JAPAN INTERNATIONAL COOPERATION AGENCY

NATIONAL INSTITUTE OF HYDRAULIC RESOURCES,

THE DOMINICAN REPUBLIC

THE STUDY ON INTEGRATED RURAL DEVELOPMENT PROJECT OF YAQUE DEL SUR RIVER BASIN IN THE DOMINICAN REPUBLIC

Volume II

ANNEX – 1 ; MASTER PLAN STUDY ON THE AGRICULTURAL DEVELOPMENT PROJECT IN THE YAQUE DEL SUR RIVER BASIN

JULY 1999

Nippon Koei Co., Ltd.

Pasco International Inc.

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ACRONYMS AND ABBREVIATIONS

AGLIPO	Project Aguacate Linon y el Pozo
Asentamiento	Agrarian Reform settlement
BAGRICOLA	Banco Agricola (Agricultural Bank)
BID	Banco Interamericano de Desarrollo (Inter-American Development Bank)
CAASD	Corporacion de Acueducto y Alcantarillado de Santo Domingo (Santo Domingo Water Supply and Sewerage Corporation)
CADER	Centro de Administración del Desarrollo Rural (Center for Administration of Rural Development)
CDE	Corporación Dominicana de Electricidad (Dominican Electric Corporation)
CEA	Consejo Estatal de Azúcar (Governmental Sugar Council)
CEDOIS	Centro Dominicano de Organizaciones de Interés Social (Dominican Center for Organizations of Social Concern
CESDEM	Centro de Estudios Sociales y Demograficos (Center for Demographic and Social Studies
CEVEMA	Centro de Venta de Materiales Agripecuaris (Agricultural Input Sub Centers)
CIAS	Centro de Investigación Agropecuaria de San Juan (Agricultural Research Center in San Juan)
CIAZA	Centro de Investigaciones Agricola en Zonas Aridas (Research Center for Arid Zone)
CIDA	Canadian International Development Agency
COEE	Emergency Reservoir Operation
CORAASAN	Corporacion de Acueducto y Alcantarillado de Santiago (Santiago Water Supply and Sewerage Corporation)
DEFINPRO	Central Bank's Department of Financing
DDR	Departmento Distritos de Riego (Irrigation District Department)
DGF	Dirección General Forestal (General Forestry Directorate)
DNP	Dirección Nacional Parque (National Parks Directorate)
DR	Dominican Repulbic
FAO	Food and Agriculture Organization of the United Nations
FDA	Fundación Para el Desarrollo Agropecuario (Agricultural Research Fundation)
FDD	Fundación Dominicana de Desarrollo (Dominican Foundation for Development)
FED	Fondo Europeo de Desarrollo (Europian Development Fund)
FEPROCA	Federación de Productores Campesinos (Federation of Farmers in Azua)
FTZ	Free Trade Zones
FUDECO	Fundación Para el Desarrollo Comunitario (Foundation for Community development)
FUNDASUR	Foundation for the Development of the South
GDP	Gross Domestic Product
GTZ	German Society of Technical Cooperation
IAD	Instituto Agrario Dominicano (Dominican Agrarion Institute)
IBRD	International Bank for Reconstruction and Development
IDB	Interamerican Development Bank
IFAD (FIDA)	Fondo Internacional Para el Desarrollo Agricola (International Fund for Agricurtural Development
IICA	Inter-American Institute for Agricultural Cooperation
IMF	International Monetary Fund
INAPA	Instituto Nacional de Aguas Potables y Alcantarillados (National Institute of Potable Water and Sewerage)
INDESUR	Instituto para el Desarrollo Del Suroeste (Institute for the Southwest Development)
INDOTEC	Instituto Dominicano de Tecnologia Industrial (Dominican Institute of Industrial Technology)
INDRHI	Instituto Nacional de Recursos Hidraulicos (National Institute of Hydraulic Resources)
INESPRE	Instituto Nacional de Estabilizacion de Precios (Price Stabilization Institute)
INPOSDOM	Instituto Postal Dominicano (Dominican Postal Institute)

IPM	Integrated Pest Management
ISA	Instituto Superior de Agricultura (Superior Institute for Agriculture, ISA)
JAD	Junta Agroempresareal Dominicana (Dominican Agribusiness Council)
JICA	Japan International Cooperation Agency
Juntas de Regantes	The highest level of water user organizaton: a grouping of Irrigation Associations
Junta Directiva	Board of Directors of the Junta de Regantes
MCM	Million Cubic Meter
NGO	Non-governmental Organization
nucleo	Lowest-level organizational unit in the Junta de Regantes, usually consisting of farmers sharing a single turnout
OEA (OAS)	Organización de Estados Americanos (American States Organization)
OFWMP	On-farm Water Management Project
ONAPLAN	Oficina Nacional de Planificación (National Planning Office)
ONAMET	Oficina Nacional de Meteorologia (National Office of Meteorology)
OTTT	Oficina Técnica de Transporte Terrestre (Technical Transportation Office)
PLANAR	Plan Nacional de Agua Rural (Rural Waterway National Plan)
PLANIACAS	Plan Nacional de Investigaíon, Aprovechamiento y Control de Aguas Subterráneas (National Plan of Study, Use and Control of ground Water)
PLANDZF	Plan Nacional de la Zona Fronteriza (Border Zone Development Plan)
PMF	Probable Maximum Flood
PRISA	Programa Integrado de Salud en el Suroeste (Intergrated Local Program in the Southwest)
PROFAMILIA	Asociación Dominicana Pro Bienestar de la Familia (Family Welfare Office)
PROSEMA	Programa de Servicios de Maquinarias Agricolas (Agricultural Machines Service Program)
PRODAS	Proyecto de desarrollo Agricola en San Juan dela Maguana (San Juan de la Maguana Agricultural Development Project)
PROMAF	Projcto Manejo de Aguas a Nivel de Finca (On-farm Water Management Project)
PROMASIR	Programa de Mejoramiento y Administracion de los Sistemas de Riego
PROMATREC	Projecto de Manejo deTierras Regadas y Cuenca
SCF	Standard conversion factor
SEA	Secretaria del Estado de Agricultura (Ministry of Agriculture)
SEEC	Secretaria de Estado de Education y Cultura (Secretary of State Education and Culture)
SEOPC	Secretaria de Estado de Obras Publicas y Comunicaiones (Secretary of Public Works and Communication)
SESPAS	Secretaria de Estado de Salud Pública y Asistencia Social (Secretary of State Pubic Health and Social Assistance)
SINACAR	Sistema Nacional de Capacitacion de Asociaciones de Regantes (National System for Training of Water Users Association's Member)
SINAPBRI	Sistema Nacional Autogestionario de Producción Bajo Riego (National System for Self-sustainable Irrigated Agriculture Production)
SSID	Servicio Social de Iglesias (Dominican Churches Social Services)
SURENA	Subsecretaria de Estado de Recursos Naturales (Subsecretary of Natural Resources)
tarea	Measure of land, 0.063 hectares
toma	Turnout
UASD	Universidad Autonoma de Santo Domingo (Autbonomus University of Santo Doming)
UNPHU	Universidad Pedro Henriquez Urena (University Pedro Henriquez Urena).
USAID	United States Agency for International Development
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization
WUO	Water User Organization
YSURA	Yaque del Sur-Azua. Irrigation system serving Azua Valley

CURRENCY EQUIVALENTS

US $1 =Dominican Peso 14.0 = Japanese Yen 126
as of February 1998 (Master Plan Study)
US $1 =Dominican Peso 15.5 = Japanese Yen 112
as of January 1999 (Feasibility Study)

1. INTRODUCTION

1.1 Authority

This is the Annex –1 of the report which the JICA Study team prepared in accordance with the Scope of Work (S/W) for the Study on the Integrated Rural Development Project of the Yaque Del Sur River Basin in the Dominican Republic (the Study) agreed upon between the Government of the Dominican Republic (GORD) through the National Institute of Hydraulic Resources (INDRHI) and the Japan International Cooperation Agency (JICA) in July 2nd 1997.

1.2 Objectives of the Study

The objectives of the Study are (1) to prepare a Master Plan on an integrated rural development project of the Yaque Del Sur river basin of which components shall include water resources development and agricultural and rural development, (2) to conduct a feasibility study of priority areas selected in the Master Plan and (3) to transfer technology, which is used for this study, to the Dominican Republic counterpart personnel through on-the-job training in the course of the Study.

2. PROJECT BACKGROUND

2.1 General Economic Conditions in the Dominican Republic

The Dominican Republic's estimated population of 7.89 million has grown at a 2 percent annual rate in the 1990's decreasing from 2.9 percent in the 1970's and 2.3 percent in 1980's. Despite the fact that 45% of the population is rural, urbanization has rapid and 2.4 million people live in Santo Domingo, the capital. The unemployment rate was estimated at 16.6 % in 1996 in addition to a sizable informal sector. Of the economically active population, the service sector employed 27.2% in 1997, while commerce absorbed 23.2%, Industry 17% and agriculture 13.8% (Central Bank , 1997). Tourism and export processing operations (Free Export Zones) have become significant source of growth for the country. Desegregated GDP data for the last five years are shown in Table 2.1.1

In 1990 the Government undertook a new Economic Program that combined stringent stabilization measures and unification of foreign exchange market with financial system, trade, pricing and tax reforms. In September 1994 the Government moved again to stabilize the economy following the fiscal and monetary excesses. Since then growth has been positive and real GDP growth was estimated at 5 % in 1997. Per capita growth averaged 4 % during 1994-1997 period. Inflation rate has been very low achieving a record low of 3.95% in 1996. (Central Bank, 1997).

Trade reform was initiated in 1990 and the country's membership in the WTO has brought about further liberalization commitments in 1994 after the conclusion of the Multilateral Trade of Agreement of the Uruguay Round. In 1995 import surcharges were removed which lowered average duties on imports.

Later on the Government introduced a technical rectification before the World Trade Organization (WTO) for eight commodities considered very sensitive for the Dominican agriculture. Those commodities are: Poultry parts, powdered milk, red beans, rice, garlic, onion, corn and refined sugar. For those commodities the country set a different bound tariff and special safeguards.

In June 1997 the Government enacted a law eliminating import tariff for agricultural inputs and agricultural machinery.

During the last two years, the Government has carried out a major reform effort aimed at improving transparency and effectiveness of the laws affecting competition. New custom regulations have been instituted. Major elements of the tax laws and the labor code have reformed with new implementing regulations under development. Banking law was also reformed. A new Foreign Investment Law was enacted by the executive branch on November 1995.

Infrastructure is good and the country has an advanced telecommunication system, but suffers from electrical shortages which has forced industries and private homes to buy their own power generators.

Manufactures contributes 17 percent of GDP. Free zones have shown outstanding performance. In 1996 there were around 434 companies operating in 34 industrial parks and providing employment to 164,639 people. In 1996 free zones exports reached US$1,869 million (ONAPLAN, 1997).

Tourism has become the principal source of foreign exchange, contributing some US$1,837 millions in 1996. For 1997 revenues from tourism were estimated in US$2,047,798 millions. During 1996, 2,064 people visited the Dominican Republic with a per capita spending of US$91/ day and an average stay of 11 nights/person (Central Bank, 1997).

The country is endowed with a diverse topography and abundant rainfall across most of the country allowing year around agricultural production with limited amount of irrigation. However, there are some geographical areas, specially the southwest region, where there is not enough rainfall throughout the year to sustain agricultural production. The agricultural sector has been losing importance due to government interest in promoting growth of free zones and the array of government interventions which introduced price distortion and reduced the sector competitiveness.

Because of that, the country has to import significant amount of foodstuff to satisfy domestic demand. The main imported foodstuffs are wheat, corn, dairy products, sorghum, milk, cooking oil, rice and red beans (see Table 2.1.2.). In 1996 food import accounted for US$535 million (17% of total imports).

The main exports commodities are sugar and by-products, tobacco and cigars, cocoa, and coffee, which are considered the traditional export along with mineral exports such as Ferro nickel and dore (a combination of gold and silver). Export earning in 1996 amounted US$821 millions. Other agricultural commodities exported include banana, pineapple and yautia. (see Table 2.1.3).

The current account of the balance of payments has registered persistent deficits, due mainly to growing merchandise trade deficit. Merchandise imports were valued at U$3,216 million in 1996 against exports of US$821 million. Although surpluses in services expanded, they have not compensated for the goods deficits. In order to bridge the gap the country depends on unilateral transfer mainly remittances from Dominican living abroad.

Rice is the main staple food along with red beans, cassava and plantain. Rice is produced mainly in the Cibao area and San Juan in the south. Plantains are produced in great quantity in the Cibao area as well as in the southwest specially Barahona and Azua. Cattle production is concentrated in the higher quality range lands of the central and eastern regions. Commercial pork and poultry are being raised in the Cibao valley.

2.2. National Development Policy

In August 1996 the new administration explained the country's social and economic development strategy based on six broad objectives:

(1) To achieve a sustained annual GDP growth of 7-8%;

(2) To strengthen an economy based on the private sector and oriented towards foreign trade;

(3) To keep an inflation rate of below 10 percent a year;

(4) To keep a financial equilibrium of the consolidated public sector, a rational Government expenditure and an increase in taxes to 20 percent of GDP;

(5) To increase (double) Government spending in social expenditure giving greater emphasis to health services, social security and also to basic technical and vocational education, and;

(6) A Government fundamentally dedicated to facilitating a competitive economy, to ensure investment in infrastructure and putting into effect an integrated strategy to improve equity and eradicate poverty.

In order to achieve those goals, the Government decided to re-orient Government spending on the following area:

(1) Increase salaries of public employee, in greater proportion to teachers and physicians working in public places.

(2) Increase Government funding to the electricity company, the State University (Universidad Autonoma de Santo Domingo), as well as other decentralized institutions such as INDRHI, the National Institute for Housing (INVI), the Special Fund for Agricultural Development (FEDA) and the State Sugar Council (CEA).

(3) Increase the amount of funding being devoted to honor the external debt.

The restructuring of Government spending toward social sectors together with further economic reform is expected to bring about a positive impact on production and would help to mitigate poverty through job creation and income generation.

The Government sectoral policy in agriculture have been defined in the following areas:

a) Agricultural Production:

- Promote food production to achieve self-sufficiency on the main staple food (rice, red beans, plantain and cassava)
- Promote production of traditional and non-traditional export crops to increase foreign exchange earning.
- Enhance the level of agricultural production from small farms and increase their level of income.

b) Marketing and Price Policies

- Promote the elimination of all tariff and non tariff barrier to domestic agricultural production and trade.

- Promote trade liberalization and market access for agricultural commodities.
- Reduce price controls on both agricultural inputs and final goods and keeping some price intervention for some sensible crops.
- Promote private initiatives which would strengthen domestic agricultural markets.

c) Credit Policy

- Increase credit access to the agricultural sector through budgetary allocation to the Agricultural Bank and the Reserves Bank.
- Continue credit support to the main food crops (especially rice) to the agrarian reform settlement and small farmers.

d) Land Reform Policy

- Provide Land Reform Settlers with definite titles to increase their capacity to obtain credit.
- Consolidate and strengthen settlements support services on production, infrastructure and market development.

e) Irrigation Policy

- Increase investment on irrigation facilities and maintenance of the existing facilities.
- Improve irrigation system management by extending and increasing water charges and transfer of the irrigation system to water users.
- Promote the enactment and implementation of the National Water Code
- Promote a new legal and institutional arrangement for the management of major river basins.

f) Natural Resource Policy

- Promote recuperation and protection measures to prevent soil erosion.
- Encourage crop zoning according to soil quality and water availability
- Adopt a holistic approach on watershed management putting more attention to agricultural production systems and the needs of small farmers.

g) Research and Extension Policy

- Promote coordination between research and extension systems.
- Promote efficient management mechanism of Agricultural Research Centers decentralizing their operation and incorporating the private sector and farmers.

2.3. Regional Development in the Basin of the Yaque del Sur

The Yaque del Sur river basin (the Study Area) is located in the Southwest region considered the least developed part of the country. The highest concentration of poverty persists in the southwest. According to the Study "Focalizacion de la Pobreza en la Republica Dominicana" (Focusing Poverty in The Dominican Republic), the Region comprises the highest percentage of poor household with more than 75% of them living in poverty. Similarly 55 percent of the population earn less than RD$750 a month and 24 percent between RD$750 and DR$1,000 in 1993. The Government has identified that region has the top priority for the regional development to reduce poverty and regional imbalances.

Bahoruco, Azua and Barahona, which are the main provinces in the Study Area, are among the provinces with the highest level of poverty in the Southwest region. A Government Study showed that 82% of aqueduct does not use chlorine to disinfect water which does not guarantee the water quality for human consumption. Similarly 68 percent of the household does not have access to latrines and the global deficit in nutrition in pre-school children was 10%. Chronic malnutrition and deficit in size related to age was 20% (SESPAS, 1996) as shown in Table 2.3.1.

3.1. Administration and Socio-Rural Conditions

3.1.1 Administration and Areas

The Study area is about 7,100 km2 or 14 % of the territory of the whole country. Administratively, the Study area is under the full or partial jurisdiction of two regions, 6 provinces, 29 municipal districts and 150 rural sections. Rural sections are the most basic subordinate organization in the community. Each province has a local capital with local government and main public offices. The total population of the Study area is estimated at 621,000 in 1993 or about 10 % of the country population. The total number of households is estimated at 145,200. The average family size is 4.28. The population density is very low with 87 person/km2 (compared to 149 persons/km2 nationwide). The administrative structures and population are summarized below:

Name of Region	Name of provinces	No. of municipal district	No. of rural section	Total population related to the Study area in 1993	Estimated total population related to the Study area in 1998
	Barahona	10	48	111,539	174,949
South	Bahoruco	6	27	85,624	111,662
	Independencia	2	6	7,230	8,180
South West	San Juan	6	29	169,500	268,140
	Azua	10	35	194,209	211,937
North	La Vega	1	5	52,902	58,408
Total		29	150	621,004	833,276

The Study area is one with the lowest population growth rate. Between 1981 and 1993, the southwest region had an average population growth rate of 1.5 % compared to 3.2 % of the national growth rate. But the average growth rate hides some disparities among provinces. For instance, Azua had a population growth rate of 3 % while San Juan increased its population by 0.7 % during the period 1981-1993 and Barahona only 1.3 % during the same period. Data on Population, based on the 1993 Census, by related provinces and municipal districts are presented in Table 3.1.1.

This behavior may be explained by different factors. First, during the 1980's there was an increase in the migration process from the region, specially in Bahoruco and Barahona and (Tamayo and Vicente Noble mainly) to Europe and the United States. Second Azua might have received some people from other provinces in the south to work in agriculture. It is expected that population will increase but at a lesser path than in 1980's. The projected population in the Study area in 1998 is about 833,000.

3.1.2. Land Tenure

In the land tenure structure in the Dominican Republic, only 20 % of the farmers owned 88 % of the total agricultural land. Since 1962 the Government began a process of land distribution among landless peasants. At that time the Dominican Agrarian Institute (IAD) was created by Law to manage the land settlement program.

Land ownership is highly concentrated in the Study area. Information from the

Agricultural Census of 1981 (the latest figures available) shows that around 85% of the farms owns less than 80 tareas (5 ha) with an average size of one ha as shown in the following table. Although there is not official up to date figures on land tenure in the Study area, information gathered during the Rapid Rural Appraisal indicates that there have been more land fragmentation. As a consequence the amount of land available for a rural family to generate food and income for his/her family has been greatly reduced.

Farm Size in the Study area According to the Agricultural Census, 1981

Size Range	Number of farms	%	Acreage (tareas)	%	Average farm size (tareas)
Country	385,060	100%	46,245,767	100%	111
0-80 tareas	314,665	82%	5,185,999	11%	16
81-160 tareas	32,543	8%	3,686,128	8%	113
> 160 tareas	37,852	10%	37,373,640	81%	987
El Valle Subregion(1)	53,590	100%	2,803,115	100%	61
0-80 tareas	47,108	88%	946,219	34%	20
81-160 tareas	3,915	7%	946,899	34%	242
> 160 tareas	2,567	5%	909,997	32%	355
Enriquillo subregion(2)	27,444	100%	2,279,619	100%	91
0-80 tareas	21,032	77%	291,774	13%	14
81-160 tareas	2,373	8%	258,029	11%	109
> 160 tareas	4,039	15%	1,729,816	76%	428

Note:
(1) Includes Azua, San Juan and Elias Piña Provinces
(2) Includes Barahona, Bahoruco, Independencia and Pedernales provinces
Source: Oficina Nacional de Estadisticas. 7mo. Censo Nacional Agropecuario.

3.1.3 General Information of the Sample Households

(a) Socio-economic Survey

To collect useful information from the Study area, a household survey was conducted among 150 farmers spread out among 13 communities of 4 provinces of the Study area.

The survey priority was stressed on Barahona and Bahoruco provinces because of less availability of socio-economic data than that of other areas. Seventy percent of the sample was allocated to these two provinces. Less emphasis was set on Azua and San Juan where 30 and 15 household were drawn, respectively.

The sample selection was done based on two criteria: farm size and water availability (irrigated or rainfed). Three types of farm size were considered based on the land tenure structure of the information available from the Agricultural Census: a) Less than 80 tareas (5 ha) ; b) between 81 and 160 tareas (5 to 10 ha) and; c) more than 160 tareas (more than 10 ha). For each farm size selected households were equally divided into irrigated and non irrigated farms. The sampling distribution is presented in the following table. The survey form used is attached to Annex-1.

Household Survey Distribution

	0-80 tareas (<5ha)		81-160 tareas (5-10ha)		> 160 tareas (>10ha)		Total
Province	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	
Barahona/Bahoruco							
Tamayo	8	9	1	1	1	1	21
Vicente Noble	7	8	1	1	1	1	19
Fundación	9	9	1	1	1	1	22
Cabral	7	8	1	1	1		18
Neyba	4	4	1	0	1	0	10
Galvan	6	7	1	0	1	0	15
Total	**41**	**45**	**6**	**4**	**6**	**3**	**105**
Azua							
El Sisal*	4	4	1	0	1	0	10
Las Yayas	4	4	1	0	1	0	10
Padre las Casas	4	4	1	0	1	0	10
Total	**12**	**12**	**3**	**0**	**3**	**0**	**30**
San Juan							
Sabana Alta	2	2	1	0	0	0	5
Bohechio	2	2	1	0	0	0	5
Juan de Herrera	2	2	1	0	0	0	5
Total	**6**	**6**	**3**	**0**	**0**	**0**	**15**
GRAND TOTAL	**59**	**63**	**12**	**4**	**9**	**3**	**150**

Major topics addressed in the farmer's survey included among others :

- General information of interviewee (General characteristics of farmers)
- Land use, land tenures, cropping pattern, production and marketing of products
- Irrigation system and water use
- Institutional supporting system to farmers (Credit, Technical Assistance, etc.)
- Rural Organization
- Identification of problems on farming, water availability and marketing of agro-products.
- Desires and demand of farmers for agricultural Development

(b) Social Features

Most farmers have lived in the area for more than 25 years. The average farmer is 46 years old with an average of 35 years as farmer. The average household consists of 5 members including the spouse and children and headed mostly by a male (95%). Regarding education, 43% of farmers only achieved a primary level and 17% is illiterate. However, Only 22% of the farmers interviewed went to secondary school and university.

Farmers in the area produce major food crops as the main source of income. The main crops planted are plantain and banana in Barahona, Neyba and Azua; sweet potato in Azua and San Juan; cassava in Barahona and Azua; rice and red bean in San Juan, sorghum in Barahona and; corn, and industrial tomato in Azua. In the mountainous area, coffee is the crop more extended among farmers. As livestock is concerned, cattle, swine and poultry are produced in small scales mostly for family consumption .

About 93% of the household depends on agricultural activities as the main source of

income, while 7% derived their income from such activities as working in other farms, as employee of public or quasi public enterprises and engaging in commercial activities. Some households receive remittances from relatives leaving outside of village specially in the United States and Spain. In fact 18.7% of the household interviewed received remittances in 1997. In the case of Vicente Noble in Barahona and in Azua the percentage of households receiving remittances is higher than other villages. There has been some migration to both Santo Domingo and abroad specially the United States and Spain. Young females are the segments of the population who migrate to Europe. In terms of household monthly expenses, 82% is devoted to food consumption and 7% clothing; 8% medicines and 2% education.

In regard with the type of housing, only 9.3% of the household live in good housing with cement wall and ceiling of cement. Most houses are made of wooden wall and tin roof (41%). Regarding drinkable water 69% of the farmers interviewed did not have access due to lack of aqueducts at the villages. Most farmers use Liquid Petroleum Gas (LPG) to cook their meal (82%) and only 15% use wood and charcoal. The Government has kept the price of LPG subsidized to encourage its use and curve down the use of fuelwood and charcoal. About 74 % of the farmers have access to electricity although there is some power shortages during the day. The electric power shortages have severely affected irrigation on those farms that have electrical water pumps.

(c) Land Tenure and Land Use

Regarding the land tenure structure in the Study area, most farmers own some land (82%) with an average size of 71 tareas (4.4 has); 17% of the farmers were beneficiaries of the Government land reforms program with an average plot of 32 tareas (2 ha). Most of the owned land was inherited (85%). There are some beneficiaries of agrarian reforms who cultivate additional plots of lands through leasing from other settlers and sharecropping. Farmers benefiting from the latest government land distribution received lower amount of land.

It is noticeable the presence of sharecropping and leasing in the Study area. 15 % of the farmers interviewed are engaged in sharecropping giving away between 33% and 50% of their production to the land owner. The annual rate for leased land varies among villages and depends on soil quality and access to water. It ranged from RD$50/ta/year (RD$800/ha/year) to RD$200/ta/year (RD$3,200/ha/year). In the Study area few own livestock or grassland. Livestock is raised to satisfy household demand.

Due to lack of financial arrangement as well as deficient access to irrigation water, the land is not used intensively the year around. In this sense the cropping intensity among farmers remains relatively low. Unit yields for the crops cultivated for the interviewed farmers within the Study area are as follow:

Kinds of Crop	Yield (ton/ha)	Zone
Plantain	18	Barahona, Bahoruco
Banana	26	Barahona, Azua
Corn	1.5	Azua
Sorghum	2.2	Barahona
Cassava	5.7	Barahona, Azua
Pigeon Peas	3.1	San Juan, Neyba
Sweet Potato	10.3	Azua, San Juan
Red Beans	0.9	San Juan
Rice	3.3	San Juan
Industrial tomato	21.2	Azua

About two thirds of farmers use fertilizer on their plot specially in the production of rice, plantain, banana, industrial tomato and red beans. Insecticides and fungicides are more widespread for industrial tomato and red beans around Azua and San Juan. The use of fertilizer per crop among farmers interviewed is a follow:

Crop	Amount of fertilizer used (kg/ha)		
	N	P	K
Plantain	180	86	86
Banana	200	50	50
Red Beans	32	32	24
Rice	105	60	60
Pigeon peas	15	15	15
Industrial tomato	150	75	75

Most of the production in the Study area is being channeled into the market through local Middlemen (60%) and agroprocessing plant factories (17%). There is not a developed marketing system because most of the production is being consumed within the region. The great majority of animals are sold within the Study area from farmers to middlemen.

The average wage paid to hired labor was around RD$80/day. But it ranged from RD$45/day in the production of cassava in Azua and Barahona to RD$100 in rice production areas (San Juan). There exist some seasonal shortages of labor in San Juan , Azua and Barahona.

Most farmers rely on machinery (59%) and animal (11%) for land preparation. About 72% use the machine service from the government (SEA) at a subsidized rate. However, 41 % revealed that the service was not available when they needed it. Only 8.7 % of the household carry out cultivation using exclusively manpower.

Regarding irrigation system, 86 % of the respondent farmers who had access to irrigation water, have been using it for more than 15 years. For those who have water access, only 16 % irrigate their fields directly from rivers while 62 % take it from canals and 22 % from wells. The periodicity of the irrigation depends on the type of crop and water

availability Irrigation is done mostly during the day and the average irrigation period is 2.3 days and the irrigation interval is 3 days in average. In the San Juan area the length of the irrigation is 3.8 days. .

(d) Institutional Supporting Services to Farmers

Extension services or transfer of technology from governmental officials are an important factor if farmers desire to attain sustainable crop production as well as higher level of yield. Those who received technical assistance knew the name of the extension technician from SEA. However, 47 % expressed that they did not receive technical assistance last year from any technician. This fact has affected the introduction of improved crop technologies including high yielding varieties.

In the Study area few farmers participated in training course on cropping technology and only in San Juan the number was significant (66%). Most courses are being sponsored by SEA. Two out of three farmers answered positively to the question of affiliation to farmers organization and could also identify the names of the associations. However the level of participation in the association activities is very limited. Those who were beneficiaries of land settlements belonged to association created by the Agrarian institute. When asking the reason to be part of the association the benefits were a) to obtain credit (40.7%), to get better prices for their crops (32%); and to have access to irrigation water (25%). Only in Azua and San Juan operate water user associations.

Some farmers identified Non Government Organizations which are operating in the area providing technical assistance, production credits and sponsoring social services such as vaccinations and medical care as well as construction of water facilities for human consumption, latrines and community services.

The greater part of farmers in the Study area do not have sufficient financial resources, therefore they have to depend on production loans to undertake their crop production. According to the survey, 45 % of the farmers could not get credit needed to buy agricultural inputs. Farmers who obtained loans for their crops got them from the Agricultural Bank (BAGRICOLA). The interest rate for those loans ranged from 18% to 28% annually.

None of the farmer interviewed received credit for production from commercial banks and around 10% had to use local lenders to borrow money for their agricultural operations. The interest rate paid to these local lenders is very high and in most cases was around 20%/month (more than 240% a year). Few farmers obtained loans for their crop activities from Non Government Organization at a interest rate of 30% annually.

(e) Identification of Problems on Crop Production and Marketing Intention of Farmers

Farmers were asked to identify and rank the three main problems they faced. A numerical ranking system was used for this question assigning three points to the first problem identified by each farmer, two points to the second problem and one point to the third problem. Based on that ranking, the interviewed farmers ranked their main problems related with crop production in the following descending order :

Ranking by Farmers	Total Points	Problems
First	252	Availability to irrigation water
Second	231	Drought
Third	140	Access to credit
Fourth	107	Insect
Fifth	92	Soil fertility
Sixth	73	Lack of technical assistance

The main problem facing irrigation was insufficient water and electricity to operate the water pumps. The Study area faced a prolonged drought period that aggravated the problem of lack of irrigation water. Problems associated with the inability of farmers to obtain agricultural loans were lack of collateral, high interest rate and small scale operation. The Study area was also affected by the presence of white fly on tomato and red bean production.

In the case where farmers did not participate on any farmer's association, the main reasons not to be a member were the absence of association in the village, disagreement with the association's leaders and lack of interests or time to participate.

The type of ranking was used to identify marketing problems of agro-products faced by farmers in the Study area. Marketing problems were ranked as follow:

Ranking by Farmers	Total Points	Problems
First	270	High control by local middlemen
Second	237	Farmgate price fluctuation
Third	103	Poor road conditions
Fourth	74	Lack of market outlet
Fifth	72	Lack of support service

The main actions identified by farmers which could help agricultural development in the Study area is related to water availability and management. Demands expressed by farmers were:

Ranking by Farmers	Total Points	Desires and Demand
First	240	Construction of irrigation infrastructure
Second	148	Access to subsidized credit
Third	132	Construction of aqueducts
Fourth	108	Access to subsidized inputs
Fifth	80	Construction of community infrastructure
Sixth	74	Promotion of job creation activities
Seventh	60	New land settlement

3.2 Natural Conditions

3.2.1 Land Resources

(1) Soils

There is a soil study at reconnaissance level made by the Organization of American State in 1967 which covers the land of the entire Study area. In this study, soil maps at scale 1:250,000 were prepared with 18 soil mapping units. The area of each mapping unit is shown in the following table and its distribution is illustrated on Fig.3.2.1.

Name of soil association	Area (km2)	Proportional extent (%)
Valle Nuevo	34	0.4
San Juan Hatico	136	2.0
Quita Coraza	574	8.0
Azua Plain	426	6.1
Elias Pina-Las Matas	9	0.1
La Jina-Yuma	514	7.2
Los Bucaros	165	2.4
Cacheo	259	3.7
Guama	451	6.3
Constanza	31	0.4
Guanita	2	-
Guanito Villarpanda	216	3.1
Yabonico	55	0.9
Suelos Aluvales Recientes	417	5.9
Cinagas Costera e Interior	65	1.0
Playa Costera y Dunas	6	0.1
Terreno Escabroso no Calizo and Calizo	3743	52.0
Lake and Lagoon	29	0.4
Total	7,100	100.0

Main characteristics of each soil association are shown in Table 3.2.1. The characteristics of main soil associations are outlined as follows:

(a) Terreno Escabrosos Calcareous and none Calcareous (Undulated Calcareous and none Calcareous Soils).

This association include soil with very undiluted topography. The parent materials vary considerably from basic metamorphic rocks, sedimentary rocks, calcareous rocks, diorite and granite rocks. Most of the soils are none calcareous derived from metamorphic rocks. Generally the soils are shallow, with many large bolder on surface; the soils are prone to erosion. The fertility is low. Because of these characteristics the use of these soils is for forest and recreation.

(b) Quita Coraza Soil Association

This group of soils extend from the foot of Neyba mountain range up to the

beginning of Azua plain. The climate is arid. Soils are derived from calcareous parent materials. The soils present accumulation sand and rock fragments. Soil color is mainly gray. The topography is variable from undulated to slightly slops. Most of the area of these soils are unproductive due to their rockiness, and shallow profile. Soil in sloping areas are prone to erosion.

(c) La Jina-Yuma Soil Association

The soil of this association are flat with deep profile. Soil are calcareous. Internal drainage is mostly good, but due to low topographic position some part of the soils present drainage constraint and accumulation of salts. The water retention capacity vary from medium to high. The soil color is mostly dark gray; The dominant texture is clay.

(d) Guama Soil Association

These soils are formed from colluvial parent materials, mainly caliza which result in clay soil texture, and calcareous arenisca which result sandy textured soils. The topography is generally undulated. The majority of soils have dark brown color. The soil depth is generally shallow. Majority of these soils have low agricultural potential.

(e) Azua Plain Soil Association

This soil association extend from alluvial plain of Yaque del Sur river up to the foot of "El Numero" mountain. It includes soils formed of different topographic condition, from undulated (about 1/3 of the area,, and flat 2/3). Soil depth vary considerably, from deep soils to very shallow. The natural drainage condition vary according to the location of soil unit, the areas toward the cost present deficient drainage which limits theirs use. Soil texture vary from sandy loam to clay, and natural fertility is low to medium.

(f) Suelos Aluviales Recientes (Recent Alluvial Soils)

This association include most of the soils formed along Yaque del Sur river, and many are being used for intensive agriculture. Soil texture vary from sandy to clay, but majority are Silt loam. Internal drainage vary depending on soil texture and position of soils. Soil depth vary from shallow to very deep; The land is mostly flat; Soil fertility is mostly medium.

In addition to the above soil information, soil classification studies at semi-detailed level in the Study area were made for the irrigated lands of Azua, part of San Juan, Barahona, and part of Neyba valley by the Ministry of Agriculture (SEA) and/or INDRHI. Also, the Ministry of Agriculture made semi-detailed soil studies for part of Las Cuevas river and Grande (or del Medio) river.

Soil sampling and laboratory analysis were made by JICA's Study Team to clarify soil properties in areas identified as potential expansion for irrigation. The location of

soil sampling site is illustrated in Fig. 3.2.2 and the results of soil laboratory analysis are shown in Table 3.2.2.

(2) Land Capability

Land capability classification study for the entire country was made by the Organization of American States in 1967, following the classification system of USDA. The extent of lands of the Study area assessed by this land capability classification is shown in the following table and land capability map is illustrated in Fig. 3.2.3.

Land capability classes are numbered from one to eight. Classes 1 through 4 can be used for cultivation; Classes 5 through 8 cannot be cultivated in their present state under normal soil management. Twenty five % of the lands in the Study area can be used for cultivation. Remaining 75 % of the lands in the Study area cannot be used. Main causes for such a large percent of the lands not to be used are accrued from steep land slope or wetness.

Land capability classification	Definition of class	Area (km2)	Proportional extent (%)
Class-1	Class-1 soils can be used continuously for intensive crop production with minimum attention other than good farming practices.		0
Class-2	Class-2 soils have more limitation than Class-1 soils for intensive crop production, such as moderately steep slopes(2-5%).	465	6.5
Class-3	Class-3 soils have severe limitations and require more special conservation practices than Class-2 soils to keep them continuously productive. They have shallow soil, steep slopes of about 6-10% or shallow water tables.	860	12.1
Class-4	Class-4 soils have severe limitations and need a greater intensity of conservation practices for cultivated crops than Class-3 soils. Most of the time these soils should be in "permanent" crops, such as pastures	425	6.0
Class-5	Class-5 soils are not likely to erode but have other limitations, such as boulders or wetness, which are impractical to correct and thus cannot be cultivated. They should be used for pasture, range, woodland, or wildlife habitat.	565	8.0
Class-6	Class-6 soils are suitable for the same uses as Class -5 soils, but they have a greater need for good management to maintain production because of such limitations as steep slopes or shallow soils.	680	9.6
Class-7	Class-7 soils have very severe limitations and require extreme care to protect the soil, even with low intensity use for grazing, wildlife, or timber	4,035	56.8
Class-8	Class-8 soils have such severe limitations (steep slopes, rock lands, swamps, delicate plant cover) that they can be wisely used only for wildlife, recreation, watersheds, and esthetic appreciation.	70	1.0

3.2.2 Agricultural Climate

There are large difference of the climate in different zones within the Study area, mainly because large differences in land elevation. The area along Enriquillo lake is the lowest land elevation above sea level in Dominican Republic, and the Duarte peak is the highest mountains of the Dominican Republic, and both sites are within the Study area.

The climate in most part of the Study area is semi-arid and therefore agricultural production can not be undertaken at commercial level without irrigation in the semi-arid areas. The average annual precipitation in the semi-arid zone vary in the range between 500 to 1,500 mm, and the annual evapotranspiration is estimated at about 2,200 mm, with maximum daily evapotranspiration of about 7.5 mm during the period from May to July. The average annual maximum and minimum temperatures are 28 °C and 24.5 °C, respectively. In the hilly and mountain zones rainfall vary from 800 mm to about 1,300 mm per year, and the annual mean temperature of the high mountains is as low as 18°C. Climatic features in the Study area are summarized in Table 3.2.3.

3.2.3 Water Resources

(1) Surface Water

(a) Rainfall distribution in a year

Mean annual rainfall in the Study area ranges from about 500 mm in the Neyba Valley to over 1500 mm in the upper reach of the Yaque del Sur River. Monthly rainfall records at major rainfall stations in the Study area i.e., i) La Florida which represents rainfall in upper basin, ii) San Juan, iii) Azua, and iv) Tamayo are given in Table 3.2.4.

Mostly in the Study area, two peaks of monthly rainfall are observed, i.e., April to May and September to November.

Other rainfall stations maintained by INDRHI in/around the Study area are given in Table 3.2.5 and illustrated in Fig. 3.2.4.

(b) Dry and wet years

Probability (return period) of annual rainfall in the past is given in Table 3.2.6 for five stations in the Study area. Wet years in which the whole Study area received annual more rainfall than normal years are 1963, 1969, 1978, 1979, 1987, and 1992, while dry years are 1964, 1967, 1973, 1976, 1984 and 1991. Since the Study area has a vast watershed, the rainfall distribution varies by location to a large extent. In 1994, the upper basin of the Yaque del Sur River was dry at a return period of one in ten years or more, while the down reach received more rainfall than the normal years. Heavy rainfall by hurricanes in the down reach sometimes brings serious flooding which can not be controlled by the two reservoirs, i.e., Sabaneta and Sabana Yegua.

It is considered that the year of 1997 is also categorized as a "dry year". Table 3.2.7 shows monthly rainfall distribution and the magnitude of drought in 1997. It is

indicated that the drought in April and May should have affected the second cropping, particularly in San Juan area. Moreover, complete release of water of Sabana Yegua reservoir in August has caused serious water shortage for 1997/98 cropping in Azua and Barahona area.

(c) River systems

The Yaque del Sur River originates from the Central Mountain Ranges and flows into the Caribbean Sea at Barahona. The river has a catchment area of 4,972 km^2 with a total length of 156 km[1]. The San Juan River is the largest tributary joining the Yaque del Sur River at Villarpando at which catchment areas are 1,709 km^2 (El Puente) for the Yaque del Sur River and 2,011 km^2 for the San Juan River, respectively.

The Sabaneta Dam is located on the San Juan River having a catchment of 464 km^2 with a designed total capacity of 78 million cubic meter (MCM) which is 31 % of average annual runoff (248 MCM) at the dam site[2].

The Sabana Yegua Dam is situated on the Yaque del Sur River at about four km upstream the confluence with the San Juan River with a catchment area of 1,676 km^2. The designed total storage volume is 677 MCM which accounts for 112 % of the average annual runoff (605 MCM) at the dam site[3].

Rincon Lake, situated near the downstream end of the Yaque del Sur River, takes a role of a "flood retarding reservoir" in Barahona area. Since 1979, completion year of Sabana Yegua dam, few serious floods hit the downstream area, but the flood retarding effect of Rincon Lake is still expected in the event of hurricanes on to the downstream reach of the basin. Fluctuation of water level of the Rincon Lake is described in Sub-section 4.2.8 "Plan of Environmental Conservation".

Other major tributaries which join the Yaque del Sur River and the San Juan River are;

i) Mijo River (San Juan River)
ii) Los Baos River (San Juan River)
iii) Arroyo Loro Drain (San Juan River), and
iv) Viajama River (Yaque del Sur River)

The river system is illustrated in Fig. 3.2.5.

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[1] : Measured by the study team on the map of 1 in 50,000.
[2]: Average of 1988 to 1994. (Source "Comportamiento del Embalse de la Presa de Sabaneta durante los Años 1985-1995", Department of Irrigation District, INDRHI).
[3] Average of 1990 to 1995. (Source "Comportamiento del Embalse de la Presa de Sabana Yegua durante los Años 1985-1995", Department of Irrigation District, INDRHI).

(d) Discharge and Water Level Observation

INDRHI is operating a number of river gauge stations (Fig.3.2.4) in the Study area of which recording periods are shown in Table 3.2.8. INDRHI is conducting discharge measurement using current meters mostly once or twice a month for calibrating the rating curves which give a relation between the gauge readings and the discharges.

The gauge readings and discharges observed in the field are sent every month to the headquarters of INDRHI, National Hydrological Office, and converted to discharge data. However, due to shortage in number of staff who deal with the data from the whole hydrological stations in the country, processing of the field data requires long time. It is recommended to increase trained field staff for the processing of hydrological records at District level for betterment of quality of hydrological data in terms of accuracy and promptness for further hydrological evaluation.

In the Yaque del Sur River basin, a telemetric system has been adopted recently, having radio communication system at major hydrological check points along the river. They are;

i) Sabaneta dam
ii) Sabana Yegua dam
iii) Sabana Alta (end of San Juan River)
iv) Villarpando Headworks (Ysura Conveyance Canal)
v) Los Guiros (end of Azua Irrigation District)

The discharge or river gauge readings are reported every day to the headquarters of INDRHI by; CDE staff at the dam sites, staff of Irrigation Districts (Villarpando) or staff of Regional Hydrological Office (Sabana Alta, Los Guiros) of INDRHI.

(e) Low Flow

Low flow analysis was made by a logarithmic normal distribution method, of which results are given in Table 3.2.9. According to the results, the following points are clarified:

- River flows are regulated and stabilized to a large extent by Sabaneta dam and Sabana Yegua dam, particularly during the flood season by hurricanes.
- Sabana Yegua reservoir has released at least 20 m^3/sec of water through a year on the average, while 13 to 15 m^3/sec at 80 % dependability.
- At Los Guiros, boundary of Azua and Yaque del Sur Irrigation District, the mean minimum discharge through a year after the construction of the two dams is 17 m^3/sec, whereas 11 m^3/sec at 80 % dependability.
- At Conuquito, right upstream of the Santana Headworks, the mean minimum discharge through a year after construction of the two dams is 17 m^3/sec,

while 12 m^3/sec at 80 % dependability.

- The Mijo River (El Cacheo) has stable flow through years benefited by good watershed conditions, which is indicated by small difference between the average runoff and dependable runoff.
- At Hato Viejo on the Arroyo Loro River, located right upstream of the Guanito San Juan Headworks, river runoff increased and got stabilized after completion of Sabaneta dam and Jose Joaquin Puello Irrigation System, which indicates that "return flow" from the Jose Joaquin Puello System accounts for a large part of the runoff of the Arroyo Loro River.
- The Los Baos River (Vallejuelo) has small runoff compared with its catchment area (335 km^2), which indicates low possibility of surface water utilization for the river system

(f) Flood

It is reported that frequent floods had occurred before the construction of the Sabana Yegua dam and Sabaneta dam, and few serious floods occurred afterwards. According to the river discharge data available[4], the maximum discharge at El Puente, which is situated downstream of the Sabana Yegua dam is 543.2 m^3/sec (June 1972) before construction, while 342.1 m^3/sec (Hurricane "David", September 1979) just after completion of the construction. After "David", the maximum discharge at El Puente is 158.0 m^3/sec in May 1981. Fig.3.2.6 shows average monthly discharges before and after construction of the dam, which explains regulating effect of the dam clearly.

At Guazmal, which is situated downstream of the Sabaneta dam, the floods have been controlled to a large extent. The biggest discharge confirmed between 1981 (the dam construction) and 1992 is 182.8 m^3/sec in May 1984, while in September 1990, flood discharge of 637.9 m^3/sec at Paso de Lima (upstream of the dam) was recorded which was well regulated by the dam down to 37.1 m^3/sec at Guazmal. Fig.3.2.6 shows the difference of average monthly discharges between before and after construction of the dam. Due to extraction of water at the Sabaneta Headworks to Jose Joaquin Puello Irrigation System, the discharge at Guazmal has decreased through a year.

At Palo Alto, which is situated close to the confluence, the floods are mitigated by the reservoirs as shown in the Fig.3.2.6. No automatic water level recorder has been equipped at Palo Alto station, and the real peak discharge in the past is not known. However, the maximum discharges converted from the observed river gauge readings are 126.4 m^3/sec in October 1976 (before construction of the dams), and 110.8 m^3/sec in September 1979 (Hurricane David).

One very important issue on the flood in the Study area ***is the design flood***

[4] : Discharge data by INDRHI (1957-1993).

discharge of Sabana Yegua dam. The design flood inflow of the dam was estimated at 7,800 m^3/sec of which return period is 1,000 years. It is not appropriate to discuss here if the return period for the design was sufficient or not, however, the more important is the fact that the peak discharge of Hurricane David, which hit the country in August 1979, just after completion of the dam, was nearly the designed discharge (Fig. 3.2.7). In the study report of "Rehabilitacion Presa Sabana Yegua" (1993, INDRHI), the probable maximum flood (PMF) is estimated at 14,000 m^3/sec. On the basis of the "re-designed" flood discharge, the dam operation has been conducted (details are given in Sub-section 3.9.4).

Fig. 3.2.8 shows the design flood discharges of dams in the country. The PMF discharge of Sabana Yegua dam is considered to conform to the line of PMF's of the other dams. Taking into consideration the size of the dam and the influence to the downstream, it is quite reasonable to adopt the PMF as the design flood. It is recommended to realize the rehabilitation or improvement of Sabana Yegua dam soon.

(g) Sedimentation

INDRHI carried out topographic survey of the reservoir areas of Sabaneta and Sabana Yegua in 1992 and 1993[5] in order to clarify the actual sediment volume in the reservoirs.

According to the results, total sediment volume in Sabaneta reservoir amounted to 10.9 MCM, which accounts for 16 % of the designed effective capacity (67.5 MCM). Annual sedimentation rate was 0.911 MCM/year which is equivalent to a specific sediment discharge of 2.0 mm/year/km^2.

Sediment volume at Sabana Yegua reservoir was 57.6 MCM for 13 years which accounts for 11.5 % of designed effective capacity (500 MCM). Annual sedimentation rate was 4.4 MCM/year which is equivalent to a specific sediment discharge of 2.6 mm/year/km^2. Out of 57.6 MCM of sediment, 14.8 MCM was deposited below EL.373.0 m, i.e., the minimum operation level.

Taking into account a range of normal sedimentation rate at 1.0 to 2.0 mm/year/km^2, the sedimentation rates for the two dams are considered very high, which would shorten the life time of the reservoirs seriously.

Few data or records are available on sediment load of river water in the Study area. However it was confirmed in the field that the San Juan River at Sabana Alta has a high sediment load. It is considered that the drained waters from Jose Joaquin Puello, San Juan and other irrigation systems contain a lot of suspended sediment even during low-flow periods. A similar phenomenon was confirmed at down reach of Santana Irrigation System, Arroyo Drain at Guaraguao.

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[5]: "Batimetria Embalse de Sabaneta, Febrero de 1992", INDRHI. "Batimetria Embalse de Sabana Yegua, Enero de 1993", INDRHI.

It is recommended; i) to facilitate sediment traps at the major intakes not only for headworks but also for pumping stations, ii) to monitor sediment load (suspended load) at least major check points along the Yaque del Sur River (Sabana Alta, Conuquito, etc.) periodically, and iii) to check the sediment for new or proposed irrigation systems which would utilize drained water.

(2) Groundwater

The Study area are divided into four hydro-geological zones which were re-organized and defined by the "Plan Nacional de Investigacion Aprovechamiento y Control de Aguas Subterraneas (PLANIACAS)", 1983. They are i) San Juan Valley (No.8, Valle de San Juan), ii) Neyba Mountain Range (No.9, Sierra de Neyba), iii) Neyba Valley (No.10, Valle de Neyba), and iv) Azua Valley (No. 13, Valle de Azua).

(a) San Juan Valley (Valle de San Juan)

The Valley of San Juan is not known a lot from the geological and hydro-geological point of view. In the framework of the geological plan made by the PLANIACAS Project, a part of the Sierra de Neyba was charted, on the southern bank of the valley.

The Valley of San Juan serves as a "transit station" for waters of the surface and underground current which come from north and south, in other words from the Cordillera Central (Central Mountain Range) and the Sierra de Neyba (Neyba Mountain Range). Through the center of the Valley runs the dividing line of the waters between the basin which drains off toward the east, to the Yaque del Sur River, and the system of the Yabonico River which flows towards the west, to run into the Artibonito River. The Study area belongs to the eastern part of the San Juan Valley.

The Valley of San Juan does not have such clear morphotectonic boundaries as the Valley of Neyba. The valley is predominantly covered by clayey soil layers, which hampers usage of groundwater in the area. There are a number of wells in the edges of the valley, both at the foot of the Cordillera Central in the north and the east, and in the Sierra de Neyba in the south. In their majority, they are of shallow depth and small diameter, and serve for domestic demand.

According to an inventory of wells prepared for "Estudio Hidrogeologico Nacional en la Republica Dominicana" (INDRHI, 1997 - 1999), 160 wells have been identified as "representative wells" in the Study area.

(b) Neyba Mountain Range (Sierra de Neyba)

This region is divided into three or four sub-regions. The dividing line of the underground flow is supposed to be identical to that of surface water.

The northern part of the Sierra is divided into two sub-regions, i) north-western part, of which recharge rate is comparatively high in the region, ii) ***north-eastern part,***

which contributes to the usage of groundwater in the Study area along the mountain foot on the right bank of the San Juan River and the Yaque del Sur River. *South-eastern part* of the Sierra contributes to the groundwater along the Neyba - Galvan line, where a number of wells and springs are presently developed. South-western part of the Sierra contributes to maintaining of the water level of Enriquillo Lake.

The anticlinorium of the Sierra de Neyba is made up mainly of calcareous formations. The precipitations are filtered into them quickly, so that surface runoff is produced only on the occasion of heavy storms and for short duration. On the meridional sides of the Sierra which look toward the Valley of Neyba, few permanent currents exist. Karst is the dominant morphological phenomenon, so that soil development has been relatively limited, and with the exception of higher terrains, the countryside gives an impression of relative aridity, despite an annual average rainfall of some 1700 mm.

The springs which are born on the flanks of the Sierra represent the outcroppings of the systems of underground flow, which is controlled by the morphotectonic position of the Sierra between two valleys.

According to the inventory of wells prepared for "Estudio Hidrogeologico Nacional en la Republica Dominicana" (INDRHI, 1997 - 1999), 14 wells have been identified as "representative wells" in the Study area.

(c) Neyba Valley (Valle de Neyba)

The Neyba Valley is covered mostly by soils, fine-grained alluvial sediments, and lacustrine sediments, none of which are very permeable. The groundwater of the Valley comes, then, mainly from the adjacent mountains and from the Yaque del Sur River, and do not originate from direct infiltration in lands of the Valley. Lake Enriquillo, whose waters are some 40 meters below sea level, is the local drainage base. Most of the groundwater and storm run-off flow into this base.

According to the general geological situation, it is not supposed that there lies regional aquifers in the valley, and the data which are available so far support this hypothesis.

In the hydro-geological analysis, the Neyba Valley has been considered together with a part of the adjacent sierras, due to the close relationship existing between them.

According to the inventory of wells prepared for "Estudio Hidrogeologico Nacional en la Republica Dominicana" (INDRHI, 1997 - 1999), 115 wells have been identified as "representative wells" in the Study area.

It is reported that 38 tubewells are owned by INDRHI in Neyba - Galvan area, of which average discharge is between 20 and 30 liters per second. However, due to unstable electric supply, the groundwater from those wells is not utilized in a full efficiency. The depth of the tubewells ranges from 40 to 80 meters.

(d) Azua Valley (Valle de Azua)

A large part of groundwater recharge is contributed by the waters from the Yaque del Sur River, which are conveyed through the YSURA Conveyance Canal to the Azua Valley. The main problems in groundwater utilization here are the effects of the uncontrolled appearance of wells which causes damages in the excellent workable soils of the artesian zone and its neighboring areas. Intensive pumping from wells located to the north and northwest of the flooded area can alleviate the situation, and provide significant quantities of water for irrigation.

However, a strict control should be maintained over the groundwater table and salinity, in order to avoid an advance of the interface. They should avoid exploitation of southern wells from this zone except for short periods of time, but the case necessary for technical purposes such as maintenance of other wells, etc..

It is reported that the groundwater use in late 1960's was about 40 MCM per year, while the rate decreased to 30 to 35 MCM after introducing of gravity irrigation from the Sabana Yegua reservoir. On the other hand, excessive and/or ineffective usage of the surface water have been pointed out, which are caused mainly due to difficulties in water applications as follows:

- Water users' associations have been organized for the YSURA Canal System (Lateral 1 to 6), but their activities are not mature enough for satisfactory water management
- The irrigation water is supplied for 24 hours a day, which makes it difficult for farmers to distribute the water properly.
- Stable water supply both in terms of volume and schedule has not been convinced by water users

According to the inventory of wells prepared for "Estudio Hidrogeologico Nacional en la Republica Dominicana" (INDRHI, 1997 - 1999), 121 wells have been identified as "representative wells" in the Study area.

(3) Water Quality

Quality of the surface water and groundwater was evaluated for both the irrigation and domestic use. Assessment of water quality was conducted on the basis of the following data and information;

- Laboratory analysis
- Field checking by the Study Team
- Review of previous reports and evaluation

(a) Standard on Water Quality

In the Dominican Republic, the ***USDA classifications*** of irrigation water salinity and sodicity are used for irrigation water evaluation. The classifications are given according to ranges of "sodium absorption ratio (SAR) and electric conductivity (EC) or equivalent salt concentration (TDS or Cl). The classifications are given in Table

3.2.10.

Normas Dominicanas No. 436 (*NORDOM 436*) gives criteria on drinking water. Five groups are given for waters by required treatments as follows:

Group I : Waters which requires only disinfecting
Group II : Waters which requires conventional treatment such as; coagulation, sedimentation, fast filtration and disinfecting (post chlorination), or disinfecting (post chlorination) and slow filtration.
Group III : Waters which requires conventional treatment such as; coagulation, sedimentation and fast filtration and disinfection (pre and post chlorination).
Group IV : Water which does not accomplish with the bacteriological requirements for the above mentioned groups. Not recommended for water supply.
Group V : Water which does not accomplish with one or more physical, chemical and radiological requirements or contents of indicated organic contaminants. Not recommended for water supply.

Only the waters that are classified into the Group I, II and III can be used for drinking water after required conventional treatments. All the natural water for drinking must be treated at least by chlorination.

(b) Review of Previous Reports and Information

According to "Neyba Valley Saline Soil Reclamation Study" (JICA) in 1987, qualities of surface and groundwater were investigated and evaluated. INDRHI has also conducted water quality test at several locations in the Study area. The results are summarized below:

No.	Location	EC (mmho/cm)	pH	Remarks
1	Santana headworks	0.57 - 0.80	7.8 - 7.9	JICA
2	Guara Guao Drain (upstream)	1.10 - 1.20	7.6 - 7.8	JICA
3	Guara Guao Drain (downstream)	1.30 - 1.60	7.3 - 7.6	JICA
4	Rio Las Marias	2.70 - 5.00	7.8	JICA
5	Cano Ramillo	3.00 - 3.80	7.8	JICA
6	Rincon Lake	7.0	7.9 - 8.2	JICA
7	Groundwater (well) in Galvan Neyba	0.60	7.1	JICA
8	Spring water, Neyba- Galvan	0.59	7.5	JICA
9	Groundwater in Neyba Plain	1.80	7.7	JICA
10	El Rosario, San Juan River	0.66	7.4	June 1993, INDRHI
11	Los Guiros, Yaque del Sur River	0.95	8.0	March 1989, INDRHI
12	Palo Alto, Yaque del Sur River	1.10	8.1	March 1989, INDRHI

Source : Final report of "Saline Soil Improvement Project" (1988), JICA
"Programa de Calidad de Aguas", INDRHI

Few constraints or problems have been confirmed in the upper reach of the Yaque del Sur basin in San Juan and Azua Irrigation Districts so far.

(c) Laboratory Analysis

Considering the results of previous assessment of the water quality in the Study area, items of laboratory test were determined by location. Consequently, 22 items were selected for the laboratory test as follows:

- Temperature,
- pH,
- Electric Conductivity (EC),
- Dissolved Oxygen (DO),
- Chemical Oxygen Demand (COD),
- Biological Oxygen Demand (BOD),
- Number of Colon Bacillus,
- Ammonium Nitrogen (NH4-N),
- Nitrate Nitrogen (NO3-N),
- Calcium Ion (Ca++),
- Total Phosphate,
- Magnesium Ion (Mg++),
- Manganese Ion (Mn++),
- Ferrous Ion (Fe++),
- Fluoride Ion (F-),
- Sodium (Na+),
- Bicarbonate (HCO3-),
- Sulfate (SO4-),
- Suspended Solids (SS),
- Carbonate (CO3-),
- Potassium (K+), and
- Chloride

Sampling locations and the purpose of water use are given below:

No.	Location	Irrigation District	Standard/Items
Q1	Sabaneta Reservoir	San Juan ID	Irrigation, Domestic, Potable
Q2	San Juan River at San Juan City	San Juan ID	Irrigation, Domestic, Potable
Q3	Guanito-San Juan Headworks	San Juan ID	Irrigation
Q4	Mijo Headworks, Mijo river	San Juan ID	Irrigation, Domestic, Potable
Q5	Sabana Yaque Reservoir	Azua ID	Irrigation, Domestic, Potable
Q6	Head of Tabara Canal, Azua ID	Azua ID	Irrigation, Domestic, Potable
Q7	Lateral 7 (Jura river), Azua ID	Azua ID	Irrigation
Q8	Groundwater (existing well), Pueblo Viejo, Azua ID	Azua ID	Irrigation, Domestic, Potable
Q9	Groundwater (existing well), extension area, Azua ID	Azua ID	Irrigation, Domestic, Potable
Q10	Santana HW, Yaque del Sur	Lago Enriquillo ID	Irrigation, Domestic, Potable
Q11	Intake to Rincon Lake, Yaque del Sur river	Yaque del Sur ID	Irrigation
Q12	Rincon Lake	Lago Enriquillo ID	Irrigation, Domestic, Potable
Q13	Cachon (pump station of INDRHI), Yaque del Sur	Yaque del Sur ID	Irrigation
Q14	End point of Santana Main Drain	Lago Enriquillo ID	Irrigation
Q15	Groundwater, at Galvan (Pump of INDRHI)	Lago Enriquillo ID	Irrigation, Domestic, Potable
Q16	Enriquillo Lake	Lago Enriquillo ID	Irrigation

Remarks: ID; Irrigation District

The study team conducted the water sampling for the laboratory test on irrigation water on January 27, 1998 at 16 locations listed above, while samples for the test for potable water were taken on February 4, 1998. Details of the testing items and number of samples by location are given in Table 3.2.11. Sampling sites and the results of laboratory analysis are illustrated on Fig. 3.2.9 and in Table 3.2.12.

(d) Supplemental Field Tests on Salinity

Since major problems on the water quality for irrigation is considered "salinity", the study team also made supplemental field checking of water source on pH and the electric conductivity. The locations of the field checking are given in Fig. 3.2.9 together with the sampling locations for the laboratory analysis.

According to the results of the field test and the previous reports, which show similar salinity conditions at the same locations, it is considered that water in Rincon Lake and drains at the down most reach of the Neyba, is not to be used for irrigation purpose.

Rincon Lake plays three major roles as; i) irrigation water source for Neyba area, ii) flood retarding reservoir in the down most reach of the Yaque del Sur River, and iii) preservation of natural environmental valuables. Taking into consideration the high salinity level and low risks of floods after construction of the two dams, it is recommended to focus on maintaining of the environmental conditions on the utilization of Rincon Lake.

The results of the field tests are given in Table 3.2.13.

(e) Evaluation of Water

Based on the criteria of USDA classification for irrigation water use and criteria of Dominica on drinking water, the results of water quality laboratory tests are assessed as shown in Table 3.2.14. The table indicates that most of waters are usable for irrigation and drinking water use.

3.3 Agriculture and Livestock Production

3.3.1 Present Land Use

The Study area comprises approximately a total land area of about 711,000 ha. According to the land use map at scale of 1:25,000 prepared by the Inventory division of SEA, the present use of the land in the Study area is classified as indicated in the table below (Ref. to Fig. 3.3.1). About 38 % of the total land area is devoted to agriculture production, out of which 10 % is irrigated agriculture and 28.1 % is rainfed, and about 55.4 % of the Study area is covered by dry forest and bush land.

There is an area of about 13,100 ha devoted to the production of sugar cane under irrigation condition in the lower reaches of Yaque del Sur river basin. This sugar cane plantation belong to the Dominican Government, under the administration of the Barahona Sugar Mill. A law was created for the transfer of management of the land planted to sugar cane, and the sugar mill to the private sector. The future land use of this 13,100 ha planted to sugar cane will be decided by the investors to whom the government decide to make the transfers.

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[6] : Measured by the study team on the map of 1 in 50,000.

[7]: Average of 1988 to 1994. (Source "Comportamiento del Embalse de la Presa de Sabaneta durante los Años 1985-1995", Department of Irrigation District, INDRHI).

[8] Average of 1990 to 1995. (Source "Comportamiento del Embalse de la Presa de Sabana Yegua durante los Años 1985-1995", Department of Irrigation District, INDRHI).

[9] : Discharge data by INDRHI (1957-1993).

[10] : "Batimetria Embalse de Sabaneta, Febrero de 1992", INDRHI. "Batimetria Embalse de Sabana Yegua, Enero de 1993", INDRHI.

Land Use	Area (ha)	Proportional %
Agricultural land	271,000	38.1
(1) Irrigated land	71,000	10.0
(2) Rainfed land(excluding shifting culture)	46,000	6.5
(3) Shifting culture and natural pasture land	154,000	21.6
Forest and bush land	394,000	55.4
(1) Dry land forest	175,000	24.6
(2) Humidland forest	84,000	11.8
(3) Bush and shrub	135,000	19.0
Wet land	3,000	0.4
Barren land	37,000	5.2
Water bodies	4,000	0.6
Urban/village area/others	2,000	0.3
Total	711,000	100.0

Source: land use and cover map, SEA, based on 1992 landsat

3.3.2 Cropping Pattern and Farming Practice

(1) Main Crops and Cropping Patterns

In the Study area, many kinds of crops are cultivated. Since the Study area is so huge, agricultural climatic condition, irrigation condition and presence of agroprocessing factories in the Study area vary largely depending on location. The main crops in the Study area are summarized below:

Irrigation District Area	Main crops under irrigated condition	Main crops under rainfed
Azua irrigation district	plantain, banana, rice, tomato, cassava, corn, sorghum	red bean, pigeon pea, coffee
San Juan irrigation district	red bean, rice, sweet potato, corn	red bean, corn, pigeon pea, coffee
Yaque del Sur irrigation district	plantain, banana, sugar cane, cassava	
Lago-Enriquillo irrigation district	plantain, banana, sugar cane	pigeon pea, coffee

The crops cultivated in the area of above 500 ha /year are listed as main crops.

The crops occupying more extensive planted areas are irrigated in the Study area. In Azua irrigation district area, plantain, industrial tomato and banana are predominant under irrigation. In San Juan irrigation district area, red bean, rice and sweet potato are major crops. In Yaque del Sur - Lago-Enriquillo irrigation district areas, the crops occupying the larger planted area are sugar cane, plantain and banana.

Agriculture productions under rainfed condition occupy a relatively important land area, but the volume of production is small due to low yield obtained under rainfed condition in the Study area. The land area devoted to agriculture under rainfed condition is located in hilly and mountainous areas. In Azua and Lago-Enriquillo irrigation district areas, coffee and pigeon pea are predominant. In San Juan irrigation district area, crops such as bean, pigeon pea and coffee are predominant. There is negligible rainfed agriculture production

in the land areas of Lago-Enriquillo irrigation district area within the Study area.

Cropping patterns in the Study are illustrated in Fig. 3.3.2 and explained below:

(a) Cropping Pattern in Azua Irrigation District Area

A large percentage of the irrigated area in Azua is planted to plantain and banana, and these crops are grown all year around. Almost all the production of industrial tomato in Azua irrigation District is made under contract agreement between the several tomato paste companies installed in the area and the farmers. The tomato paste companies provide part or the total inputs required for production of tomato, including land preparation, fertilizers, and pest control. The tomato paste companies have their own agronomist for providing extension service to tomato farmers'. The farmers are must sell the production to the company that they made contract. Tomato is produced for tomato paste production, which is grown normally from the end of October up to the middle of March. Because the large incidence of the insect named "White fly" (Bemisia tabaci) which transmits a virus disease deadly for tomato plant, SEA has defined a fixed period during the year when tomato can be grown in Azua and other nearby area. The resolution of SEA establish that tomato can not be planted in Azua from June 1 up to September 30. In the irrigated land, other crops such as rice and corn are planted at the beginning of November and harvested from March to May.

Most of red beans and pigeon peas are cultivated under rainfed condition and they are planted on the beginning of the rainy season, generally August, and harvested at the middle of December for red beans and March for pigeon peas.

Most of crops both under irrigated and rainfed conditions are cropped once a year and cropping intensity in the main irrigation systems is shown in Table 3.3.1.

(b) Cropping Pattern in San Juan Irrigation District Area

In irrigated condition, red beans start planting at the end of October and harvested at the beginning of February due to a mild climate condition. Rice is cultivated in both seasons, (I) period from the beginning of May to the middle of September and (ii) period from the beginning of November to the middle of March. Most of sweet potato and sorghum are planted from the beginning of May to harvested from the beginning of September.

In the rainfed condition, red beans, corn and pigeon peas start being planted on the onset of the rainy season.

Most of crops both under irrigated and rainfed conditions are cropped once a year and cropping intensity in the main irrigation systems is shown in Table 3.3.1.

(c) Cropping Pattern in Lago Enriquillo and Yaque del Sur Irrigation District Areas

Plantain, banana and sugar cane are permanent crops, being planted continuously

during the year under irrigated condition. Cassava are also irrigated and planted at the beginning of May and harvested.

Pigeon pea is cultivated under rainfed condition, being planted from the beginning of April and harvested from the beginning of January.

Most of crops both under irrigated and rainfed conditions are cropped once a year and cropping intensity in the main irrigation systems is shown in Table 3.3.1.

(2) Farming Practices

Farming practices for crops in the Study area are investigated and identified based on the results of interviews to individual farmers, extension workers of SEA, local staff of Irrigation District Offices, officers of the agricultural processing factories, etc. Present farming practices of the main crops in the Study area are summarized in Table 3.3.2 which indicates methods of land preparation, planting, fertilization, irrigation, pest control, weed control and harvesting, and varieties of crops. Present farming practices of main crops in the irrigation district area are given below:

(a) Farming Practices in Azua Irrigation District Area

In Azua almost all the land preparation for planting tomato, and for other crops, is done using mechanical traction, while animal traction is used in small irrigation systems located along river banks or isolated areas. The number of tractors available for land preparation in Azua zone is not sufficient to satisfy peak demand during land preparation for planting tomato. There are some 60 tractors, including small and big size tractors, to cover all the land preparation activities in Azua area. Most of the tractors belong to private owners, including the 3 tomato paste factories located in Azua.

(i) Farming Practices for Tomato Production

Due to the high risk of contamination of tomato plantation with the deadly virus disease transmitted by the White fly (Bemisia tabaci), SEA has defined some farming practices that should be applied by tomato farmers, including the limitation of planting period of tomato from October to December, and some norms for the management of the crop from seedling up to harvest. Among the requirement for tomato plantation indicated by the Ministry of Agriculture are: 1) to grow seedling free from virus infection, 2) there should no be a long difference of time in planting contiguous land areas, 3) to make efficient chemical control of White fly (Bemisia tabaci), 4) monitoring of the population of White fly, etc.

Tomato is mostly planted by transplanting method. Tomato seedlings are grown largely in open field seedbed and in less extend in seedling trays kept in shaded areas. Irrigation is applied at intervals between 8 to 10 days. The large majority of farmers have not receive training on the proper application of

irrigation water. Application of irrigation water is very poorly managed by most farmers in Azua area, causing frequent excess or deficit of water available in the root zone of the crop. Poor management of on-farm irrigation is one of the main causes of soil degradation such as waterloging, salinization, and soil erosion with the loss of natural and applied plant nutrients, and therefore causing low yield of tomato and other crops. Fertilizers are applied twice during the growing period of tomato; the first amount of fertilizers is applied shortly after transplanting, and the second application is made at the beginning of flowering stage. Very few farmers make soil analysis to determining the amount of fertilizers required by the crop. The average amount of fertilizer applied very in the range of 10 to 15 kg/ha of nitrogen, and 5 to 10 kg/ha of phosphorous and potassium nutrients. Weed control is done manually using hoe. Harvesting of tomato in done manually.

(ii) Farming Practices for Plantain and Banana Production

The farming practices normally implemented for the production of plantain and banana which are the other major crops of Azua zone, consist first in preparation of land by harrowing and plowing; then planting is done after opening the holes by hand at planting distance of 2.5 m by 3 m, resulting in an average density of about 1,300 plants per ha. Fertilization is done by most farmers three to four times per year, but almost all farmers apply fertilizers without proper knowledge of the quantity and kind of fertilizers need for their land. Irrigation interval is between 15 to 20 days. Same as for tomato farmers, on-farm management of water is very deficient, causing frequent waterloging in the plantain and banana fields. Weed control is done manually. Majority of farmers in Azua do not make any kind of control against pest and disease in plantain and banana.

The main problems identified by farmers in Azua irrigation area are the difficulties in attaining agricultural credit, frequent scarcity of irrigation water, scarcity of farming machinery's, lack of technical assistance and/or training for the proper management of crop, small margin of benefit left to them due to the intervention of middlemen in the marketing of produce.

(b) Farming Practices in San Juan Irrigation District Area

In the area of San Juan irrigation zone red bean and rice are the major crops under irrigation condition. About 70 % of the total number of irrigated farms in San Juan zone have less than 5 ha, some 15 % of the farms have land area between 5 to 6 ha, and the remaining 15 % of farms are larger than 6 ha. (PRODAS' Survey, 1997).

(i) Farming Practice for Red Bean Production

In the process of land preparation for planting red bean, about 80 % of small farmers (farm smaller than 4 ha) and middle farmers (farm between 4 to 9 ha) use tractors for plowing the land, and the remaining 20 % of small and

medium farmers make land plowing using animal traction. About 60 % of small and medium farmers make the land harrowing using animal traction. Some 98 % of large farmers (farms larger than 9 ha) use tractor for land preparation activities.

Because the problem of large incidence of the insect known as White fly (Bemisia tabaci), which transmit a deadly virus for the bean plantation, the Ministry of Agriculture has a regulation defining the period of the year (November to December) when bean can be planted in San Juan, and other areas of the country. About 90 % of farmers plant the variety of bean named PC-50. Some 50 % of all bean farmers acquire the seeds from SEA, while the rest keep planting material from the previous harvest or buy in the local market. Only 37 % of small bean farmers make the seed germination test before planting bean, while some 55 % of medium and large farmers usually make the seed germination test. Almost all farmers in the irrigated areas of San Juan plant bean using animal traction, only some 6 % of large farmers use mechanical traction for planting bean.

Irrigation of bean plantation is made using the border strip flooding method. The border strips are prepared by most farmers using animal traction. There are large differences in the length of border strips prepared by farmers of San Juan area, which mostly depends on the slope of the farm. The length of border strips is between 20 to 30 m for the larger percentage, other relative large % of farmer use border with length between 10 to 20 m, other large group make border of length varying between 30 to 40 m. The frequency of irrigation by most bean planters vary between 8 to 15 days interval.

All farmer apply fertilizers to their bean plantation. About half of the farmers make two applications of fertilizers to the bean and the other half make only one application of fertilizers. The kind and quantity of fertilizer applied vary widely among farmers. A large percentage of farmers use compound fertilizers such as 15-15-15 or 16-20-0 for the first application and Urea or Ammonium Sulfate for the second application. The quantity of fertilizers applied varies between 20 to 40 kg/ha of each plant nutrients N-P-K respectively. Larger farm size farmers normally apply greater quantity of fertilizers in comparison with small size farmers.

The main insects and disease affecting the production of bean in San Juan area are (1) the insect named White fly (Bemisia tabaci) which transmit a virus disease known as "Golden Mosaic", (2) the "Roya" disease which is caused by a fungus known as Uromyces appendicualatus, (3) Antracnosis which is caused by a fungus known as Colletotrichum lindemuthianum, (4) Insect of Empoasca species, and Lepidopterus species, etc. The Majority of bean producing farmers make 3 to 4 application of insecticides and/or fungicides for the control of insects and diseases. The first application of pesticides is normally done 10 to 15 days after plant germination. Few farmers know about the economic threshold

criteria for control of pest and diseases. Majority of farmers are not aware of the best kind of pesticide and the appropriate dosage that should be applied for controlling insects an disease on bean crop. About 19 different kind of insecticides are used for insect control, and the dosage of one pesticide varies in an ample range among farmers form 200 ml/ha up to 1000 ml/ha.

The main kind of weed affecting bean cultivation are Rottboellia species, Amaranthus species, Eleusine species, Parthenium species, Cyperus species, Euphorbia species, and Sorghum species. All farmers that have small farm plot make the control of weeds manually using hoes; some 87 % of farmers of middle size farms make the control of weeds manually, and the 13 % of middle size farmers use a combination of herbicides and manually, while about 75 % of large size farmers make the control of weed manually and the remaining 25 % of large farmers use a combination of herbicides and manually for controlling weeds. Approximately 25 % of middle and large farmers use a combination of hoes and weeding machines pulled by horse for mechanical control of weeds. The number of times that farmers make weed control vary between 1 to 3 weeding per cropping season.

Beans are harvested manually by all farmers. The separation of the bean grain from the pods is made by either waking horses on top of a pile of beans, by passing tractors on top of a pile of beans, or using a machine designed locally specially for this purpose. Cleaning of bean grains is made manually by the majority of farmers by taking advantage of naturally blowing winds for separating grains from leaves and dirt. Few farmer use flowing machine for cleaning of bean grains.

The main problems identified by bean producers are similar between small, middle size, and large farmers. Among the main problems commonly cited by bean farmers are (1) large incidence of insects and diseases; (2) scarcity of irrigation water; (3) inadequate preparation and management of land (lack of land leveling, drainage problem, erosion, salinization); (4) agricultural credits are not readily available, little amount, not available at the needed time, and at very high interest rate; (5) poor quality of seeds; (6) insufficient technical assistance; and (7) small margin of benefit in commercialization of bean due to the intervention of middlemen.

(ii) Farming Practice for Rice Production

Farming practices for rice production in San Juan vary depending on the size of farm of individual farmers. A large percentage of small farmers use animal traction for the various land preparation activities, while the majority of large rice farmers use tractors for land preparation.

About 90 % of rice farmer use the direct seedling method, while only 10 % use the transplanting method. The rice varieties used by farmers in San Juan are relatively old fashioned or traditional local varieties, such as Isa-40, Juma 58, IR-

6, Isa-21, Tanioka, Toño Brea, Mingolo, etc. Rice farmers says that they choose variety based on characteristics such as of short growing period, resistant to drought, high yield, etc. Approximately half of the rice farmers use seed materials that they keep from previous harvest, about 25 % of rice farmers use seed provided by rice millers, and only a small percentage get seeds from the Ministry of Agriculture. About the quality of rice seed the majority of farmers consider that they use good quality seeds, while less than 20 % of rice farmers consider that the seeds they use are of regular or poor quality. All farmers make the pre-germination of rice seeds previous to plant. The quantity of seed used for planting 1 ha of land varies largely among rice farmers of San Juan. Some farmers use 120 to 150 kg/ha of seeds.

All rice farmers in San Juan area apply fertilizers to the crop. Majority of farmers divide the total amount of fertilizers in 3 applications. Rice farmers usually apply different amounts of compound fertilizer such as the formula (N-P-K) 15-15-15, 12-24-12, and 16-20-0, and also apply either ammonium sulfate or Urea. Majority of rice farmers drain their field before apply the fertilizers. The average amount of fertilizer applied by rice farmers in San Juan is about 500 kg/ha of the compound 15-15-15 plus 200 kg/ha of Urea.

All farmers recognize that the incidence of insects and diseases are important problems affecting rice production in San Juan area. About 80 % of rice farmer in San Juan apply different kinds of insecticides and fungicides for controlling insects and diseases, but the remaining 20 % of rice farmers do not use chemicals for pest control. The majority of farmers that make chemical control of insects and plant diseases make 3 or 4 applications during the rice cropping season.

The control of weeds is made by about half of the farmers using only herbicides and the other half use a combination of herbicides and manual weeding. Rice farmers usually make weed control twice during the cropping season.

Harvesting of rice is done manually by about 40 % of rice farmers in San Juan, about 40 % of rice farmers harvest by using a combination of manually and using combines machinery, while the remaining 20 % harvest rice using only combine harvesters.

The main problems identified by rice farmers in San Juan are 1) insufficient availability of irrigation water; 2) difficulties for land preparation; 3) use of low yielding varieties and poor quality seeds; 4) lack of agricultural credit; 5) lack of technical assistance, more than 60 % of rice farmers said that they do not receive any kind of technical assistance; 6) monocropping of rice; 7) poor drainage and salinity problems; 8) high incidence of insects and diseases.

(c) Farming Practices in Lago-Enriquillo and Yaque del Sur Irrigation District Areas

The crops largely planted in Lago-Enriquillo and Yaque del Sur Irrigation District Areas are plantain, sugar cane, and bananas. Farming practices for plantain and banana in Lago-Enriquillo and Yaque del Sur Irrigation District Areas area are similar as those described for Azua area.

(i) Farming Practice for Sugar Cane Production

The land area actually planted to sugar cane in the Barahona sugar corporation is decreasing steadily due to the poor farming practices for sugar cane production implemented. The cane varieties still used are very old, not innovation of varieties have been introduced since long ago. The main cane varieties are named PR-980, UCW-5465, PR-1028, RD-7511, B-7678, etc.; The characteristics of these varieties have been declining and some of them have become very susceptible to diseases such as the "Carbon" fungus disease. Although the varieties have different requirements, they are all managed with same farming practices, such as same level of fertilizers, planted indistinctly without considering soils conditions, etc.

All the sugar cane grown in this area is irrigated. Frequent shortage of irrigation water and poor drainage condition of a significant percentage of the area planted to cane are among the main problem affecting the production of sugar cane. The plan for irrigation of sugar cane land is to apply 10 to 12 irritations during the growing period of cane, this irrigation program can not be met frequently, and/or the quantity of water applied is not sufficient. Irrigation water is suspended between 30 to 90 days before harvesting the cane.

Weed control are not properly done. The recommended level of plant nutrients are N: 100 to 125 kg/ha, P2O5: 45 kg/ha, K2O is not required to be applied. But the actually level of nutrients applied is about half of the recommended level.

Many insects and fungus disease affects the production of sugar cane in Yaque del Sur - Lago Enriquillo area. The main insects includes Distraea saccharalis, Sigga flava, Diaprepes abbreviatus, and Phyllophaga species. The main plant diseases affecting sugar cane in Yaque del Sur - Lago Enriquillo areas are the "Roya" caused by Puccinia melanocephala, "Carbon" caused by Ustilago scitaminea, the "pineapple" disease caused by Ceratocystis paradoxa, etc.

It is recommended that replanting of sugar cane should be done about every 5 to 6 years due to significant decrease in yield as sugar plantation get old. Because financial constraints, very small areas of sugar cane are replanted every year. Replanting of cane are practiced for an interval of 10 to 15 years. Some times, sugar cane are harvested after 2 or 3 years. Harvesting of sugar cane is done manually normally during the period from January to June.

(d) Farming Practices in the Mountain Areas of Azua, San Juan and Lago-Enriquillo Irrigation District Areas.

In the hilly and mountainous areas of Azua and San Juan areas, the crops largely planted under rainfall condition are coffee, pigeon pea, and red bean. Farming practice in most the coffee plantations are very primitive, most coffee plantations are very old without rehabilitation. The commonly used coffee variety is "Typica" which is old variety and low yielding. Majority of small farmer that plant coffee can not apply necessary amounts of fertilizers. Average yield of coffee grain in the Study area is only 0.25 ton/ha, but few farmers that can invest in the rehabilitation and fertilization of their coffee plantation are obtaining yield as high as 2 ton/ha of coffee grain.

Production of bean, pigeon pea, and others crops in the mountain areas is at the subsistence level. All farming activities are done by family labor, the application of inputs such as fertilizers and pesticides is almost none. The average obtained yields of grain crops is very low. Primitive agricultural production in the mountain areas is one of the main causes of deforestation and soil erosion within the Study area.

3.3.3 Crop Yield and Crop Production

(1) Crop Yield

Yields of crops in the Study area both under irrigated and rainfed conditions are estimated as follows:

(unit:ton/ha)

Main Crop	Azua Irrigation District Area		San Juan Irrigation District Area		Yaque del Sur Irrigation District Area		Lago Enriquillo Irrigation District Area		National Level	
	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
Plantain	13	18	12	17		18		18	14	19
Banana	13	26	14	24	12	26	12	26	18	28
Red bean	0.3	0.9	0.4	1.1	0.25	0.9	0.25	0.9	0.5	0.9
Rice		2.5		3.0		2.2		2.2		3.2
Sugar cane						30		30	28	30
Tomato		25		23		24		24		21
Sweetpotato	7	12	8	13	7	12	7	12	9.5	14
Cassava		9	5	10	5	8	5	8	7	9
Corn		2	0.9	2.0	0.8	1.8	0.8	1.8	1	2.2
Sorghum		3.5		3.5		3.3		3.3	2.2	4
Pigeon pea	0.95	1.7	0.95	1.9	0.87	1.3	0.87	1.3	1.1	1.6
Coffee	0.25		0.25				0.25		0.3	
Cocoa	0.3		0.3				0.25		0.3	
Papaya		48		52				48		60
Pepper		15		16				14		14
Melon		35		34				35		35
Eggplant		16		17				15		15

As shown in the above table, yields of crops in the Study area are low in general. Compared with crop yields at national level, those in the Study area are low both under

irrigated and rainfed conditions.

It is considered technically that the main causes of low yield may be attributed to 1) the extensive use of very old crop varieties; 2) poor quality of seeds used by majority of farmers; 3) poor farming practices, specially inadequate land preparation, low level and/or improper management of fertilization and pest control, improper crop rotation; 4) large losses during harvest, 5) poor soil management against soil salinity and soil erosion and 5) shortage of irrigation water and/or improper irrigation water management.

(2) Crop Production

In the Study area, land potential is not fully exploited. As previously mentioned, cropping intensity is very small even in the irrigated area, averaging about 80% per year. Such low intensity is accrued from the fact that land preparation and harvesting are not able to be carried out due to shortage of the number of tractors and their attachments, and shortage of farm labor and shortage of irrigation water supply. Also access to credit for fertilizer and chemicals is so limited that farmers could not expand area to be cultivated.

Food crops such as pigeon pea and red bean under rainfed condition are cultivated by shifting cultivation of which interval ranges between 3 and 5 years. The cultivated lands for them are fully depending on the rainfall.

As a result, the harvest area of crops in the Study area largely fluctuates year by year. As present harvest area of the Study area, harvest areas of the major crops in the Study area is calculated as an average figure during the last 5 years as shown below:

(unit: ha)

Main Crop	Azua Irrigation District Area		San Juan Irrigation District		Yaque del Sur Irrigation District		Lago Enriquillo Irrigation District		Total Area in the Study Area	
	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
Plantain	30	4,050	10	215		5,600		700	40	10,560
Banana	30	790	20	160		1,420	15	20	65	2,390
Red bean	970	930	2,300	9,050		60	240	120	3,510	10,100
Rice		325		8,000		30		45		8,400
Sugar cane						1,140		7,060		8,200
Tomato		3,170				60		90		3,320
Sweet potato	230	150	60	2,090	170	20	30	40	450	2,300
Cassava		525	440	330		260		450	440	1,560
Corn		970	750	1,010		50	310	150	1,060	2,180
Sorghum		860		735		40		60		1,690
Pigeon pea	1,500	260	5,900	320		15	1,040	90	8,440	685
Coffee	6,400		1,500				4,200		12,100	
Cocoa	400		200				300		900	
Papaya		144		220						360
Pepper		80		140						220
Melon		35		75						110
Eggplant		75		160				10		245