4.7 Water Demand and Water Balance in the Yaque del Sur Basin

4.7.1 Water Demand

(1) Irrigation Water

Irrigation water demands were estimated in Sub-section 4.5.1 based on the proposed conditions, namely, enhanced irrigation efficiencies by improvement of irrigation facilities, and proposed cropping patterns. Results of the calculation are given in Table 4.x for each irrigation system and are summarized in Table 4.7.1.

(2) Municipal Water

INAPA program does not envisage a long term development plan and the designed capacity of the future municipal water supply has not been estimated in the river basin. Forecast of the municipal water demand consisting of potable water demand and industrial water demand is therefore simply estimated based on the present condition and applying the projected population in 2010. Forecasted water demand is however considered to be negligible small for the overall water balance study compared with the irrigation demand, and hence it is not accounted.

(3) River Maintenance Flow

River maintenance flows are the minimum flows that are required to maintain proper utilization of the rivers and normal functions of river flows. Specifically, the maintenance flow is needed for inland navigation, fishery, tourism, maintaining of good water quality, avoidance of salt water intrusion, avoidance of river mouth closure by sedimentation, protection of river structures, maintenance of groundwater table, etc. The maintenance flow has a significant meaning in a basic plan of river development for allocation of water right and water balance studies for the river basin.

In case no river maintenance flow is specified for a river, it will be determined by the organization that maintains the river on the basis of existing water rights and coordination between water users.

Since there exists no clear concept of "river maintenance flow" in the Dominican Republic as mentioned in Section 3.9, certain amount waters should be running as the maintenance flow to play roles as mentioned above.

Taking into account the projected population in the Project area and minimum requirements for domestic purposes (assumed at 50†liters/persons/day), the emergency requirements in discharge are more or less 0.5†m^3/sec.

In order to provide the required flow for the salt intrusion, maintenance of the wild life and species, etc, one cubic meter per second (1.0†m^3/sec) which is equivalent to *31.5†MCM/year* is to be secured on the downstream of Palo Alto.

On the upper reach of Palo Alto, *0.5†m^3/sec* is considered the minimum maintenance flow, which is presumably covered by the return flow and baseflow of the Yaque del Sur River through the year.

4.7.2 Water Balance

(1) Basic Condition of Water Balance Study

Based on the water demands estimated, water balance is examined in order to estimate irrigable area by irrigation system. The basic conditions of the water balance study are as follows:

(a) The water balance study is carried out based on the available water resources at present. New water development is not included in the study. Proposed water requirements with improved irrigation efficiency are used for estimating irrigable area.

(b) The study area is divide into three hydrological blocks; (i) San Juan block, (ii) Azua block, and (iii) Yaque del Sur - Lago Enriquillo block. San Juan block, consisting of Sabaneta dam and its commanding irrigation systems, i.e., José Joaquin Puello, San Juan and Hato del Padre, and other independent irrigation systems such as Mijo, Vallejuelo, Guanito San Juan, and other small systems in the block, is treated as "independent block" of which available water resources can be used only for the block. Azua irrigation block and Yaque del Sur / Lago Enriquillo irrigation block count on waters from Sabana Yegua dam and San Juan block. The block diagram for the water balance study is shown in Fig.†4.7.1.

(c) For the water balance under proposed conditions, the same volume of water distributed to Azua block through YSURA Head Race Canal under present conditions was allocated. The saved waters by the improved conditions were used for expanding the irrigation area in the Azua block.

(d) The water balance is examined on the "demand" basis. The water requirements for irrigation systems (intake point) are summed up, then runoff from the residual catchments between the intakes, and return flows from the irrigation areas are deducted from the total requirements.

(e) Probability or return period of sufficient irrigation is set at 80†%, which means that the proposed water requirements are guaranteed for four years out of five years.

(f) Irrigation efficiencies account losses between the intakes and farm fields. Operation or management losses upstream the intakes are not considered.

(g) The water balance study is conducted for 14 years from 1981 to 1994 consisting of 27 cropping seasons. The irrigation areas are determined based on the available waters at the dams or headworks.

(h) Water requirements for other purposes than irrigation are not accounted because of their small volume compared with those of irrigation.

(i) Three types of irrigation areas were given in the study. The first is *the present irrigation areas which are reported in the statistics*. The second is so called *irrigable areas under present conditions with 80†% probability*. The last is the *irrigable areas under future (with-project) conditions with 80†% probability*.

(2) Water Balance Analysis

Results of the water balance study are given in Table 4.7.2 to Table 4.7.7. Table

4.7.2 and 4.7.4 show distributed volume of waters under present and proposed conditions by block. Table 4.7.5 to 4.7.7 show the three types of irrigation areas which are mentioned above.

Results of analysis are explained by the hydrological block in the following.

(a) San Juan Block

(i) Sabaneta dam

Simulation of operation of Sabaneta dam was carried out. First, a simulation under present conditions (water requirements given in Sub-section 4.7.1) was examined. The total command area is 5,526†ha. The results of the simulation are summarized below:

Cropping season		Results
1	1981	sufficient
2	1981/82	sufficient
3	1982	sufficient
4	1982/83	sufficient
5	1983	sufficient
6	1983/84	sufficient
7	1984	sufficient
8	1984/85	sufficient
9	1985	insufficient
10	1985/86	sufficient
11	1986	sufficient
12	1986/87	sufficient
13	1987	sufficient
14	1987/88	sufficient
15	1988	sufficient
16	1988/89	sufficient
17	1989	sufficient
18	1989/90	sufficient
19	1990	insufficient
20	1990/91	sufficient
21	1991	sufficient
22	1991/92	insufficient
23	1992	sufficient
24	1992/93	sufficient
25	1993	sufficient
26	1993/94	sufficient
27	1994	insufficient

Four times of "insufficient" out of 27 cropping seasons are more than 80 %, which explains that *the water resource itself is sufficient for the three irrigation systems even under present conditions*. It is considered that operational losses of the systems hamper the waters to reach farm fields properly.

Then the simulation under proposed or with-project conditions was carried out covering the commanding area of 8,826†ha. On the basis of the proposed cropping patterns and water requirements, the irrigation areas were adjusted proportionally taking into account the results of dam simulations. The number of "insufficient" seasons are allowed *up to five times* in total.

(ii) Independent Irrigation Systems

Independent irrigation systems of which water balances can be evaluated individually are Mijo, Vallejuelo, Guanito San Juan irrigation systems. Intake points of other small irrigation systems are assumed to be on the San Juan river at the end of San Juan Block. The water balances for the independent systems were examined based on the available water at the intake points.

Mijo irrigation system is evaluated to have water shortage under present conditions, while other systems are evaluated to have sufficient water resources under the present conditions.

(b) Sabana Yegua Dam

Water release of the dam is determined by the total irrigation demands at Villarpando headworks and discharges of the San Juan river at Sabana Alta according to the following equation:

Qout = Wreq - Qsa, where

Qout: required discharge from the dam
Wreq: water demand at Villarpando headworks
Qsa: river discharge at Sabana Alta

The simulation of Sabana Yegua dam was carried out based on the required discharge (Qout). The results shows that the water resources are not sufficient to meet the irrigation demands under the present conditions at the probability level of 80 %. Sixteen (16) seasons out of 27 seasons results in "failure" (insufficient water supply) in the simulation of the dam operation.

(c) Azua Block

Irrigation systems in the Azua block, i.e., (i) irrigation areas along YSURA Head Race Canal (A0 area), (ii) irrigation areas along the Yaque del Sur river (A1 area), and (iii) YSURA irrigation area covered by the YSURA Canal, have sufficient volume of water resources at their intake points under present conditions.

The irrigation requirements for new areas such as Amiama Gomez and Biafara Irrigation Systems were included in the water balance under the proposed conditions. The total amount of waters diverted into the YSURA Canal was controlled so as not to exceed the volume under the present conditions.

The volume of the irrigation waters for the A1 area were controlled and adjusted proportionally along with those of Yaque del Sur - Lago Enriquillo block (B1 to B6 areas).

(d) Yaque del Sur - Lago Enriquillo Block

Yaque del Sur - Lago Enriquillo block was divided into six areas (B1 to B6) for the water balance study as illustrated in Fig.†4.7.1. According to the simulation under the present conditions, the water resources were evaluated "insufficient" as

mentioned above to accommodate all the irrigation areas in the block at 80†% probability level. The irrigable areas for the present conditions were first estimated as given in Table 4.7.7. Then, using reduced unit irrigation requirements (liter/hectare/second) for the proposed conditions, the irrigation areas were expanded proportionally taking into account the available waters at Sabana Yegua dam.

A big reduction of sugarcane area in the proposed cropping patterns of the Santana Irrigation System (B2 area) resulted in a large increase in the irrigable area of other systems (B1, B3, B4, B5, B6) up to their proposed areas. Only B2 area can not be irrigated to a full extent of the proposed area under the proposed conditions.

4.8 Water Resources Development Plan

4.8.1 Basic Concept

The total volume of available water resources in the Study area is not sufficient for the present water demands as mentioned in the Sub-section 4.1.1. Therefore, main concerns in the water resources development in the Study area are considered;

i) To increase the volume of water in the Basin,
ii) To decrease losses in water use, and
iii) To use the available water several times, i.e., re-use of the water.

The trans-basin water extraction is the only measure for the first, but it is not a realistic option considering the fact that some waters are being distributed to Azua and Las Matas by the trans-basin canals.

Thus, the purposes or concepts of the water resources development in the Study area are considered; "***how to decrease the losses in water use***", and "***how to re-use the limited waters***".

4.8.2 Water Resources Development Plan

(1) San Juan Area

(a) José Joaquin Puello Dam Development Plan

The proposed José Joaquin Puello dam is located at Cargagual, about 13 km from the Sabaneta headworks, the beginning point of the José Joaquin Puello canal.

The concept of the José Joaquin Puello dam is not only a reservoir but a regulating reservoir. The catchment area at the dam site is only 9 km2, and the runoff from the catchment is not a big amount. The reservoir will be fed by the José Joaquin Puello canal. The capacity of the canal is 8 m3/sec and the residual capacity of the canal to the irrigation demand will be used to feed the reservoir.

According to the water balance simulation under the proposed conditions, the annual water demands at Sabaneta dam is 200 MCM, while the average estimated inflow is 270 MCM. Certain percentage of the 70 MCM can be conveyed by the José Joaquin Puello canal and be stored at the proposed reservoir.

The plan of the reservoir is given in Fig. 4.8.1. The capacity is estimated at 9.5 MCM with a dam height of 30 m at 545 m amsl. The sedimentation rate of

2.0 mm/km2/year will bring 0.9 MCM of sediments for 50 years, which is 10 % of the storage volume.

Taking into consideration these basic features of the proposed dam, the development of the José Joaquin Puello dam is worth of further feasibility study. The dam size will be determined based on a preliminary optimization study in terms of hydrology and cost. Then physical investigations on geology, construction material should be conducted.

(2) Azua Area

(a) Sabana Yegua Dam Rehabilitation Project

As mentioned in Chapter 3, the water level of the reservoir is currently controlled at 386.0 m from July to September, to accommodate the revised design flood inflow of 14,000 m3/sec (PMF)1. The storage volume at the level of EL 386.0 m is about 200 MCM, which is 150 MCM less than that of EL 396.4 m, namely the maximum operation level2. The rehabilitation project of Sabana Yegua dam consists of;

(i) Improvement of the existing spillways to increase the discharging capacity and raise the operation level of the reservoir,
(ii) Establishment of operation rules and manuals for not only emergency but also for normal operation
(iii) Provision of the flood warning system, and
(iv) Training of CDE and INDRHI staff

Among the above components, (ii) to (iv) will be covered by the overall water management plan or the Yaque del Sur Water Management Center Project mentioned in Section 4.4. A technical study on the rehabilitation is being carried out by INDRHI.

(b) Azua Valley Groundwater Development Project

In Azua Valley, groundwater is utilized extensively for irrigation purpose. In particular, in the extension area of the Ysura Canal System, where little water is available from the canal, a large-scale "tomato" cultivation is being practiced using groundwater and drip irrigation system. However, it was pointed out by the previous studies that the groundwater potential here is not very high.

On the other hand, in the southern part of the irrigated areas by the laterals of Ysura system, poor drainage conditions are caused by artesian flow of groundwater and poor irrigation water management. It is estimated that a large part (about 30 %) of the groundwater is recharged by the irrigation water there.

Taking into these conditions into account, a "groundwater development project

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[1] : "Rehabilitacion Presa Sabana Yegua, Etapas 2 y 3 Adecuacion de la Capacidad de Descarga Rediseño de los Vertederos de Operacion", INDRHI, 1993

[2] : The volume is derived from the storage curve which was revised in 1993.

for conjunctive use" is considered an appropriate development approach in the Azua Valley.

The project will consists of;

Extension or Improvement of Ysura Canal,

Groundwater development in the poor drainage area situated in the down reach of the laterals or other potential areas

The excess or certain percentage of irrigation water at the proposed area will be distributed by the new canal to the extension area, and the deficits will be compensated by the groundwater development.

An intensive study of the groundwater development is being carried out by INDRHI as "PLANIACAS II" which selects a number of existing wells and make an inventory on basic features of the wells such as location, discharge, depth, owner, pumping hours, structures, etc.

Groundwater development potential of the proposed area will be clarified by the results of the project, but it is considered that the proposed yield of a tubewell in the project area ranges from 20 to 30 liters per second, which covers 20 to 30 hectares of farm fields of upland crops. The structure of a well will be an intermediate to deep tubewell with an electric driven rotary pump. The groundwater potential of the project area is estimated at 50 to 75 MCM/year or 5,000 to 7,500 hectare meter per year. In this situation, it is assumed that the groundwater potential itself is sufficient for irrigating the project area of some 1,100 ha for vegetables and other upland crops. The important point is exploitation rate of the groundwater. The groundwater table should be monitored and maintained between 5 m and 20 m so as not to cause land subsidence or inundation. The conjunctive use of groundwater and surface water seems to be a appropriate project approach in the area.

(3) Barahona/Neyba Area

(a) Neyba-Galvan Groundwater Development Project

It is well known that the Neyba area has few surface water resources exclusively available for the area. Accordingly, people's living also largely depends on the groundwater. The intensive development of groundwater for rural development and irrigation is required. Taking into account the high water demands for irrigation, conjunctive use with drained water from the Santana Irrigation Area should also be considered for the irrigation purpose.

The potential area of the groundwater development is limited along the foot of alluvial fan of along the Neyba-Galvan road, with a length of 15 km in the east to west direction and a width of 3 km.

According to the previous study conducted, the appropriate interval of the deep tubewells whose discharge is 25 to 50 liters per second, is more or less one kilometer so as not to affect each other. However, on the other hand, it is rather difficult to irrigate 100 ha (1 km2) of farm field with one tubewell. It is considered more practical and feasible to distribute tubewells more densely and control the discharge of each well according to the groundwater table. Some monitoring wells should be

distributed for the monitoring purpose.

Since the groundwater is the sole water source in the project area, the exploited groundwater would also be used for drinking or domestic purposes. To save limited waters of good quality, it is recommended to use the groundwater for dilution of drained water from the Santana irrigation area to reduce the salinity level.

It is considered that the conjunctive use of groundwater and drainage water would have potential to irrigate 500 to 1,000 ha of farm fields in the northern part of the Neyba Valley.

Further investigations such as pumping tests and geo-physical survey are required to determine the target yield and locations of exploitation.

(4) Studies for Future Projects

(a) Justification Study on Water Resources Development

A number of dam development projects have been identified in the Yaque del Sur River basin, including the above mentioned projects, namely Mijo, Los Baos, and Monte Grande. Some of these projects have been studied on some technical aspects such as geology, land suitability of proposed irrigation areas, hydropower facilities, etc. However, most of the identified projects have not been studied and can not be evaluated without any basic features such as availability of water resources, geological conditions, topographic conditions, land use and suitability of the proposed irrigation area, etc.

It is necessary to organize these candidate projects and select several projects for further steps; (i) basic and physical investigations on geology, soil and land suitability in the proposed irrigation area, (ii) optimization of development scale based on the water balance simulations, (iii) project formulation, (iv) preliminary design and cost estimate, and (v) economic analysis for justifying the projects.

(b) Rincon Lagoon Aquasphere Resource Study

Utilization of Rincon Lagoon as a reservoir is one of the possible alternatives to irrigate a large area in the Neyba Valley. It is technically possible to extract excess waters from the Yaque del Sur River to the lagoon. However, at this moment, the water quality is judged "not suitable" for irrigation purpose, because of its high salinity level. Furthermore, some adverse effects to the ecological conditions in/around Rincon Lagoon are expected by sediments, change in salinity level and water level, etc. Basic investigations, such as bathymetric survey of the lake, are necessary for the evaluation of the feasibility of the projects. The project formulation will be determined in connection with the project "Water Conservation in Rincon Lagoon" mentioned in Sub-section 4.9.2.

4.9 Plan of Environmental Conservation

4.9.1 Reforestation in the Upper Watershed Areas of Grande River

(1) General

As already mentioned in 3.8.2, the deforestation is one of biggest problem in the

country. In the study area, the problem in the upper watersheds causes critical sedimentation in reservoirs, such as Sabaneta dam and Sabana Yegua dam. According to the landuse map (Fig. 3.3.1), the natural conditions of the upper watershed of San Juan River, Yaque del Sur River, Grande River and Las Cuevas River which follow the reservoirs are critical for the soil conservation. Natural past and extensive agriculture land occupy large area and generally the grade of inclination is high.

In the upper area of the Sabaneta Dam, the PRODAS has already initiated a reforestation project, and in the watershed of Las Cuevas River, one of the principal rivers of the upper area of the Sabaneta Yegua Dam, the INDRHI is conducting a reforestation project. In the others, Yaque del Sur and Grande River, no soil conservation project has carried out so far. Between the 2 watersheds, the condition of vegetation of the Grande river watershed is worse, because of the distribution of the larger natural pasture areas and extensive agriculture areas.

The watershed of Grande river is 676Km^2 large. As shown in the figure, concerning the condition of the vegetation, a large parts are occupied by the natural pasture (243 km2 and 36%), extensive agriculture lands (102 km2 and 15%) in the watershed. Also in the area, small communities are distributed. There are around 5 communities (cecciones) and 42000 peoples. They are small farmers who practice extensive farming like shifting cultivation. It is understood that the almost deforested area is occupied by natural pasture and extensive agriculture land.

(2) Basic Concept

In this plan, the perception of the problem and the basic concept of the plan is shown in following figure. For the soil conservation, in the most critical area in the watershed is where local people practice the shifting cultivation using fire to open a farm from forest or bush. Frequently the fire spread over the forest or bush around the farm, so that larger area of vegetation is going to degrade. Increase of the local population and the change of the agricultural system directly affect vegetation condition.

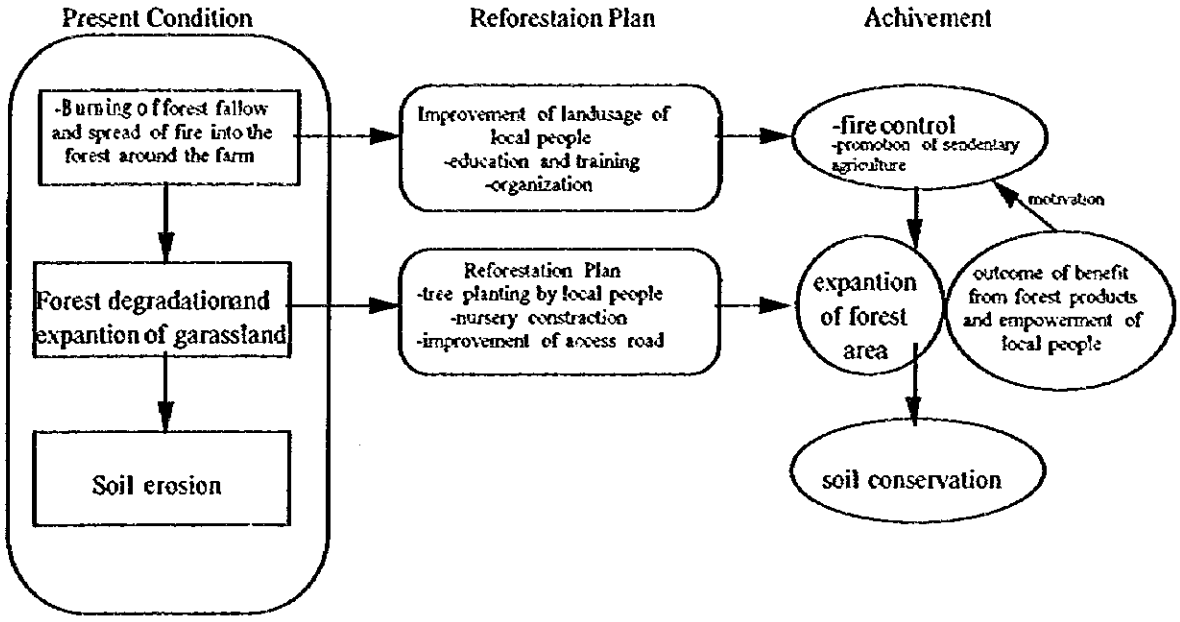
Under the above mentioned understandings, the most important concept in this plan is to change of the local people's role, from as agents who cause deforestation to as agents who create and manage forests. For this concept, participation of the local people is essential. The people's participation should related to all stages of the plan, such as the planning stage of reforestation, nursery construction, implementation of planting, and the stage of maintenance and management.

Also empowerment of local people is one of the important concepts of the plan. The local people are extremely interested in improving their income as well as improving their living environment. The improvement of their economic condition resulting from outcome of benefit from forest products will motivate them to create and conserve forest.

The people living in the project area have stayed there and used the land for certain period. But actually they illegally occupied the public land. As a prerequisite condition to

advance the project, it is necessary to make a regulation between the organizer of the project and the local people for the land possession and the share of benefits from forest products.

Figure Basic Concept of the Reforestation Program



(3) Selection of Model Area and Schedule of the Plan

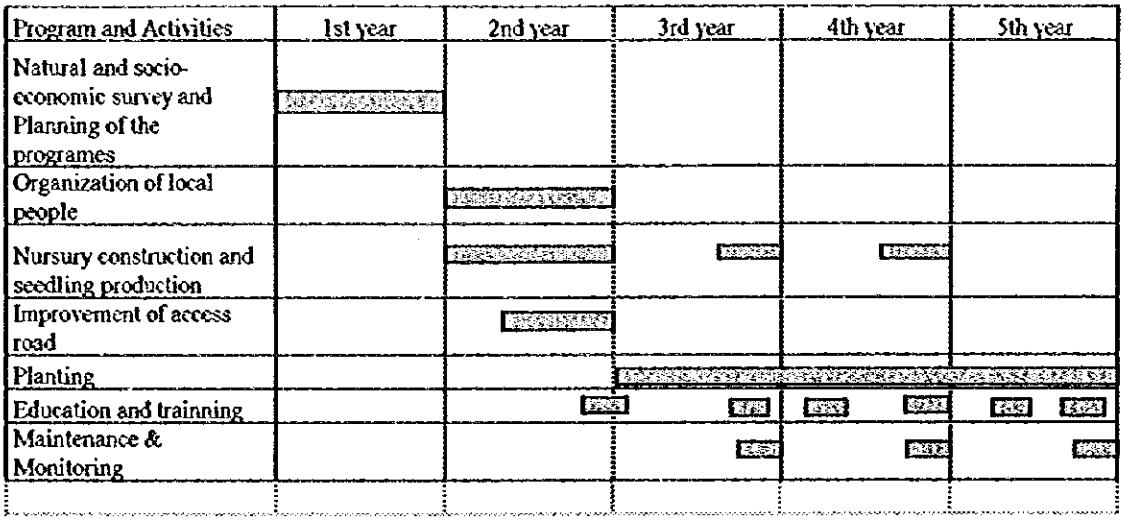
To establish the method of reforestation in the whole watershed of Grande River, in this plan, a model area is selected following the next criteria:

(a) Area used as extensive agricultural land,
(b) Area whose grade of inclination is high,
(c) Area along the river, and
(d) Area around the local communities.

The selected area is along Arroyo Limon River, a tributary of Grande River, as shown in Fig. 4.9.1. The area is around 3,000 ha. large. The grade of inclination is generally very high, which is 32 to 40 degree. Annual rainfall is 800 to 1,000mm. Several communities (paraje) exist in the area, which are La Majaguita, Gajo de Monte, El Botancillo, El Montazo and Los Guayuyuos. People practice shifting cultivation in the area.

The plan takes 5 years as shown in the figure below. In the plan period, the total reforested area will be 720 ha. large. The number of family participating in the plan is 720.

Figure Schedule of the Plan



(4) Improvement of Land Usage of Local People

(a) Education and Training for Fire Control and Soil Conservation

The main cause of the forest degradation is the spread of the fire used by the local people when they practice the shifting cultivation. Without fire control, any reforestation plan will be failure. It is necessary to plan a program of education and training in order that the people recognize the importance of forest for environmental conservation and also for enrichment of their living. In the program, the agricultural techniques for forest and soil conservation, such as establishment of fire cut zone and terracing are learned by local people.

(b) Promotion of Sedentary Agriculture

Shifting cultivation practiced by the local people causes forest fire and requires a large forest areas to convert for farms. To conserve and create forest, it is necessary to change the farming system, from shifting cultivation to sedentary agriculture. In this program, the techniques for the sedentary agriculture, such as vegetable farming and agroforestry system are learned by local people.

(5) Reforestation Plan

(a) Planting System

Local people's participation in the process of forest establishment, which are program planning, seedling production, planting, management of the forest, and the harvest, are required. To carry out the plan under the people's participation, the local people are organized and small groups as working unit are formed up.

Participants of a group which consists of around 60 families work under instruction of specialists from a consultant. The consultant works with a group for 3 months from the stage of land preparation to the seedling planting. After that, the consultant shifts to another group to continue the planting program. After all, for 1

year the consultant relates with 4 groups or 240 families. While this cycle, the nursery work is always continued by some contracted workers from the local people.

Not only trees species for soil conservation and timber production, but also coffee and some fruit trees which the farmers prefer are also planted. These trees' products serve to generate benefit for local farmers.

(b) Nursery Construction

In the model area, there is no sufficient land to establish a large nursery because of the topographic condition and is not always sufficient water supply to product seedlings. Also long distance transportation of seedlings and other materials is difficult because of the poor road condition. Therefore several small nurseries rather than a large nursery should be constructed.

Four nurseries, each one in the area of Gajo de Monte, El Montazo, Las Gayuyos and El Botancillo will be constructed in the plan. The scale of a nursery is mentioned below:

- Area of Nursery : 1500m2
- Plant Production Capacity : 300,000
- Facilities : Seed and Seedling Bed, Irrigation System, Hut for Labor Stay, Shed

(c) List of Proposed Plant Species

The model area belongs to the zone of subtropical humid forest in transition to the subtropical dry forest and to the zone of low mountain humid forest. The list of the species which are adequate to plant in the such zones is shown in the next table.

Table List of Proposed Plant Species

Local Name	Scientific Name	Main Use
Pino	Pinus occidentalis	Timber
Pino	Pinus caribea	Timber
Caoba	Swietenia mahagoni	Timber
Cedro	Cedrela odorata	Timber, Shade tree for coffee farm
Roble	Catalpa longissima	Timber
Juan Primero	Simaruba glauca	Pole for construction
Nin	Azardiractha nin	Fire wood, Timber
Casuarina	Casuarina equicetifolia	Erosion control
Bambu	Bambusa bambus	Erosion control along rivers. Material for handicraft making
Cafe	Coffea arabica	Coffee production
Guama	Inga vera	Fruit, Shade tree for coffee farm
Cajuil	Anacardium occidentalis	Fruit
Buen Pan	Artocarpus heterophyllus	Fruit
Jagua	Genipa americana	Fruit

(d) Improvement of Access Road

The road conditions from San Juan until the model area are mentioned next :

-From San Juan until Guanito, hard surface and 2 lanes, through the year easily accessible;

-From Guanito until Bohechio, loose surface, sometimes difficult access in rainy season ;

-From Bohechio until the model area, cart track only, accessible in only 4 wheeled vehicle in some way in dry season, inaccessible in vehicle in rainy season.

The access condition is the worst between Bohechio and the model area. The distance between them is around 27 km. It is impossible to become accessible in all the way by vehicle because of the geographic condition. However to efficiently carry out the plan, improvement of the access road is crucial.

In this plan, the accessibility by vehicles from Bohechio until the model area, and in the area will be improved as much as possible. In the inaccessible parts by vehicles where the improvement will be impossible, donkeys are used as means of transportation.

(e) Education and Training

Education and training for the local people to know the method of planting, management and maintenance, harvesting, processing, and marketing. The rule of harvesting and benefit share is also established in the meeting of the education and training course.

(f) Monitoring

Monitoring of growth of the planted trees is conducted by the local participants and specialists from the consultant. Especially in the first 2 years after the planting, careful watching for damage caused by drought, weeds, and blight and insects is important.

(6) Organization and Management

(a) Organization and Management

The organizations to carry out this plan are proposed as shown in the next figure.

(i) Headquarters of INDRHI

The headquarters of INDRHI work as a coordinator among various organizations relating to this plan, such as sponsors and other governmental organizations. Also they manage the whole plan and support the activities in the model area.

(ii) Site Coordinator from INDRHI

Some site coordinators from INDRHI always stay at a local office in Bohechio. They work as coordinator between the consultant, headquarters of INDRHI and the organization of local people. They supervise and manage the progress of the plan and report it to the headquarters.

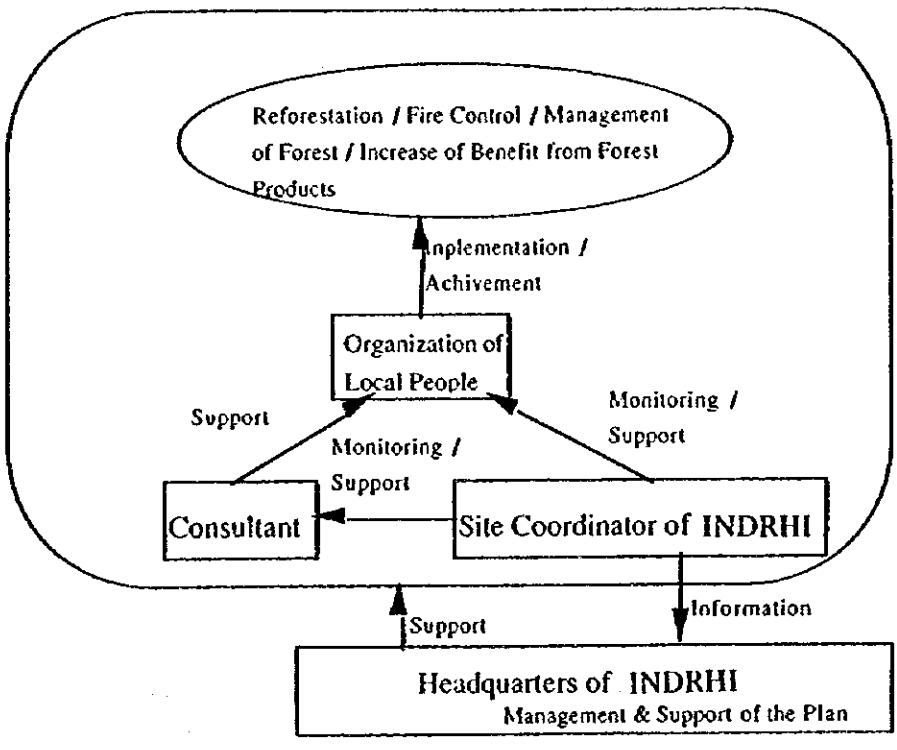
(iii) Consultant

The consultant directory relates with the local people to implement the plan. It works as coordinator between the organization of local people and the INDRHI, and also as for education and training to the local people.

(iv) Organization of Local People

A group of local people consists of 60 families. The group actually works to implement planting seedlings and managing them. It is also a unit to receive education and training course from the consultant.

Figure Organization of the Plan



(7) Costs

The total plan cost is estimated to be 14,958,090 peso as shown in the next Table.

Table. Plan Costs (peso)

Program & Activities	Amount	Remark
Natural & socio-economic survey and Planing	533,760	Natural environmental survey 83,400 peso, Socio-economic survey 166800peso, Planing 83,400peso
Organization of Local People	266,880	-
Nursery Construction	444,000	installation 85,000, hut construction 5,000, irrigation 15,000, small equipment 6,000, per a nursery, total 4 nurseries
Seedling Production	960,000	0.8 peso/seedling * 1,200,000 seedlings
Improvement of Access Road	9,072,000	27 km
Planting	1,872,000	land preparation 1,300peso/ha, planting 1,300 peso/ha, total 720 ha
Education & Training	320,260	10 days/group with 3 instructor, total 16 groups
Monitoring	209,190	total 100days
Equipment and Facilities	1,280,000	4 wheeled vehicle, office construction, etc.
Total	14,958,090	

4.9.2 Wildlife Conservation in Rincon Lagoon

(1) General

In the Rincon Lagoon, covered by the national park of 47 km^2, several kinds of valuable wildlife species exist. Recently the fluctuation of water level and the lack of water are considered to affect the wildlife existence. The important wildlife species are mentioned below:

(a) water flora

Loto (Nelumbo lutea), Lila de Agua (Nymphaea spp.), Yerba de Hicotea (Nymphaea ampla), and Yerba de Cotorra (Ceratophyllum demersum).

(b) fauna

Camaroncito de Rio (Palaemon pandaliformis) as well as various endemic fish species, e.g. Limia and Gambusia. The largest population of Hicotea (Trachemys decorata), which are endemic of the island. The following bird species have been reported on and around the lagoon: Pato Cripllo (Oxyura dominicana), Pato Espinoso (Oxyura jamaicensis), Flamenco (Phoenicopterus ruber), Garza Pechiblanco (Hydranassa tricolor), Coco Oscuro (Plegadis falcinellus), Pato de la Florida (Anas discos), Gallinuela (Porzana carolina), and Gallito Prieto (Jacana spinosa).

The lagoon worked as a retarding basin for flash and flood water from Yaque del Sur river. It is possible the water volume introduced from the river to the lagoon was reduced after the construction of the Sabana Yegua Dam, because of the reduction of discharge of the river in rainy season as shown the following table. From September to December, the mean of dependable discharge between 1980 to 1990 reduced to less than half of that between 1968-1979.

After the construction of the dam, although the water level fluctuation is observed, the

water level between these 10 years is not able to judge to decline as shown in Fig. 4.9.2. Although the existence of some important species as described above is understood, there is no sufficient data to judge the impact to them by the water level fluctuation. A long term monitoring of the condition of the fauna and flora is necessary to understand the relation between the environmental change and its impact to wildlife.

Table Mean of Dependable River Discharge at Palo Alto Station (m^3/sec.)

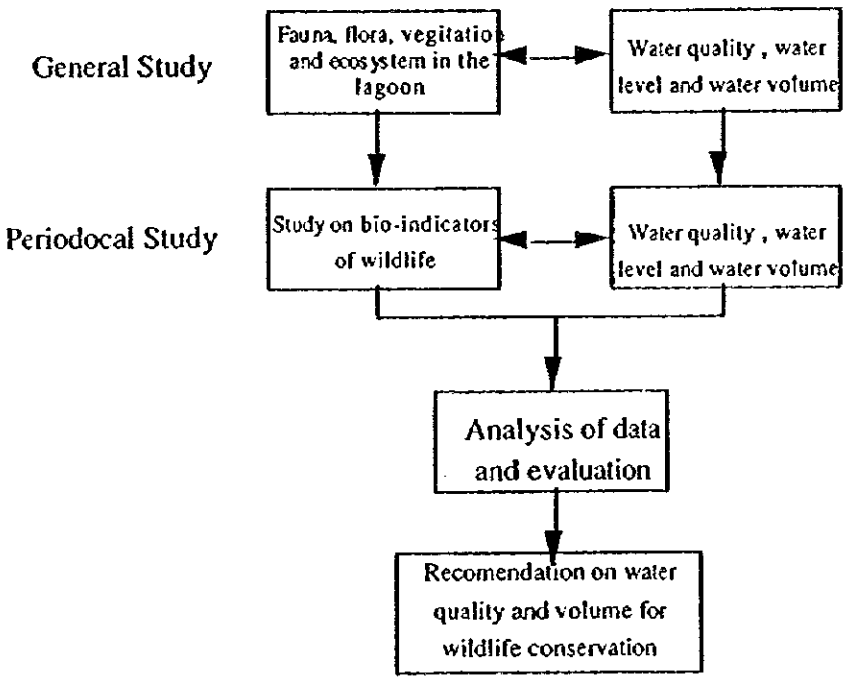
Period	Jan	Feb.	Mar	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1968-1979	6.3	3.0	3.3	5.3	19.0	29.3	21.6	20.4	43.6	50.2	33.5	19.4
1980-1990	9.8	7.8	6.6	7.0	17.1	18.1	20.3	12.1	17.4	21.6	14.5	9.1

Source: Planning Dept. INDRHI

(2) Basic Monitoring Study of Fauna and Flora in Rincon Lagoon

This study project is progressed as shown in the next figure.

Figure. Progress of the Study



(a) Period and Frequency of the Study

The total study period is 10 years. In the first half of the first year, a study to understand the general condition of the fauna and flora is conducted. After the study, from the second half of the first year until the tenth year, periodical studies focusing on

some bio-indicator are carried out every two months. The study will be totally carried out 58 times.

(b) General Study on Fauna and Flora

The general study on fauna and flora, and also water condition is conducted. The object area of the study is whole area of the lagoon. The items of the study are:

- Description of Fauna and Flora and their Quantity
- Drawing of Vegetation Map
- Condition of Ecosystem
- Measurement of Water Level and Topography of Bottom of Lagoon
- Water Quality of the Lagoon (Temperature, pH, COD, DO, NH4-N, NO3-N, Total Phosphate, Number of Colon Bacillus, EC)

Considering the result of the study, the planing of the periodical study, concerning the selection of the focused areas and the livings as bio-indicators, items of water quality analysis, and the detailed study method, is made.

(c) Periodical Study

The periodical study is conducted every two months to monitor the condition of fauna and flora and to understand the relation between the water fluctuation and its impact for livings in the lagoon. In the survey, some bio-indicators and areas selected from the result of the general study are focused. The study method will be made after the analysis of the result of the general study. The survey of the water level and the water quality is also conducted.

(d) Evaluation and Recommendation for Wildlife Conservation

As the result of analysis and evaluation of the data, some recommendations concerning water condition for wildlife conservation are made. Water introduction from Yaque del Sur River to the lagoon may be one of topics of the recommendations.

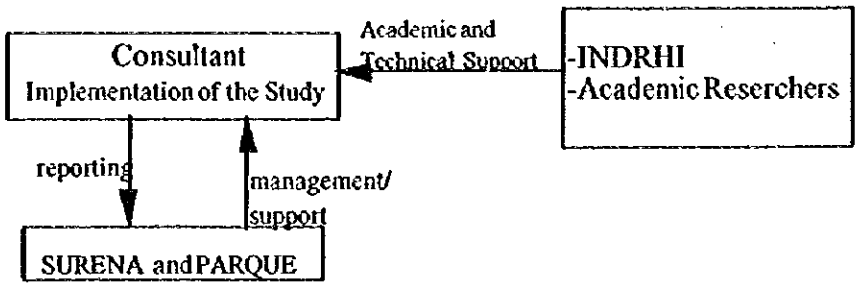
(3) Necessary Equipment and Facilities

The facilities required are a hut to observe the fauna and to stay overnight, several boats with motor, and a 4 wheeled vehicles. Necessary equipment for the survey is some binoculars and a 40 power telescope.

(4) Organization and Management

The organizations which relate to this plan are shown in next figure. The Sub-secretariat of Natural Resources (SURENA) and National Direction of Parks (PARQUE) are the main organizations to coordinate and manage the plan. Implementation of the field survey and the analysis are conducted by a consultant. The INDRHI and academic researchers work as academic and technical advisor to the consultant.

Figure. Organization and Management



(5) Costs

The total plan cost is estimated to be 4,561,680 peso as shown in the next table.

Table Plan Costs

Program & Activities	Cost	Remark
General Study	277,640	field survey 75,060peso, measurement 8,400 peso, analysis 62,550 peso, planing for periodical study 12,510 peso, analysis of water quality 15,000 peso
Periodical Study	2,902,600	field survey 411,162 peso, measurement 121,800 peso, analysis 411,162 peso, analysis of water quality 870,000 peso
Evaluation and Recommendation	133,440	-
Equipment & Facilities	1,248,000	4 wheel-vehicle, boats and motors, telescopes, hut construction, etc.
Total	4,561,680	-

4.10 Initial Environmental Examination (IEE)

4.10.1 General

In the 4th chapter, there are several proposed projects for the purpose of the integrated rural development in the study area. Those projects will contribute to the improvement of social and economic condition in local and national level. However, it would be possible that implementation of the projects would unexpectedly affect social, economic and natural environment in the area.

In this study, to avoid mainly negative impacts to environmental conditions by the proposed projects, the IEE is conducted. The purpose of the IEE is to judge whether the Environmental Impact Assessment (EIA) will be necessary or not in the feasibility study.

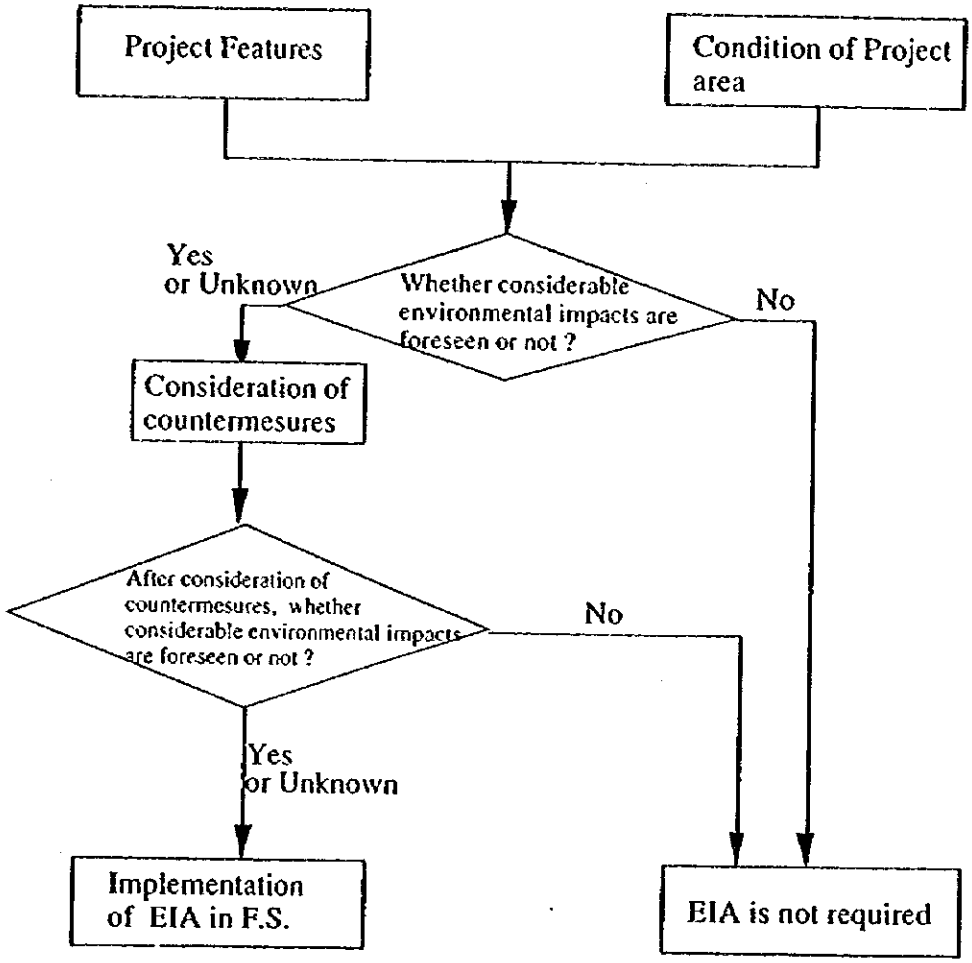
4.10.2 Basic Concept

The IEE will be conducted as shown in following figure. First, the project features and the condition of the project area are understood. Then it is examined whether considerable environmental impacts will occur or not. If no impacts are expected, the EIA is not carried out. If any, countermeasures for the impacts will be considered. Then the project with the

countermeasures is examined again. As the result of it, if no considerable impacts are expected, the EIA is not required in the Feasibility Study. On the contrary, in case that still some considerable impacts are foreseen, implementation of the EIA in the feasibility study will be decided.

In this study, totally 26 proposed projects are listed. The all project will be examined. The check list was used to conduct the IEE

Figure Implementation of IEE



4.10.3 Condition of Project Area and Project Features

The condition of project area and the project features of the 26 proposed projects are summarized in Table 4.10.1.

4.10.4 Environmental Impacts and Countermeasures

The foreseen environmental impacts and some countermeasures for the impacts are summarized in Table 4.10.2. The necessity of the EIA also is put in the same table .

4.10.5 Result of IEE

As the result of the IEE, the implementation of the EIA is required for the 3 projects shown next. The summary of the IEE result is shown in the following table.

- Improvement of Irrigation and Drainage Systems in the Lower Reaches of the Yaque del Sur River

  Expected environmental impacts are soil salinization, the change of groundwater level, water pollution in the construction stage, increase of agrochemical and fertilizer use, health and water born diseases, water right, disturbance of farms, and change of lifestyle of local people. In these impacts, a considerable impact is soil salinization. By the improvement of drainage canal networks to remove salt contained in the soil layer and to maintain the salt content low, drainage water will contain much more salt than before. The salt would accumulate in another place. Also the life style change of local people should be taken into consideration. The establish of the water user's organization will cause the change of social system of the community. From view point of project implementation, the evaluation of social environment of the community regarding social structure, education level, and leadership is important to function the organization.

- Jose Joaquin Puello Dam Development Plan

  Expected environmental impacts are deforestation, erosion and degradation of soil, loss of biodiversity, water pollution in the construction stage, and health and water born diseases. In these impacts, considerable impacts are deforestation and erosion and degradation of soil. Some bush area will be inundated by the reservoir. Soil erosion in the watershed area will cause sedimentation in the reservoir. There is no agricultural land and resident, so that disturbance of farm and resettlement will not occur.

- Galvan Groundwater Irrigation Project

  Expected environmental impacts are soil salinization, change of groundwater level, and problem of water rights. In these impacts, considerable impacts are soil salinization and the change of groundwater level. In the project area, the problem of soil salinization is observed. The project cause the groundwater rising which often become a trigger of soil salinization.

Table Summary of IEE Result

Environmental Impacts	Proposed Project	1)YSURA Extension Area Development Project	2)Nueva Ecija Irrigation System Improvement Project	3)Quantity San Juan Irrigation System Improvement Project	4)YSURA Area Irrigation System Improvement Project	5)YSURA Headrace Small Irrigation System Improvement Project	6)Pampanga Small Scale Gravity Irrigation System Improvement Project	7)Pampanga del Sur Lower Reaches Irrigation and Drainage Project	8)Sabana Yegua Dam Rehabilitation Project	9)Jose Joaquin Puello Dam Development Plan	10)Galvan Groundwater Development Project	11)Galvan Groundwater Irrigation Project	12)Azua Groundwater Development Project	13)Plan of Villarpando Water Management Center	14)Marquesal Mini-Hydropower Project	15)Rural Water Supply Plan	16)Other Social Infrastructure Improvement Plan	17)Rural Road Improvement Plan	18)Plan for Agricultural Cooperatives	19)Plan for Seed Multiplication	20)Plan for Credit Services	21)Plan for Marketing Information System	22)Plan for Strengthening CIAZA Research Center	23)Plan for Strengthening Extension Services	24)Coffee Production Improvement Project	25)Reforestation in the Upper Watershed Areas of Grande Riviere	26)Wildlife Conservation in Rincon Lagoon
Natural Environment	Deforestation	D	D	D	D	D	D	D	D	A	D	D	D	D	B	B	D	D	D	D	D	D	D	D	C	P	D
	Erosion and Degradation of Soil	D	D	D	D	D	D	D	D	A	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	P	D
	Soil Salinization	C	C	C	C	C	D	A	D	D	D	A	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	Loss of Biodiversity and Wildlife	D	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	P	P
	Change of Grandwater Level	C	C	C	C	C	D	C	D	D	D	A	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	Intrusion of Seawater	D	D	D	D	D	D	D	D	D	D	D	C	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	Environmental Pollution esp. Water Pollution	D	D	D	D	D	D	C	C	B	D	D	C	C	C	D	D	C	D	D	D	D	D	D	C	C	D
	Increase of Agrochemical and Fertilizer Use	B	D	D	D	D	D	B	D	D	D	B	D	D	D	D	D	D	D	E	D	D	D	D	B	D	D
Social Environment	Health and Water Born Diseases	C	C	C	C	D	D	C	D	B	E	B	B	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	Water Rights	C	C	C	C	D	B	C	D	E	C	B	B	C	D	D	D	D	D	D	D	D	D	D	D	D	D
	Resettlement	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
	Disturbance of Farms	C	C	C	C	C	C	C	D	C	D	C	D	D	C	D	D	D	D	D	D	D	D	D	D	D	D
	Change of Lifestyle of Local People	D	D	D	D	D	D	C	D	D	D	D	D	D	D	P	P	P	C	D	C	D	D	D	P	D	D
	Gender	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	E	D	D	D	D	D	E	E	D
	Degradation of Landscapes	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
EIA is Required or Not?		×	×	×	×	×	×	○	×	○	×	○	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

A: Serious environmental impact is expected, B:Small environmental impact is expected, C: Although environmental impact is expected, it will be reduced by countermeasures,
D: No environmental impact is expected, E: Unknown, P: Positive impact is expected

4.11. Action Plan

4.11.1 General

In the master plan, 25 projects have been formulated as follows:

These consist of one project for the agricultural development, six (6) projects for agricultural support services, nine (9) projects for irrigation and drainage development including strengthening water users organizations, four (4) projects for rural infrastructure development, two (2) projects for environmental conservation and four (4) projects for water resources development. These projects are co-related and should be executed in an efficient way through proper combination and appropriate scheduling. The implementation of phases and priorities of the projects are proposed in the action plan. Salient features of these projects are summarized in Table 4.11.1 and location of these projects is shown in general map. The implementation schedule of these projects is illustrated in Fig. 4.11.1.

4.11.2 Target Year

The master plan is formulated as a 10 year Plan up to the year of 2,010.

4.11.3 Project Assessment and Implementation Schedule

For the economic evaluation for these projects, benefit and cost are estimated as shown in Table 4.11.1. Benefits of agricultural development projects and irrigation and drainage development projects are estimated as difference in farm profit coming from crop production between the future with-project and without-project conditions. Farm gate prices of farm inputs and outputs in the study area in 1998 were used in the evaluation. With respect to credit service and seed multiplication plans, simple cash flow statement is prepared for assessment. For the projects related to other agricultural support service, overall water management, rural infrastructure, environment and water resources, benefits are not calculated. Costs of these projects are estimated based on the market prices of 1998 in the Dominican Republic. The exchange rate used in the cost estimate was 14 Dominican Pesos = one US. Shadow wage rate and standard conversion factors for costs are not used for economic evaluation in this study. Under such condition, the agriculture and irrigation/drainage projects are economically evaluated by internal rate of return. Other projects are not economically evaluated. All projects are preliminarily assessed in view of environmental and social impacts.

(1) Agricultural Development Plan

The coffee production improvement project aims to increase coffee productivity in area of about 7,200 ha located in Azua and Bahoruco provinces. The project component consists of (1) promotion and/or strengthening the 180 coffee producer associations, (2) reinforcement of 5-coffee specialist and 15-extension workers by education and training, (3) performance of 2 pilot projects (each 40ha), (4) replacement of 1.2 millions of old coffee trees, (5) improvement and/or replacement of post harvest facilities and (6) improvement of roads of 84 km in length including 18 km-access road. The target farmers are the small farm holders of about 3,500. The total construction cost is 249.8 million Pesos. Implementation period is assumed at 11 years. An annual benefit at the full stage is 77.1 million Pesos.

Internal rate of return is 13 %. The project expects the effects and impacts such as (1) improvement of production, quality and value added, (2) strengthening of bargaining power through increase of consignment sales from the association, (3) improvement of income and living conditions of farmers, (4) revitalization of local economy in village and regional levels, (5) creation of employment opportunities, (6) improvement of transportation system. The Ministry of Agriculture is in charge of implementation of the project.

(2) Agricultural Support Plans

Credit services: Poor access to agricultural credits in the study area is one of the most serious factors for agricultural production to farmers. We proposed to set up (1) Rural Development Fund in Agricultural Bank(RDF) and (2) Fund for the Rural Poor(FRP) in FEDA. Group credit will be provided through these Funds with organization such as water users organizations, farmers associations, women groups, groups of community and so forth in order to reduce handling charge. The interest rate of credit to be expected is 8 % /annum under the assumption of risk hedge of 20 % for recovery from the groups. Credit amounts of RDF and FRP are 8 and 5 million US equivalent, respectively. The cash flow of these funds for 5 years indicates that the projects appear financially sound.

Research services: In order to provide agricultural bases with the proposed agricultural and irrigation/drainage development projects, CIAZA research center will be strengthened. Project components consist of (1) improvement of CIAZA institutional capacity, (2) training programs for CIAZA researchers, (3) reinforcement of CIAZA facilities and (4) development of a sustainable source of funding for research activities at CIAZA. The project total cost is 24 million Pesos consisting of procurement cost of facilities and equipment, training cost, operation and management costs for 5 years. The increase in the research capacity at CIAZA will result in the adoption and spread of better farming practices and appropriate farm inputs which in turn will increase production in the proposed agriculture and irrigation/drainage projects.

Extension services: The project components consist of (1) education and training for all extension workers (178) in the study area in terms of technical issues, methodological aspects, managerial aspects and organizational aspect, (3) trainer being composed of professional staff of SEA and universities, (4) training performed by short course, workshop, seminars, conference and field trips for 5 years, (5) reinforcement of training centers at Barahona and San Juan provinces. The total cost is 30 million Pesos for 5 years. SEA is in charge of this project. Improving the institutional capacity to prepare projects, the project would lift one of the major bottlenecks for the financing of rural investments and significantly increase the investment pipeline of the funding agencies. Likewise the training of extension workers will result in the provision of better extension services to the agricultural producers, and consequently, an increase in the production and productivity. The project will also increase cooperative's capacity to adopt technology and become institutionally stronger.

Seed Multiplication services: Deterioration of seeds is the one of the most important factors in the study area. For solving problems, we propose the existing organizations of CIAZA research center and Association of farmers of San Juan de la Maguana(APASJM)

should be strengthened to increase improved seeds. For this purpose, cold stores and drying floor will be constructed. Equipment for tissue culture will be reinforced. Farming machines such as tractors and their attachments necessary for land preparation, spraying, harvest, threshing and related farming activities will also be procured. The total cost of the project is 27.4 million Pesos excluding annual operation and replacement costs. The project will be constructed for two years. An annual cash flow statement indicates that this project is financially justifiable. SEA will be in charge of the implementation of the project.

Market Information System services: Agricultural market information is very important both producers and suppliers. We propose that agricultural market information system in the study area should be strengthened through reinforcement of function of the ongoing pilot market information system project with the Junta Agroempresarial Dominicana, Inc (JAD). In this plan, a branch information office will be established in each province in the study area with proper communication facilities. The total cost is 7.5 million Pesos including operation and maintenance costs. The implementation period is 5 years. The project will play a very important role in providing information such as prices, places of sale, grade requirement , output , agro-processing enterprises, statistical data, etc., with both the demand and the supply sides.

Agricultural Cooperative: Agricultural cooperative's capabilities for (1) agricultural production procurement and distribution from small farmers and (2) processing/marketing will be strengthened. For this purpose, new "Yaque del Sur Farmer Marketing Board" will be instituted as a body federated by four farmer's federation at provincial level. The total cost is 19.7 million Pesos containing procurement of office equipment, technical assistance, training, vehicles, operation cost, etc,. The project will be implemented for 5 years. SEA will be in charge of implementation of this project. An increase in the number of cooperatives involved in marketing and other non farm activities is expected. The reduction on marketing cost and the increase of farm prices will result on higher income for farmers. Additionally, the provision of marketing services by the Marketing Board will result on a reduction of post-harvest losses and consequently a greater supply of agricultural production from the study area.

(3) Overall Water Management Plan

Since water resources in the Yaque del Sur river are very limited, efficient use of water resources is an essential key to undertake agricultural development in this river basin. The overall water management of the Yaque del Sur River is the most promising and quick yielding project with urgent needs, comparatively low costs and big impacts. The concept of the plan is to improve and enhance the overall irrigation efficiency of each irrigation system by decreasing operational losses. The project components comprise (1) construction of Yaque del Sur Water Management Center at Villarpando headwork site, (2) rehabilitation of the existing Villarpand0 headwork, (3) installation of telemetering system and related buildings and (4) training for staff related to the water management. The total cost is 84 million pesos. The project implementation including training program is 5 years. INDRHI is responsible for project implementation and operation. The project will provide base for efficient and real-time overall water management in the Yaque del Sur river basin. After the completion of the project, an efficient irrigation water delivery can be materialized

for not only Azua Irrigation District and Yaque del Sur - Lago Enriquillo Irrigation Districts, but also San Juan Irrigation District. And, irrigation efficiency can be increased and results in an increase of multi-cropping index in the irrigation areas. In this sense, the project will vitalize the existing institutions, generate opportunities of employment.

Development of the WUOs will also strengthen farmers' activities and enhance their social positions and consciousness for betterment of their living standards by their own efforts. Collection of water charges will be ensured by stable water supply to each farmer, which will be an outcome of the project. The water charge will be used to maintain the facilities and organizations leading to the sustainability of the project.

(4) Irrigation and Drainage Development Plan

All the irrigation and drainage development projects shall consist of the reinforcement of WUO and the improvement of irrigation facilities. "Farmers participatory approach to the Project" is a key subject as previously explained in Section 4.5.1. Based on this theme, beneficiaries will participate to the design and construction activities as well as full responsibility on O&M works of irrigation systems under WUO.

INDRHI is a governmental executing agency for all the activities of the project implementation. All the irrigation and drainage improvement works are implemented by contract basis under the supervision of INDRHI. WUOs are set up by beneficiaries themselves under full assistance of a local government and INDRHI. For this setting up and reinforcement of WUOs, INDRHI will form a taskforce consisting of specialists for general coordination, institution, water management, operation and maintenance, general affairs, account, and legal aspect.

In the design stage, WUO or the farmer's representatives will participate to the design of the rehabilitation and improvement works in order to incorporate the farmers' desires into the design. WUO and a local government will act as a coordinator in the arrangement of the right of way for the construction of project facilities. Small farmers are expected to participate to the construction of irrigation and drainage facilities as a work force. Beneficiaries under technical assistance from the WUO technical staff or government agencies will construct small facilities such as field canals.

All irrigation and drainage projects will bring about greater irrigation benefits, increase farm income of farmers and improve quality of farmer's life. In addition to these benefits, various secondary and intangible benefits and favorable socioeconomic impacts are expected: increase in employment opportunity, activation of village and regional economy, promotion of agro-industries and commercial activities, improvement of local transportation, improvement of farm products, improvement of the nutritional status of the rural population, etc,.

(i) Night Storage Pond Project

In order to utilize the limited river water resources efficiently, the JICA Study Team recommends the daytime water distribution with the provision of night storage

ponds in the large-scale irrigation systems. The project provides 31 night storage ponds. The total construction cost is estimated at 841.5 million pesos, out of which cost of night storage pond is 419.8 million pesos. Annual irrigation benefit is 318.7 million pesos. The implementation period is 4 years. Internal rate of return is 20 %. The night storage pond project consists of four (4) existing irrigation systems of which improvement works of water management with reinforcement of WUOs are now being performed in PRODAS and/or PROMASIR. Among four (4) systems, J. J. Puello is the most advanced area in the water management executed by beneficiaries themselves under WUO "the Sabaneta Dam Irrigation Committee" for O&M of irrigation and drainage facilities. It is, therefore, recommended that INDRHI construct a night storage pond in one of the lateral canals as a pilot project under PRODAS. The night storage pond needs daily operation of the irrigation systems, which gives water users difficulty in the water management. The objectives of the pilot project is :

- To confirm the training effect to farmers in the operation of the irrigation system with a night storage pond,
- To establish the operation method of the pond carried out by farmers themselves,
- To evaluate the effect of the pond in the water saving,
- To evaluate the pond in relation to the negative impact like water -born diseases.

(ii) Guanito San Juan System Improvement Project

The project provides two (2) night storage ponds and improvement of irrigation canals. The total construction cost is estimated at 75 million pesos. Annual irrigation benefit is 16.3 million pesos. The implementation period is 2 years. Internal rate of return is 14 %. According to the water balance study, river water resources are nearly sufficient for irrigation in the Guanito San Juan area. This result indicates no necessity of urgent improvement works including main canal improvement with provision of lining in the most lower reaches and provision of night storage ponds. If anything, WUO should be established earlier than the physical works, since the irrigation system is relatively functioning well.

(iii) Ysura Area Irrigation Improvement Project

Ysura Canal has to newly supply water from this year to the Biafara and Amiama Gomez irrigation areas in addition to the existing YSURA area. Also, the YSURA extension area can not get sufficient water at present due to poor irrigation facilities and water management. Under such situations, water saving by efficient use of water in the existing YSURA area is essential and urgently needed to allocate water to these new irrigation schemes. In order to realize the efficient use of water besides the reinforcement of YSURA Canal Committee, the project should include (1) improvement and/or replacement of about 180 related structures of canals, (2) rehabilitation of main canal and lateral canal, (3) rehabilitation of Tabara intake and (4) provision of 14 night storage ponds provides 31 night storage ponds. The total cost is estimated at 458.6 million pesos. Annual irrigation benefit is 159.2 million pesos. The

implementation period is 3 years. Internal rate of return is 21 %.

(iv) YSURA Extension Area Development Project

As the irrigation efficiency is improved in the YSURA Canal area and other areas situated in the upstream of the extension area, amount of water allocated to the extension area is expected to increase. Thus the implementation of this project will be laid behind the others. Small-scale groundwater irrigation schemes will be conducted ahead with setting up WUO in accordance with the irrigation needs on the basis of the results of the investigation of groundwater resources carried out by PLANIACAS II. The total cost is estimated at 353.7 million. Annual irrigation benefit is 24.8 million pesos. The implementation period is 3 years. Internal rate of return is 5 %.

(v) YSURA Headrace Small Irrigation System Improvement Project

Farmers are diverting water freely from the head race by pipes installed by themselves all year round even in no water-using period without any payment of water charge. For solving such no control of irrigation water use, present intake facilities should be replaced to permanent intake structures. The total cost is estimated at 51 million pesos. An annual irrigation benefit is 22.4 million pesos. The implementation period is 3 years. Internal rate of return is 24 %. Since much amount of water not used in the area returns back to the Yaque del Sur river, this project is a secondary project from the viewpoint of the importance in water saving. Prior to or at least in parallel to the implementation of the improvement works, INDRHI and beneficiaries should make an agreement to set up WUO of beneficiaries executing water management and maintenance works by themselves in accordance with the instruction of INDRHI. The physical works will be implemented after completion of the YSURA Area Improvement Project.

(vi) Yaque del Sur Lower Reaches Irrigation and Drainage Improvement Project

The Santana irrigation and drainage system that occupies about 60 % of this project area is one of the oldest large-scale irrigation system built in 1916. Much amount of water is wasted through the ruined irrigation system with very poor water management. In this connection, the irrigation and drainage improvement works are the key point to create irrigation water by improvement of irrigation efficiency. The left bank area is served by many small and medium scale pump irrigation systems and one gravity system; the Vicente Noble. The area suffers from water deficit in the river every year and the daily irregular interruption of electric supply. The project provides rehabilitation and improvement of the existing irrigation facilities including Santana head work and construction of 21 night storage ponds and irrigation canals in the left side area of the Yaque del Sur river for replacement of pumping systems.

The total cost is estimated at 2,424.4 million pesos. An annual irrigation benefit is 672 million pesos. The construction period is 7 years. Internal rate of return is 18 %. It is considered that top priority should be put on this project under the condition that the farmers organize WUO prior to the implementation of the improvement works in

order to carry out O&M works by themselves under the full technical assistance from INDRHI.

(vii) Galvan Groundwater Irrigation Project

Since this project are formulated based on the insufficient information, the project should be finalized on the basis of the results of the investigation being carried out by PLANIACAS II, which is expected to be finalized in 1999. In the project, about 20 tube wells will be constructed with provision of small irrigation canals. The total cost is estimated at 65.5 million pesos. An annual irrigation benefit is 25.8 million pesos. The construction period is 3 years. Internal rate of return is 24%. INDRHI assists farmers to make small canals and WUO one by one tube well system.

(viii) Yaque del Sur Small Gravity Irrigation System Improvement Project

Small gravity irrigation systems, of which the most are of free intake type are endowed with sufficient river water in the middle and lower reaches up to the Santana headworks of the Yaque del Sur river. Much amount of excess water diverted but not utilized in their fields probably returns back to the Yaque del Sur river. Taking such a situation into account, the improvement works are not so urgently required and placed behind the other projects. INDRHI should assist farmers to set up WUO and commit O&M works to WUO after the improvement works of the irrigation systems. The project works are composed of (1) construction of intakes with steel slide gates, (2) protection works for main canals and roads against floods and (3) improvement of canals and related structures. The total cost is estimated at 382.1 million pesos. An annual irrigation benefit is 130.6 million pesos. Internal rate of return is calculated at 22 %.

(5) Rural Infrastructure Development Plan

Rural Road Improvement Plan: The project aims to improve and newly construct rural roads with related structures between irrigation systems and villages and among villages and procurement of machinery for maintenance of these roads. The total length of rural roads to be improved and/or newly constructed is about 432 km in the study area. In addition, it is planned that access and farm roads will be installed in the reforestation project and the coffee improvement project proposed in this study. The total construction cost excluding the roads of the projects is estimated at 223 million pesos. These works will be implemented for 10 years under management of SEOPC. After the completion of the project, transportation of farm inputs and outputs are expected to be good even in the rainy season, which will reduce the marketing costs, improve quality of life of the local people and reactivate economy in village and regions.

Rural Water Supply Plan: Service rate of rural water supply in the study area is lower than that of national level. In this plan, it is planned to achieve the service rate of the national level for coming 10 years. The target of rural water supply systems is to construct 10 water supply systems and to provide services to 3000 People. Water sources of the system are seven (7) from river water and three (3) from groundwater. The total construction cost is estimated at 74 million pesos.

Rural Electrification Development Project: After preliminary study of selection of rural electrification development projects, Magueyal mini-Hydropower Development project is proposed. The construction will be done for 6 years. The total construction cost is estimated at 156 million pesos. Possible power generation is expected to be 22 GWh /year. INDRHI is an executing agency for the implementation of the project.

Other Social Infrastructure Improvement Plan: The number of community hall in the study area is insufficient It is proposed that 19-community hall is constructed at municipality level. Also seven (7) offices for water user's associations to be newly established will be constructed for conference and office work of O&M of irrigation facilities. The total construction cost is estimated at 124 million pesos. The construction will be undertaken for 10 years.

(6) Water Resources Development Plan

In San Juan irrigation district, Jose Joaquin Puello dam development project is proposed to optimize the water resources given by Sabaneta dam and to absorb operational losses between the dam and the irrigation areas. José Joaquin Puello dam development project requires technical feasibility study, paying special emphasis on the study of hydrology (optimization of the dam), geological investigations, preliminary design and cost estimate. Budget allocation and/or arrangement will be proceeded in parallel with the study.

Sabana Yegua dam rehabilitation project is considered a promising project that is equivalent to new dam development project of a capacity of 100 MCM. Provided that the project is implemented, the normal operation level will be recovered to the original level that is 10 m higher than the present one. Since major water resource development projects are not expected for Yaque del Sur - Lago Enriquillo irrigation districts, this project is considered as the best alternative of water resources development for the basin. Sabana Yegua Dam Rehabilitation Project of which technical feasibility study is being undertaken will be commenced in the earlier stage among the proposed water resources development projects.

Groundwater projects will start from technical investigations such as pumping tests, development of observation wells, etc. Distribution of wells will be determined according to the results of the investigations, and then detailed design and construction works will be done.

(7) Soil and Water Conservation Plan

Reforestation Plan in the Upper Watershed area of the Grande River: Soil erosion in the Yaque del Sur river basin is critical due to forest degradation and expansion of grassland in the basin which are caused by people's activities. Such areas necessary for soil conservation are very huge. The basic concept of this project is (1) to carry out reforestation and (2) to perform appropriate land use introducing sedentary agriculture. It will be performed as a pilot scheme at first. In the implementation, farmer's participatory approach

should be introduced from the planning stage to the implementation stage. The project covers 720 ha for reforestation in the Rio Grande river basin that is carried out by 720 farmers in 5 villages. It contains formulation of farmer associations, construction of nursery beds and rural roads and monitoring work. The project will be implemented for 5 years. The total cost is estimated at 14.5 million pesos. The results and experiences obtained from this pilot scheme will be applied to the remaining area in the Rio Grande river basin. INDRHI is responsible for the implementation of the project in close cooperation with local administrations.

Wildlife Conservation in Rincon Lagoon: There are several kinds of valuable wildlife species in and around Rincon Lagoon with an area of about 47 Km2. It is said at present that the water level of the lake decreases after the completion of the dam construction in the Yaque del Sur River basin, which may affect environmental change to wildlife. This project aims to identify the environmental change and the situation of wildlife. Monitoring study of fauna and flora in and around Rincon Lagoon takes 10 years. The total cost is estimated at 2.85 million pesos. SURENA and PARQUE will be a executing agency in coordination with INDRHI.

5 SELECTION OF HIGH PRIORITY AREA(S) AND HIGH PRIORITY PROJECT(S)

5.1 General

The Study area is a land area of about 7,100 km^2 covering with the entire basin of the Yaque del Sur river and areas served/or to be served by the water sources of the Yaque del Sur river. Administratively, there are main four provinces such as Azua, Barahona, Bahoruco and San Juan in the Study area, consisting of 29 municipalities and 150 rural sections.

The Study area is defined as the poorest areas in the country. Most of the people are engaged in agriculture and its related activities. With the exception of agriculture, there are no big potential resources to be developed. It is, therefore, principally sound that the agricultural development in the Study area should be properly performed.

The Study area is very large and considerably different on locations from the view point of availability of land resources, climatic conditions, river and groundwater resources, social features, agricultural conditions, economic conditions, extension of irrigation system and so forth. These situations seriously affect local people's life mode, life quality, living standard and so on.

Under such situations, selection of high priority area(s) for development in the Study area should be made for the most depressed areas in viewpoint of the followings:

- Living standard of people
- Access to the social services
- Access to water resources

On the other hand, availability of data and information on the level of municipality and rural sections are very limited and an accurate identification of the characteristics of areas on such levels could not be performed. Therefore, it is considered sound to select priority area(s) on the level of province.

5.2 Factors for Selection

For selection of the high priority area(s), the features of each province will be assessed from the following evaluation factors.

(1) Living standard of people

  (a) Total profit from agriculture per farm household

(2) Access to the social services

  (a) Extension service ratio of potable water
  (b) Medical service
  (c) Illiterate rate

(3) Sociological features

(a) Unemployment

(b) Farm size

(4) Access to water resources

(a) Rainfall

(b) Ratio of areas under irrigation system per flat lands

(c) Irrigation efficiency

It is designed for the evaluation of the features of province that the weighted points are given to each evaluation factors as follows:

Evaluation Factor	Weighted point
(i) Living standard of people	(30)
(1) total income from agriculture per farm household	
(ii) Access to the social services	(15)
(2) extension service ratio of potable water	5
(3) medical service	5
(4) illiterate	5
(iii) Sociological features	(15)
(5) unemployment rate	7.5
(6) farm size	7.5
(iv) Access to water resources	(40)
(7) rainfall	15
(8) ratio of areas under irrigation system per flat land	15
(9) irrigation efficiency	10
Total	100

Each evaluation factor is further graded into as the following table.

Evaluation factor	Grade	Description	Point
1. Total annual farm profit /household: (Due to lack of data about farm household, we estimated farm income based on the profit of irrigated farmers)			30
	Grade-1	Above 50,000 peso	10
	Grade-2	50,000 to 40,000	20
	Grade-3	Less than 40,000 peso	30
2. Extension service ratio of potable water: (comparison with service rate of national level, 67 %)			5
	Grade-1	Above 67%	2.5
	Grade-2	Less than 67%	5
3. Medical service: (comparison with rate of the number of doctors/1,000 people, 0.72 doctors/1000 people)			5
	Grade-1	Above 0.72	2.5
	Grade-2	Less than 0.72	5
4. Illiterate rate: (comparison with illiterate rate of the national level, 21 %)			5
	Grade-1	Less than 21	2.5
	Grade-2	Above 21	5
5. Unemployment rate: (comparison with unemployment rate of the national level, 18 %)			7.5
	Grade-1	Less than 18%	3
	Grade-2	Above 18 %	7.5
6. Farm size: (we use farm size for the farmers in the existing irrigation systems due to shortage of data)			7.5
	Grade-1	Above 3 ha	3
	Grade-2	Less than 3 ha	7.5
7. Rainfall: (annual rainfall of 500 mm is the boundary of dry and semi-dry climate indicating possibility of crop selection, and/or rate of annual evapotranspiration/annual rainfall is 4)			15
	Grade-1	Above 500 mm	5
	Grade-2	Less than 500 mm	15
8. Rate of irrigated area/Arable land: (rate of irrigation area /arable land classified into 2, 3 and 4 classes in USDA classification			15
	Grade-1	Above 60	5
	Grade-2	30-60	10
	Grade-3	Less than 30	15
9. Present irrigation efficiency: (present irri. efficiency is set as efficiency for estimate of present irrigation water requirement for upland crops)			10
	Grade-1	Above 30 %	5
	Grade-2	Less than 30 %	10

5.3 Selection of High Priority Area(s)

Based on the selection criteria, four provinces are evaluated as follows:

Evaluation factors	Azua province			San Juan province			Barahona province			Baboruco province		
	figure	grade	weighted point	figure	grade	weighted point	figure	grade	weighted point	figure	grade	weighted point
(1) total annual farm profit per household (1000peso)	52.6	1	10	41.3	2	20	35	3	30	35	3	30
(2) extension service ratio of potable water (%)	61	2	5	44	2	5	69	1	2.5	53	2	5
(3) medical service(no. of doctor/1,000 people)	0.14	2	5	0.06	2	5	0.3	2	5	0.09	2	5
(4) illiterate rate (%)	36	2	5	35	2	5	28	2	5	36	2	5
(5) unemployment rate (%)	48	2	7.5	48	2	7.5	35	2	7.5	49	2	7.5
(6) farm size (ha)	1.73	2	7.5	3.48	1	3	1.57	2	7.5	1.57	2	7.5
(7) annual rainfall (mm/year)	660	1	5	930	1	5	460	2	15	470	2	15
(8) rate of irrigated area per arable land (%)	84	1	5	92	1	5	40	2	10	18	3	15
(9) present irrigation efficiency (%)	31-32	1	5	30-40	1	5	32-35	1	5	28	2	10
Total points			55			60.5			87.5			100

The above table indicates that Bahoruco province has the highest scores of 100 points, following Barahona (87.5 points), San Juan (60.5 points) and Azua (55 points). Among provinces, the higher two provinces of Bahoruco and Barahona have been selected as high priority areas.

5.4 Selection of Project for Feasibility Study

As mentioned in the basic development concept, development includes agriculture in the hilly and the flat area. The selected area (in Bahoruco and Barahona provinces) lies in the semi-arid zone with little rainfall, where most of farmers are therefore engaged in the irrigated agriculture.

Since the most important crop in the selected area is plantain, the most important matter is to increase and stabilize its production for the stable farm management and improvement of farmer's lives. For that purpose, the limited water resources should be utilized effectively under the pressure to the water. Consequently, the feasibility study is carried out, proposing model integrated rural development projects, of which main components are improvement of the existing irrigation system and establishment and strengthening of the water user's organization.

Agricultural land is extended along the Yaque del Sur river in the selected area. The land between Los Guiros and Santana headworks receives sufficient water and therefore the development for this area is not considered very urgent. The lower reaches of Santana headworks are the most serious area suffering from the chronic water shortage caused by the deteriorated facilities and suspension of the pump operation due to the continual power cut. On the other hand, the selected area is the most depressed area in terms of the living conditions of the villagers. Accordingly, the feasibility study is to be conducted for this selected area of about 6,000 ha. The area under the sugar corporation is however excluded from the area of the feasibility study.

Villarpando weir has difficulties to control water due to the structural disadvantage and deteriorated gates at present. Agricultural development in the selected area requires more precise discharge control at Villarpando, therefore the feasibility study will include the rehabilitation of the Villarpando headworks and water distribution program.

Tables

Table 1.3.1 List of Counterparts and JICA experts

Name	Official Position
Counterparts	
Gilberto Reynoso	Chief Counterpart,
Rafaela Lima	Infrastructure engineer, INDRHI
José Ogando Montero	Agronomist, INDRHI
Nelson E. De Los Santos Mateo	Structural engineer, INDRHI
Mayra A. Sánchez Santana	Hydrologist, INDRHI
Yasiris González Pineda	Environmentalist, INDRHI
Alice E. Bautista R.	Sociologist, INDRHI
Sergio J. Tejada R.	Irrigation and drainage engineer, INDRHI
Felipe Felix	Infrastructure engineer, IAD
Martha Corsino	Infrastructure engineer, IAD
Antonis Mesa	Agronomist, SEA
JICA experts	
Kenjiro Onaka	Team leader
Hiroyosi Matsuura	Irrigation and drainage engineer
J. Delos Santos	Agricultural support expert
Luis Rosado	Agronomist
Nobuo Sambe	Hydrologist
Kunita Okuwa	Infrastructure engineer
Fumiaki Murakami	Structural engineer
Masahiro Ichikawa	Environmentalist

Table 2.1.1 The Dominican Republic: Gross Domestic Product by Origin, 1992-1997

(Unit : million of RD$, constant price of 1970)

SECTORS	1992		1993		1994	
	Value	%	Value	%	Value	%
Agriculture	554.5	13.6	558.4	13.3	548.5	12.5
Mining	95.3	2.3	61.0	1.5	114.8	2.6
Manufacture	772.0	18.9	788.3	18.8	810.8	18.5
Construction	352.3	8.6	387.9	9.2	413.6	9.4
Commerce	501.7	12.3	505.2	12.0	512.8	11.7
Hotels, Bar & Rest.	180.0	4.4	218.3	5.2	251.0	5.7
Transport	274.3	6.7	287.5	6.8	293.3	6.7
Communications	107.7	2.6	119.2	2.8	133.7	3.1
Electricity and Water	75.9	1.9	87.7	2.1	91.0	2.1
Finance	224.3	5.5	222.1	5.3	222.8	5.1
Housing	230.3	5.7	232.4	5.5	234.7	5.4
Government	361.2	8.9	372.4	8.9	386.2	8.8
Other Services	346.2	8.5	357.3	8.5	366.9	8.4
TOTAL GDP	4,075.7	100.0	4,197.7	100.0	4,380.1	100.0

SECTORS	1995		1996		1997	
	Value	%	Value	%	Value	%
Agriculture	581.4	12.7	636.7	12.9	674.6	12.7
Mining	125.6	2.7	128.6	2.6	137.5	2.6
Manufacture	805.3	17.6	838.8	17.0	897.6	17.0
Construction	437.2	9.5	494.0	10.0	568.1	10.7
Commerce	556.9	12.1	607.0	12.3	658.1	12.4
Hotels, Bar & Rest.	292.7	6.4	325.6	6.6	359.0	6.8
Transport	310.6	6.8	335.5	6.8	362.0	6.8
Communications	159.7	3.5	185.7	3.8	214.1	4.0
Electricity and Water	87.3	1.9	96.3	2.0	102.6	1.9
Finance	224.6	4.9	228.8	4.6	235.3	4.4
Housing	238.7	5.2	242.5	4.9	247.4	4.7
Government	387.7	8.4	409.8	8.3	421.7	8.0
Other Services	380.9	8.3	395.7	8.0	413.5	7.8
TOTAL GDP	4,588.6	100.0	4,925.0	100.0	5,291.5	100.0

Source: Banco Central de la Republica Dominicana, Informe de la Economia Dominicana, 1997

Table 2.1.2 The Dominican Republic: Main Imports

(Unit ; Millions of US$)

ITEM	1994	1995	1996
TOTAL IMPORTS	2,563.1	2,786.4	3,216.0
Petroleum	521.7	604.9	776.9
Durable Goods	405.0	297.6	297.2
Medical & Pharmaceutical products	66.5	72.4	93.4
Capital Goods	410.5	340.0	368.5
Agricultural and Forestry products			
Food Products	116.3	186.5	186.8
Milk	50.7	64.3	81.0
Corn	17.5	57.9	61.4
Wheat	39.1	50.4	35.8
Cooking oil	4.1	39.4	53.4
Rice	0.2	10.7	2.6
Woods products	48.3	51.8	55.2
Raw material for agriculture	42.1	77.2	76.6

Source : Central Bank. Quarterly Bulletin, July - September 1997.

Table 2.1.3 The Dominican Republic: Main Exports, 1993-1996

(Millions of US$)

Item	1993	1994	1995	1996
TOTAL	511.52	644.03	766.67	821.39
Sugar	111.66	144.66	131.98	169.36
Coffee	20.47	63.20	81.92	64.85
Cacao	32.95	55.73	59.50	65.01
Tobacco	15.21	22.27	27.33	43.58
Minerals	132.20	201.65	286.94	271.05
Other Agriculture	56.31	53.60	45.40	48.50
Other Industory	24.04	22.27	39.13	49.11
Non Ttraditional Agriculture	56.31	53.63	45.41	48.51
Banano	11.95	16.57	9.92	12.03
Coconut	4.99	4.99	5.85	6.57
Avocado	3.12	2.13	2.93	3.79
Yautia	2.93	3.08	3.97	5.20
Melons	0.89	1.33	3.37	3.51
Pineapple	7.22	4.07	3.69	3.45
Sweet Potato	1.59	1.62	2.14	2.82
Plantain	0.20	0.18	0.23	2.32
Oranges	2.11	2.49	2.91	2.91
Green Pepper	0.90	0.76	1.09	1.07
Cut Flowers	2.17	2.21	1.93	1.72
Beef	13.50	9.50	3.20	-
Others	4.74	4.70	4.17	3.12
Other Item	62.37	27.03	49.07	61.42

Source : Central Bank, Statistical Bulletin, 1997

Table 2.3.1. Dominican Republic: Main Health Problems in the Study Area

CAUSES	AREA		
	AZUA	SAN JUAN DE LA MAGUANA	BAHORUCO
1.- Labor	4,673	5,630	1,740
2.- Diarrhea	3,095	2,839	571
3.- Respiratory infections	2,563	2,449	442
4.- Blood pressure	1,466	1,928	9
5.- Accidents	90	1,505	116
6.- Unknown fever	-	1,415	-
7.- Tifus fever	320	214	-
8.- Severe malnutrition	320	715	157
9.- Severe Anemia		712	112
10.-Urinary infections	348	104	10
11.-Others	3,662	5,811	1,243
TOTAL	16,537	23,322	4,400

CAUSES	AREA	
	BARAHONA	INDEPENDENCIA
1.- Labor	4,395	457
2.- Diarrhea	1,978	275
3.- Respiratory infection	1,417	312
4.- Abortion	779	30
5.- Accidents	544	79
6.- High blood pressure	245	112
7.- Alergies	290	90
8.- Intoxication	42	118
9.- Tifus fever	53	152
10.-Urinary infection	140	134
11.- Others	2,179	350
	12,062	2,109

Table 3.1.1 Population in the Study Area

	NUMBER OF HOUSEHOLD	POPULATION	MEN	WOMEN	ILLITERACY (%)
BARAHONA PROVINCE					
PROVINCE TOTAL	**39,001**	**164,835**	**85,359**	**79,476**	**28.60**
BARAHONA	15,489	66,145	32,856	33,289	
VICENTE NOBLE	4,220	17,937	9,539	8,398	
CABRAL	3,005	12,576	6,480	6,096	
EL PENON	1,747	7,639	3,968	3,671	
FUNDACION	1,664	7,242	3,744	3,498	
BAHORUCO PROVINCE					
PROVINCE TOTAL	**24,449**	**101,742**	**52,031**	**49,711**	**36.00**
NEIBA	4,598	19,132	9,577	9,555	
GALVAN	3,170	13,834	7,290	6,544	
TAMAYO	4,108	18,912	9,686	9,226	
UVILLA	3,768	14,613	7,494	7,119	
AZUA PROVINCE					
PROVINCE TOTAL	**45,806**	**194,209**	**100,560**	**93,649**	**36.10**
AZUA DE COMPOSTELA	16,387	72,642	36,492	36,150	
GUAYABAL	2,325	8,973	4,910	4,063	
LAS CHARCAS	2,584	9,534	4,873	4,661	
LAS YAYAS DE BIAJAMA	2,943	11,472	6,167	5,305	
PADRE LAS CASAS	6,303	25,881	13,366	12,515	
PERALTA	3,780	12,847	6,551	6,296	
SABANA YEGUA	2,428	10,732	5,681	5,051	
TABARA ARRIBA	3,274	14,621	8,070	6,601	
ESTEBANIA	1,387	5,958	3,097	2,861	
PUEBLO VIEJO	4,395	21,549	11,403	10,146	
SAN JUAN PROVINCE					
PROVINCE TOTAL	**57,032**	**247,029**	**128,589**	**118,440**	**35.40**
SAN JUAN	29,055	129,167	66,519	62,648	
BOHECHIO	2,413	9,417	5,004	4,413	
JUAN DE HERRERA	4,236	16,825	8,964	7,861	
VALLEJUELO	3,099	14,091	7,629	6,462	
INDEPENDENCIA PROVINCE					
PROVINCE TOTAL	**9,510**	**38,185**	**19,908**	**18,277**	**34.10**
JIMANI	1,919	8,147	4,150	3,997	
MELLA	662	2,395	1,245	1,150	
CRISTOBAL	1,408	4,835	2,571	2,264	
LA VEGA PROVINCE					
PROVINCE TOTAL	**78,400**	**335,140**	**170,633**	**164,507**	
CONTANZA	12,147	52,902	27,560	25,342	
Total	**142,514**	**610,018**	**314,886**	**295,182**	

Source: 7th National Census on Household and Population

Table 3.2.1 Main Characteristics of Soil Associations in the Study Area

Name of Soil Association	Relief	Soil Depth	Natural Drainage	Texture	Natural Fertility
Valle Nuevo	Very Ondulated	Shallow; Rocky	Well to excessive	Mostly Clay	Low
San Juan Hatico	Slightly slooping to Flat	Moderately deep to Deep	Slow internal drainage	Silty Clay and Silty Loam	Medium to High
Quita Coraza	Very variable from almost flat to undulating	Very shallow and Moderately deep	Well	Mostly sandy	Mostly Low, some area medium
Azua Plain	Flat to slightly slooping	Very largely from deep to Shallow	Vary from Well to imperfect drainage	Loam, Sandy Loam, and Clay loam	Low to Medium
Elias Piña Las Matas	Irregular	Shallow to medium	Slow to imperfect	Mostly Clay	Medium to Low
La Jima-Yuma	Flat to slightly sloping	Mostly Deep	Well to imperfet	Mostly Clay	Medium
Cacheo	Very irrigular, undulating	Shallow	Well to excessive	Sandy, and Silty loam	Low to very low
Guama	Undulating	Shallow	Well to imperfect	Vary from Sandy to Clay	Low to very low
Constanza	Sligthly sloping to Flat	Moderately deep	Moderately well	Loam and Clay loam	Medium to high
Guanita	Shallow	Ondulating	Well to excesively	Loamy clay	Low
Guanito-Villarpanda	Flat, and sligth slope	Shallow	Well to excessive	Sandy, Sandy clay	Very low
Yabonico	Undulated	Shallow	Well drained	Sandy clay	Low
Recent Alluvium	Flat	Vary from Shallow to deep	Very from well to imperfect	Mainly is siltloam, there are sandy, Clay	Medium to low
Cienegas Costeras e Interior	Flat		Very poor		Very low
Terrenos Escabroso Calcareous and none Calcareous	Undulated	Shallow	Vary from excessive to imperfect	Vary variable	Low

Table 3.2.2 Results of Laboratory Analysis of Soil Samples (1/2)

(1) Soils of Azua Extension Area

Sampling Site	Pueblo Viejo 1-1		Pueblo Viejo 1-2		Pueblo Viejo 2		Lateral 6-1		Lateral 6-2		Finca 3-1	
Soil Depth (cm)	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60
Organic Carbon (%)	1.33	1.16	1.28	1.13	0.52	0.29	1.33	0.35	1.22	0.28	1.39	0.81
Total Nitrogen (%)	0.42	0.41	0.40	0.38	0.35	0.45	0.48	0.44	0.41	0.38	0.46	0.44
pH in Water (1:2)	8.1	8.3	8.5	8.6	8.5	8.7	8.4	8.5	8.1	8.3	8.4	8.6
Electric Conductivity (mmhos/cm)	2.10	1.23	2.70	1.26	2.06	1.18	3.50	1.33	3.10	1.10	2.86	1.5
Available Phosphorous (ppm)	9.00	20.0	11.00	21.00	4.00	4.00	10.0	4.0	8.6	3.8	15	6
Potassium (meq/100ml)	0.11	0.62	0.13	0.71	0.60	0.52	0.58	0.13	0.56	0.10	0.55	0.26
Calcium (meq/100ml)	29.4	13.6	32.1	14.3	8.24	11.60	10.60	7.71	9.50	7.23	11.8	15.5
Magnesium (meq/100ml)	4.60	2.64	5.10	3.10	4.69	7.23	2.54	2.24	2.48	2.17	2.29	3.59
Sodium (meq/100ml)	0.18	0.77	0.21	0.83	3.19	2.13	2.75	3.16	2.61	2.98	3.33	3.51
Cation Exchange Capacity (CEC)	34.3	17.6	32.5	17.9	16.7	21.5	16.50	13.20	15.90	13.00	18	22.9
Calcium Carbonate (%)	7.3	26.3	9.1	27.7	32.2	33.4	21.9	25.1	20.2	24.6	27.8	26.6
Soil Particles distribution												
Clay (C) (%)	10	16	11	14	28	12	16	10	16	10	12	20
Silt (S) (%)	70	70	68	62	44	54	72	62	72	62	76	70
Sand (s) (%)	20	14	19	24	28	34	12	28	12	28	12	10
Textural Class	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL	SL

(2)Neyba Valley

Sampling Site	Finca 3-2		Finca 3-3		Rosario-1		Rosario-2		Rosario-3		Aguacatico 1	
Soil Depth (cm)	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60
Organic Carbon (%)	1.33	0.92	1.45	1.10	1.33	0.23	2.44	0.48	1.72	0.32	0.58	0.29
Total Nitrogen (%)	0.42	0.45	0.50	0.50	0.49	0.45	0.45	0.40	0.47	0.43	0.43	0.44
pH in Water (1:2)	8.2	8.6	8.1	8.5	8.0	9.6	9.3	9.6	8.4	8.5	8	8.2
Electric Conductivity (mmhos/cm)	2.55	1.26	2.75	1.32	0.42	0.78	3.28	4.50	1.80	2.10	0.26	0.74
Available Phosphorous (ppm)	12.00	5.0	13.00	5.00	17.00	5.00	15.0	4.0	15.0	5.0	5	3
Potassium (meq/100ml)	0.49	0.22	0.44	0.21	0.46	0.46	0.70	0.52	0.61	0.49	0.14	0.1
Calcium (meq/100ml)	11.1	14.3	10.7	12.7	7.58	5.75	5.35	5.80	6.60	6.20	6.62	6.7
Magnesium (meq/100ml)	2.13	3.10	2.05	2.95	2.45	3.44	2.53	3.28	2.49	2.95	1.17	3.76
Sodium (meq/100ml)	2.98	2.71	2.85	2.98	0.52	3.75	8.35	8.82	5.40	6.50	2.51	0.5
Cation Exchange Capacity (CEC)	17.4	20.9	16.7	20.3	11.0	13.4	16.90	18.10	14.90	16.30	10.4	11.1
Calcium Carbonate (%)	25.9	27.7	23.8	22.5	28.5	34.0	23.7	27.7	25.1	29.5	28.6	35
Soil Particles distribution												
Clay (C) (%)	13	17	15	11	14	50	56	17	15	11	24	24
Silt (S) (%)	74	68	69	69	66	26	24	68	69	69	50	56
Sand (s) (%)	13	15	14	20	20	24	20	15	14	20	26	20
Textural Class	SL	SL	SL	sL	SL	C	C	SL	SL	sL	SL	SL

(2) Soils of Neyba Valley Area

Sampling Site	Aguacatico 2		Aguacatico 3		Aguacatico 4		Aguacatico 5		Aguacatico 6		Baitoa Seca 1	
Soil Depth (cm)	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60
Organic Carbon (%)	0.87	0.29	0.87	0.52	0.90	0.33	0.66	0.40	0.88	0.52	1.16	0.52
Total Nitrogen (%)	0.44	0.42	0.44	0.41	0.44	0.40	0.43	0.43	0.40	0.38	0.48	0.54
pH in Water (1:2)	8.2	8.3	8.3	8.5	8.1	8.4	8.1	8.0	8.3	8.2	7.5	7.8
Electric Conductivity (mmhos/cm)	0.90	1.93	0.96	3.16	1.40	1.93	0.80	2.10	0.96	3.16	32.5	14.6
Available Phosphorous (ppm)	4.00	2.0	4.00	5.00	6.00	2.00	4.0	3.0	4.0	5.0	4.00	3.00
Potassium (meq/100ml)	0.06	0.12	0.14	0.05	0.08	0.12	0.12	0.10	0.14	0.05	0.61	0.30
Calcium (meq/100ml)	6.5	3.1	18.1	17.5	6.50	3.14	7.20	6.10	18.10	17.50	31.0	20.50
Magnesium (meq/100ml)	3.13	1.56	1.70	3.33	3.13	1.56	2.10	3.35	1.70	3.33	9.60	6.13
Sodium (meq/100ml)	0.88	0.91	1.66	3.69	0.88	0.91	2.20	1.20	1.66	3.69	13.3	7.25
Cation Exchange Capacity (CEC)	10.5	5.7	21.6	24.6	11.2	5.7	11.60	10.80	20.70	18.60	54.5	34.2
Calcium Carbonate (%)	28.0	26.3	18.4	21.6	27.0	26.3	24.3	27.4	18.4	21.6	25.1	35.4
Soil Particles distribution												
Clay (C) (%)	28	38	42	28	28	38	30	34	42	38	14	12
Silt (S) (%)	50	38	40	45	50	38	48	52	40	45	58	54
Sand (s) (%)	22	24	18	16	22	24	22	14	18	16	28	34
Textural Class	LC	LC	C	LSC	LC	LC	LC	LC	SC	LSC	LS	FL

Sampling Site	Baitoa Seca 2		Baitoa Seca 3		Baitoa Seca 4		Baitoa Seca 5		Baitoa Seca 6		Salado 1	
Soil Depth (cm)	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60
Organic Carbon (%)	1.10	0.52	1.39	0.58	0.81	0.46	1.18	0.96	1.10	0.90	1.5	0.4
Total Nitrogen (%)	0.40	0.41	0.47	0.41	0.48	0.52	0.44	0.40	0.40	0.40	0.45	0.4
pH in Water (1:2)	8.6	8.5	8.1	7.9	8.4	8.4	8.2	8.1	7.9	8.2	8.2	8.4
Electric Conductivity (mmhos/cm)	0.71	0.90	3.08	4.62	1.42	1.73	2.60	3.20	2.06	1.18	7.9	4.8
Available Phosphorous (ppm)	10.0	11.0	10.0	3.00	7.00	3.00	8.0	3.0	6.0	3.0	10	8
Potassium (meq/100ml)	0.10	0.22	0.23	0.07	0.09	0.08	0.33	0.07	0.11	0.09	0.26	0.1
Calcium (meq/100ml)	14.0	15.0	15.1	13.9	11.10	8.10	13.40	10.80	12.80	11.10	18.8	15.3
Magnesium (meq/100ml)	3.93	2.57	4.28	4.64	1.58	2.64	1.30	3.10	2.90	3.10	5.3	6.2
Sodium (meq/100ml)	1.54	2.03	2.06	2.62	3.52	2.51	3.10	2.80	3.19	2.20	1.9	2.8
Cation Exchange Capacity (CEC)	19.6	19.8	21.7	21.2	16.3	13.4	17.80	16.90	18.90	16.40	26.5	24.6
Calcium Carbonate (%)	16.1	9.34	13.1	13.1	36.5	16.9	16.2	14.3	18.3	15.5	15.7	12.4
Soil Particles distribution												
Clay (C) (%)	30	30	20	10	40	28	29	14	28	30	13	22
Silt (S) (%)	54	56	56	80	26	60	56	62	44	48	57	58
Sand (s) (%)	16	14	24	10	34	12	15	24	28	22	30	20
Textural Class	LSC	LSC	SL	SL	C	SL	LSC	SL	SL	SL	sL	SL

Table 3.2.2 Results of Laboratory Analysis of Soil Samples (2/2)

(2) Soils of Neyba Valley Area

Sampling Site	Salado 2		Salado 3		Salado 4		Grajos 1		Grajos 2		Grajos 3	
Soil Depth (cm)	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60
Organic Carbon (%)	1.30	0.30	1.45	0.44	1.35	0.39	1.62	0.46	1.86	0.41	0.35	0.23
Total Nitrogen (%)	0.44	0.40	0.40	0.40	0.44	0.42	0.45	0.43	0.51	0.41	0.40	0.40
pH in Water (1:2)	8.4	8.6	8.2	8.3	8.0	8.2	7.8	8.0	7.8	8.1	8.9	8.9
Electric Conductivity (mmhos/cm)	7.30	6.43	6.8	6.10	7.60	4.50	10.1	6.25	9.90	6.81	0.40	0.48
Available Phosphorous (ppm)	14.00	5.0	10.0	12.00	11.0	7.00	12.0	8.00	15.0	6.00	5.00	3.00
Potassium (meq/100ml)	0.40	0.42	0.34	0.29	0.40	0.35	0.10	0.05	0.10	0.02	0.17	0.09
Calcium (meq/100ml)	14.6	11.4	16.1	12.4	14.70	11.20	19.6	15.6	16.6	8.42	5.38	10.8
Magnesium (meq/100ml)	5.80	6.35	5.7	6.00	5.70	6.40	6.34	7.62	3.38	1.69	1.95	3.28
Sodium (meq/100ml)	1.40	1.96	1.70	1.85	1.65	2.70	1.90	2.60	1.80	1.80	0.66	0.78
Cation Exchange Capacity (CEC)	22.3	20.1	23.8	20.4	22.50	20.8	27.9	25.9	21.9	11.9	8.16	15.0
Calcium Carbonate (%)	16.2	20.4	17.1	17.9	15.1	13.7	17.3	24.2	15.5	15.9	11.4	19.0
Soil Particles distribution												
Clay (C) (%)	12	18	10	16	16	17	6	26	6	14	14	30
Silt (S) (%)	74	53	78	50	72	64	6	56	72	28	11	48
Sand (s) (%)	14	19	12	24	12	19	88	18	22	58	75	22
Textural Class	SL	LC	SL	SCL	SL	SL	s	SL	S	Ls	Ls	LC

Sampling Site	Grajos 4		Grajos 5		Grajos 6		Guaraguao 1		Guaraguao 2		Guaraguao 3	
Soil Depth (cm)	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60
Organic Carbon (%)	1.25	0.35	0.82	0.32	1.43	0.42	1.45	0.35	1.16	0.99	1.57	0.46
Total Nitrogen (%)	0.44	0.41	0.42	0.40	0.44	0.40	0.58	0.55	0.44	0.44	0.44	0.49
pH in Water (1:2)	8.0	8.0	8.2	8.4	8.1	8.3	7.8	8.2	8.1	8.2	7.8	8.4
Electric Conductivity (mmhos/cm)	4.50	3.20	5.10	4.70	9.6	5.80	9.19	6.43	2.40	3.76	15.9	8.43
Available Phosphorous (ppm)	7.0	4.0	8.0	6.0	10.0	7.00	18.0	6.00	21.0	11.0	10.0	6.00
Potassium (meq/100ml)	0.13	0.06	0.11	0.07	0.12	0.06	0.48	0.49	0.50	0.40	0.50	0.35
Calcium (meq/100ml)	10.60	11.30	9.50	8.60	18.8	15.4	14.4	11.2	13.0	11.0	19.9	12.4
Magnesium (meq/100ml)	4.53	5.20	3.68	3.80	6.28	7.56	5.76	6.71	5.10	4.81	13.3	6.03
Sodium (meq/100ml)	1.32	1.75	1.23	1.21	1.90	2.60	1.35	2.00	2.31	3.44	11.7	7.35
Cation Exchange Capacity (CEC)	16.60	18.20	14.50	13.60	27.2	25.6	22.0	20.4	20.9	19.7	45.4	26.1
Calcium Carbonate (%)	15.1	18.8	14.6	15.2	16.3	23.4	15.9	22.4	15.5	19.4	18.8	17.9
Soil Particles distribution												
Clay (C) (%)	12	10	16	10	7	24	8	68	32	66	10	66
Silt (S) (%)	9	62	72	62	6	56	78	22	54	24	78	26
Sand (s) (%)	79	28	12	28	87	20	14	10	14	10	12	8
Textural Class	s	SL	SL	sL	s	C	SL	C	SCL	C	SL	C

(2) Soils of Neyba Valley Area

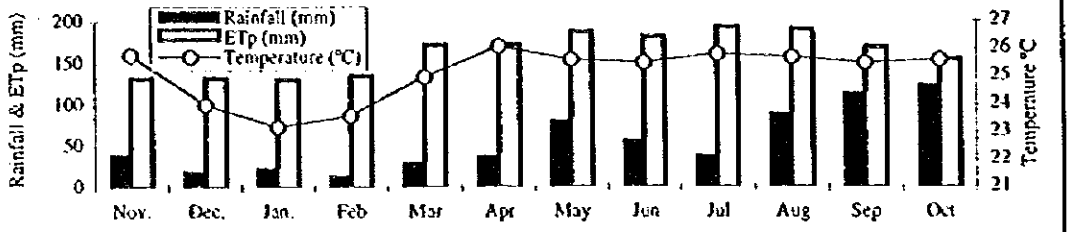
Sampling Site	Guaraguao 4		Guaraguao 5		Guaraguao 6		Guaraguao 7		Mella 1		Mella 2	
Soil Depth (cm)	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60
Organic Carbon (%)	1.35	0.39	1.50	0.40	1.30	0.30	1.42	0.40	1.16	0.46	1.91	0.46
Total Nitrogen (%)	0.46	0.43	0.45	0.40	0.44	0.40	0.40	0.40	0.38	0.33	0.47	0.43
pH in Water (1:2)	8.0	8.3	8.2	8.4	8.4	8.6	8.0	8.2	8.4	8.0	7.8	8.1
Electric Conductivity (mmhos/cm)	7.30	4.70	7.90	4.80	7.30	6.43	6.80	6.30	0.31	1.60	0.46	5.13
Available Phosphorous (ppm)	15.0	7.0	10.00	8.00	14.00	5.00	12.0	7.0	11.0	6.0	24.0	4.0
Potassium (meq/100ml)	0.50	0.43	0.26	0.10	0.40	0.42	0.31	0.28	0.22	0.18	0.24	0.11
Calcium (meq/100ml)	14.60	11.70	18.8	15.3	14.60	11.40	15.70	13.30	12.70	15.60	14.30	12.90
Magnesium (meq/100ml)	5.80	6.60	5.30	6.20	5.80	6.35	6.10	6.40	1.76	2.61	1.50	3.55
Sodium (meq/100ml)	1.23	2.90	1.90	2.80	1.40	1.96	1.60	2.40	0.26	0.41	0.18	3.40
Cation Exchange Capacity (CEC)	22.20	21.60	26.5	24.6	22.3	20.1	23.80	22.30	14.9	18.8	16.2	20.0
Calcium Carbonate (%)	14.6	15.2	15.7	12.4	16.2	20.4	15.9	18.5	12.7	17.0	9.1	17.3
Soil Particles distribution												
Clay (C) (%)	16	10	13	22	12	55	13	11	34	36	24	54
Silt (S) (%)	72	62	57	58	74	28	57	53	32	44	54	32
Sand (s) (%)	12	28	30	20	14	17	30	36	28	20	22	14
Textural Class	SL	SL	Ls	SL	SL	C	SL	SL	LC	SLC	SL	C

Sampling Site	Mella 3		Charco 1		Charco 2		Charco 3		Charco 4		Charco 5	
Soil Depth (cm)	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60	0 to 30	30 to 60
Organic Carbon (%)	0.35	0.23	1.30	0.40	1.42	0.37	1.18	1.00	1.57	0.45	1.35	0.39
Total Nitrogen (%)	0.40	0.40	0.45	0.45	0.55	0.50	0.45	0.40	0.44	0.49	0.46	0.48
pH in Water (1:2)	8.9	8.9	8.3	8.5	7.9	8.3	8.0	8.2	7.8	8.4	8.2	8.4
Electric Conductivity (mmhos/cm)	0.40	0.48	4.30	5.80	8.40	5.80	2.50	3.00	15.9	8.43	7.3	4.70
Available Phosphorous (ppm)	5.0	3.00	12.10	5.00	16.0	5.00	19.0	10.0	10.0	6.00	14.6	7.20
Potassium (meq/100ml)	0.17	0.09	0.12	0.09	0.43	0.50	0.50	0.40	0.50	0.35	0.48	0.43
Calcium (meq/100ml)	5.38	10.8	15.20	11.80	12.8	11.2	12.2	10.8	19.9	12.4	14.4	10.9
Magnesium (meq/100ml)	1.95	3.28	5.50	6.30	4.70	6.71	4.70	4.65	13.3	6.03	5.8	6.60
Sodium (meq/100ml)	0.66	0.78	1.30	2.70	1.64	2.00	2.31	3.40	11.7	7.35	1.2	2.90
Cation Exchange Capacity (CEC)	8.16	15.0	23.2	21.1	19.5	18.4	17.9	18.7	45.4	26.1	21.8	20.8
Calcium Carbonate (%)	11.4	19.0	17.2	20.3	15.9	21.4	14.8	18.0	18.8	17.9	14.1	14.9
Soil Particles distribution												
Clay (C) (%)	14	30	14	50	8	68	32	66	10	66	16	64
Silt (S) (%)	11	48	66	26	78	22	54	24	78	26	72	26
Sand (s) (%)	75	22	20	24	14	10	14	10	12	8	12	10
Textural Class	Ls	LC	SL	C	SL	C	SCL	C	SL	C	SL	C

Table 3.2.3 Climatic Features in the Study Area

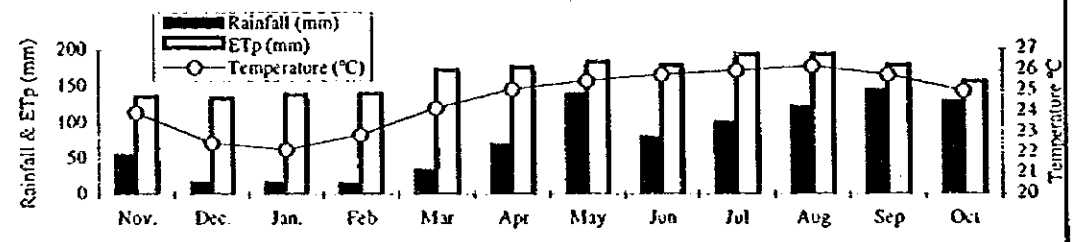
Climatic Data of Azua Irrigation Area

Month	Nov.	Dec.	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Rainfall (mm)	40	19	23	14	30	38	80	57	38	88	113	123	663
ETp (mm)	131	131	130	134	171	171	186	180	192	189	168	154	1937
Temperature (°C)	25.8	24	23.2	23.6	25	26.1	25.6	25.5	25.8	25.7	25.5	25.6	
Relative Humidity (%)													



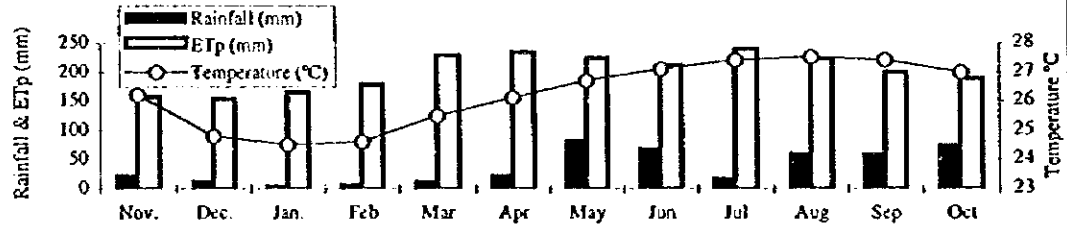
Climatic Data of San Juan Irrigation Area

Month	Nov.	Dec.	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Rainfall (mm)	56	17	17	16	34	70	140	81	101	123	146	130	931
ETp (mm)	135.4	133.6	138.2	140	172	175	183	178	192.5	193	177.5	155.2	1973.4
Temperature (°C)	24	22.5	22.2	22.9	24.2	25.1	25.5	25.8	26	26.2	25.8	25	
Relative Humidity (%)	73.3	71.2	70.4	69.1	67.8	69.5	73.3	71.1	69.1	69.6	71.9	74.2	
Wind Speed (km/day)	60.1	58.2	58.6	58.2	57.7	58.1	61	61	57.8	58.5	61.1	62.6	



Climatic Data of Lago Enriquillo Irrigation District, Neyba Area

Month	Nov.	Dec.	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Rainfall (mm)	33.4	22.4	9.4	10.3	20.9	39.7	61.1	60	26	59.1	59.4	64.4	466
ETp (mm)	140.3	133.4	136.6	135.7	178	181.9	196.8	182.9	190.3	188.5	180.3	165	2010
Temperature (°C)	25.3	25.3	24.9	25	25.5	26.2	26.8	27.4	28	28	27.5	26.7	
Relative Humidity (%)	75.1	72.8	73.2	72.8	72.1	72.6	76.2	76.3	72.2	73.1	76.4	78.3	
Wind Speed (km/day)	222.7	228.5	249.6	278.4	303.4	299.5	276.5	284.2	297.6	278.4	253.4	228.5	



Climatic Data of Vaque del Sur Irrigation District, Batey 3, Barahona

Month	Nov.	Dec.	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Rainfall (mm)	24.1	13.2	5.9	8.6	13.6	23.2	83.8	69	18.9	59.5	60	75.2	455
ETp (mm)	156.8	153.8	164.7	177.6	228	234	223.2	210.4	238.7	222.4	199	188	2396.6
Temperature (°C)	26.2	24.8	24.5	24.6	25.5	26.1	26.7	27.1	27.4	27.5	27.4	27	
Relative Humidity (%)	73	71.7	71.2	69.9	69.2	69.6	75.1	74.4	70.7	71.8	73.8	73.8	
Wind Speed (km/day)	222.7	228.5	249.6	278.4	303.4	299.5	276.5	284.2	297.6	278.4	253.4	228.5	

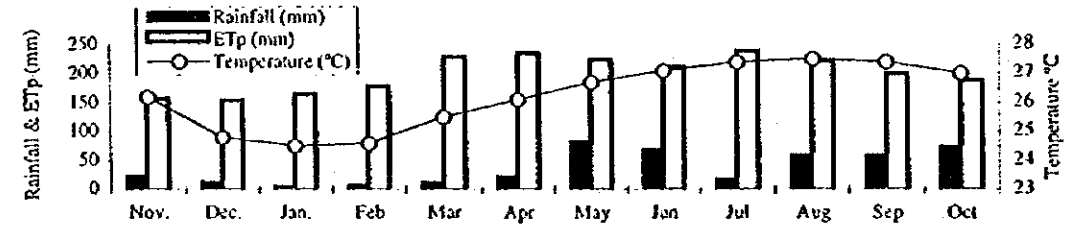


Table 3.2.4 Monthly Rainfall at Major Stations (3/4)

Station: La Florida (4907)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1960				141.0	256.0	193.0	126.0	138.0	65.0	49.0	130.0	17.0	
1961	20.0	49.0	73.0	26.0	59.0	173.0	126.0	140.0	179.0	145.0	84.0	29.0	1089.0
1962	11.0	5.0	31.0	35.0	224.0	162.0	139.0	166.0	97.0	16.0	62.0	18.0	933.0
1963	20.0	4.0	31.0	112.0	298.0	158.0	227.0	179.0	151.0	302.0	143.0	6.0	1631.0
1964	0.0	2.0	0.0	45.0	8.0	127.0	141.0	166.0	108.0	133.0	20.0	0.0	751.0
1965	0.0	0.0	0.0	65.0	269.0	73.0	200.0	231.0	181.0	230.0	8.0	0.0	1257.0
1966	2.0	0.0	59.0	163.0	36.0	6.0	130.0	84.0	75.0	194.0	61.0	103.0	915.0
1967	28.0	16.0	43.0	28.0	70.0	85.0	69.0	134.0	63.0	39.0	72.0	7.0	655.0
1968	6.0	12.0	22.0	0.0	165.0	330.0	114.0	123.0	122.0	184.0	57.0	79.0	1214.0
1969	10.0	1.0	39.0	0.0	97.0	232.0	208.0	231.0	315.0	297.0	117.0	52.0	1599.0
1970	33.0	16.0	4.0	48.0	202.0	166.0	112.0	228.0	449.0	153.0	130.0	4.0	1545.0
1971	2.0	12.0	28.0	91.0	165.0	123.0	168.0	202.0	257.0	214.8	73.0	9.0	1344.8
1972	8.0	18.0	230.5	94.0	95.0	157.0	154.0	109.0	152.0	79.0	25.0	38.0	1159.5
1973	8.0	72.0	78.0	83.0	32.0	181.0	234.0	218.0	178.0	190.0	17.0	20.0	1316.0
1974	0.0	83.0	52.0	117.0	279.0	97.0	181.0	93.0	243.0	188.0	89.0	27.0	1454.0
1975	0.0	74.0	24.0	126.0	131.0	170.0	221.0	141.0	430.0	90.0	232.0	36.0	1672.0
1976	0.0	7.0	4.0	119.0	45.0	268.0	105.0	214.0	208.0	178.0	54.0	24.0	1226.0
1977	14.0	16.0	0.0	84.0	134.0	23.0	89.0	325.0	217.0	244.0	207.0	11.0	1415.0
1978	17.0	12.0	367.0	224.0	199.0	217.0	114.9	304.0	29.0	201.0	46.0	2.0	1582.0
1979	0.0	0.0	16.0	0.0	337.0	43.7							
1980	96.3	0.0	0.0	92.7	168.9	102.5	125.1	121.1	369.2	196.7	92.0	40.5	1405.0
1981	33.6						324.9	224.6	155.0	315.1	41.6	152.4	
1982	97.8	101.5	12.9	145.5	194.5	122.5	189.7	117.7	224.2	68.4	85.1	26.5	1386.3
1983	7.9	0.6	70.5	26.4	190.3	197.8	60.5	163.8	110.0	265.3	103.3	13.3	1149.7
1984	40.4	69.2	14.1	16.4	207.0	358.8	203.1	133.2	255.6	177.0	38.5	0.0	1513.3
1985	0.0	19.5	19.8	81.1	145.2	45.5	235.1	149.7	249.6	312.0	229.8	0.0	1471.3
1986	51.5	0.0	52.6	283.2	190.6	169.7	32.6	147.3	128.1	215.0	84.1	0.0	1355.1
1987	0.0	24.5	45.2	95.4	238.9	230.5	62.0	82.1	263.2	125.8	27.5	102.2	1297.3
1988	0.0	15.2	137.6	79.7	138.0	191.3	170.4	360.3	145.2	0.0	150.0	65.9	1455.6
1989	26.8	56.0	161.8	219.9	158.1	105.7	88.2	137.9	260.5	210.1	170.1	56.5	1701.6
1990	0.0	15.4	36.8	43.9	55.0	135.5	122.5	174.9	174.5	260.1	128.3	68.1	1215.0
1991	0.0	0.0	88.1	131.7	347.3	0.0	57.7	126.6	140.2	89.7	113.2	0.0	1065.5
1992	0.0		173.6		299.7	153.5	111.6	282.2	529.6	169.9	105.8	32.0	
1993	160.9	28.3	59.2	111.1	434.0	221.6	32.4	143.6	129.6	127.7	120.9	0.0	1569.3
1994	7.9	36.0	40.9	140.0	103.8	15.1	63.8	36.9	162.3	86.1	159.0	66.1	917.9
1995	4.9	49.7	81.1	22.0	172.8	174.2	167.7	179.7	210.9	313.4	60.5	0.0	1433.9
1996	53.5	63.2	73.1	218.5	248.8	114.1	37.8	91.1	58.2	189.8	50.9	23.6	1222.6
1997	12.7	56.6	6.0	2.0	33.7	132.0	47.9	208.4	136.9	119.7			755.9
Average	20.9	26.6	55.0	92.0	175.8	147.0	134.6	172.0	196.3	170.0	94.1	31.4	1286.7

Source : National Hydrological Office, Planning Department, INDRHI

Table 3.2.4 Monthly Rainfall at Major Stations (2/4)

Station: San Juan

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1960													
1961	0.0	12.6	58.9	23.6	13.0	53.7	127.9	34.2	77.5	230.5		4.0	642.9
1962	1.0	0.0	16.5	110.3	142.3	61.8	43.6	75.8	58.8	150.2	9.1		674.4
1963	9.9	17.5	44.9	112.3	199.4	67.9	64.7	74.7	225.2	269.9	102.8	4.3	1193.5
1964	26.9	0.0	0.0	107.3	48.7	248.1	41.7	128.9	102.4	93.2	102.2	0.3	893.7
1965	7.1	37.8	5.4	56.9	409.3	19.4	223.5	244.0	248.5	157.9	28.1	73.6	1511.5
1966	2.9	0.5	41.9	96.1	246.5	151.5	97.2	144.2	87.2	106.6	100.6	61.9	1137.1
1967	7.3	37.4	9.9	29.0	52.4	101.8	60.4	76.9	44.0	92.3	20.8	1.0	533.2
1968	10.7	35.9	8.0	8.9	51.9	95.3	310.4	124.3	122.2	182.3	70.7	34.5	1052.5
1969	8.1	2.1	22.2	103.7	182.6	50.6	109.4	136.6	179.8	135.8	57.6	2.0	990.5
1970	12.3	22.9	0.0	37.2	213.4	174.7	142.0	187.4	261.2	101.8	12.4	3.8	1157.1
1971	3.8	2.3	27.2	73.2	158.2	85.8	124.4	177.6	179.8	218.8	69.7	30.2	1151.0
1972	33.0	13.4	136.4	29.6	74.4	158.3	148.2	128.2	152.3	154.8	8.2	19.4	1056.2
1973	5.4	16.8	29.8	36.1	109.1	116.5	131.3	87.4	67.0	93.2	9.2	7.1	708.9
1974	9.0	45.2	37.4	66.8	81.6	101.7	44.1	92.1	221.9	61.2	87.3	0.6	848.9
1975	1.8	0.0	32.5	20.3	50.9	11.5	90.0	131.1	217.4	82.4	122.0	32.4	792.3
1976	0.0	1.2	0.0	84.2	2.5	23.4	13.4	170.2	124.1	119.2	7.6	2.7	548.5
1977	25.5	0.4	0.0	64.1	86.5	0.9	29.0	131.8	159.9	58.4	89.3	2.3	648.1
1978	4.5	19.9	75.9	119.4	197.9	162.8	133.9	56.7	153.7	156.5	53.4	4.2	1138.9
1979	0.0	12.8	89.6	19.0	250.9	148.3	104.4	356.8	127.2	114.6	52.4	8.0	1284.0
1980	2.6	13.1	0.0	45.4	215.6	44.7	63.8	69.6	178.2	81.1	68.0	9.3	791.4
1981	45.5	64.9	6.7	45.1	214.6	120.8	206.4	73.9	49.1	323.5	34.3	84.0	1269.8
1982	27.8	11.7	0.0	112.6	232.2	17.4	117.3	9.1	112.1	41.6	47.5	3.9	733.2
1983	0.9	7.6	45.1	127.9	176.6	45.2	148.5	99.0	80.6	221.8	32.1	24.8	1010.1
1984	70.1	11.5	31.4	24.4	124.8	171.7	59.8	70.3	229.6	72.7	24.6	13.1	903.8
1985	0.0	4.9	9.2	107.3	152.3	12.0	71.2	107.7	102.0	137.2	84.7	0.0	788.5
1986	11.8	1.7	6.2	158.3	108.1	55.2	84.8	116.7	32.0	211.4	57.7	0.0	883.9
1987	11.4	11.7	34.2	156.8	245.6	92.0	90.6	131.0	174.8	105.6	30.0	40.0	1123.7
1988	12.3	4.9	117.5	38.2	66.9	100.9	169.4	109.9	244.7	68.8	60.6	21.8	1015.9
1989	1.8	44.8	40.2	17.0	110.8	71.4	105.0	348.9	150.0	41.6	58.9	39.8	1030.2
1990	8.7	7.3	11.7	49.8	22.5	58.6	118.4	158.6	271.2	159.1	39.1	0.0	905.0
1991	0.0	3.6	30.5	58.3	142.3	18.4	27.8	94.6	68.8	62.2	25.8	0.0	532.3
1992	140.1	1.6	91.0	155.2	290.0	12.2	50.1	100.5	326.6	59.3	104.4	26.9	1267.9
1993	66.8	18.3	30.8	130.9	246.2	129.1	37.9	75.4	158.0	34.7	49.4	0.0	968.5
1994	4.0	11.1	72.2	119.3	28.9	0.9	50.2	68.2	59.0	184.8	62.1	3.9	664.6
1995	7.6	31.3	20.7	34.6	143.2	29.3	163.5	93.0	78.7	156.3	80.5	27.3	866.0
1996	45.0	42.1	53.9	29.1	111.0	45.1	108.2	170.5	67.1	117.7	99.6	16.0	906.3
1997	16.4	26.2	5.5	1.7	59.5	49.2	63.3	101.9	181.1	151.6	50.0	16.8	723.2
Average	17.4	16.1	33.6	70.0	139.9	80.9	101.4	123.0	145.8	130.0	55.7	17.2	929.0

Source. National Meteorological Office, Santo Domingo

Table 3.2.4 Monthly Rainfall at Major Stations (3/4)

Station: Azua

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1960													
1961	0.0	15.4	37.4	109.6	24.5	21.2	15.8	138.0	13.9	172.4	26.4	39.2	614.8
1962	2.0	0.0	43.4	40.0	119.8	52.0	101.0	216.2	39.4	73.0	32.2	9.6	728.6
1963	146.2	12.4	20.6	12.4	105.8	135.0	31.4	158.0	56.6	735.2	38.0	23.8	1475.4
1964	0.0	0.0	0.0	10.8	86.6	64.0	36.1	140.1	58.7	71.0	6.2	0.0	473.5
1965	1.0	0.0	0.0	15.4	153.4	49.8	15.0	32.0	89.2	8.8	3.4	0.0	365.0
1966	0.0	0.0	18.4	27.6	139.0	11.6	70.4	58.2	126.2	134.8	111.2	6.6	704.0
1967	2.0	26.8	9.4	15.0	5.8	50.4	3.4	11.4	76.6	129.0	22.4	6.6	358.8
1968	39.8	90.6	4.4	12.4	13.6	85.2	41.0	94.0	49.2	24.4	35.8	15.6	505.2
1969	0.0	12.2	8.0	129.8	67.2	95.0	0.0	51.1	122.8	138.0	63.8	11.4	699.3
1970	17.4	16.0	0.0	0.2	27.2	120.8	6.4	87.5	94.1	107.6	10.8	11.0	499.0
1971	8.0	0.0	30.7	18.6	74.1	43.0	15.0						189.4
1972					38.3	57.0	32.2	46.3	98.1	147.4	0.0	2.7	422.0
1973	1.2	5.5	11.2	21.8	50.5	29.7	1.3	62.8	176.0	19.4	8.5	2.1	390.0
1974	1.2	5.5	11.2	21.8	50.5	29.7	1.3	62.8	176.0	19.4	8.5	2.1	390.0
1975	1.2	0.0	10.3	0.0	26.5	5.3	124.6	30.7	207.3	26.8	49.1	96.6	578.4
1976	6.7	22.8	11.8	37.1	40.5	13.8	0.0	49.7	91.5	175.5	7.6	7.7	454.7
1977	0.5	0.0	1.5	0.0	132.1	1.5	10.2	16.9	15.3	121.2	61.5	11.3	372.0
1978	0.0	13.6	16.6	94.7	92.2	72.9	24.8	55.6	78.5	192.9	19.0	0.0	670.8
1979	0.8	19.7	44.8	13.0	60.8	175.8	183.7	203.1	691.7	225.5	27.6	0.0	1546.5
1980	0.0	23.8	0.4	33.0	169.2	9.6	16.2	154.3	119.7	83.0	29.0	45.4	674.6
1981	85.9	22.6	9.3	3.3	188.8	190.8	79.4	100.5	311.2	128.1	37.2	15.0	1173.1
1982	2.5	14.0	1.0	52.5	72.8	24.8	18.9	81.7	30.2	56.8	53.2	0.0	408.4
1983	1.3	0.0	54.0	14.9	113.8	193.2	21.1	19.8	18.4	98.5	23.7	1.2	563.9
1984	35.5	0.5	17.8	24.9	26.4	85.2	55.9	92.4	70.6	71.2	80.8	0.5	567.7
1985	9.3	0.8	36.2	18.8	43.7	8.2	34.1	56.0	268.0	229.2	71.8	0.5	776.5
1986	25.3	2.5	8.3	197.1	199.9	149.0	21.5	53.9	22.7	68.4	26.3	1.4	726.3
1987	8.8	19.6	120.4	69.2	63.1	19.5	2.3	2.2	141.3	39.8	39.9	248.7	774.8
1988	1.3	59.6	7.5	68.1	25.1	56.9	151.1	169.2	67.9	50.2	53.5	0.0	710.9
1989	1.7	7.3	151.8	35.9	76.2	11.8	62.7	53.6	49.0	65.6	48.8	0.0	564.4
1990	3.7	4.7	0.3	23.6	7.4	10.7	4.2	9.7	130.5	410.2	59.6	0.0	664.6
1991	0.0	20.3	10.0	41.0	124.0	15.5	34.4	41.7	124.4	14.5	48.4	0.0	480.2
1992	16.5	21.6	43.8	124.2	94.1	9.3	22.4	46.8	75.1	145.3	42.7	8.0	649.8
1993	359.5	21.8	13.2	15.9	245.5	26.1	6.8	69.0	35.2	11.2	17.7	21.4	813.3
1994	13.2	12.6	76.3	20.7	59.0	0.0	0.5	154.2	93.2	203.8	132.4	18.7	784.6
1995	2.5	8.7	24.2	26.8	109.9	83.5	85.6	236.0	76.8	120.2	3.2	41.3	818.7
1996	2.5	13.2	159.4	18.4	65.1	52.3	39.5	29.7	35.2	40.7	119.2	1.2	576.4
1997	12.8	0.2	64.6	0.5	1.9	44.9	20.6	225.0	145.0	47.3	23.7	23.5	660.0
Average	22.5	13.8	30.0	38.0	80.0	56.9	37.9	87.9	112.7	122.6	40.2	18.7	647.9

Source: National Meteorological Office, Santo Domingo

Table 3.2.4 Monthly Rainfall at Major Stations (4/4)

Station: Tamayo

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1960													
1961													
1962													
1963								27.0	12.5	378.6	14.4	9.0	441.5
1964	3.4	0.0	15.6	0.5	17.9	18.5	41.0	474.5	6.8	105.3			
1965		0.0	0.0	16.7	216.0	10.6	56.9	44.2	32.7	24.6	24.7	66.8	492.3
1966	3.6	0.6	3.9	19.1	141.3	14.5	12.0	9.7	109.8	67.9	124.6	4.1	509.1
1967	2.2	32.2	32.1	21.9	0.0	55.8	0.0	0.4	90.5	29.9	0.0	0.0	265.0
1968	4.8	19.8	1.6	18.4	10.0	85.1	15.4	51.9	54.7	19.0	5.1	3.3	289.1
1969	8.7	2.0	0.7	59.2	90.6	118.4	30.3	40.6	45.5	54.5	27.5	45.1	524.1
1970	63.7	11.4	7.6	10.8	28.2	37.0	14.4	78.1	67.8	20.9	38.3	3.8	382.0
1971	9.6	13.1	11.3	51.9	47.7	10.8	32.3	15.5	47.2	23.3	52.1	0.4	296.2
1972	2.8	6.0	22.8	95.7	50.9	621.9	8.5	61.9	46.3	33.8	0.0	0.0	950.6
1973	4.1	7.6	2.8	18.2	5.0	38.4	1.0	48.1	56.9	95.5	3.4	0.0	281.0
1974	8.5	1.8	0.0	16.4	166.6	40.8	0.0	28.5	145.0	39.9	15.6	16.7	449.8
1975	2.2	4.0	8.6	0.0	25.3	24.0	15.6	10.5	126.7	60.9	23.5	89.5	390.0
1976	13.4	1.3	0.0	15.6	1.7	55.0	3.4	98.6	59.5	50.6	3.5	58.8	361.6
1977	1.5	2.1	0.0	12.3	271.2	12.4	3.8	57.7	6.2	60.0	56.0	15.8	499.0
1978	9.9	51.1	12.4	81.2	86.1	2.6	0.0	44.8	29.2	22.3	14.8	0.2	604.6
1979	1.9	13.3	68.6	29.4	82.3	151.5	120.0	94.1	206.8	37.2	6.4	0.0	811.5
1980	0.0	43.2	1.0	9.2	106.0	4.7	1.9	188.2	17.9	2.9	15.0	12.7	402.7
1981	16.1	6.3	14.4	4.4	70.0	53.4	11.8	142.8	64.1	45.6	38.2	13.6	481.7
1982	1.8	0.0	31.8	53.0	53.2	15.6	76.9	5.1	17.0	11.5	4.6	1.0	271.5
1983	6.2	0.0	17.4	42.0	68.5	56.2	14.0	13.2	25.7	50.1	48.5	0.0	341.8
1984	6.0	1.0	3.1	18.5	9.8	18.2	60.0	34.7	30.5	50.0	7.0	9.9	248.7
1985	0.0	3.2	6.7	19.8	41.2	39.1	43.8	30.0	81.1	210.0	178.8	1.6	655.3
1986	0.8	1.4	27.8	30.6	73.0	154.8	2.7	6.3	0.1	13.6	13.2	4.5	348.8
1987	3.5	11.3	16.4	28.4	63.1	18.9	0.0	19.9	155.2		25.7	134.5	
1988	0.0	0.0	19.7	35.1	7.0	26.9	38.5	29.4	89.4	1.5	6.9	0.0	254.4
1989	0.0	3.6	95.0	13.6	6.1	6.2	16.2	27.5	26.1	40.7	33.3	34.3	303.6
1990	8.7	3.5	0.0	89.7	0.0	9.6	38.2	8.2	18.1	127.7	50.4	0.0	354.1
1991													
1992	3.0	15.5	40.5	162.8	42.7	27.4	27.2	40.0	51.2	18.8	42.6	25.3	497.2
1993	72.8	8.2	8.3	80.6	49.3	75.0	30.0	52.0	28.0	0.0	45.4	0.0	449.6
1994	0.0	0.4	4.9	91.7	90.2	0.0	4.0	19.5	54.0	102.2	105.5	85.0	557.4
1995	28.4	53.5	56.6	15.9	45.0	43.3	88.0	181.9	39.0	199.3	0.0	61.0	812.9
1996		17.1	105.9	115.1	35.8	34.2	32.1	8.0	78.6	105.5	58.1	26.1	616.5
1997	2.7	5.2	52.9	12.4	13.9	126.7	38.8	16.4	50.0	22.4	19.2	13.7	378.3
Average	9.4	10.3	20.9	39.7	61.1	59.9	26.0	59.1	59.4	64.4	33.4	22.4	447.6

Source: National Meteorological Office, Santo Domingo

Table 3.2.5 Inventory of Rainfall Stations Related to the Study

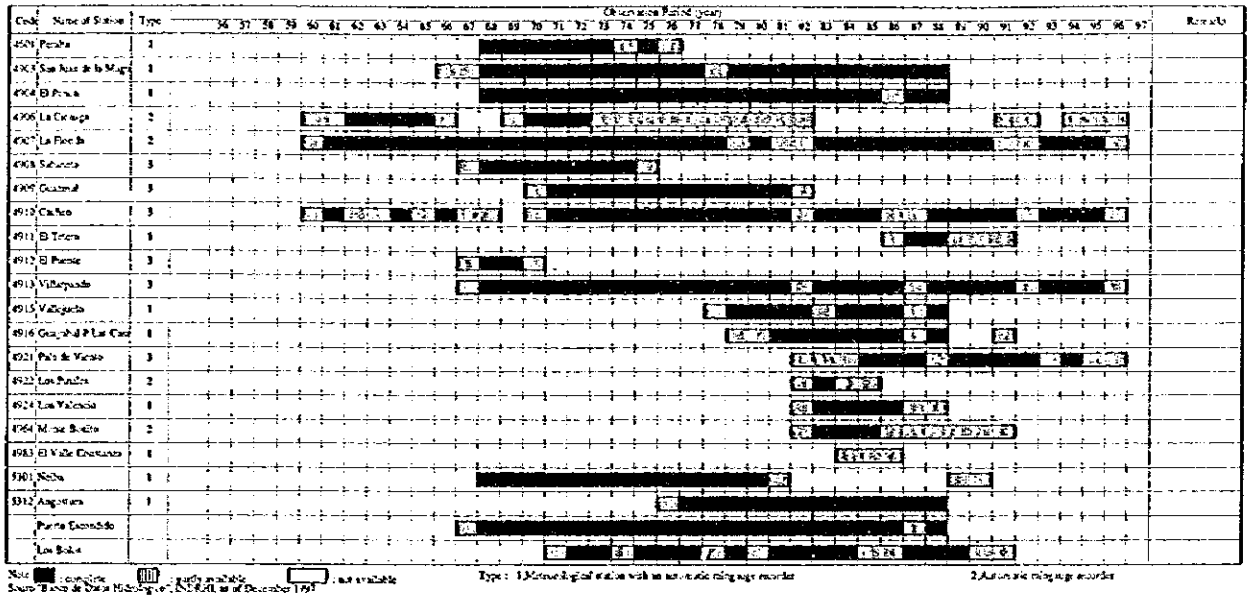


Table 3.2.6 Wet and Dry Years in the Study Area

Year		La Florida Mean		San Juan Mean		Azua Mean		Barahona Mean		Tamayo Mean	
		(mm)	(yrs)	(mm)	(yrs)	(mm)	(yrs)	(mm)	(yrs)	(mm)	(yrs)
1961		1089.0	-4			614.8					
1962		973.0	-9			728.6	+3				
1963	W	1631.0	+8	1193.5	+7	1475.4	+113				
1964		751.0	-110	897.7		473.5	-5				
1965		1257.0		1511.5	+34	365.0	-17				
1966		915.0	-15	1137.1	+5	704.0	+3	1051.7		509.1	+4
1967	D	659.0	-629	533.2	-54	358.8	-18	724.6	-9	265.0	-10
1968		1214.0	-3	1052.5	+4	505.2	-4	746.8	-8	289.1	-7
1969	W	1599.0	+7	990.5	+3	699.3	+3	1346.5	+8	524.1	+4
1970		1545.0	+5	1157.1	+5	499.0	-4	887.0	-4	382.0	-3
1971		1344.8	+3	1151.0	+5			914.5	-3	296.2	-6
1972		1160.5	-3	1096.2	+4			1169.5	+4	950.6	+97
1973		1316.0	+3	708.9	-7			608.6	-32	281.0	-8
1974		1454.0	+4	848.9	-3	390.0	-12	1253.1	+5	449.8	+3
1975		1672.0	+9	792.3	-4	578.4	-3	789.9	-6	390.0	-3
1976	D	1226.0	-3	548.5	-42	454.7	-6	742.2	-8	361.6	-3
1977		1415.0	+4	648.1	-11	372.0	-15	1002.9		499.0	+4
1978	W	1582.0	+6	1138.9	+5	670.8	+3	1121.5	+4	404.6	
1979	W	1405.0	+4	1284.0	+10	1646.5	+287	1740.0	+51	811.5	+33
1980		1386.3	+3	791.4	-4	674.6	+3	1053.6	+3	402.7	
1981		1149.7	-4	1269.8	+9	1173.1	+24	1435.3	+12	481.7	+4
1982		1513.3	+5	733.2	-5	408.4	-9	815.3	-5	271.5	-9
1983		1471.3	+4	1010.1	+3	563.9	-3	1183.0	+4	341.8	-4
1984		1355.1	+3	903.8		567.7	-3	584.1	-46	248.7	-14
1985		1297.3		788.5	-4	776.6	+4	997.8		655.3	+10
1986		1465.6	+4	883.9	-3	776.3	+4	1080.0	+3	348.8	-4
1987	W	1701.6	+10	1123.7	+5	774.8	+4	1423.9	+11	476.9	+3
1988		1215.0	-3	1015.9	+3	710.9	+3	704.7	-11	254.4	-12
1989		1085.5	-5	1030.2	+4	564.4	-3	1011.6		303.6	-5
1990		1569.3	+6	905.0		664.6	+3	1075.2	+3	354.1	-4
1991	D	917.9	-15	512.3	-82	480.2	-5	983.1			
1992	W	1433.9	+4	1267.9	+9	649.8		1112.5	+3	497.2	+4
1993		1222.6	-3	968.5	+3	813.3	+5	968.5		449.6	+3
1994		917.9	-15	664.6	-10	781.6	+4	1622.4	+28	557.4	+5
1995		1433.9	+4	866.0	-3	818.7	+5	945.5	-3	812.9	+33
1996		1222.6	-3	906.3		576.4	-3				
1997											

Note: ex. "-82"= dry year with a probability of 1 in 82 years recurrence
"+9"= wet year with a probability of 1 in 9 years recurrence

Source: Calculated by the Study Team using the records by National Meteorological Office and National Hydrological Office of INDRHI

Table 3.2.7 Drought Condition by Month in 1997

	La Florida		San Juan		Azua		Tamayo	
	(mm)	(yrs)	(mm)	(yrs)	(mm)	(yrs)	(mm)	(yrs)
Jan	12.7	+4.1	16.4	+3.9	12.8	+4.4	2.7	+2.4
Feb	56.6	+4.8	26.2	+4.4	0.2	-4.7	5.2	+3.2
Mar	6.0	-3.1	5.5	-2.4	64.6	+5.0	52.9	+5.5
Apr	2.0	-7.7	1.7	<-100	0.2	-37.5	12.4	-3.1
May	33.7	-23.6	59.5	-4.1	1.9	<-100	13.9	-2.8
Jun	132.0	+2.7	49.2	+2.1	83.5	+4.2	126.7	+6.0
Jul	47.9	-16.4	63.3	-3.6	20.6	+2.7	38.8	+4.3
Aug	208.4	+4.3	101.9	-2.2	275.0	+16.2	16.4	-3.7
Sep	136.9	-3.4	181.1	+4.2	145.0	+4.6	50.0	+2.7
Oct	119.7	+2.1	151.6	+3.9	47.3	-3.8	22.4	-2.6
Nov	47.5	-4.1	50.0	+2.6	23.7	+2.0	19.2	+2.8
Dec			16.8	+4.0	18.7	+4.7	17.7	+4.2
Annual			723.2	-4.9	660.0	+2.9	378.3	-3.1

Table 3.2.8 Rivergauge Stations Related to the Study

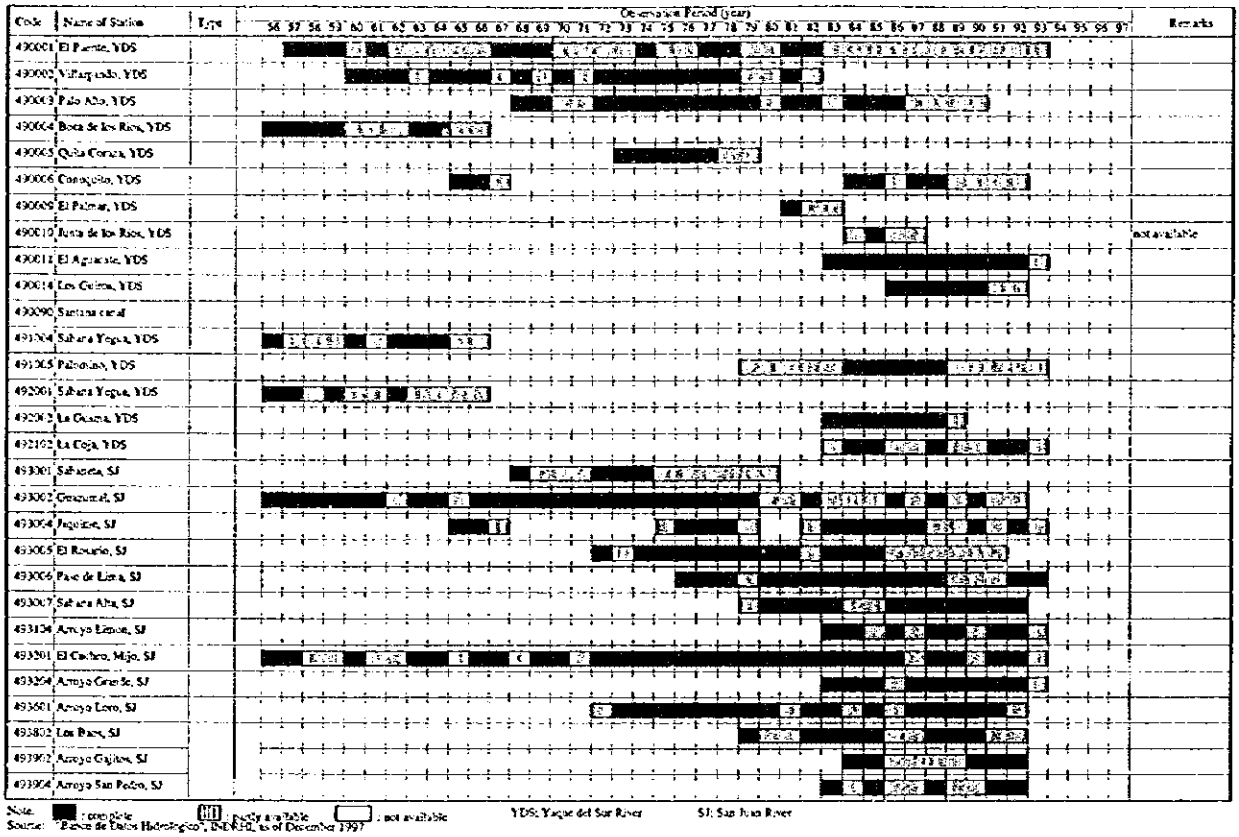


Table 3.2.9 Dependable River Discharge at Each Hydrological Check Point

unit: m³/sec

Code	Station	Period	Probability	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Remarks
D1	Sabaneta	1968-1980	Mean	5.0	4.6	4.2	4.3	7.2	9.4	10.1	10.8	17.1	18.1	10.8	7.1	
			80%	4.1	3.8	3.4	3.1	5.0	5.4	6.2	6.9	12.3	13.9	8.7	6.4	
			90%	3.8	3.5	3.0	2.6	4.3	4.3	5.0	5.7	10.6	12.4	7.9	6.0	Before Sabaneta Dam
D1a	Guazmal	1956-1979	Mean	5.5	4.3	3.9	4.9	9.6	12.7	12.6	14.1	18.4	20.2	13.2	8.1	
			80%	4.2	3.2	2.5	2.9	5.4	6.4	7.2	8.7	12.9	12.5	9.0	5.5	
			90%	3.7	2.8	2.1	2.4	4.2	4.9	5.8	7.1	11.1	10.3	7.6	4.7	Before Sabaneta Dam
	Guazmal	1980-1992	Mean	4.3	3.8	3.1	2.8	6.8	6.6	7.8	7.6	8.8	9.8	5.9	4.8	
			80%	2.4	2.7	2.3	1.8	2.4	3.0	3.7	4.3	5.5	5.7	4.6	3.2	
			90%	1.9	2.3	2.0	1.5	1.7	2.2	2.8	3.4	4.5	4.6	4.1	2.6	After Sabaneta Dam
D2	Sabana Alta	1979-1992	Mean	7.4	5.7	4.5	5.8	20.5	20.2	15.8	15.8	25.5	26.3	19.2	10.7	
			80%	5.0	3.4	3.7	3.6	7.0	7.8	6.7	9.2	12.9	17.7	13.9	7.5	
			90%	4.2	2.7	3.4	3.0	4.7	5.5	4.9	7.4	9.8	14.9	12.1	6.4	
D3	El Puente	1957-1979	Mean	12.9	9.7	8.4	11.2	20.3	29.2	20.9	19.8	30.1	33.0	28.0	20.6	
			80%	9.1	7.0	6.0	6.7	11.8	14.9	11.9	13.5	20.2	24.1	18.3	12.6	
			90%	7.9	6.1	5.2	5.4	9.5	11.4	9.4	11.5	17.1	20.9	15.3	10.3	Before Sabana Yegua Dam
	El Puente	1980-1993	Mean	24.4	24.5	22.0	20.6	21.6	25.5	29.1	21.3	20.4	21.5	21.7	21.2	
			80%	16.9	17.5	15.2	16.0	15.1	13.2	17.2	18.2	15.6	18.8	18.1	18.7	
			90%	14.5	15.2	12.9	14.1	12.9	10.2	13.9	16.9	14.5	17.7	16.6	17.6	After Sabana Yegua Dam
D4	Villarpando	1960-1982	Mean	25.2	19.7	18.4	20.2	36.9	54.5	46.4	43.8	66.6	70.9	53.9	39.3	
			80%	12.1	8.1	8.5	8.9	18.7	23.0	20.9	28.4	39.8	42.7	33.0	20.8	
			90%	9.2	5.9	6.4	6.6	14.3	16.6	15.5	22.8	32.4	34.8	27.1	16.2	
D6a	Quita Corasa	1973-1979	Mean	22.5	17.5	16.5	14.8	31.2	45.7	29.5	35.1	47.5	56.6	43.0	37.8	
			80%	10.5	8.0	8.8	8.7	14.2	14.7	13.4	19.5	38.8	44.6	28.5	15.9	
			90%	-	-	-	-	-	-	-	-	-	-	-	-	
D6b	Los Guiros	1986-1992	Mean	18.8	16.9	16.8	18.3	24.1	25.3	23.7	26.9	40.2	38.5	28.4	20.3	
			80%	15.6	14.0	12.9	12.5	11.4	12.2	13.1	20.1	26.1	28.7	21.7	17.1	
			90%	-	-	-	-	-	-	-	-	-	-	-	-	
D6c	Conaquito	1984-1993	Mean	19.0	17.4	17.8	17.4	25.2	29.4	22.4	21.7	33.4	29.0	28.1	21.9	
			80%	13.2	12.7	13.0	11.4	13.0	12.8	12.7	14.3	17.8	19.2	18.0	16.7	
			90%	11.2	-	11.3	-	-	9.4	-	-	13.7	-	-	-	
D8a	Palo Alto	1968-1979	Mean	6.3	3.0	3.3	5.3	19.0	29.3	21.6	20.4	43.6	50.2	33.5	19.4	
			80%	2.5	1.1	0.9	0.8	5.5	9.7	4.8	9.8	27.6	30.5	19.3	7.2	
			90%	1.8	0.7	0.6	0.4	3.5	6.4	2.8	7.3	22.7	24.7	15.4	4.9	
	Palo Alto	1980-1990	Mean	9.8	7.8	6.6	7.0	17.1	18.1	20.3	12.1	17.4	21.6	14.5	9.1	
			80%	4.8	4.2	3.8	3.4	5.6	6.0	4.0	5.5	7.1	10.8	5.8	6.0	
			90%	-	-	3.0	2.6	-	4.0	-	4.0	5.1	8.2	4.1	-	
D10	El Cacheo	1957-1993	Mean	2.4	2.0	1.9	2.4	5.3	7.2	5.8	5.8	7.8	7.8	5.5	3.4	
			80%	2.0	1.6	1.4	1.4	2.8	4.2	3.2	4.0	4.7	5.4	3.8	2.5	Mijo river
			90%	1.8	1.5	1.2	1.2	2.1	3.4	2.6	3.4	3.8	4.6	3.2	2.2	
D11	Hato Viejo	1972-1980	Mean	0.7	0.4	0.4	0.4	1.0	0.9	1.1	1.4	2.4	2.3	1.8	1.3	
			80%	0.6	0.3	0.2	0.2	0.4	0.3	0.5	0.8	2.1	1.9	1.4	1.0	Guanito-San Juan
			90%	-	-	-	-	-	-	-	-	-	-	-	-	
	Hato Viejo	1981-1992	Mean	1.9	1.7	1.5	1.3	1.9	1.6	2.0	2.3	2.8	3.3	2.8	2.1	
			80%	1.6	1.5	1.2	1.0	1.1	1.0	1.4	1.7	2.2	2.6	2.4	1.8	
			90%	1.4	1.4	1.1	0.9	0.9	0.9	1.2	1.6		2.3		1.6	
D12	Vallejuello	1978-1995	Mean	0.52	0.37	0.43	0.51	0.70	0.78	0.69	0.79	0.73	0.62	0.57	0.51	
			80%	0.32	0.22	0.23	0.26	0.34	0.28	0.23	0.21	0.25	0.30	0.25	0.27	Vallejuelo
			90%	0.26	0.18	0.18	0.20	0.26	0.19	0.15	0.12	0.17	0.22	0.18	0.21	

Table 3.2.10 USDA Classification of Irrigation Water

(1) Sodicity

Sodium class description		SAR
S1	Low sodium water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops may accumulate injurious concentrations of sodium	<10
S2	Medium sodium water will present an appreciable sodium hazard in fine-textured soils having high cation exchange capacity, especially under low leaching conditions, unless gypsum is present in the soil.	10 - 18
S3	High sodium water may produce harmful levels of exchangeable sodium in most soils and will require special soil management - good drainage, high leaching and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium except that amendments may not be feasible with waters of very high salinity.	18 - 26
S4	Very high sodium water is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible.	> 26

Source: Suelos Salinos y Sodicos, Personal del Laboratorio de Salinidad de los Estados Ubidos de America

(2) Salinity

Salinity class description		EC(μS/cm)
C1	Low salinity water can be used for irrigation with most crops on most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices, except in soils of extremely low permeability.	<250
C2	Medium salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control..	250 - 750
C3	High salinity water cannot be used on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.	750-2250
C4	Very high salinity water is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.	>2250

Source: Suelos Salinos y Sodicos, Personal del Laboratorio de Salinidad de los Estados Ubidos de America

Table 3.2.11 Matrix on Items Analyzed by the Laboratory Test

Items \ Location		Location of Sampling															
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
1	Electric Conductivity (EC)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
2	Dissolved Oxygen (DO)	○	○	×	○	○	○	×	○	○	○	×	○	×	×	○	×
3	Chemical Oxygen Demand (COD)	○	○	×	○	○	○	×	○	○	○	×	○	×	×	○	×
4	Biological Oxygen Demand (BOD)	○	○	×	○	○	○	×	○	○	○	×	○	×	×	○	×
5	Number of Colon Bacillus	○	○	×	○	○	○	×	○	○	○	×	○	×	×	○	×
6	Temperature (°C)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
7	Ammonium Nitrogen (NH4-N)	○	○	×	○	○	○	×	○	○	○	×	○	×	○	○	○
8	Nitrate Nitrogen (NO3-N)	○	○	×	○	○	○	×	○	○	○	×	○	×	×	○	×
9	pH	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
10	Calcium Ion (Ca++)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
11	Total Phosphate	○	○	×	○	○	○	×	○	○	○	×	○	×	×	○	○
12	Magnesium Ion (Mg++)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
13	Manganese Ion (Mn++)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
14	Ferrous Ion (Fe++)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
15	Fluoride Ion (F-)	○	○	×	○	○	○	×	○	○	○	×	○	×	×	○	○
16	Sodium (Na+)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
17	Bicarbonate (HCO3-)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
18	Sulfate (SO4--)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
19	Suspeoded Solids (SS)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
20	Carbonate (CO3--)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
21	Potassium (K+)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
22	Chloride	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎

NOTE: ◎; Test for two samples
○; Test for only one sample out of two samples

Table 3.2.12 Water Quality (EC, pH) in the Study Area

Code	Location	Date	EC (mS/cm)	pH	Details	Source
SI	Sabana Alta, SJ	Dec 23,97	0.56	8.2	End of San Juan ID	
	El Cacheo, Mijo river	Dec 23,97	0.13	8.5	Mijo headworks	
	Arrojo Loro	Dec 23,97	0.58	8.1	Main drain of JJ Puello	
	Paso de Lima, SJ	Dec 23,97	0.17	8.2	Upstream of Sabaneta	
	El Rosario, SJ	Jun 29,93	0.65	7.4		INDRHI
A1	El Puente, YDS	Dec 22,97	0.27	7.5	Downstream of SY dam	
	Los Guiros, YDS	Dec 22,97	0.83	8.4	End of Azua ID	
	- do -	Mar 17,89	1.10	8.1		INDRHI
	Quita Corasa, YDS	Jan 7,98	1.06	8.2		
	Villarpando, YDS	Jan 8,98	0.51	8.4	Downstream of headworks	
	Tabara river	Jan 8,98	0.43	8.4	Downstrem of Tabara HW	
	Los Toros, Viafara river	Jan 8,98	0.35	8.4	Ysura conveyance canal	
BN1	Santana headworks, YDS	Jan 7,98	0.91	8.1		
	- do -	1988	0.57 - 0.80	7.8 - 7.9		JICA Saline Soil
	Palo Alto, YDS	Jan 7,98	1.36	7.9		
	El Jobo, YDS	Jan 7,98	1.09	7.7	Upstream of the intake to Rincon	
	Palo Alto, YDS	Mar 16,89	0.95	8.0		INDRHI
	Habanero, YDS	Jan 7,98	1.36	7.8	Downmost reach of YDS	
	El Caheon, YDS	Jan 7,98	0.95	7.2	Between No.9 and 11	
	Rincon lake (laguneta seco)	Jan 8,98	5.10	7.9		
	Rincon lake (northern shore)	Jan 8,98	7.20	8.3		
	Rincon lake (Cablar)	Jan 8,98	8.40	8.9		
	- do -	1988	7.00	7.9 - 8.2		JICA Saline Soil
	Arroyo Drain, Guara Guao	Jan 8,98	2.00	7.9	Main drain at Santana	
	- do -	1988	1.30 - 1.60	7.6 - 7.8		JICA Saline Soil
	- do - (upstream)	1988	1.10 - 1.20	7.6 - 7.8		JICA Saline Soil
	Spring, Las Marias	Jan 8,98	0.54	7.4		
	- do -	1988	0.59	7.5		JICA Saline Soil
	Enriquillo lake	Jan 8,98	>100.00	8.0		
	Las Marias river, Neiba	Jan 8,98	2.00	8.2	Drain of northern Neiba Plain	
	- do -	1988	2.70 - 5.00	7.8		JICA Saline Soil
	Ramillo channel	Jan 8,98	14.80	8.2	Drain of central Neiba Plain	
	- do -	1988	3.00 - 3.80	7.8		JICA Saline Soil
	Bermesi river	Jan 8,98	11.40	7.6	Drain of southern Neiba Plain	
	Groundwater, Galvan Neiba	1988	0.60	7.1		JICA Saline Soil
	Groundwater, Neiba Plain	1988	1.80	7.7		JICA Saline Soil
	Majagual, Colotrado, Manguito	1988	0.27 - 0.33	7.6 - 7.7	Rivers north of Neiba Valley	JICA Saline Soil
	Enriquillo Lake	Oct 28,93	88.2 - 98.5	8.2 - 8.3		INDRHI

NOTE: EC; Electric conductivity
YDS; Yaque del Sur River
SJ; San Juan River

Table 3.2.13 Water Test Results and Relevant Drinking Water Quality Standards (1/2)

Samples assumed mainly for potable purpose

Drinking water test carried out in Rep. Dominica	*Units* As supplied by testing company (ppm=mg/L)	USEPA Drinking Water MCLs (mg/L)	Rep. Dominica DW MCLs Disinfection only (mg/L)	Sedimntn. Filtration, Disinfctn. (mg/L)	Traditional Treatment (mg/L)	WHO Drinking Water MCLs (mg/L)	Q1 Sabaneta Reservoir Irrig/Domestic/Pot.	Q2 San Juan River, San Juan City (Ir Do Po)
ammonium-N	mg/L	no MCL	none	none	none	(1)*	0.018	0.18
manganese	ppm	no MCL	0.50	1.00	2.00	0.02	0.01	0.01
nitrate	mg/L	10	45.00	50.00	60.00	none	1.26	4.26
Escherichia coli	+/- (100 ml)	no '+'				no '+'	positive	positive
bicarbonate	ppm						95.4	258
calcium	ppm		200.00	300.00	400.00		23.6	94.4
chloride	ppm	250				(0.05)*	30.5	34.4
fluoride	mg/L	2				(1.5)*	1.38	0.128
iron	ppm	0.3				0.05(50)*	ND	0.1
magnesium	ppm		100.00	200.00	300.00		4.88	9.75
phosphate	ppm						2.48	13.79
potassium	ppm						1.00	2.28
sodium	ppm						9.19	11.6
sulfate	ppm		400.00	400.00	400.00		2.46	2.88
pH	no units	6.5--8.5	9.0	6.0--9.5	5.5--9.5	6.5--8.5	8.2	7.8
Hardness	ppm						not done	not done
TSS	ppm		none	1000	none		50	30
DO	mg/L		>=80	>=70	>=60		4.06	3.25
		← Standards →					← Results →	

Samples assumed mainly for irrigation purpose

Drinking water test carried out in Rep. Dominica	*Units* As supplied by testing company (ppm=mg/L)	USEPA Drinking Water MCLs (mg/L)	Rep. Dominica DW MCLs Disinfection only (mg/L)	Sedimntn. Filtration, Disinfctn. (mg/L)	Traditional Treatment (mg/L)	WHO Drinking Water MCLs (mg/L)	Q3 Hato Viej. Arroyo, Rolo R.	Q8 Pueblo Viejo Grndwater (Ir Do Po)
ammonium-N	mg/L	no MCL	none	none	none	(1)*	not done	0.077
manganese	ppm	no MCL	0.50	1.00	2.00	0.02	0.04	0.02
nitrate	mg/L	10	45.00	50.00	60.00	none	not done	1.66
Escherichia coli	+/- (100 ml)	no '+'				no '+'	not done	not done
bicarbonate	ppm						310	314
calcium	ppm		200.00	300.00	400.00		56.1	65.00
chloride	ppm	250				(0.05)*	103.8	103.2
fluoride	mg/L	2				(1.5)*	not done	not done
iron	ppm	0.3				0.05(50)*	3.741	0.02
magnesium	ppm		100.00	200.00	300.00		29.2	12.0
phosphate	ppm						not done	5.54
potassium	ppm						7.95	3.1
sodium	ppm						99	44.3
sulfate	ppm		400.00	400.00	400.00		41.2	103.2
pH	no units	6.5--8.5	9.0	6.0--9.5	5.5--9.5	6.5--8.5	8.0	7.3
Hardness	ppm						not done	not done
TSS	ppm		none	1000	none		140	90
DO	mg/L		>=80	>=70	>=60		not done	1.83
		← Standards →					← Results →	

Note: MCL; maximum contaminant limits, Ir.; Irrigation purpose, Do; domestic purpose, Po; potable purpose

Table 3.2.13 Water Test Results and Relevant Drinking Water Quality Standards (2/2)

Samples assumed mainly for potable purpose

Drinking water test carried out in Rep. Dominica	Q4 Mijo Head-Works, Mijo R. (Ir Do Po)	Q5 Sabana Yegua Reservoir (Ir Do Po)	Q6 Tabara Canal, Ysura R. (Ir Do Po)	Q7 Jura River Lateral 7 (Ir)	Q9 Azua Extension Grndwater (Ir Do Po)	Q10 Santana, Yaque del Sur, (Ir Do Po)	Q12 Rincon Lake (Ir Do Po)	Q15 Galvan Grndwater (Ir Do Po)	*Drinking water test carried out*
ammonium-N	0.9	0.064	0.028	not done	0.011	0.014	1.042	1.016	NH_4^+
manganese	0.01	0.01	0.01	0.14	ND	0	0.02	0	Mn_2^+
nitrate	5.86	2.88	3.54	not done	245	0.57	11.90	8.78	NO_3^-
Escherichia coli	ND	positive	positive	positive	ND	positive	ND	positive	*E. coli*
bicarbonate	85.4	157	175	359	280	254	380	419	HCO_3^-
calcium	16.2	39.5	44.0	114	72.5	74.6	76.5	96.8	Ca_2^+
chloride	26.8	42.2	53.6	734.9	49.8	53.5	3350	80.3	Cl^-
fluoride	0.415	0.121	0.135	not done	0.199	0.186	0.415	0.258	F^-
iron	0	0.02	53.6	0.42	0	0.02	0.06	0.02	Fe^{2+}
magnesium	4.82	8.88	9.75	10.3	12.5	26.2	240	20.2	Mg^{2+}
phosphate	10.03	4.06	3.16	not done	3.86	5.19	7.98	1.34	PO_4^{3-}
potassium	0.80	2.02	17.6	13.7	3.35	4.00	42.0	0.75	K^+
sodium	8.51	26.4	25.0	491	35.9	93.3	2118	27.0	Na^+
sulfate	2.16	4.15	3.98	37.8	49.8	53.5	333	3.38	SO_4^{2-}
pH	8.2	8.0	8.3	7.4	7.2	8.0	8.7	6.9	pH
Hardness	not done	not done	not done	not done	not done	not done	not done	not done	Hardness
TSS	110	80	80	520	60	120	240	1360	TSS
DO	4.87	5.48	6.9	not done	5.28	6.69	6.09	5.48	DO

Results

Samples assumed for irrigation purpose

Drinking water test carried out in Rep. Dominica	Q11 Intake to Rincon L., Yaque R. (Ir)	Q13 Cachon, Yaque del Sur River (Ir)	Q14 Arroyo, Main Drn. Endpoint (Ir)	Q16 Enriquillo Lake (Ir)	*Drinking water test carried out*
ammonium-N	not done	not done	not done	not done	NH_4^+
manganese	0.01	0.05	ND	0.08	Mn_2^+
nitrate	not done	not done	not done	not done	NO_3^-
Escherichia coli	not done	not done	not done	not done	*E. coli*
bicarbonate	403	296	318	326	HCO_3^-
calcium	106	96.4	87.2	654	Ca_2^+
chloride	88.1	161	134	58194	Cl^-
fluoride	not done	not done	not done	not done	F^-
iron	0.06	0.02	0	0.4	Fe^{2+}
magnesium	30.3	22.2	30	2900	Mg^{2+}
phosphate	not done	not done	not done	not done	PO_4^{3-}
potassium	3.38	2.69	8.15	785	K^+
sodium	63.6	110	121	1478	Na^+
sulfate	63.3	17.4	81.5	1029	SO_4^{2-}
pH	7.4	7.6	8.0	7.9	pH
Hardness	not done	not done	not done	not done	Hardness
TSS	100	160	160	2360	TSS
DO	not done	not done	not done	not done	DO

Results

Note:

1. The top row of sampling locations are possibledrinking water sources, the lower row irrigation water sources.

2. USEPA : Drinking water regulations and health advisories. <http://www.epa.gov/OST/Tools/dwstds1.htm 1 (October 1996)

3. WHO: Guidelines for drinking water quality (second edition) /Vol. 2 Health criteria and other supporting information. Geneva : WHO, (1996)

4. Values in brackets with an asterisk are WHO Raw Supply Criteria

5. ND; not detective

6. Enclosed figures by squares indicate values over permissible limits.

7. Ir; Irrigation purpose, Do; domestic purpose, Po; potable purpose

Table 3.2.14 Water Test Results and Relevant Irrigation Water Quality Standards (1/3)

Water Quality Standards

Water test carried out in Rep. Dominica	*Symbol / Explanation*	*Units* As supplied by test co. (mg/L=ppm)	FAO Irrigation Water Guidelines Degree of Restriction on Use (mg/L unless meq/L stated) None	Moderate	Severe	USDA Irrigation Water Quality	Rep.Dom. Irrigation Water Quality
ammonium-N	NH_4^+	mg/L					
bicarbonate	HCO_3^-	ppm					
bicarbonate	HCO_3^-:overhead sprinkling	meq/L	<1.5	1.5--8.5			
calcium	Ca^{2+}	ppm					300
calcium	Ca^{2+} (ppm /40.1 : meq/L)	meq/L					
carbonates	CO_3^{2-}	ppm					
chloride	Cl^-	ppm					500
chloride	Cl^- : (surface irrigation) : (sprinkler irrigation)	(ppm / 35.4 = meq/L)	<4 meq/L <3 meq/L	4--10meq/L >3 meq/L			
Escherichia coli	pos/neg or colony count	+/- (100 ml)					5000
fluoride	F^-	mg/L	<1.0				0.6-1.7
iron	Fe^{2+}	mg/L	<5.0				1
magnesium	Mg^{2+}	ppm					200
magnesium	Mg^{2+} (ppm / 24.3 : meq/L)	meq/L					
manganese	Mn^{2+}	ppm	<0.20				1
nitrate	NO_3^-	mg/L	<5	5--30			50
phosphate	PO_4^{3-}	ppm					
potassium	K^+	ppm					
sodium	Na^+	ppm					
sodium	Na^+ : (sprinkler irrigation)	meq/L	< 3 meq/L	> 3 meq/L			
SAR	SAR =Na/((0.5(Ca+Mg)) $^{0.5}$	no units	< 3	3--9			
sulfates	SO_4^{2-}	ppm					400
pH		no units	6.5--8.4	6.5--8.4	6.5--8.4		
EC_w	Electrical Conductivity (a measure of the water salinity)	mmho/cm (=mS/cm) EC is a salinity measure				C1 (low): < 250 C2 (med): 250- 750 C3 (high): 750-2250 C4 (v. high): > 2250	
TSS	Total Suspended Solids	ppm					1000
BOD5	5d Biol. Oxygen Demand	mg/L					5
COD	Chem. Oxygen Demand	mg/L					
DO	Dissolved Oxygen	mg/L					>=70%sat

FAO: *Water quality for agriculture / FAO irrigation and drainage paper 29 rev. 1.* Rome : FAO, (1985)

Table 3.2.14 Water Test Results and Relevant Irrigation Water Quality Standards (1/3)

Water Quality Standards

Water test carried out in Rep. Dominica	*Symbol / Explanation*	*Units*	FAO Irrigation Water Guidelines			USDA	Rep.Dom.
		As supplied by test co. (mg/L=ppm)	Degree of Restriction on Use (mg/L unless meq/L stated)			Irrigation Water Quality	Irrigation Water Quality
			None	Moderate	Severe		
ammonium-N	NH_4^+	mg/L					
bicarbonate	HCO_3^-	ppm					
bicarbonate	HCO_3^-:overhead sprinkling	meq/L	<1.5	1.5 - 8.5	>8.5		
calcium	Ca^{2+}	ppm					300
calcium	Ca^{2+} (ppm /40.1 : meq/L)	meq/L					
carbonates	CO_3^{2-}	ppm					
chloride	Cl^-	ppm					500
chloride	Cl^- : (surface irrigation) : (sprinkler irrigation)	(ppm / 35.4 = meq/L)	<4 meq/L <3 meq/L	4 - 10meq/L >3 meq/L	>10 meq/L		
Escherichia coli	pos/neg or colony count	+/- (100 ml)					5000
fluoride	F^-	mg/L	<1.0				0.6-1.7
iron	Fe^{2+}	mg/L	<5.0				1
magnesium	Mg^{2+}	ppm					200
magnesium	Mg^{2+} (ppm / 24.3 : meq/L)	meq/L					
manganese	Mn^{2+}	ppm	<0.20				1
nitrate	NO_3^-	mg/L	<5	5-30	>30		50
phosphate	PO_4^{3-}	ppm					
potassium	K^+	ppm					
sodium	Na^+	ppm					
sodium	Na^+ : (sprinkler irrigation)	meq/L	< 3 meq/L	> 3 meq/L			
SAR	SAR =$Na/((0.5(Ca+Mg))^{0.5}$	no units	< 3	3 - 9	> 9		
sulfates	SO_4^{2-}	ppm					400
pH		no units	6.5--8.4	6.5--8.4	6.5--8.4		
EC_w	Electrical Conductivity (a measure of the water salinity)	mmho/cm (=mS/cm) EC is a salinity measure				C1 (low): < 250 C2 (med): 250- 750 C3 (high): 750-2250 C4 (v. high): > 2250	
TSS	Total Suspended Solids	ppm					1000
BOD5	5d Biol. Oxygen Demand	mg/L					5
COD	Chem. Oxygen Demand	mg/L					
DO	Dissolved Oxygen	mg/L					>=70% sat

FAO: *Water quality for agriculture / FAO irrigation and drainage paper 29 rev. 1.* Rome : FAO, (1985)

Water Quality Standards

[illegible]	>8.5
4 - 10 meq/l >3 meq/L	>10 meq/l
5 - 30	>30
3 - 9	>9