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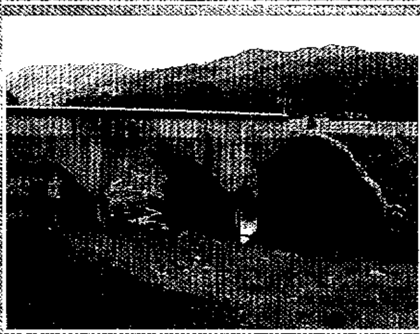
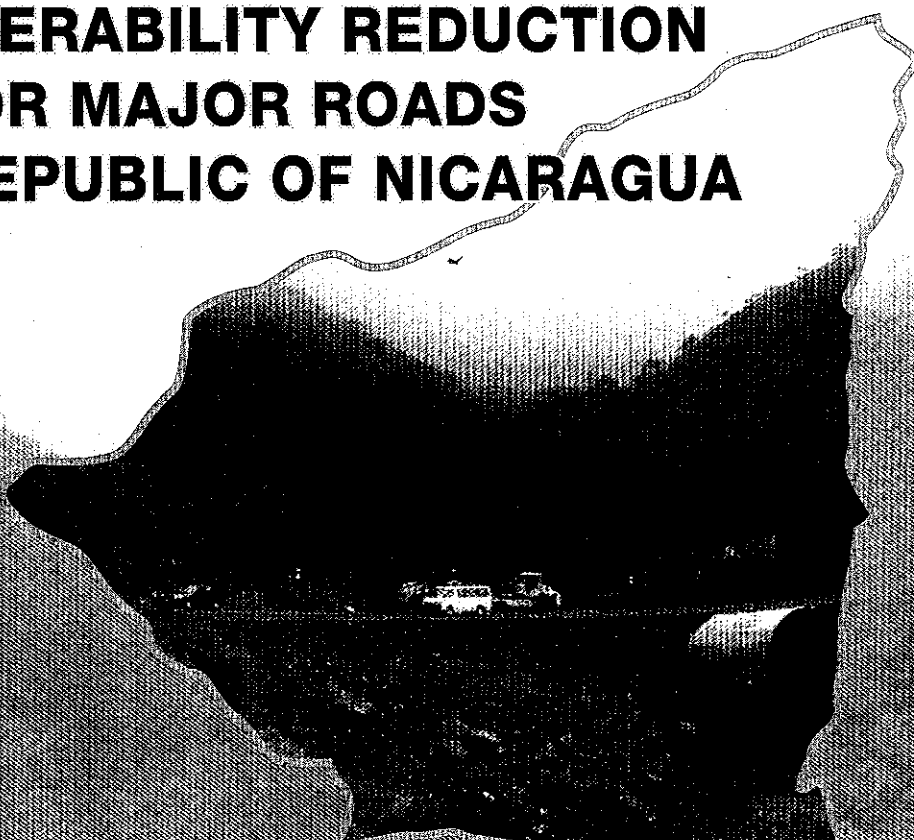
JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

MINISTRY OF TRANSPORT AND
INFRASTRUCTURE
REPUBLIC OF NICARAGUA

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





FINAL REPORT

Volume 3 of 5

ROAD DISASTER PREVENTION PLAN REPORT

January 2003

Oriental Consultants Company Limited
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Japan Engineering Consultants Company Limited

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LOCATION MAP

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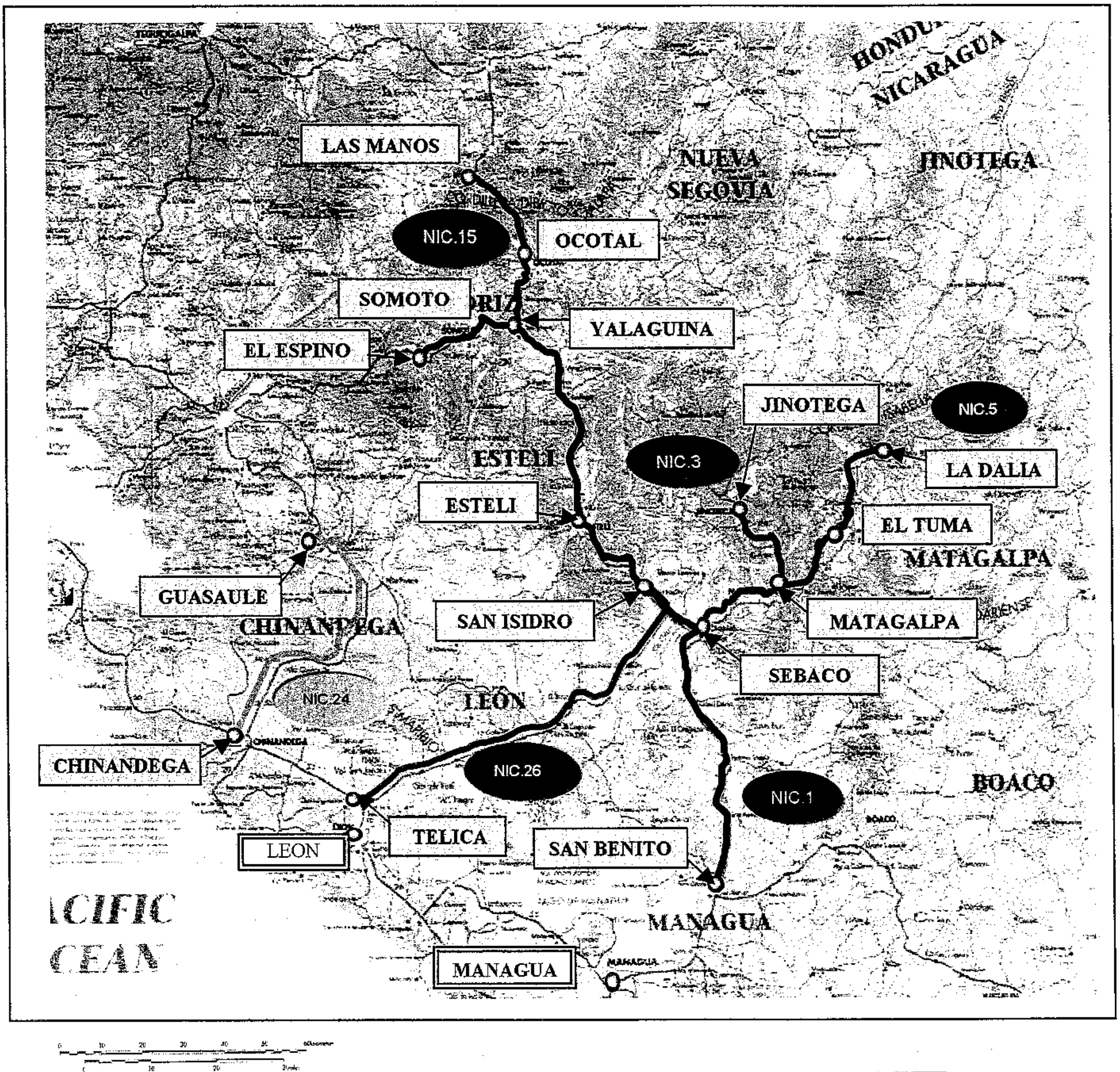

Legend

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

FINAL REPORT

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<u>**List of Abbreviations**</u>

(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

CHAPTER 1
INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Plan

Following the end of the civil war of the 1980's, the Government of Republic of Nicaragua (GRN) has promoted the democratization and the reconstruction of the domestic economy.

Nicaragua is frequently subjected to natural disasters, such as volcanic activity, earthquakes and typhoons, and these disasters have delayed the recovery of infrastructure destroyed in the civil war. Indeed, around 1,500 km of paved roads and 6,000 km of unpaved roads were adversely affected by the Hurricane Mitch in October 1998. It caused the complete collapse of 22 bridges and the partial destruction of 46 bridges.

The GRN adopted the National Transportation Plan, which includes proposals for the improvement of the road network, in February 2002. However disaster prevention plans were not established in the Plan, and after periods of bad weather the road network is often left in a poor condition. There are numerous vulnerable spots on major roads regarding road disaster.

Consequently, this road disaster prevention plan has been produced to assist MTI in identifying potential disaster spots and implementing vulnerability reduction plans on whole roads in Nicaragua.

1.2 Objectives of the Plan

1.2.1 Basic policy

The basic policy is to prepare an Implementation Plan and to promote the implementation projects to counter potential disasters. The following should be the responsibility of MTI on its roads :

- To identify highly critical disaster spots on objective roads,
- To identify high traffic demand on the objective roads,
- To identify areas of high economic production along objective roads,
- To identify feasible places for countermeasures on objective roads,
- To formulate reduction plans for vulnerable spots on the objective roads,
- To prepare detailed countermeasures for road disaster prevention spots, and
- To formulate an implementation plan.

1.2.2 Objective Roads

The objective roads are the following major roads. The location of these project roads is shown in the "Location Map".

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

1.2.3 Explanation of Terms

There are three important terms, defined below.

- **Disaster Potential Spots**

Inspection spots where, after screening, are assessed to need countermeasures.

- **Disaster Critical Spots**

Disaster potential spots where are assessed to be dangerous to third persons, etc.

- **Disaster Prevention Spots**

Disaster critical spots where are assessed to have a high feasibility for prevention measures.

1.2.4 Application Scope

This report can be used to assist the development of the implementation plan, and for preparing a budget investment plan and financial plan. Road disaster prevention planning considers all the following items: inspection of vulnerable spots, causes of problems, the identification of critical spots and road disaster prevention spots, natural condition survey, traffic survey and traffic demand forecast, environmental survey, planning of countermeasures, construction plans and costs, economic and financial analyses, investment planning, feasibility study, and the execution of implementation plans.

1.3 Plan Procedure

The procedure for road disaster prevention planning for is as shown in Figure 1.3.1.

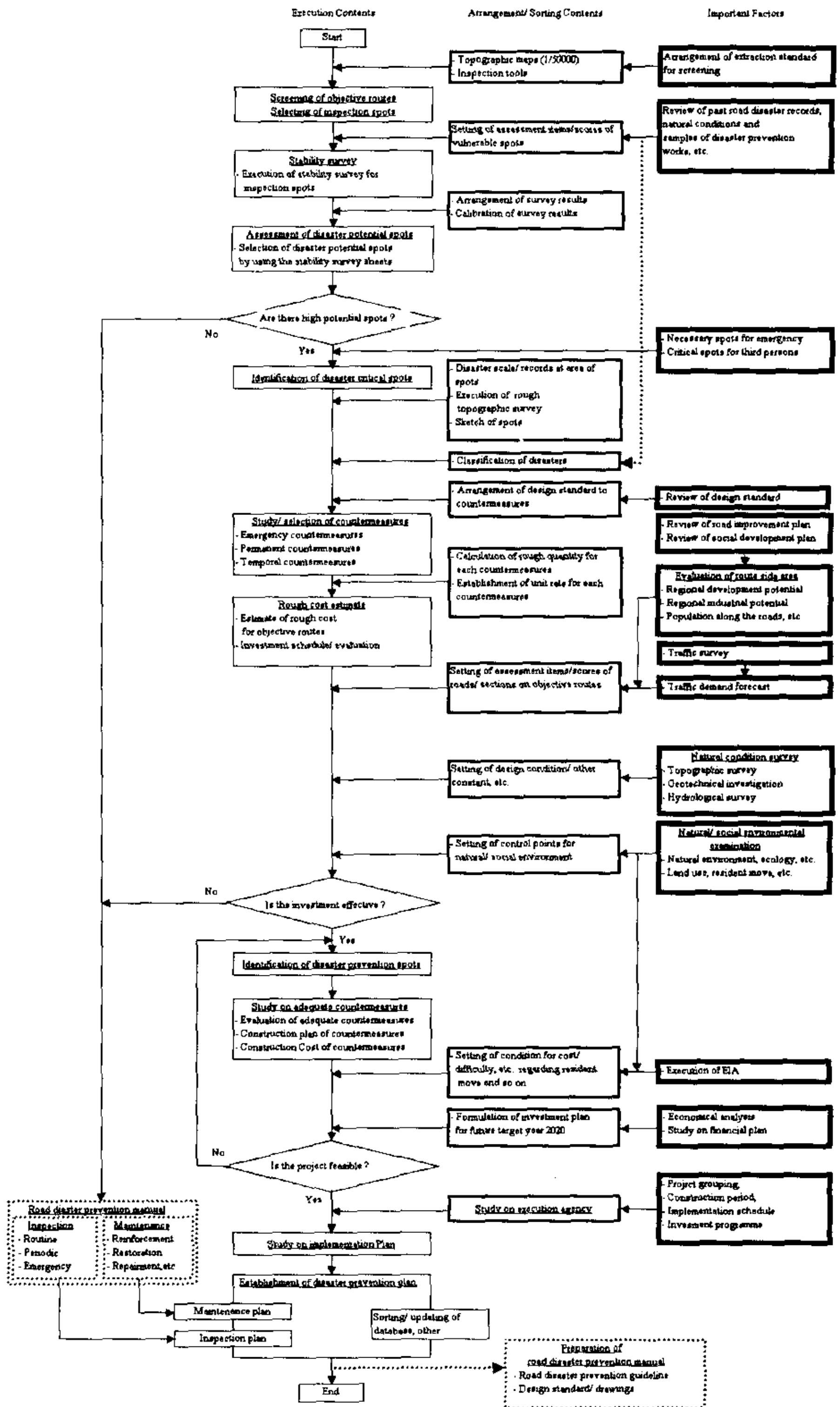


Figure 1.3.1 Plan Procedure

CHAPTER 2

SCREENING

CHAPTER 2 SCREENING

2.1 Objectives

The objectives of screening are as follows.

- Objective inspection of vulnerable spots,
- Early detection of vulnerable spots, and
- Understanding the characteristics of vulnerable spots.

2.2 Inspection Tools

For data collection, inspectors should use the following tools at vulnerable spots.

- Topographic maps (s=1/50,000),
- Road inventory data,
- Digital video camera, and
- Measuring tape.

2.3 Arrangement of Inspection Spots

2.3.1 Selection of Inspection Spots

Inspection spots for screening are classified into the following road disaster types.

- Rockfalls, collapsing,
- Rock collapsing,
- Slope slide,
- Debris flow, and
- Scouring of bridge foundation.

Screening items should be reviewed before establishing the assessment items of inspection spots. Items at selected inspection spots should take account of each disaster factor by using updated checking lists.

The check lists to select inspection spots should include :

- Spots admitted as obvious disaster potential, and
- Spot where is necessary to inspect past disaster records.

2.3.2 Rockfalls, Collapsing

Engineers should inspect sites where at least one of the following factors pertinent to Rockfalls/ Collapsing is present :

- where the cut/ embankment has a natural slope of 15 meters or more high, or a natural slope of 45 degrees;
- where unfixed stones or boulders exist on slope surfaces;
- where the soil or rock structure is vulnerable;
- where very old countermeasures are installed; and
- where it is necessary to inspect the effects of countermeasures.
-

2.3.3 Rock Collapsing

Engineers should inspect the following sites pertinent to Rock Collapsing.

- where a cut slope or natural slope is 7 meters or more high.

2.3.4 Slope Slide

Engineers should inspect for sloop slide at :

- Critical spots where slope-slide occurs;
- Prevention areas where slope-slide occurs; and
- Spots where the slope-slide phenomenon is admitted.

2.3.5 Debris Flow

Engineers should inspect all the following types of sites :

- Spots where streams cross bridges and/ or box-typed culverts on roads,
  1. Except spots across streams in tunnel,
  2. Except spots with clearance under a bridge deck of 10 meters or more, and with bridge span of 20 meters or more;
- Spots with an area of basin of 0.01 km2 or more;
- Spots where a stream bed of 10 degrees or more exists; and
- Spots where a riverbed of two degrees or more exists.

2.3 6 Scouring of Bridge Foundation

Engineers should inspect all bridges except where :

- Spots where there is obviously no scouring in stagnant river areas;
- Simple span bridges with no piers, sturdy riverbank protection and complete river improvement works both upstream and downstream;
- There is no damage at scouring protection around bridge foundations and there is adequate scouring protection around bridge foundations;
- Pile and/ or caisson foundations remain adequately embedded (15 meters or more deep, and 8 times the transverse pier width) against either the deepest riverbed or the design riverbed (the depth from riverbed to the bearing stratum); and
- The bridge span is less than 15 meters (except where there are past disaster records and/or a high potential of disaster).

CHAPTER 3

STABILITY SURVEY

CHAPTER 3 STABILITY SURVEY

3.1 Objectives

After the screening of objective roads is completed, stability surveys should be carried out at spots where there is a need to inspect. The data shown below are needed for each inspection survey. This data should be also be used for maintenance work:

a) Stability survey sheets,
b) Tables of inspection results,
c) Figures of inspection results,
d) Record of each inspection spots, and
e) Past disaster record of each inspection spot.

3.2 Survey Tools

The following tools should be brought to the inspection spots for a stability survey.

- Stability sheets,
- Tables for survey results,
- Figures for survey result,
- Inventory data and maps,
- Binoculars,
- Camera,
- Rock hammer,
- Marking materials,
- Tape measure.

3.3 Review of Related Data

3.3.1 General

The following additional data should be assembled for each site.

- Natural Condition,
- Socioeconomic,
- Road Network,
- Past disaster records (disaster type, location, disaster magnitude, disaster circumstance, disaster photograph, date, and cause),
- Past disaster prevention work (when, prevention type, prevention cost, etc.),
- Road inventory,
- Topographic map (scale = 1/50,000) (annotated with disaster location, type and

magnitude), and

- Aerial photographs

3.3.2 Natural Condition Data

1) Topography

The topography of Nicaragua is divided into three broad areas as follows: The Pacific plains area (including the volcanic mountain range), the Central mountain range area and the Atlantic coastal plain.

Of the study area roads, Nic.1, Nic.3, Nic.5 and Nic.15 are located in the central mountain range area, and Nic.24 and Nic.26 are located on the Pacific plain.

2) Geology

The oldest bedrocks of Nicaragua are considered to be the metamorphic rocks and granites which stretch northeast/southwest along the border with Honduras. At present, only gully erosion is seen and these rocks are weakened by heavy rain. The top layers have become soil through weathering and this is susceptible to be the source of debris flow during the hurricane season on some of the mountainside slopes.

Nic.15 Line runs through these areas, where terrace sand and gravels are distributed on the slopes, along with a variety of Quaternary deposits giving various geological combinations such as metamorphic rock and terrace sand/gravel, or decomposed granite soil and terrace sand/gravel.

It is confirmed through this Study that the black schist of Rivas Faces is distributed along narrow area on Nic.1, Nic.3, Nic.15 and Nic.26.

It is commonly said that the bedrock as distributed along project roads is in good condition. However, it is clear they can be fractured or become unstable and collapse likea landslide when they are cut as shown in Figure 3.3.1. More than 50% of the rocks in Nicaragua are volcanic, classified as effusive rocks of Paleocene and Neocene Periods.

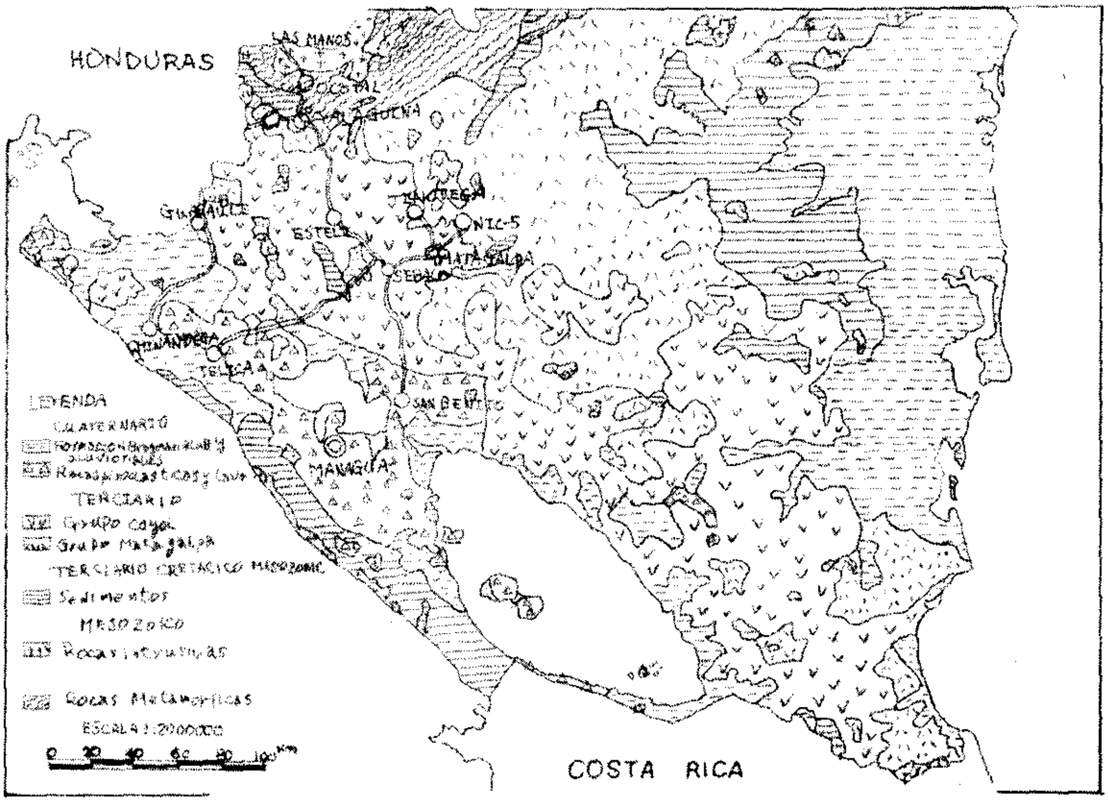


Figure 3.3.1 Geological Map of Nicaragua

Table 3.3.1 shows the records of volcanic eruption in Nicaragua in recent years.

Table 3.3.1 Main Volcanic Eruption in Nicaragua

Name of Composite	Mountain Height	First Eruption	Eruption Type	Affected
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

A hazard map is officially published based upon these records of volcanic activities. It is clear through Figure 3.3.2 that Nic.24 and Nic.26 could have a major effect on traffic depending upon the size of any volcanic activity, related to the Western Nicaragua fault. Records for all seismic sizes and centres (1992-1998) are also available and here the distribution of spots with an intensity of more 4.0 is shown in Figure 3.3.2.

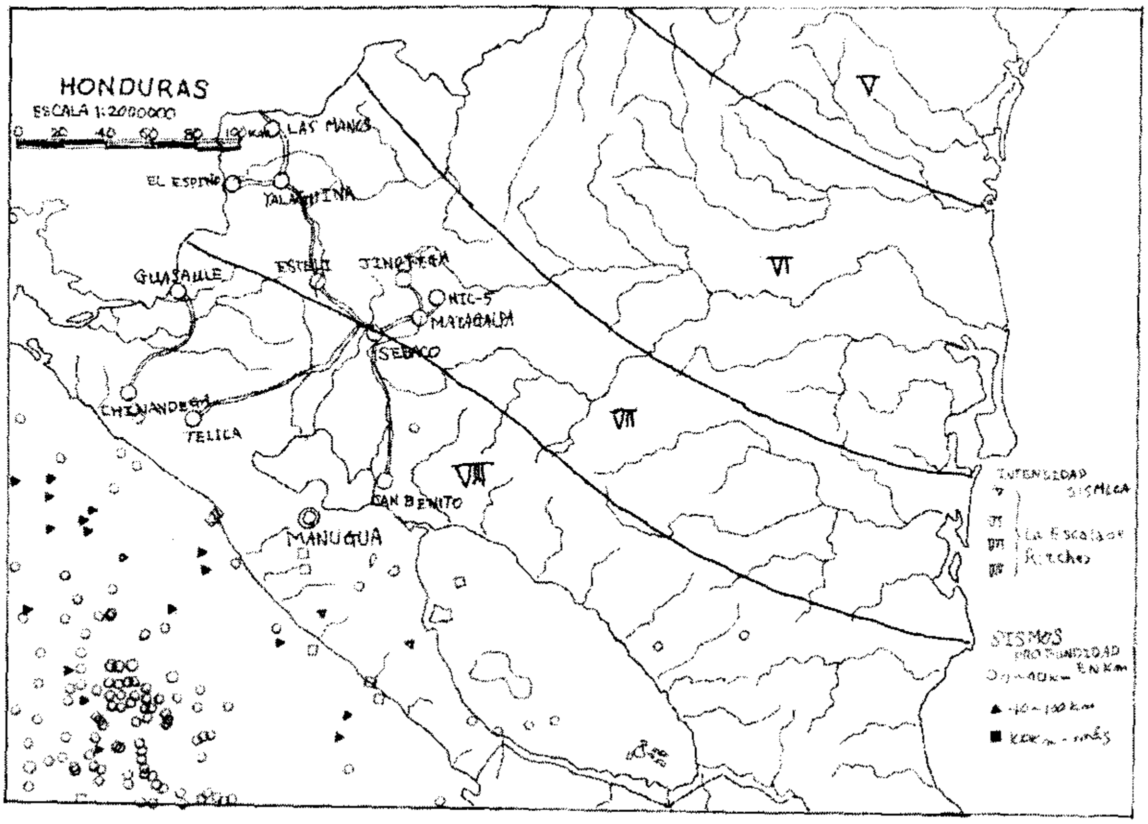


Figure 3.3.2 The Seismic Intensity

Legend (Explanation for Seismic Intensity)

	Most people perceive and many are awaked. 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 will be damaged.	Acceleration: 44-94
VIII	Strong buildings will also be damaged, chimney, monument, and walls will fall down, furniture falls sideways. Sand and mud will gush out a little bit and well water will change.	Acceleration: 94-202

3) Meteorology

The characteristics of rainfall and mean annual temperature in the study area are as shown in Table 3.3.2.

Table 3.3.2 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: INTEL

4) Hydrology

Tables 3.3.3 and 3.3.4 show the watersheds of Nicaragua sourced by INETEL.

Table 3.3.3 Pacific River watersheds 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

Table 3.3.4 Atlantic River watersheds of Nicaragua

Code	Atlantic watershed	Area (km^2)	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, INETEL

Within the study area, Nic.1 Nic.3, Nic.5 and Nic.15 fall in the Atlantic watershed, whilst Nic.24 and Nic.26 are mainly in the Pacific watershed.

3.3.3 Socioeconomic Condition Data

1) Land Use

According to the National Transport Plan (NTP) of Nicaragua, February 2001 land uses in Nicaragua are as shown in Figure 3.3.3. The detailed characteristics are presented in Table 3.3.5.

Table 3.3.5 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%

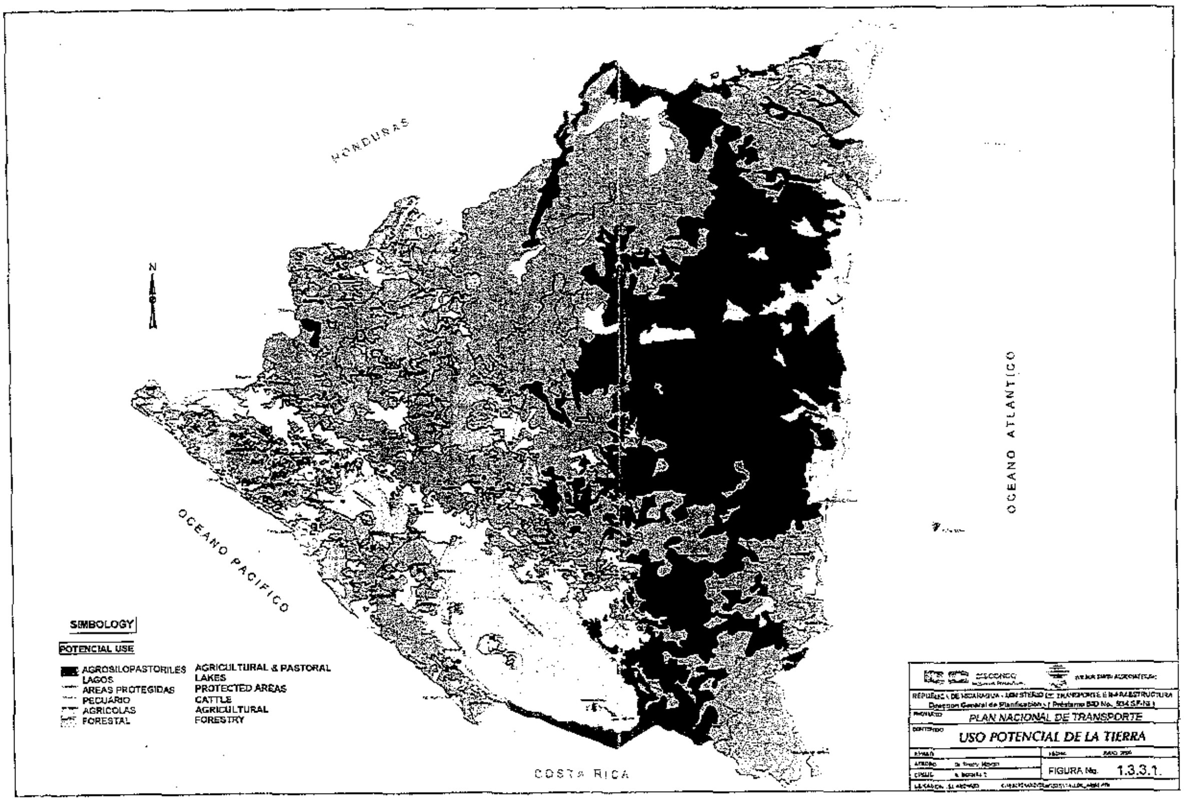


Figure 3.3.3 Land Use Map

2) Population

The roadside population in 1998 is shown in Figure 3.3.4. These data relate to the population in towns and villages along the project road. According to Figure 3.3.4, NIC.1, NIC.3 and NIC.24 higher roadside populations than the other routes.

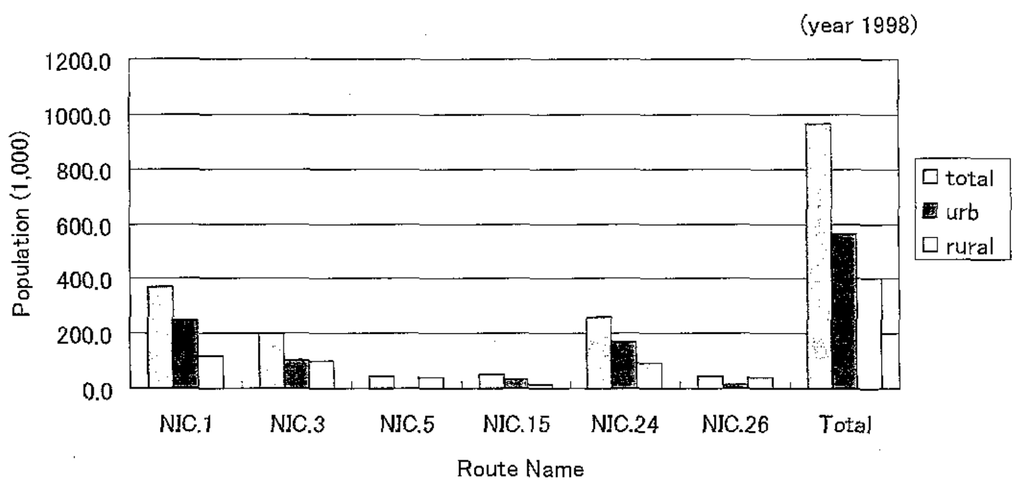


Figure 3.3.4 Roadside Population in 1998

Figure 3.3.5 shows the future forecast population between 1971 and 2019. The growth in population between 1971 and 1998 is around 30%. Growth between 1998 and 2019 will be a around 2.3. In the Matagalpa area it is forecast to be almost 4.

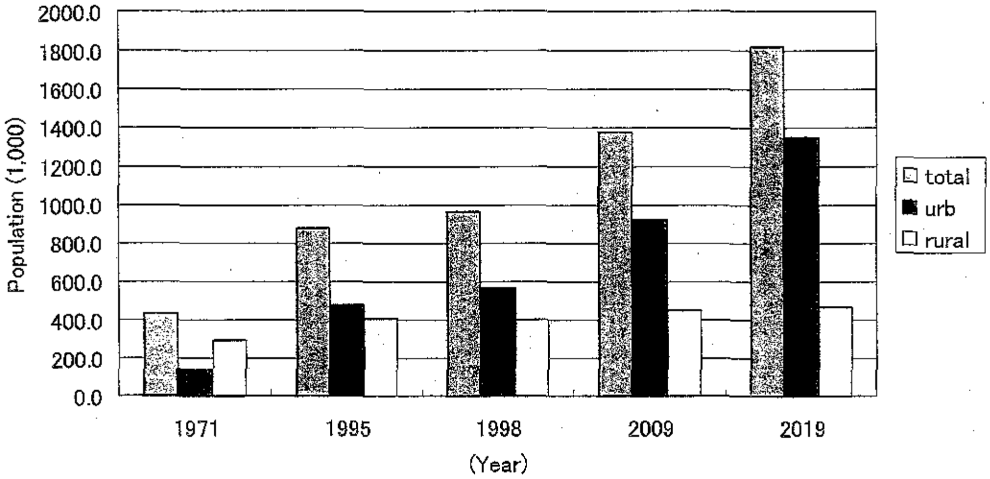


Figure 3.3.5 Roadside Population Between 1971 and 2019

3) Vehicle Registrations

These data are kept from year 1995 as shown in Figure 3.3.6. Around three-quarters of the country's vehicles are registered in the Managua region. The total growth rate in registrations was approximately 74 % between 1995 and 2000, with a growth in Managua of nearly 80 % in the same period.

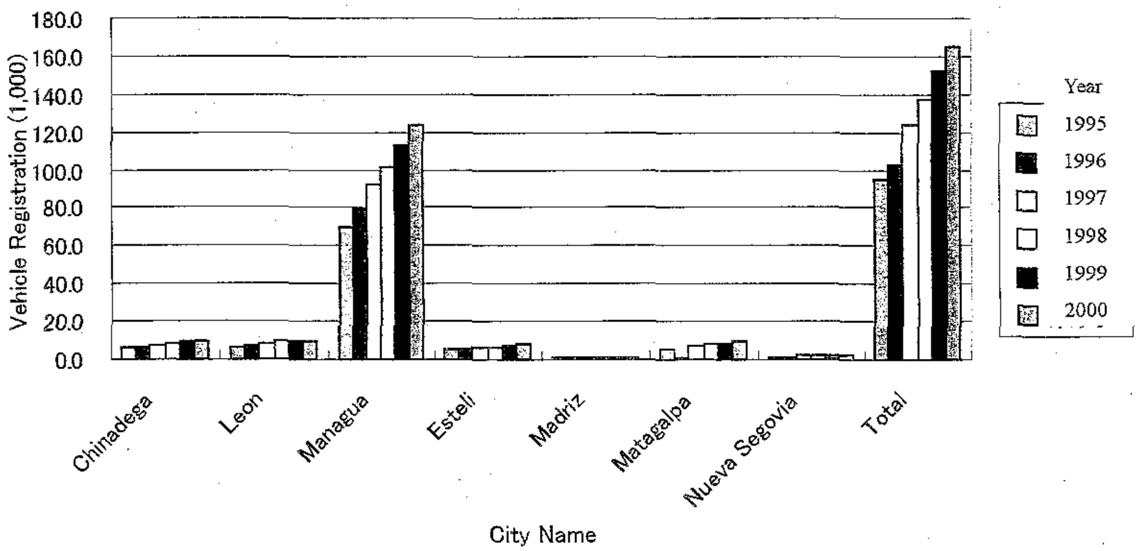


Figure 3.3.6 Vehicle Registration of Main Region

Table 3.3.6 shows the vehicle registrations by vehicle type and region for the year 2000. Managua region accounts for 76 % of total registrations, with car and pick up vehicles are forming 70 % of all vehicles in Managua.

Table 3.3.6 Vehicle Registration of Each Vehicle Type in Region (in year 2000)

	Chinadega	Leon	Managua	Esteli	Madriz	Matagalpa	Nueva Segovia	Total
Rooute	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

3.3.4 Road Network Data

1) Road Network

Based on the information of the Direction of Road in MTI in 1999, Nicaragua has a total road network of 19,000 km consisting of 41.8 % (8,000 kilometers length) Basic Road Network maintained by the Central Government, and 58.2% (11,000 km) Rural Road Network maintained by MTI. Only 10.1% of network is paved roads, and the entire stretch of earth roads and almost half of the gravel roads become impenetrable during each rainy season. Table 3.3.7 and Figure 3.3.7 show the National Road Network in Nicaragua.

Table 3.3.7 National Road Network

Administrational Classification	Total Length	
Basic Road Network	7,920.92	41.8%
Paved Road	1,794.14	9.5%
Gravel Road	5,359.23	28.3%
All Year Earth Road	767.55	4.1%
Rural Road Network	11,025.70	58.2%
Paved Road	119.08	0.6%
Gravel or Stone Paved Road	34.86	0.2%
All Year Earth Road	10,871.76	57.4%
Total National Road	18,946.62	100.0%

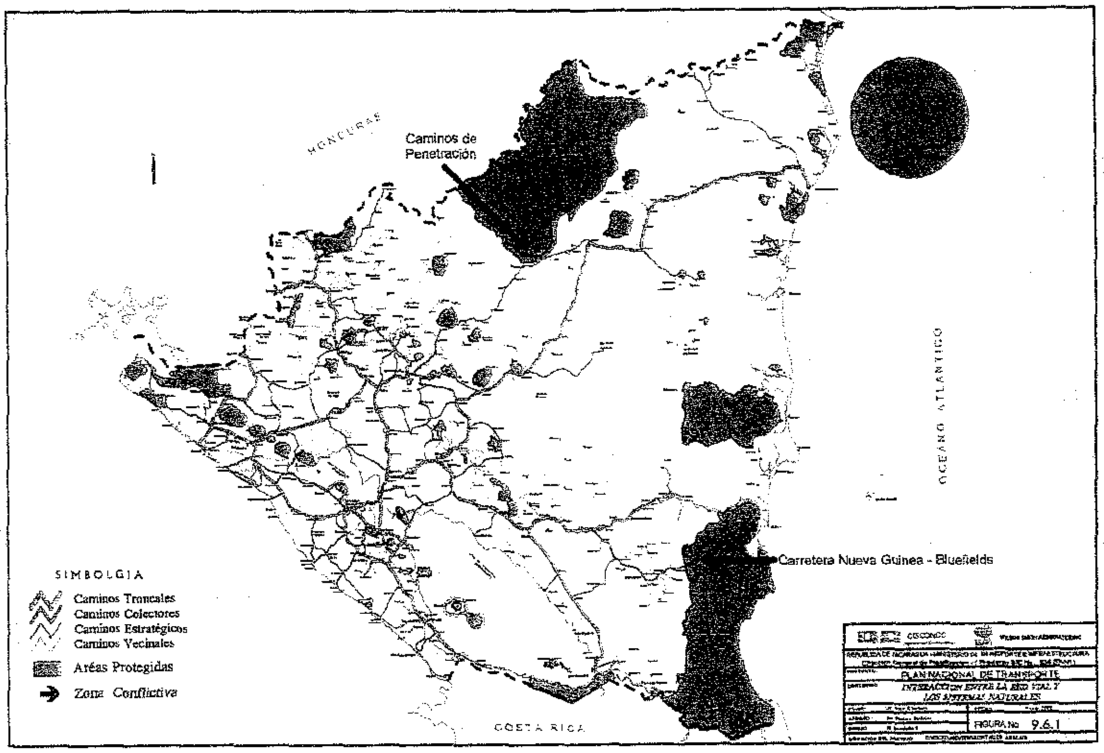


Figure 3.3.7 National Road Network in Nicaragua

2) Road Classification

Of the Basic Road Network in Nicaragua, the National Transportation Plan (NTP) recommended the following classification of 7,442.6 km length of the Basic Road Network.

Class A: (14 trunk roads, 1,748 km)

Class A roads are trunk roads (totaling 1,748 km of paved roads) handling between 80% and 90% of national traffic. The function of the trunk roads are to secure integration of national and international traffic.

Class B: (30 collectors, 636 km)

Class B roads are collectors connecting important population centers to the Class A road network. The function of the collector road is to provide access to the trunk road network for major and minor traffic.

Class C: (50 strategic local roads, 2,052 km)

Class C roads are existing local roads with the possibility of extending its functions to the following:

- To serve as a national and international trunk road
- To serve as a collector road
- To serve as a new trunk road
- To serve as an access to a port or airport

Class D: (Local Penetrating Road)

Class D roads are local roads penetrating, and providing service to, local areas, and linking these with the Class A, B, C network.

Based on the above classification, the objective roads for this study are Class A, Trunk Roads, with the exception of NIC 5 which is classified as a Class B, Collector Road, due to magnitude of traffic as shown in Table 3.3.8.

Table 3.3.8 Road Classification

Objective Road	Classification	Function
NIC 1	Class A	International Trunk Road
NIC3	Class A	National Trunk Road
NIC5	Class B	Collector connecting with population center
NIC 15	Class A	International Trunk Road
NIC 24	Class A	International Trunk Road
NIC 26	Class A	National Trunk Road

The average physical geometric characteristics of the country's paved roads are shown in Table 3.3.9.

Table 3.3.9 Geometric Characteristics of Paved Roads

The width of crown	6.0 - 10.0 m
The width of pavement	6.0 – 7.3 m
Right of way	20.0 – 40.0 m
Gradient	2 – 3%
Design Speed	60 – 80 Km
Maximum vertical	3 - 8%

3.3.5 Past Disaster Records

1) Past Disaster Record

Most disasters in Nicaragua are caused by topographical and meteorological conditions. Table 3.3.10 show the record of past disasters in the country.

2) Distribution of Road Damage by Disaster Type

Factors causing road disasters are heavy rains and floods caused by hurricanes, along with consequential landslides, as shown in Figures 3.3.10 and 3.3.11. Volcanic eruptions and earthquakes as shown in Table 3.3.11, Figure 3.3.12 and 3.3.13.

Table 3.3.10 Past Disaster Record (1/2)

No.	Year	Event	Place	Affectations
1	1609	Momotombo Volcano Volcanic Eruption	Old Leon	Evacuation of the population that inhabited the Old Leon City
2	1610	Earthquake	Old Leon	Evacuation of the population that inhabited the Old Leon City
3	1670	Masaya Volcano Lava Eruption (Lava falling down)	Masaya	The lava leakage coming from Nindiri Volcano covered an area from 2.12 kilometers. With a volume of 106x 10 mts.
4	1772	Masaya Volcano Lava Eruption	Masaya	From 16th to 23rd March, it produced the second lava eruption, that produced lava flow to the north and east of the volcano, covering a 7.51 kilometer area. And a volume of 22.5x10 mts, reaching around very near Sabanagrande.
5	1876	Hurricane Alluvion		From 2nd to 4th October, Managua city was covered by water and mud flows that came from ranges and the mountains located in the south of the city. The city remained semi destroyed.
6	1926	Earthquake Strong sysmic movement in Nicaragua	All the country	On Friday 5 November at 2:00 in the morning, a violent earthquake shaked all the country, Nicaragua. In Leon, the 80% of the building suffered breakdowns, and in Managua, the 50% of the buildings were damaged. In Managua also, the water dam from Ticuantepe was completely buried
7	1931	Earthquake	Managua	On March 31st, at 10:45 am, a shake of magnitude between 5.3 and 5.9 in the Ritcher scale destroyed the growing Managua city, causing losses in human lives. A thousand died and 2 thousand suffered injuries.
8	1968 and 1971	Cerro Negro Volcano		It caused 2 km long in lava flow during 53 days of activity. It expulsed big quantity of ashes, and brought up an eruptive column that affected an area from 5.7 km2, and destroyed a big quantity of acres of cultivated land.
9	1972	Earthquake	Managua	On December 23rd, there were three shakes of big magnitude, that caused the loss of lives to 10,000 persons. 20,000 were injured and 60,000 houses were destroyed. Estimate damages for 772 millions dollars.
10	1082	Hurricane Alleta	Pacific zone	In may affected la pacific zone, damaging road and bridges, infrastructure damages in the Occident, and also in agriculture. It were recorded 69 dead and estimate losses: 480 millions dollars.
11	1988	Hurricane Joan	Atlantic Coast	It destroyed the city of Blufields, Rama City and Corn Island. Results: 148 dead, 184 injured, 23,200 destroyed houses. Infrastructure damages: roads, bridges, power wires and communications. It affected more than 500,000 persons. Total losses: 840 millions dollars.
12	1991	Flood	Rama City	In July, the grow of the Escondido River caused flood in Rama City and La Esperanza Port, affecting around 20,000 persons, causing material damages in houses and animals
13	1992	Cerro Negro Volcano Eruption		XIV Cerro Negro Eruption, violent and short period. It forced to the evacuation of the peasant population. It expeled thousands cubic meters of ashes and sand, and the eruptive column height reached the 26 thousand feet. It affected 11,578 manz. of cultivable lands. 565 houses were semi destroyed and there were 100 injured. Estimated losses: 19 millions dollars.
14	1992	Pacific Coast Tsunami	Pacific coast	September 1st at 19:15 hrs, there was a shake in the button of the sea with a magnitude of 7.2 in the Richter scale, that affected the Pacific Coast. The tsunami caused waves from 8 and 15 mts height and affected the cost in 250 km length. 26 urban comunities suffered the consecuences from the phenomenom that left 116 dead, 63 dissapeared and 489 injured. Totally, there were 40,500 people affected. The estimated looses in damages: 25 millions dollars
15	1993	Tropical Storm Gert	South Atlantic Autonomous Region	On August 15th, at 12:00 hours, the tropical storm Gert whipped Blufields coasts with a speed of 17 km7hr., strongly affecting the South Atlantic Autonomous Region. It left13 dead, 24 disappeared, 62,192 injured, 252 destroyed houses and 292 damaged houses
16	1993	Tropical Storm Bret	North Atlantic Autonomous Region	In September, the North Atlantic Autonomous Region was affected by the Bret Tropical Storm, causing 1,138 destroyed houses, 1,530 damaged houses, and 65,029 people injured. The estimate losses are around 5.1 millions dollars.

Table 3.3.10 Past Disaster Record (2/2)

No.	Year	Event	Place	Affectations
17	1995	Flood	All the country	The intense rains that began on september 25th continued until october 11th. During those 18 days generated serious economic damages to the urban population an the rural population form the regions I, II, IV, and VI. 3,525 people were affected, 32 people died, 1,343 injured, 71 destroyed houses, 161 partially damaged, 1,214 affected wells , 1,050 floos latrines, 1,525.3 km of damaged roads and 13 destroyed bridges. Estimated economic losses of 17, 219,363.00 dollars. 11, 643,788.00 belonged to the agriculture production.
18	1995	Volcanic Eruption	León	On November 19th, the Cerro Negro Volcano's eruption affected an area from 9,839 manz. (1manz= 10,000mts2) with volcanic sediment (sand) covering
19	1996	Hurricane Cesar	North Atlantic Autonomous Region	On July 27th, Hurricane Cesar beat around 30 kms of the Atlantic Coast, aproximately to the north of Blufields, crossing the country in direction to the Pacific coast on the Padre Ramos Estuary, in Chinandega Department. It caused more than 100,000 affected, including 31,828 injured and economic losses for more than 29 millions dollars.
20	1998	Hurricane Mich	All the country	The worst natural disaster in the Nicaraguan history. Intense rains that began on october 22 and continued until october 31.The most critical period during the 27th and 31th october.The hurricane stay stacionary between the 21:00 hours on october 28th until the 19:00 hours from the 29th.Mitch go throw the land about 50 km south west from Trujillo city in Honduras. Mitch caused 870,000 victims, 2400 death, 287 hurts, 938 people disappear.US$1504 millions material loss(94% from de active, 6% production), 145,700 houses affected, 3,750 houses destroyed, 80% from the road network: 8000km road damage, 3800ml bridges damage, 42 bridges destroyed , 29 bridges semi destroyed.The total loss on the business area are consist on: US$ 14,4 millions in export (including the shrimp export), US$ 31,3 millions on agro products, US$ 8 millions on factory, US$ 18 millions on electric , US$ 20 millions on potable water, US$ 12 millions on connection , US$84 millions on the health area, US$ 51 millions on education.

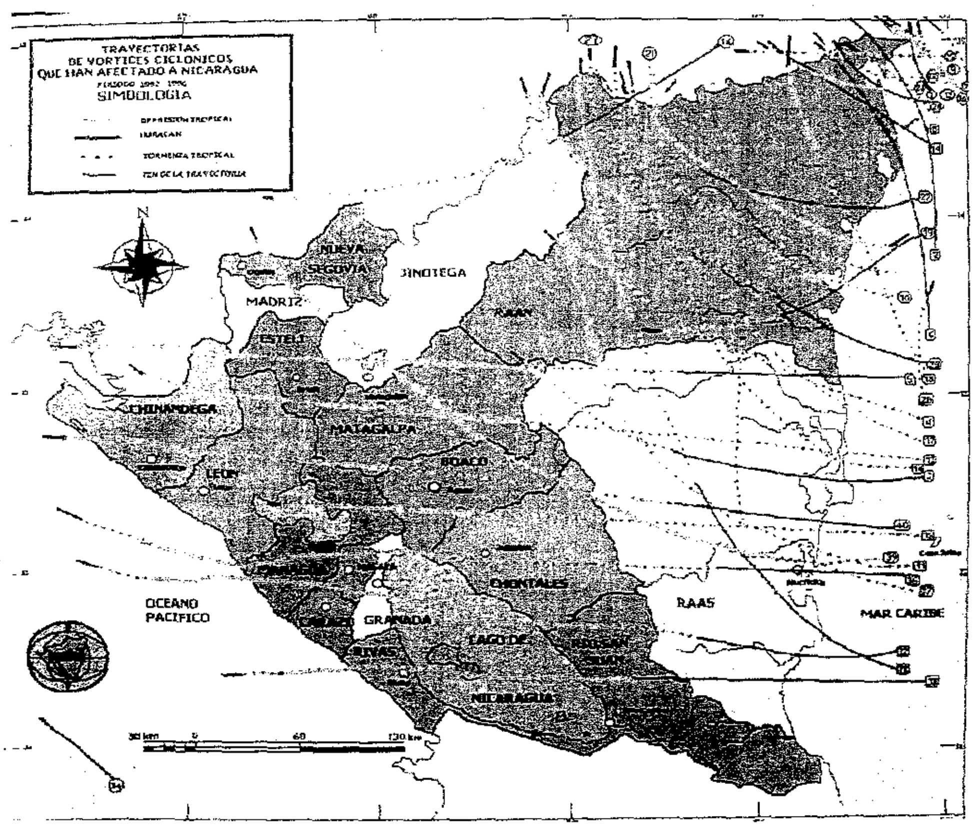
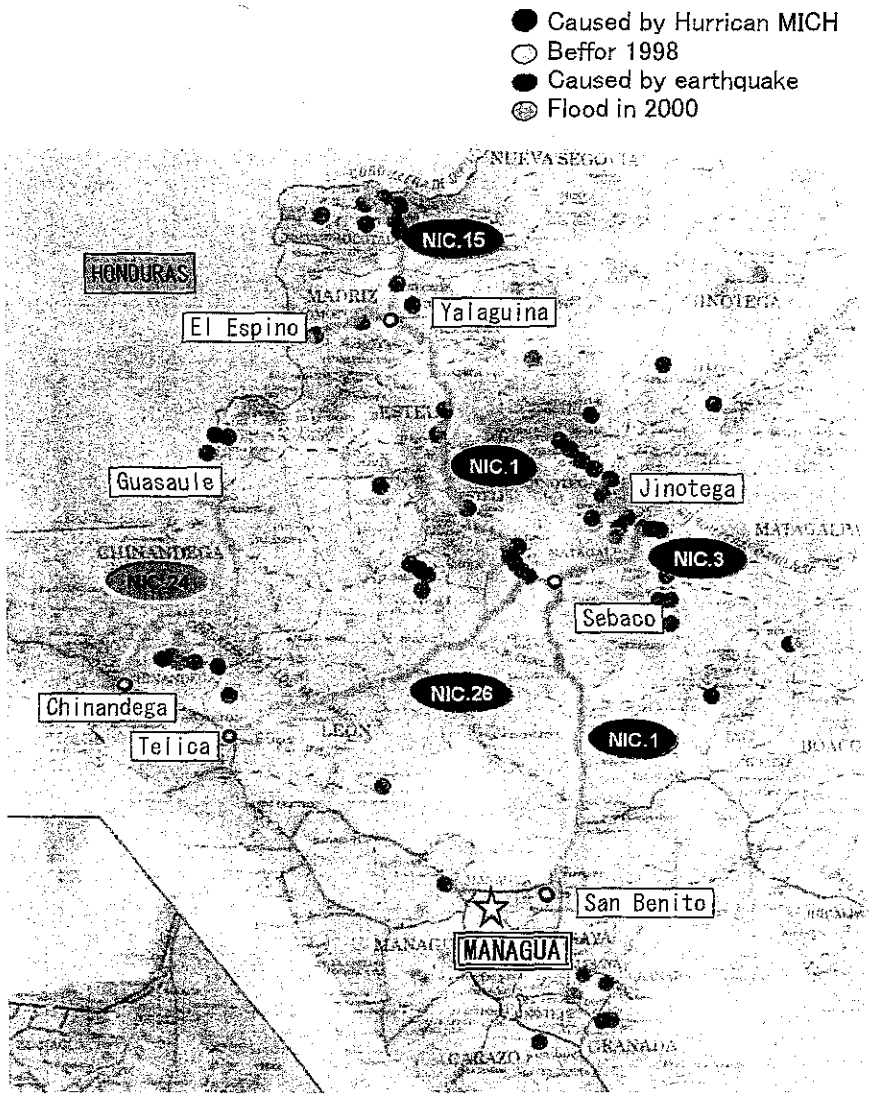


Figure 3.3.10 Route of Past Hurricanes

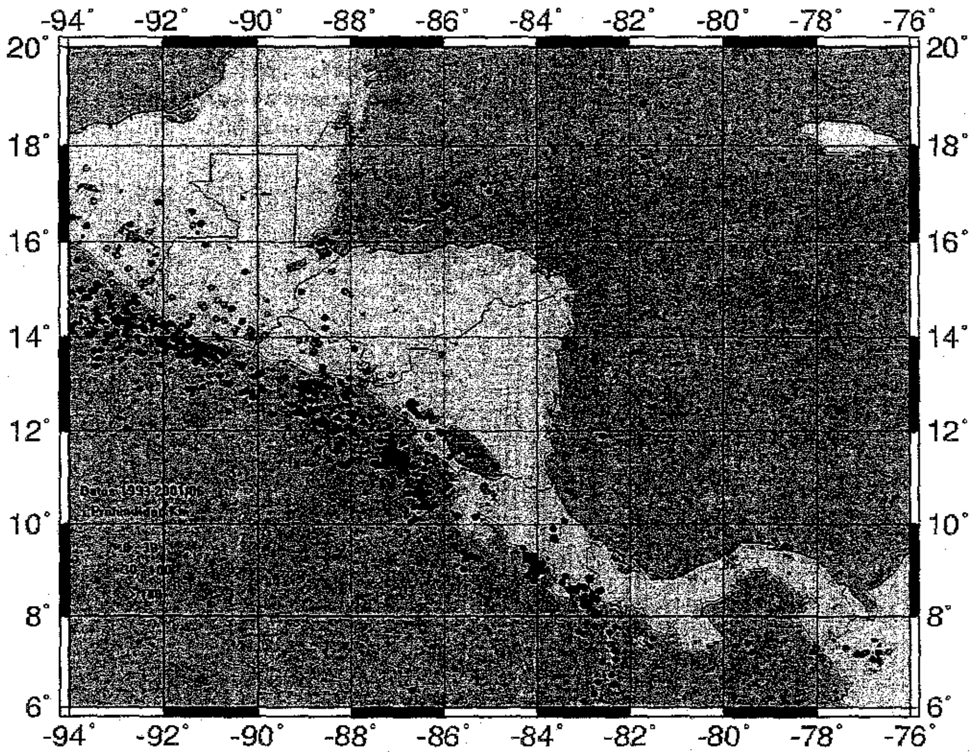


(INETER)

Figure 3.3.11 Location Map of Landslides

Table 3.3.11 Frequency of Earthquake on Objective Road

Road Name	Section	Grade
Nic1	From San Benito to Las Maderas	4
	From Las Maderas to Ciudad Dario	3
	From Ciudad Dario to Sebaco	2
	From Sebaco to El Espino	2
Nic 3	From Sebaco to jinotega	2
Nic15	From Yalaguina to Las Mands	2
Nic 24	From Cinandega to Estero Real	4
	From Estero Real to Guasaule	3
Nic26	From Terica to El Jicalral	5
	From El Jicalral	3



(from INETER)

Figure 3.3.12 Distribution of Epicenter

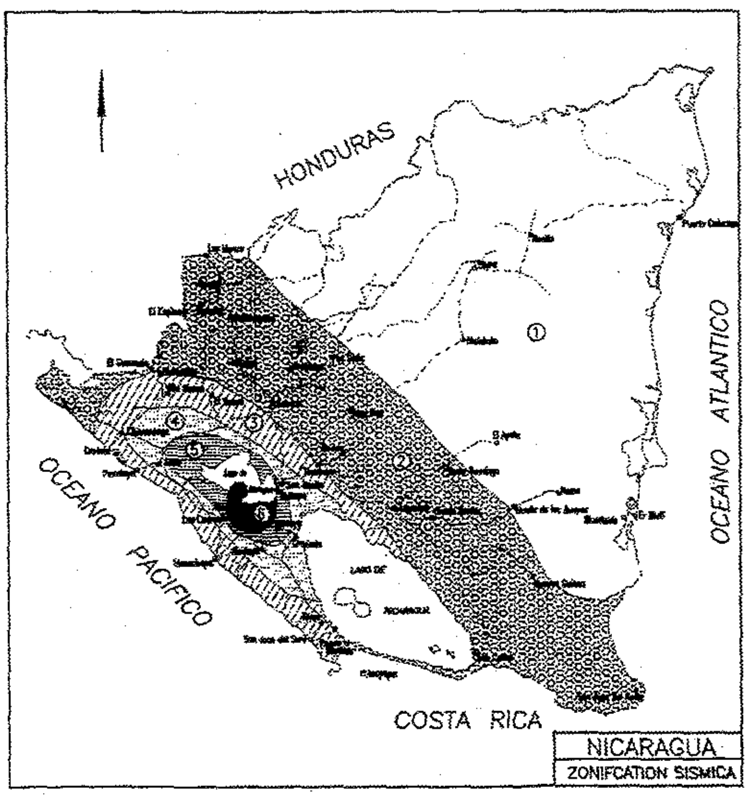


Figure 3.3.13 Classification of Earthquake

3.4 Survey Sheets

3.4.1 Stability Survey Sheets

The "Stability Survey Sheets" are composed of items which vary according to each road disaster type. The key factors for each are noted below.

- Rockfalls, collapsing : countermeasure, disaster record, stability in case of earthquake and total evaluation
- Rock collapsing, : countermeasure and total evaluation
- Slope slide : disaster record, countermeasure and total evaluation
- Debris flow :countermeasure, road structure, disaster record, assumed disaster type, total evaluation
- Scouring of bridge foundation : stability of riverbed and revetment, situation of abutment and pier, transformation, total evaluation

A sample of a Stability Survey Sheet is shown in Figure 3.4.1. Other sheets are presented in page A1-5 to page A1-9 in Appendix-1.

Stability Investigation Table (Rock Falling, Collapse)

Item		Factor	Cut Slope Clasification		Grades	Evaluation Grade	Natural Slope Clasification		Grades	Evaluation Grade
Topography	Topography that contains collapse factor	G1:Talus	One corresponds to G1		3		Several correspond to G2		3	
		G2: Collapsing traces					One correspond to G2		2	
		: Nick line is clear	No correspond to G1		0		No correspond to G2		0	
		G3:Erosionable terrace lap	Several correspond to G2,3		3		Several correspondto G1,3		3	
		over hang, slope that contains water	Corresponds to G2,3		2		One correspond to G1,3		2	
		debris flow traces	No correspond to G2,3		0		No correspond to G1,3		0	
		G4:There is a ridge in the peak, over hang	Corresponds to G4			(6)	Corresponds to G4			(6)
Soil, Geology, Structure	Soil that ruins	Soil that is easily erosionable (Soil that lose resistence by absorbing water, others)	Notable		8		Notable		2	
			A little notable		4		A little notable		1	
			No correspond		0	(8)	No correspond		0	(2)
	Quality of the erodable rock	High density in cracks or fragil layer. Soft rock easily erosionable. Quality of quickly erosion.	Notable		12		Notable		6	
			A little notable		6		A little notable		4	
			No correspond		0	(12)	No correspond		0	(8)
	Collapse Structure	LAYER DIRECTION (stratification, weak line)	Correspond		8		Correspond		2	
			No correspond		0		No correspond		0	
		Soils upon impervios rocks (Hard rock in the superior area/ inferior part is soft)	Notable		6		Notable		4	
			A little notable		4		A little notable		3	
			No correspond		0	(14)	No correspond		0	(6)
Soil Surface Condition	superficial soil condition, , loosening and boulder stone		Unstable		12		Unstable		24	
			A little unstable		6		A little inestable		12	
			Stable		0		Stable		0	
	Collapsed rocks		Correspond			(12)	Correspond			(24)
	and bounder stone are unstable— a little unstable									
	Inflow water situation		There is inflow water		8		There is inflow water		4	
			leak out a little		4		Leak out a little		2	
			No exist		0	(8)	No exist		0	(4)
	Surface soil condition		denude soil-vegetation		5		Denude soil-vegetation(grass)		16	
			Compound (vegetation, stru		3		Compound (denude soil, grass,		10	
			Structures		1	(5)	Trees		6	(16)
Shape	Inclination(i), Height		Soil	H>30m	18		Height	H>50m	10	
				H≦30, i>norma	15			30≦H<50m	8	
				i≦norma,15	10			15≦H<30m	6	
				i≦norma,15≦H<30	5			H<15m	4	(10)
			Rock	H≧50m	18		Inclination	i≧70°	10	
				30≦H<50m	16			45°≦i<70°	10	
				15≦H<30m	12			i<45°	5	(10)
				H<15m	10	(18)				
Deformation	Slope and cliff deformation (fisility, little rocks falling,scouring, piping hoe, subsidence, conceiving, tree fall, joint, open joint, work done deformation)		Several correspond,somewhat clear		12		Several correspond,somewhat clear		10	
			Correspond. Not so clear		8		Correspond. Not so clear		5	
			No exist		0	(12)	No exist		0	(10)
	Slope deformation and close cliffs. (rock falling, collapse, joint, conceiving, others)		Several correspond,somewhat clear		5		Several correspond,somewhat clear		4	
			Correspond. Not so clear		3		Correspond. Not so clear		2	
			No exist		0	(5)	No exist		0	(4)
	Total		Slope: Total grade			0	Natural Slope Total grade			0

hundimiento, hinchamiento, arbol caída, grieta, grieta abierta, deformación de obras realizadas)

Inspector's Name	

[Treatment Works] (Bi)=(Ai)+α o (Ai)X0

Efficiency of the works done	Evaluation Grade: Slope	Evaluation Grade: Cliff
Well protection of the rock falling and foreseen collapses. Or if disasters occur, it works sufficiently.		
It protects in certain degree the rock falling and foreseen collapse. It works when disasters occur, but not		
It protects in some parts the rock falling and foreseen collapses. When disasters occur, it works somewhat.		
There is no any kind of treatment. Or if it exist, it is not working at all.		
	(B1:Slope)	(B2:cliff)

[History] ○
*There is no need to make history evaluation if rock falling or slope/cliff collapsing has no occurred after the realization of the threatment work.
→(C) es 0

Frequency clasification and disaster degree.	Evaluation Grade
After the recent threatment, it caused a traffic disturb. (The work done, did not operate)	
Dit not caused problems to the traffic, but there is history that big rocks and collapses reached the road. (The work was not efficient)	
There is the history that fallen rocks and collapses reached the slope lap or cliff lap. (The work done it is functioning in certain degree, but it is necessary to do a complementary work)	
	(C)

(D)=MAX(B,C)

- Evaluation through the factor point
- Evaluation by History
- The highest between (B) and (C)

[Stability in case of ea

Stable
Unstable

*If you notice G4 of To stones are unstable, yo

[Total Evaluation]

Countermeasure	Evaluation
It is needed to take counterm	
To respond to the elaboration	
There is no need of new countermeasures.	

Figure 3.4.1 Sample of Stability Survey Sheet (Rockfalls, collapsing)

3.4.2 Tables of Survey Result

The survey results of inspection spots should be entered into the "Table of Survey Result" according the following items. (These tables of inspection results are presented in pages A1-1 of Appendix-1).

- No. : number to be controlled
- Name of the Road
- Road Classification : National road, Rural road, etc.
- Name of the Site
- Inspection Item
  - A: Rockfalls, collapsing
  - B: Rock collapsing
  - C: Slope slide
  - E: Debris flow
  - H: Scouring of bridge foundation
- Traffic Restriction : In advance - 1, In special - 2, No - 3
- Restriction Criteria :
- Detour : Exist - 1, Nothing -2
- Inspection of result year **
- History of Disaster : Yes – 1, No but admitted – 2, No - 3
- Inspection Result of year 2002 : score of factor, countermeasure and disaster record

  Total evaluation : countermeasure necessary - 1
: disaster prevention record necessary - 2
: no necessary - 3
- Proposed Countermeasure work : type, norm, quantity, cost
- Stability in case of earthquake : stable - 1, unstable - 2.

3.4.3 Figures of Survey Result

The survey results of inspection spots should be written onto the maps contained in the "Figure of Survey Result" according the following items. (The sample figure of inspection result is presented in page A1-2 in Appendix-1).

Unique identifier as follows

N001 A 030 (1)

Route No. — N001
Inspection item — A
Serial No. of site — 030
Integral evaluation — (1)

- Route No. : N001 (This means Nic. 1)
- Inspection item
  - A: Rockfalls, collapsing
  - B: Rock collapsing
  - C: Slope slide
  - E: Debris flow
  - H: Scouring of bridge foundation
- Serial No. of site : site of thirtieth (30) on Nic.1
- ○,△,x : mark for site inspection
  - ○ : Inspection site in 2002
  - △ : Inspection site in before 2002
  - x : Inspection site where has the damaged record
- Integral evaluation
  - (1) : It is necessary countermeasures
  - (2) : It is necessary to consider prevention work
  - (3) : It is not necessary countermeasures

3.4.4 Record of Inspection Spots

The survey records of inspection spots should be written into the table of "Record by inspection site". A sample table of inspection site is presented in page A1-3 in Appendix-1.

3.4.5 Past Disaster Records of Inspection Spots

The past disaster records of inspection spots should be also written into the table of "Record by site of inspection". A sample table is presented in page A1-4 in Appendix-1.

3.5 Assessment Items/ Scores of Disaster Potential/ Critical Spots

3.5.1 General

As described in Chapter 2, after screening has been carried out at inspection spots, engineers should carry out a stability survey. Engineers should enter scores onto the survey sheets at that time. After surveying, it is very difficult to assess the inspection spots as a disaster potential spots or disaster critical spots.

The important factors used to define disaster potential spots and disaster critical spots are set out below.

3.5.2 Definition of Disaster Potential Spot

Traffic volumes on the 6 objective major roads are different. Traffic demand is forecast to increase on all roads by 2019. Therefore, traffic volume is not included as an assessment factor.

Disaster potential spots are defined where the following exist.

- boulders on slope surfaces,
- Many cracks on rock surfaces,
- Small rocks falling, and
- Disaster records regarding rock-fall, rock collapsing, slope slide, and scouring of bridge foundations.

- **for bridge : seventy (70) score over.**

<Definition>

This score should be assessed according to : riverbed incline (15), bridge location (20), minimum span length (15), ratio of river flow blockage by piers (15), and clearance under the deck (10). The total score for all factors is 75 points. A disaster potential spot is defined when the score is 70.

Where there are unusual bridge sites, a lower score may also indicate a disaster potential spot, for example where the bridge location is at bend on the river, an abutment protrudes into the river, or the foundation is constructed of a bent pile.

- **for cut/ embankment slope : sixty (60) score over**
-

<Definition>
The score of cut and embankment slope should be assessed according to : soil or rock structure (8 or 12), vulnerable mechanics (14), unfixed stones or boulder stones of slope surfaces (12), slope incline or height (18), and slope transformation (12). The total score of these factors is 64 or 68 points. Selected disaster potential spots of cut/ embankment slope should score 60 or more.

For rock collapsing, scoring comprises crack scale of rocks (30), continuous horizontal cracks (10), condition of soft or hard rocks (11 or 15), and direction of bedrock (15). The total score for these factors is 66 or 70 points. Selected disaster potential spots of rock collapsing, should score 60 or more.

For debris flow, scoring comprises the area of the basin (10), steepest mountain torrents incline (10), area of slope incline in 30 degree over (8), and area of field grass or tree (8). The total score of these factors is 36 points, but the total original score was 56 points. The ratio of these highly important factors and the total original score is 0.64. Therefore, the score of debris flow could be up to 64 points. Selected disaster potential spots of debris flow, should score 60 or more.

The results of the definitions regarding each type of disaster potential spot are presented in Appendix-3.

3.5.3 Definition of Disaster Critical Spots

Disaster critical spots should be defined, considering the following items identified at disaster potential spots.

- Disaster scale/ records at the spot,
- A necessary spot for emergency,
- Critical spot for third persons,
- Topographic data from preliminary topographic surveys, and
- Sketches of site conditions.

As noted in Section 3.5.1 (Definition of Disaster Potential Spots), there are key definitions used to assess the disaster critical spots. The results of these definitions for each type of disaster critical spot are presented in Appendix-3.

From these definitions, the score for disaster critical spots is 90 for bridge foundation scouring and 70 for rock-falls, rock collapsing and slope slide.