 km South-West of Ocotal which is stretching into North-East/South-West direction. This area is faced with the Palaeozoic strata as bordered with this structure line. In other words, faults and joints are in existence with large and small fracture width as caused by such tectonic movement, and these are geological factors to affect the stability of cutting slope. One of another features of this area rests with the rise of sea level in the Quaternary period, that is, it deposited during interglacial period consisted of the terrace sand and gravel of the Pleistocene Epoch along CoCo River and its branch Depilto River, and distributed on the metamorphic rock and partly on the weathering zone of granite. This granite has become decomposed granite soil through weathering and the particle size of weathered crystal grains is so large and called as coarse grains granite soil in Japan. Due to angular shape of crystals remained, it can resist against rain to some extent as a slope. At present, only gully erosion is seen but it is weak for strong rain. As a matter of course, top layer has become soil through weathering so it made a geological factor to cause debris flow during typhoon season on some of the mountainside slope. NIC.15 Line is running through these areas, where terrace sand and gravel is distributed on the slope, and various combination for rock and Quaternary deposits is seen such as metamorphic rock and terrace sand/gravel, or decomposed granite soil and terrace sand/gravel. However, at present, only gully erosion is seen for the slope with some 70 degrees. But displacement is also seen in some natural slope where decomposed granite soil is distributed so its stability should be taken notice.

Similarly to these old rocks, most of the bed rock in Nicaragua are composed of Mesozoic sedimentary rock, which are divided into Matagarpa Facies and Rivas Facies of Jurassic upper-lower Cretaceous. These rocks are covered widely with volcanic rock of Tertiary Era which gushed out thereafter therefore the they are distributed in South-East of Iyas glaben zone of metamorphic rock. It is confirmed through this Study that the black schist of Rivas Facies is distributed in narrow area in NIC.1, NIC.3, NIC.15 and NIC.26. The black schist in this district is fissile which is characteristics to schist but it makes sound slope because it was formulated in older era and is highly sticking and through such coincidence that rocks not fractured by tectonic movement are distributed on the slope or schistosity shows anti-dip slope. It is not certain if these black schist exist in volcanic rock here because the surface layer was eroded or it was lifted up by dislocation or volcanic activities. It is commonly said that the bedrock as distributed along the project road is under good conditions as the slope by chance but, in many cases, they are fractured or become unstable and collapsed like landslide when they are cut.

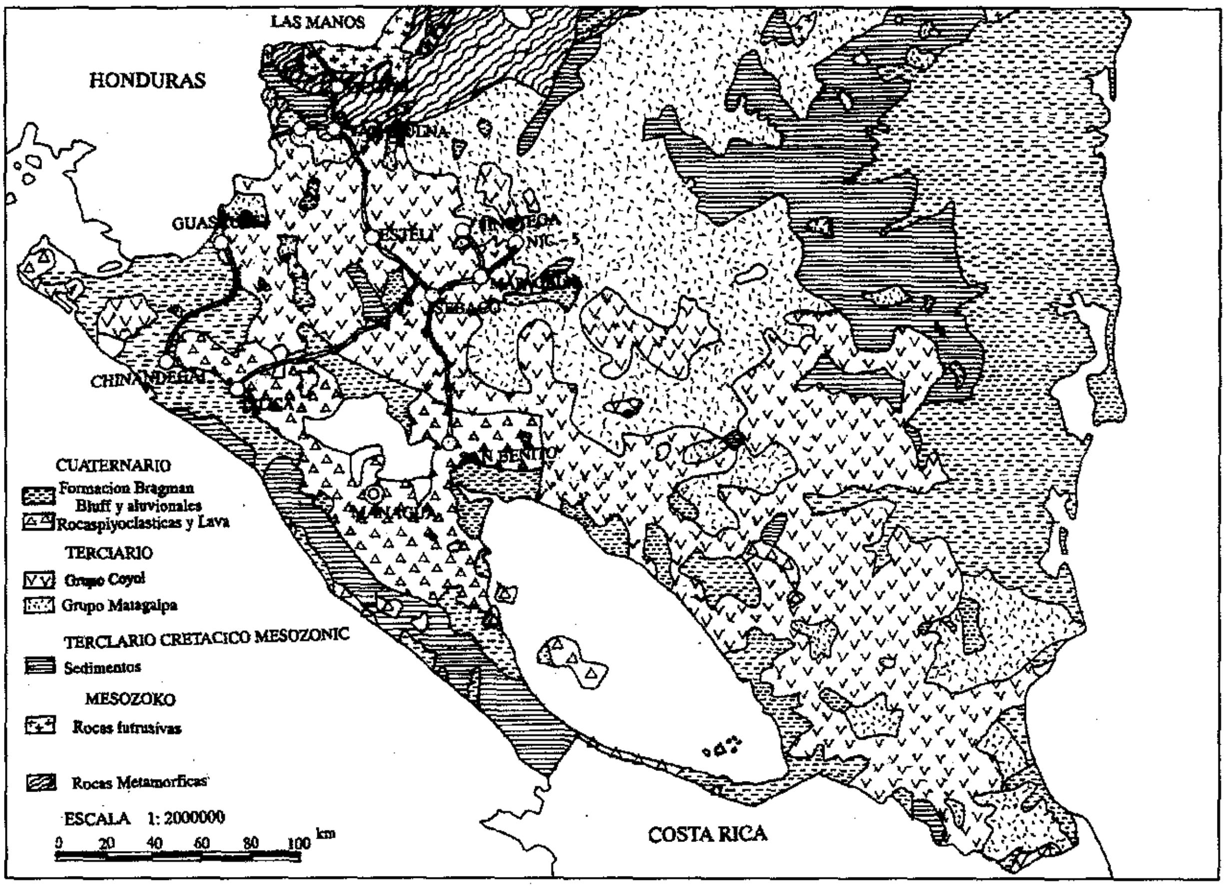


Figure 2.1.1 Geological Map of Nicaragua

More than 50% of the rocks in Nicaragua are volcanic rocks and they are classified as effusive rocks of Palaeogene and, Neogene of Tertiary, and Quaternary. There are some differences petrographic in effusive rock according to the time of activities but they are categorized similar rocks in terms of road engineering. The strength of the lava of andesite as erupted out in a great volume is similar when it is hit with a hammer. However, sufficient observation should be made where the factors for collapse are to be studied because the weathering, joint peculiar to volcanic rock, or bedding plane and structure of lava flow, or crack interval are quite varied depending upon the era of eruption and the place of distribution. In this connection, the main rocks distributed in the Study area and surrounding area are basaltic, andesite-basalt, andesite, rhyolite and other lava and such effusive rocks as tuffbreccia, dacitic agglomerate belonging to Palaeogene, and lava of quarts-andesite, pyroclastic rock, welded tuff belonging to Eeocene. They are widely distributed in NIC.1, NIC.3, NIC.26 etc. Moreover, these lava flow indicates various eroded topography by combination with tuffs. And the most peculiar is the plain plateau called Mesa and strong lava flow as strong against erosion is seen on the top, thereunder tuffs are distributed making sharp slope made through weathering. Especially, NIC.1 has close connection with this topography.

The volcanic rocks of Quaternary Era are recognized with white tuff of Plaistocene, agglomerate, tuff with pumice, andesite-quartz/andesite, and ryolite. And new un-cemented volcanic ash is distributed to cover them. NIC.24 Line is related with this layer.

Alluviam is distributed around Managua Lake, Nicaragua Lake and surrounding area, and the existing rivers valleies. Especially, there exists flat plains around the Lakes and the shore line fluctuates owing to subsidence of big graben and change in sea water level, and it is supposed that the transverse continuity of sediments soil is bad due to effusive material of active volcano. Therefore, it is desired to carry out a boring survey newly when embankment or structures are prepared in such low areas.

2) Instability and the Recent Seismic Scale due to Quaternary Volcanic Activities

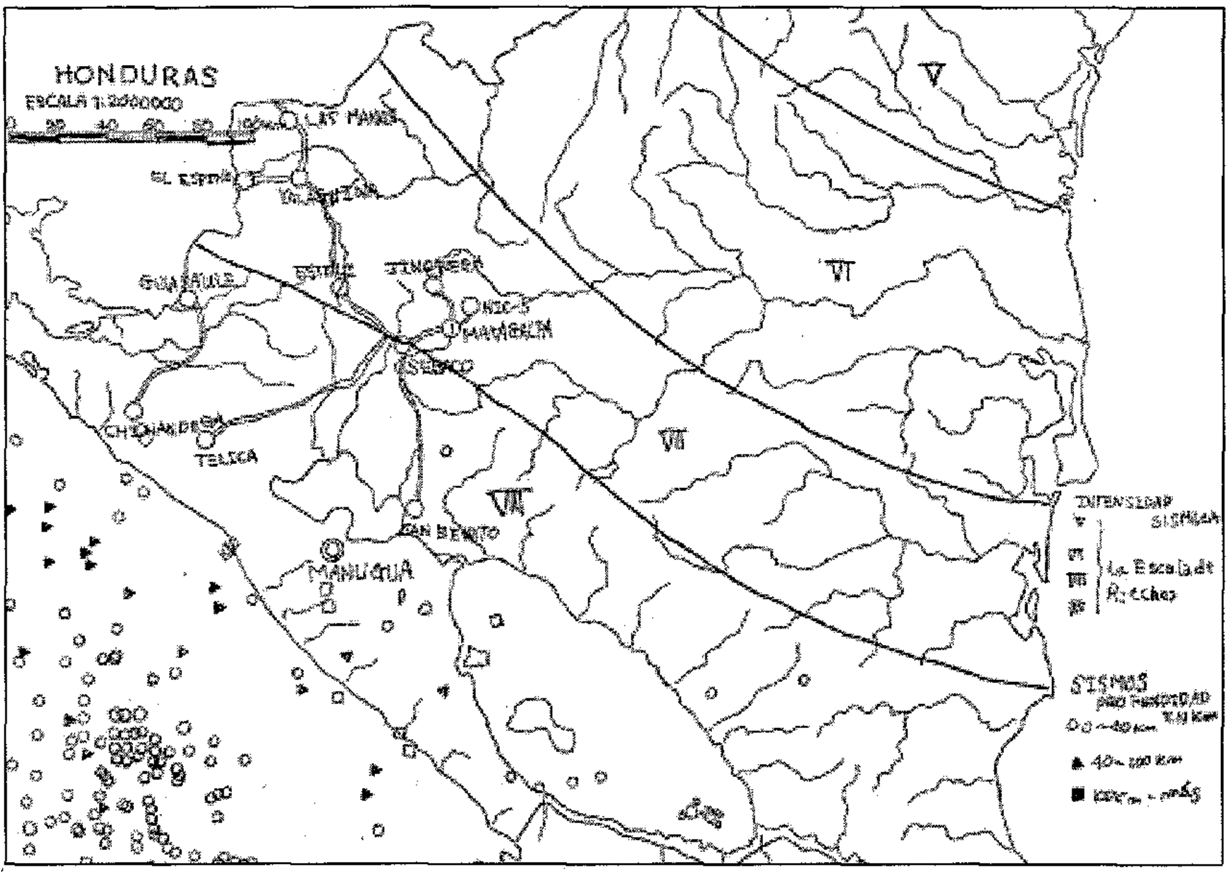
In Nicaragua, a large rift valley zone is stretching in North-West/South-East along the Pacific sea shore. And various phenomena have been recognized such as the penetration of sea water along with the subsidence thereof. At present, there exist seven active volcanoes in this rift valley zone in addition to Managua Lake and Nicaragua Lake. According to the plate tectonics theory, Cocos Plate is said to be sliding into Americas Caribbean Plate. Cocos plate is the one which is stretching into Guatemala and Costa Rica. Near Nicaragua, there exist fracture which is directly crossing with volcanic line 40 km North-West of Managua, around the borders of Honduras and Costa Rica. The plates as sandwiched between them are said to be classified into fracture zone of Western Nicaragua and Eastern Nicaragua. The width of each fracture is 60 % for the Pacific coast (about 300 km) of Western Nicaragua fracture and 40 % in Eastern Nicaragua fracture. In Western Nicaragua fracture, there exist seven composite volcanoes including Cosiguina, San Cristobal, Telica, Cerro Negro, Las Pilas, Momotombo, Apoyeque in North-West direction. Similarly, Eastern Nicaragua fracture has four composite volcanoes including Masaya, Momotombo, Concepcion and Madera in North-West direction. It is said that in the boundary area of the fracture there happened vast eruption of Consigiuna in 1835 near the border with Honduras and Sta Maria in 1902 near the border with Costa Rica. In recent years, Masaya volcano near Managua will correspond although a little bit away from these locations. Table 2.1.1 shows the records of eruption in Nicaragua in recent years.

A hazard map is officially published based upon these records of volcanic activities.

Table 2.1.1 Main Composite Volcano Eruption in Nicaragua

Name of Composite	Mountain Height	First Eruption	Eruption	
			Eruption Type	PersonsAffected
Cosiguina	846.7 m.	1835	Karakatoan	Unknown
San Cristobal	1,745.0 m.	1680	1680-1982 (have) 1971-1984 (volcanic gas)	70,000
Telica	1,040.0 m.	1529	1981-1982 (lava) *1982 (Estrombolia)*	100,000
Cerro Negro	490.0 m.	1850	1850-1968(have) 1971,1992 (volcanic ash)	20,000
Las Pilas	1,072.0 m	1952	1952(gas) 1954(volcanic ash)	Unknown
Momotombo	1,258.0 m.	Unknown	1609-1909 (lava) 1976 (volcanic gas)	20,000
Masaya	637.0 m.	1529	1529-1989 (lava) 1965-1988 (volcanic gas)	20,000
Concepcion	1,610.0 m.	1833	1833-1957 (lava) 1906-1988(volcanic ash)	500,000

Sources: INETER



Legend (Explanation for Seismic Intensity)

V	Most people perceive and many are awakened. Unstable things fall down.	Acceleration: 10 - 21
VI	All people perceive and many rush outdoor with surprise.	Acceleration: 21 - 44
VII	Most people rush outdoor and poorly made things are damaged.	Acceleration: 44 - 94
VIII	Strong buildings are damaged. Chimneys, monument, and walls fall down, and furniture falls sideways. Sand and mud gushes out and well water will change.	Acceleration: 94 - 202

Sources: INTER

Figure 2.1.2 The Seismic Intensity

It is clear through this Figure that NIC.24 and NIC.26 will make large traffic trouble depending upon the size of volcanic activities as related with Western Nicaragua fracture. Records for all the seismic size and seismic center distribution for 1992-1998 are also available but here the distribution of more than magnitude 4.0 is shown in Figure2.1.-1. There is no special feature showing deep connection with the fracture in this Fig but the results are obtained to forecast the plate subsidence through the distribution map showing the seismic depth. The seismic intensity in Nicaragua is shown hereunder and the distribution is also shown as Figure 2.1.1.

2.1.3 Meteorology

Nicaragua is in the tropics and semi-tropics. It has a rainy season and a dry season. The rainy season is from April to November, with the dry season period between December and March.

The Pacific plains area is divided 2 seasons clearly and precipitation totals around 800-1,500mm. The mean annual temperature in this area is approx. 27-29°C.

The central mountains range area is cooler because of its higher altitude. The mean annual temperature is approx.22-26 °C. The precipitation around NIC.1and NIC.3 in this covered savannah area is lower. The West ridgeline of this mountain area receives much precipitation, and is covered by forest as well as being the source of many rivers.

The Atlantic coast plains area has more precipitation, (more than 2,500 mm per year) and is generally tropical. The Southeast portion of this area is very humid area with rainfall in the region of 4,000 – 6,000mm per year.

The characteristic of precipitation and mean annual temperature around study area are shown in Table 2.1.2.

Table 2.1.2 Annual Mean Temperature and Precipitation

Direction	Area (km^2)	Annual mean Temperature (°C)	Annual mean Precipitation (mm)	Mean Altitude (m)
Chinandega	4,926	27	800 - 1,500	144
Esteli	2,335	20	800 - 1,500	645
Jinotenga	9,755	20	1,000 - 2,000	736
Leon	5,107	26	800 - 1,300	134
Matagalpa	8,523	18	700 - 1,700	490
Nueva Segovia	3,123	20	1,000 - 1,700	688
Madriz	1,602	20	800 - 1,500	700

Sources: INTER

Generally, the routes of hurricanes stall on the Atlantic or the Pacific, and skirt around Nicaragua. Where high winds cross Nicaragua, it is usually in the form of a tropical cyclone. However, Nicaragua has often taken a direct hit by hurricane. Of the recorded instances of tropical cyclones in the country, 45% were Hurricane category, 50% were Tropical Storms and 5% were Tropical Depressions. The frequency distribution by month is shown in Table 2.1.3.

Table 2.1.3 Frequency of Tropical Cyclones in Nicaragua

Month	Frequency (%)
September	30
October	25
June	12.5
July	10
December	10
May	7.5
August	5
Total	100

The region with the highest impact of Tropical Cyclones is the North Atlantic Coast. The case of Mitch, which is forth-largest hurricane recorded in the Atlantic area, crossed the Honduras on 26 and 27 September 1998, and caused great damage. In the study area, there are some rock collapse along the road, and massive bridge damage along NIC.24.

2.1.4 Hydrology

The hydrological watershed of Nicaragua is divided 2 directions, the Pacific watershed and Atlantic watershed. The Pacific watershed is subdivided into eight, and the Atlantic one is subdivided into 13. The characteristics of the watershed of Pacific side are generally cramped with rivers of less than 20km except for the Estero Real River. Their flows are not continuous and stream widths are narrow. The watershed on the Atlantic side is much larger with river sources in the central mountains range area, except for the San Juan River. This river has its source in the Nicaraguan rift valley and it feeds both Lake Managua (1,040km^2) and Lake Nicaragua (8,200km^2). Table 2.1.4 shows the Pacific River watershed and Table 2.1.5 shows the Atlantic River watershed.

Table 2.1.4 Pacific River watershed of Nicaragua

Code	Pacific watershed	Area (km^2)	Precipitation (mm)
58	Negro	1,428	1,859
60	Estero Real	3,690	1,682
62	Btween Estero Real & Volcan Cosiguina	429	1,881
64	Bttween Volacan cosiguina & Tamarindo	2,950	1,670
66	Tamarindo	317	1,175
68	Between Tamarindo & Brito	2,768	1,537
70	Brito	276	1,316
72	Btween Brito & Sapoa	325	1,625

Sources: Cencas Hidrograficas, INETER

Table 2.1.5 Atlantic River Watershed of Nicaragua

Code	Atlantic watershed	Area (km²)	Precipitation (mm)
45	Coco	19,969	1,937
47	Ulang	3,777	2,405
49	Wawa	5,372	2,820
51	Kukalaya	3,910	3,800
53	Prinzapolka	11,292	2,586
55	Grande de Matagalpa	18,445	2,095
57	Kurinwas	4,457	2,725
59	Betweene Kurinwas & Escondido	2,034	3,564
61	Escondio	11,650	2,772
63	Btween Escondido & Punta Gorda	1,593	3,710
65	Punta Gorda	2,868	3,552
67	Btween Punta Gorda & San Juan	2,229	4,510
69	Sun Juan	29,824	1,694

Sources: Cencas Hidrograficas, INETER

Within the study area, NIC.1 NIC.3, NIC.5 and NIC.15 fall in the Atlantic watershed. NIC.24 and NIC.26 are mainly in the Pacific watershed. The recent inundation of the Estero Real River severely damaged NIC.24. It caused reduced capability for run-off by deforestation and affecting agricultural land. It is one of main factors causing floods and landslides.

2.2 Socioeconomic Conditions

2.2.1 Land Use

According to the National Transport Plan (NTP) of February 2001 land use in Nicaragua is shown in Figure 2.2.1. The detailed characteristics are presented in Table 2.2.1.

2.2.2 Population

In 1990, the population was 3.871 million, according to the NTP, and the density was 32 inhabitants per square kilometers. By 1998 the population had grown to a total 4.803 million. Populatio forecasts indicate that it will grow to 9.53 million by 2019 and to 7.6 million inhabitants by 2025. Certainly, the population in Nicaragua is experiencing rapid growth.

The current birth rate in Nicaragua is 4.6%, more than the Latin American average (2.9%), and the world average (2.7%). The death rate in Nicaragua is 0.8 %, similar to the Latin American average of 0.7. It is estimated that 30% of the population died in the civil war between 1975 and 1986. Average life expectancy is 66 years, and the average age is extremely young at 16.1 years.

Table 2.2.1 Characteristics of Land Use

Symbols	Characteristics	Area	%
A	Proper land for annual cultivation: corn, bean, rice, potatoes, linseed, camomile, fresh- weather garden vegetables; semi-perennials cultivation: sugar caine, pineapple, banana; perennial cultivation: coffe, citrics,cacao; double purpose cattle, and/or forestal production. Soils with cliff less than 15%; altitude weather conditions without mid summer warm period. (>500 meter over sea level)	176.86	1.5%
A-1	Proper land for annual cultivation: cotton, soja, peanut, corn, rice, tobacco, sesame, sorghum, garden vegetables of warm weather; semi-perennials cultivation: sugar caine, prennials: citrus and fruits; double purpose cattle and/or forest production (fine wood). Soils with cliffs less than 15%, warm weather (<300 m.o.s.l.) and benign mid summer heat.	359.135	3.0%
A-2	Land for annual cultivation: corn, sorghum, cotton, sesame, soya, peanut, perennials; citrus and fruits; double purpose cattle and forestal production (fine wood). Solis with cliffs less than 15%, warm weather to hot and defined summer heat period.	291.770	2.4%
A-3	Similar to the previous but with a hard weather risks on the first seed time. Annual cultivation: sorghum, and sesame (last seed time), fruits of dry zones (tamarind, avocado, fat cattle and/or forest production (fine wood and energy). Soils with cliffs less than 15%; warm weather to hot with hard mid summer heat.	-	-
A-4	Similar to the previous but with a hard severe weather risks on the first seed time, annual cultives: sorghum and sesame (last seed time), frutals on a dry zone (tamarind, scourge in high and intermediate zones; fat cattle and/or forest production (energy). Soils with a cliffs less than 15%; weather from warm to hot, with severe mid summer heat. Soils prioritised for irrigation.	-	-
A-5	Proper lands for perennial cultivation of forest environment (coffe, cardamon, citrus, fruits); double purpose cattle and/or forest production (fine woods). Soils with cliffs between 15 and 50%, from fresh to cold weather. (>500 m.o.s.l.)	553.425	4.5%
Total agriculture and farmer vocation		1,381,190	11.4%

Source: the National Transport Plan in Nicaragua, February 2001

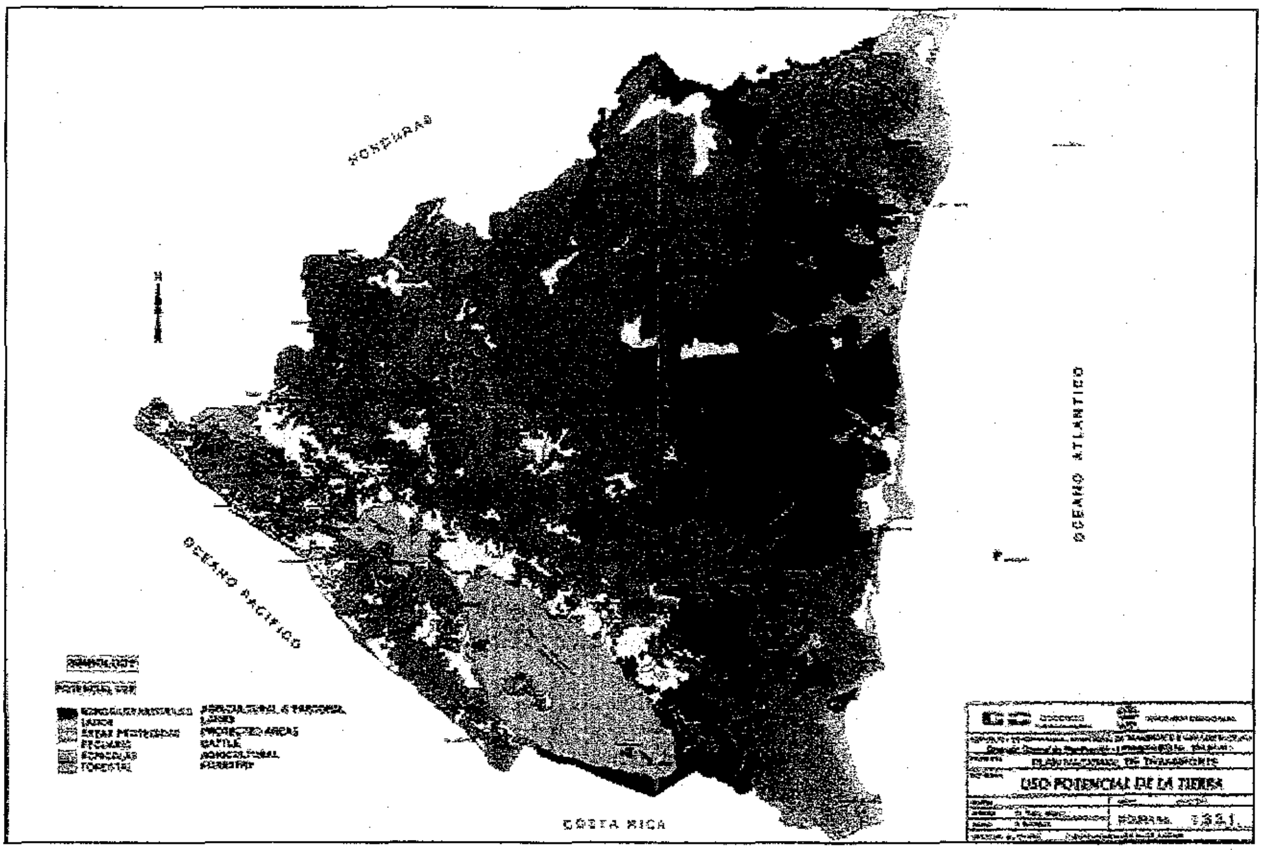


Figure 2.2.1 Land Use Map

The population in towns and villages alongside the objective roads in 1998 is shown in Figure 2.2.2. NIC.1, NIC.3 and NIC.24 are comparatively more densely populated than the other routes. Tipitapa and Esteli on NIC.1, Matagalpa on NIC.3 and Chinandega on NIC.24 contain approximately 60 % of the total roadside populations on these roads. Figure 2.2.3 shows how this population is expected to grow to 2019. The growth rate of population from Year 1971 is approximately 30 % over against Year 1998. The growth between 1998 and 2019 is over 80%. This highest growth area is expected to be Matagalpa.

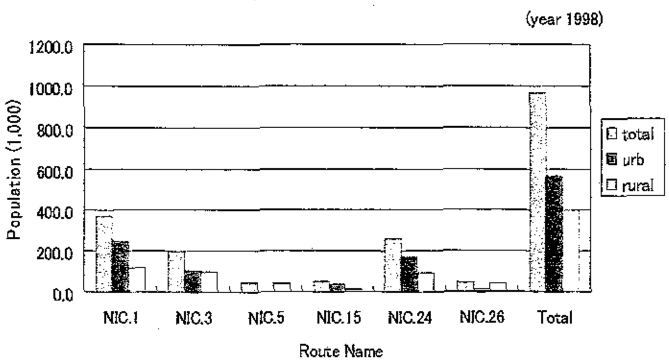


Figure 2.2.2 Roadside Population in 1998

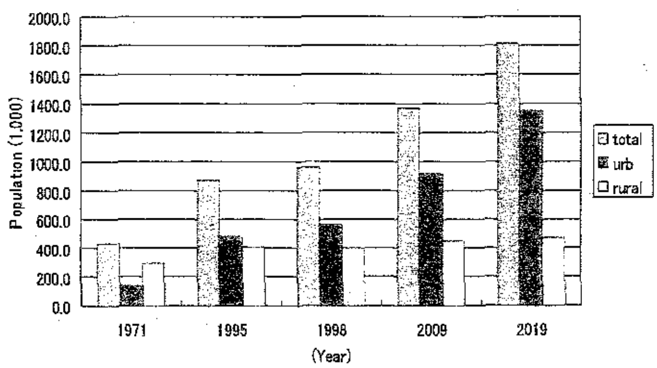


Figure 2.2.3 Roadside Population Between 1971 and 2019

2.2.3 Economy

During the period 1960 to 1977 Gross Domestic Product (GDP) increased by three times, to its peak in 1977 of US$2,934.3 millions. Per capita income at that time was US$1,169.8, and recorded exports were worth US$941.6 millions. The fiscal deficit was only 9.8% of GDP, the current account was in deficit at 8.1% of GDP, and external Debt was almost 39.0% of GDP.

During the 1980's, the economy of Nicaragua registered a sharp decline. Headline inflation 1988 was 33%, and GDP slumped to 62% if the 1977 value. The value of exports and per capital income were 40% of their 1977 values. The fiscal deficit of the non-financial public sector was 20.3% of GDP. The deficit of the current account of the balance of payments increased to 59.4% by 1992, and losses of the state financial system increased to a staggering 48% of GDP. Technically, the state-owned banks were insolvent.

Since 1990, Nicaragua has attempted to fight hyperinflation and started building the bases for firm economic development of the country. A stability program and structural adjustments were put in place, and the support of international community external funds were provided.

Fiscal and monetary controls were implemented to halt the currency slide and to counter inflation. These were coupled with a massive privatization process, financial reforms to the public sector, and a reduction in state beaurocracy.

Monetary reform in February 1991 introduced the golden Cordoba, (C$1.0 golden Cordoba = US$1.0 and C$5.0 millions of olds cordobas) and a macro-devaluation of 400%. This was accompanied by a freeze on public sector salaries in an attempt to reduce demand for goods and counter inflation.

The reform package also included strengthening financial markets. The Government stopped setting interest rates, and adjusted the credit policy of Central Bank. The economic system reforms were designed to support private sector banks, and to reduce the role of the state in the management of financial resources.

These measures started to create the conditions for a strong economy with price stability. By 1998 total deposits in private banks had grown to 61.0% of GDP, and foreign currency deposits represented 41.8% of GDP.

2.2.4 Vehicle Registration

Figure 2.2.4. shows vehicle registrations in selected Departments from 1995 to 2000. Nearly 75% of the country's vehicles are registered in Managua. The growth rate is forecast to be around 74 % between in 1995 and in 2000, with a growth in Managua of 80 %.

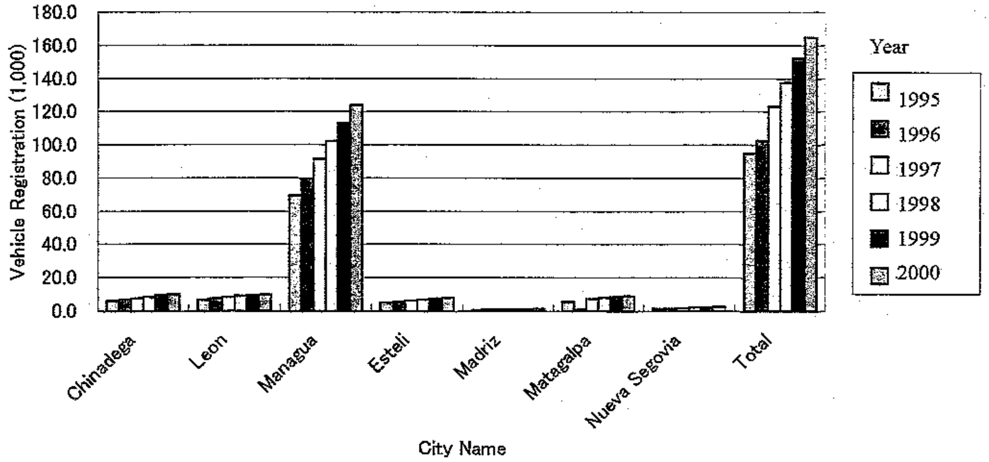


Figure 2.2.4 Vehicle Registration of Main Region

Table 2.2.2 shows forecast vehicle registrations by vehicle type in the year 2000. Managua region will take around 76 % of all registrations. Car and pick up vehicles will be about 70 % of all vehicles in Managua, a much a higher ratio than other Departments.

Table 2.2.2 Vehicle Registration of by Vehicle Type and Region (year 2000)

Rooute	Chinadega	Leon	Managua	Esteli	Madriz	Matagalpa	Nueva Segovia	Total
	24	26	1	1	1,15	1,3,5	15	
Bus	320	343	2,875	213	48	271	79	4,149
Car	1,729	2,519	45,820	1,245	145	1,251	212	52,921
Heavey Truck	402	31	1,636	82	0	75	14	2,240
Right Truck	933	928	7,971	1,030	146	1,580	403	12,991
Pick up	2,953	3,331	40,380	3,642	572	4,086	1,008	55,972
Small Pick up	31	11	1,584	14	0	34	0	1,674
Small Bus	336	350	3,368	113	11	98	6	4,282
Mini Trailer	0	0	0	0	4	0	0	4
Motorcycle	1,337	1,138	12,803	1,005	184	1,046	399	17,912
Trailer Truck	298	138	1,595	116	2	82	19	2,250
Back hoe	0	0	1	1	0	0	0	2
Tractor	701	465	312	23	7	74	22	1,604
Trailer	705	735	5861	509	112	713	205	8,840
Total	9,745	9,989	124,206	7,993	1,231	9,310	2,367	164,841

Souse: Statistics Indicator of Transport Sector
July 2001, Ministry of Transport and Infrastructure