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

5.1 General

The Study area is defined as the poorest area 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 such as minerals. Therefore, it is principally sound that the agricultural development in the Study area should be properly performed.

Selection of high priority area(s) for development in the Study area should be made for the most depressed areas considering the following: (i) Living standard of people, (ii) Access to social services and (iii) access to water resources. 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 province level.

5.2 Factors for Selection and Evaluation

For selection of the high priority area, the features of each province will be assessed from the following 9 evaluation factors such as (i) total farm profit per farm household, (ii) extension service ratio of potable water, (iii) medical services, (iv) illiterate rate, (v) unemployment rate, (vi) farm size, (vii) rainfall, (viii) ratio of irrigated area/arable land and (ix) irrigation efficiency. The evaluation of the features of the provinces is designed so that the weighted points are given to each evaluation factor, and is further graded as follows:

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 irrigated farmers)			30
	Grade-1	Above 50,000 peso	10
	Grade-2	50,000 to 40,000	20
	Grade-3	Less than 40,00 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

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

Evaluation factors	Azua province			San Juan province			Barahona province			Baoruco 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	1.7	2	7.5	1.7	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			55.0			60.5			87.5			100.0

The above table indicates that Bahoruco province has the highest scores of 100.0 points, followed by Barahona (87.5 points), San Juan (60.5 points) and Azua (55.0 points). Among the provinces, the two higher provinces of Bahoruco and Barahona have been selected as high priority areas.

5.3 Selection of Project for the 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 the 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 farmers' 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, whose main components are improvement of the existing irrigation system and establishment and strengthening of the water users' 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 areas suffering most seriously from the chronic water shortage caused by the deteriorated facilities and suspension of the pump operation due to the continual brownout. 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 in controlling water due to the structural disadvantage and the 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.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

(1) As a result of the Master Plan Study on the Agricultural Development in the Yaque der sur River Basin Agricultural Development Project, the constraints of agricultural development are revealed as summarized below.

i) The Study area is classified as semi-arid to arid area having scarce rainfall with large variation in occurrence and amount. Majority of annual rainfall is concentrated in several months in the rainy season and rainfall patterns are unstable. The river runoffs in the dry season reduce remarkably to small amounts.

ii) In the Study Area, shifting cultivation has been practiced. It induced that many forest trees were cut down, vegetation in the basin remarkably got reduced, and soil erosion and soil degradation were caused. This further causes sediment problems in Savaneta and Savana Yequa dams as well as in irrigation canals, and declined agricultural productivity of soils.

iii) The existing irrigation facilities are superannuated, and diversion structures and other appurtenant structures are insufficient for ensuring proper water delivery. Besides, the water management system is not set up yet. This condition leads to inefficient water use, remarkably low irrigation use efficiency, and lowering of annual cropping intensity.

iv) The crop production is decreasing due to degraded quality of seeds and seedlings, low agricultural inputs, improper water management and inadequate cultivation techniques, etc.

v) Agricultural support services such as extension services, research, seed multiplication, agricultural information, agricultural credit, etc. are limited due to shortage of budget, well trained staff, agricultural equipment and tools.

vi) The basic rural living infrastructures are insufficient.

(2) It is confirmed that the following points are prerequisite for ensuring the successful agricultural development in the Project area.

i) To alter the shifting cultivation to sedentary agricultural cultivation, as well as to promote reforestation

ii) To introduce the low cost agricultural production techniques to enable to sustain soil fertility required for the upland development in rainfed area.

iii) To introduce the improved irrigation techniques consisting of use of high quality seeds and seedlings, adequate cultivation techniques, proper irrigation water management

iv) To set up the proper agricultural production infrastructures consisting of improvement of existing irrigation facilities, construction of irrigation

facilities for night storage, change of pump irrigation systems into gravity irrigation systems, improvement and construction of inspection roads and diversion structures

v) To establish and strengthen the farmers water users associations responsible for O&M of irrigation facilities.

vi) To set up Yaque der sur Water Management Center responsible for river basin water management

vii) To construct rural and social infrastructures consisting of rural roads, rural water supply facilities, rural electrification, community center, etc.

viii) To improve and strengthen the agricultural support services consisting of practical technique research, training for capacity building to extension workers and leading farmers, preparation of land registration and land tenure shifting services required for credit service, establishment of model agricultural cooperative, network of market information system

ix) To set up institution for agricultural support services consisting of raising of agricultural techniques of extension workers, strengthening of CIAZA Agricultural Research Center, introduction of group credit, promotion of seed multiplication by CIAZA and private sector, strengthening of agricultural cooperatives, introduction of agricultural information system, etc.

x) To execute monitoring for the purpose of preservation of Rincon lake

(3) As a result, twenty-seven (27) development programs have been formulated in the Master Plan Study on the Agricultural Development in Yaque der sur River Basin, which consists of agricultural development program, agricultural supporting services program, river basin water management program, irrigation development program inclusive of setting up of water users association, rural infrastructure improvement program, environmental preservation program and water resources development program.

(4) With respect to living conditions of people and social set-up and water resource, most economically depressed areas were selected in the Study Area. Then in view of high economic efficiency, high model effect and a large number of beneficiary, the existing irrigation area having about 6,000 ha in the lower Yaque der sur river basin including improvement of Villarpando headworks was selected as the first stage development.

6.2 Recommendation

(1) On the basis of the above-mentioned result, it is recommended to carry out the feasibility study on the existing irrigation area having about 6,000 ha in the lower Yaque del sur river basin coupled with the imporvement of Villarpando headworks and its function.

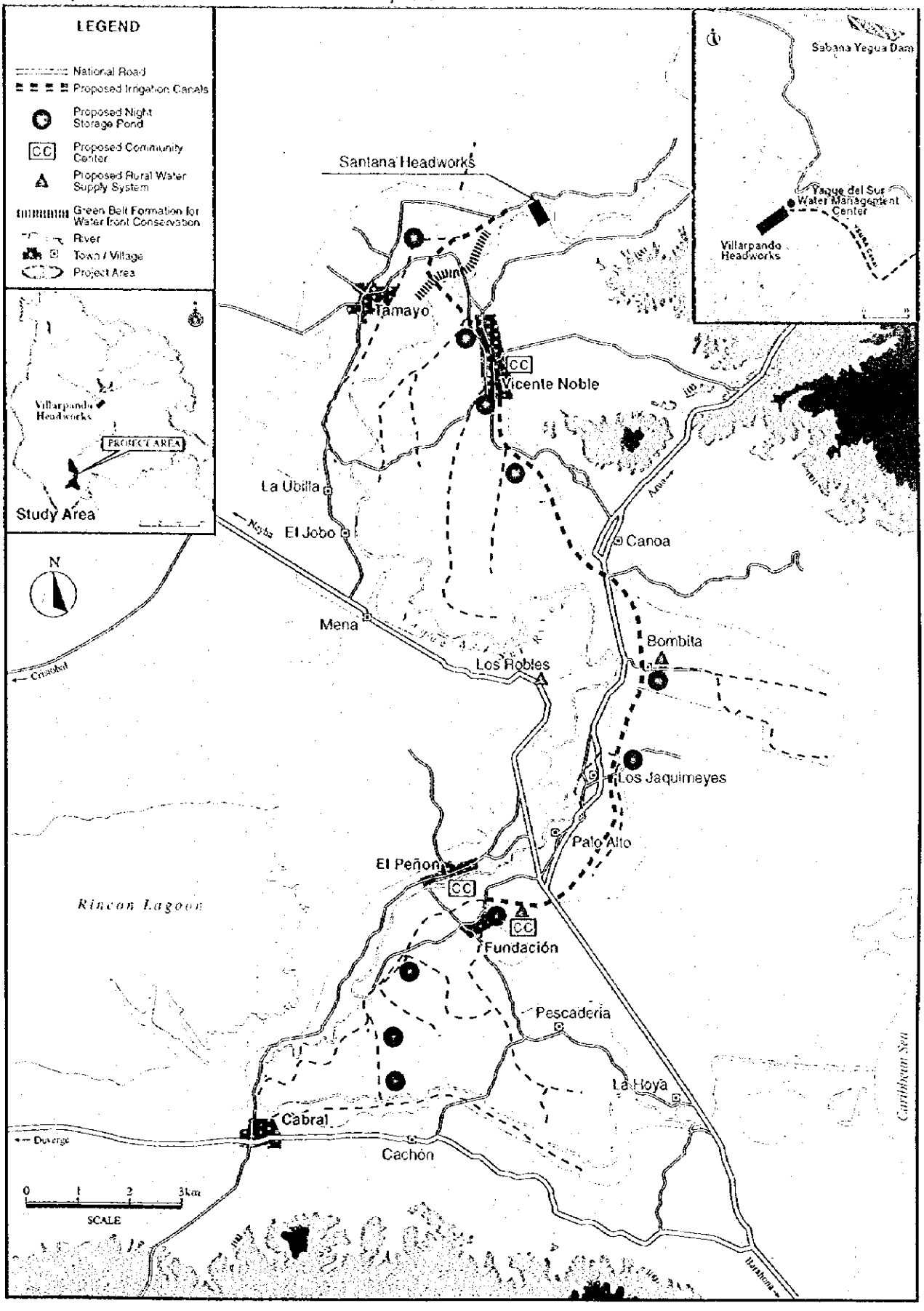
PART 2 :

FEASIBILITY STUDY ON THE AGRICULTURAL DEVELOPMENT IN THE LOWER YAQUE DEL SUR

JICA

The Study on Integrated Rural Development Project of Yaque del Sur River Basin in the Dominican Republic

General Development Plan in the Lower Yaque del Sur



7. PRESENT CONDITION OF THE PROJECT AREA

7.1 Administration and Socio-Rural Conditions

7.1.1 Administration and Areas

Administratively, the Project Area is fully or partly under the jurisdiction of Barahona and Bahoruco provinces, 5 municipal districts (Vecente Noble, El Penon, Fundacion, Tamayo, and Uvilla) and 13 rural sections. The total population of the Project Area related to the administrative jurisdiction to the Project was estimated at about 68,000 in 1998. The total number of households is estimated at 15,800 out of which about 30 % own farms. The average family size is 4.3. The population density is very low at 82 person/km^2.

7.1.2 Land Tenure

There are few data on land tenure in the Project area. Information gathered through INDRHI shows an average size farm of 1.3 ha for the farmers who received irrigation services from the Project area. According to the report 'Plan de Recuperacion y desarrollo integral del municipio de Tamayo y Su Entorno' prepared by SAR in 1998, 25% of the lands in the planned area is owned by farmers with a definite land title, 43% without a definite land title and other governmental land and other tenurial system.

7.1.3 General Information of the Households in the Project Area

In order to elicit in more detail the needs and wants of the communities within the Project area, a series of four workshops were held. The workshops included producers, Non-Government organizations (NGO's), health workers, Women Organizations and local Government administrators.

Regarding agriculture, there was a consensus among the different communities that irrigation water was not sufficient. That, in turn, is affecting the possibility of increasing agricultural production and income. In the case of the communities of Fundación, Jaquimeyes, Palo Alto, Peñón, and Tamayo, the effect of flooding (caused by Hurricane George) on their plots was identified as a major problem. Two other problems identified in all communities were the inability to access credit for crop production and the high concentration of intermediaries in the Project area.

Regarding health issues, the lack of doctors and health centers were cited as the main problems facing the communities in the Project area. The most common diseases identified by participants, were water related diseases such as respiratory infections, diarrhea, parasites, and skin problems.

Regarding education, the lack of school facilities and the high illiteracy rate were considered the most compelling problems in the Project area.

Most of the communities do not have garbage disposal systems and aqueducts. The lack of sanitary systems (latrines) was identified as a major problem that is affecting the health of community dwellers.

The main actions, identified by participants, that could increase the standard of living were the construction of an irrigation infrastructure and the construction of a social infrastructure such as clinics, schools and latrines.

The agricultural economic survey was conducted for about 60 farmer samples in the Project area. The general information of the households in the Project area is outlined below based on information from 62 farmers in the Project area selected from the previous survey during Phase-1 period. The details are shown as annex tables.

Most farmers interviewed in the feasibility Project area own some land with an average size of 20 tareas (1.3 hectares). Some farmers were beneficiaries of the government land reforms program with an average plot of 32 tareas (2 ha). The average households consist of 5 members. Regarding education, 51.6% of farmers achieved only a primary level. The illiteracy rate in the Project area is quite high and was estimated at 31%. 45% of the population in the study area have no access to aqueducts at the villages.

Farmers in the area produce plantain as the major food crop. Additionally, some farmers grow banana, cassava, corn, and industrial tomato. As for livestock, cattle, swine, sheep and poultry are produced in small scales mostly for family consumption. About 78% of hauseholds have access to electricity although there are some power shortages during the day. The electric power shortages have severely affected irrigation on those farms, which have electrical water pumps especially in Penon, Jaquimeyes, Fundación and La Hoya. Main crops in the Project area are plantain, followed by cassava, tomato, corn, papaya, melon, pepper and other crops cultivated on a small scale.

A farm economic analysis was performed among about 60 sample farmers. The farm budget was prepared for three categories of farmers; small farmer (below 1ha), medium farmer (1-2 ha) and large farmer (above 2ha). The results are summarized in the following table: Details are shown in Table 20.

Farm Budget

Item	Scale of Farm		
	Small	Medium	Large
Family size(person)	5	5	4
Range of farm size (ha)	Below 1	1-2	Above 2
Number of sample	15	30	14
Average farm size (ha)	0.61	1.3	4.3
Gross farm income (DR$)	25,350	57,210	210,280
Non-farm income (DR$)	11,500	11,500	0
Total gross income (DR$)	36,850	68,710	210,280
Production cost (DR$)	2,697	8,730	48,820
Living expense (DR$)	34,320	56,950	111,750
Total outgrow (DR$)	37,020	65,680	160,570
Surplus (DR$)	-170	3,030	49,710
% of plantain income per gross farm income	80	80	80
% of non-farm income per total gross income	31	17	0
% of food expenditure per total living expense	56	47	38
Living expense per person per month (DR$)	572	949	2,328
Surplus per person per month (DR$)	-34	606	12,428

It may be concluded that most of the farmers in the Project area remain at a subsistent level of living.

7.2 Natural Conditions

7.2.1 Land Resources

(1) Soils

A soil study at a semi-detail level was carried out by INDRHI in 1982. That soil study included the entire area of the Project area and identified six (6) soil series and five soil associations. The area of each soil series and associations is shown below.

Soil Series or Associations	Area (ha)	Proportional Extent (%)
Fundacion	2,270	32.6
Funacion-Bombita	2,270	12.1
Canoa-Bombita	180	2.6
Canoa	130	1.9
Santana	80	1.1
Jaquimeyes-Tamayo	345	5.0
Tamayo-Fundacion	260	3.7
Tamayo	1,470	21.1
Habanero	350	5.0
Vicente Noble	150	2.2
Others not Classified	885	12.7
Total	6,960	100.0

(2) Land Capability

The soil study made by INDRHI in 1982 presented an assessment of land capability for the land area of the present feasibility study. The land capability assessment was made following the USDA classification system, and the results are summarized in the following table.

Soil Series or Association	Map Symbol	Capability Class	Area (ha)	% of Total Study Area	Limiting Factors	Recommended Use
Fundación	Fu	IIs	2,270	32.6	Salinity risk if irrigation is not properly managed	Plantain, banana,
Fundación-Bombita	Fu-Bo	IIIsh	840	12.1	The salinity risk is higher than Fundación series. Irrigation & Drainage must be properly managed.	Rice, plantain, banana
Canoa- Bombita	Ca-Bo	Vhs	180	2.6	Imperfect natural drainage, salinity	Rice, coconut, pasture.
Canoa	Ca	Vsh	130	1.9	Imperfect natural drainage, salinity risks	Rice
Santana	Sa	VIsh	80	1.1	Coarse texture & Frequent Flood risk	Vegetables during dry season
Jaquimeyes-Tamayo	Ja-Ta	IIIsh	345	5.0	Poor drainage	Plantain, Tomato, Banana
Tamayo-Fundación	Ta-Fu	IIs	260	3.7	Little limitations	Plantain, banana, tomato, pepper
Tamayo	Ta	IIs	1,470	21.1	Little limitations	Plantain, banana, tomato, pepper
Habanero	Ha	IIIes	350	5.0	High content of carbonates	Improved pasture
Vicente Noble	VN	IIIes	150	2.2	Erosion risk,	Plantain, banana, tomato, pepper
Others not Classified			885	12.7		
TOTAL			6,960	100		

7.2.2 Agricultural Climate

The main climatic feature of the Project area is its arid condition, with potential evapotranspiration being about 3 times that of annual rainfall. The average annual rainfall is 662 mm, with two short rainy periods, first from May to June, and second from August to October. The total rainfall of the two rainy seasons makes up about 70% of the total rainfall. The highest monthly rainfall is in September with an average of 105 mm/month,

and the lowest rainfall occurs in January and February, with about 17 mm/month. Mean monthly temperature and relative humidity are 26.3 C and 74 %, respectively. There are no large variations in the average monthly temperature and relative humidity. Agroclimatically, a small amount of rainfall and its erratic distribution is the main serious constraint of agricultural development.

7.2.3 Hydrology

(1) Yaque del Sur River in the Project Area

The area of "Yaque del Sur Lower Reaches Irrigation and Drainage Project" is located on the downstream of Santana headworks. The headworks are situated at 51 km from the Caribbean Sea and the average river gradient below is 1/1,700 or 0.0005882.

The Yaque del Sur River runs south-westerly from Quita Coraza through a valley which ends near Santana headworks to the north of Vicente Noble. From this point, the river turns its course to the south. Tamayo is situated at right in the flow direction of the river and is subject to inundation.

From here, the river flows southward to Mena and then turns toward Canoa to the south of Vicente Noble. Part of the waters, particularly during the wet season, flow southerly through Caña Trujillo and Dren Los Tomates toward Rincon Lagoon. From Canoa, the river goes southward to Palo Alto. The river stretch between Canoa and Palo Alto is sandwiched by the national road and a railway or another national road, which blocks the flood waters and causes inundation in the area.

From Palo Alto, the river turns to the southwest flowing to Cabral, then turns to the east towards the Caribbean Sea. The tide affects the river water level up to La Hoya, which is located 5 km from the confluence. The river course is given in Figure 22.

(2) Available Water at the Yaque del Sur River

The 80 % of dependable discharges at Santana headworks vary from 11 to 20 m^3/sec. The dependable flow at Villarpando headworks, Santana headworks and Palo Alto are given below:

unit: m^3/sec

Station	Period	Probability	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Villarpando	1960-1982	Mean	25.2	19.7	18.4	20.2	36.9	54.5	46.4	48.8	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
Conuquito	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	-	-	-
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	-

(3) Flood

Due to lack of sufficient duration of river flow records, it is difficult to estimate the probable flood of longer return periods at Santana headworks. Judging from the design floods of other river basins in the country, an approximate specific discharge of 1.0 $m^3/sec/km^2$ is assumed at a 1 in 50 year recurrence level. Thus, 1 in 50 years a flood at Santana headworks is estimated to be 4,600 m^3/s. However, out of the catchment area of 4,578 km^2, some part is covered by the catchment of the dams (Sabaneta 464 km^2, Sabana Yegua 1,676 km^2), and the floods should be reduced by the dam effect. 1 in 50 years floods from the residual catchment of the dams (2,460 km^2) and the discharges from the service spillways (900 m^3/sec for Sabaneta, 600 m^3/sec for Sabana Yegua) amounts to about 4,000 m^3/sec, which can be regarded as a design flood at Santana headworks. The design flood discharge at Villarpando headworks (3,570 km^2) is similarly estimated at about 3,000 m^3/sec.

(4) Water Quality

Water quality was checked on pH and salinity (electric conductivity) to compare with the previous field tests (Ref. Table 21). The pH and electric conductivity (EC) values at Santana headworks, El Jobo, Palo Alto, and Cachon are given as follows:

Location	Phase-2 (Dec. 1998)		Phase-1 (Jan. 1998)	
	pH	EC (m S/cm)	pH	EC (m S/cm)
Santana headworks	7.6	0.49	8.1	0.91
El Jobo	7.8	0.49	7.7	1.09
Palo Alto	7.9	0.47	7.9	1.36
Habanero	7.8	0.56	7.8	1.36
El Cachon	7.8	0.54	7.2	0.95

Mainly due to more river flow during this study period (Phase-2), both the pH and EC values are considered low enough for irrigation at any location along the Yaque del Sur River.

7.3 Agriculture Production

7.3.1 Present Land Use

The Project area covers a total area of about 6,960 ha. The present land use of this area is estimated using the topographic map at scale 1:5,000 prepared by the JICA Study Team, statistical data from INDRHI and SEA, and a field survey. An estimated net area of approximately 5,885 ha or about 84.6 % of the Project area is devoted to irrigated agriculture production. The land covered by irrigation systems is used at a low intensity rate, mainly due to shortage of irrigation water. The land use for the rest of the Project area is occupied by towns, villages, roads, and other buildup areas of about 760 ha; Shrubs and bush of about 190 ha; and rivers and other water bodies of about 125 ha as shown in Figure 23.

7.3.2 Cropping Pattern and Farming Practices

(1) Main Crops and Cropping Patterns

The main crop planted in the Project area is plantain, followed by banana, cassava,

pepper, tomato, corn, melon, papaya, beans, and rice. The recent 5-year average of total area planted in the Project area is about 4,430 ha as shown below. An annual cropping intensity in the Project area is estimated at 0.75. Plantain, banana, and papaya are grown all year round. Other crops are planted at the onset of the two rainy seasons, generally in May or August. The present cropping pattern is indicated in Figure 24.

Crop	Average Planted Area (ha)	% of Total planted area
Plantain	3,430	77.4
Banana	170	3.8
Cassava	160	3.6
Pepper	140	3.2
Tomato	120	2.7
Melon	115	2.6
Papaya	110	2.5
Corn	70	1.6
Beans	50	1.1
Rice	20	0.5
Sweet Potato	20	0.5
Pigeon pea	10	0.2
Eggplant	15	0.3
TOTAL	4,430	100.0

(2) Farming Practices

Present farming practices in the Project area were investigated based mainly on the results of interview to 59 farmers, information from extension workers of SEA, and local staff of irrigation district offices.

Farming practices implemented by a large percentage of the farmers in the Project area are so poor, which becomes a serious cause of the low yields of crops in the Project area. The crop yields are lower than that of the Yaque del Sur River Basin. The basic problems of farming practices are shown below: Among these problems, items c) and e) seriously affect yields of crops in the Project area.

(a) Land preparation is not done in a timely and proper manner due to lack of mechanical power

(b) Most farmers use poor quality of seeds and seedlings.

(c) The level of application of farm inputs such as fertilizer and chemicals is low.

(d) Farm input is not always applied at the right time and right volume.

(e) Management of on-farm water is poorly done and irrigation water is scarce.

The farming practices of main crops and their problems such as plantain, banana, cassava and tomato are shown in detail in Table 22.

7.3.3 Present Crop Yield and Crop Production

The average yield of crops within the Project area is estimated based on results of a farm survey as shown below: The estimated crop production in the Project area is estimated as shown in the following table.

Crop	Average Yield (ton/ha)	Average Planted Area (ha)	Total Annual Production (ton)
Plantain	18	3,430	61,740
Banana	24	170	4,080
Cassava	6.5	160	1,040
Pepper	13	140	1,820
Tomato	21	120	2,520
Melon	30	115	3,450
Papaya	44	110	4,840
Corn	1.8	70	126
Beans	0.9	50	45
Sweet potato	12	20	240
Eggplant	15	15	225
Pigeon pea	1.5	10	15
Rice	2.2	20	44

Livestock production in the Project area is negligibly small. Only a few farmers are keeping cows using grass from areas of poor drainage conditions and left-over from sugarcane and agriculture.

7.3.4 Main Problems in Agriculture Production

The main problems in agricultural production are accrued from main global factors such as low cropping intensity and low yield of crops. The components of such factors are analyzed in detail and are summarized in Figure 25.

7.4 Marketing and Prices

7.4.1 Marketing System of Main Agricultural Crop Production

The marketing system for agricultural commodities in the Project area is simple as explained in Section 3.4.1. Staple food crops are about 10% of plantain production, while most production of cassava, corn, red beans, pepper and rice are consumed in the Project area. It is estimated that 90% of plantain production in the Project area are classified as class one and is transported to the Santo Domingo market or to export. Plantain growers sell their production directly to truckers and local middlemen at the farm gate. In the case of bananas, the entire production is sold at the farm gate to local intermediaries and channeled to local market outlets. Melon and papaya are produced under contract with local exporters. Only a small fraction of the production, which does not meet the requirement for export, is sold at local market and Santo Domingo. Tomato is produced under a contract with the processing plants with an agreement among producers, the processing firms and SEA and sold to domestic market by the firms.

7.4.2 Marketing of Farm Inputs

In the Project area farmers obtain fertilizers, agrochemical inputs and seeds from the Center for Input Sales (CEVEMA) run by the SEA and private agrochemical stores located in the agricultural areas. Plantain seedlings are obtained from SEA and from previous production. SEA provides machine services for land preparation through the Center for Machine Services (CESMA) located in Barahona. 50% of the machinery is in critical condition and only 13 tractors are available for land preparation.

7.4.3 Trade Condition

The most important export in the Project area is plantain, which is exported to the USA and Europe. Especially, plantains cultivated in Tamayo and Vicente Noble are called "Barahona plantain" and usually have higher prices both at the national and export markets than plantain coming from the Northwest region (Mao and Monteeristy provinces) of the country. Most of the exports are shipped through Haina Port, which is about 110 km from the Project area. After Hurricane George, there was some government intervention in the marketing of agricultural products in the region to provide assistance to producers and consumers. In some cases the government has banned plantain exports to avoid shortage in the domestic market.

7.4.4 Marketing Information System

A marketing information system is practically not used in the Project area. Price information at different levels in the marketing channel is collected by extension agents and sent to Santo Domingo on an irregular basis. In Santo Domingo the data collected is used for statistical purposes more than to establish marketing policy actions and develop policy objectives.

7.4.5 Market Place Condition

The market infrastructure in the Project area is not adequate or non-existent. Only in Vicente Noble and Tamayo does an infrastructure exist. However, there are no facilities for the display and storage of products. Agricultural produces are displayed on the ground and there is not much concern for their quality and preservation. The degree of value added is minimal and prevails an array of measures and weights for buying-selling transactions. There is no supervision by the local authorities or any public institutions on safety and product standards.

7.4.6 Prices of Agricultural Products

Farm gate prices of the main crops in the Project area show some fluctuation throughout the year. After Hurricane George, plantain prices skyrocketed. At the consumer level, plantain prices went up from DR$1.25/unit in August to DR$6.50 in November. The marketing margin between the producer and consumer price ranges from 35 to 70% of the final price. In most cases, the market with the heaviest influence of local middlemen determines price mechanism. In the case of the industrial tomato, there is a predetermined price established in the production contract by the agroindustries. Farm gate prices of the main crops are shown in Figure 26.

7.4.7 Agroprocessing Facilities

The level of agroprocessing in the area is very low. Plantain does not undergo any kind of transformation while industrial tomato production is transported to processing plants in Azua. Papaya and melon are also transported fresh to the nearest port in Haina. The only processing plant within the Project area is a rice mill located in Canoa.

7.5 Irrigation and Drainage

7.5.1 Present Irrigation Areas and their Systems

(1) Present Irrigation Areas

The objective area in the Phase II stage, which is shown in Figure 27, is the irrigation area served by the Yaque del Sur River in the downstream of the Santana headworks except the area managed by CEA. The area is largely classified into four areas. First is the upstream right bank of the Yaque del Sur River, so-called the Tamayo area. Second is the upstream left bank area, so-called the Vicente Noble area. Third is the Canoa-Palo Alto area in the middle reaches. Fourth is the Peñon-Fundación area in the lower reaches. The irrigation area was measured by use of detailed maps with a scale of 1 : 5,000 prepared in the beginning of Phase II by our JICA Study Team. The irrigation area is estimated at 5,885 ha net in the downstream of the Santana headworks. The results are summarized as follows.

Irrigation System	Area (ha)
Tamayo area	940
Area served by small irrigation system	624
Area served by Santana system	316
Vicnete Noble area	1,393
Canoa- Palo Alto area	815
Penon-fundacion area	2,737
Total	5,888

Note: measured by planimeter excluding settlement area and hilly area and then multiplied by 0.9

The Tamayo and Vicente Noble areas are served by a gravity irrigation system. One –third of the Canoa- Palo Alto area belongs to the Vicente Noble irrigation system. Two-third of the Canoa – Palo Alto area and the Peñon-Fundación areas are totally served by pumps.

The Tamayo and Vicente Noble areas have been severely damaged by floods caused by Hurricane George along the Yaque del Sur River. Many fields turned into uneven small patches by erosion and sediment, which urgently need land leveling for the application of irrigation water. Farmers are gradually performing a land leveling by tractors and motor graders. The Palo Alto and Peñon-Fundación areas were not severely damaged.

(2) Irrigation Systems

Existing irrigation systems are shown in Figure 27 and listed in Table 23.

There exist several small gravity irrigation canal systems in the Tamayo area. One is a system diverted from the Santana headworks, which is managed by CEA. It is called the Habitantes canal. The head intake of this canal is one of the seven intake gates of the Santana headworks, i.e., the other six gates serve the Santana main canal. Other intake gates are two canal systems called the Charco Blanco and the Añon-Uvilla canals. Both canals divert water from the Yaque del Sur River by free intakes. All these canals are totally earthen canals. They are characterized as deep especially in the upstream reaches and meander.

Besides the Lateral B and Lateral H canals of the Santana canal system, which supplies water to the sugarcane plantation under the management of CEA, limited private

lands located on the way of these canals are also served.

The Vicente Noble area is served by one gravity irrigation canal system. This system consists of a head intake, a headrace and two main canals and several laterals diverting from these main canals. The intake does not have a weir. The two main canals are provided with stone masonry lining most reaches. The laterals are earthen-made. It is also characterized that all the canals are excessively deep and wide and meandering. A large amount of water is required to raise the water level to divert the supply of water to fields. Private-owned small diesel pumps can be seen along the river.

Most of the canals in the Tamayo and Vicente Noble areas were buried with sediment or washed away by the flood of Hurricane George in 23 September 1998. INDRHI is doing its best to restore the damaged canal system. As of the end of December 1998, many canals were restored.

The Canoa-Palo Alto area and Peñon-Fundación area are mostly served by pump irrigation canal systems. There are 29 pumping stations including two CEA pump stations and five IAD pumping stations along the Yaque del Sur River.

All the pumps are of the electric motor-driven type and had functioned well with exception to a few pumps. However, the flood caused by of Hurricane George damaged most of the pumping stations. Nearly half of all the pump stations are working well as of the and of December 1998. Suction pits are buried with sediment in most pumping stations located in the Canoa-Palo Alto area. Some of pumps were inundated with flood water on 23 September 1998. Canals are mostly of the earth canal type and partly provided with concrete lining or stone masonry. Canal systems are not maintained well and are more or less deteriorated.

Canal-related structures are also deteriorated or do not exist. Most major canals have no inspection roads.

(3) Villarpando headworks

The headworks consists of a weir and an intake equipped with three sluice gates to YSURA Head Race, and a sand flushing sluice equipped with one radial gate. To lead river water from the center of the river to the intake, an access canal has been provided. The weir portion has a crest length of 870 m across the river, which is largely divided into two parts such as an overflow section of 115 m wide and an earthfill dam section in the remaining part. The overflow section is made by rock masonry works. The crest elevation is El. 287.60 m. The earthfill section has a crest elevation of El. 292.60 m in the portion contacting the intake and the flow section so that even maximum design flood of 1,250 m^3/sec is safely drained at the water level of El. 291.00 m, and El. 290.00 m in the other part, which are designed to function at the time of the design flood of more than 740 m^3/sec. The earthfill section is of the center core type protected by random rock fill in the upstream and downstream surfaces.

All the intake gates are manually operated. At present, only one out of the three gates can be operated while the other two gates are damaged in the spindles. The gate operation is carried out by hoisting and hanging by a backhoe according to the Azua

irrigation zone staff. It is impossible to operate frequently and timely as required. The sand flushing gate has also been damaged in the hoisting equipment and left in a closed position. Due to no opening of the gates, the water way to and in front of the intake gate suffers from the sedimentation of sand and gravel. Such conditions allow silt, sand, and gravel easy access into YSURA head race.

The headworks was largely damaged in the right side earthfill section by the flood of Hurricane George on September 23, 1998. According to the gate operator, the river water level reached its peak at AM. 7:30. The water level had been over the crest of the intake structure. After that, the water level suddenly decreased. The right side dike was estimated to be broken at this time. Concrete structures suffered little damages. The sand scouring sluice, which was out of order and left in a closed position was completely damaged with twisting in the gate leaf. The right side earthfill section was almost completely washed away in all the sections, although the center core of the earth dike remained in some parts. The river water coming from the San Juan River flows through the damaged portion. Water coming from the Sabana Yegua Dam is being led to the intake structure by simple training-dike tentatively made with river deposit. INDRHI is planning to reconstruct the right side dike as emergency works.

7.5.2 Organization for Operation and Maintenance

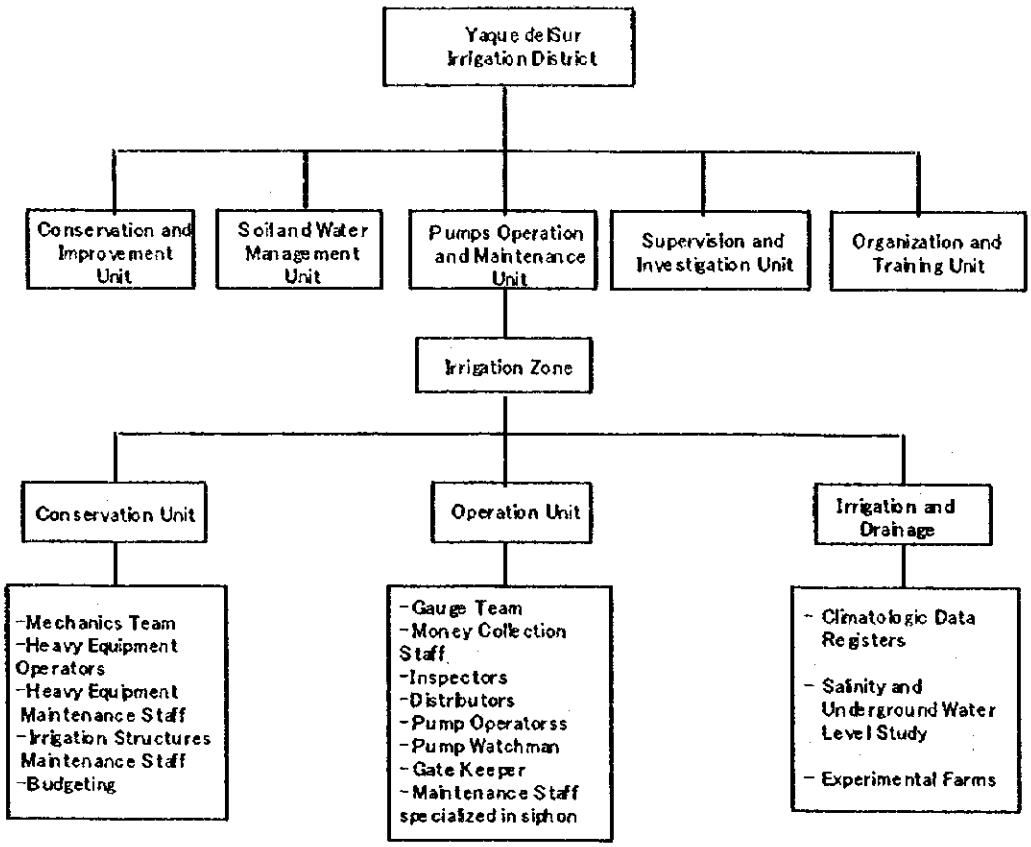
The Project area belongs to Yaque del Sur Irrigation District except for the Tamayo area, which belongs to the I.D. Lago Enriquillo.

(1) Irrigation District Office

(a) Organization

Organization structures of Yaque del Sur and Lago Enriquillo Irrigation District are the same as other irrigation districts. The District office has five units: Conservation and Improvement, Water and Soil Management, Pumps Operation and Maintenance, Supervision and Investigation, and Organization and Training. Under a district manager, one or two staffs are assigned in each of the units and one irrigation zone office exists. This zone office substantially works in the operation and maintenance of irrigation.

Organization of Yaque del Sur Irrigation District



The unit of conservation consists of a mechanic team, operators of heavy equipment, maintenance staff of heavy equipment, maintenance staff of irrigation and drainage facilities, and others. The unit of operation consists of a gauging team, water charge collectors, irrigation inspectors, irrigation distribution staffs, pump operators, pump watchmen, as well as others. The unit of irrigation and drainage consists of staffs of climate data compilation and soil investigation.

(b) Budget

Total budget of the I.D. Yaque del Sur is about DR$ 23 million as shown in the following table. Personnel payroll accounts for about one-fourth and rehabilitation and maintenance of irrigation and drainage facilities account for nearly a half of the total budget. The budget, excluding the budget for the canal construction contracted in Santo Domingo (54.82 km), is about DR$ 19.5 million. Budget per one hectare is around DR$ 710.

Budget during the last two (2) years:

(Unit : DR$)

Year	1996	1997
Personnel payroll	5,688,348.00	6,324,240.00
Fuel and lubricant expense	943,735.70	900,437.00
Administrative expenses	150,251.00	250,343.00
Vehicle repairing	101,240.00	240,343.54
Pump repairing	300,000.00	350,343.50
Small work construction	1,600,400.00	1,547,340.00
Rehabilitation of hydraulic structure	500,000.00	670,340.00
Floodgate installation	200,000.00	240,350.00
Canal construction contracted in Santo Domingo (54.82 km)	4,429,623.21	3,430,347.80
Rehabilitation and/or construction of berm with equipment (152.25km)	2,100,736.90	2,550,600.00
Weed cut and sediment extraction (labor) (545 km)	3,035,966.90	2,500,340.00
Canals and/or drainage cleaning with equipment	3,205,486.40	3,400,000.00
Collection of water charge	500,000.00	600,000.00
GRAND TOTAL	22,620,788.11	23,005,024.84

Note : Years 1996 and 1997 are before the Irrigation District Lago Enriquillo was separated from I.D Yaque del Sur. Thus the figures above include both Yaque del Sur and Lago Enriquillo.

(c) Water users and water charge

As shown in the following table, water users registered in INDRHI total about 4,500 in the Project area.

Number of Registered Water Users and Water Charge

Year 1997

Canal	Water users	W. users paid	Total W. charge (DR$)	Collected amount (DR$)	W.users paid (%)	Collected amount (%)
Vicente Noble	1,053	282	285,847	82,013	26.8	28.7
Santana	88	7	25,944	3,343	8.0	12.9
Los Habitantes	316	26	99,235	14,894	8.2	15.0
Charco Blanco	99	7	31,081	1,466	7.1	4.7
El Jobo	176	12	67,788	6,097	6.8	9.0
Palo Alto	182	32	48,189	7,933	17.6	16.5
Palo de Leche	277	94	58,705	18,646	33.9	31.8
La Isleta	467	193	62,749	31,389	41.3	50.0
La Hoya	147	25	27,989	8,760	17.0	31.3
Penon	248	78	45,860	17,338	31.5	37.8
Pescaderia	75	5	17,995	405	6.7	2.3
Jaquimeye	291	86	69,575	23,256	29.6	33.4
Fundación	206	50	47,351	9,993	24.3	21.1
Las Elenas	149	42	21,970	11,241	28.2	51.2
Bombita	19	6	5,158	2,687	31.6	52.1
Guaba de Mena	75	4	20,748	462	5.3	2.2
Habanero	52	3	35,221	9,779	5.8	27.8
Hato Viejo	156	77	24,908	12,073	49.4	48.5
Mena Penon	50	6	22,977	3,742	12.0	16.3
Total	4,126	1,035	1,019,290	265,517	25.1	26.0

Source : Division de usuarios, INDRHI

According to the General Regulation 555, the water charge is decided based on the expenses required for O&M of irrigation and drainage facilities including all the office expenses. Based on this Regulation, INDRHI estimates that about DR$ 600 / ha is needed for the O&M in I.D. Yaque del Sur. The unit rate of the water charge is, however, set at a very low rate as follows.

Yaque del Sur Irrigation District

- Plantain and upland crops: DR$ 160 / ha up to 10 ha
  DR$ 320 / ha for acreage over 10 ha
- Paddy DR$ 320 / ha up to 10 ha
  DR$ 640 / ha for acreage over 10 ha

In case that water is taken by private pumps, the water charge is half of the above values.

Lago Enriquillo District (former Neiba Irrigation Zone) : DR$ 110 / ha

It is, however, a fact that only about 1,000 users or only 25 % of total registered users paid water charges in 1997. This tendency did not change in 1998. The amount of water charge collected in 1997 was only DR$ 266 thousand or only DR$ 45 / ha. This amount is less than 10 % of the total amount required for O&M works.

The collection of water charge is managed by one person in charge. Farmers have to go to the office to pay water charge. The reasons why farmers do not pay water charge are, according to the farmers, (i) the water service is insufficient, water cannot be obtained sufficiently and timely, (ii) sometimes the person in charge of distribution gives water to farmers who do not pay water charge, and (iii) the office is far from the farmers' houses.

(2) Water User's Organization

INDRHI has put a high priority on the formulation of water user's organization (WUO) for entire irrigation systems and strengthening existing organizations in order to execute operation and maintenance of irrigation and drainage systems by farmers themselves in line with the policy of the beneficiaries participatory approach.

I.D. Yaque del Sur started to guide farmers to form WUOs and got fruitful results in that water users associations were founded in several pumping irrigation systems. The works to organize farmers, however, have been obliged to suspend, since all the forces of I.D Yaque del Sur have been concentrated into emergency works to restore the irrigation systems damaged by Hurricane George.

According to the Organization and Training Unit of the I.D Yaque del Sur, WUOs were founded in Peñon and Fundación areas in early 1990s and the Unit newly started to be engaged in the organizing nucleus and association of water users in 1998. As of December 1998, following organizations were set up.

Name of Community	No. of Association	No. of Nucleus	Inaugurated Year
Jaquimeyes	1	4	1998
Peñon	3	19	Around 1991
Peñon 1	1	5	
Peñon 2	1	6	
Palo de Leche	1	8	
Bombita	1	7	1998
Pescaderia	1	11	1998
Fundación	1		Around 1991

Water users organizations developed by the INDRHI are managed by the following members:

Board of Directors in Association
- One - President
- One - Vice president
- One - Treasurer
- One - Secretary

Three - Other Committee Member

The association is generally made in each pumping stations. Under the association, several nucleuses are established in each lateral. In each nucleus, a distributor, an assistant and a maintenance staff are to be nominated by the members. It is determined that the distributor and the assistant have to work for water distribution in their area. They are requested to record the date when water is distributed. The maintenance staff has to direct and supervise members to make the canals clean. Actually the formation of nucleuses differs a little bit from the original one as stated below.

In the Fundación area, nucleuses have been organized under the Agricultural Association founded in 1982. In each nucleus one distributor and two maintenance staffs are nominated from the members and are working on a voluntary basis. According to a member of the Association of Palo de Leche, the Palo de Leche pump irrigation canal system has eight (8) laterals, in each of which a nucleus is organized. Water distribution is made by conference among nucleuses and between members in each nucleus.

WUO of Jaquimeyes is not actually working, because the pumping operation has been stopped since the suction pit was buried with sediment on September 23.

It has been recognized that the merits of an organization are the decrease of water dispute between water users and the decrease of unfair water distribution in such that a person who has power and money receives more water than others. If unfairness in the water distribution between nucleuses or among members is pointed out, it is corrected in the conference between nucleus or among members. They have not, however, experienced water distribution carried out in accordance with the water distribution schedule nor have they been making the water distribution schedule. They verbally confirm water distribution schedule in the meeting in the drought season. Regulations, water distribution rules, and operation and maintenance manuals have not yet been prepared. The collection of water charge by WUO was once tried, but ceased due to accounting problems such that collected money was lost.

7.5.3 Present Operation and Maintenance

(1) Operation

As already explained, water distribution rules, and operation and maintenance manuals have not been prepared in written forms in both I.D Office and WUOs. In the main canals to lateral canal levels, water diversion schedules are approximately fixed. For example, one lateral canal distributes water from Monday to Wednesday and the other lateral distributes from Thursday to Sunday. In each lateral canal, the irrigation inspector and the water distributor hired by INDRHI distribute water at the requests of farmers. In the area where a nucleus is organized, a person nominated for water distribution works as a coordinator requests the INDRHI staff to distribute water. These processes are being carried out with no written water regulation rules and manuals.

(a) River water diversion at Santana intake, other intakes and pumping stations

The Santana irrigation canal system and the other systems located in the downstream

of the Santana freely take water from the Yaque del Sur River during the period when water is abundant, but once river flow is insufficient, they alternatively take water during a week, 4 days for the Santana intake (CEA) and 3 days for other systems. The Santana intake takes all water from Sunday 4:00 p.m. to Thursday 2:00 p.m. weekly, while other intakes and pumping stations can take water for the other days.

(b) Operation of gravity irrigation canal systems

The Vicente Noble irrigation canal system is operated by a person in charge of water distribution, a gatekeeper and a few assistants employed by INDRHI. Usually turnout gates are operated simply by an on-off basis on a few days or weekly rotation by lateral canals. Then, water is distributed to fields in accordance with the requests from farmers. During the drought period, most of the river water is taken by the Vicente Noble intake. Discharge is not measured at any points.

As for the canals managed by CEA such as Lateral B and Lateral H of the Santana irrigation system, water is exclusively supplied to the sugarcane fields from early morning to P.M. 2:00 and then from 2:00 to early morning farmers can take water to their fields.

(c) Operation of pump irrigation systems

As for a pump irrigation system, a person in charge of water distribution and two pump operators (daytime and night time) are usually engaged in one pumping station. The person in charge directs the pump operators to operate pumps in accordance with the requests from farmers or from the board of directors of WUO newly founded in 1998. Pump operators are presently not recording the operation such as electricity consumption, pump operation hours, and number of pumps operated. The most important points are reliability of electricity supply and availability of river water during the drought period. Electric supply is erratic in these years. All the pumps are motor-driven pumps. Thus the operation is disturbed by the erratic stop of electric supply. The river water is very small during drought periods, since all the water is diverted at the Santana and Vicente Noble intakes.

(d) On-Farm Level Operation

Plantain fields are irrigated by basin irrigation method about once a month. Fields planted with tomatos are irrigated by the furrow irrigation method at 10 to 12 day intervals. In the case of plantain, which is the dominant perennial crop in this zone, farmers prefer to supply water to the fields at night time since plantain falls down due to soil-softening with water and by strong wind prevailing at daytime. Participation of women in farming practices is limited at the planting and harvesting times. Major farmers usually employ workers for water distribution. The employment fee is generally 80 pesos with a meal to 100 pesos for daytime work and about 150 pesos for nighttime work.

(e) Transportation equipment for field operation

Some inspectors and water distributors have assigned motorcycles from INDRHI and others have their own motorcycles, but most of them don't have any. They receive three (3) gallons of gasoline every Monday. It is, therefore, difficult for a person who has

no transportation means to visit the sites along the canals and it is supposed that water diverted to laterals is flowing with no control or where nucleuses are organized, is distributed by farmers.

(2) Maintenance

(a) Data availability in Irrigation District and Zone Office

It is the responsibility of the District and/or the Zone Conservation and Improvement Unit to make an inventory of all the irrigation and drainage canals and the related structures and keep all the data indicating their locations, dimensions, quality of materials and actual situations. In case of pumps, the Pump Operation and Maintenance Unit has responsibility for such works. These data, however, have not been kept by the Irrigation Office except for general data such as length of major canals and list of pumps, although they are the most important basic data in preparing the maintenance and repair programs and to carry out some necessary investigation and design for repairing works.

(b) Maintenance and repairing

Most of the canals and the related structures are maintained by the Irrigation District Office. Generally it seems that maintenance works are not frequently executed in all the irrigation systems in the Area, although immediate after the flood caused by Hurricane George, INDRHI is doing rehabilitation works in full swing to restore the damaged irrigation systems.

The water users' organizations and farmers carry out only minor routine works such as canal cleaning on voluntary basis or temporally employed by INDRHI. When repair is needed, WUO or farmers refer to the Irrigation District office.

(c) Maintenance equipment

I.D. Yaque del Sur has heavy equipment such as trucks, bulldozers, excavators and a motor grader as listed below. Heavy equipment that can be employed include only one truck, one bulldozer and one excavator. In addition, after Hurricane George, the Irrigation District received two excavators, which are being used at Vicente Noble area.

-	Truck ,10 m^3		out of order
-	Truck, 6 m^3		good
-	Bulldozer	3 nos.	1 no. good
			2 nos. out of order
-	Excavator	8 nos. in total	1 no. good
			2 nos. under repairing
			5 nos. out of order
-	Motor grader	1 no.	under repairing

Also I.D. Lago Enriquillo has heavy equipment as listed below. Heavy equipment which can be employed include only one dump truck, two backhoes, one bulldozer and one motor grader.

-	Dump truck	1 no.	Good
-	Drag line	1 no.	Out of order
-	Back hoe	4 nos.	2 nos. good
			2 nos. out of order
-	Bulldozer	2 nos.	1 no. Good
			1 no. out of order
-	Motor grader	1 no.	Good

7.5.4 Results of Farm Household Survey

A total of 59 farmers were interviewed. All the farmers take irrigation water from the Yaque del Sur River. According to the farmers, the three main problems affecting agricultural production, 73% said firstly and 15 % said secondly the difficulty of irrigation. Nearly 90 % of all farmers feel there is insufficient water in the dry season. They think the insufficient water is caused by reasons such as inadequate water diversion at Villarpando, inadequate diversion at their headworks, poor condition of canal systems, insufficient quantity of water in the river in dry season, difficulty of pumps in maintenance and frequent interruption of electric supply, poor water management in canal systems, powerful people taken water, and others. Nearly 90 % of farmers replied that they were willing to participate in a water users organization that is responsible for the operation and maintenance of the irrigation systems.

7.5.5 Problems in Irrigation

A main problem in the irrigation sector pointed out by most of farmers and the staffs of INDRHI is water shortage in the dry season. It is mainly due to two main causes; one is insufficient river water and the other is inefficient use of water in the canal systems and the fields.

The insufficient river water is caused by the absolute shortage of the river water resources or man-caused problems. The absolute shortage of the river water resources rarely occurs except in the drought season of an extreme dry year. Most of the causes of the insufficient river water are caused by man, for example, improper diversion of water in Villarpando headworks and other intakes including Santana headworks and Vicente Noble intake, stop of pump operation due to the interruption of electric supply, and so on.

Inefficient use of water in the fields is being caused by various things such as no care of water distribution due to shortage of operation staffs and no transportation means, difficulty of water distribution with no control structures, and so on. These problems are logically explained in Figure 28.

7.6 Rural Infrastructure

7.6.1 Living Environment

A rural infrastructure has not been sufficiently developed due to the population pressure, deterioration of facilities, and damages by the hurricane George. Meanwhile, there are certain gaps among the villages in the Project area. Their major problems are

observed on 1) drinking water supply, 2) farm roads, and 3) social infrastructure as shown in Figure 29.

7.6.2 Roads

The Project area has good accessibility traversed by the national road network, namely secondary national roads, route 44, 46, and 48 and tertiary national roads, routes 514, 529, and 531 as shown on Figure 30. Route 44 branches off from the primary national road route 2 at Cruce de San Juan, and runs along the eastern boundary of the Project area linking Barahona city in the south. Routes 46 and 48 branch off from the route 44 and connect major cities in the Project area, leading to the west. Their inventory is presented in Table 24 and below.

Category	Total	Tamayo	Vicente Noble	El Peñon	Fundación
Secondary national road *1	38 km	-	-	-	-
Tertiary national road *1	21 km	-	-	-	-
Rural road *1	37 km	-	-	-	-
Farm road *2	114 km (1.7)	20 km (1.9)	30 km (1.9)	13 km (1.4)	47 km (1.5)
Canal inspection road *2	15 km	5 km	9 km	0 km	1 km

Source ; *1 SEOPC, *2 JICA Study Team (1/5,000 map) Remark ; Figures in parentheses show the road density (km/km^2)

Rural roads are normally gravel or earth surface with a width of 4-6m. The roads are maily utilized by the farmers for their daily farming activities. Though the maintenance is also to be carried out by the responsibility of SEOPEC district office, and partly conducted by the farmers or community. Their activities is quite limited due to lack of budget, therefore the condition is recognized to be poor especially with muddy surface in the rainy seasons and raising of dust. Improvement of rural roads, especially the earth roads is essential.

7.6.3 Rural Water Supply

Almost towns and villages in the Project area are included in multiple water supply systems (called "acueducto multiple") established by INAPA. Six multiple water supply systems exist in the Project area, but are, however, not satisfactorily operated in recent years. Moreover, their beneficiaries are facing shortage of water and low quality because of system deterioration and pressure by the increasing village population. In the Project area, there are still some villages suffering the lack of INAPA's water supply system, i.e. Bombita, Los Robres, and Altagracia. The villagers in these villages are mainly depending on some point source, such as river, irrigation canals, etc, taking water in the neighboring systems or purchasing expensive water from supplier by tanker for drinking and cooking purpose. The actual status of the rural water supply is shown in Figure 31 and Table 25, and summarized as follows.

INAPA system	Condition	Villages	Population	Remarks
With INAPA system	Quantity & Quality acceptable	Cabral, Cachón, Palo Alto, El Peñoo	17,400	
	Quantity acceptable but salty	La Hoya, Hato Viejo, Pescaderia	1,600	Buying drinking water from supplier
	Quantity not enough or partially supplied	Fundación	5,600	Buying bottled drinking water or from supplier
	System damaged by hurricane and no water supplied	Canoa, Uvilla, El Jobo	16,500	
	System damaged by hurricane and partially supplied	Vicente Noble, Tamayo, Mena	41,100	
	No water available for long time	Jaquimeyes	2,500	
Without INAPA system		Altagracia	900	Taking water from Fundación System
		Los Robles	400	Taking water from Yaque del Sur River
		Bombita	1,100	Taking water from Yaque del Sur River, canals or supplier

Source ; JICA study team (INAPA district office and interview survey)

7.6.4 Rural Electrification

The Project area is traversed by CDE grid with transmission lines of 138kV, 69kV, 34.5kV and 12kV to supply electricity to each community as shown in Figure 32. Most the area is energized, however they are facing shortage of power, low voltage, power cut-off due to the lack of total power generation and increasing loss caused by deterioration. Such situations, the existing pumping stations of INAPA and INDRHI are also facing the shortage of electricity affecting their operation of rural water supply and irrigation water. The present condition is summarized as follows.

CDE system	Condition	Estimated Population	Villages
With CDE system	Acceptable	67,700	Vicente Noble, Tamayo, Uvilla, El Jobo, Cabral, Cachón, Mena,
	Low Voltage or frequent power cut-off	18,600	La Hoya, Hato Viejo, Pescaderia, Palo Alto, El Peñon, Fundación, Canoa, Altagracia, Jaquimeyes
Without CDE system	No Electricity (CDE system was out of order)	900	Los Robles,

Source ; Study team (CDE district office and interview survey)

7.6.5 Other Social Infrastructures

In the Project area, there are 15 schools, 9 health care facilities, 51 churches, and 12 community halls. Inventory of the social infrastructures within the Study area issummurizd below and tabulated in Table 3.6.5 in Annex 2 . Especially, in the project area, only major cities have community centers that provide spaces for the villager's socila and cultural activities and these centers have no related facilities. In the rural areas, there are not eeven community hall.

	Barahona			Baboruco	
	Vicente Noble	El Peñon	Fundación	Tamayo	Uvilla
School	3	2	5	2	3
Hospital & Clinic	3	2	2	1	1
Church	12	9	12	9	9
Community hall	2	3	2	2	3
Post office	1	0	0	1	0
Park	1	1	2	2	0
Baseball ground	2	4	5	2	2

Source; Study team

7.7 Agricultural Support Services

7.7.1 Extension and Research

(1) Extension

The South regional office of SEA in the Barahona zone containing 3 agricultural sub-zones and 23 agricultural areas is responsible for extension services in the Project area as shown in Figure 33. Total number of extension works in the project area is 23. As explained in section 3.7 (3), most extension workers have no knowledge of agricultural technoloty because they have few opportunity to receive such technology due to shortage of technical education and training. It is essential to improve capability of these extension workers. As for work load, one extension worker is responsible for about 200 farmers and 260ha of which figure is not always harder. It is considered appropriate that present extension service to individual farmer should be changed to farmer's group for efficient and proper provision of such services. Moreover, there are no systemetic methodology for extension service. Since supervision system for activities of extension workers is so poor that proper extension services to farmers could not be performed. Though in January 1998, SEA provided motorcycles to all extension workers in the Project area, there are no scheduled visits to farmers on a regular basis. In addition to SEA, the Agrarian Institute is providing some extension service to the Land Reform Beneficiaries.

SEA has a training center in Barahona that has a total area of 15,050 m^2 and consists of 5 buildings, a garage, two rooms with capacity for 44 people cachas wellas dormitories to accommodate 45 peoples. In additions, the center has a kitchen/caffeteria with a capacity for 50 peoples. It has an experimental farm with one ha in Neyba. However, the buildings need some refreshing. Also there is a lack of furniture and teaching aids as well as a computerized system for training.

(2) Research

There is no agricultural research center in the project area. The Barahona experimental station, located in Palo Alto, has about 300 tareas (18.8 hectares) where is operated by 2 researchers. Research work is not undertaken in this station. It faces some problems of irrigation water availability due to deterioration of irrigation and drainage facilities.

7.7.2 Agricultural Credit

(1) Credits Systems

Most of the financing of agricultural business comes from the Agricultural Bank, and local moneylenders, as well as commercial banks, tomato agroprocessing firms and some NGOs. One of the main constraints found in the Study area is the inability to access formal credit. The main constraints have been identified as lack of available credit amount, lack of definitive land title, high interest rate, high transaction costs to process individual loan request and complex procedures for obtaining loans. Among those, the farmers in the project area are so poor that they have no mortgage. Also most farmers has no definitive land title and lands can not be used as mortgage for the agricultural bank.

(2) Activities of Credit Services

Agricultural bank has a branch in Tamayo, Vicente Noble and Barahona cities in the project area. The total number of bank loans, values and coverage area that the Agricultural Bank provided farmers in the Project area in 1997 was estimated to be 310, 9.5 million DR$ and 870 ha. Agricultural Bank loans for crops totaled DR$ 9.5 millions in 1997 that are equivalent to about 17% of total credit demand of farm inputs that are required when the irrigation project of is implemented in the future. About 70% of the total amount of the loans were allocated to the plantain cultivation. It is estimated that 7 % of the farmers in the Project area received loans of 2,100 DR$ on an average and also the loans covered 15% of the Project area. Details are shown in Table 3.7.1 in Annex II. The farmers who cultivated tomato in Azua province make a contract with the agricultural processing firm and receive credit from the firm. The NGOs such as LEMBA, FUNDASUR, SSI and FIME provide a small credit service to the farmers in the project area. Most farmers who can not receive credit services from the agricultural bank are obliged to get loan with high interest rate of 20% per month from the money lenders. Repayment of loans is done at the harvest season.

7.7.3 Seeds Multiplication

There is no seed multiplication system in the Project area. Most of the seeds and seedlings of plantain, cassava and banana are produced individually by farmers. CEVEMA is responsible for the distribution of seed material for the request of farmers.

7.7.4 Agricultural Association

In the Project area there are 72 farmers' associations. About 30 is assumed to be agricultural cooperatives. Other cooperatives are consumer cooperatives, transportation cooperatives and so on. It is estimated that about 15% of the farmers in the project area participate in the agricultural cooperatives. The business of most agricultural cooperatives is to provide small credit services to the member of the agricultural cooperative. The member of an agricultural cooperative is so small as less than 50. The agricultural cooperative has no capacity to deal with cooperative collection of farm output and cooperative purchase of farm inputs, one of the common function of the agricultural cooperative. The cadres of the agricultural cooperatives are short in capability for organizational and financial management. These cadres have few opportunity to receive education and training services from the Governments. So most agricultural cooperatives are institutionally weak. Though most farmers of the associations recognize that the benefits for participating in the association are the ability to get better access to credit, prices and market, actually solidality among the members are weak and agricultural cooperatives are not active.

In order to activate the present agricultural cooperatives, the followings are considered. (1) It is principal that capability of the cadres of the agricultural cooperative should be improved by organizational, managerial and financial education and training, (2) The member of the agricultural cooperative should be increased institutional power should be reinforced, (3) Since about 80% of the project area is grown by plantain, the agricultural cooperatives should be formed, being paid on plantain farmers.

7.7.5 Non-Government Organization

There are 18 NGOs in and around the Project area. They provide and deliver technical assistance, training and services in the various fields to the farmers and residents on a small scale. Such activities are extended to agricultural development, credit support to farmer's association, community development, improvement of rural infrastructure and so on. The presence of Non-Government Organizations in the Project area have, noticeably become an alternative way to provide technical assistance and training to farmers and rural residents.

7.7.6 Problems in Agricultural Support Services

Based on the household survey, the community workshops and data collected by the JICA study team, a set of problems was identified for the provision of agricultural support services within the Project area. A weak agricultural support service has resulted in low levels of agricultural production and investment in the Study area. The main problems identified are laid out in Figure 34.

7.8 Environmental Aspects

7.8.1 Description on Environmental Condition of the Project Area

(1) Social-economic Issues

In the Project area and its surroundings, there are approximately 66 thousand residents. Vicente Noble and Tamayo are comparatively larger towns in the Project area. In the Barahona province in which almost all of the Project area is located, 30 % of the people engage in activities of agriculture, fishery, or livestock farming. Concerning the organizations formed by local people in the Project area and its surroundings, the organizations relating to agriculture are occupied in major cases.

(2) Health and Sanitary Issues

After Hurricane George, the condition of the drinking water supply has deteriorated especially in the northern parts of the Project area. In the case of hospitalization caused by water born diseases in Barahona and Bahoruco provinces, acute diarrhea is a major case in both provinces. Concerning medical facility, there are some kinds of facilities in all municipalities or district municipalities.

Concerning agrochemical use, according to the interview survey, about 29 % of farmers do not apply fertilizers, and about 36% do not use pesticides.

(3) Natural Environmental Issues

The Project area is located in a semi-arid zone. The annual rainfall is about 450 mm. Generally the Project area is occupied by low lying land whose altitude is less than 30 m above sea level. Particularly, the altitude of the southern part of the Project area including Los Jaquimeyes, El Penon, Fundacion and La Hoya is very low, which is less than 10 m above sea level. On the other hand, the altitude of the northern part is relatively high, which is 10 to 30 m.

Concerning land use and vegetation, irrigated agriculture areas occupy almost all areas. In the area, plantain and banana are the major crops. Some salinization areas are observed in the southern part of the Project area and the area around Canoa.

Concerning the water quality of Yaque del Sur River in the Project area, the water test results of pH and TSS are below the normal amount in the Dominican Republic for irrigation water quality, while those of EC correspond to the level C3 (high) of the normal.

7.8.2 Environmental Problems for Local People in the Study Area

According to the interview survey done by the study team, the local people recognize the problems relating to water, both for drinking and irrigation, as main environmental problems.

7.9 Consideration on Hurricane George

7.9.1 General

In the Dominican Republic, Hurricane George brought the most serious damage in of the recent 20 years. The hurricane landed at the Dominican Republic in the morning (around 9 o'clock) of September 22 as a "Category 2" hurricane in Saffir-Simpson Scale[8]. The hurricane passed through the country late in the day (about 11 o'clock at night).

7.9.2 Rainfall

According to the rainfall records observed by INDRHI and Oficina Nacional de Meteorología (ONAMET), the total rainfall during the hurricane in/around the Project area amounted to 60 to 500 mm. In the upper basin of the Yaque del Sur River including the San Juan River, intensive rainfall was received during the passage of the hurricane, which brought rapid increase of water levels at Sabaneta and Sabana Yegua Dams.

As mentioned in the next section, the flood inflows to the dams were similar to those of Hurricane David in 1979, but the flood damages by George were much more serious than those by David. It can be surmised that the rainfall on the downstream of the dams was also very heavy during the hurricane period, and it caused floods or inundation on the lower reach.

7.9.3 Flood Discharge

Hydrographs at Sabaneta and Sabana Yegua Dams during the hurricane period are shown in Figure 35 and Figure 36. Total volumes of inflow to the dams were 67.7 MCM for Sabaneta Dam and 288.3 MCM for Sabana Yegua Dam. The peak inflow discharges

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[8] Classified by wind speed and pressure.
Category 1: wind; 65 – 82 knots or 33 to 42.2 m/sec, or pressure; over 980 Mb
Category 2: 83 to 95 knots or 42.3 to 48.9 m/sec, or 965 to 979 Mb
Category 3: 96 to 113 knots or 49.0 to 58.1 m/sec, or 945 to 964 Mb
Category 4: 114 to 135 knots or 58.2 to 69.5 m/sec, or 920 to 944 Mb
Category 5: Over 135 knots or less than 920 Mb

were 2,254 m^3/sec (5:00AM on September 23), and 7,987 m^3/sec (0:00AM on September 23), respectively. Specific discharges for the peaks are 4.8 m^3/sec/km^2 for the both dams.

7.9.4 Casualties

It is reported that a number of residents were swept away to their death at Mesopotamia in San Juan City. The area is located in the lower river course and subject to inundation by floods, and is densely populated. Announcements or orders for evacuation were issued in advance of Georges' approach to the area, but some of the residents remained to watch their houses and properties. Most of the casualties were from those who failed to get out in time.

It is reported in the final report of "Mision OCHA/UNDAC Luego del Paso del Huracan Georges" (October 1998) that the dead and missing by the hurricane totaled 347 in the country.

7.9.5 Flood Prone Area

According to the field survey, several locations were identified as "flood prone" or "high flood risk" areas. They are:

- Residential area near the lower river course (San Juan, El Jobo, La Ubilla)
- Near meandering or bending points of the river (Santana or Tamayo, Canoa, Palo Alto)
- Locations blocked by roads, railways, dikes, etc.(Jaquimeyes)

It should be noted that the inundation damage is not serious or negligible on the downstream of Palo Alto, such as El Peñon, Fundación, Cabral, Cachón, La Hoya and Habanero. The reasons are probably because of overflow of the floodwaters on the upstream at Tamayo, Canoa, Jaquimeyes, etc.

7.9.6 Effects of Dams

Sabaneta Dam met George soon after completion of improvement works on its emergency spillway by PRODAS. Before the improvement, the maximum operation level during hurricane seasons (September and October) was set at 636 m AMSL, which is seven (7) meters lower than the ordinary maximum operation level of 643 m. After completion of the improvement works, the operation manual was revised in August 1998, and the maximum operation level was set at 643 m through the year.

One month before George came, the reservoir water level was 638 m, while one week before it was 643 m, maximum operation level. On September 23, the water level instantaneously exceeded the crest of the emergency spillway, and a peak flood outflow of 1,500 m^3/sec was recorded. The improvement of the emergency spillway having been completed, the operation itself is considered to have had nothing improper. The overflowed water eroded the downstream slope of the spillway, but affected neither stability of the dam itself nor a village on the downstream.

Designed flood inflow of the **Sabana Yegua Dam** is 7,800 m^3/sec (1 in 1,000 year flood at the design stage) and the total discharge capacity of spillways is no more than 3,000 m^3/sec. The capacity of the service spillway is only 630 m^3/sec. On September 1st of 1979, soon after the completion of the dam construction, the dam received flood by David of which peak inflow was about 8,000 m^3/sec. After that event, several review studies have been conducted. At present, a peak flood inflow of 22,386 m^3/sec (PMF) is proposed for the improvement of the dam. Taking into account the capacity of the existing spillways, the maximum operation level was controlled during hurricane seasons at 386 m, which is 10 m lower than that of ordinary season. The water level just before the hurricane was 384.5 m. However, the water level increased rapidly by 10 m within 10 hours from 19 o'clock on September 22 to five (5) o'clock on September 23, while the hurricane passed the area. Then the water level gradually increased up to 398.28 m, which is only 2 m lower than the crest of the emergency spillway.

It can be said that Sabana Yegua Dam operated well during the hurricane period fully demonstrating its flood control effect. If the dams did not exist, uncontrolled flood discharge on the downstream may have been a few times larger. However, even with the dams, it should be also noted that there was certain possibilities of a serious flood damages by using the emergency spillway.

7.9.7 Activities of Institutions against George

As Hurricane George approached the territory of the Dominican Republic, responsible institutions on the hurricanes took a series of measures.

(1) Emergency Reservoir Operation Committee (COEE)

Operations and actions, which the Emergency Reservoir Operation Committee (COEE) took during the hurricane period, were as follows:

On 18 th of September, 1998, Friday, the COEE meeting was held and the Committee declared to keep permanent contact from that day, on which Hurricane George passed Puerto Rico and entered the eastern territory of the Dominican Republic.

On that day, breaking 96 hours before the expected hurricane's landing, it was instructed to maintain water levels of all the reservoirs below the ones recommended according to the emergency operation rules.

(2) INDRHI

As part of preventive actions of COEE, INDRHI performed necessary measures for the protection of the irrigation and river systems handled in the following manners:

(a) To distribute all the staffs concentratedly at strategic points, such as rivers and susceptible low places to be flooded.

(b) To keep motorgraders and excavators on standby for the assumed restoration works before the passage of the hurricane for efficient activities to be taken later.

(c) To operate gates of irrigation facilities to avoid destruction of facilities and or occurrence of inundation.

(d) To work in collaboration with Civil Defense in calling attention to the residents in flood prone areas, irrigation areas and downstream of the dams during of emergency period.

(3) ONAMET

In the presence of the atmospheric phenomenon of high intensity such as Hurricane George, bulletins are issued every three (3) hours.

On Saturday, September 19, there were certain discrepancies between the interpretation of the reports received from the Miami Hurricane Center and the possible affected areas in the Dominican Republic, as Hurricane George approached. This caused delay of implementation of some preventive measures on various levels.

On Monday, September 21, they started issuing the bulletin every three (3) hours under the condition of "Notice" which was announced according to the location, direction, wind speed and possible route of the hurricane.

(4) Civil Defense

On Monday, September 21, they started to organize committees of Civil Defense at each city or town in the country, consisting of the City Council, volunteers such as Red Cross and other groups, aiming at receiving instructions from the headquarters of the Civil Defense in Santo Domingo.

The Red Cross strengthened their offices with highly qualified personnel for the Civil Defense. Shelters for refugees from the hurricane were prepared and their houses were ready to be watched to avoid vandalism or burglary after the hurricane.

The Civil Defense notified the people in the flood prone areas such as in river banks, river beds, downstream of the dams. However, in many cases, they met opposition by the people that were afraid of assault.

8. THE AGRICULTURAL DEVELOPMENT ON THE LOWER YAQUE DEL SUR RIVER

8.1 Basic Development Concept

8.1.1 Development Constraints

As explained in Chapter 7, the high priority area is the least developed area in the Yaque del Sur River Basin. The annual rainfall is small, averaging 660mm. 70% of the annual rainfall is concentrated during the rainy season. Under such conditions, agriculture in the Project area cannot be performed without irrigation water.

Main constraints on agricultural development in the Project area are: (i) existing irrigation facilities are deteriorated and their operation/maintenance do not properly function, an overall irrigation efficiency in the Project area is very low, which brings about great loss of irrigation water within limited water sources. (ii) Villarpand intake weir ,which delivers Yaque del Sur River water into the Azua irrigation district area and Yaque del Sur /Lago Enriquillo irrigation district area, has its deterioration, malfunction in its structure and its improper operation, waters are not properly allocated to the Project area especially in dry season. (iii) Improved irrigation farming cannot be introduced due to the present poor irrigation facilities. (iv) Due to poor access to credit services for introduction of improved irrigation farming technology, only 7% of the total farmers in the Project area receive loans from the agricultural bank. (v) Agricultural research and extension services are poor. (vi) Farmgate price is lower because marketing margin from producers to consumers is bigger. (vii) The average farm size in the Project area is small, being 1.3 ha.

Under such conditions, yield of plantain, the main crop in the Project area, is as low as 18 tons/ha and an annual cropping intensity amounts to only 75% despite the fact that the Project area is categorized into the irrigated lands. As a result, the farmers in the Project area, most of which are plantain growers, have low agricultural incomes and few surplus in their economy. Engel's coefficient is over 50%. It may be concluded that the farmers remain at the subsistent level of living. Furthermore, environmental conditions around the farmers are poor due to shortage of rural infrastructure. It is necessary to deal with these constraints and problems in order to implement agricultural development efficiently.

8.1.2 Basic Development Concept

The overall objectives of the Project are (i) stabilization of the farmer's economic situation by increasing farm income, (ii) improvement of life quality for the farmers and (iii) creation of job opportunity for local people and improvement of social welfare. The basic development concepts of the agricultural development in the Project area are:

(1) Increasing crop yields by the introduction of improved irrigation farming technology

(2) Increasing annual cropping intensity by increasing an overall irrigation efficiency and effective use of river water that is made by improvement of the existing irrigation systems, setting up and strengthening water user's organization, and strengthening overall water management in the Yaque del Sur River Basin.

(3) Strengthening the support services for agricultural development

(4) Improvement of rural infrastructure

The crop productivity can be enhanced through improved irrigation farming technologies such as use of high quality seeds and seedling, appropriate application of fertilizers and chemicals at the right time and volume, proper on-farm irrigation practices, etc. Especially, for plantain that grows on about 80% of the lands in the Project area, replanting at an interval of 5 years will be performed to keep a level of 24 tons/ha as the target yield.

It is planned that an annual cropping intensity should be maximum as water supply is permitted and is targeted at 113% with project condition as opposed to 75% in the present condition. For obtaining this purpose, the following measures will be taken. (i) Santan intake weir and the existing irrigation facilities will be improved and new construction of main canals from Santana intake weir that unify the existing small free intakes, night storage ponds, O&M roads, etc, will be made, (ii)Water user's organization with three tiers will be formulated and O&M for irrigation system by water user's organization will be strengthened, (iii)To properly allocate river water to Azua irrigation district area and Yaque del Sur/Lago Enriquillo irrigation districts (including the Project area), Villarpand intake weir will be improved, (iv) For effective use of river water including released water from Sabana Yequa Dam, the Yaque del Sur Water Management Center, which will monitor and evaluate water budget at relevant control points, operate and maintain facilities directly and indirectly according to the results of evaluation and coordinate water distribution through a year at real time, will be made.

In order to reinforce agricultural services for agricultural development in the Project area, the following actions will be taken: (i) With respect to research services, a research program of adaptive and applied on-farm research for plantain will be carried out on a sub-let basis of private sectors. (ii) Extension services in the Project will be given not to an individual farmer but to a nucleus of water users. In order to strengthen extension services, training programs will be carried out to extension workers along with leaders of nucleus of water users to develop their capacity. (iii) A most serious constraint of access to credit services in the Project area is that considerable farmers have no definite land title and can not get loans. In the Project, land ledger will be made by the cadastral survey and land registration will be made for the provision of a base for farmers to get loans. (iv) It is considered necessary as a first step that agricultural cooperatives, which are able to provide services to farmers, should be strengthened as a model agricultural cooperative. A market information system, which will provide farmers with timely information to make sound economic decision, will be introduced.

With respect to reinforcement of rural infrastructure in the Project area, improvement of the existing rural structure and planning, which the related Ministries manage, will not be dealt with in the Project. As a result, rural water supply systems and multipurpose community centers will be provided to improve quality of life for farmers.

Development plans are formulated on six sectors of (i) agricultural development, (ii) agricultural support service, (iii) overall water management (iv) irrigation and water user (v) rural infrastructure and (vi) environmental conservation to achieve these purposes.

8.2 Agricultural Farming Improvement Plan

8.2.1 Land Use Plan

As the irrigation development plan is formulated to improve and/or rehabilitate the existing irrigation area of 5,885 ha, new irrigation areas will not be created. Then, future land use of the Project area will not be changed as it is. The irrigation project will provide sufficient irrigation water to increase crop production by increasing crop yield and cropping intensity through implementation of irrigation systems. The annual cropping intensity will be expected to increase from 0.75 at present to 1.13 after the Project.

8.2.2 Proposed Cropping Pattern

It is not proposed to introduce new crops into the Project area, taking into account (i) the farmers' experiences, (ii) farmers' preference to the crops, (iii) marketability and profitability of present crops, (iv) soil suitability for the crops and (v) local consumption as staple foods. The crops to be planted with project condition will be the same as those under the present condition, such as plantain, banana, cassava, pepper, tomato, melon, papaya, sweet potato, eggplant, pigeon pea, corn, bean, and rice. It is considered possible that wheat, onion, grape and oranges be intoroduced in the project area from the viewpoint of profitability or substituted crops. The Dominican Republic entirely depends on import of wheat. The government has tried to make an experiment for wheat production at San Juan in the Yaque del sur river basin and at Bani outside of the Yaque del sur river basin on a small scale. The results from these site indicates that yield of wheat is relatively favourable. Onion, grape and orange are cultivated on a small scale near the project area , of which market is greately expected for domestic one as well as one for Haiti. Grape is imported. If appropriate varieties of these crops to the project area are selected, it is expected that these varieties should be introduced into the project area . As mentioned in section 8.3.1, it is necessary to make a research work for these 4 crops.

For formulating cropping patterns, special emphasis is given to the following points:

(1) Planting period of tomato for processing is fixed during the cool season from the beginning of October through December in order to minimize the damages due to pests and diseases, especially 'white fly'.

(2) Planting period of red bean, pepper, eggplant and melon is also fixed during the cool season from the beginning of November through March in order to minimize the damages due to pests and diseases.

(3) Repeating cultivation of tomato for processing is prohibited in order to prevent damages due to the repeating.

(4) 80 days improved variety of pigeon pea is introduced instead of present 270 days variety in order to minimize the irrigation water requirement and to effectively utilize the rainfall.

(5) In order to obtain the highest yield of plantain and banana, replanting will be performed every 5 years for plantain and every 2 years for banana. Inter-cropping will be introduced at the replanting time.

The areas proposed to be planted by each crop with project conditions is decided by augmenting the area of each existing crop proportionally to the percentage occupied at present by each crop, except rice and banana.

The proposed cropping pattern is shown in Figure 37. Proposed planting area by each crop in the Project is shown below:

	Crop	Proposed Area (ha)	Proportional Distribution (%)
1	Plantain	4550	77.3
2	Tomato	250	4.3
3	Sweet potato	450	7.6
4	Melon 1	100	1.7
	Melon 2	100	1.7
5	Pepper	190	3.3
6	Papaya	240	4.1
7	Cassava	220	3.7
8	Banana	170	2.9
9	Pigeon pea	140	2.4
10	Corn	100	1.7
11	Bean	60	1.0
12	Eggplant	30	0.5
13	Rice 1	20	0.3
	Rice 2	20	0.3
	TOTAL	6,640	113.0

8.2.3 Proposed Farming Practices

Proper farming practices are essential for realizing the full agricultural potential in the Project area. It is necessary to carry out farming using an appropriate farming practice along with the development and strengthening of institutional support. The most important factors in farming practices to be introduced into the Project area will focus on (i) use of good quality seedlings and seeds, (ii) an appropriate dosage and time of application of fertilizer and chemicals (for control of insects and nematodes) and (iii) adequate on-farm water management. The proposed farming practices were formulated by referring to the farming guideline prepared by SEA, data from experienced farmers in the Project area and data from other information. The proposed farming practices are shown in Table 26.

8.2.4 Anticipated Yields and Crops Production

The target yield of crops under with project condition is set considering potential yields of recommended varieties and yields obtained by some advanced farmers within the Project area. The anticipated yield and total production of crops with project condition is as follows:

	Crop	Anticipated Yield (ton/ha)	Harvested Area (ha)	Anticipated Production (ton)
1	Plantain	24	4,550	109,200
2	Tomato	30	250	7,500
3	Sweet potato	17	450	7,650
4	Melon	40	200	8,000
5	Pepper	18	190	3,420
6	Papaya	52	240	12,480
7	Cassava	12	220	2,640
8	Banana	36	170	6,120
9	Pigeon pea	3	140	420
10	Corn	2.8	100	280
11	Bean	1.5	60	90
12	Eggplant	20	30	600
13	Rice	4.5	40	180

8.2.5 Requirement of Farm Inputs

The total requirement of farming inputs in the Project area at the full development stage of the Project is estimated based on the recommended farm input criteria mentioned in section 8.2.3 and is summarized as follows:

	Crop	Seedlings/Seeds	Fertilizers (ton)			Pesticides	Labor
			N	P	K	Kg or lit	Man-day
1	Plantain	10 million seedlings	728	500	910	68,300	55,200
2	Tomato	890 kg	178	134	134	12,500	80,600
3	Sweet potato	2,500 tons of cuttings	41	41	41	3,300	35,550
4	Melon	410 kg	86	74	210	8,200	30,600
5	Pepper	252 kg	39	28	28	3,150	37,800
6	Papaya	120 kg	36	22	22	4,800	33,800
7	Cassava	48 tons of cuttings	20	13	13	16,500	24,600
8	Banana	374,000 seedlings	51	26	26	2,600	20,600
9	Pigeon pea	2,800 kg	6	6	6	140	6,700
10	Corn	4,000 kg	9	6	6	200	4,500
11	Bean	7,500 kg	5	6	2	180	3,600
12	Eggplant	120kg	18	14	14	480	9,300
13	Rice	6,400kg	8	5	4	280	5,200

8.2.6 Labor Requirement

In principle, land preparation for all crops is carried out by mechanical power. Other farming activities from seeding to harvest are conducted by manpower. The farm labor balance for an average farm size farmer of 1.3 ha and for the whole Project area was analyzed to clarify whether a serious labor shortage would occur and bring about big problems on farming with project condition. Labor requirement was calculated based on the proposed cropping pattern. The results are shown in Table 27. The peak labor requirement is in January. Monthly labor requirement in January for 1.3-ha farmer is calculated at 24 man-days, while available farm household labor per month is 50 man-days. Annual total labor requirement for the whole Project area is estimated at 850,000 man-days, while annual total available farm household labor is one million man-days. As a result, shortage of labor will not occur with project condition in both farmers and the whole Project area.

8.2.7 Crop Budget

The profitability of crops with and without project conditions is analyzed by preparing crop budget and is summarized in the following table: Details are shown in Table 4.2.5 in Annex 2.

(DR$/ha)

Kind of crop	With project condition			Without project condition		
	Gross income	Production cost	Primary profit	Gross income	Production cost	Primary profit
plantain	88,028	21,864	66,164	67,140	16,460	50,680
tomato	97,350	25,570	71,780	74,640	22,580	52,060
sweet potato	69,480	16,390	53,090	49,040	14,090	34,950
cassava	58,340	18,810	39,530	31,600	16,580	15,020
rice	39,600	29,820	9,780	19,360	22,720	-3360
bean	21,750	16,360	5,390	13,050	12,430	620
pigeon pea	27,280	9,640	17,640	13,640	9,570	4,070
eggplant	93,100	21,230	71,870	69,830	18,470	51,360
corn	12,240	10,260	1,980	7,870	7,030	840
melon	105,600	36,870	68,730	79,200	31,010	48,190
pepper	108,900	25,550	83,350	78,650	21,580	57,070
papaya	156,900	26,280	130,620	131,795	23,485	108,310
banana	40,724	22,284	18,440	27,770	16,660	11,110

8.3 Plan for Strengthening Agricultural Support Services

8.3.1 Extension and Research Services

(1) Research

Since plantain occupies about 80% of the cultivation area in the Project, an increase of the yield of plantain is the most important factor to improve farm income of the farmers in the Project area along with introduction of new crops with high profitability.

A research program of adaptive and applied on-farm research would be implemented in the Project area. The topics to be emphasized would be:

(a) Integrated Pest Management;

(b) Feasibility of New Crops in the Project area

(c) On-farm water management issues

For 'Integrated Pest Management', the research works will be carried out for (i) identification of insects and nematodes that affect plantain in the field at present, (ii) identification of natural enemies of insects and nematodes, (iii) multiplication of identified natural enemies of insects and nematodes and (iv) field dissemination of natural enemies in the Project area.

For techinical and economical feasibility of new crops in the Project area, research work will be performed for (i) adaptability of onion, wheat, grape and orange and (ii) tests for crop research such as variety test, fertilization, pest control and water requirement.

For on-farm water management, research work will be done for (i) validation of advantages of basin irrigation method compared to furrow irrigation, (ii) effect of irrigation intervals on crop yield, and (iii) effect of amount of water applied on crop yield.

It is planned that this research program will be carried out by a sub-let contract with Universities and/or private sector. The research period is about 2 years. In principle, the Palo Alto experimental station in the Project area will be used for conducting the research work. For this purpose, the irrigation facilities in the experimental station at Palo Alto should be improved because these facilities are deteriorated as explaned in section 7.7.1(2).

(2) Extension Services

(a) Approach of Extension Services to Farmers

After the implementation of the irrigation project, 200 nucleus of water users consisting of 15-25 farmers will be established in the Project area. In addition there will be 14 sub-committees composed of 20 nucleus on an average. Further, 4 Association will be established to include all 14 sub-committees. It is planned that extension service in the Project will be given not to individual farmers but to groups as nucleus of water users. The objective number of nucleuses of water users is 200. It is planned that one extension worker will cover 10 nucleus of water users. Therefore, the Project will demand 20 extension workers.

Extension workers would provide services: (i) arrangement of scheduling of land preparation, (ii) arrangement of supply the following of farm inputs to farmers, (iii) monitoring of cultivated area, harvested area, yield, farm inputs, etc, and (iv) technical guidance on farm practices and management. Furthermore, extension workers would manage demonstration plots to be made in the Project on selected farms in the Project area.

(b) Training Program

In order to strengthen extension services, training programs are carried out to extension workers along with leaders of nucleus of water users. The objective number for training is 20-extension workers and 200-leaders of nucleus of water users.

Training for extension workers will be performed on four aspects: (i) technical issues (crop production, soil conservation and management, water management, integrated pest management, etc), b) methodological aspects (use of audiovisual aids such as the use of computers, how to prepare a presentation with local inputs, overhead projectors, etc.), c) managerial aspects (bookkeeping for farmers, farming planning, loan requests preparation and resource mobilization) and, d) organizational aspects (community participation, institutional strengthening for agricultural associations and marketing skills, community development and plan and program evaluation).

Similarly, training would be provided to the leaders of nucleus of water users on managerial skills, leadership and organization.

This training would be carried out during a 2 year period and would include short courses, workshops, seminar, and field trips.

Specialists on different subjects would offer training to the extension workers and farmers. The SEA extension Department would be in charge of the training program and would coordinate efforts with academic institutions such as ISA and UASD for the provision of trainers.

The SEA training center in Barahona would be used for the training activities. Although the centers have the physical infrastructure, some remodeling equipment and furniture is needed.

(c) Demonstration Plots

Demonstration plots of 0.2 ha each would be set up at 10-selected innovative farmer's plots to assist on the transfer of technology by the extension workers and dissemination of proposed farming practices to farmers in the Project area. These farms will be operated by innovattive farmers under the technical guidance of the extension workers.

8.3.2 Credit Services

One of the main constraints found in the Project area is the inability to access formal credit due to lack of definitive land title, lack of mortgage, high interest rate of loan, complex procedures to obtain a loan, low availability of fund by credit institutions, etc. Among these, lack of definitive land title is the most serious problem. Farmers in the Project area are so poor that lands seem to become mortgage to receive loans. Considerable farmers have lands without definitive land title.

It is proposed that a cadastral survey, which would help in the clarification and provision of definite land title to most of the farmers in the Project area, shall be conducted. The cadastral survey will be made by a sub-let contract with private firms. The survey will be done for about 7,000 ha including net irrigation areas during a 5-years period. Cadastral maps that show an area of each land plots, land use item, name of landowner and tenure status of each land plots will be prepared on a scale of 1/1,000. Based on the results of the cadastral survey, legal services on transfer of definite land tilte to the farmers will be made.

It is proposed that the cadastral unit that will be set in the proposed implementation office as shown in Chapter 9 will carry out legal services on definitive land title to farmers.

It is proposed that group loan program will be applied in the Project. The objective groups in the Project area are the nucleus of irrigation water users that will be set up in the Project. Technical assistance and training would be given to farmers on procedures from preparation credit requests to repayment.

8.3.3 Agricultural Cooperatives and Agricultural Information Center

(1) A Model Agricultural Cooperative

Due to the low managerial capacity of farmer organizations and their inability to provide market services to the farmers in the Project area, almost all agricultural cooperatives do not function at present. It is considered necessary as the first step that agricultural cooperatives, which are able to provide services to farmers, should be strengthened as a model agricultural cooperative. As mentioned previously, most of the farmers in the Project area are plantain growers. Among the present about 20 agricultural cooperatives in the Project area, 'the plantain grower association of Vicente Noble' would be selected as a pioneer cooperative. This association was instituted in 1987. The total number of members is 16. Cooperative activities are poor at present.

In additon to the present provision of micro-credit services, it is planned that the agricultural cooperative should function to do cooperative collection of plantain and cooperative purchase of farm imputs. Improvement of 'the plantain grower association of

Vicente Noble' is planned focusing on (i) increasing of the members of this association (target: 100 members), (ii) improvement of capability of board members (president, vice president, treasurer and secretary), (iii) strengthening market development and (iv) strengthening procurement power of farm inputs.

The project component consists of (i) institutional and managerial guidance and training, (ii) provision of start up funding and (iii) procurement of one truck, 3-scale, computers and office facilities and (iv) construction of small storehouse for farm inputs.

Under the guidance of one market specialist hired from the private sector, the board members will be trained on institutional, marketing and managerial aspects through on-the-job-training for one year. The board members should increase members of the association, develop new markets of plantain for Santo Domingo, and export and strengthen cooperative sales of plantain and cooperative procurement of farm inputs. The start up fund for operation, which consists of farm inputs, operation cost of vehicle, administrative costs, etc., will be invested. Details are shown in Table 6.2.5 in Annex 2.

(2) Marketing Information Systems

For the Project area it is proposed that a Market Information System which would provide farmers with timely information to make sound economic decision be introduced. The Dominican Agribusiness Council (JAD) could handle the headquarters of the Market Information System in Santo Domingo. Under JAD, it is planned that new branches of market information centers at farmers'cooperative in Barahona and Baoruco provice will be set up. At this moment, in Baoruco province, the branch will be established in the 'the plantain grower association of Vicente Noble'. In terms of market information, it would provide weekly information on local prices for agricultural products and inputs, and potential buyers of their product.

Staff required for operation consists of 1-manager, 1-secretary and 2-system operators. Office equipment such as computers, fax, printer, etc will be requested. Also vehicles are needed. Details are shown in Table 6.2.6 in Annex 2. Furthermore, education and training programs for system operators will be carried out.

8.4 Overall Water Management Plan

In the Master Plan, it is recommended to allocate all the waters in the San Juan River basin to consume there. Then, according to the residual water volume at Sabana Alta (end of the San Juan River basin), water release from Sabana Yegua Dam (Yaque del Sur River) will be determined. The waters from the San Juan and the Yaque del Sur Rivers will be divided at Villarpando Headworks to Azua and the downstream. Villarpando is the key point for the water management of the Yaque del Sur River Basin, particularly for the lower reach. Thus, the Yaque del Sur Water Management Center Project was also selected as a priority project for the feasibility study. The project components are described in the following:

8.4.1 Telemetering System

Objectives of a telemetering and telecontrolling system (hereinafter referred to as "telemetering system") are;

- Realization of prompt and accurate communication,
- Easy handling and/or processing of data, and
- Overall water management supervision for a large area.

The overall water management system which is proposed in the Master Plan is given in Figure 16. Out of the system components, the following stations and functions are selected :

- Yaque del Sur Water Management Center at Villarpando,
- Villarpando headworks control station,
- Sabana Yegua Dam station,
- Sabaneta Dam station,
- Sabana Alta hydrometric and raingauge station,
- Los Guiros hydrometric station,
- Santana headworks control station,
- Rincon Lagoon hydrometric and water quality monitoring station, and
- Palo Alto hydrometric and raingauge station
- San Juan hydrometric station

The telemetering system for the irrigation water management will consist of the following stages by priority:

(1) Priority-1

Priority-1 consists of basic components or minimum requirements for the telemetering system. The data from Sabaneta Dam, Sabana Yegua Dam and Villarpando headworks are collected and sent to the Center automatically or manually. The discharge data at the dams will be observed and sent by verbal communication to the Center.

(2) Priority-2

Priority-2 includes the telemetering system for the Yaque del Sur Lower Reach Irrigation and Drainage Project, additional telemetric stations and sensors.

(3) Priority-3

Priority-3 includes functions of training on water management mainly at the Water Management Center at Villarpando, and other components for the whole telemetric system for grasping the condition of the Project area more precisely.

Location of the stations are shown in Figure 38.

8.4.2 Water Management Organizations

Water management will be conducted and supervised conforming to proposed water management institutions which is proposed in the Master Plan. The management level is divided into three levels, namely;

- Inter-basin water management (LEVEL-1),
- Basin water management (LEVEL-2), and
- Irrigation area water management (LEVEL-3)

The Project area is divided into three (3) hydrological basins, namely, San Juan, Azua and Barahona-Neiba. The inter-basin water management (Level-1) is the top-level and overall management which coordinates water allocation between the basins. Operation of Sabaneta Dam for San Juan and Las Matas, Villarpando headworks and Sabana Yegua Dam for Azua and Barahona-Neiba basins, would belong to the level.

The central office or administrative functions for the overall water management would be established at the Yaque del Sur Water Management Center. The Center would be independent not only from Irrigation Districts of INDRHI but also from local administrations. The Center should be organized directly under the control of the headquarters of INDRHI. Staff of the Center should be also the staff of the headquarters of INDRHI.The activities and functions are discussed and supervised by a committee which consists of water-related institutions such as INDRHI, INAPA, CDE, water users' organizations (WUO).

The existing organizations for the operation of Sabana Yegua Dam and Sabaneta Dam are the Council on the Control of Dam Basins and the Committee for the Operation of Dam Basins.

The Yaque del Sur Water Management Center will take a part of the roles of the said Committee on the management of the two dams.

Santana Field Office will be situated on Level 2, and control the waters to several irrigation areas such as the sugarcane farm of CEA, the Yaque del Sur Lower Reach Irrigation and Drainage Project, and other small irrigation schemes in Yaque del Sur and Lago Enliquillo Irrigation Districts.

The water management organizations are shown in Figure 39.

8.4.3 Yaque del Sur Water Management Center

The Yaque deo Sur Water Management Center (hereinafter referred to as the Center) are (i) to monitor and evaluate water budget at relevant control points, (ii) to operate and maintain facilities directly and indirectly according to the results of evaluation, (iii) to coordinate water distribution through a year, and (iv) training of staff and WUOs. The Center will collect basic data on hydrology and operation of facilities from the Irrigation District in each basin, process and evaluate the data, modify and determine the operational rules of the dams and Villarpando headworks, water distributing schedules, and giive instructins on operation to the Irrigation Districts, and supervise their activities.

Training and guidance for the WUOs and staff of the Irrigation Districts will also be conducted by the Center.

The Center will consist of 6 units such as data processing, evaluation, operation and maintenance, coordination, extension and training and administration. The chief of the Center will be high ranked staff of headquarters of INDRHI and at least one technical staff will be assigned for 24 hour work system.

The Center will be located at Canoa near Villarpando headworks. The proposed location is on the hilltop on the left bank of the Yaque del Sur River beside Villarpando headworks.

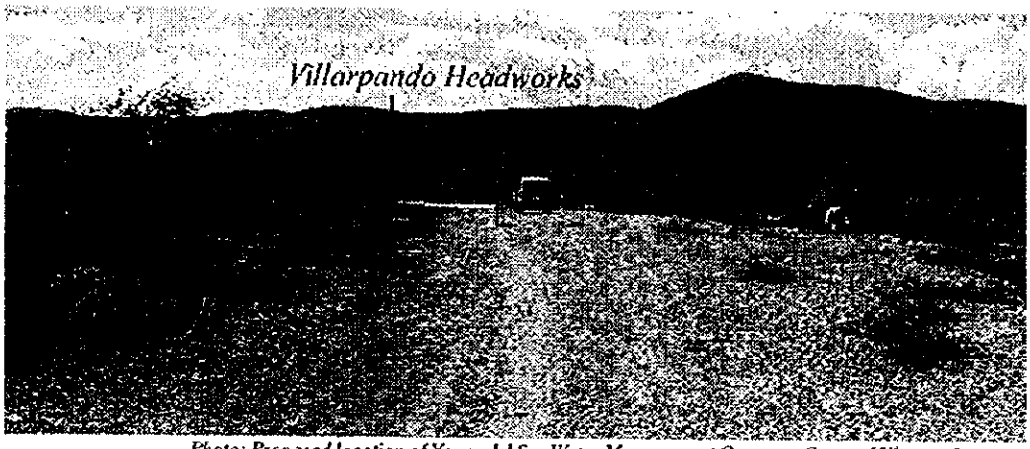


Photo: Proposed location of Yaque del Sur Water Management Center at Canoa, Villarpando

The proposed building of the Center will have two floors consisting of a operation room with display, supervisory equipment booth, radio communication room, administration room, utilities, meeting hall, and accommodations for the operators. A sketch of the Center building is shown in Figure 40.

All the data and information will be sent and compiled to the Center, and the instructions on the operations of Sabaneta Dam, Sabana Yegua Dam and Villarpando headworks will be discussed and issued by the Center. A senior engineer of INDRHI will be assigned as the representative of the Center and will stay during ordinary working hours and emergency periods. At least one engineer will be at the Center at all times.

The Center will be independent from the Irrigation Districts, and its activities will be supervised directly by the headquarters of INDRHI.

8.4.4 Santana Field Office

Santana Field Office of the Yaque del Sur Water Management Center will be built at Santana headworks on the right bank of the river. The functions of the field office is to maintain and monitor the telemetric stations and warning stations below Quita Coraza, operate the Santana headworks and the Main Canal according to the water management authorities such as Irrigation Districts and/or the water users' associations, which will be established in the future. The station will be facilitated with an office space, telemetering

equipment, a processing unit with display, radio communication equipment, accommodations for the operators, utilities, and so on.

8.4.5 Project Works

The Yaque del Sur Water Management Center Project consists of i) telemetering facilities, ii) Water Management Center at Villarpando, iii) Santana Branch Office, iv) civil works for installing the telemeter facilities, and iv) Training for staffs for the water management. The following project works will be included for the above mentioned overall water management system.

(1) Priority-1

- Yaque del Sur Water Management Center (building and facilities for operation of the telemetering system) at Villarpando,
- A raingauge and a water level gauge (telemetric) at Sabana Yegua Dam (common use with flood/discharge warning system),
- A raingauge and a water level gauge (telemetric) at Sabaneta Dam (common use with flood/discharge warning system),
- Rivergauge stations (telemetric) at Sabana Alta on the San Juan River, and Los Guiros on the Yaque del Sur River,
- A water level gauge (telemetric) at the head of Ysura Head Race Canal, and upstream and downstream of the Villarpando headworks,
- Telemetering facilities and radio communication equipment in each station, and
- Repeater stations at San Juan and Los Guiros

(2) Priority-2

- Raingauges (telemetric) in the upper catchments of Sabaneta and Sabana Yegua Dams and Los Guiros
- Water level gauges (telemetering) at Conuquito (upstream of Santana headworks) and at the head of the Santana main canal,
- Santana Field Office which is supposed to maintain the telemetering and flood warning system for the lower Project area[9],
- A telemetric station in Rincon Lagoon with a raingauge and water quality (pH and EC) sensors, and
- A repeater station at El Peñon (common use with flood/discharge warning system)

(3) Priority-3

- Training facilities, vehicles and training programs for the Water Management Center,
- Remote control cameras (ITV) at Sabaneta and Sabana Yegua Dams and monitoring equipment at the Center, and
- A water level gauge and a raingauge (telemetering) at Palo Alto

[9] Yaque del Sur Lower Reach Irrigation and Drainage Project

8.5 Irrigation Development Plan

8.5.1 Basic Development Concept

The irrigation development project is the most important sector of the Project to aim to alleviate the poverty or directly to increase income of farmers, because irrigation is indispensable to sustain the agriculture in the dry climate of the Project area. Water resources of the Yaque del Sur River are limited and water users have been asked to efficiently use the limited water resources as much as possible in recent years. However, INDRHI cannot sufficiently carry out the operation and maintenance of the existing irrigation and drainage facilities due to the shortage of funds. Under such conditions, many irrigation and drainage facilities have deteriorated with no rehabilitation.

In line with the principle of the beneficiaries participatory approach, INDRHI has put a high priority on the formation of water user's organization (WUO) for all irrigation systems in the nation and strengthening of existing WUO in order to execute O&M of irrigation and drainage systems by the farmers themselves. It is desired under such circumstances that water users themselves positively participate in the irrigation water management and maintenance activities of irrigation facilities, and finally operate and maintain all the irrigation and drainage systems including all the expenses required for their activities. The irrigation development plan is, therefore, formulated placing an emphasis on assisting the self-standing of water users who work for operation and maintenance of irrigation and drainage facilities.

The irrigation development plan is composed of irrigation water management improvement plan, irrigation facilities improvement plan, and Villarpando headworks improvement plan.

Table 28 shows the Project design matrix of the comprehensive irrigation development project.

8.5.2 Irrigation System and Irrigation Area

It is proposed to provide a new main canal from the existing Santana weir so as to supply water the existing irrigation systems in Tamayo, Vicente Noble and the left side of the Yaque del Sur River. About the right side bank, however, the downstream 11 pump irrigation areas of about 1,280 ha in total have difficulty to be economically and topographically covered by gravity irrigation system. They are, therefore, improved as pump irrigation areas as they are.

In both the proposed main canal system and the existing pump systems to remain, night storage ponds are proposed to be provided along the main canal or near the pump stations in order to enhance the efficient use of water.

The proposed irrigation area and irrigation systems are shown in Figure 41. The irrigation area with project condition is demarcated in terms of the irrigation systems as follows:

- Tamayo area	940 ha
Area served by proposed main canal	(624 ha)
Area served by Santana system	(316 ha)
- Vicente Noble area, served by main canal	1,393 ha
- Canoa-Palo Alto area, served by main canal	815 ha
- Peñon-Fundacion area,	2,737 ha
served by proposed main canal	(1,459 ha)
served by exist. pump station	(1,277 ha)
Total irrigation area (The Project area)	5,885 ha
- Irrigation area served by the proposed main canal	5,532 ha
The Project area served by the proposed main canal	4,292 ha
Sugarcane area of CEA	1,241 ha

8.5.3 Irrigation Water Requirement and Water Balance

(1) Irrigation Water Requirement

The irrigation water requirements with project condition were estimated in accordance with the proposed cropping pattern on the assumption that the irrigation water efficiency is 0.47 for upland crops and 0.58 for paddy. Annual irrigation water demand in the Project area is estimated at 171 million m^3. The unit irrigation requirement is estimated at 1.24 liter/sec/ha at the head of the proposed main canal or 1.11 liter/sec/ha at the head of the laterals during peak irrigation season. Thus the design unit irrigation requirements are determined to be 1.3 liter/sec/ha for the Santana intake and the main canal and 1.2 liter/sec/ha for the laterals and the pump irrigation systems.

(2) Water Balance

The water balance considered in the Master Plan is under an "ideal" condition with enhanced irrigation efficiencies for all the irrigation systems. However, it is necessary to consider conditions during the transition period from the without-project to the fully developed condition. The water balance under a condition with; i) improved water distribution at Villarpando, ii) enhanced irrigation efficiency at the Lower Yaque del Sur Irrigation Area, and iii) present irrigation efficiency (without project condition) for the other existing irrigation systems, is considered for determining the irrigable area and evaluating the Project.

The simulation results show that the available volume of the water for the Project area would decrease by eight (8) percent. In other words, it can be said that eight per cent of the proposed Lower Yaque del Sur Irrigation Area (5,885 ha) might not be fully irrigated without the improvement for the other systems.

8.5.4 Basic Plan of Irrigation Facilities

Major project facilities to be improved or constructed are:

Villarpando headworks	Construction of gated sluice to supply water to Yaque del Sur downstream (1.83 x 2.5 m x 3nos : design discharge = 30 m^3/sec) Replacement of intake gates (1.83 x 2.5 m x 3nos) Replacement of Sand flushing gate (R:7.2m, W:4.0m, radial type)
Santana headworks	Reconstruction of intake and sand flushing sluice (intake: 1.75 x 1.75 m x 9nos, sand flushing : 2.8 x 2.8m x 2nos) - Measuring device: Parshall flume at the end point of intake
Main Canal	Total length : 20.8 km Canal type : concrete flume (w:4.5m, h:2.0m, l=1.4km) and, trapezoidal concrete lining (w:1.5-0.7m, 19.4 km) - Maximum design discharge : 7.2m^3/sec
Lateral Canal	- Total length : 50 km (newly constructed: 26 km, rehabilitated: 24 km) - Canal type : trapezoidal concrete lining - Design discharge : 0.05– 1.5 m^3/s
Regulation Ponds	Number : 10 nos. Effective capacity : 15,000 – 35,500 m^3 Shape : rectangular (length 80m-120m for one side) Effective depth : 1.8 m Lined by concrete on inside slope of the pond and by impervious material on the bottom
Inspection Road	Total length : 13.5 km in Main canal (newly constructed) and 50 km in lateral canal (newly constructed and rehabilitation) Road width : effective width = 5 m with gravel metaling
Siphon	Siphon 1 Total length : 650 m Design capacity : 6.4 m^3/s Double pipe type: diameter 1500mm Siphon 2 Total length : 250 m Design capacity : 4.6 m^3/s Box Culvert : 1.8 x 1.8 m
Regulation pond along main canal	Number : 11 nos. Effective capacity : 2,000 – 10,000 m^3

(1) Improvement of Villarpando headworks

Water to the Azua area is diverted through sluice gates and water to Yaque del Sur - Lago Enriquillo area flows over the fixed weir. The former type is insensitive against the variation of water level and the latter is sensitive against that. It means that the flow to the Azua area is very stable and that to the Yaque del Sur - Lago Enriquillo area is unstable.

In order to precisely divert water between the Azua area and the Yaque del Sur-Lago Enriquillo area, it is proposed to provide a gate structure to discharge water to the Yaque del Sur downstream. The structure has the same gate type as the existing intake diverting water to Azua area. The sill of the sluice gates and the gate width will be also set at the same elevation or the same dimension as that of the intake. Considering the required discharge of 30 m^3/sec at the period of peak water demands, the structure will be equipped with three sluice gates having a span of 1.83 m and the height of 2.5 m.

The existing intake gates and the sand flushing gate will be replaced with new gates, which are operated by both electric motor and manually.

(2) Improvement of Santana headworks

The Santana headworks is to be used as a headworks for the proposed main canal as well as the existing Santana canal. The existing intake and sand-flushing sluice are to be totally replaced with new ones. The overflow section will remain as it is.

The size of the proposed intake gate is determined at 1.75 m x 1.75 m in consideration of manual operation in addition to electric operation. Nine (9) sluice gates will be installed to meet the peak water demand of 25 m^3/sec consisting of 7.2 m^3/sec for

the Project area and 18 m^3/sec for the Santana canal. Three gates are equipped for the proposed main canal system and six gates are for the Santana canal system. The crest elevation of the operation deck of the intake is set at 37.5 m, almost the same elevation as that of the existing deck. The sand-flushing structure will be almost similar to the existing one in the scale. Two sluice gates, which have a 2.8 m in height and 2.8 m in width are to be provided.

(3) Main Canal

The route of the proposed main canal is shown in Figure 41 roughly, and a detailed description is given in Drawing 4.5.1 - 4.5.4 in Annex 2. The total length is about 21 km. A reinforced concrete flume type is adopted in the reaches of about 1.3 km from the Santana headworks to the inlet of the siphon No.1, which is a crossing structure under the Yaque del Sur River. The main canal, in other than the first reaches, will be a concrete-lined canal having a trapezoidal cross section. The primary features are shown below:

- Design discharge : 7.2 m^3/sec – 0.47 m^3/sec
- Design velocity : 1.45 m/sec – 0.53 m/sec
- Bottom width : 4.5 m in flume section
  1.5 m – 0.7 m in trapezoidal section
- Canal height : 2.0 m in flume section
  1.85 m – 0.70 m in trapezoidal section.

(4) Flood protection dike and Siphon

A flood protection dike is proposed in parallel to the main canal in the same reaches as the concrete flume works from the Santana headworks to the inlet of the siphon No.1. The primary features are shown below:

Crest width : 4 m
Crest elevation : around 36.5 m at just downstream of the Santana headworks
: around 34.6 m at the meeting point with the Vicente Noble-Tamayo road.
Height of the dike : around 3 m on an average
Riverside slope of the dike : protected by gabion.

Siphon structures are to be provided on the main canal crossing the Yaque del Sur River and crossing the depression at Canoa, which becomes a flood way of the Yaque del Sur River. The design discharges are 6.4 m^3/sec and 4.6 m^3/sec, respectively. The siphon No.1 will be of double circular pipe type, which is composed of 2 lanes of pre-cast concrete pipes having a diameter of 1.5 m wrapped with reinforced concrete. The total length is about 700 m. The siphon No.2 is of a single concrete box type having inside dimensions of 1.8 m high and 1.8 m wide. The total length is about 250 m.

(5) Regulation Pond along the main canal and the related structures

The night storage ponds will be provided along the main canal. The required storage capacity is determined on the assumption that the pond stores irrigation water of 12 hours supposing the outflow of 12 hours against the inflow of 24 hours at the time of the

peak irrigation requirement of 1.2 lit/s/ha.

The ponds have a rectangular shape surrounded by an earthen bank. The inside slope of the bank will be protected with concrete lining. The bottom will be compacted with impervious clay material. The related structures consist of an inlet and a check followed by a drop, an outlet and a spillway.

Irrigation Area and Effective Storage of the Night Storage Pond

No. of Pond	Irrigation Area	Irrigation Area (ha)	Effective Storage Capa. (m^3)
1	Tamayo	624	34400
2	Vicente Noble	495	30400
3	Vicente Noble	518	28500
4	Vicente Noble	323	17800
5	Canoa	257	22900
6	Jaquimeyes- Palo Alto	255	20600
7	Fundacion-Pescaderia	365	27100
8	Fundacion south	230	18900
9	Fundacion south	232	14400
10	Fundacion south	277	20100

(6) Pump systems

If all the pump stations are operated simultaneously during the drought period when the river water is small, water will become short and pump stations located in the most downstream would easily draw sea water. During this time, it is most effective to continuously pump water for 24 hours to meet the river flow. It needs rotation of pump operation among pump stations. Some of the pump stations have to be operated during night time. Meanwhile, irrigation should be practiced during daytime. In order to fill the gap between the pump operation and the irrigation practice, a night storage pond should be provided. Against the interruption of electricity, which frequently occurs, the pond is effective. Storage capacity is determined to be able to store the amount of water corresponding to 12 hours of peak irrigation water requirement. The regulation ponds will be similar structurally to the night storage ponds to be provided in the gravity irrigation system. The irrigation area of the pump stations and the capacity of the regulation ponds are as follows:

List of Regulation Pond in the pump irrigation systems

No. of Pond	Name of Pump system	Irrigation Area (ha)	EffectiveStorage Capa. (m^3)
1	Mena IAD	144	7500
2	Guaba de Mena	82	4300
3	Palo de Leche	162	8500
4	Penon I	117	6100
5	Penon II	108	5700
6	La Guinea	61	3200
7	Paso de Elena	24	1300
8	Cabellero	77	4000
9	LaHoya	104	5400
10	Habanero	175	9200
11	Dumit	33	1800

Note: Irrigation areas are subject to investigation in detail.

(7) Improvement of existing irrigation systems

Water supply from the night storage pond is to be limited during the daytime or the time when farmers are working in the fields from the view of efficient use of water. The existing laterals and sub-laterals need twice as much present flow capacity. Most of the

laterals and sub-laterals are earth canal at present. These canals will be, therefore, improved with provision of concrete lining or wet stone masonry for mainly increasing the canal capacity. Some of the existing canals, which are excessively deep with much meandering will be replaced by newly constructed canals. Field canals will be improved by slope trimming and repairing the embankment.

(8) Inspection road

Inspection roads will be provided for the operation and maintenance of the main canal and laterals in the reaches where a road is not available. The inspection road will be 6 m to 5 m in width.

(9) Work Quantity

The work quantities for all project works are summarized in the following table.

a) Villarpando headworks Excavation 9,000 m^3, Backfilling 28,000 m^3 Concrete : 2,000 m^3 Gate installation 6 nos. (roller gate, 1.8*2.5 m) 1 nos. (radial gate, R=7.2m) Trashrack 3 nos.	d) Regulation Ponds; 21 nos. Excavation : 160,000 m^3 Embankment : 118,000 m^3 Lining Concrete : 8,000 m^3 Clay embankment : 95,000 m^3
b) Santana headworks Excavation 18,000 m^3, Backfilling 6,500 m^3 Concrete 3,000 m^3 Gate installation : 9 nos. (roller gate, 1.75*1.75 m) : 2 nos. (roller gate, 2.8*2.8 m) Trashrack : 9 nos.	e) Siphon 1&2 Excavation : 51,000 m^3 Backfilling : 33,000 m^3 Concrete work Concrete : 6,900 m^3 Form work : 12,400 m^3
c) Main Canal (Total length : 20.8 km) Earth work (including inspection road) Excavation : 79,000 m^3 Embankment : 265,000 m^3 - Lining Concrete : 16,000 m^3 - Structures [nos.] Check=20, Turnout=15, Culvert=30, Drop=14, Drain cross=37	f) Lateral canal : length: 84 km (lateral 50km, sub-lateral 34km) Earth work (including inspection road) Excavation : 153,000 m^3 Embankment : 388,000 m^3 Lining Concrete : 26,000 m^3 - Structures [nos.] Check=160, Turnout=155, Culvert=189, Drop=56, Drain cross=108

8.5.5 Plan of Setting up and Strengthening Water Users' Organization

(1) Objective of WUO

The main objective of WUO is that beneficiaries themselves operate and maintain the irrigation and drainage facilities. In addition, WUO is expected to play a role as a communication channel for farming management especially for the mobilization of tractors and distribution of farm inputs like fertilizer and pesticide.

(2) Share of O&M works

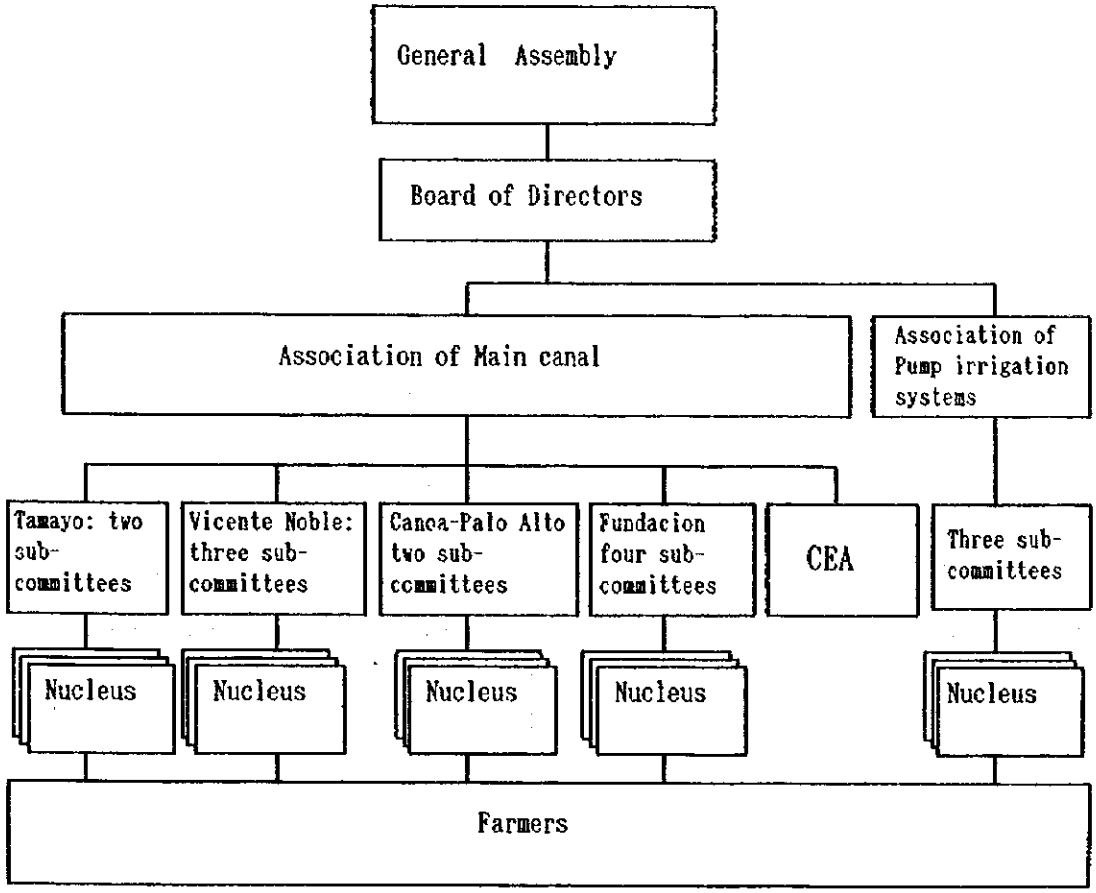
INDRHI should take charge of the operation and maintenance of the Santana headworks as well as the Villarpando headworks, since the Santana is related to both CEA and the Project. WUO should share a responsibility for operation and maintenance for all the irrigation and drainage facilities except the Santana headworks in the future, provided that INDRHI would share a large scale repairing works. Most of the irrigation systems such as the main canal, night storage ponds, pump stations, and lateral and sub-lateral canal systems will be actually operated and maintained by work forces consisting of technical and management staffs employed by WUO. Field canals will be operated and maintained by a farmers communal work system under the responsibility of each of nucleus, which are the

smallest units of WUO.

(3) Structure of WUO

WUO will be composed of the hierarchy of nucleuses, sub-committees, associations, and an irrigation committee in accordance with the irrigation system levels as shown in the following figure.

Organization of Yaque del Sur Lower Reaches Irrigation Committee
(Tentative name)



All the farmers in the Project area should be members of the WUO. The number of nucleuses is around 200. The number of members is a little over 20 and the area in each nucleus is a little less than 30 ha.

The General Assembly, as a maximum authority, will be held usually twice a year. The General Assembly will be responsible for important and essential matters such as the approval or reform of by-laws, the election of the board directors, the rewards for the board directors, the approval of water charge and budget of the Irrigation Committee.

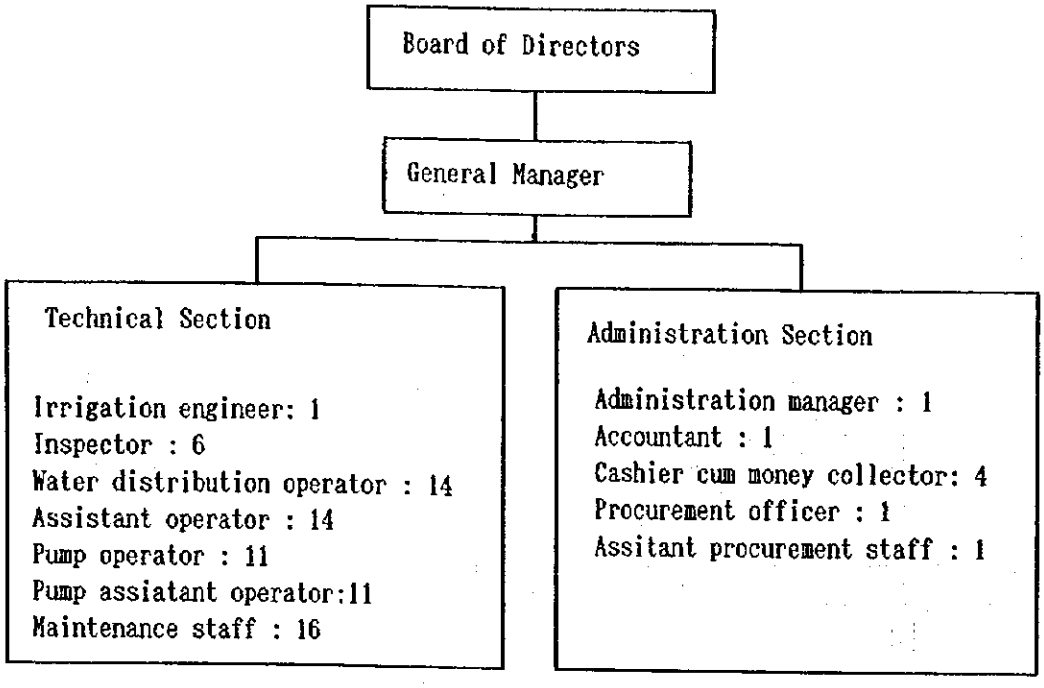
The Board of Directors is responsible for the management and administration of the Irrigation Committee and employ and manage technical and administration staff that are the actual work force for operation and maintenance of irrigation and drainage facilities. The

associations and the sub-committees watch the work force at the respective level. The main duties of the nucleus are to make irrigation rotation schedules among fields, and to operate and maintain field canal systems.

(4) Work forces

The Irrigation Committee will employ technical and management staff who actually assist WUO in preparing maintenance programs, irrigation schedules and directly carry out O&M in the conveyance systems including the proposed night storage ponds and administrative management including collection of water. Staffing of technical and administration sections is estimated as follows.

Organization of Work Force



(5) I.D office of INDRHI

Instead of the commission of irrigation water management to WUO, Irrigation District and Zone offices of INDRHI will reduce their office scale and staffing. They will function as a superintendent and will watch the water distribution at key diversion points and assist and advise WUO in the operation and maintenance works and as a maintenance force to carry out large-scale repairing and maintenance works for major facilities .

(6) O&M Facilities and Equipment

WUO would need office space, light equipment and tools for the water management and routine operation and maintenance works. One head office and two branch offices are proposed for this Project. The head office will be located in Vicente Noble or Tamayo, and two branch offices will be located in Penon and Fundacion. These offices will be not only be working for WUO, but will also serve as a community center in the area. Equipment and tools necessary for carrying out the operation and maintenance works of

the facilities are as follows:

(a) Equipment and tools for field works

- Light truck : 5
- Motorbikes : 9
- Bicycles : 74
- Chain saws and cutters,
- Walkie-talkies : about 10 sets
- Hand shovel, hand plow, etc..

(b) Equipment for office works

- Mini van : 1
- Personal desk and chair, meeting desk
- Locker and bookshelf : 20 sets
- Telephone set : 5 handsets
- Copy machine : 3 sets
- Personal computer sets : 5 sets

Besides, Irrigation District Office should reinforce a dump truck, a motor grader, a backhoe and a bulldozer in addition to the present force of equipment.

(7) Operation and Maintenance Cost

The O&M costs are estimated at least DR$ 6 million / year for the whole WUO in the Project. This It is equivalent to DR$ 1,000 / ha. The costs, however, do not include the costs of large scale repair of heavy construction equipment and an allotment to INDRHI. Considering these costs, the O&M costs will be a thousand and a few hundreds pesos / ha.

(8) Irrigation Water Charge

As for the price of water charge, it is appropriate that the water charge is DR$. 1,000 /ha/year in consideration of the O&M costs, farmers' intention, and farmers' capacity to pay with project condition. Many of farmers have a sense that the water charge of DR$. 1,000 /ha/year is not expensive, if the irrigation water management is properly practiced. Also, farmers will have a sufficient capacity to pay it with project condition.

It is proposed for the initial stage of the Project to simply determine the water charge in proportion to the agricultural land owned by each of farmer irrespective of both the kinds of crops (except paddy) and the planting area of crops. In any way, the rate should be determined considering the office works and the fairness of the burden through sufficient discussion among farmers, INDRHI, and experts.

A nucleus chief and a treasurer will collect the water charges from the member farmers and deposit the collected money into the bank account of WUO. If a farmer or a nucleus does not pay the water charge on time, the money collector with a representative of sub-committees should instruct them to pay the charge. In order to expedite the payment

of water charges, it is recommended to include some punishment and incentive in by-laws.

(9) Approach to Setting up of Water User's Organization

The following process will be taken for newly setting up WUO.

(a) Formation of nucleus

- Preliminary investigation- demarcation of tertiary blocks and identification of resources - farmers and leaders' capability, education level, physical conditions,
- Setting-up of a working team consisting of principally one organizer and one assistant,
- Orientation of farmers in each tertiary block,
- Preparation of lists of farmers and farmers' irrigation area, bylaw and water management rules,
- Formation of nucleuses and election of nucleus chief and other directors such as a treasurer, a water distributor and a maintenance chief,
- Preparation of sketch maps indicating field canal system and location of irrigation area of every farmer,
- Training farmers, and rehabilitation and improvement of field,
- Commission of O&M of field canals in the tertiary block to the nucleus,

(b) Formation of sub-committees, associations and the Irrigation Committee

- Establishment of a sub irrigation committee and selection of the president and other directors upon the completion of the formation of the nucleuses at all the areas commanded by one night storage pond or served by pump stations,
- Training the president and other directors, and employment and training of technical and administration staff, and then commission of O&M works to the sub-committee,
- Establishment of an association upon the completion of the construction of the main canal or the improvement of all the pump irrigation systems, and then establishment of the Irrigation Committee.

(10) Manpower deployment

In order to fulfil the institutional development works, the Project will form a Division composed of an institutional expert, organizers, operation and maintenance experts of irrigation facilities, and others. One organizer and one assistant who will be selected from the leading farmers in the target area will form a team and will work at the front line to organize the farmers. Manpower required for the field activities is estimated at five (5) organizers and five (5) assistants on the assumption that the organization is completed in four years. Total manpower required for the set-up and reinforcement of WUO is estimated at about 700 M/M including an institutional expert, operation and maintenance experts, and water management experts.