No.

MINISTRY OF PUBLIC WORKS AND TRANSPORT
REPUBLIC OF COSTA RICA

THE STUDY
ON
CAPACITY DEVELOPMENT
IN
BRIDGE REHABILITATION PLANNING, MAINTENANCE AND MANAGEMENT
BASED ON
29 BRIDGES OF NATIONAL HIGHWAY NETWORK
IN
COSTA RICA

FINAL REPORT
2 of 3
MAIN TEXT

February 2007

JAPAN INTERNATIONAL COOPERTATION AGENCY

Oriental Consultants Company Limited

Chodai Company Limited

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The following foreign exchange rates are applied in the Project:

USD 1.00 = 116.91 JPY (as of August 2006)

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PREFACE

In response to the request from the Government of the Republic of Costa Rica, the Government of Japan decided to conduct the Study on Capacity Development in Bridge Rehabilitation Planning, Maintenance and Management based on 29 Bridges of National Highway Network and entrusted to study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Dr. Masaaki TATSUMI of Oriental Consultants Co., Ltd. and consist of Oriental Consultants Co., Ltd. in association with Chodai Co., Ltd. to Costa Rica, between September 2005 and January 2007.

The team held discussions with the officials concerned of the Government of Costa Rica and conducted the technical assistance for Capacity Development in bridge maintenance and rehabilitation as well as reinforcement and rehabilitation design for 10 selected bridges at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report in February 2007.

I hope that this report will contribute to develop their capacity in bridge maintenance and rehabilitation of Costa Rica, 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 Costa Rica for their close cooperation extended to the study.

February 2007

Kazuhisa MATSUOKA
Vice President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

February 2007

Mr. Kazuhisa MATSUOKA,
Vice President
Japan International Cooperation Agency (JICA)
Tokyo, JAPAN

We are pleased to submit to you the Final Report of the Study on Capacity Development in Bridge Rehabilitation Planning, Maintenance and Management based on 29 Bridges of National Highway Network.

This Study was conducted by Oriental Consultants Co., Ltd. in association with Chodai Co., Ltd. under a contract to JICA, during the period from September 2005 to January 2007. In conducting the Study, we have completed the technical assistance for Capacity Development in bridge maintenance and rehabilitation as well as reinforcement & rehabilitation design for 10 selected bridges.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, Ministry of Foreign Affairs of Japan, Ministry of Public Works and Transport (MOPT), National Road Counsel (CONACVI), JICA Costa Rica Office, and Embassy of Japan in Costa Rica for their cooperation assistance throughout the Study.

Finally, we hope this report will contribute to further cooperation of Costa Rica.

Very truly yours,

Masaaki TATSUMI
Team Leader, Study Team of the Study on Capacity Development in Bridge Rehabilitation Planning, Maintenance and Management based on 29 Bridges of National Highway Network

Project Location Map

29 targeted bridges Location

Project Outline

1. Country	Republic of Costa Rica
2. Name of Study	The Study on Capacity Development in Bridge Rehabilitation Planning, Maintenance and Management based on 29 Bridges of National Highway Network in Costa Rica
3. Counterpart Agency	Ministry of Public Works and Transport
4. Objectives of the Study	・ Assistance for the Capacity Development on the Bridge Rehabilitation Planning, Maintenance and Management ・ Implementation of Inspection, Diagnosis and Rehabilitation & Reinforcement Plan for Bridges on Trunk Roads ・ Establishment of Tools for the Bridge Maintenance（Bridge Management System (BMS), Manual & Guideline）

1. The Study Area

・29 bridges on National Road Network (Route 1, 2, 4, 32, 218) including 10 bridges for Rehabilitation & Reinforcement Planning

・Governmental Agencies, Stakeholders relevant to the Bridge Maintenance.

2. Components of the Study

1) Formulation and implementation of the Capacity Development Program for Bridge Management & Maintenance

a) Capacity gap assessment
b) Formulation of the Basic policy and the Plan of the capacity development
c) Implementation of the Capacity development

2) Evaluation of the Exiting Condition (Inspection/Diagnosis) : on 29 bridges

a) Establishment of the Inspection method and Implementation of the site inspection
b) Establishment of the Evaluation method of bridge deficiency and Selection of 10 prioritized bridges

3) Formulation of the Rehabilitation & Reinforcement Plan for Bridges：on 10 bridges

a) Implementation of the Detailed inspection
b) Implementation of Studies on natural conditions (River conditions, Geological examination)
c) Implementation of Bridge loading test (technical transfer of the testing procedure is a main objective)
d) Examination and Selection of construction plans for the rehabilitation & reinforcement
e) Elaboration of the Rehabilitation & reinforcement design and drawings.
f) Implementation of the Preliminary construction plan, Cost Estimation and Economic analysis
g) Implementation of IEE and Stakeholders meetings, Assistance on formulation of the ToR for EIA

4) Establishment of tools for the bridge maintenance (Bridge Management System (BMS), Manual & Guideline)

3. Narrative Description

Capacity Development

"Capacity Gap Assessment" was conducted in basis of interviews with relevant institutions in order to comprehend existing issues of the bridge maintenance on Individual, Organizational and Institutional/Social levels. Throughout the PCM method (Problem & Objective Analysis), Basic policies and CD program, which comprises 13 prototype modular projects, were formulated. As a main supporting body for the implementation of the program, "Bridge Maintenance Consulting Group (BMCG)" was organized sector-crossingly with members from Public-Private-Academic sectors. To enhance the implementation, 5 integrated modular projects were further clustered and allocated to 5 working groups formed in BMCG to prepare preliminary Work Breakdown Structure (WBS) & Action plans (PO). During the study period, Human Resource Development aimed at improvement of individual capacities were anticipated prior to initiation of the full-scale program, while an organizational structure was proposed for organizational capacity development by the Study team. At the end of the Study, PPP regional seminar were designed and conducted together with the Counterpart Agency in order for Costa Rica to initiatively disseminate outputs/outcomes amongst PPP countries. Through the presentations at the seminar by counterparts, a progress currently stepped of the capacity development was verified.

Rehabilitation & Reinforcement Plan and Tools for the Bridge Maintenance & Management

The site inspections were undertaken on 29 study bridges and the evaluation method for bridge deficiency was established. 10 prioritized bridges were selected to implement the detailed inspection, planning & designing for bridge rehabilitation/reinforcement, construction plans & cost estimation and economic analysis. After streamlining procedures in harmonization with actual states of the bridge maintenance in Costa Rica, BMS was thoroughly established. In addition, other supplemental tools for the bridge maintenance i.e. Bridge inspection manual, BMS operation manual and Guideline for the bridge management were elaborated.

4. Conclusion and Recommendations

- 5 integrated modular projects were abstracted and streamlined throughout the Study. In addition, BMCG and Working groups were organized for further implementation. It is recommended that the bridge management is duly to be implemented in accordance with those 5 integrated modular projects for future scene of the bridge management in Costa Rica.
- It is recommended that each Working group is to be uninterruptedly operated focusing on the following aspects.
  - Individual Capacity Improvement of MOPT & CONAVI Officials
  - Long-term Human Resources Development & Technical Information Exchanges
  - Improvement of Regulations & Standards
  - Promotion of Advocacy of Government Officials & Public Relations
- Continuous Monitoring & Evaluation on Outcomes for Capacity Development Process is consequently to be required

SUMMARY OF PROJECT

Study Period: From September, 2005 to February, 2007
Counterpart Agency: Ministry of Public Works and Transports, National Road Counsel

S.1 Background and Objectives of the Study

The road network in Costa Rica reaches over 35,000 km of total length and comprises international trunk roads named Pan-American Highway. Since the overland mode is the most predominant transportation in the Central America comparing with the air or the marine transportation mode, improvement of the road network is a key factor on developing and integrating economy in the region. Consequently, it is a common understanding that deficiency on the road maintenance shall socio-economically produce immense and regional-wide impacts in the Central America.

Under the circumstances that most of 1,330 bridges on the national highway suffer from severe deteriorations caused by earthquakes, river flowing and increasing traffic volume, deficiency on the road maintenance has allowed those deteriorations to reach more critical levels. The National Development Plan of Costa Rica states that the bridge rehabilitation on trunk roads is particularly key tractions to accelerate the economic growth in the country.

Given the preceding, the Government of Costa Rica requested the Government of Japan to implement technical assistances on the bridge management system. In response to the request, the Study was decided to conduct. The Study was conducted on the 29 targeted bridges on trunk roads focusing on an assistance for the capacity development for the bridge reinforcement, rehabilitation and the bridge management with the following schedule.

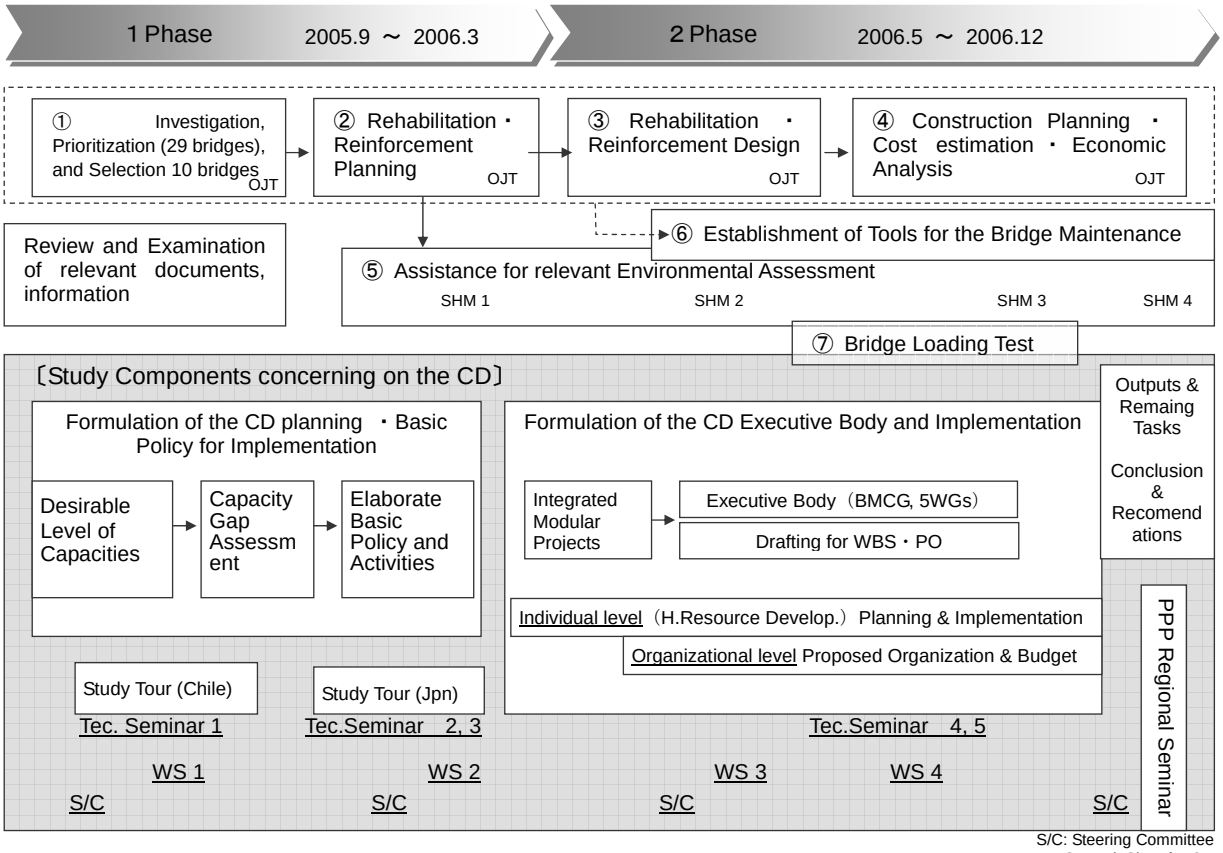

Figure 1.1. Components and Schematic Process of the Study

S.2 Review and Examination of Relevant Documents and Data

National and Socio-economic conditions were reviewed on the following items.

- Natural condition: geography, climate, seismic
- Socio-economic state: Land use, Population data/Social index, Economy and Industry
- Present state of the road network
- Present state of the road maintenance

S.3 Existing Condition of Bridges and Status of Bridge Maintenance

In order to comprehend a present state of bridges and the bridge maintenance, the following items are examined.

- Existing condition of bridges in Costa Rica
- Bridge Design Standards
- Bridge Maintenance (Executive organization, Bridge maintenance system)

S.4 Capacity Gap Assessment

The full-scale capacity gap assessment was jointly conducted with counterpart officials of MOPT and CONAVI in order to evaluate capacities at "Individual", " Organizational" and "Institutional and Social" levels in terms of the bridge maintenance, and thereby to identify existing problems. The assessment was implemented throughout interviews with relevant institutions as follows:

a) MOPT, its related departments and regional offices
b) CONAVI, its related departments and regional offices
c) Other relevant government ministries and agencies such as MOH, MIDEPLAN, CNC, MINAE, SETENA and etc.
d) University of Costa Rica and its related research institutes such as LANAMME
e) Costa Rica Architect and Engineering Association
f) Private sector such as contractors and design companies
g) Users such as truckers, passengers and citizens

The procedures for the capacity gap assessment include the following steps. 1) Designing capacity gap assessment score sheets, 2) Interviews and collection of data/information from relevant stakeholders, 3) Preliminary assessment of capacity gaps as well as Full-scale assessment of capacity gaps. PCM (Project Cycle Management) analysis including the problem analysis and the objective analysis were employed to solve the bottleneck against the ideal bridge management.

Upon the problem analysis, the core problem of "Inappropriate Bridge Maintenance" was derived from i) insufficient bridge maintenance capacity, ii) weak organizational structure on bridge maintenance, iii) insufficient budget for bridge maintenance, iv) insufficient enforcement of laws, regulations and standards, and v) insufficient knowledge management on bridge maintenance.

S.5 Basic Policies For Capacity Development

In order to solve problems identified by the problem analysis, the program for the total management of the bridge maintenance and rehabilitation, which is composed of the cluster of 13 proto-type modular projects, is consequently proposed throughout the objective analysis and the alternative analysis.

S.6 Implementation of Capacity Development for Comprehensive Bridge Maintenance Program

13 proto-type modular projects identified were integrated into 5 full-scale modular projects. Throughout formulation of PDM (Project Design Matrix), the cluster of 5 integrated full-scale modular projects is regarded as the bridge maintenance program.

Integrated Modular Project 1 (MP-1): Individual Capacity Building Project for MOPT and COMAVI		
1	Individual Capacity Improvement Project for Inspection and Diagnosis	"Individual" level
2	Individual Capacity Improvement Project for BMS Operation, Priority Selection and Rehabilitation Planning of Bridges	"Individual" level
3	Individual Capacity Improvement Project for Implementation of Rehabilitation of Bridges	"Individual" level
Integrated Modular Project 2 (MP-2): Institutional Building Project for MOPT and CONAVI		
1	Organization Strengthening Project for Direction of Bridges of MOPT	"Organizational" level
2	Organization Strengthening Project for New Bridge-related Department of CONAVI	"Organizational" level
Integrated Modular Project 3 (MP-3): Long-term Human Resources Development and Technical Exchange Project		
1	Long-term Human Resources Development Project	"Individual" level
2	Public-Private-Academic Technical Exchange Project	"Organizational" level
3	PPP Countries Technical Exchange Project	"Social" level
Integrated Modular Project 4 (MP-4): Regulation and Standards Improvement Project		
1	Technical Regulations and Design Standards Improvement Project	"Institutional" level
2	Procurement Regulations and Procedures Improvement Project	"Institutional" level
Integrated Modular Project 5 (MP-5): Promotion of Public Relations and Advocacy Project		
1	Asset Management Advocacy Project for Financial and Planning Authorities	"Institutional" level
2	Bridge Users Public Relations and Advocacy Project	"Social" level
3	Tax Payers Public Relations and Advocacy Project	"Social" level

As a main body for the implementation of the capacity development program, "Bridge Maintenance Consulting Group (BMCG)" which consists of representatives from various organizations was established to form 5 working groups. In order to concrete the program implementation, the preliminary WBSs as well as POs are drafted. The full-scale WBSs and POs will be formulated as the 5 years plan in the course of a series of the BMCG meetings held in the financial year 2007 in order for the plan to be initiated from the financial year 2008.

As a part of assistances for the organizational capacity development, the study team proposed both an organizational structure and a budgetary arrangement for the bridge maintenance.

In order to realize further dissemination toward PPP countries, PPP Regional Seminar was held at the end of the study, which allowed to introduce the outline and to extend outputs/outcomes of the study to neighboring countries on the bridge management.

S.7 Human Resource Development

The Human Resource Development plays a part of roles of the capacity development program upon the individual level, which comprises mainly technical training activities for the bridge management. These activities were anticipated to the initiation of the program development and regarded as inputs for the Program (integrated modular project 1, 3).

Technical training activities have been introduced and initiated essentially aiming upon the counter-parts technical staff at the beginning of the study. The activities were thoroughly practiced in manner of both On-the-Job (OJT) and Technical Seminar basis to aim an enhancement of Knowledge, Skill & Attitude. In addition, it is remarked that an Overseas Study Tour was applied for the study, which was aimed to obtain supplementary effects and amplify effectiveness on both the technical training and dissemination.

S.8 Existing Condition and Site Inspection of the Study Bridges

29 Study Bridges (17 bridges of the concrete girder type, 12 bridges of the steel girder type) were examined and visually inspected. The relevant documents and data, e.g. bridge inventories in MOPT, drawings, the history of repair, traffic volume, topography map, river information, were collected and reviewed to comprehend the condition of each bridge. The bridge engineers from MOPT joined with the Study Team to implement the visual inspection for all bridges as the "On-Job-Training", effectively using the inspection sheets.

Member	Results (Deterioration)	Bridge No.	Remarks（Possible cause）
Superstructure	Deck slab is severely damaged.	14 bridges	Heavy traffic volume is one of the major. all bridges on Route 1 have damaged on their deck slabs, whereas the bridges on Route 2, which were constructed in 1960s to 1970s same as the bridges on the Route 1
	Damages of connection nodes between a stringer and a crossbeam are largely observed.	Steel truss	Caused by the lack of rigidity of the floor frames.
	Bearings were broken by the earthquake. (main girders displaced by 10 cm along the transversal direction)	No.26, 27, 28	Bridges are located on the Route 32 nearby the Limon port where the earthquake occurred
	Deformations of main girders are observed for the PC Box girder bridges.	No.17, 20	Predominantly caused by an insufficient quality control during construction.
Substructure	Slope collapses around abutment are observed.	Most of the bridges	
	Scouring around foundation at piers or abutments is also observed.	Some of the bridges	Bridge No. 16, the pile foundation is exposed more than 2 m below the bottom of footings by scouring.
Accessories	Expansion joint, railing are damaged.	29 bridges	Insufficient maintenance
Anti-seismic measures	Insufficient countermeasures against bridge falling (reinforcement :substructure, enlargement: overlapped length of girders. width of bridge seat		
Countermeasure For live load	Insufficient load carrying capacity against HS20-44+25%		Bridges on Route 1 and 2 were designed with the H15-S12 of live load and the bridges on other routes were designed with HS20-44.

S.9 Selection of 10 Bridges for Rehabilitation, Reinforcement

Under collaboration between MOPT bridge engineers and the Study team, selection of prioritized bridges for rehabilitation were processed and finalized in accordance with the comprehensive deficiency evaluation of bridges whose criteria consists of a degree of deterioration observed, a weight determined by the functional importance as structural parts as well as a weight determined by the potential negative impact that those damages presenting may affect structural parts of bridges. In the Study, the Analytic Hierarchy Process (AHP), a decision support method was to be utilized for the evaluation of bridge deficiency.

10 bridges for rehabilitation, reinforcement shall be selected not only based on results of the evaluation of the bridge deficiency, but also other points of view, which it will be indeed a purpose of the Study, that outputs of the study are to be widely applicable and expandable for the bridge maintenance in Costa Rica.

S.10 Plan for Rehabilitation, Reinforcement and Improvement of 10 Selected Bridges

The plan for rehabilitation, reinforcement was formulated throughout an evaluation of results from both the detailed design (Visual Inspection, Concrete core sampling test, Schmidt hummer test, Phenolphthalein test, Detection of R-bar position, Measurement of steel plate thickness) and the structural analysis.

In this particular case of the Study, since it is required to completely re-check and secure both the load carrying capacity satisfying HS20-44+25% and quake-resistibility satisfying the local anti-seismic codes, a structural analysis with computed structural models were applied for verifying sectional forces or stresses at each members in order to determine a necessity as well as specific conditions to reinforce.

Bridge Loading Test was conducted mainly aiming at the technical transfer to MOPT engineers. Based on the results of the stress frequency measuring at the steel deck beam bridge, fatigue failure was evaluated to estimate the residual life.

S.11 Detailed Design for selected 10 bridges

Methods of the rehabilitation, the reinforcement for 10 bridges were summarized as follows.

Table 11.1 Superstructure ("O": Applicable method)

Member	Methods	R1			R2			R4		R32		R216
		2	3	7	12		16	17	19	20	26	29
		ST	ST	RI	SI	RI	RI	PB	SI	PB	SI	PI
Deck Slab	Slab thickness increasing (upper side)			O			O					
	FRP bonding				O	O			O		O	
	Replacement: PC deck	O	O									
Floor frame Main girder: Steel	Replacement: frames	O	O	N/A		N/A	N/A	N/A		N/A		N/A
	Steel plate thickness increasing		O	N/A		N/A	N/A	N/A	O	N/A		N/A
	Additional members	O		N/A		N/A	N/A	N/A		N/A		N/A
	Replacement: steel plate			N/A		N/A	N/A	N/A	O	N/A		N/A
	Out cable			N/A	O	N/A	N/A	N/A	O	N/A		N/A
Main girder: RC, PC	Girder height increasing	N/A	N/A	O	N/A				N/A		N/A	
	FRP bonding	N/A	N/A		N/A		O		N/A		N/A	O
	Steel plate bonding	N/A	N/A	O	N/A	O			N/A		N/A	
Accessories	Replacement: Expansion joint	O	O	O	O	O	O	O	O	O	O	O
	Bearing repair						O				O	
	Replacement: railing	O	O									
Pavement	Asphalt paving	O	O	O	O	O	O	O	O	O	O	○
	Waterproofing	O	O	O	O	O	O	O	O	O	O	○

Table 11.2 Substructure ("O": Applicable method)

Member	Methods	R1			R2		R4		R32		R216
		2	3	7	12	16	17	19	20	26	29
		ST	ST	RI	SI,RI	RI	PB	SI	PB	SI	PI
Substructure	Beam section increasing				O			O		O	O
	Concrete Jacketing	O	O	O		O					O
	Concrete protection						O		O		
Foundation	Footing widening	O	O	O	O	O	O	O		O	O
	Additional piles	N/A	N/A	N/A	N/A	O	N/A	O	N/A		N/A
Anti-Falling-down	Bridge seat widening, Displacement limitation system	O	O		O	O		O		O	O
	Connection system (chain)		O		O			O		O	
Protections	Slope protection (Masonry)	O			O	O					
	Riverbed protection (Gabion)	O	O		O	O				O	O

S.12 Preliminary Construction Planning and Cost Estimate

Work execution for the Project without entire traffic closure is crucial considering social and economic aspects because those bridges are located at highly important trunk roads in Costa Rica. It shall be a plan that construction works are basically to be executed on one side of the bridge in order to secure one-way traffic on the other side all the time. Consequently, the construction period is to be estimated 60 to 190 days.

Estimated cost for the Project counts 360,000 to 3,270,000 USD (42,088,000 to 382,300,000 JPY) including contingency which is equivalent to 5% of the total direct costs.

S.13 Economic Analysis

The aim of this economic analysis includes subjects such as: 1) consideration of the suitable economic analysis method for bridge rehabilitation & reinforcement, 2) trial this analysis against the 10 selected bridge, and 3) systemized this method to be extended to another bridge.

Based on the “with case” and “without case” for bridge rehabilitation & reinforcement, project costs & benefits are examined. The project benefits are evaluated as the reduction costs which are the costs in the case of “without case”.

Project costs, which are described in the chapter12, were converted as the economic cost to be employed. Operation & maintenance costs were calculated taking into account cots for the periodical and detailed inspections, replacement of the paving and reinforcement of members in accordance with the bridge type and material aging etc. Social costs were calculated based on “Detour Cost” & “Waiting Cost” due to traffic closure & restriction. Detour Cost is raised when the bridge falls down and there are detour route. Waiting Cost is raised when the traffic restriction for one-direction during the construction work etc..

“Future scenario”, which is a basis for the analysis, was determined for each bridge under the engineering judgment based upon results of the inspections and age of bridge.

The analysis results that there are 8 bridges whose EIRR exceeds to 20% and that the highest NPV (discount rate=12%) appears at Chirripo bridge (No.26) on the Route 32, which means that the rehabilitation and the reinforcement is to be quite effective.

S.14 Bridge Management System (BMS)

The study team researched the condition of the existing information systems for roads & bridges to grasp present issues, prior to formulation of the bridge management system.

The Bridge Management System (BMS) was established as a supporting tool for the technical judgment to be taken upon implementation of inspections, evaluation & analysis and maintenance of the bridge structural components. The functions of the system are as follows;

- Function for the registration and the renewal of the data
- Function for the administration of data such as evaluation of deficiency, prioritization of repair and cost estimation
- Function for the retrieval of data including bridge inventory and bridge inspection data and display for a location of a bridge.
- Function for output of bridge inventory

The System administrates all relevant data unified in the sole server.

S.15 Tools for the Bridge Maintenance Management

As supporting tools for the Bridge Maintenance, 1) the Inspection Manual, 2) the Operation Manual for Bridge Management System and 3) the Guideline for the Bridge Management were elaborated.

The inspection manual is prepared mainly for the bridge inspectors and bridge engineers, which comprises how to implement the inventory survey, the procedures of the routine inspection and the methods to evaluate the bridge deteriorations. The operation manual is prepared mainly for the system administrator and bridge engineers, which instructs the methods of operation and maintain Bridge Management System. The guideline is prepared mainly for the bridge engineers who engage in the bridge maintenance activities, and instructs the concept of the bridge maintenance, cause of the deterioration of the bridge, the method of the detailed inspection, the method of the loading test and the bridge repair methods.

S.16 Technical Support for the Environmental Examination

Within this study, the field investigation was carried out for 10 selected bridges while the information collection such as literature reviews and interviews with competent environmental agencies/or organizations such as SETENA were conducted. Based on those collected environmental information, the IEE of the proposed project was conducted. From the IEE, it is found that no significant potential environmental impacts are recognized since the proposed project is a rehabilitation/maintenance-oriented project. However, potential environmental impacts of following environmental factors such as the temporal water quality degradation, traffic jams, noise/vibration, the treatment of the construction waste, the set-up of the construction yards, infectious diseases such as dengue and malaria to the construction workers during the construction period would not be negligible. Several bridge sites may be

located in adjacent areas of the important ecological and/or cultural sites or inside of the national parks. Also, it is likely that several illegal squatters stay at two bridge sites.

Since the environmental licenses are to be required for implementation of the proposed bridge rehabilitation plans, suitable ways of the environmental license approach abiding by both Costa Rican EIA Law and JICA Guideline were discussed based on the potential negative impacts to be associated with this rehabilitation plan. Key directions and concepts for ToR development of environmental studies as well as the environmental management program were summarized.

It can be said that all selected 10 rehabilitation plans are categorized into "Category B1" by Costa Rican EIA Law while "Category B" by JICA Guideline.

During the Study, stakeholder meetings were held 4 times in order for relevant information to be disclosed to the public, which their questions & answers arisen were reported on the MOPT's web site.

S.17 Conclusion & Recommendation

Throughout the Study, "Capacity Development in Bridge Rehabilitation Planning, Maintenance and Management Based on 29 Bridges of National Highway Network" has commenced and efficaciously expanded on strengthening capability of the maintenance of bridge in Costa Rica. Along with a technical examination for the rehabilitation of 29 bridges inclusively the design for repair works of the 10 selected bridges, which represent structural features of totality, as well as multiple advocacy activities for the Asset Management, awareness and comprehension on the concept of Capacity Development have been extensively rewarded with positive results and efficacy.

Recommendations based on the Study are summarized as follows.

1) Implementation of Comprehensive Bridge Maintenance Program via Formulation of Full-scale Work Breakdown Structures & Operation Plans for 5 Integrated Modular Projects, which are to be finalized in the financial year 2007 and to be commenced from the year 2008 for 5 years rolling.

2) Smooth Continuous Operation of BMCG & 5 Working Groups on the following tasks.

- Individual Capacity Improvement of MOPT & CONAVI Officials
- Strengthen New Strategy for MOPT Bridges & Create Proposed Bridge Conservation Department for CONA
- Long-term Human Resources Development & Technical Information Exchanges
- Improvement of Regulations & Standards
- Promotion of Advocacy of Government Officials & Public Relations

3) Continuous Monitoring & Evaluation on Outcomes for Capacity Development Process

THE STUDY ON CAPACITY DEVELOPMENT IN BRIDGE REHABILITATION PLANNING, MAINTENANCE AND MANAGEMENT BASED ON 29 BRIDGES OF NATIONAL HIGHWAY NETWORK IN COSTA RICA

FINAL REPORT

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■ APPENDIX

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ABBREVIATIONS

AASHTO:	American Association of State Highway and Transportation Officials
AHP:	Analytic of Hierarchy Process
ASTM:	American Standard for Testing and Materials
BBS:	Budget Breakdown Structure
BCIE:	Banco Centroamericano de Integración Económica (Central American Bank for Economic Integration)
BID:	Banco Interamericano de Desarrollo (Interamerican Development Bank)
BMCG:	Bridge Management Consulting Group
BMS:	Bridge Management System
CABEI:	Central America Bank of Economic Integration
CAD:	Computer-Aided Design
CAFTA:	Central American Free Trade Agreement
CB:	Capacity Building
CBS:	Cost Breakdown Structure
CCTU:	Costa Rican Chamber of United Transporters
CD:	Capacity Development
CFIA:	Costa Rica Federation of Engineers and Architects
CGA:	Capacity Gap Assessment
CIC:	Civil Engineers' Association
CIDA:	Canadian International Development Agency
CNC:	Consejo Nacional de Concesiones (National Concession Counsel)
CONAVI:	Consejo Nacional de Vialidad (National Road Counsel)
CRC:	Costa Rica Colone
C/P:	Counter Part
EIA:	Environmental Impact Assessment
EIRR:	Economic Internal Rate of Return
FOB:	Free on Board
FRP:	Fiber Reinforced Plastic
FS:	Feasibility Study
FTAA:	Free Trade of the American Agreement
FY:	Financial Year
GDP:	Gross Domestic Product
GIS:	Geographic Information System
GPS:	Global Positioning System
GTZ:	Gesellschaft f r Technische Zusammenarbeit (The German Agency for Technical Co-operation)
HDM-III:	Highway Design and Maintenance Standard Model version III
HWL:	High Water Level
ICE:	Instituto Costarricense de Electricidad (Costa Rican Institute of Electricity)
IDB:	Inter-American Development Bank
IEE:	Initial Environmental Examination

JBIC:	Japan Bank for International Cooperation
JICA:	Japan International Cooperation Agency
JPY:	Japanese Yen
KfW:	Kreditanstalt fur Wiederaufbau
LAN:	Local Area Network
LANAMME:	Laboratorío Nacional de Materiales y Modelos Estructurales (National Laboratory of Materials and Structural Models)
LWL:	Low Water Level
MIDEPLAN:	Ministerio de Planificación Nacional y Política Ecónomica (Ministry of National Planning and Economic Politics)
MINAE:	Ministerio del Ambiente y Energía (Ministry of Environment and Energy)
M/M:	Minutes of Meeting
MOF:	Ministry of Finance
MOH:	Ministry of Health
MOPT:	Ministerio de Obras Publicas y Transportes (Ministry of Public Works and Transport)
MOPTT:	Ministry of Public Works, Transport and Telecommunications (Chile)
NPV:	Net Present Value
O&M:	Operation and Maintenance
OD:	Origin and Destination
OJT:	On-the-Job Training
PC:	Prestressed Concrete
PCM:	Project Cycle Management
PDM:	Project Design Matrix
PO:	Plan of Operation
PPP:	Plan Puebla Panamá
RAM:	Responsibility Assignment Matrix
RC:	Reinforced Concrete
RICAM:	International Mesoamerica Road Network
ROW:	Right of Way
SCF:	Standard Conversion Factor
SETENA:	Secretaría Técnica del Ambiente (Technical Secretary of the Environment)
SICA:	Sistema de la Integración Centroamericana (System of the Central American Integration)
SIECA:	Secretaría de Integración Económica Centroamericana (Economic Integration Secretary of Central American)
SIGVI:	Sistema Integrado de Gestión Vial (Integrated System of Administration Vial)
SINA:	Ministry of Environment and National System of Environmental Organizations
SINAC :	Sistema Nacional de Áreas de Conservación (The National System of Conservation Areas)
SOP:	Secretary of Publics Works (Mexico)
SPEM:	Sistema de Programacion y Ejecucion del Mantenimiento Vial (System of Programming and Execution of the Maintenance Vial)

STP:	Standard Penetration Test
SWRF:	Shadow Wage Rate Factor
TA:	Technical Assistance
TOR:	Terms of Reference
TPD:	Traffic per Day
TTC:	Time Travel Cost
UNDP:	United Nations Development Program
USD:	US Dollar
VOC:	Vehicle Operation Cost
WAN:	Wide Area Network
WBS:	Work Breakdown Structure
WS:	Workshop

Costa Rica Colones (¢): Unit of Costa Rica Currency: $US 1 approx. ¢ 516 as of August 2006

CHAPTER 1 OUTLINE OF THE STUDY

1.1 Background of the Study

Costa Rica is approximately 51,100 km^2 in area with a population of 430,000 people. It is bordered by Nicaragua to the north, Panama to the south, the Caribbean Sea to the east, and the Pacific Ocean to the west.

Costa Rica is one of the member countries of "the System of Central American Integration (SICA)" and is expected to play an important role in developing and integrating the economy in region. In order to extend the economic integration, it is essential to support the improvement of the infrastructures in the transport sector. In particular, improvement of the road network is selectively listed in the prioritized subjects in the Puebla-Panama Plan (PPP) which is a region-wide economic-development program ratified in Mesoamerica. The PPP allows that overland transportation would be promoted because it is advantageous in Central America in terms of its cost effectiveness when compared with other transportation modes such as by-air or by-ship.

It is clearly stated in the National Development Plan (2002-2006) of Costa Rica that the "acceleration of the economic growth" is an integral component of the plan and that bridge construction and the rehabilitation of trunk roads are particularly key elements to be strategically prioritized in the construction and conservation of the road network.

The road network in Costa Rica has a total length of over 37,300 km and comprises international trunk roads running through the country, which geographically link Central America. Most of the 1,330 bridges on the national highway (7,775km) suffer from severe deterioration due to material aging. Insufficient and inadequate maintenance works have accelerated this damage and have led to the decline in bridge performance. The PPP's regional code requires a particular load carrying capacity for international trunk roads. This is not achieved satisfactorily to sustain the necessary capacity for land transportation as a main commercial route. In addition, due to the fact that the country is geologically situated right on the volcanic belt, it is critical for the bridge maintenance in Costa Rica to take into account disaster prevention measures which are aimed at protecting the road infrastructure from natural disasters such as eruptions and earthquakes. Accordingly, it is essential that an assistance program be rendered for improving the capacity of the bridge management, which comprises comprehensively inspection, the diagnosis of deterioration of existing bridges as well as the planning for reinforcement and rehabilitation of bridges.

Given the preceding, the Government of Costa Rica has requested the Government of Japan to execute a feasibility study for the implementation of a bridge management system, and to select 30 bridges as a part of the Feasibility Study. In response to the above request, it has been decided to conduct "The Study on Capacity Development in Bridge Rehabilitation Planning, Maintenance and Management" based on 29 bridges on National Highway Network in Costa Rica.

1.2 Objectives of the Study

The Study is to be conducted on the 29-targeted bridges on the trunk road network. These are Bridge Nos. 1 to 8 on National Highway Route 1, Bridge Nos. 9 to 16 on National Highway Route 2, Bridge Nos. 17 to 19 on National Highway Route 4, Bridge Nos. 21 to 28 on National Highway Route 32, and Bridge No. 29 on National Highway Route 218. The Study is to be focused on assistance for the capacity development for bridge reinforcement and rehabilitation as well as bridge management. The main objectives of the Study are stated as follows:

(1) To support the implementation of the capacity development program for a Bridge Management System for the individual, organizational and social/institutional levels.

(2) To conduct a diagnosis of the bridges and to evaluate their current condition.

(3) To formulate rehabilitation/reinforcement/improvement plans for 10 prioritized bridges.

(4) To produce design drawings of the rehabilitation/reinforcement/improvement for 10 prioritized bridges.

(5) To conduct preliminary cost estimation/construction planning and economic analysis.

(6) To establish the Bridge Management System (BMS) as a practical tool for the implementation of the bridge maintenance.

(7) To produce standard Manuals and Guidelines for bridge inspection as well as for bridge rehabilitation/reinforcement/improvement and maintenance.

(8) To support the relevant environmental assessments in accordance with the JICA Guideline for environmental and social considerations, which it is necessary to enforce prior to the implementation of any rehabilitation/reinforcement/improvement.

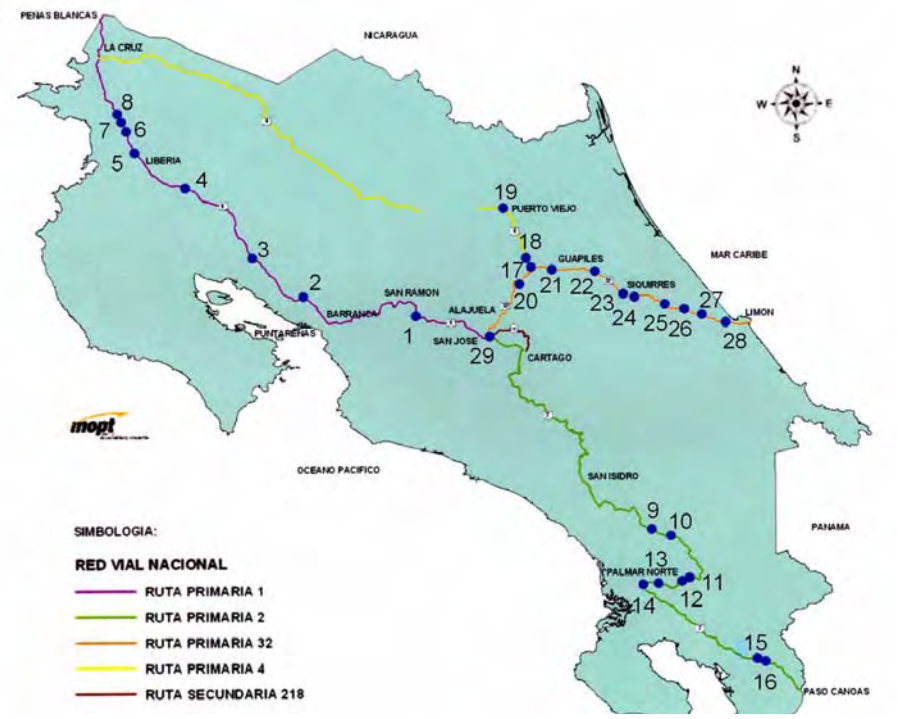


Figure 1.1. Location of the targeted bridges (29 bridges)

1.3 Components and Process of the Study

Figure 1.2 shows the comprehensive components of the study to embody the objectives mentioned earlier. The counterpart agency is the Planning Direction and the Bridge Design Department of the Ministry of Public Works and Transport (hereinafter described as "MOPT") as well as the Planning Direction of the National Council of Roads (hereinafter described as "CONAVI").

The Capacity Development (hereinafter described as "CD") for Costa Rica shall focus on the improvement of capacities on the "Individual"," Organizational" and "Institutional/Social" levels. In addition, the Study shall highlight assistance to the establishment of the Bridge Conservation Department in CONAVI, which are institutionally planned to.

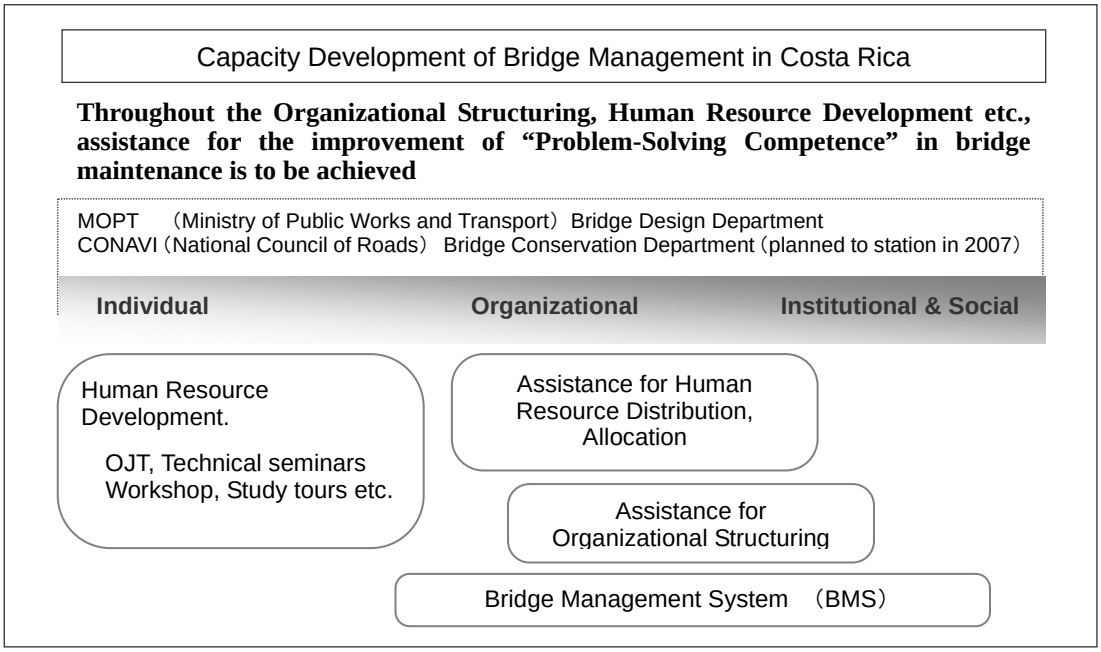


Figure 1.2. Objectives and Components of the Study

Figure 1.3 shows a schematic of the study process. The upper section concerns the technical components of the Study and the lower section concerns the CD.

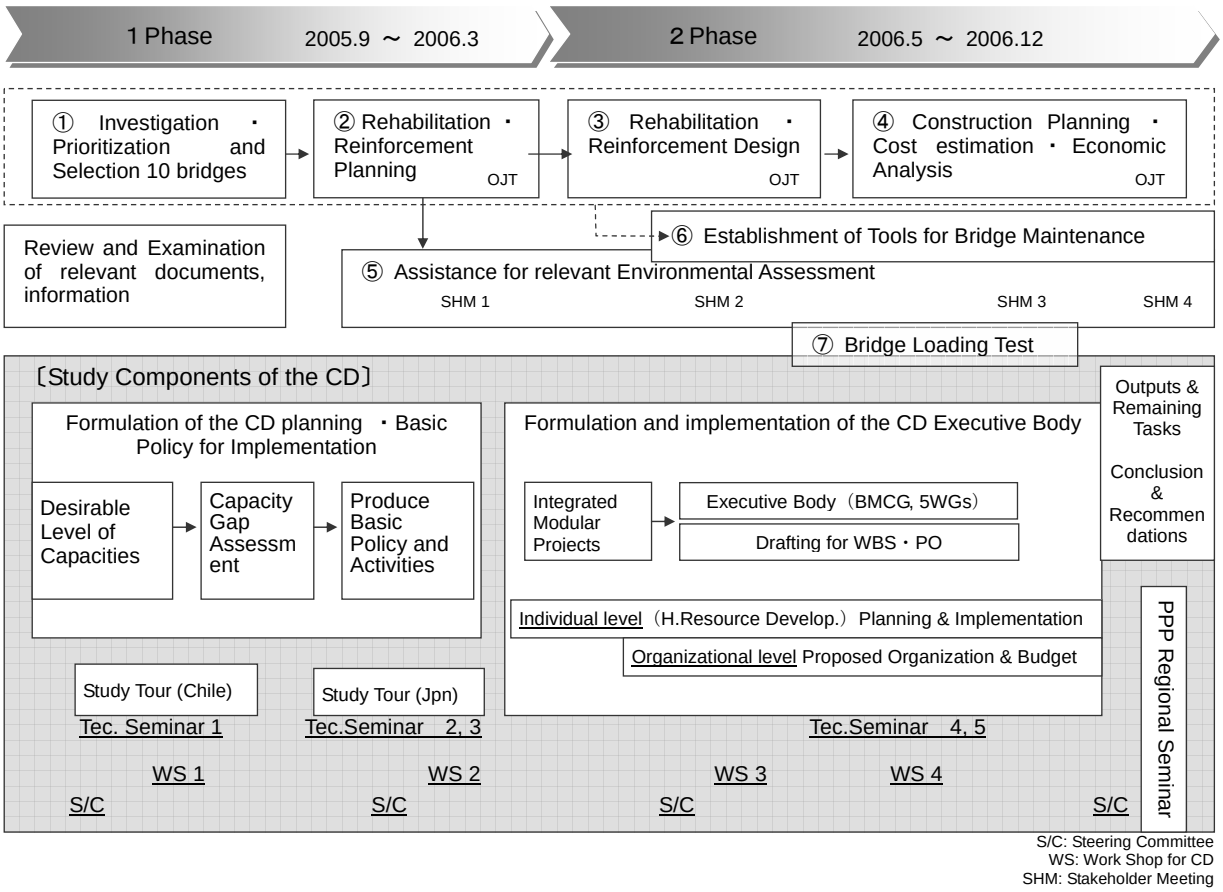


Figure 1.3. Schematic of the Components and Process of the Study

The technical components of the Study and its workflow are as follows:

1) Investigation of the current status of the 29 bridges; Diagnosis of any deterioration found; Prioritization and Selection of 10 prioritized bridges.

2) Formulation of the Bridge Rehabilitation/Reinforcement/Improvement Plan for the 10 selected bridges.

3) Elaboration of the Bridge Rehabilitation/Reinforcement/Improvement Design, Drawings and Quantity survey for the 10 selected bridges.

4) Formulation of the Preliminary construction planning, Cost estimation and Economic Analysis for the 10 selected bridges.

5) Assistance for the relevant environmental assessment based on the Rehabilitation/Reinforcement/Improvement Plan in 2) above, as well as the Construction planning for the 10 selected bridges.

In addition, the following will also be carried out:

6) Establishment of the Bridge Maintenance Tools (e.g. Bridge Management System (BMS), Inspection and Operation manuals for the BMS, Guidelines for bridge maintenance)

7) Implementation of Bridge Loading Tests

Managerial components concerning the CD are summarized as follows:

1) Capacity Gap Assessment

- Determination of the desirable future state of capacities on the "Individual", "Organizational" and " Institutional & Social " levels.
- Gap assessment of the capacity differentials between the current and desirable states.
- Problem-Objective analysis at the "Individual", "Organizational" and " Institutional & Social " levels by means of Project Cycle Management (PCM)

2) Formulation of the Basic Policy for Capacity Development

- Based on results from the problem analysis, 13 prototypes of modular projects are identified in total, comprising 4 projects on the "Individual", 3 projects on the "Organizational" and 6 projects on the " Institutional & Social " levels.
- 10 basic policies for the comprehensive bridge management are proposed. As the policy states, it is essential that the importance of a political commitment shall be recognized to secure a well-balanced allocation of the budget which enables the "Ad-hoc basis bridge maintenance" to be converted into " Preventive maintenance".

3) Implementation of Capacity Development

- The 13 proto-types of modular projects identified are integrated into 5 full-scale modular projects, taking into account the tasks screened-out at the "Individual", "Organizational" and " Institutional & Social " levels.
- As a main executive body for the implementation of the 5 full-scale modular projects, "Bridge Maintenance Consulting Group (BMCG)" which consists of representatives from various organizations such as MOPT, CONAVI, planning and financial authorities and academic institutions was established to form 5 working groups. The preliminary Work Breakdown Structures (WBS) and Plan of Operations (PO) of the 5 full-scale modular projects are to be finalized and embodied in the financial year 2007 in order for the objectives to be achieved within 5 years starting from the financial year 2008.
- The study team proposed both an organizational structure for MOPT, CONAVI and a budgetary arrangement for the bridge maintenance including the rehabilitation, reinforcement and improvement works. These are fundamental issues to be carefully linked with the activities of the BMCG.
- Individual capacity is to be implemented based on the "Human Resource

Development Plan", which is incorporated into the integrated modular project-1 aimed at improvement of the technical competences at the individual level. Counterparts are trained on the basis of On-the Job training (OJT), and in addition 5 technical seminars will be held to disseminate technical know-how to Costa Rican engineers.

4) PPP Regional Seminar

- In order to realize further dissemination toward PPP countries, a PPP Regional Seminar was held in December 2006, which allowed an introduction to the outline of the study to be presented and extended the outputs/outcomes of the comprehensive CD on bridge management to neighboring countries.

This report is for conveying the entire activities and results described above and comprises the following chapters:

Chapter 1	Outline of the Study
Chapter 2	Existing Situation in Costa Rica
Chapter 3	Existing Condition of Bridges and Status of Bridge Maintenance
Chapter 4	Capacity Gap Assessment
Chapter 5	Basic Policies For Capacity Development
Chapter 6	Implementation of Capacity Development for a Comprehensive Bridge Maintenance Program
Chapter 7	Human Resource Development
Chapter 8	Existing Conditions and Site Inspection of the Study Bridges
Chapter 9	Selection of 10 Bridges for Rehabilitation and Reinforcement
Chapter 10	Plan for Rehabilitation, Reinforcement and Improvement of 10 Selected Bridges
Chapter 11	Design for Rehabilitation, Reinforcement and Improvement of 10 Selected Bridges
Chapter 12	Preliminary Construction Planning and Cost Estimate
Chapter 13	Economic Analysis
Chapter 14	Bridge Management System
Chapter 15	Tools for Bridge Maintenance Management
Chapter 16	Technical Support for Environmental and Social considerations
Chapter 17	Conclusions & Recommendations

The workflow of the Study and Schedule is shown in Figure 1.4. Detailed item conducted in the Study during September 2005 to December 2006 are described as below.

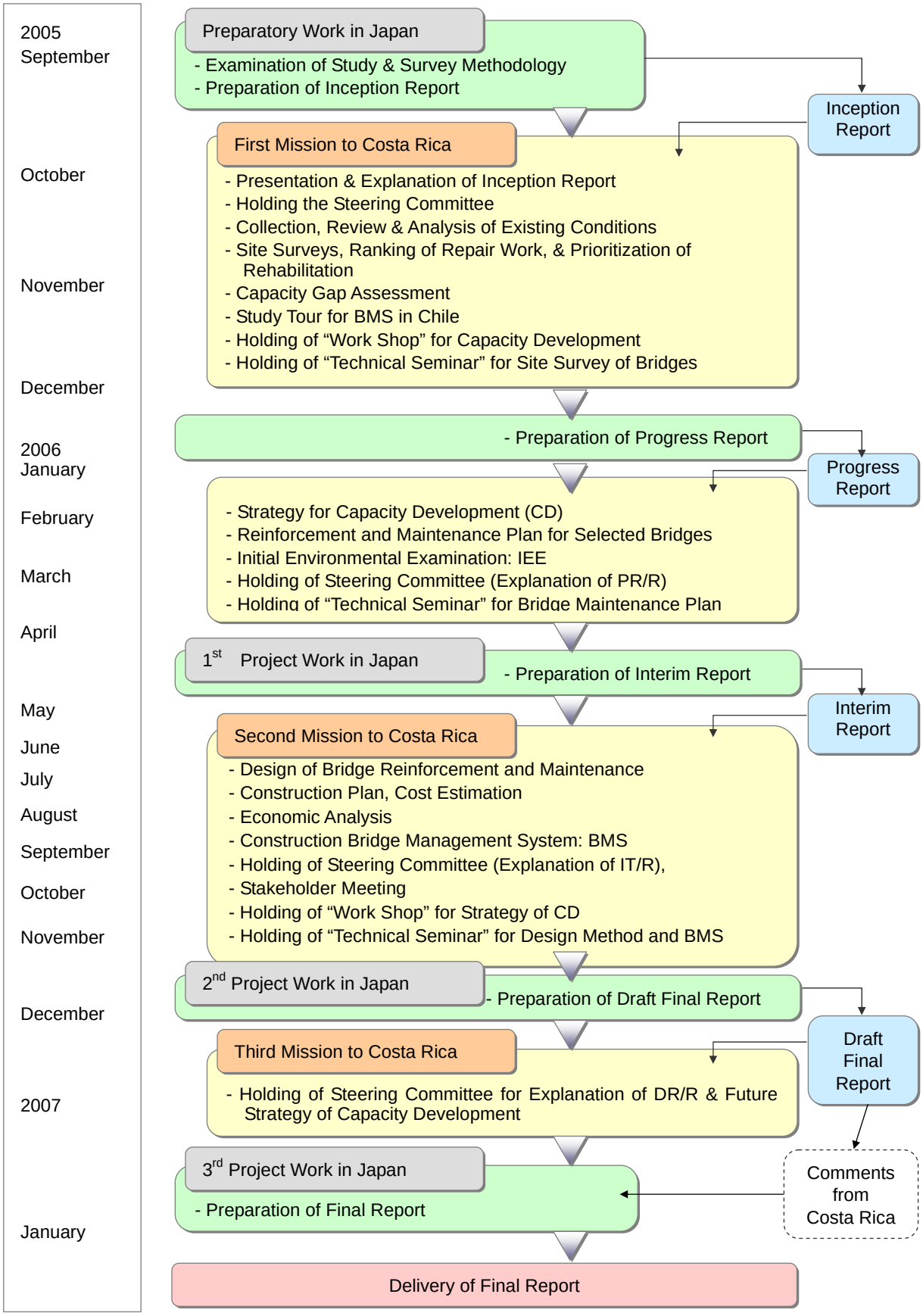


Figure 1.4. Study Workflow and Schedule

CHAPTER 2 EXISTING SITUATION IN COSTA RICA

2.1 National Condition

2.1.1 Geography

Costa Rica is located in the southern part of the Central American isthmus, between 8° and 11° North latitude. It's bordered on the north by Nicaragua, and on the southeast by Panama. The Caribbean Sea is located in the northwest and the Pacific Ocean is found west and south. At its widest point, it measures 300 km across. In total size it is 50,700 km^2.

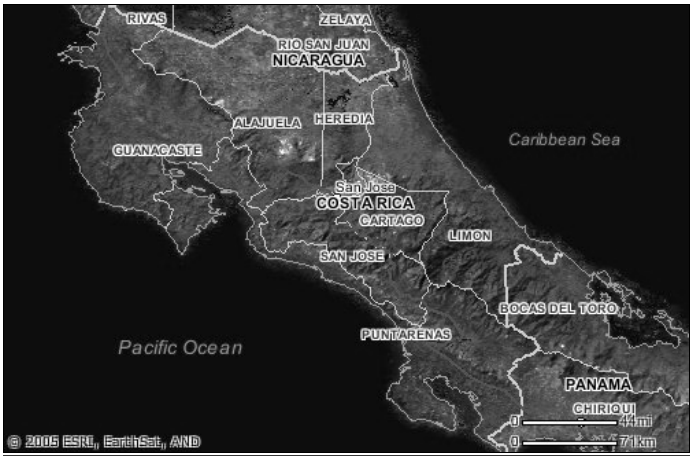


Figure 2.1.1. Location Map of Costa Rica

It's capital is San Jose, whose neighboring major cities are Alajuela and Heredia it lies in the middle of the Central Valley. Two-thirds of the population lives in this valley.

1) Provinces

Costa Rica is divided into seven provinces.

San Jose:	The capital, where over one third of the population lives, it stands at approximately 1,170 meters altitude.
Heredia :	North of San Jose, up to the Nicaraguan border.
Alajuela:	West of Heredia, to the Nicaraguan border and it has the volcanic Poás National park.
Guanacaste:	The northwest part of the country. One of the most diverse regions of the country with cloud forests, have active volcanoes, national parks and beach resorts.
Puntarenas:	Covers most of the Pacific coast and its lowlands, from near the most western parts of Costa Rica down to the Panamanian border including the Manuel Antonio national park.
Limon:	The Caribbean east coast of the country has several biological reserves and national parks, and a largely Jamaican-rooted bilingual population.
Cartago:	Northeast of San Jose, it has volcanoes.

2) Mountains

The land of Costa Rica is divided into a backbone of volcanoes and mountains. It is an extension of the Andes-Sierra Madre chain, which runs along the western side of the Central America. Costa Rica is part of the Pacific "Rim of Fire" and has seven of the

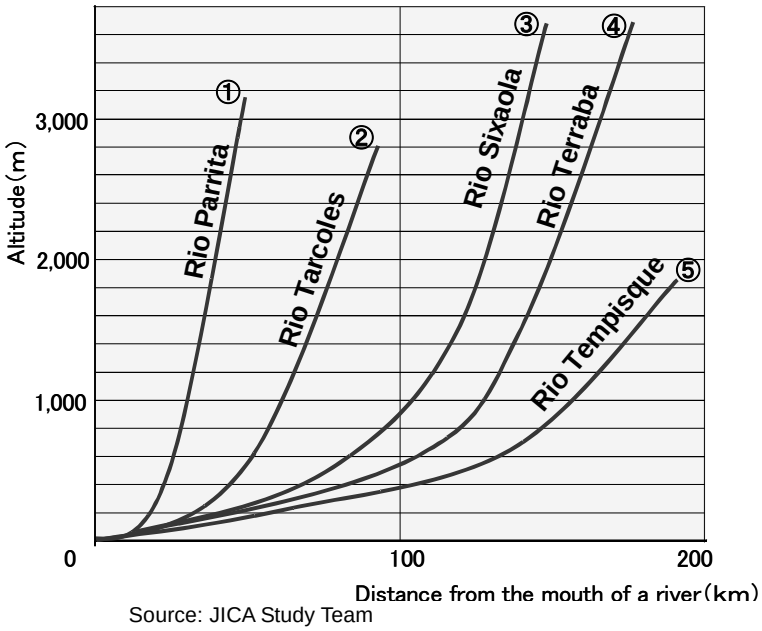
isthmus's 42 active volcanoes plus dozens of dormant or extinct cones.

The Cordillera de Talamanca, the country's oldest and southernmost range, includes Mt. Chirripó, Costa Rica's highest mountain at 3,820 m. The Central Volcanic Range features the volcanoes Turrialba, Irazú, Barva and Poás. In the northwest is the Tilarán Range, whose altitude reaches 1,700 m at the Monteverde Cloud Forest. Northwest is the Guanacaste Range. Near the Nicaraguan border, this range includes five active volcanoes, Rincon de la Vieja, and Miravalles, which is being used to generate geothermal energy.

3) River

The rivers of Costa Rica are characterized by steep slopes of riverbeds. The major typical rivers of Costa Rica are shown in Figure 2.1.2 which have less than 200 km of river length. The starting point of rivers is located at an altitude that goes from 3,820 m to 1,600 m. From its section to an altitude of 600 m there are steep slopes of riverbeds, and then the river flows with a slow flood down to Pacific Ocean or Caribbean Sea.

The substructure of many bridges has been exhausted by natural disasters which are localized torrential downpours by a tropical cyclone, volcanic activity, and slope collapse by the earthquake and sediment and flood damage



Source: JICA Study Team

Figure 2.1.2. River Profile of Major River in Costa Rica

2.1.2 Climate

1) Meteorology

Costa Rica's climate is divided into two seasons, which are rainy and dry. The dry season runs from January through May, and the rainy season from May to November and December.

The topography of Costa Rica has an influence on weather patterns. The dry and rainy seasons are shown on each slope of the mountain ranges which are the Pacific slope and the Caribbean slope.

On the Pacific slope the rainy season begins in May and it continues until November. This is a period in which the trade winds coming from the north-east are much reduced in intensity, and as a result, storms often come in from the Pacific Ocean in September and October. In the northern half of the country the Pacific slope is located with an intense dry season.

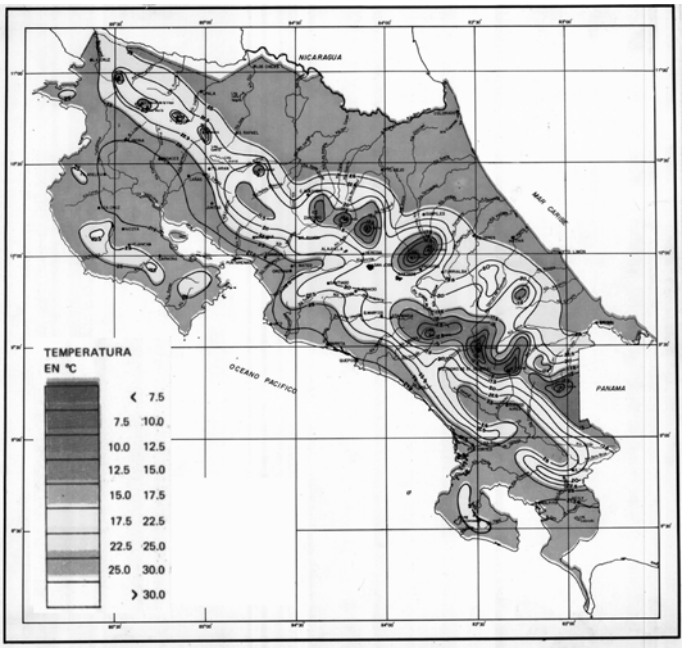
On the Caribbean slope the rainy season begins from mid to late April and continues through December and sometimes January. The wettest months are July and November, with a dry spell that occurs around August or September. Major storms, occasionally hit this slope between September and February, when it will rain continuously for several days, but an average rainy season day will begin clear with a few hours of sunshine that will give way to clouds and rain by the afternoon. In contrast, the driest months are February and March.

On the Central Valley, there is a 20 °C temperature for most of the year and this area has a lower rainfall than other areas.

2) Temperature

Costa Rica's Annual Medium Temperatures Distribution Map (1961-1990) published by the National Meteorological Institute shows the Annual Medium Temperatures of the Pacific Slope which are higher than those in the Caribbean slope. The isotherm (lines that gather points with the same temperature value) of 27.5° gathers at the lower basin of the Tempisque River and extends along the Pacific Coast towards Ciudad Cortes.

In the Caribbean slope, the highest annual medium isotherm observed is 25°C, it approximately extends along the base of the orographic system near the localities of Upala, Puerto Viejo, Guapiles, Siquirres, and Bribri.



Source: ATLAS Cimatologico de Costa Rica
Ministorio de Aglicultura y Ganaderia Instituto Meteorologico Nacional

Figure 2.1.3. Annual Medium Temperatures Distribution Map

In the Volcanic Mountain Range of Guanacaste and in the Tilaran Mining Mountain Range, whose tops are found in minor altitudes of 2,000 m, these islands represent very reduced areas surrounded by the isotherm of 17.5°C, instead in the Central Volcanic Mountain Range in which the tops oscillate between 2,000 m and 3,400 m, the minimum values represent the isotherms of 12.5 °C and 10°C. In the Talamanca Mountain Range due to the tops are higher than 3400 m, 10°C and 7.5°C isotherms are observed.

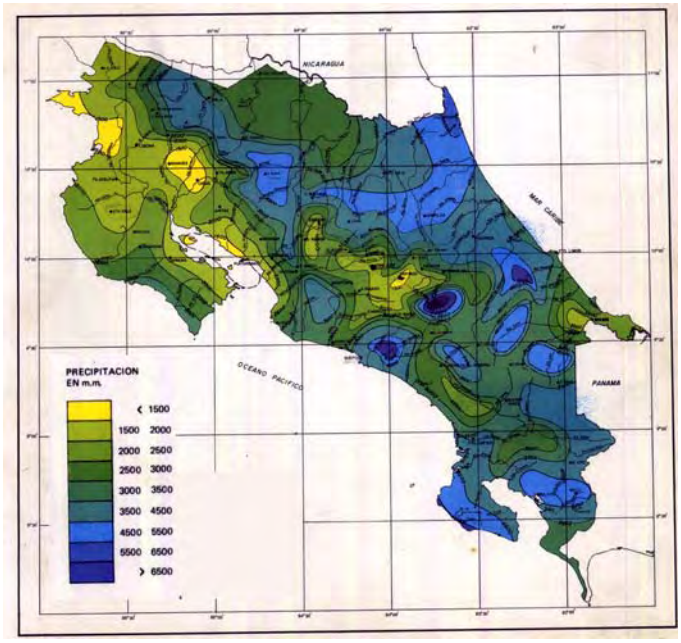
Table 2.1.1 shows the difference of time temperature variation. Time temperature is modified by the altitude, in the lower lands the amplitude reaches higher values than in those places located in a higher altitude. The amplitude is lower in San Jose, Pavas, Alajuela, which are located over 900 m above sea level, than the amplitudes of Puntarenas and Liberia that are almost at sea level.

Table 2.1.1. Time Difference between Maximum and Minimum Temperature

Region	Altitude (m)	Max °C	Time	Min °C	Time	Difference °C
Puntarenas	3	33.5	13:00	23.0	05:40	10.5
Palmar Sur	16	31.0	13:20	24.0	01:40	7.0
Liberia(Llano Garnde)	85	34.0	13:00	20.5	03:00	13.5
Aeropto Juan Sta. Maria	921	27.4	13:40	18.6	02:30	8.8
Pavas	997	26.0	13:10	18.8	06:30	7.2
San Jose	1,172	23.1	11:00	17.5	03:00	5.6

3) Precipitation

Figure 2.1.4. shows the annual average precipitation map in Costa Rica published by the National Meteorological Institute based on the years 1961-1980. The areas of less than 1,500 mm of precipitation are distributed on four relative area in Costa Rica, the first is in the Northwest of the country in the Santa Elena Peninsula and the coast sector in front of the Papagayo Gulf, the second is Bagaces and Cañas including surrounding areas, the third is in the coast of the Nicoya Gulf, Costa de Pajaros, Chomes and extended to the mouth of the Aranjuez River, the fourth is the central region of the country and it includes the city of Cartago.



Source: ATLAS Cimatologico de Costa Rica
Ministorio de Aglicultura y Ganaderia Instituto Meteorologico Nacional

Figure 2.1.4. Annual Average Precipitation Map

The maximums precipitations are dispersed out in the mountain area. Maximums of 5,500 and 6,500 mm are observed in the Caribbean slope in the coast sector between the Colorado River and the San Juan River, also in the basin of the Banano River, the Pacific slope Quepos, Savegre and the Naranjo River, and Osa Peninsula, which extends from Punta Llorona until Madrigal Beach. The highest precipitation areas are located in the Basin of Pejibaye River and the Grande de Orosi River; the values are over 7,000 mm per

year.

In the Pacific Slopes, it generally rains in the afternoon hours between 1 p.m. and 5 p.m. This happens due to the precipitation production of clouds that reaches its maximum development after the maximum temperature happens and because it is in the afternoon hours when the maximum humidity transport is produced by the western breezes. The precipitation of convective origin predominates, characterized by very big drops and accompanied by an electric storm.

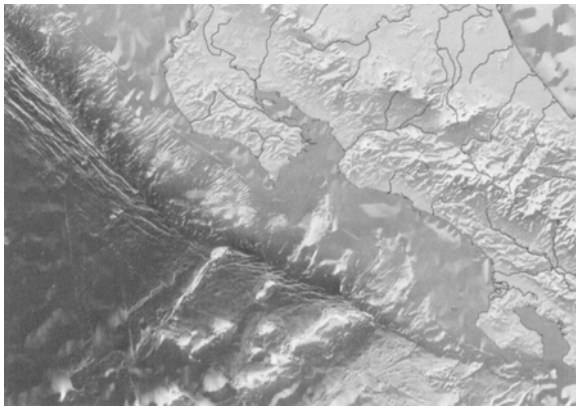
When precipitations outside this pattern occur is due to the presence of some meteorological system that is altering the normal conditions, as in the case of the Pacific Temporal occasioned by the lower pressures located in the Caribbean.

In the Caribbean slope, precipitations have completely different characteristics which generally proceed of non convective stratified clouds due to the orographic effect that is produced by the interaction between the trade winds and the orography. It is almost produced always during the middle of the night and early morning. Only in the Tortuguero and Barra Colorado Plains the precipitations are produced in the afternoon hours and they are occasioned by the frictional convergence which is very high at those times.

2.1.3 Seismic

Costa Rica is located in a region were several lithosphere plates interact, for this reason, the geotectonic activity and the earthquakes are important phenomenon in the geological construction of the territory, because of its frequency and significant magnitude; they have a great relevance for society.

The most important earthquake activity in Costa Rica has happened mainly when El Coco plate slides under the national territory through a subduction process, which has an initial depth of 10 km and reaches maximum depths of 200 km, generating a continuous seismic zone which is inclined to the North East.



Source: Atras tectonico de Costa Rica
Percy Denyer Water Montero Guillermo E. Alvarado

Figure 2.1.5. Fault Line Map of Costa Rica

A meaningful part of the seismic activity of Costa Rica is located inside the mountainous system that goes across the country in a NW direction, generating a seismic threat that is meaningful because it has a relatively low depth (<=20 km), for the frequency of the major magnitude earthquakes (5- 6.5) and because it happens in faults located in zones were there are important population settlements.

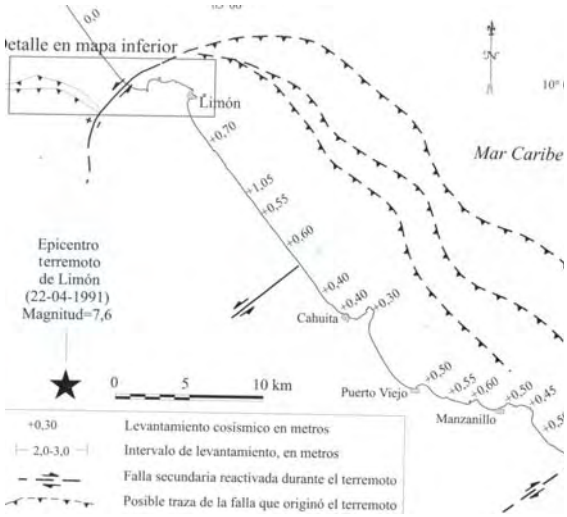
Basically Costa Rica can be divided in three ante arches, which are:

- **North-East Ante Arch**: conformed by the Santa Elena and Nicoya Peninsulas, and the Tempisque and Nicoya Gulfs basins. Diverse evidences indicate that the Nicoya Peninsula is being lifted in its coast zone and some sectors are been inclined. The fact is that between the zones some rising and caving is occurring in rigid rocks, fractures and faults, which are translated in the occurrence of superficial earthquakes.

- **Central Ante Arch**: It is located inside the zone comprehended between Barranca and Dominical; there is a series of faults going in a northeast to north direction. One of the most destructive earthquakes that had happened in this zone was on March 04, 1924 (M 7.0) which is associated with the Tarcoles fault. The superficial seismic activity registered by the National Seismic Network in this zone, shows that several located faults in this ante arch are activated.

- **South Ante Arch**: where recent raisings and rotation movements of blocks towards the northeast have being measured. Several active faults are located inside Osa and Burica, where the Canoas fault, which is sliding fast can be highlighted. In the frontal part of the Fila Costeña, the longitudinal fault is an active fault, where most of the movements have happened along it.

The last major quake was on April 22, 1991. Centered on the Caribbean side southeast of San Jose, it measured 7.6 on the Richter scale, in which the superior block moved towards the northeast about three meters in relation to the inferior block, provoking a vertical rising between 0.5 and 1.5 meters along the Caribbean from the Limon Harbor to the Panama Border.



Source: Atras tectonico de Costa Rica
Percy Denyer Water Montero Guillermo E. Alvarado

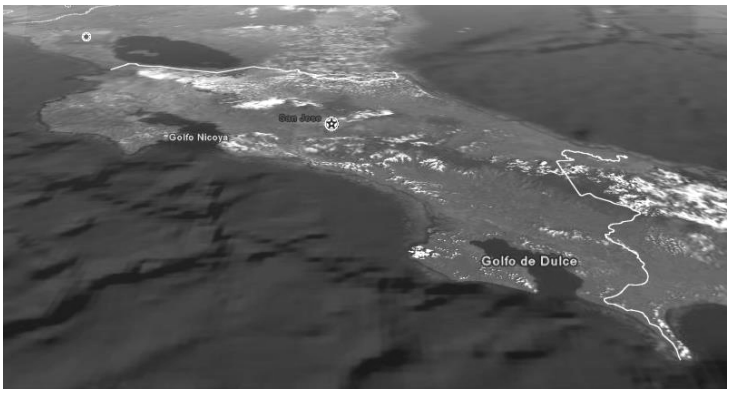
Figure 2.1.6. Map of the Earthquake on April 22, 1991. Centered on the Caribbean Side

2.2 Socio-Economic Condition

The following section is described as the socio-economic condition in Costa Rica.

2.2.1 Land Use

The total land area is 51,100 km^2 which is composed with by land: 50,660 km^2 and by water: 440 km^2. For the details for cropland, the area of "arable land" that is cultivated for crops like wheat, maize, and rice that are replanted after each harvest is 4.41%, the area of "permanent crops land" that is cultivated for crops like coffee that are not replanted after each harvest is 5.88% (source: World Factbook; CIA).



Source: Google Earth

Figure 2.2.1. Overview of Land in Costa Rica

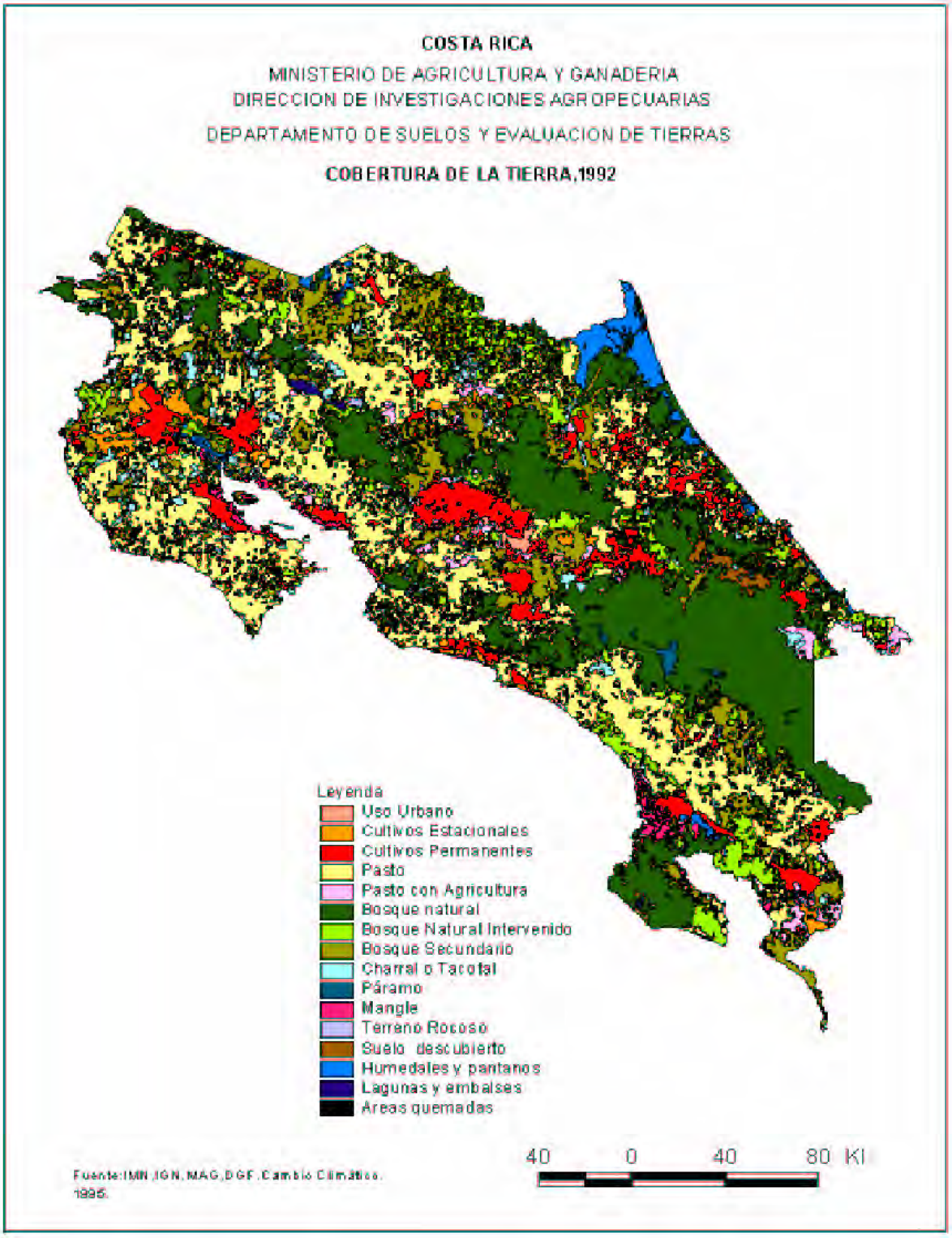
The National reservation area is covered by 12,800 km^2 (25.6%) (Source: Estado de la Nacion 2004).

Since 1972, urban area has been increased about 80,000 hectares and its share of total land is only 0.4% in 1999. Table 2.2.1 shows the area of each land use category. Figure 2.2.2 shows land use map colored by same category of Table 2.2.1.

Table 2.2.1. Land Use (1972, 1999)

Category	1972 hectares	%	1999 hectares	%
Urban Use	14,792.00	0.3	22,599.20	0.4
Cultivate area				
Seasonal Crops	101,355.00	2.0	132,955.20	2.6
Permanent Crops	246,278.60	4.8	369,209.80	7.2
Pastures	820,557.00	16.1	1,565,076.30	30.7
Pasture with Agriculture	66,430.30	1.3	101,459.90	1.9
Mangle	66,523.10	1.3	49,374.30	0.9
Forest				
Natural Forest	2,085,906.00	40.7	1,286,456.30	25.2
Intervened Natural Forest	367,090.10	7.2	484,071.40	9.5
Secondary Forest	882,164.30	17.3	695,903.10	13.6
Marginal				
Rocky Terrain	15,292.10	0.3	8,567.10	0.2
Discovered Soil	0	0	26,469.20	0.5
Wet Lands and Swaps	113,267.00	2.2	106,058.30	2.1
Lakes and Reservoirs	18,432.00	0.4	9,797.00	0.2
Weed Land	292,287.40	5.7	228,444.60	4.5
Bleak Plateau	19,625.10	0.4	13,495.30	0.3
Burnt Areas	0	0	10,063.00	0.2
Total	5,110,000.00	100.0	5,110,000.00	100.0

Source: Ministry of Agriculture and Cattle (MAG)

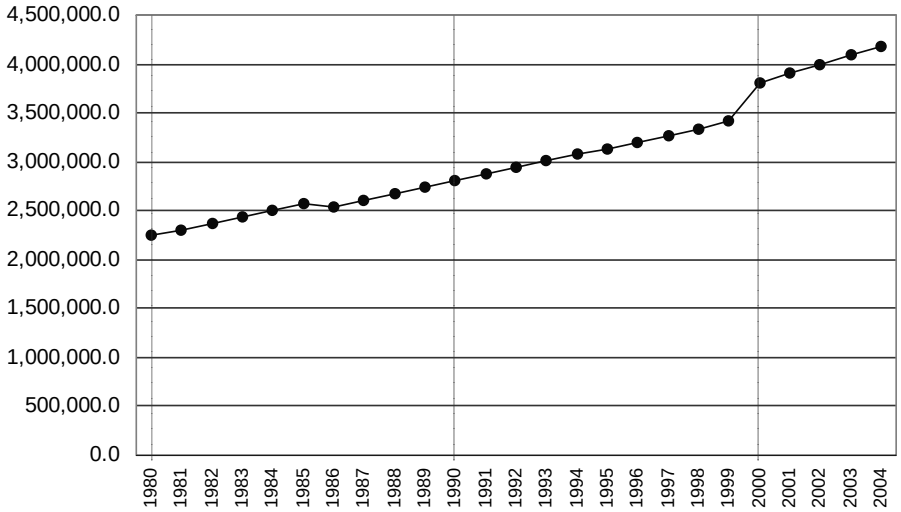


Source: Ministry of Agriculture and Cattle (MAG)

Figure 2.2.2. Land Use Map in Costa Rica in 1992

2.2.2 Population and Social Index

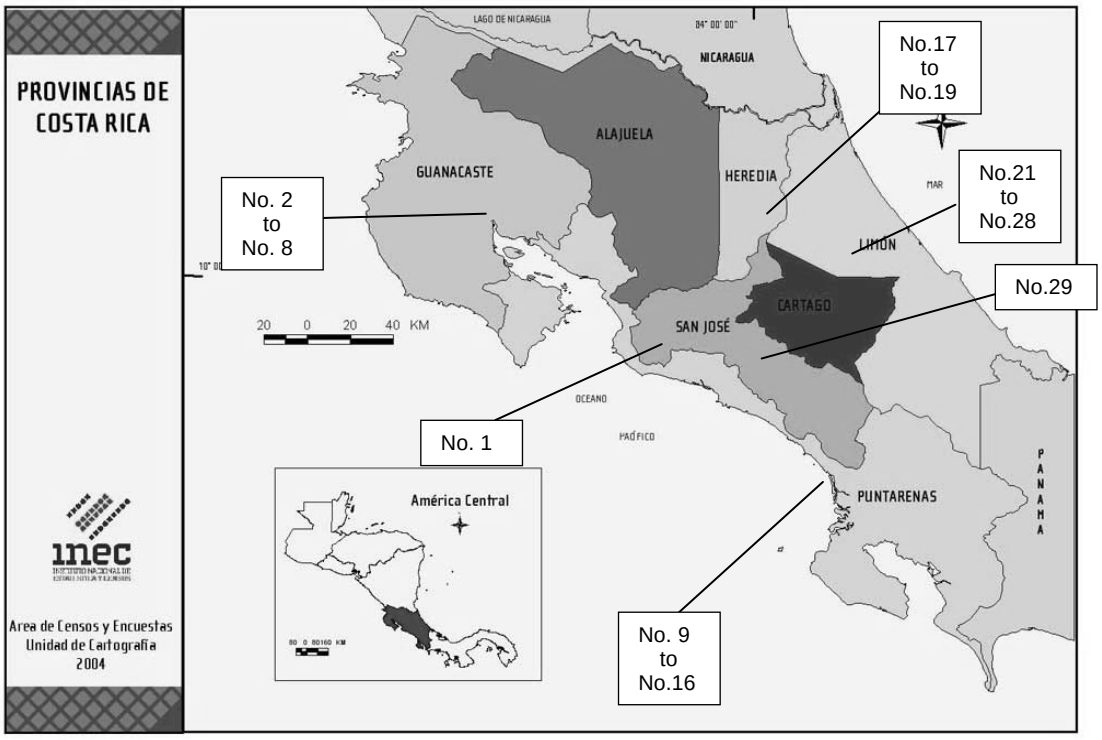
In 2004, population in Costa Rica was 4,178,755 habitants and the annual increase ratio is about 2 or 3 %. For two decades, population has increased approximately 1.7 times. The following figure (Figure 2.2.3) shows the tendency of population change since 1980.



Source: Banco Central de Costa Rica HP, National Institute of Statistics and Censuses (INEC)

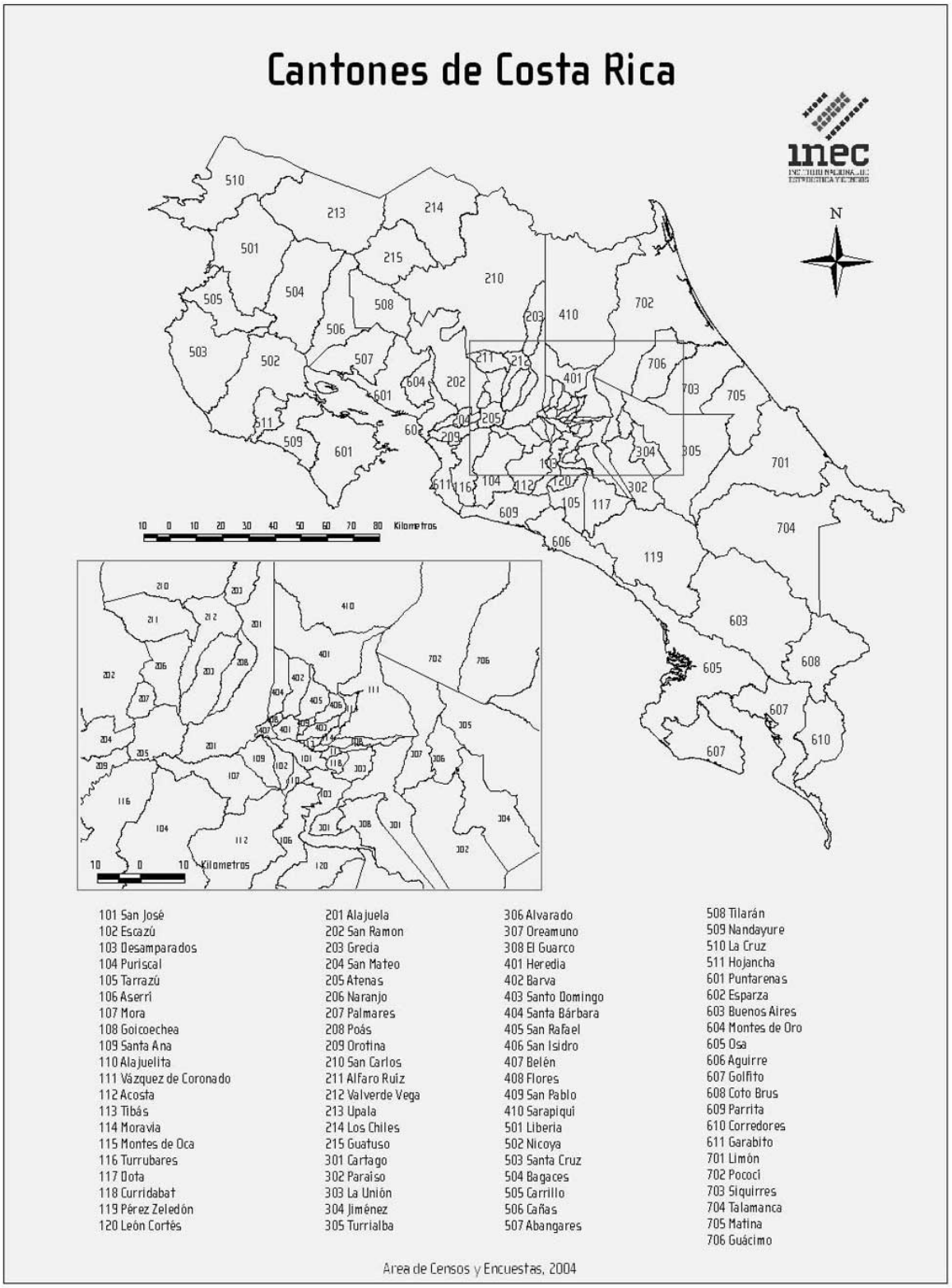
Figure 2.2.3. Population Change since 1980

In Costa Rica, local organization is divided by “Provincia”, “Canton” and “Distrito”. There are 7 Provinces and 81 Cantons shown in Figure 2.2.4. and 2.2.5.



Source: National Institute of Statistics and Censuses (INEC)

Figure 2.2.4. Province in Costa Rica and Bridge Location



Source: National Institute of Statistics and Censuses (INEC)

Figure 2.2.5. Cantons in Costa Rica

According to the population in each province, population in San Jose province occupies 36% of the total population. The Second largest population is in Alajuela province (Figure 2.2.6.). From another point of view which is population density, San Jose has the highest density and it has much difference between national average and other provinces' density (Figure 2.2.7.).

In this study, historical provincial population data such as 1973, 1984 and 2000 are collected. Figure 2.2.8. shows the increase ratio based in 1973 population in each province. This results show that Limon province remarks the highest ratio of increased population, on the other hand, Guanacaste and Puntarenas province remark under national average. These provinces have national road Route 1 and 2, and more than half of the bridge study.

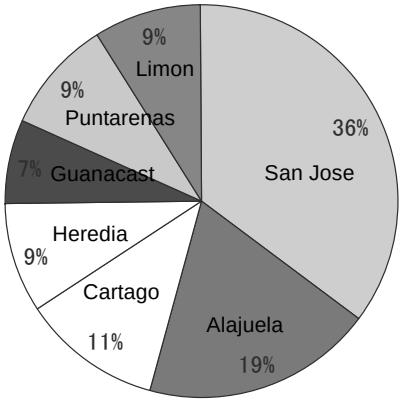


Figure 2.2.6. Population Share in Each Province

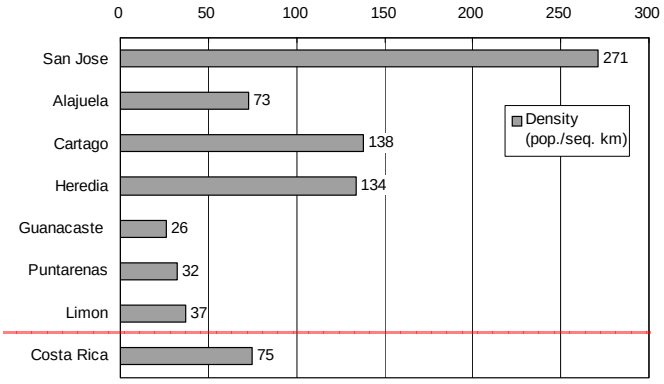
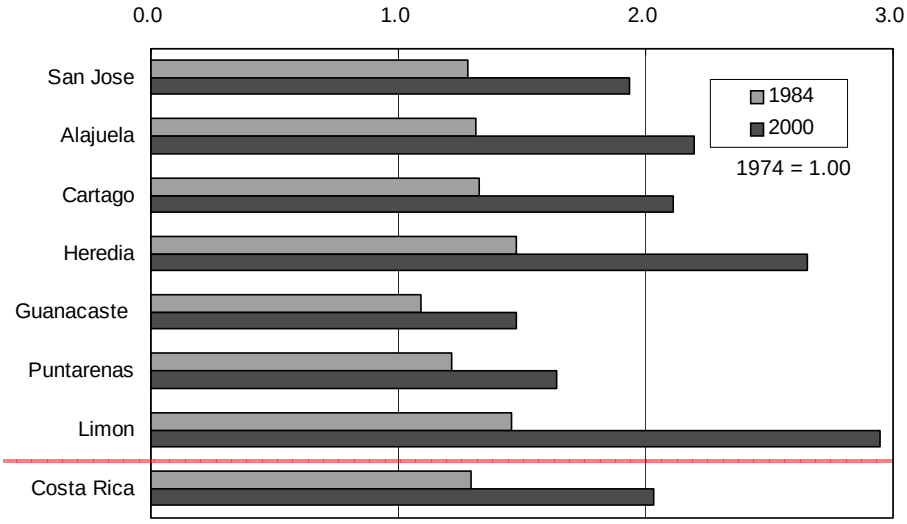


Figure 2.2.7. Population Density



Source: Tendencias del Desarrollo Costarricense Version 2003 (OdD)

Figure 2.2.8. Population Change in Each Province based on 1974

Detail statistics for each province is described as follows (Table2.2.2.).

Table 2.2.2. Provincial Data

Province	San Jose	Alajuela	Cartago	Heredia	Guanacaste	Puntarenas	Limon	Costa Rica
Population								
1973	695,163	326,032	204,699	133,844	178,691	218,208	115,143	1,871,780
1984	890,434	427,962	271,671	197,575	195,208	265,883	168,076	2,416,809
2000	1,345,750	716,286	432,395	354,732	264,238	357,483	339,295	3,810,179
Components of Pop. in each year group								
0-14 years	30%	33%	32%	30%	33%	35%	37%	32%
15-29 years	27%	27%	27%	28%	26%	26%	27%	27%
30-59 years	34%	33%	33%	35%	32%	31%	30%	33%
60 over years	9%	8%	7%	8%	9%	7%	6%	8%
Area (km^2)	4,966	9,758	3,125	2,657	10,141	11,266	9,189	51,100
Density (pop./seq. km)	271	73	138	134	26	32	37	75
Pop. in Urban	1,081,847	259,184	286,394	241,790	1,081,847	143,444	125,917	2,249,414
(%)	80%	36%	66%	68%	409%	40%	37%	59%
Pop. in Rural	263,903	457,102	146,001	112,942	153,400	214,039	213,378	1,560,765
(%)	20%	64%	34%	32%	58%	60%	63%	41%

Source: Tendencias del Desarrollo Costarricense Version 2003 (OdD)

In the stage of progress report, it was difficult to collect the future estimated population and the origination which has to be responsibly done. For the next stage of this study such as economical analysis, we will be collecting information about the national frame work including estimation of population, economical index and so on.

Other basic index for the level of social condition such as “Life expectancy”, “Birth rate” and “Infant Mortality” is compared with other Central American countries in Table 2.2.3. It is clear that Cost Rica has better social condition than any other neighbor country.

Table 2.2.3. Index for Social Condition with Neighbor Country

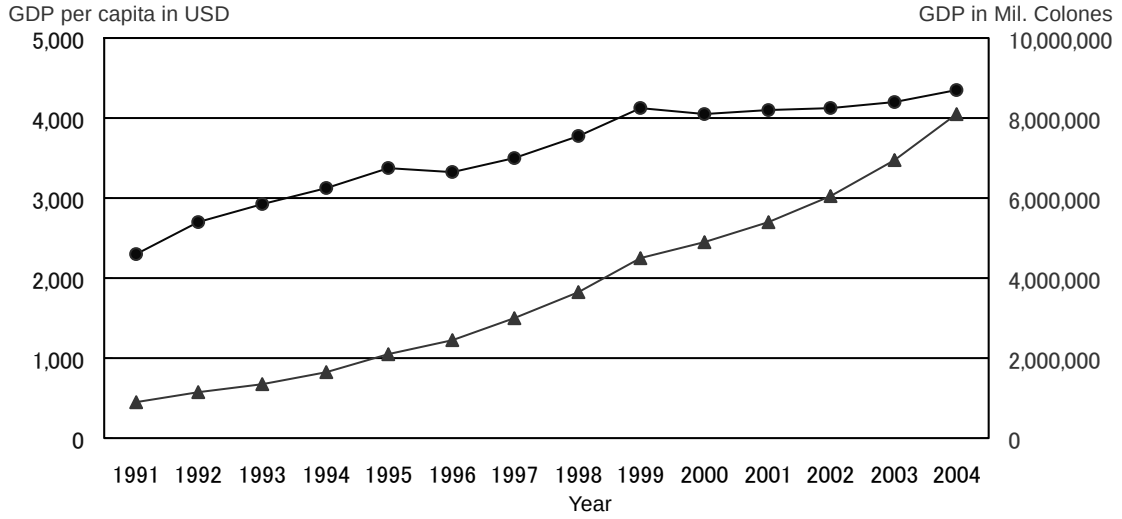
Country	**Costa Rica**	Guatemala	El Salvador	Honduras	Nicaragua	note
Population	**4,016,173**	14,655,189	6,704,932	6,975,204	5,465,100	July 2005 est.
Population Growth rate	**1.48%**	2.57%	1.75%	2.16%	1.92%	2005 est.
Birth rate	**18.6**	34.11	27.04	30.38	24.88	births/1,000 population (2005 est.)
Death rate	**4.33**	6.81	5.85	6.87	4.49	deaths/1,000 population (2005 est.)
Net migration rate	**0.5**	-1.63	-3.67	-1.95	-1.19	migrant(s)/1,000 population (2005 est.)
Infant mortality rate						
total	**9.95**	35.93	25.1	29.32	29.11	deaths/1,000 live births
male	**10.85**	36.74	27.98	32.84	32.6	
female	**9**	35.09	22.08	25.63	25.44	
Life expectancy at birth						
total population	**76.84**	69.06	71.22	69.30	70.33	years (2005 est.)
male	**74.26**	67.37	67.61	67.71	68.27	
female	**79.55**	70.84	75.01	70.97	72.49	
Total fertility rate	**2.28**	4.53	3.16	3.87	2.81	children born/woman (2005 est.)
Literacy						definition: age 15 and over can read and write
total population	**96.0%**	70.6%	80.2%	76.2%	67.5%	
male	**95.9%**	78.0%	82.8%	76.1%	67.2%	(2003 est.)
female	**96.1%**	63.3%	77.7%	76.3%	67.8%	

Source: The World Factbook, CIA

2.2.3 Economy and Industry

Costa Rica's basically stable economy depends on tourism, agriculture, and electronics exports. Poverty has been substantially reduced over the past 15 years, and a strong social safety net has been put into place. Foreign investors remain attracted by the country's political stability and high education levels, and tourism continues to bring in foreign exchange. Low prices for coffee and bananas have hurt the agricultural sector. The government continues to grapple with its large deficit and massive internal debt. The reduction of inflation remains a difficult problem because of rises in the price of imports, labor market rigidities, and fiscal deficits. The country also needs to reform its tax system and its pattern of public expenditure. Costa Rica recently concluded negotiations to participate in the US-Central American Free Trade Agreement, which, if ratified by the Costa Rican Legislature, would result in economic reforms and an improved investment climate.

Figure 2.2.9. shows the Gross Domestic Products ("GDP") at market prices. Circle dot line shows the series of total GDP in Millions of colones and triangle dot line shows the series of GDP per capita in USD. These have had a steady increase for about one decade. The GDP real growth rate in 2004 is 3.9%.



Source: Banco Central de Costa Rica HP, National Institute of Statistics and Censuses (INEC)

Figure 2.2.9. Change of GDP and GDP per capita in 1991-2004

The GDP composition by sector in 2004 is as follows; a) agriculture: 8.5%, b) industry: 29.7% and c) services: 61.8%.

Especially, Tourism has the important role for the economy in Costa Rica. Indications of tourism are shown in Table 2.2.4, which has increased almost 2 times in the last seven years.

Table 2.2.4. Change of GDP and GDP per capita in 1991-2004

	1997	1998	1999	2000	2001	2002	2003	2004
International Tourist	811,490	942,853	1,1031,585	1,088,075	1,131,406	1,113,359	1,238,692	1,452,926
Income million USD	719	884	1,036	1,229	1,096	1,078	1,199	1,357
Investment million USD	78	209	25	38	48	173	60	56
Number of Rooms	27,860	28,084	28,826	29,497	31,706	33,126	35,003	36,299

Source: Estado de la Nacion 2004

The economical situation with neighboring countries is shown in Table 2.2.5. According to this table, Costa Rica is better than any other neighbor country.

Table 2.2.5. Index for Economical Condition with Neighbor Country

Country	**Costa Rica**	Guatemala	El Salvador	Honduras	Nicaragua	note
GDP - per capita	**$9,600**	$4,200	$4,900	$2,800	$2,300	purchasing power parity (2004 est)
real growth rate	**3.90%**	2.60%	1.80%	4.20%	4%	2004 est
Unemployment rate	**6.60%**	7.50%	6.30%	28.50%	7.80%	2003 est

Source: The World Factbook, CIA

For the exports, the total export value has been increased since 1997. Main traditional exports goods are Coffee, Banana, Meat and Sugar. However, these traditional exports are not only by amount but also by unit price, which has been reduced since 1997 as shown in Table 2.2.6. On the other hand, exports at Free-trade zone are increasing steadily.

Table 2.2.6. Exports FOB by Main Products

unit: million US$

		1997	1998	1999	2000	2001	2002	2003	2004
Total exports FOB		4,205.5	5,525.6	6,662.4	5,849.7	5,021.4	5,263.5	6,102.2	6,301.5
Traditional exports		1,049.2	1,142.6	969.4	877.8	738.8	691.1	793.8	800.7
COFFEE		402.3	409.4	288.7	272.0	161.8	165.1	193.6	197.6
	Quintals	2,705.5	2,918.2	2,801.8	2,854.8	2,769.8	2,548.6	2,665.4	2,360.1
	Price/quintal	148.7	140.3	103.1	95.3	58.4	64.8	72.6	83.7
BANANA		577.3	667.5	623.5	546.5	516.0	477.5	553.1	543.3
	Tons	2,019.0	2,150.0	2,087.2	1,975.0	1,859.6	1,693.6	1,940.8	1,915.4
	Price/ton	285.9	310.5	298.7	276.7	277.5	281.9	285.0	283.7
MEAT		28.3	24.0	27.2	30.7	25.5	21.5	22.3	21.7
	Tons	12.9	10.2	13.6	14.6	11.1	8.8	9.7	8.4
	Price/ton	2.2	2.3	2.0	2.1	2.3	2.4	2.3	2.6
SUGAR		41.3	41.8	30.0	28.6	35.5	27.0	24.8	38.1
	Quintals	2,180.7	3,358.0	3,231.7	3,025.0	3,624.0	2,941.5	2,383.9	4,490.5
	Price/quintal	18.9	12.5	9.3	9.5	9.8	9.2	10.4	8.5
Other exports		3,156.3	4,382.9	5,693.0	4,972.0	4,282.6	4,572.4	5,308.3	5,500.7
Agriculture and fishery		716.8	757.8	573.5	526.6	539.6	565.0	596.1	671.6
Manufactured goods		1,121.0	1,244.4	1,134.7	1,090.2	1,029.3	1,022.7	1,077.2	1,208.1
Assembled goods		427.2	444.5	396.1	398.9	366.4	354.1	331.7	373.3
Free-trade zones		891.3	1,936.2	3,588.8	2,956.3	2,347.4	2,630.6	3,303.3	3,247.8

Source: Banco Central de Costa Rica HP, National Institute of Statistics and Censuses (INEC)

For the exports to other countries, main partner that is North America is reducing the amount of export goods. On the other hand, relationship with Central America, Caribbean Community and Others in Latin America has been enforced since 1997 (Table 2.2.7.).

Table 2.2.7. Exports FOB by Main Countries

unit: million US$

	1997	1998	1999	2000	2001	2002	2003	2004
Total exports	4,205.5	5,525.6	6,662.4	5,849.7	5,021.4	5,263.5	6,102.2	6,301.6
Central America	410.9	479.4	531.9	557.5	558.9	524.0	575.4	662.1
Guatemala	135.2	156.9	160.9	168.7	175.7	169.8	181.7	196.5
El Salvador	99.1	101.6	105.1	118.7	131.4	111.0	124.8	143.3
Honduras	66.3	82.5	92.5	97.4	99.4	99.4	105.0	128.6
Nicaragua	110.3	138.4	173.4	172.7	152.2	143.8	163.9	193.7
North America	1,121.6	1,187.5	1,021.0	926.3	820.8	842.7	892.8	930.8
Canada	66.8	78.2	29.7	21.2	22.1	25.0	26.7	25.1
United States	991.8	1,054.0	927.3	845.4	757.4	756.0	824.0	852.5
Mexico	62.9	55.2	63.9	59.7	41.3	61.7	42.0	53.2
Caribbean Community	30.0	36.6	31.2	42.1	50.4	48.6	55.7	56.6
Barbados	1.3	1.6	1.9	2.6	2.5	2.4	2.4	2.6
Belize	1.5	2.7	1.5	1.9	2.1	2.1	2.5	2.0
Guyana	0.4	0.9	0.6	1.5	1.2	0.8	0.7	1.1
Trinidad & Tobago	3.2	3.6	3.6	3.1	4.3	4.7	6.3	7.4
Others	23.5	27.8	23.6	32.9	40.3	38.6	43.8	43.6
Others in Latin America	277.0	340.6	288.6	272.2	280.0	272.2	274.6	322.5
Panama	78.9	91.2	105.6	105.7	117.0	109.5	121.1	135.5
Colombia	28.9	32.3	14.4	15.5	13.2	15.5	15.3	20.3
Venezuela	17.9	20.9	13.6	20.3	20.8	15.8	15.6	25.1
Brazil	3.3	3.4	2.5	1.7	4.4	12.1	7.4	6.3
Argentina	8.7	5.7	1.1	1.4	1.3	0.2	0.4	0.7
Chile	26.0	19.3	15.2	3.2	3.5	2.8	2.7	4.7
Ecuador	9.1	9.9	8.4	9.9	10.5	9.2	8.2	11.7
Peru	14.3	15.3	10.0	7.6	7.2	5.7	8.9	8.4
Bolivia	0.9	0.6	0.3	0.2	0.2	0.1	0.1	0.1
Uruguay	1.4	2.1	1.4	0.7	1.4	0.6	0.7	0.5
Paraguay	0.2	0.7	0.0	0.0	0.1	0.0	0.0	0.0
The rest of Latin America	87.5	139.0	116.2	106.1	100.5	100.7	94.1	109.0
Europe	885.5	962.8	740.8	629.3	550.4	547.9	608.6	643.0
Asia	111.3	82.6	39.3	50.2	39.1	35.6	51.8	52.6
Oceania	4.6	3.9	2.6	2.6	1.2	1.2	1.8	2.3
Africa	12.1	8.4	8.2	8.2	3.3	3.8	3.7	8.3
Other countries	34.0	43.1	13.8	6.1	3.7	2.7	2.7	2.2
Assembled goods	427.2	444.5	396.1	398.9	366.4	354.1	331.7	373.3
Free-trade zones	891.3	1,936.2	3,588.8	2,956.3	2,347.4	2,630.6	3,303.3	3,247.8

Source: Banco Central de Costa Rica HP, National Institute of Statistics and Censuses (INEC)

2.2.4 Motorization

Harmonized with the increase of GDP, vehicle registration has increased continuously, and it is 228 vehicle/1000 people in 2004 (Figure 2.2.9., Table 2.2.8.).

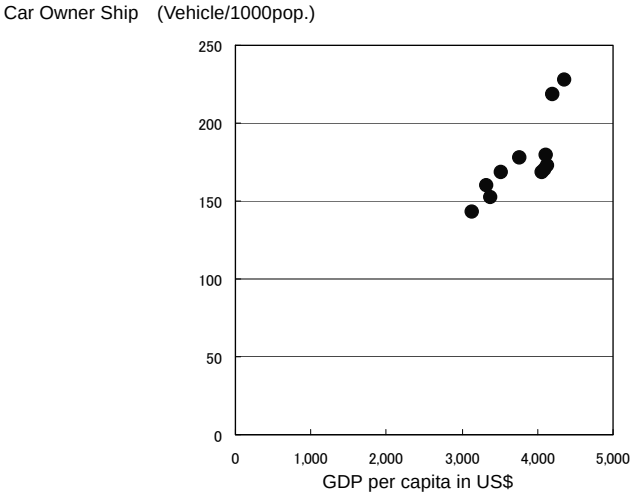


Figure 2.2.10. Relationship between Car Owner Ship and GDP per capita

Table 2.2.8. Vehicle Registration in 1994-2004

Year	Reg. No. of Vehicle	Population	GDP per capita in US$	Vehicle/1,000pop.
1994	439,235	3,070,918	3,131.3	143
1995	477,778	3,136,020	3,378.4	152
1996	511,670	3,202,440	3,322.4	160
1997	551,750	3,270,700	3,508.5	169
1998	594,148	3,340,909	3,763.5	178
1999	612,300	3,412,613	4,116.2	179
2000	641,302	3,810,187	4,062.4	168
2001	664,563	3,906,742	4,092.4	170
2002	689,763	3,997,883	4,117.4	173
2003	894,501	4,088,773	4,193.5	219
2004	952,295	4,178,755	4,353.3	228

Source: Anuario Estadistico del Sector Transporte 2002 (MOPT), Estado de la Nacion 2004

2.3 Road Network Configuration and Condition

This section is described as existing road network and service level of road condition in Costa Rica.

2.3.1 Road Classification

According to the road related law "No.5060 Ley General de Caminos Publicos", roads in Costa Rica are classified as National Road "RED VIAL NACIONAL" and Rural Road "RED VIAL CANTONAL" for different treatment of administration. Each road is classified by 3 categories in depth.

National Roads are in a network as a national trunk road, and its length is 7,775km. Rural roads are 29,498 km long. Total road network is 37,273 km long in November 2005.

MOPT is in charge of formulation basic policies and executing the construction of national roads network, and maintenance of them is done by CONAVI. Maintenance and management of rural Roads are officially done by each province government, but actually done by MOPT because of the budget and limited number of staff in local government.

Table 2.3.1. shows the classification definition in law and its length.

Table 2.3.1. Road Classification Definition and its Length

National Road	7,475km Constructed by MOPT, Maintained by CONAVI
Classification	Definition, Route number, Length
Primary	**Trunk road network to serve corridors, characterized by transit volumes relatively high and with a proportion of international trips, inter-provincials or long distance** Route No. 1 to 99 1,948 km
Secondary	**Routes which connect important main country roads which are not served by primary highways like other centers of towns, production or tourism that generates a considerable inter-regional or inner trips** Route No. 100 to 299 2,736 km
Tertiary	**Routes which serve like collectors of the transit for the primary and secondary highways, and that constitute the main roads for the regional inner trips of between important districts** Route No. 300 to 935 2,791 km
Rural Road	24,798km Constructed and Maintained by MOPT
Classification	Definition
Neighbor Roads	**Public Roads that give direct access to privatively owned property and other rural economical activities, they gather settlements and towns with the National Road Network and they are characterized by having lower transit volumes and high proportions of short distance local travels..**
Local Streets	**Public Roads included inside the square of an urban area, not classified as urban travels of the National Road Network.**
Non Classified Roads	**Non classified roads inside the previously described categories: such as horseshoe road, trails and paths, which give access to only a few users, which will be responsible to cover the maintenance and improvement costs.**
Total	37,273 km

Source: Definition: No.5060 de 22-8-1972 Ley General de Caminos Publicos revisada en No.6676 de 12 de enero de 1979

Source: Length: Calculated by "Road Inventory Data in Nov. 2005" MOPT

Planning section in MOPT has the Geographic Information System ((hereafter referred to as "GIS") data for road network and its property data, which is established by ARC-GIS software. GIS data had been digitalized on the screen using the geographical image map scaled 1:50,000 where most of the national road network is established and some of the property data such as pavement condition is already stored.

For the bridges, MOPT is developing its location in ARC-GIS. However many of its location data is stored in inventory data which has a deference in actual location. Therefore each location is checked one by one for about 1,300 bridges. Locations of traffic volume collection described in the next section are also in the same situation so that it is under construction now.

According to the category of national road, 29 study bridges are on the "Primary" road except No.29 Bridge on Route 218.

Figure 2.3.1. shows the network colored by 3 categories of road classification in the whole country of Costa Rica, Figure 2.3.2. shows the Metropolitan Area, Figure 2.3.3 to 2.3.9 show the network in each province in detail.

For the road design standard, the Department of Road Design in MOPT, uses a hybrid between the followings Standards as its elements of geometric design criteria:

- A Policy on Geometric Design of Highways and Streets (1994), AASHTO, U.S.A.
- Manual of Road Geometric Project (1995), SOP (Secretary of Publics Works), Mexico
- Rules for Geometric Design of Regional Roads (2004), SIECA (Secretaría de Integración Económica Centroamericana: Central American Secretary of the Economic Integration)

Actually they mix these three specifications for a specific design for national or rural road.

It is important to say for PPP (Plan Puebla Panamá), it is necessary to use the SIECA specifications.

In this moment, they are working in the elaboration of a National Manual for Cantonal Roads.

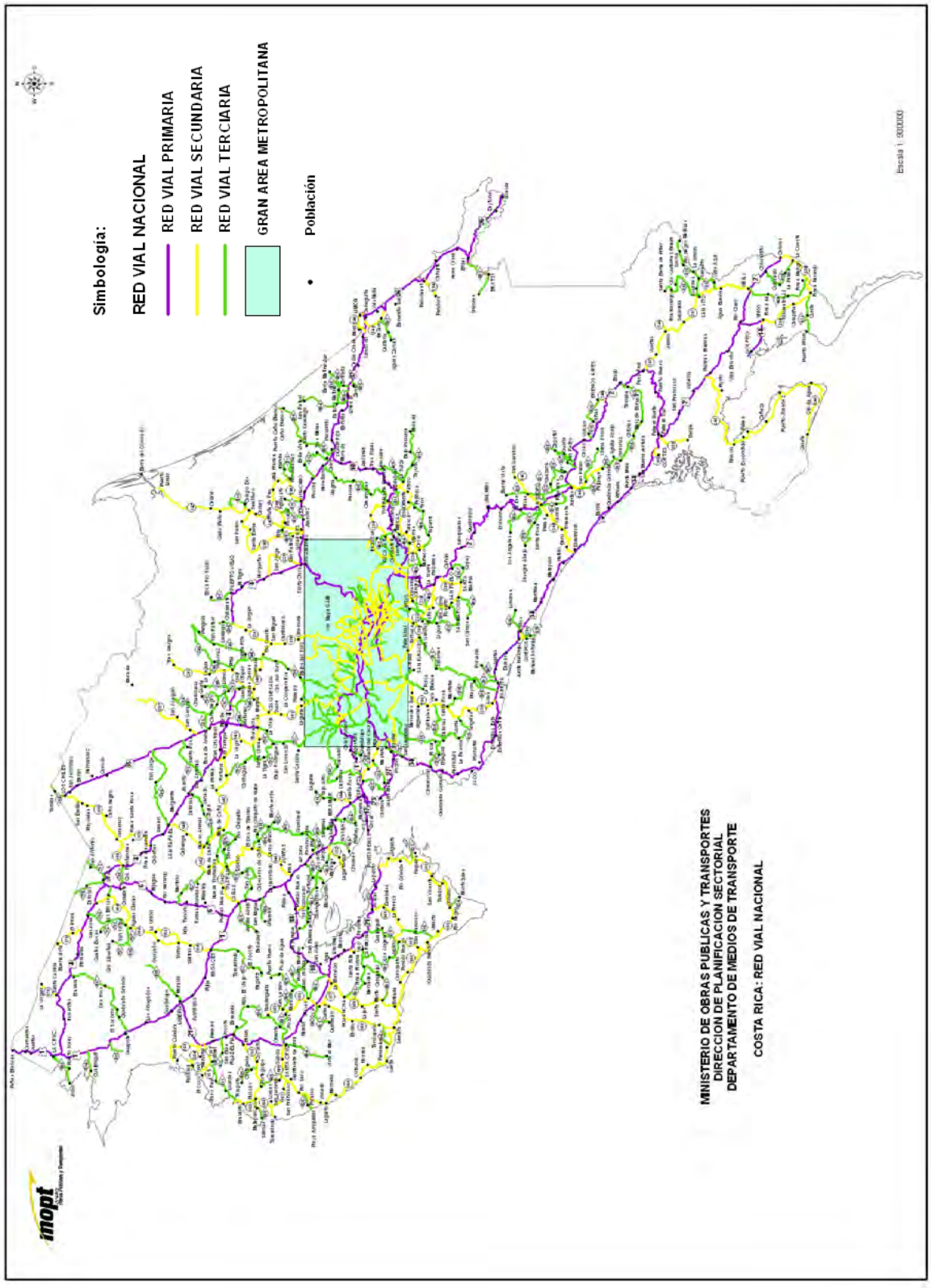


Figure 2.3.1. Road Network (Each Category) in Costa Rica

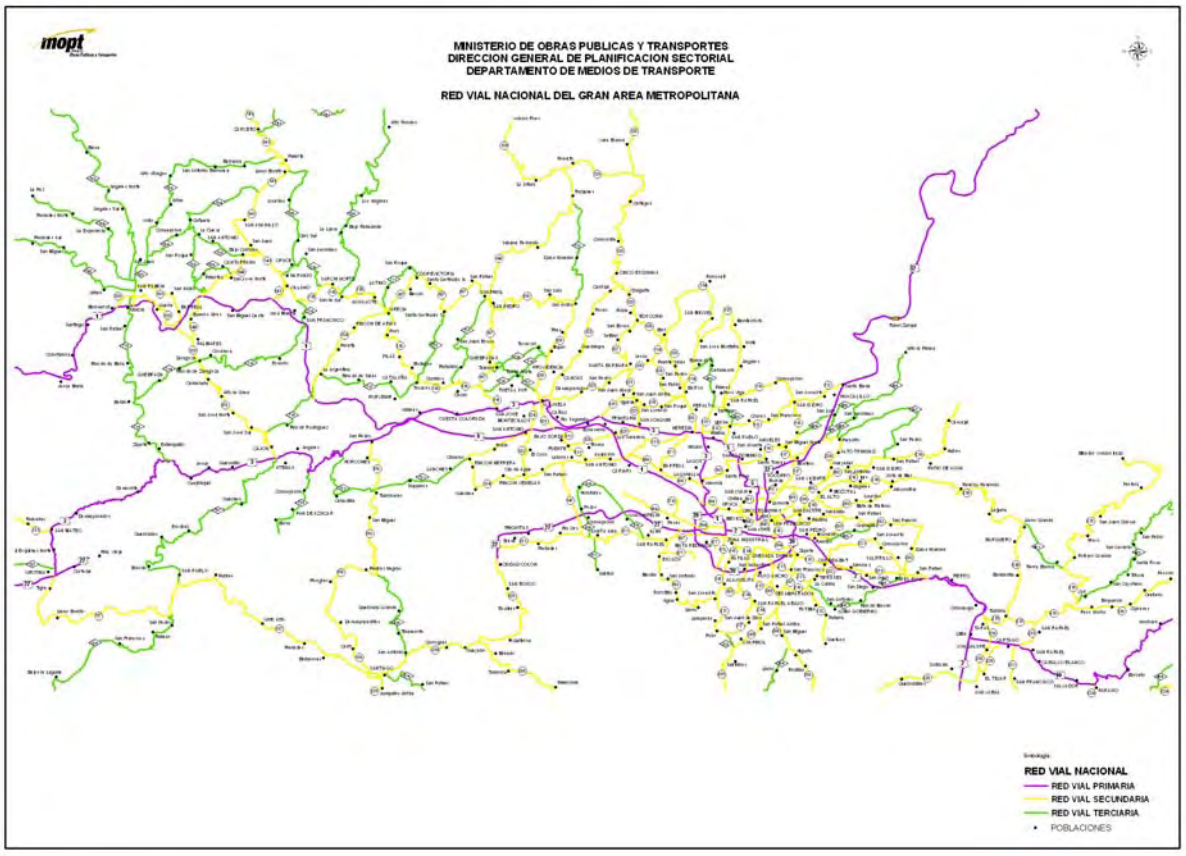


Figure 2.3.2. Road Network (Each Category) in the Great Metropolitan Area

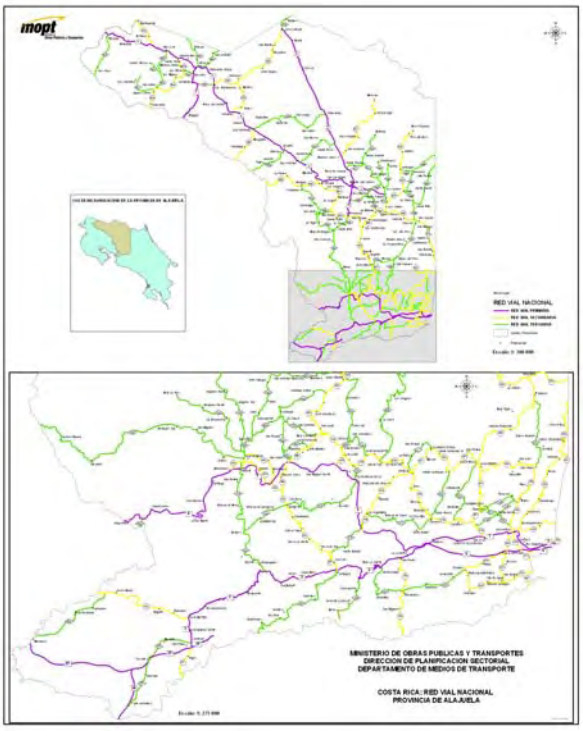


Figure 2.3.3. Road Network in San Jose Province

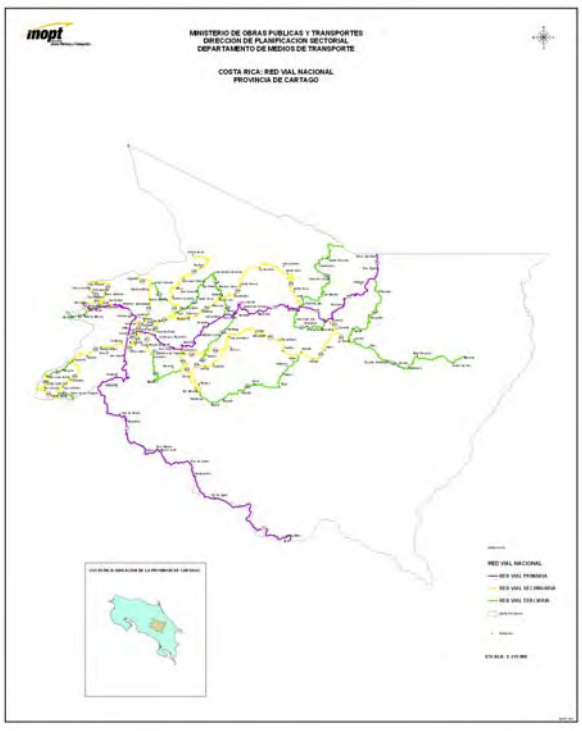


Figure 2.3.4. Road Network in Cartago Province

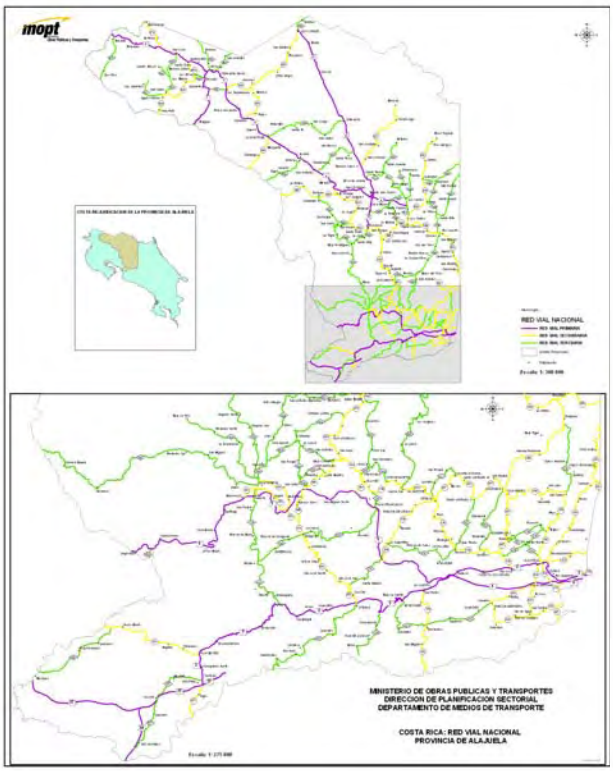


Figure 2.3.5. Road Network in Alajuela Province

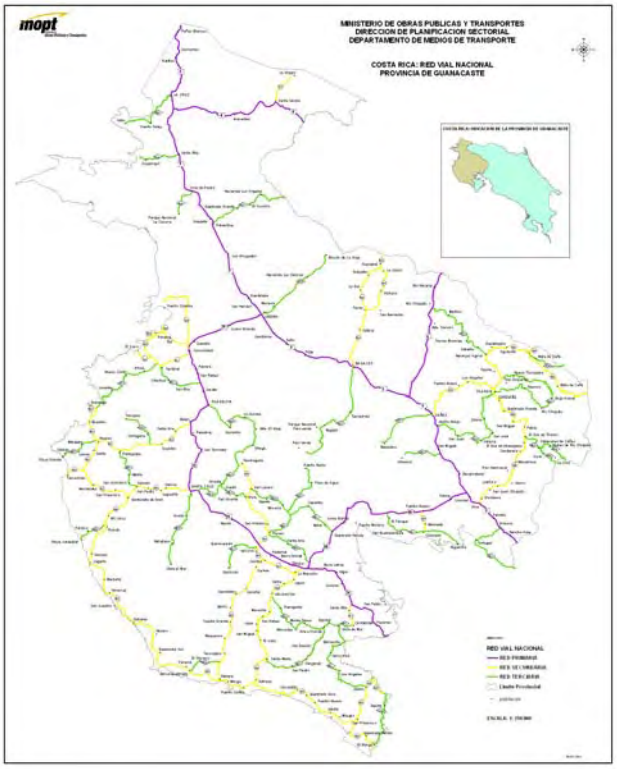


Figure 2.3.6. Road Network in Guanacaste Province

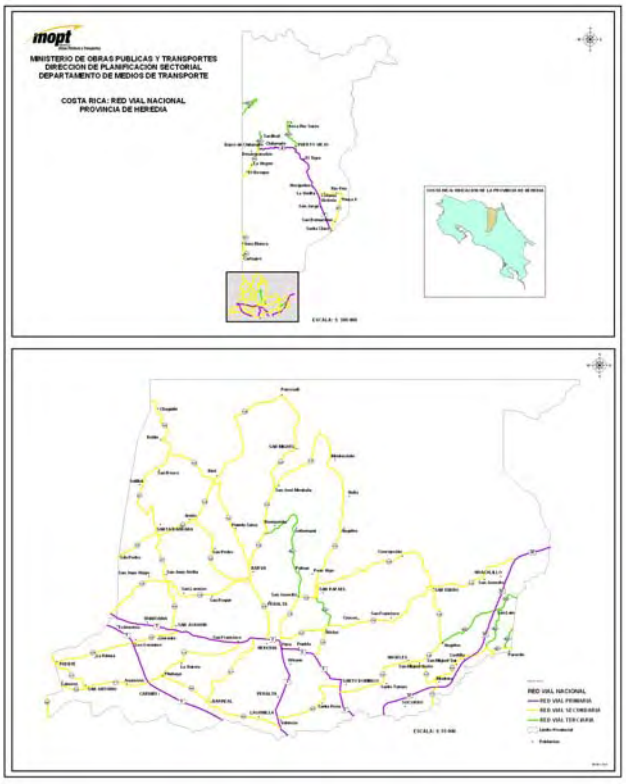


Figure 2.3.7. Road Network in Heredia Province

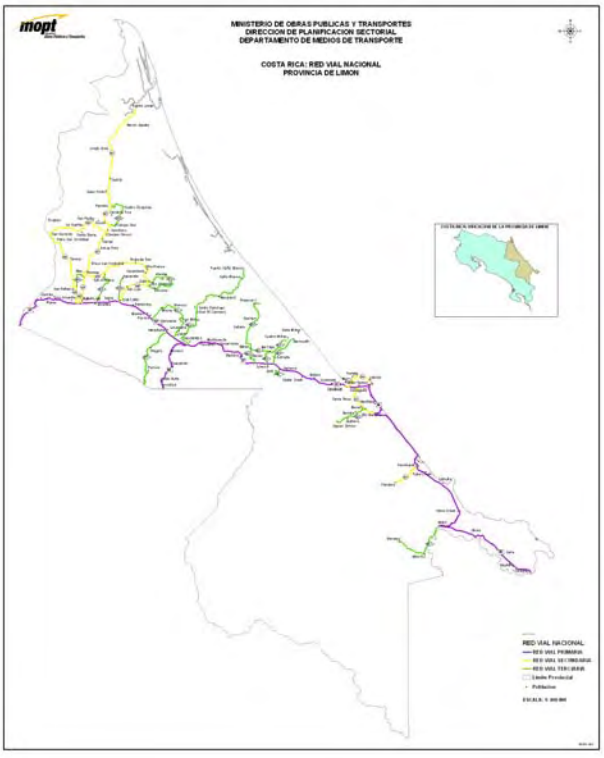


Figure 2.3.8. Road Network in Limon Province

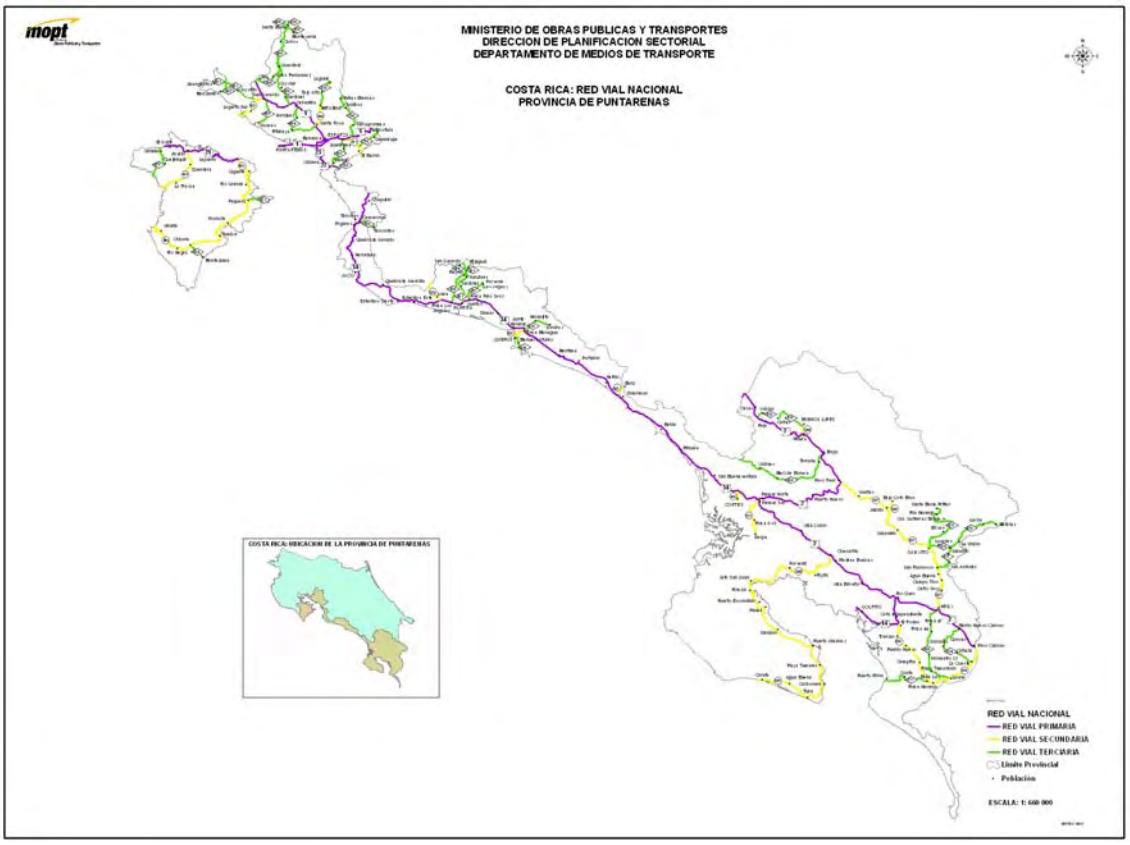


Figure 2.3.9. Road Network in Puntarenas Province

2.3.2 Traffic Volume

Traffic Volume in Costa Rica has been collected by Planning Section in MOPT since 1987. There are 533 stations on the national road. For example, route 1 has 22 stations, route 2 has 21 stations, route 4 has 15 stations, route 32 has 9 stations and route 218 has 9 stations.

Vehicles are divided by 5 classified categories for traffic volume, such as 1.Passenger Car, 2.Truck (2-axial), 3.Truck (3-axial), 4.Bus and 5.Ttuck (5-axial). Traffic per Day (TPD) is just summed up to the counted data of each category.

In the report of annual traffic volume, there is an estimated traffic volume in the sheet. This estimated data is calculated by the method of trends of the previous year (using the same ratio of annual increase ratio). It is not used for traffic planning but used just for estimation of number of enumerators.

According to the inventory data for the national road section, which includes traffic volumes, even on the primary road, there is 13% of its length in a range of more than 10,000 vehicles per day, 21% is in the range between 5,000 to 9,999 vehicle per day, 56% is in the range between 1,000 to 4,999. On the secondary class, about 85% of its length is in a range of less than 5,000 vehicle per day and on the tertiary class is 42% of its length is in a range of less than 500 vehicles per day.

Table 2.3.2 shows the % share of the traffic volume range for each class of national road, and the outline of traffic volume on each route in Costa Rica is shown in Figure 2.3.10..

Table 2.3.2. Traffic Volume for Each Class of National Road

Unit % share of its category of traffic volume (vehicle per day)

Class	more than 10,000	5,000-9,999	1,000-4,999	500-999	less than 500	no data	Total	km
Primary	**13%**	**21%**	**56%**	7%	2%	1%	100%	1,948
Secondary	8%	6%	**37%**	**13%**	**34%**	1%	100%	2,735
Tertiary	0%	1%	11%	12%	**76%**	0%	100%	2,791
Total	6%	8%	32%	11%	42%	1%	100%	7,475

Source: National Road Condition Data in Nov. 2005, Planning Section, MOPT

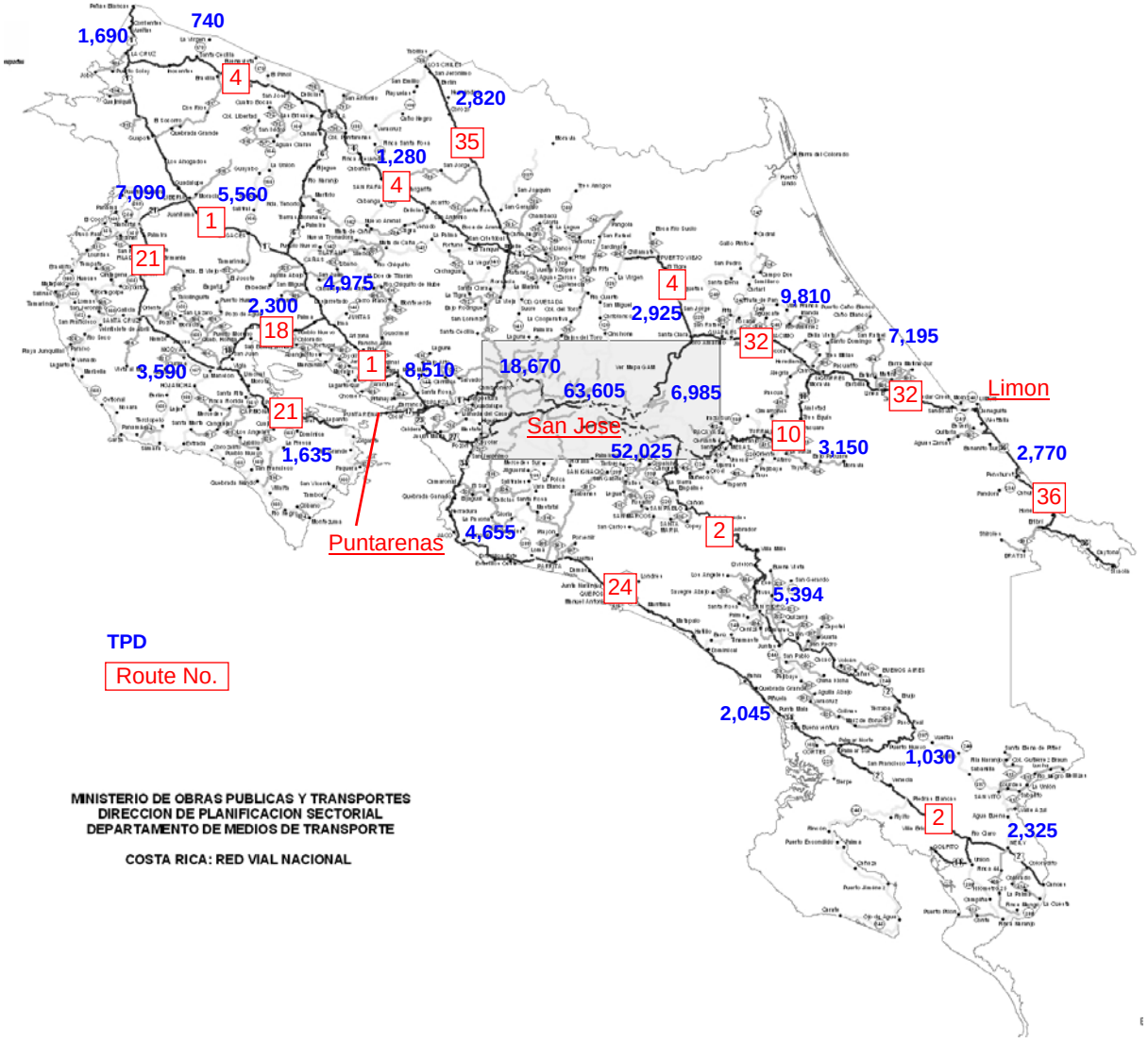
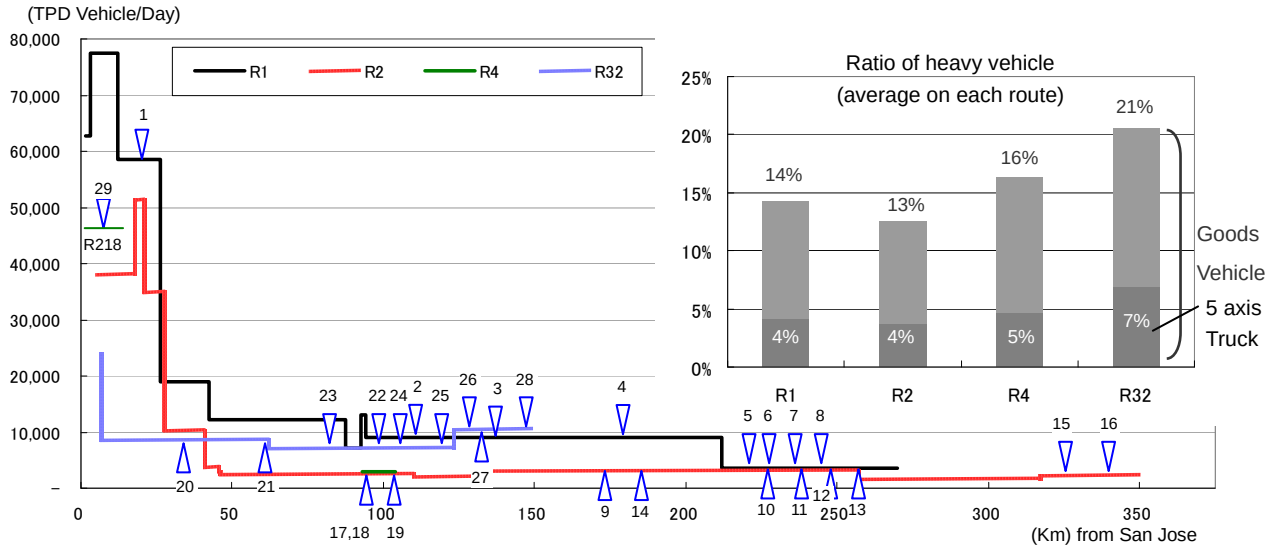


Figure 2.3.10. Traffic Volume on Each Route in Costa Rica

Furthermore, the route which 29 bridges are located such as Route1, 2, 4 and 32 and 218 has characteristics of traffic volume as follows;

- Traffic volume on more than 50km far from San Jose is,
  - Route 1: 13,000 TPD
  - Route 2: 5,000 TPD
  - Route 32: 10,000 TPD
- Route 32 has more heavy vehicles on the roads than any other route. It seems to be caused by the goods transported to Limon port for export (and import).
- 29 study bridges are located on the road that has about 5,000-10,000 TPD except No.1 (60,000 TPD) and No.29 (45,000 TPD).

Traffic volume changes on each route are shown in Figure 2.3.11. and Table 2.3.3.



Source: Traffic Volume Data 2002-2003, Planning Section, MOPT

Figure 2.3.11. Traffic Volume on Each Route

Table 2.3.3. Traffic Volume on Each Route

Route	Station	Survey 12/24Hr.	Kp	Light Vehicles	Two Axles	Three Axles	Buses	Five Axles	Total	(24Hr./12Hr.)	TPD	Ratio of Heavy Vehicle	Ratio of Five axles
1	101	24	1.5	57.397	1.346	1.035	2.387	597	62.762	1.29	62.762	9%	1.0%
1	106	12	3.0	52.145	1.247	828	2.118	1.284	57.622		77.552	10%	2.2%
1	EP15	24	12.0	54.123	1.158	657	1.507	1.031	58.476	1.3	58.476	7%	1.8%
1	122	12	26.4	12.119	382	218	738	647	14.104		18.982	14%	4.6%
1	157	12	42.5	7.525	327	325	457	375	9.009		12.125	16%	1.2%
1	513	24	87.5	5.448	334	246	596	594	7.218	1.45	7.218	25%	8.2%
1	512	12	92.4	8.279	336	190	517	401	9.723		13.086	15%	4.1%
1	506	12	94.0	5.996	218	119	245	129	6.707		9.027	11%	1.9%
1	501	12	212.0	2.255	60	38	141	162	2.656		3.575	15%	6.1%
1	755	12	270.0	1.402	57	52	141	128	1, 780		2.396	21%	7.2%
2	EP10	24	5.0	34.972	830	494	1.032	689	38.017	1.41	38.017	8%	1.8%
2	568	12	17.8	32.87	953	611	1.402	888	36.724		51.441	10%	2.4%
2	165	12	20.9	23.058	544	285	574	479	24, 940		34.934	8%	1.9%
2	166	12	27.6	6.748	180	94	192	99	7.313		10.244	8%	1.4%
2	EP07	24	40.7	3.174	136	78	166	204	3.758	1.39	3.758	16%	5.4%
2	572	12	45.5	1.842	78	39	111	96	2.166		3.034	15%	4.4%
2	682	12	46.0	1.565	78	62	93	76	1.874		2.625	16%	4.1%
2	741	12	110.0	1.165	64	47	97	95	1.468		2.056	21%	6.5%
2	709	12	135.0	1.922	90	50	104	86	2.252		3.154	15%	3.8%
2	223	12	257.0	1.039	36	26	48	68	1.217		1.705	15%	5.6%
2	711	12	317.0	1.457	48	20	52	65	1.642		2.3	11%	4.0%
2	EP04	12	350.0	264	11	4	1	10	290		406	9%	3.4%
4	158	12	31.0	1.83	75	38	81	76	2, 100		2, 940	13%	3.6%
4	182	12	37.0	1.671	144	64	83	119	2.081		2.913	20%	5.7%
32	174	12	6.7	15.428	322	217	660	561	17.188		24.063	10%	3.3%
32	328	12	62.0	4.812	251	145	472	522	6.202		8.683	22%	8.4%
32	247	12	123.0	3.795	308	208	376	391	5.078		7.109	25%	7.7%
32	278	12	149.0	5.711	337	226	662	625	7.561		10.585	24%	8.3%

Source: Planning Section, MOPT

For the description of route 32, the percentage of heavy vehicles is higher than the other routes. Table 2.3.3. shows the statistics of the amount of trade in each port in Costa Rica in 2002 where Limon port is located at the end point of route 32 from San Jose, is the main port in this country.

Table 2.3.4. Tones of Goods Deal with the Port

Unit: Tons in 2002

	Caldera	P. Morales	Puntarenas	Limon y Moin	Total
Export	200,723	201,118	2,510	3,298,387	3,702,738
Import	2,105,481	34,203	70,927	3,857,165	6,067,776
Total	2,306,204	235,321	73,437	7,155,552	9,770,514

Source: Anuario Estadistico del Sector Transporte 2002, MOPT

Another traffic related survey such as "Axial Load Survey" is also conducted in MOPT.

2.3.3 Road Maintenance

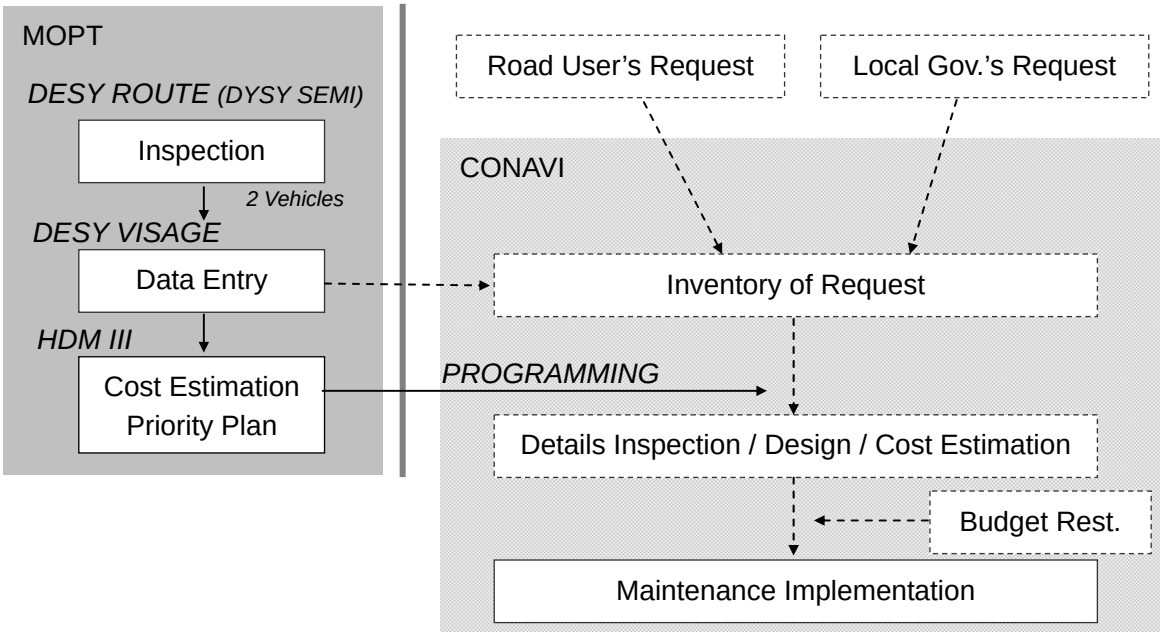
The section is described as the Road maintenance especially maintenance and rehabilitation of road pavement in Costa Rica.

At first, it should be highlighted that there are different system for road maintenance between national road and rural road.

For the national road, CONAVI is in charge of making the budget and decision for maintenance and rehabilitation. Primary inspection, data entry to inventory database and priority plan for maintenance are conducted by MOPT. MOPT submit " PROGRAMACION" to CONAVI in every year that contains the program list for the rehabilitation plan including the estimated cost used by HDM-III. For handling of HDM-III, the inspection system "DESY ROUTE" and database system "DESY VISAGE" are on action. DESY ROUTE is the special vehicle for the automatic inspection on the condition of pavement and road elements (note: there were tow vehicles in MOPT, but these were not in used because of troubles in the system, now DESYSEMI is acting on behalf of DESY ROUTE as a manual inspection data entry system) supported by French government. HDM-III is the international system which is introduced and enforced to use by IMF.

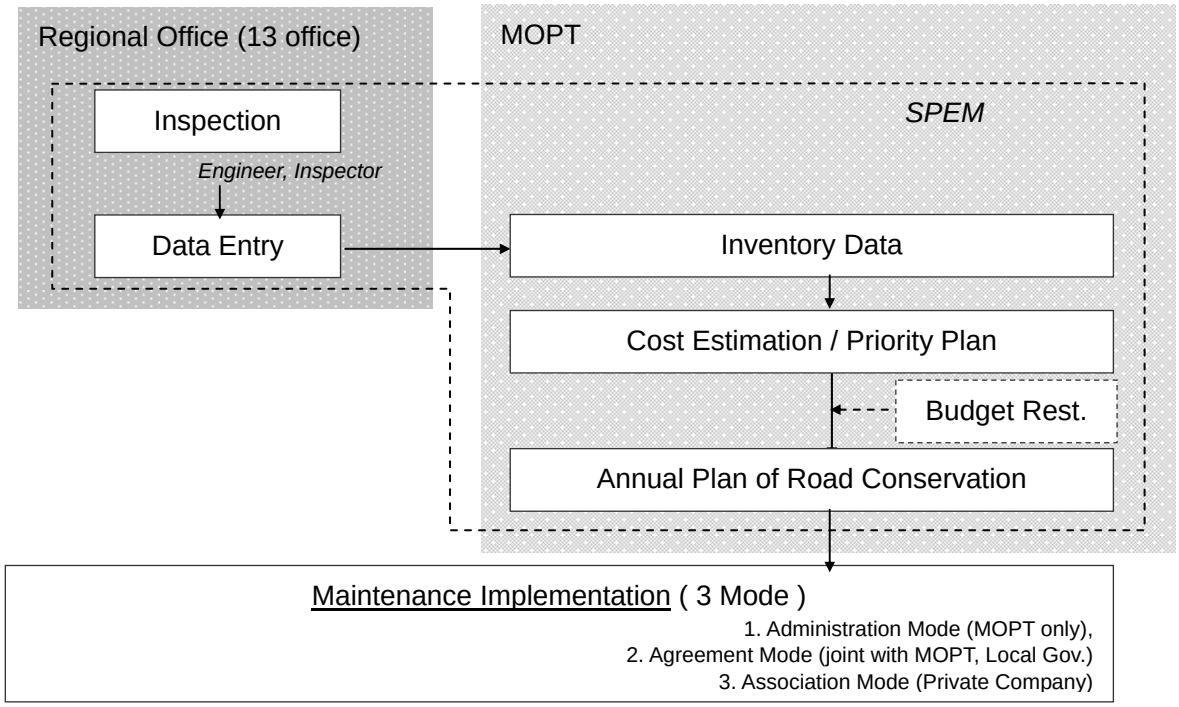
For the rural road, MOPT and local government are in charge of making the budget and the decision for maintenance and rehabilitation. The system for the pavement management system is named as "SPEM: Sistema de Programacion y Ejecucion del Mantenimiento Vital" which is established by MOPT's engineers supported by GTZ in 1990's. However, there are still rural roads wich condition has not been inspected yet.

Figure 2.3.12 shows the outline of the stream for pavement maintenance system of "National Road" and Figure 2.3.13 shows the outline of the stream for "Rural Road". Both system treat the bridge only as the condition of pavement.



Source: Planning Section (MOPT), Planning and Control Department (CONAVI)

Figure 2.3.12. Outline of Stream for National Road Maintenance



Source: Planning Section (MOPT)

Figure 2.3.13. Outline of Stream for Rural Road Maintenance

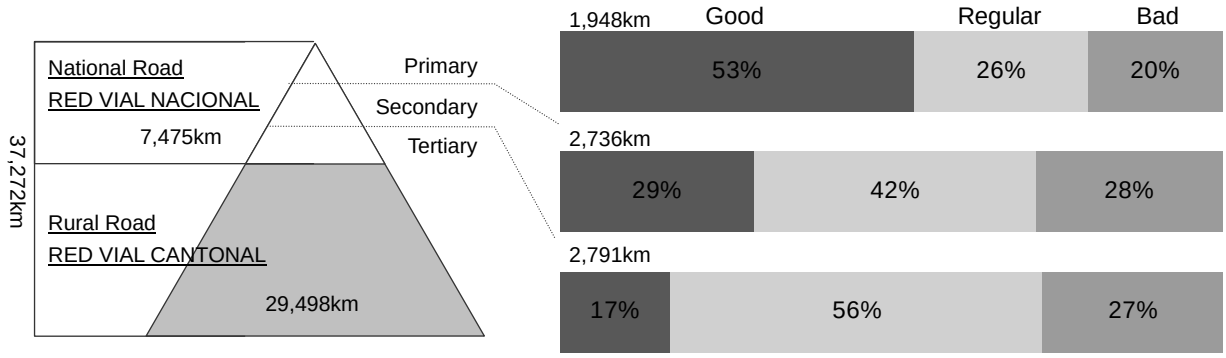
Table 2.3.5. shows the human resource for inspector and planner for the planning of road pavement rehabilitation in MOPT.

Table 2.3.5. Human Resource for Road Pavement Rehabilitation Plan in MOPT

		MOPT		Local Office: 13 Offices (In each local office)
		Administrative Department	Transport Department	
Inspector	Engineers	-	-	2
	Professional Staff	-	2	-
	Technical Staff	4	1	about 3
Data Processor	Engineers	-	-	-
	Professional Staff	-	6	-
	Technical Staff	1	4	-
Prioritization	Engineers	-	4	-
	Professional Staff	-	4	-
	Technical Staff	2	-	-

Source: Planning Section, MOPT

The inspection manual for national road, road surface condition is identified in 3 categories such as “good”, ”regular” and “bad”. Figure 2.3.14. shows the pavement condition of National Highway in these 3 categories in November 2005 using the inventory data done by MOPT. According to this data, Primary road of National Highway is stated that good condition share 53% in total length, on the other hand, Tertiary road is as only 17%.



Source: National Road Condition Data in Nov. 2005, Planning Section, MOPT

Figure 2.3.14. Road Pavement Condition in National Road