JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NATIONAL DIRECTION OF BASIC SANITATION (DINASBA)
NATIONAL SECRETARIAT OF URBAN DEVELOPMENT
NATIONAL SECRETARIAT OF POPULAR PARTICIPATION
MINISTRY OF HUMAN DEVELOPMENT
THE REPUBLIC OF BOLIVIA

THE STUDY ON GROUNDWATER DEVELOPMENT IN RURAL AREAS IN THE REPUBLIC OF BOLIVIA

FINAL REPORT

MAIN REPORT

June 1996

ENVIRONMENTAL TECHNOLOGIC CONSULTANTS CO., LTD.
SUMIKO CONSULTANTS CO., LTD.

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PREFACE

In response to a request from the Government of the Republic of Bolivia, the Government of Japan decided to conduct a study on Groundwater Development in Rural Areas and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bolivia a study team headed by Mr. Kenichi Takashima, Environmental Technologic Consultant Co., Ltd., and composed of staff members of Environmental Technologic Consultant Co., Ltd. and SUMIKO Consultants Co., Ltd., (three times between October 1994 and March 1996.)

The team held discussion with the officials concerned of the Government of Bolivia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Bolivia for their close cooperation extended to the team.

June 1996

Kimio Fujita
President
Japan International Cooperation Agency

June 1996

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Kimio Fujita,

Letter of Transmittal

We are pleased to submit you the final report of the Study on Groundwater Development in Rural Areas in the Republic of Bolivia.

The study was conducted by Environmental Technologic Consultant Co., Ltd. and SUMIKO Consultants Co., Ltd. under a contract to JICA for 21 months from October 1994. We had conducted the field study three times to hold discussions with officials concerned in Bolivia and to carry out field surveys, developing water supply database for the Departments of Chuquisaca, Oruro, Tarija, Santa Cruz and four Provinces of La Paz with their close cooperations and formulating the regional groundwater development strategies based on the database. We had also carried out pilot projects including test well drilling, construction of the water supply facilities, operation and management education and sanitary education.

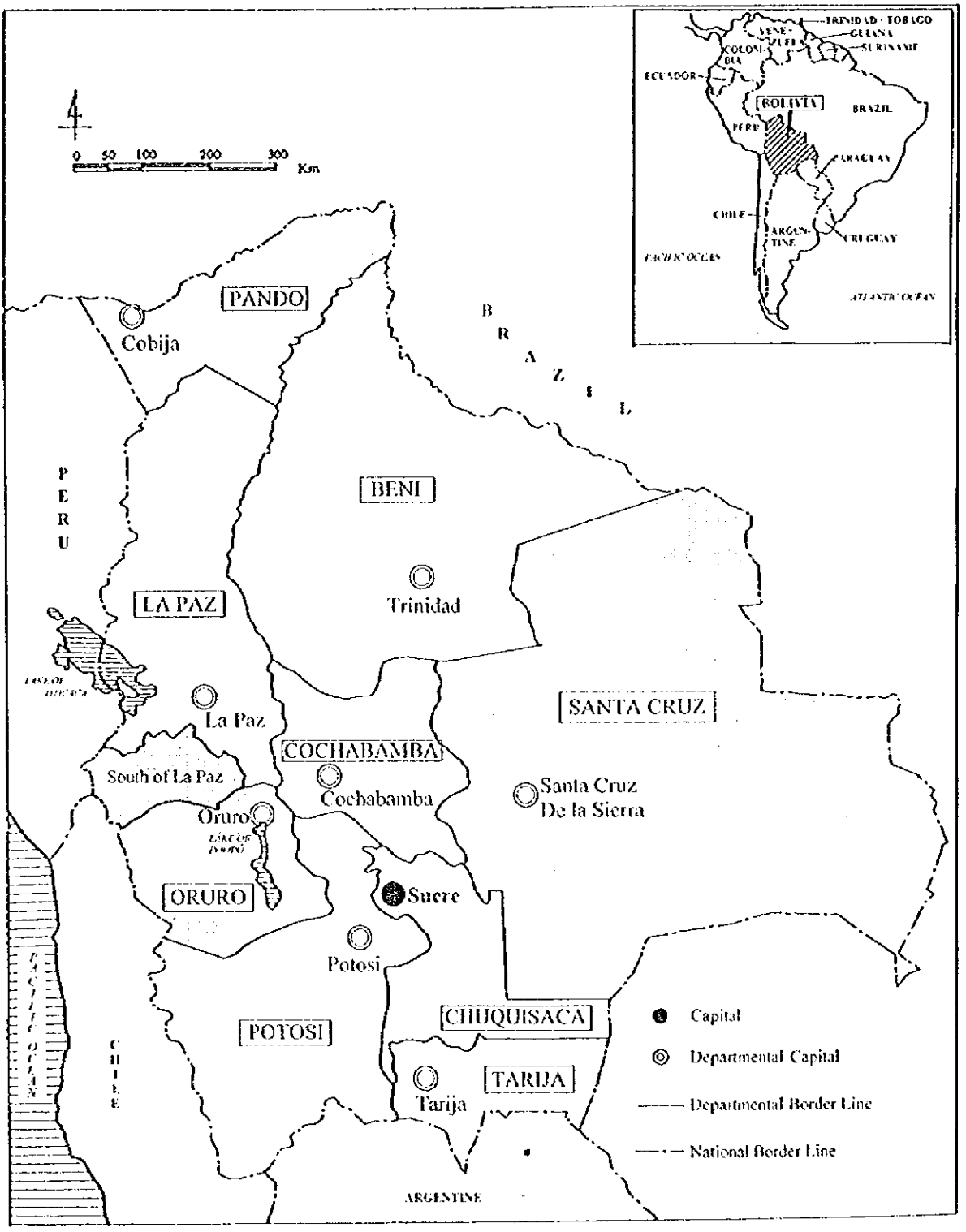
We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and other officials concerned. We would also like to express our deep gratitude to the Ministry of Human Development, five Prefectures and authorities concerned as well as the Embassy of Japan in Bolivia and the JICA Bolivia Office for close cooperations and assistance extended to us throughout our field study.

Finally, we hope that this report will contribute to promotion of groundwater development and improvement of public health and living conditions in rural areas in the Republic of Bolivia.

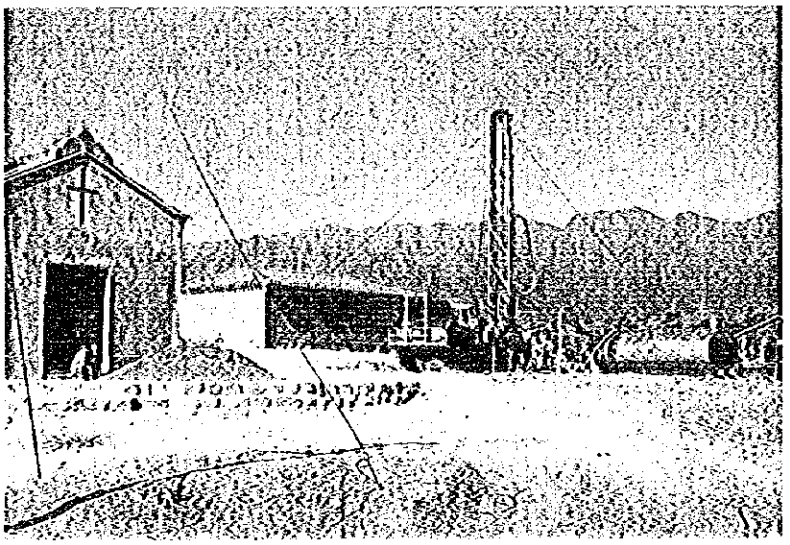
Very truly yours,

高島 謙一

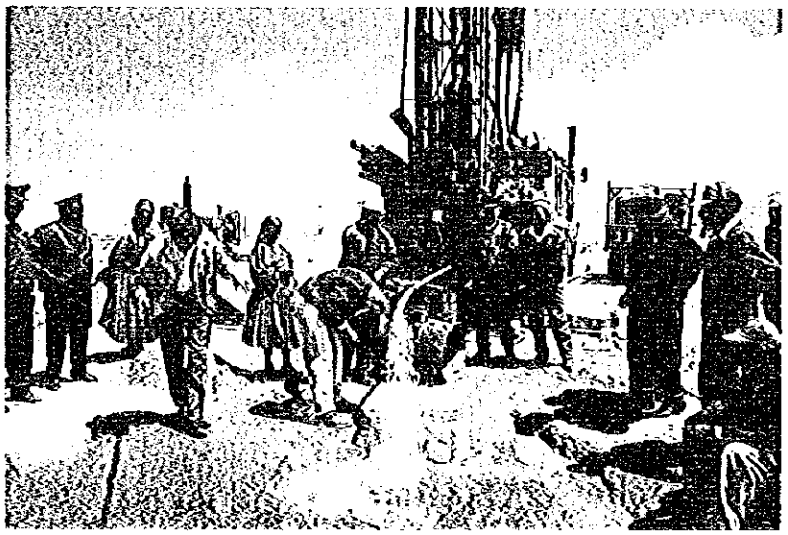
Kenichi Takashima
Team Leader
The Study on Groundwater Development in Rural Areas in the Republic of Bolivia



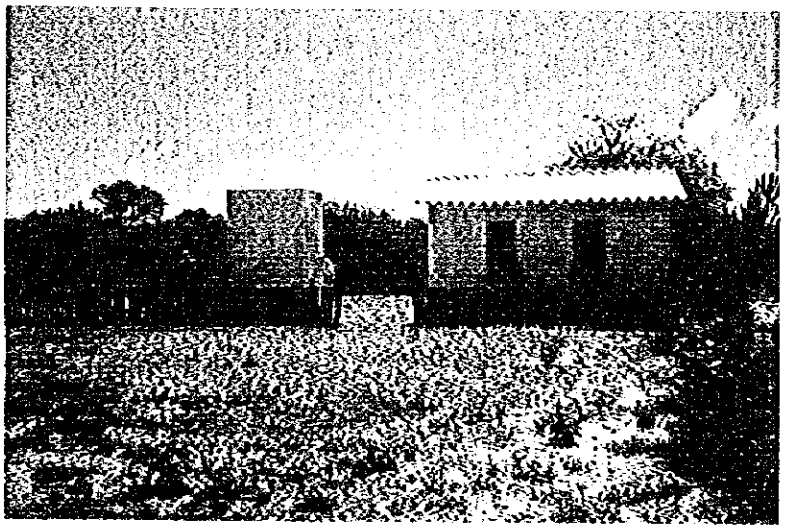
Location Map of the Study Area



Test well drilling (La Chosa)



Pumping test (Patacamaya)



Water supply facility of pilot project (Campo León)

SUMMARY OF THE PROJECT

1. Outlines of the Study

The Study on Groundwater Development in Rural Areas was conducted to formulate the regional groundwater development strategies by Department based on the water supply database. The water supply database was built up for the Study Area that includes four Departments (i.e. Chuquisaca, Oruro, of Tarija, Santa Cruz), and the Southern Part of Department of La Paz, and then based on this water supply database, the strategies for development of groundwater in the Study Area were formulated. Furthermore, the feasibility studies on water supply development project had been also conducted through the implementation of four pilot projects at four water supply blocks which were selected from each Department in the Study Area with the exception of La Paz.

2. Water Supply Condition in the Study Area.

The Study Area covers an area of 532,361 km^2 large, and a total population of 2,570,000 in which the population of departmental capitals are included (INE 1992 Census). In other words, the Study Area accounts for 48.5% of the national wide area, and 40.1% of the total national population.

The Study was conducted on a Departmental basis, but data was collected for the water supply block, which is the smallest unit of community or locality for a water supply system. A water supply block was defined as a community, besides the departmental capital, with a population of over 120 for the Department of Santa Cruz, and as community with a population of over 50 for the other four Departments. According to the water supply database, the number of water supply blocks in the Study Area is 4,265, and its total population is 1,400,000 approximately.

Table 1 shows the outline of the water supply condition of each Department in the Study Area. The water supply coverages of urban area and rural area of the Study Area are calculated to be 82% and 23% respectively. Beside, there are 3,020 blocks, or 71% of the total, which has not existing water supply system.

Table 1 Current Water Supply Circumstance in the Study Area

Department	Population	Current water supply coverage (%)			Number of blocks classified by current water supply coverage			
		Urban area	Rural area	Total	>=60%	<60%	No existing system	Total
Chuquisaca	289,129	88.5	16.4	19.6	131	135	957	1,223
S. of La Paz	126,277	26.0	16.4	17.0	51	39	672	762
Oruro	137,448	63.3	21.3	33.0	62	129	353	544
Tarija	200,158	88.8	36.8	54.8	158	133	220	511
Santa Cruz	652,135	83.8	26.4	51.5	221	186	818	1,225
Total	1,405,147	81.7	23.3	40.5	623	622	3,020	4,265

Note: Based on the water supply database. Urban area consists of cities with population of 2,000 or more.

In Bolivia, the shortage of drinking water supply in rural area is serious, comparing with the ones in urban area. A majority part of the communities in rural area has not any kind of water supply system, and is in serious shortage of water.

The main cause of the lag of water supply service in rural area is assumed to be the difficulty in the development of water resource. Up to now, the main sources of water that had been developed in rural area are surface water or groundwater from shallow aquifer, whose produce quantity is insufficient and quality is doubtful generally. Numerous communities with existing water supply system have to face with inevitable water shortage in the dry season every year.

The development of groundwater in the Study Area is lag due to the lack of equipment, financial resource, technique, etc. though its potential is high. It is assumed that the development of groundwater is indispensable to meet the needs of drinking water supply of inhabitants in rural communities.

3. Water Supply Database

Water Supply Database was built up to compile, process and manage a large amount of information relevant to the socioeconomic situation, water supply condition, sanitary condition, existing water supply systems, existing wells, etc. in each water supply blocks.

It consists of 254 numeric data fields, and data on 4,265 water supply blocks, 890 water supply systems, 808 existing wells had been input. Beside, it also stores 12 kinds of graphic data such as the road network map, administrative map, etc. Among them, 175 pieces of well geographical column maps are included.

4. Groundwater development strategies

During the Study, the groundwater development strategies had been formulated, aiming at the stabilization of drinking water supply services in rural area. Through this formulating process, the target water supply coverages of each Department had been determined, the case study on several project implementation strategies, project types had been carried out, and based on these results, the implementation plan had been formulated, with a list of appropriate blocks selected for the project implementation.

1) Targets

The strategy target year had been determined to be the year 2000 (i.e. in five years period, from 1996). Following, the target water supply coverages in rural area and in urban area of each Department had been determined separately, after examined the project scale that can be carried out in five years period. The target water supply coverages are given as 89% for the urban area and as 38% for the rural area, making an average of 54% for the Study Area in total. Given that the current average water supply coverage of the Study Area stands at 40.5%, this target marks a 13.5% increase.

2) Selected projects

Table 2 shows the outline of the project with the blocks selected as the most appropriate communities for the implementation plan. For five Departments in the Study Area there are 456 blocks, with 255,785 beneficiaries in total. This number of beneficiaries marks 16% of total population of the Study Area in the target year. Beside, it is assumed that for five Departments, 9 sets of drilling rig are required to make able the project implementation in five years period.

Table 2 Outline of the Proposed Project

	Population (in 2000)	Target water supply coverage (%)			Number of blocks	Number of beneficiaries	Required number of rigs
		Urban area	Rural area	Total			
Chuquisaca	312,073	90	30	33	98	57,295	2
S.of La Paz	119,750	80	30	34	46	19,957	1
Oruro	139,800	80	40	51	72	31,009	1
Tarija	245,262	90	50	65	85	35,128	2
Santa Cruz	794,792	90	40	62	155	112,396	3
Total	1,611,677	89	38	54	456	255,785	9

Note: The number of rigs are as required for each Department to complete the drilling works in 5 years period.

3) Organizations responsible to the project implementation

It is assumed that the individual prefectural governments should be the organizations responsible for the implementation of drilling works, and the prefectural governments or the municipal agencies are responsible for the construction of water supply facilities. Furthermore, it is assumed that once the water supply had been completed, its operation and maintenance should be carried out by the cooperatives formed by the beneficiaries in the individual communities, under the jurisdiction and instructions of the competent prefectural government.

4) Estimation of project cost

As shown by Table 3, it is assumed that the total project cost for all five Departments is US$ 71.30 million, of which US$ 39.50 million should be shared by external finance, while US$ 31.80 million should depend on Bolivian domestic financial sources. The procurement of drilling equipment, and the cooperation in conducting the drilling works in one year term to instruct the Bolivian technicians on the utilize of drilling equipment, are proposed to be financed by foreign countries or international organizations through no-compensation financial aids.

Table 3 Estimated Project Cost

(Unit: million US dollars)

Department	Investment Amount			Breakdown of Project Cost			
	Foreign Funds	Domestic Funds	Total	Procurement of Rig	Water Supply Equipment	Drilling Work	Water Supply Work
Chuquisaca	9.0	6.9	15.9	7.8	3.2	2.0	2.9
S. of La Paz	4.5	3.0	7.5	4.1	1.4	1.0	1.0
Oruro	5.7	4.4	10.1	4.2	2.3	2.0	1.6
Tarija	9.0	5.4	14.4	7.8	2.7	2.1	1.8
Santa Cruz	11.3	12.1	23.4	9.6	4.9	3.3	5.6
Total	39.5	31.8	71.3	33.5	14.5	10.4	12.9

(Note) The rigs shall be procured and the drilling work for the 1st year shall be carried out with foreign funds. The drilling work for the next year onward shall be carried out by the Bolivian side. The cost relating to water supply equipment consists of the procurement of casing, screening materials, water pump, generator.

5) Project implementation plan

Development priority of the water supply blocks is assumed to lay in the blocks with bigger population, lower coverage and easier drilling work. Based on this proposition, the implementation plan has been formulated, in such a manner that the project is started from the area which covers many first priority blocks and with easy access conditions, and gradually extended to the surrounding areas, in order to obtain the most efficient drilling works, and transportation of drilling machines, while taking into consideration the parity of annual investments during the period of project implementation. Table 4 shows the schedule of the drilling works that had been prepared as a main part of the implementation plan.

Table 4 Stage Plan of Drilling Works

		1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Chuquisaca	No. of blocks	19	28	20	20	11	98
	Total drilling depth (m)	1,300	2,050	2,300	3,000	2,950	11,600
S. of La Paz	No. of blocks	7	14	9	9	7	46
	Total drilling depth (m)	450	1,000	1,350	1,450	1,200	5,450
Oruro	No. of blocks	16	19	16	13	8	72
	Total drilling depth (m)	1,950	1,900	2,400	2,050	2,100	10,400
Tarija	No. of blocks	14	19	21	16	15	85
	Total drilling depth (m)	1,550	2,600	2,450	2,900	3,250	12,750
Santa Cruz	No. of blocks	20	36	40	39	20	155
	Total drilling depth (m)	2,100	4,350	4,600	4,500	5,100	20,650
Total	No. of blocks	76	116	106	97	61	456
	Total drilling depth (m)	7,350	11,900	13,100	13,900	14,600	60,850

Note: The drilling works are to be completed in five years for each departments.

5. Project Feasibility Study

The study on the feasibility of the water supply development project had been carried out by means of the geophysical prospecting surveys, test borings at 9 locations, and pilot projects at 4 communities. Through 4 pilot projects, the water supply facilities are constructed to test the installation feasibility of water supply system, and conduct experiments on the education of operation and maintenance of water supply system, and on the education of sanitation subjected to the inhabitants in rural communities of Bolivia.

The results of the study on the four communities of the pilot projects are summarized in Table 5, in which, the results of drilling test are also shown. The results show that at all four communities, the productivity of the test well is beyond the needs of the community.

Table 5 Outlines of Pilot Project Communities and Test Well Drilling

Department	Community	Population (persons)	Drilling depth (m)	Yield (l/sec)	Static water level (m)	Dynamic water level (m)
Chuquisaca	Campo Leon	237	411	2.25	190.0	282.9
Oruro	Corque	1,558	100	2.00	6.5	26.1
Tarija	La Chosa	371	127	7.55	(artesian)	-
Santa Cruz	San Carlos	480	260	10.00	57.5	93.0

Through the pilot projects, the water supply plan using the drilling test wells had been made, construction cost, operation and management cost had been calculated, and were used to examine the feasibility of the water supply plan.

The construction cost of these water supply systems were extremely beyond the financial ability of the inhabitants concerned. And it is considered that such construction cost should be financed by public investment funds.

Even at Campo Leon, where the economical condition is worst comparing with other communities, the cost required for the daily operation and maintenance of the water supply system is within the tariff payment ability of the inhabitants. Consequently, it is assumed that the daily operation and maintenance of the water supply system can be maintained with the self-help efforts of the inhabitants. But, for the sustainability of the water supply system in long term, the external supports are assumed to be important, and it appears the need to establish the maintenance and management systems with the combined supports of prefectural government, municipal agency, and private companies concerned as well.

6. Recommendation

1) The groundwater development project should be implemented as soon as possible, to fill the needs of drinking water in daily life of rural inhabitants, improve their living standard, and stabilize their public welfare. The government and the prefectural governments should confer with related agencies about the responsibility-sharing, the cooperation system and the raising funds, in order to promote a quick implementation of the project.
2) The Bolivian government and the prefectural governments do have the will and the ability to implement the project continuously in long term. The implementation of the project is assumed to be feasible, because the Bolivian government, the prefectural governments, the municipal agencies would be able to bring out the project by their own financial ability, if they have obtained the international cooperation in procuring of drilling equipment and technical transfer. The reorganization of local government is ongoing now, and it is expected that the works will be transferred smoothly from ex-CORDES to prefectural governments, and the UNASBAs (Unit of Basic Sanitation) will be strengthened appropriately.

After all, the project implementation is assumed to be totally reasonable, either in terms of project operation, project maintenance and project management.

3) The main targets of this project are the dispersed communities in rural area, and it is assumed that the prefectural government should take responsibility to bring out the project. The prefectural governments should strengthen the project implementation organization, ensuring personnel required, improve their technical ability, establish the financial foundation, etc., in order to perform the adequate and efficient implementation of the project.

4) Efforts should be done to conduct appropriate explanations to the inhabitants concerned on the meaning of the project and on their considerable responsibility, to promote their participation in the project implementation. Once the water supply system had been installed, the beneficiaries should take responsibility in the system operating and maintaining, under the jurisdiction and instructions of the competent prefectural government. Prefectural governments should promote the education program on sanitation and maintenance of the water supply system toward the inhabitants in rural communities, and strengthen the supporting systems to help inhabitants in managing and maintaining the water supply systems, and ensure the sustainability of these systems. The women's participation in the management and maintenance of the water supply systems should be promoted in order to strengthen the organization of managing and maintaining these systems.

5) Furthermore, an information system should be established to manage the information on the water supply conditions in rural communities, and supervise the progress of the water supply project implementation. More efforts are required to update the water supply database, extend its use to the departments standing outside of the Study Area, utilize it in formulating the water supply plans, and in the management of groundwater development project.

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Conversion Rate (March 1996)

1 US Dollar =	105 Yen
1 US Dollar =	5.0 Bolivianos
1 Boliviano =	21 Yen

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ABBREVIATIONS

BID	Inter-American Development Bank (Banco Interamericano de Desarrollo)
BM	World Bank (Banco Mundial)
CAP	Drinking Water Committee (Comite de Agua Potable)
CARE	American Cooperation of Remittance to the Exterior (Cooperacion Americana de Remesas al Exterior)
CODEMA	Departmental Council of Environment (Consejo Departamental del Medio Ambiente)
CODETAR	Regional Development Corporations of Tarija (Corporacion Regional de Desarrollo de Tarija)
CORDECH	Regional Development Corporation of Chuquisaca (Corporacion Regional de Desarrollo de Chuquisaka)
CORDECRUZ	Regional Development Corporation of Santa Cruz (Corporacion Regional de Desarrollo de Santa Cruz)
CORDEOR	Regional Development Corporation of Oruro (Corporacion Regional de Desarrollo de Oruro)
CORDEPAZ	Regional Development Corporation of La Paz (Corporacion Regional de Desarrollo de La Paz)
CORDES	Regional Development Corporations of Departments (Corporacion Regional de Desarrollo)
CORPAGUAS	Potable Water and Sewerage Corporation (Corporacion de Agua Potable y Alcantariolado)
COSAALT	Corporation of Potable Water and Sewerage Service in Tarija (Cooperativa de Servicios de Agua Potable y Alcantanillado de Tarija)
CRS	Catholic Relief Service
DF/R	Draft Final Report
DIA	Declaration of Environmental Impact (Declatoria de Impacto Ambiental)
DINASBA	National Direction of Basic Sanitation (Direccion Nacional de Saneamiento B sico)
DSA	Direction of Environmental Sanitation (Direccion de Saneamiento Ambiente)
EIA	Environmental Impact Assessment
ELAPAS	Local Enterprise of Portable Water and Sewerage in Sucre (Empresa Local de Agua Potable y Alcantarillado Sucre)
FEGASA	Livestock Federation (Federacion de Ganaderos)
ANESAPA	National Association of Drinking Water and Sewerage Service Enterprises (Asociacion Nacional de Empresas de Servicio de Agua Potable y Alcantarillado)
FIS	Fund for Social Investment (Fond de Inversion Social)
FNDR	National Fund for Regional Development (Fondo Nacional de Desarrollo Regional
FONAMA	National Fund for Environment (Fondo Nacional para el Medio Ambiente)
F/R	Final Report

GAPS	Administration of Drinking Water and Sanitation (Gestion en Agua Potable y Saneamiento)
GEOBOL	Geological Service in Bolivia (Servicio Geologico de Bolivia)
Hydat	Database of Hydrogeology (Banco de Datos Hidrogeologico)
Hygraf	Graphic Database of Hydrogeology (Grafico Banco de Datos Hidrologico)
IC/R	Inception Report
IEE	Initial Environmental Examination
INE	National Institute of Statistics (Instituto Nacional de Estadistica)
IT/R	Interim Report
JICA	Japan International Cooperation Agency
JST	JICA Study Team
lcd	litter per capita per day
LPP	The Law of Popular Participation (Ley de Participacion Popular)
MDH	Ministry of Human Development (Ministro de Desarrollo Humano)
MDSMA	Ministry of Sustainable Development and Environment (Ministerio de Desarrollo Sostenible y Medio Ambiente)
M/M	Minutes of Meeting
MUV	Ministry of Urban Planning and Housing (Ministerio de Urbanismo y Vivienda)
NGO	Non Governmental Organization
OMS	World Health Organization (Organizacion Mundial de la Salud)
OPS	Pan American Health Organization (Organizacion Panamericana de la Salud)
OTB	Organization of Basic Territory (Organizacion Territorial de Base)
PNUD	United Nations Development Program (Programa de Naciones Unidas para el Desarrollo)
PROSABAR	Project of Rural Basic Sanitation (Proyecto de Saneamiento Basico Rural)
PRORPAAL	Program of Pre-investment for Rural Potable Water and Sewerage (Prpgrama Rural de Preinversion de Proyectos para Agua Potable y Alcantarillado)
Q/N	Questionnaire
SAMAPA	Municipal Corporation of Drinking Water and Sewerage in La Paz (Servicio Autonomo Municipal de Agua Potable y Alcantarillado de La Paz)
SAGUAPAC	Corporation of Rural Waterworks and Sewerage in Santa Cruz (Servicio de Agua Potable y Alcantarillado de Santa Cruz)
SELA	Corporation of Drinking Water and Sewerage in Oruro (Servicio Local de Acueductos y Alcantarillado de Oruro)
SENMA	National Secretary of Environment (Secretaria Nacional del Medio Ambiente)
SIMAS	Water and Sewerage Monitoring System (Sistema de Monitoreo de Agua y Saneamiento)
SNAP	National System of Protection Area (Sistema Nacional de Areas Protegidas)
SNAU	National Secretary of Urban Affairs (Secretaria Nacional de Asuntos Urbanos)
SNS	National Secretary of Health (Secretaria Nacional de Salud)
S/W	Scope of Work

T.G.N.	General Treasury of Nation (el Tesoro General de la Nacion)
TOR	Terms of Reference
UNASBA	Unit of Basic Sanitation (Unidad de Saneamiento Basico)
UPRA	United Programs of Rural Area and Farming (United Programas Rurales y Agropecuarios)
UNDP	United Nations Development Program (PNUD)
UNICEF	United Nations International Children's Emergency Fund
VES	Vertical Electric Sounding
WB	World Bank
WHO	World Health Organization
WID	Women in Development
WSB	Water Supply Block
WSD	Water Supply Database
YPFB	Bolivian National Oilfield (Yacimientos Petroliferos Fiscales Bolivianos)

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

During the "Ten Years of International Water Supply and Sanitation" (1981~1990), propounded by the United Nations, the Government of the Republic of Bolivia (hereinafter referred to as "the Government of Bolivia") has made efforts to expand water supplies and sanitation and to improve water quality and water services. However, due to delays in the furnishing of infrastructure in rural areas, adequate results have not been obtained and public health problems such as high infant mortality rates and cholera epidemic are yet to be solved.

Under such circumstances, the Government of Bolivia formulated the "National Development Plan for Water Supply and Sanitation" in 1991. This plan is aimed at raising the water supply coverage in rural areas, where measures have been delayed, from 30% to 60% by the year 2000 under the slogan of "Water for All".

The Government of Bolivia reorganized the previous division of the Ministry of Urban Affairs into the National Direction of Basic Sanitation (DINASBA), National Secretariat of Urban Affairs of the Ministry of Human Development and appointed DINASBA as the agency responsible for the promotion of the above-mentioned National Development Plan. In the meantime, the Government has deemed that the implementation of projects be promoted by Regional Development Corporations of the respective Departments as part of the decentralization program. Close connections between the central and regional governments and the strengthening of each organization are therefore being desired.

Given such background, the Government of Bolivia has requested the Government of Japan on August 1992, the formulation of a groundwater development plan in relation to the above-mentioned National Development Plan. In response to the request, Japan International Cooperation Agency (JICA) has dispatched the preparatory study team in December 1993. Both countries agreed to conduct the Study on Groundwater Development in Rural Areas (hereinafter referred to as "the Study") and concluded the Scope of Work (S/W) on December 13, 1993. The Study was commenced in October 1994 and ended in June 1996.

1.2 Objectives of the Study

The objectives of the Study are as follows.

1) To build up a water supply database for the Departments of Chuquisaca, Tarija, Santa Cruz and Oruro and the southern part of the Department of La Paz and to formulate groundwater development strategies up to the year 2000 with development priorities attached thereto.

2) To conduct feasibility studies on water supply for the pilot projects to be implemented at four (4) water supply blocks. One representative water supply block is selected from each Department with the exception of the Department of La Paz. In the case where one water supply facility can supply water for plural water supply blocks, the plural water supply blocks are regarded as one water supply block.

3) To perform technology transfer to the Bolivian counterpart personnel through the Study in order to raise the levels of water supply planning, servicing of water supply facilities, furnishing of project implementation systems for fee collection, etc., operation and maintenance of water supply facilities, groundwater development technologies, etc.

1.3 Study Area

The Study Areas covers the rural areas in the Departments of Chuquisaca, Tarija, Santa Cruz and Oruro, and the southern part of the Department of La Paz. The southern part of the Department of La Paz consists of four (4) Provinces; Aroma, Gualberto Villarroel, Pacajes, and José Manuel Pando. The total area is 532,361 km^2 and the total population excluding departmental capital cities is 1,472,427 in 1992.

The Study was conducted on a Departmental basis but the data was collected for the water supply block, which is the smallest unit of community or locality for a water supply system. A water supply block was defined as a community, besides the capital city of a Department, with a population of over 120 for the Department of Santa Cruz and as community with a population of over 50 for the other four(4) Departments. The total number of water supply blocks amounts to 4,265 according to the water supply database.

Table 1-3-1 shows the outline of each Department in the Study Area.

Table 1-3-1 Outlines of the Study Area

Department		Chuqui-saca	South of La Paz	Oruro	Tarija	Santa Cruz	Total
Area(km^2)		51,524	19,005	53,588	37,623	370,621	532,361
Total Population[1)]		453,756	125,343	340,114	291,407	1,364,389	2,575,009
	Capital	131,769	-	183,422	90,113	697,278	1,102,582
	Others	321,987	125,343	156,692	201,294	667,111	1,472,427
No. of Provinces		10	4	16	6	15	51
No. of Sections		27	20	30	11	46	134
No. of Cantons		116	139	153	184	118	710
No. of WSB[2)]		1,223	762	544	511	1,225	4,265

Note : 1) Population is based on the INE 1992 Census

2) WSB = Water Supply Block

1.4 Scope and Schedule of the Study

The Study was carried out through the following three (3) phases:

Phase I: Formulation of Regional Groundwater Development Strategies in Each Department

A water supply database was built up in order to facilitate the formulation of regional groundwater development strategies of each Department in the Study Area. Based on the database, regional groundwater development strategies was formulated with development priorities attached thereto for each water supply block. Upon classifying the water supply blocks according to characteristics, four (4) pilot projects was selected as models to carry out the feasibility study in Phase II and Phase III.

Phase II: Detailed Study for the Pilot Projects

Studies concerning the feasibility of water source development was carried out for the pilot projects selected in Phase I. Education for the technology transfer of operation and maintenance techniques for water supply facilities and experimental health education of residents was also carried out for the purpose of stable supplying of sanitary water.

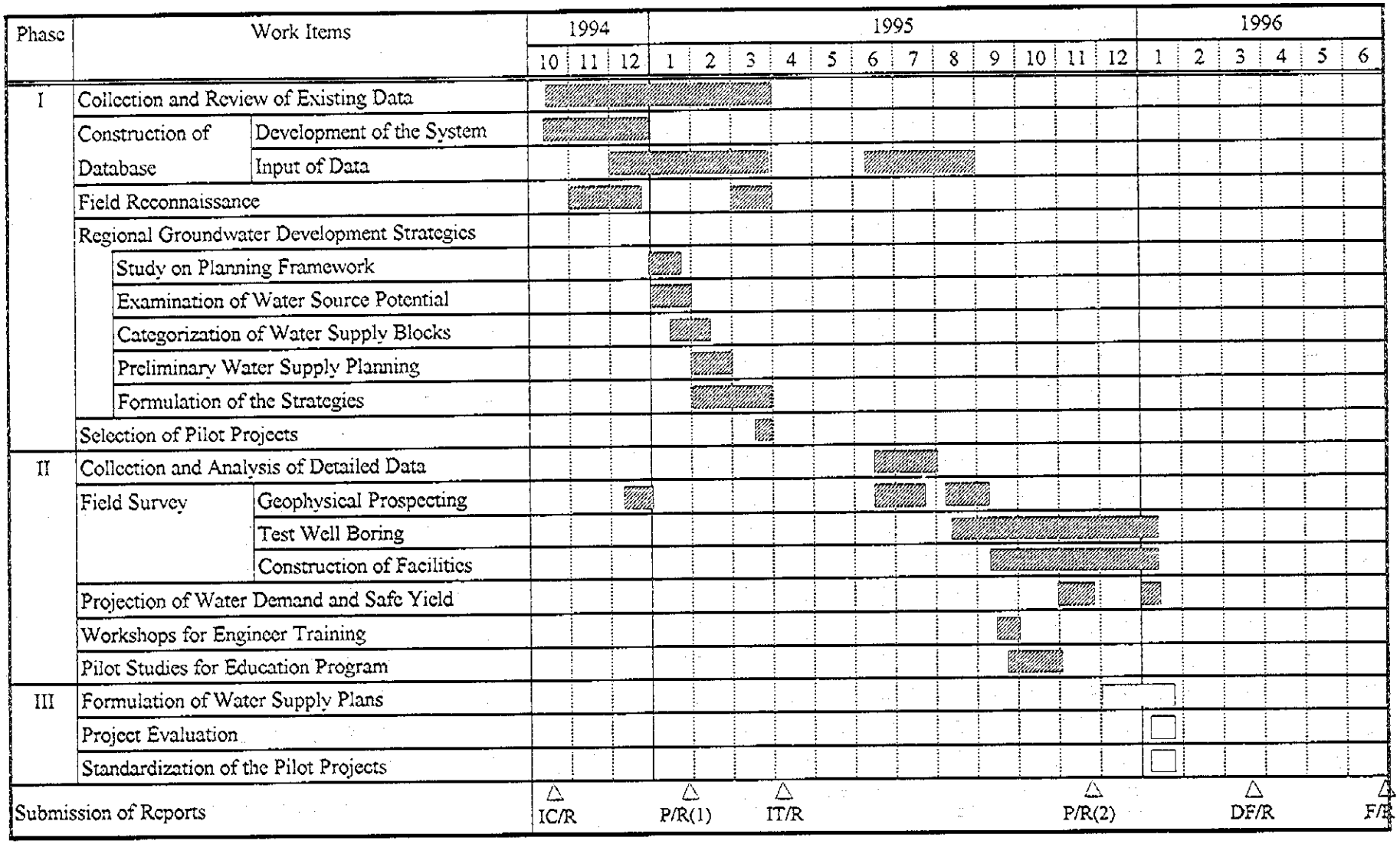
Phase III: Formulation of Water Supply Projects Relevant to the Pilot Projects

Based on the results of the Study in Phase II, water supply plans, that take the environment and the role of women in development (WID) into consideration, was formulated along with the operation and maintenance program and health education programs to enable sustainable development. Furthermore, these projects was fed back to the groundwater development strategies.

Figure 1-4-1 shows the time schedule of the entire Study.

The Study at Bolivia had been conducted during the periods from October 1994 to March 1995, and from June 1995 to January 1996.

The Regional Development Corporations (CORDES) of the respective Department were responsible for the data collection and data input in Phase I, under the instruction of the Study Team. Based on the collected data, the data analysis and the formulation of groundwater development strategies had been conducted. Numerous workshops had been held in order to improve the abilities of the CORDES on the water supply planning, the operation and management of the water supply system, etc. as a part of the technology transfer.



(Notes) Study in Bolivia Work in Japan

Figure 1-4-1 General Work Schedule of the Study

1.5 Study Organization

The official agency of the Japanese side for conducting the Study is Japan International Cooperation Agency (JICA). JICA had appointed Environmental Technologic Consultants Co., Ltd. (ETC) and Sumiko Consultants Co., Ltd. (Sumiko) as consultants to carry out the Study.

The JICA Study Team consists of thirteen (13) members as follows.

Name	Field in Charge
Kenichi Takashima	Team Leader
Hirotaka Nishimoto	Hydrological and Geological Analysis
Masao Odagaki	Water Quality Analysis/ Environmental Consideration
Takao Ogawa	Geophysical Prospecting/ Geological Analysis
Hiroatsu Narita	Water Supply Planning/ Operation and Maintenance Planning
Guido J. Acurio	Social Analysis/ WID Consideration
Masanori Ito	Organizational and Institutional Analysis / Sanitary Education
Norio Mochizuki	Economic and Financial Analysis
Nguyen My Tuan	System Engineer
Takeshi Sijimaya	Well Boring Advisor
Akio Chida	Well Boring Advisor
Toshimitsu Ozeki	Well Boring Advisor
Michihiro Ohkoshi	Well Boring Advisor

The counterpart agencies in Bolivia were the National Direction of Basic Sanitation (DINASBA) on behalf of the National Secretariat of Urban Affairs of the Ministry of Human Development, and five Regional Development Corporations (CORDES) in each Department. The CORDES have been integrated to the Prefectures in January 1996.

The Bolivian counterpart personnels are as follows.

DINASBA (National Direction of Basic Sanitation)

Ing. Jorge Calderón Monterde	Project Manager
Arq. Emira Mérida	Coordinator
Ing. Jose Luis Panozo	Sanitary Engineer/Sociologist
Ing. Yamil Maire	Hydrogeologist
Ing. Reynaldo Gonzales	System Engineer
Tec. Luis Ojopi	System Engineer
Sra. Maria del Rosario Cabrera	System Engineer
Lic. Max Paredes	Economist
Lic. Maria E. Godoy	Economist
Ing. Luis Chumacero	Sociologist

Chuquisaca (CORDECH)

Ing. Alfred Zelada E.	Coordinator
Ing. Jorge Fiengo	Hydrogeologist/ Geophysicist
Ing. Jorge Fraija	System Engineer/ SocioEconomist
Ing. Ignacion Ramirez	Well Boring Supervisor
Lic. Ramiro Martinez T.	SocioEconomist
Ing. Ricardo Gonzales	Coordinator (ex)

La Paz (CORDEPAZ)

Ing. Ricardo Quisbert	Coordinator/Water Supply Engineer
Ing. Alfredo Arias	Geologist
Ing. Ricardo Anda	System Engineer
Tec. Luis Mejia	System Engineer
Arq. Samuel Vasquez	Socioeconomist
Ing. Sergio Valdivia	Coordinator (ex)

Oruro (CORDEOR)

Ing. Mario Ramirez V.	Coordinator/Water Supply Engineer.
Ing. Marco Antonio Roses	Water Supply Engineer/Sanitary Engineer
Ing. Abel Sangueza	Hydrogeologist/ Geophysicist /Well Boring Supervisor.
Ing. Rene Leyva	Water Supply Engineer
Lic. Adolfo Morales	Sociologist
Ing. Wilfredo Rossel Crespo	System Engineer

Tarija (CODETAR)

Ing. Roberto Mérida	Coordinator/ Geophysicist / Well Boring Supervisor.
Ing. Hernan Villena	Water Supply Engineer/Hydrogeologist
Lic. Marina Reyes	Sociologist/Economist
Tec. Carlos Martinez	System Engineer
Ing. Pedro Dubravcic	Coordinator (ex)

Santa Cruz (CORDECRUZ)

Ing. Milton Berbetti A.	Coordinator/Hydrogeologist
Ing. Eugenio Verde Ramo	Water Supply Engineer
Lic. Mariela Rivera	Sociologist
Lic. Silvia Garnica	Economist
Ing. Ramiro Burgoa	System Engineer
Tec. Emilio Pedraza	Well Boring Supervisor
Ing. Victor Maldonado	Well Boring Supervisor

CHAPTER 2

OUTLINES OF THE STUDY AREA

CHAPTER 2

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2.1 General Background

2.1.1 General Aspects

1) Physical Characteristics

Located in the central part of the South American Continent, Bolivia is a land-locked country bordered by Brazil in the north and east, Peru in the West, and by Paraguay and Argentina in the south. Its surface is 1,098,581 square kilometers, and in terms of geographic and social-economic conditions, it can be divided into the following three zones: (1) the highland of the Altiplano; (2) an undulated hill zone; and (3) and the plains in the eastern parts of the country.

(1) The highland of the Altiplano accounts for 38% of the national territory and 53% of Bolivia's population, with a average height of 4,000m above sea level, with predominantly cold weather, temperature 0 to 16℃, and with average precipitation of 485mm per year.

This part of the country is home to agricultural activities concentrating on potato farming. Practically all of Bolivia's metal mining operation, one of the main industrial sectors of the nation, is distributed in this region.

(2) The undulated hill zone accounts for 13% of the national territory and 27% of the nation's population, with height between 1,000 and 3,000m above sea level, with mild climate, temperature fluctuating between 6 and 25℃, and precipitation between 500 and 1,300mm per year.

As most part of this area is mountainous, the cities and towns are located in the relatively large plateaus or in the plains stretching between mountains. It is a traditional agricultural zone with little rainfall and small plowing land areas per farming household.

(3) The plains in the eastern parts of the country occupies 59% of the national territory and is home to 20% of the nation's population, with hot and humid climate, temperature between 21 and 38℃, height between 100 and 1,500m above sea level and precipitation between 1,000 and 1,700mm per year.

Thanks to the favorable natural relief and clement climatic conditions, this part has a flourishing agricultural and forestry industry. It also commands oil and natural gas deposits.

The Landsat pictures showing the land use patterns for the Bolivian territory indicate that there are about 34,600 square kilometer of arable land, equivalent to 3.1% of Bolivia's territory. Pasture land total 266,500 square kilometers (24.3%), and forest-covered land 556,700 square kilometers (50.6%), while the non-arable land mass total 178,000 square kilometers (16.2%). In the highland and undulated-hilly regions, the land is cultivated on the crop rotation system of farming so that a considerable part of the land is left fallow at any one time, with the seasonally cultivated farming land amounting to 78% of the total farming land area. The crops grown on a large area scale include, in the order of importance, maize, potato, rice, barley, wheat, Soy bean, sugar cane, and quinua. In the eastern plains, the land is widely cultivated by the slash-and-burn

method of farming.

Much of the grassland consists of the pampas distributed in the eastern plains. These areas are mostly water-logged in the rainy and dry land in the dry season so that they can only be used as natural pastures.

The forest coverage is marked by the tropical rain forests spreading in the northern Amazon regions and the subtropical dry forests spread over part of the undulated terrain if the Departments of Tarija and Chuquisaca. The forests have a relatively sparse density of upright trees. The highlands of the Altiplano have practically no forest coverage while the eastern plains are witnessing a progressive decline in their forest coverage.

2) Political and Administrative Organization

The Constitution of the Republic of Bolivia is the juridical instrument that organize legally and politically the state in order to warranty security, justice, equality, freedom, peace and a legal regime to the Bolivian society and the use of their civil rights.

The reformed today's Constitution was decreed by the National Constituent Assembly on August 12th, 1964 and establish free, independent, sovereign, multi-ethnic and poly-cultural Government system.

Bolivia constituted as unitarian Republic adopts democratic and representative government and its exercise of power is delegated to Legislative, Executive and Judicial Powers.

(1) The Legislative Power: The legislative Branch is the National Congress composed of two Chambers, one is of Congressmen, the other is of Senators, (Art,46) elected by the people in universal and direct vote. (Art.60 & 63)

(2) Executive Power: The Executive power is exercised by the President of the Republic together with the Ministers of the State.(Art.85)

The reformed new Constitution dispose that the periods of the President and Vice President of the Republic and of the Senators and Representatives, Mayors and Councilmen are five years.(Art.87)

The President, Vice President, Ministers, and Department Employees form the Executive Organism.

The Ministries are:

- Ministry of Presidency
- Ministry of Justice
- Ministry of National Defense
- Ministry of Government
- Ministry of Foreign Affairs and Cult
- Ministry of Treasury and Economic Development
- Ministry of Human Development
- Ministry of Sustainable Development and Environment
- Ministry of Labor

- Ministry of Social Communication

Furthermore, the Executive Power rely on Governors of Department, Sub Governors of Provinces, Cantonal Magistrates.

(3) The Judiciary Power: The Judicial Power is exercised by the Supreme Court of Justice, the Constitutional Tribunal, the Superior Courts of District and other tribunals and judges which the laws establish (Art.116).

The Supreme Court of Justice is the highest Tribunal of Justice of the Republic, which is composed of a President and 11 Ministers (Art.117). The Council of Judgment is administrative and disciplinary organism of Judicial Power (Art.122).

The Ministers of Supreme Court remain in their functions for ten years (Art.126).

3) Administrative Political Division of Bolivia

The territory of the Republic of Bolivia is divided politically in Departments, Provinces, Sections, and Cantons (Art.108).

There are nine Departments and divided into 112 Provinces, 299 Sections and 1,396 Cantonese as follows.

Table 2-1-1 Administrative Division

DEPARTMENT	Capital	No. Provinces	No. of Sections	No. of Cantons
Pando	Cobija	5	15	18
La Paz	La Paz	20	74	432
Oruro	Oruro	16	30	153
Potosi	Potosi	16	38	256
Beni	Trinidad	8	14	27
Santa Cruz	Santa Cruz	15	46	118
Cochabamba	Cochabamba	16	44	93
Chuquisaca	Sucre	10	27	116
Tarija	Tarija	6	11	183
Total		**112**	**299**	**1,396**

Sources: INE, CNPV-924.1.2 and Law No. 1511 "Popular Population" (Apr.20th,1994)

4) Outline of the Study Area

The Study Area covers 580,000km^2, an area equivalent to 48.5% of the Bolivian land space. Out of which 10% (South of La Paz and Oruro) are in the high plateau, 16% (Chuquisaca and Tarija) in the valleys, and 64% (Santa Cruz and part of Tarija and Chuquisaca) in the oriental plain areas.

According to the INE 1992 Census, the population of the Study Area is 2,575,009 (40.1% of the total national population). The population of 4 provinces of Southern Part of La Paz accounts to 16% of the total population of Department of La Paz.

According to the water supply database which had been built up by the Study, the number of water supply blocks in the Study Area is 4,265. Among them, number of big cities with

population of 2,000 or more is 60 block, number of medium cities with population between 500 to 1,999 is 271, and number of small cities with population of 499 or less is 3,934.

2.1.2 Population

1) Demographic Characteristics

According to the National Census of Population and Housing effected in 1992, Bolivia has 6,420,792 inhabitants. Annual growth rate between 1976 and 1992 was 2.09%. The feminine population is 50.6% of the total. The composition by age groups shows high percentage of age under 15 years old (42%), and age over 60 years old shows only 4%. The density is 5.8 inhabitant per square kilometer. According to INE, actual population in 1995 is estimated to be 7.4 millions. Table 2-1-2 shows the demographical outline of total country and the study area. And Figure 2-1-1 shows the projection of future population.

2) Migration and Urbanization

The INE 1992 Census shows two demographic phenomena which are emphasized in recent year: the internal migration and the urbanization. Those socio-economical phenomena are attributed to the fall of mining production, the absence of other sources of development and to economical unbalance between the rural areas and the capitals of department. So there exists a definite tendency of growth in departments of Santa Cruz (4.16%) and Tarija (2.80%), thus on contrary to the department of Potosi, which has lost its population at the rate of 0.12% per year. The urbanization of the country is expressed principally by the rapid growth of three cities: La Paz, Santa Cruz and Cochabamba, which gather 2,322,000 inhabitants, or in other words, more than 1/3 of the country population. Beside, 112 cities having population between 2,000 and 200,000 inhabitants cover nearly 21% of the total population.

Table 2-1-2 Demographical Outline of the Study Area

			Population 1976	Population 1992	Annual Growth Rate	Number of House	Number of Family	Number of person by Family
Total Country		(1) Capital City	1,429,937	2,808,684	4.31%	664,807	623,716	4.50
		(2) Other Cities	495,903	886,162	3.69%	209,823	183,099	4.84
		(3) Rural Area	2,687,646	2,725,946	0.09%	826,512	638,002	4.27
		(4) = (2)+(3)	3,183,549	3,612,108	0.79%	1,036,335	821,101	4.40
		(5) Total	4,613,486	6,420,792	2.09%	1,701,142	1,444,817	4.44
Study Area	Chuquisaca	(1) Capital City	63,625	131,769	4.66%	31,988	29,770	4.43
		(2) Other Cities	13,890	23,198	3.26%	6,019	5,053	4.59
		(3) Rural Area	281,001	298,789	0.38%	75,456	63,366	4.72
		(4) = (2)+(3)	294,891	321,987	0.55%	81,475	68,419	4,71
		(5) Total	358,516	453,756	1.48%	113,463	98,189	4,62
	South of La Paz 1)	(1) Capital	-	-	-	-	-	-
		(2) Other Cities	8,744	8,512	-0.17%	3,176	2,199	3.87
		(3) Rural Area	139,292	116,831	-1.09%	45,356	(31,659)	3.69
		(4) = (2)+(3)	148,036	125,343	-1.03%	48,532	(33,858)	3.70
		(5) Total	138,036	125,343	-1.03%	48,532	(33,858)	3.70
	Oruro	(1) Capital City	124,213	183,422	2.47%	44,599	41,835	4.38
		(2) Other Cities	34,402	42,800	1.37%	13,377	10,000	4.28
		(3) Rural Area	151,794	113,892	-1.78%	62,618	31,974	3.56
		(4) = (2)+(3)	186,196	156,692	-1.07%	75,995	41,974	3.73
		(5) Total	310,409	340,114	0.57%	120,594	83,809	4.06
	Tarija	(1) Capital City	38,916	90,113	5.39%	21,377	19,574	4.60
		(2) Other Cities	33,824	72,438	4.87%	16,345	15,427	4.70
		(3) Rural Area	114,464	128,856	0.74%	31,201	26,241	4,91
		(4) = (2)+(3)	148,288	201,294	1.93%	47,546	41,668	4.83
		(5) Total	187,204	291,407	2.80%	68,923	61,242	4,76
	Santa Cruz	(1) Capital City	254,682	697,278	6.50%	152,085	143,531	4.86
		(2) Other Cities	119,923	292,181	5.72%	60,941	55,469	5.27
		(3) Rural Area	336,119	374,930	0.69%	82,823	73,682	5.09
		(4) = (2)+(3)	456,042	667,111	2.41%	143,764	129,151	5.17
		(5) Total	710,724	1,364,389	4.16%	295,849	272,682	5.00
	Total	(1) Capital City	481,436	1,102,582	5.32%	250,049	234,710	4.70
		(2) Other Cities	210,783	417,183	4.69%	95,317	88,148	4.98
		(3) Rural Area	1,011,766	1,055,244	0.06%	301,995	226,922	4.55
		(4) = (2)+(3)	1,233,453	1,472,427	1.11%	397,312	315,070	4.67
		(5) Total	1,714,889	2,575,009	2.57%	647,361	549,780	4.68

Source: INE Census

Note 1) Refered to the Provinces of Aroma, Pacajes, Villarroel and Pando

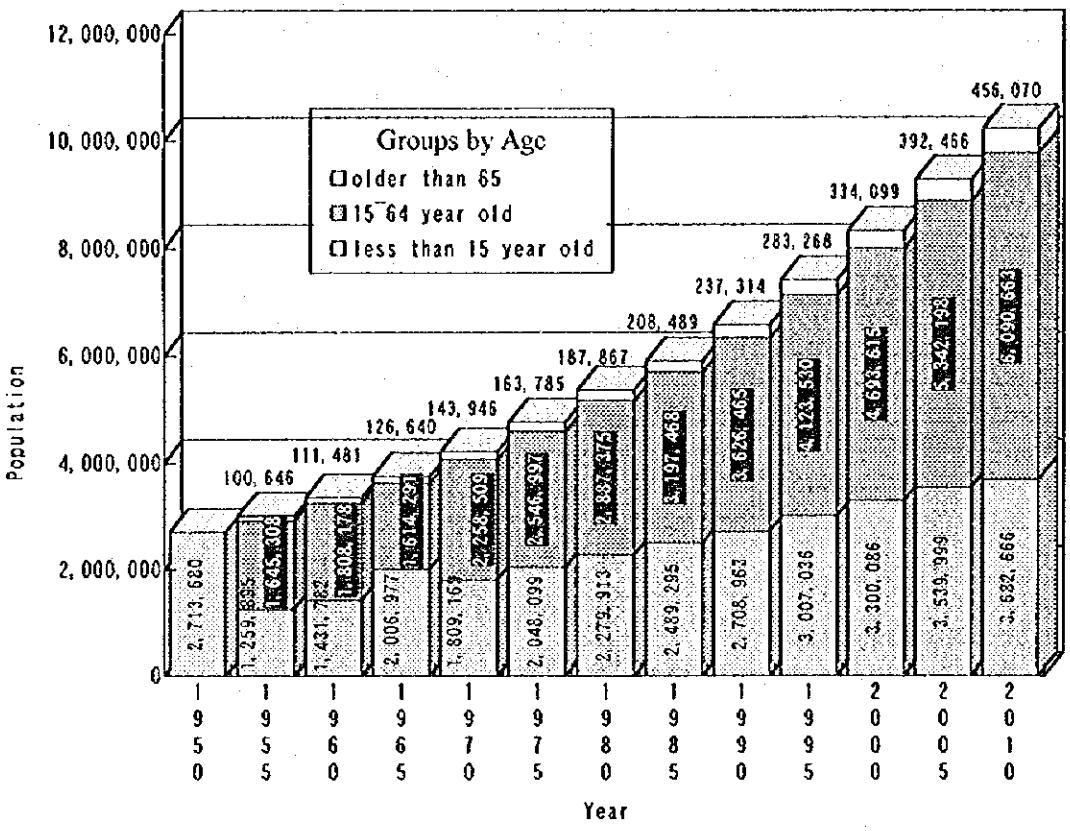

Figure 2-1-1 Projection of Future Population

3) Rural Population

The INE defines the city with the population more than 2,000 as 'urban area', and the others having less than 2,000 as 'rural area'.

For the first time in the history of the country, the urban population (58%) has exceeded the rural population (42%) in 1992, and this tendency is continuing since then. Furthermore, the rural population of the departments of La Paz and Oruro are decreasing with annual index of (-) 0.5% and (-) 1.07% respectively. The rural population of Santa Cruz and Tarija show a light annual increase of 0.69% and 0.74% respectively. As for Chuquisaca, there is an increase of 0.55% per year.

4) Demographic Outline of the Study Area

According to the INE 1992 Census, as shown in Table 2-1-2, the population of the Study Area is 2,575,009, and the average number of persons per family is 4.68. In more details, the total population of four departmental capitals of the Study Area is 1,102,582 (42.8% of the total), of other intermediate cities is 417,183 (16.2% of the total), and of rural area is 1,055,244 (41.0% of the total).

From 1976 to 1992, the average annual population growth is 5.32% in departmental cities, 4.69% in intermediate cities, and 0.06% in rural area.

As described in Table 2-1-3, in the Study Area, the number of water supply blocks, -which is defined as the smallest unit of community in this Study for the water supply planning,- is 4,265 water supply blocks. Among them, there are only 60 water supply blocks (1.4% of the total) whose population is bigger than 2000, but their total population amounts to 414,128 persons, i.e. 29.5% of the total population of the Study Area. Number of the blocks with population of less than 500 is 3,934 (92.2% of total number of blocks), and their total population is 53% of the total population in the Study Area. Figure 2-1-2 and Figure 2-1-3 show the block population and number of blocks classified by the population groups.

Table 2-1-3 Distribution of Blocks by Population Groups

Depart-ment	Population Group	>=2000 pers.	1999~ 1000 pers	999~ 500 pers	499~ 400 pers	399~ 300 pers	299~ 200 pers	199~ 100 pers	99~ 50 pers	Total
Chuqui-saca	Population	12,944	15,194	36,879	25,882	45,118	69,268	67,988	15,856	289,129
	No. of Blocks	4	11	54	59	131	286	458	220	1,223
South of La Paz	Population	8,512	10,122	10,231	7,926	8,615	19,571	36,994	24,306	126,277
	No. of Blocks	2	7	15	18	25	82	267	346	762
Oruro	Population	38,423	12,749	10,356	7,470	11,159	16,222	28,094	12,975	137,448
	No. of Blocks	8	10	15	17	33	69	198	194	544
Tarija	Population	69,325	8,880	18,867	12,426	22,397	37,381	28,084	2,798	200,158
	No. of Blocks	5	7	28	28	65	154	188	36	511
Santa Cruz	Population	284,924	44,725	60,817	38,449	61,770	98,317	63,133	0	652,135
	No. of Blocks	41	34	90	87	180	402	391	0	1,225
Total	Population	414,128 (29.5%)	91,670 (6.5%)	137,150 (9.8%)	92,153 (6.6%)	149,059 (10.6%)	240,759 (17.1%)	224,293 (16.0%)	55,935 (4.0%)	1,405,147 (100.0%)
	No. of Blocks	60 (1.4%)	69 (1.6%)	202 (4.7%)	209 (4.9%)	434 (10.2%)	993 (23.3%)	1,502 (35.2%)	796 (18.7%)	4,265 (100.0%)

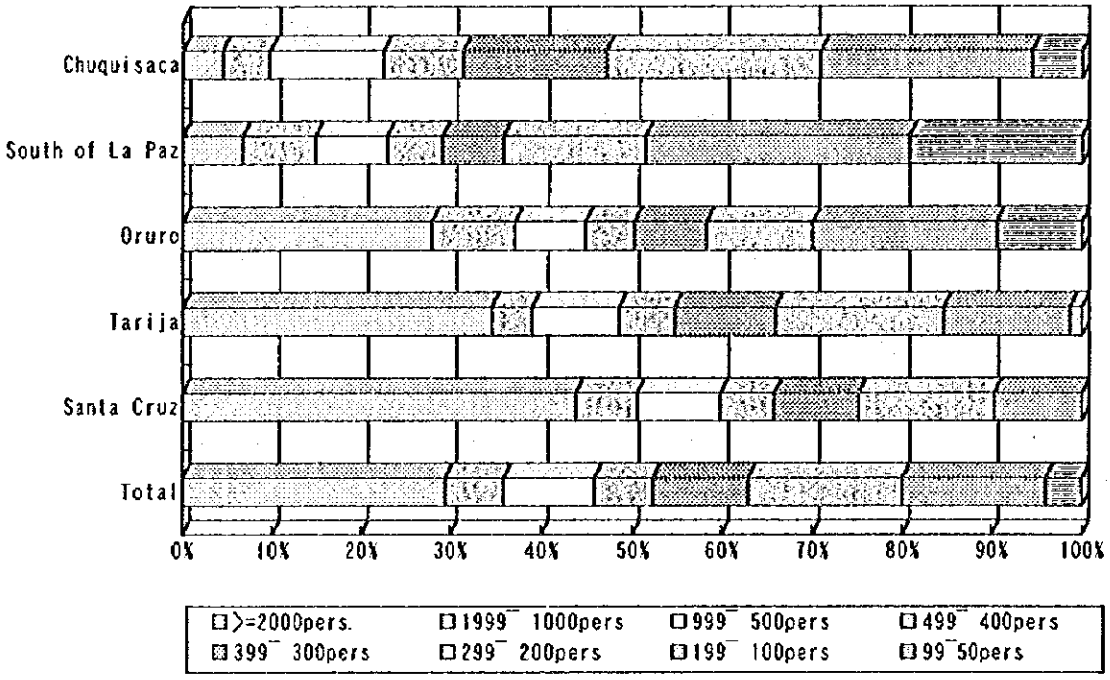

Figure 2-1-2 Block Population Classified by Population Groups

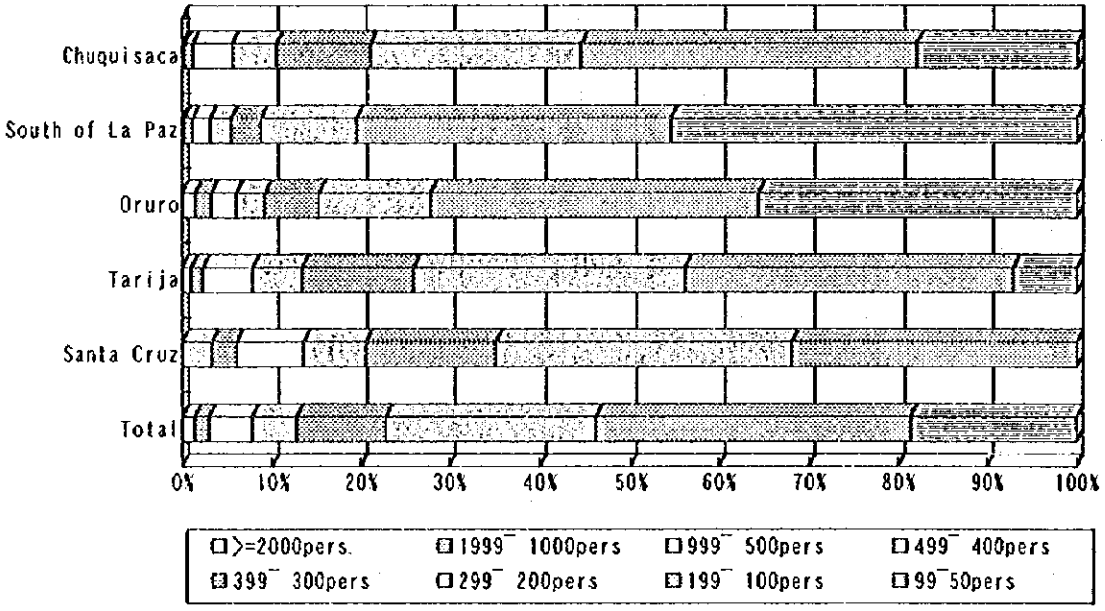

Figure 2-1-3 Number of Blocks Classified by Population Groups

The population density, population growth rate of the Province in the Study Area are shown in Figure 2-1-4 and Figure 2-1-5.

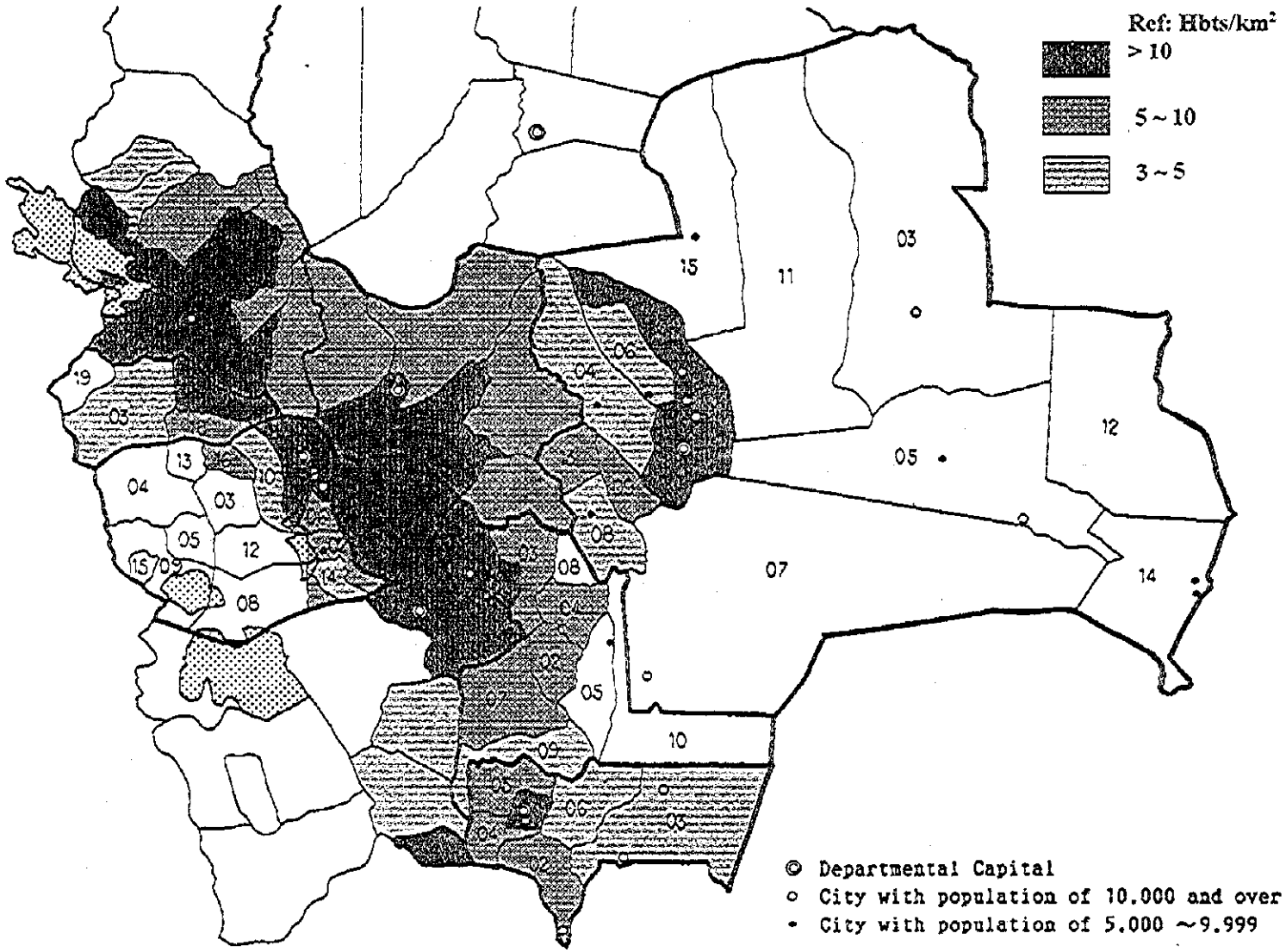

Figure 2-1-4 Population Density (1992) by Province

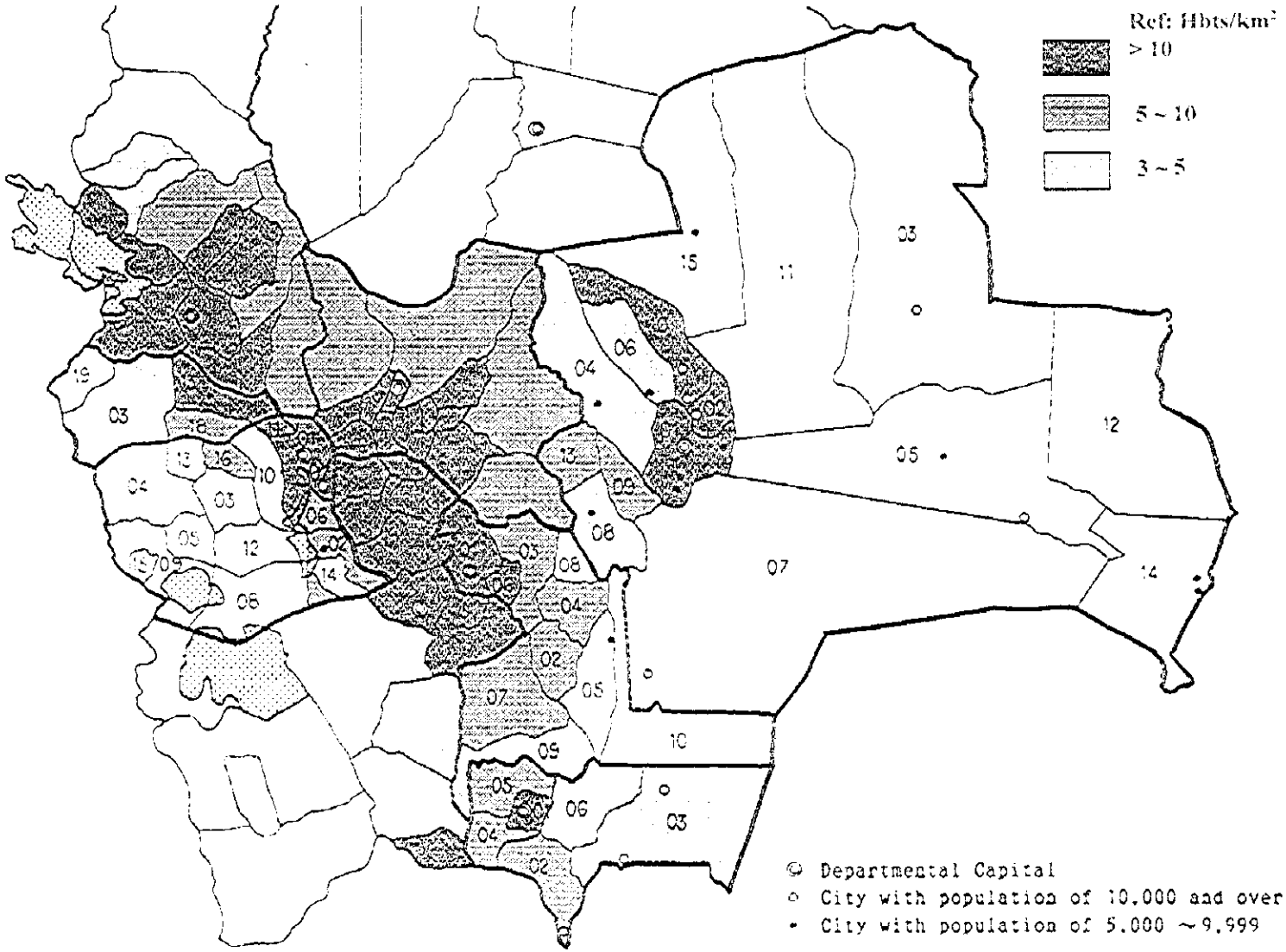

Figure 2-1-4 Population Density (1992) by Province

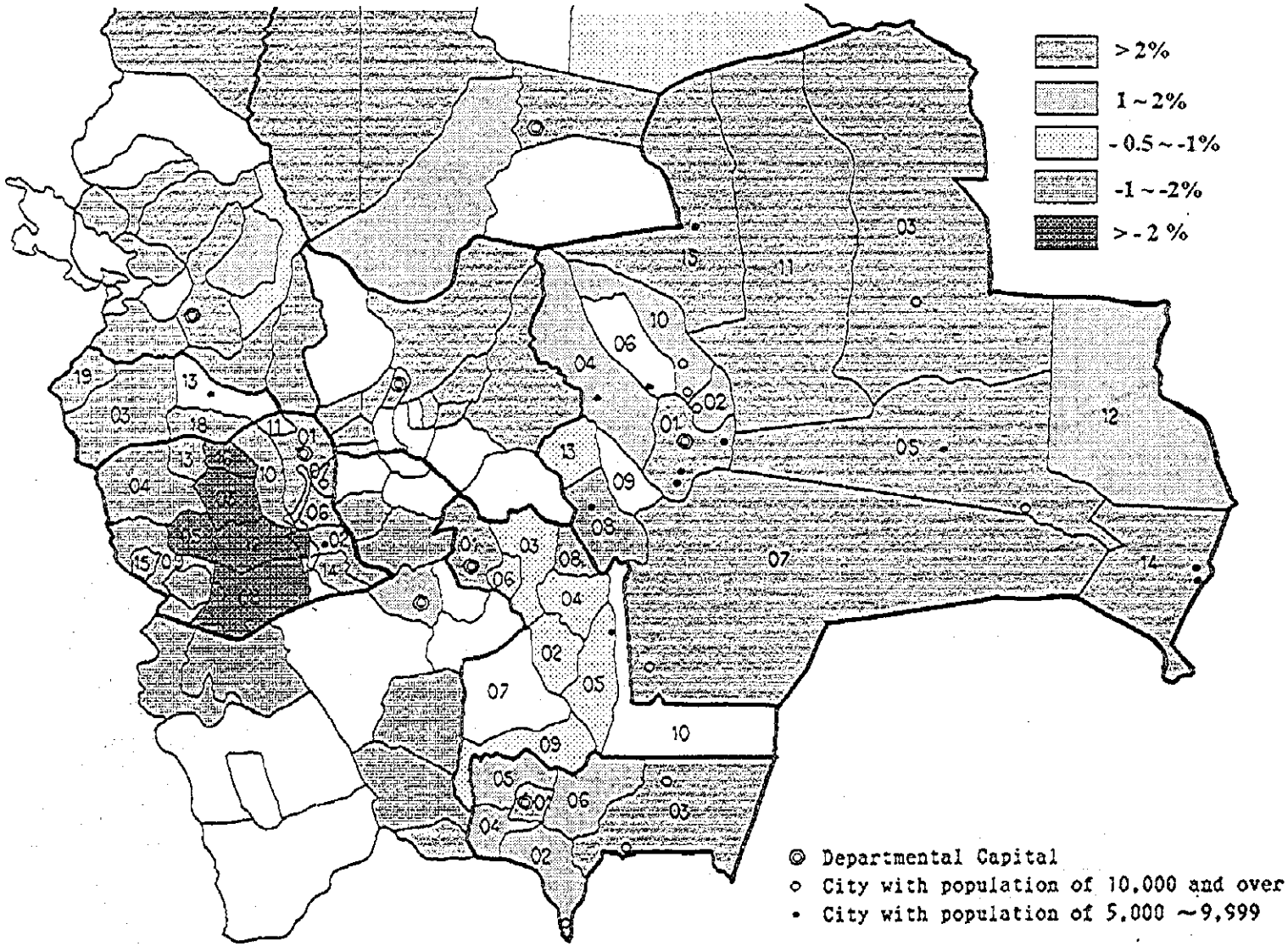

Figure 2-1-5 Population Growth Rate by Province

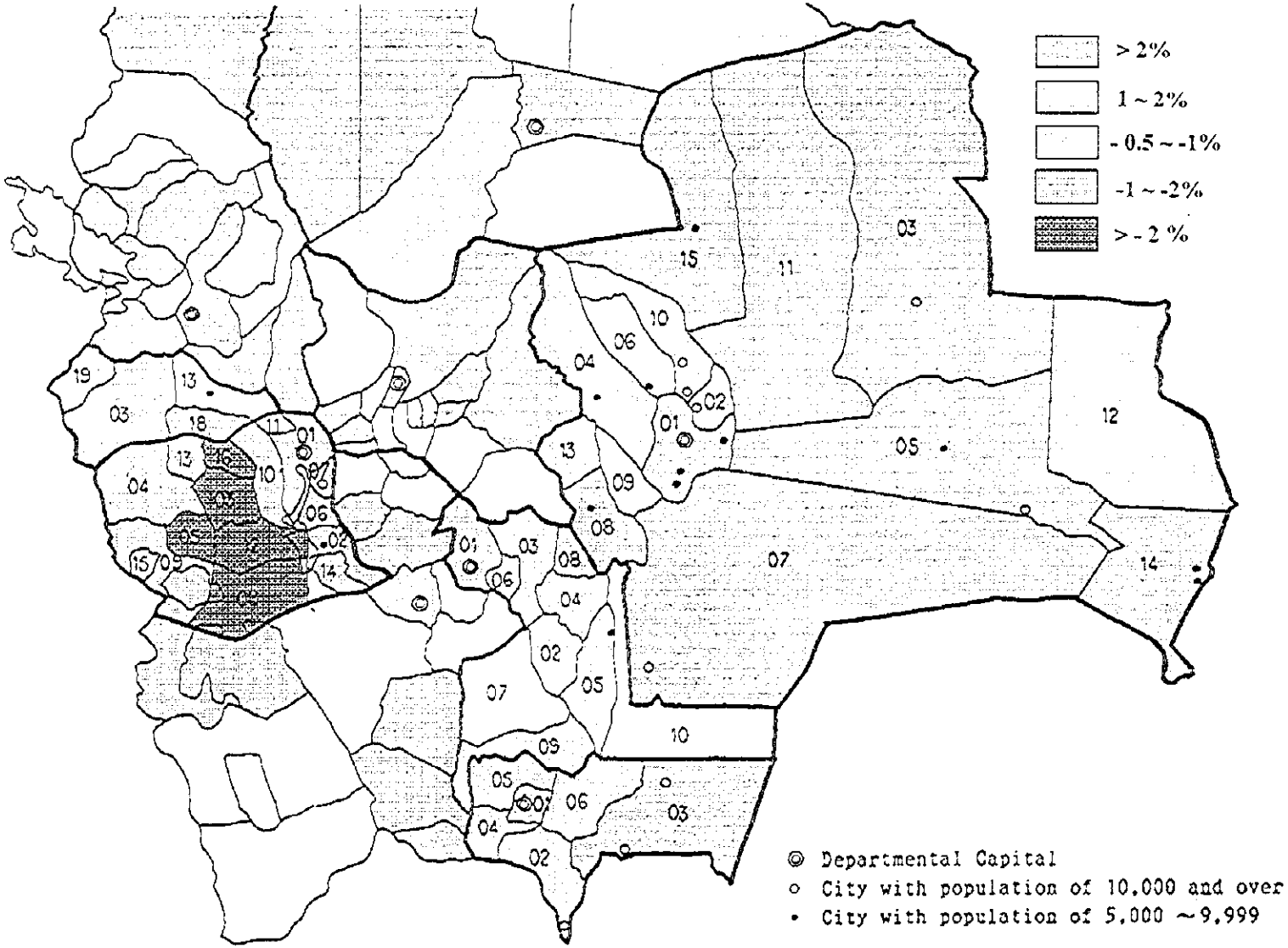

Figure 2-1-5 Population Growth Rate by Province