3.7.2. Agricultural Credit

(1) General

Since August of 1996 the Government launched a program to provide credit to the agricultural sector. Some measures taken in that direction were the debt restructuring of farmers with the Agricultural Bank, the State Bank (Banco de Reservas) and commercial banks. Furthermore, the channeled DR$300 million through the Agricultural bank to provide new loans to agriculture as well as DR$150 million through the Central Bank's Department of Financing (DEFINPRO). After the Hurricane George the Government devoted financial resources to support production of food crops. The interest rate for the final user of this latter fund is 14%.

The Agricultural Bank (BAGRICOLA) has its main role to provide credit facilities for the promotion and diversification of the agricultural production; facilitate, through technical and financial assistance, the organization of farmer cooperatives and, mobilize saving through saving accounts in order to increase agricultural production. It has been estimated that the Agricultural Bank provides around 30% of the credit for agricultural production in the country. In 1997 BAGRICOLA disbursed DR$1,200 millions to finance different agricultural activities, mainly rice, red beans, garlic, plantain and coffee. During that year credit for agricultural activities from the banking system totaled DR$4,856 millions.

Commercial Banks have reduced its participation in agricultural business caused by the new norms of provisioning and the high risk of default by farmers. Several NGO's have become interested in credit programs but often lack the funds to get started or the broaden their coverage.

(2) Credits Systems in the Project area

One of the main constraints found in the Project area is the inability to access formal credit. This in is turn prevents farmers from introducing modern techniques and increase production and income. Commercial banks in the Project area are deposit takers but are hesitant to lend to agriculture.

Most of the financing of agricultural business comes from the Agricultural Bank, and local money lender. Other financial sources are commercial banks, Agroprocessing firms, and specialized Non-profit Organizations.

The Agricultural Bank has branch offices in Tamayo, Vicente Noble and Barahona city. The Agricultural Bank has credit officials who make assessments regarding farmers loan requests and monitor the disbursement of loans. The loan officials help farmers to prepare and present crop budgets and loan requests. Often time the Agricultural Bank approves only a percentage (75-80%) of the capital needed.

(3) Activities of Credit Services in the Project area

During 1997 the Agricultural Bank offered a low percentage of loans for agricultural production in the study are mainly to plantain, banana and cassava. The average interest rate was 18%. Table 3.7.1 presents the Agricultural Bank activity in the Project area for the last three years.

A significant proportion of the agricultural business financing comes from the money lender because the requisites are less and the money is readily available. Despite its importance, there is no an assessment of the amount of money channeled to agricultural business through this outlet because they are not included in the formal financial system. The average interest rate that charged for this money lender is around 20% a month.

There exist provincial branches for most commercial Banks which also provide loans to agricultural business in a lower scale than other type of business. The industrial tomato production is financed entirely by the agroprocessing firms. In the region operate Non-Government Organizations which allocate funds to small farmers. Among the most active NGO's which provide loans are LEMBA, the Foundation for the Development of the South (FUNDASUR), Servicio Social de Iglesias (Social Services of Churches, SSI), World Vision-FIME, and Fundación de Desarrollo Dominicano (Dominicana Development Foundation.

3.7.3. Seeds Multiplication

In the Project area seed materials for plantain, cassava and banana are produced individually by farmers who used them on their plots. SEA extension agents are responsible for the distribution of seed material. They do not produce those materials. They distribute them according to the demand from farmers. Usually farmers go to SEA's office in the area or sub-zone. SEA obtains seed materials and distributes them among farmers free of charge.

There is no quality control for those seed materials. This is a major problem for the homogeneity of the production and for pest control. Seed materials are transported within and outside the area with little regard for disease diffusion.

3.7.4. Agricultural Cooperatives

(1) Kinds and Number of Cooperatives in the Project area

In the study area there are numerous farmer associations and cooperatives. Usually farmer associations are formed among those producing the same type of crops living in the same villages. Most of the association have no more than 20 members. A list of farmer cooperatives identified in the study area is shown in table 3.7.2.

Most associations are institutionally weak. Based on the Rapid Rural Appraisal it was estimated that the level of farmer's integration and identification with the association's goals are very low. Most of the time they do not prepare annual plans and their traditional

leaders have not been replaced for a younger generation. Even when they are legally approved, they do not perform business activities such as marketing of their product and procurement of the main agricultural inputs as a group.

For instance, the plantain grower association, in Vicente Noble only has 16 members, even though it has been active for more than 10 years and most farmers in that town grow plantain. They do not own office space and usually meet in the community center in Vicente Noble or in the house of a member of the board of director.

The plantain grower association tried to operate a truck for transporting the production directly to outside markets specially Barahona and Santo Domingo. The association obtained a loan from the Agricultural Bank to buy the truck and it was managed by the board of director. The activity lasted only for a couple of years. Due to problems with the payment of the mortgage, the association had to surrender the truck to the bank.

Similar experience happened with the rice grower association in Canoa. The association obtained funding from the Agricultural Bank and a IDEAC (an Non-Government Organization) to establish a rice mill. However, due to the low production of rice in the area, and lack of management, the rice mill has closed down. At present the association has a bad loan with IDEAC for more the amount of RD$400,000.

An assessment of Four Farmer Associations in the Study Area

ITEM	Asociación arroceros Miramar, Canoa	Asociación de Agricultores Yaque del Sur, Pescadería	Asociación de Agricultores de Mena Abajo	Asociación de Tomateros y Plataneros, Vicente Noble
Date Founded	Nov. 1978	September 1991	September 1995	May 1987
# of members	24	24	30	16
Does it has by-laws?	yes	yes	no	yes
Does it prepare annual work plan?	yes	no	no	no
How often holds meetings?	weekly	every two weeks	monthly	weekly
Does it own a place to meet?	yes	yes	yes	no
Is the Board of directors functioning?	yes	yes	yes	yes, but it has not renovated in the last two years
Do farmers get credit for production?	yes	yes	yes	yes
Who provided credit?	Banco Agricola, IDEAC	Banco Agricola	Banco Agricola	Banco Agricola
Have farmers participated in training programs?	some of them	a few of them	no	no
Weakness	- production of rice has been hurt by the Lack of water. Own a rice mill, but is closed due to lack of rice for processing. - Low turn out of members to weekly meetings. - insufficient credit for production and processing. - The board of director has not been changed for a long time. - The lack of profit has affected the identification of members with their association.	- Lack of irrigation water. - Problem with water pumps. -Lack of technical assistance. - Lack of support services (for land preparation, and credit). -Problem with road access. - Do not have a program to market their product and procure inputs as a group.	- Low participation of members - Lack of financial resources for production - Lack of irrigation water. - Lack of support services -Low managerial skills.	-Low participation of members - Tried to market their plantain production buying a truck. However, they could not pay the mortgage and the truck was taken away by the bank. - Low turn out of member for the association meetings. - Lack of managerial skills among the board of director.

(2) Activities of the Cooperatives

When asked about the benefit of belonging to a farmer association most farmers

indicated the ability to get better prices and market access. However, farmers do not use this mechanism to sale their crops. Lately, cooperatives have been active requesting irrigation facilities for their communities. Several cooperatives in the Project area were organized and supported by political activists who brought about conflict among farmers.

3.7.5. Non-Government Organization

(1) Kinds and Number of NGOs in the Project area

It is noticeable the presence of Non Government Organization in the Project area NGOs have become an alternative way to provide o deliver technical assistance and training to farmers and rural residents. Similarly, International Cooperation Organization allocated their funding through local grassroots organizations under the premises that those organization are more effective and are in close contact with the targeted population.

(2) Activities of the NGOs

Those NGOs work mainly on strengthening the institutional capability of farmer organization and rural organization specially women and youth. A list of NGOs and their main activities are shown in Table 3.7.3.

3.7.6 Problems in Agricultural Support Services

Based on the Household services, 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 in the Project area. The main problems identified are laid out in Figure 3.7.3.

3.8 Environmental Aspects

3.8.1 Description on Environmental Condition of the Project area

(1) Social-economic Issues

(a) Communities, Population and Economic Activities

In the Project area and its surround, some 66 thousand people live. Vicente Noble and Tamayo are comparatively large towns in the Project area. In the Barahona province in which almost parts of the Project area are located, 30 % of the people engage in activities of agriculture, fishery, or livestock farming.

Table Population in Study Area

Area	No. of Household	Population
Vicente Noble	4,220	17,937
El Penon	1,747	7,639
Fundación	1,664	7,242
Tamayo	4,108	18,912
Uvilla	3,768	14,613
Total	15,506	66,343

Table Economic Activities by People Living Barahona Province

Type of Profession	Population
Agriculture, Fishery, and Livestock Farming	15,471 (30%)
Professions out of above mentioned ones	18,380 (36%)
Non-identified or non-declared cases	17,490
Total	51,341

Source: 7th Population Census (ONE)

(b) Organization of Local People

The situation of the organizations formed by local people in the Project area and its surround is shown in table below. The organizations relating to agriculture are occupied in major case.

Table Organizations of Local People

Municipality or District Municipality	Type of Association			
	Agriculture	Livestock Farming	Fishery	Others
Vicente Noble	15	1	-	5
Fundación	25	1	2	20
Tamayo	37	-	-	30
Total	77	2	2	55

Source: Rural Organization Department, SEA

(2) Health and Sanitary Issues

(a) Health and Sanitary

The condition of the drinking water supply is shown in Figure 3.6.3. After the hurricane George, the water supply condition has deteriorated especially in the northern parts of the Project area.

The number of the case of hospitalization caused by water born diseases in Barahona and Bahoruco provinces, is shown in table below. The acute diarrhea is a major case in the both provinces.

Table Cases of Hospitalization caused by Water Born Diseases

Province	Barahona	Baboruco
Acute Diarrhea	1,974	571
Typhus	53	112
Total	2,027	683

Source: Memoria Anual Salud Publica 1996 (1997)

The number of medical facility is shown in table below. There are some kinds of medical facility in all municipalities or district municipalities.

Table Number of Medical Facilities in the Project area

Municipality or District Municipality	Poli-clinic	Clinic	Rural Clinic	Subcenter	Hospital
Vicente Noble	9	-	4	1	-
El Penon	-	-	2	-	-
Fundación	-	-	2	-	-
Tamayo	-	-	1	1	-
Uvilla	-	-	2	-	-
Total	9	-	11	2	-

Source: Memoria Anual 1997 (SESPAS)

(b) Agrochemical Use

According to the interview survey, about 29 % of farmers do not apply fertilizers, and about 36% do not use pesticides. The range of N fertilizer per hectare varies from as little as 5 kg/ha to as high as 135 kg/ha; P fertilizer varies from 5 kg/ha to 135 kg/ha; and K fertilizer varies from 5 kg/ha to 125 kg/ha.

(3) Natural Environmental Issues

(a) Climate and Topography

The Project area belongs to the semi-arid zone. The annual rainfall is about 450 mm (in Tamayo station). The months in which the rainfall is recorded over 50 mm are May, June, August, September and October, while in the other months less rainfall is recorded.

Generally the Project area is occupied by low lying land whose altitude is less than 30 m above sea level. Especially the altitude of the southern part of the Project area including Los Jaquimeyes, El Penon, Fundación 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.

(b) Land Use and Vegetation

The situation of the land use and vegetation is shown in table below. Almost areas are occupied by the irrigated agriculture area. In the area, plantain and banana are major crop.

Table Land Use in the Project area

Land Use	Area (ha)	Remark
Irrigated Area	5,885	Plantain (77%) and banana (4%) mainly occupy.
Bush Land	190	-
Town and Built Up Area	760	-
Water Body	125	-
Total	6,960	-

(c) Soil Salinization

According to a previous study (Estudios de Factibilidad y Desenos Finales del Area de Influencia de la Presa Sabaneta Yegua, Informe de Factibilidad, Tomo 2, Anexso A,

1984, INDRHI), some salinization areas are observed in the southern part of the Project area and the area around Canoa as shown in Figure 3.8.1.

(d) Water Quality

According to the result of water test done by this study team, the water quality of Yaque del Sur River in the Project area is shown in the table below. The results of pH and TSS are below the normal of the Dominican Republic for irrigation water quality, while those of EC correspond to the level C3 (high) of the normal.

Table Water Quality in the Project area

Item	Intake to Rincon L., Yaque del Sur River	Cachón, Yaque del Sur River
pH	7.4	7.6
EC (mS/cm)	1130	1150
TSS (ppm)	100	160

Concerning the water quality of the Rincon Lake, it has changed drastically after the hurricane George as shown in Table 4.4.1.

3.8.2 Environmental Problems for Local People in the Study Area

According to the interview survey done by this study team, the local people recognize items shown in table below as environmental problems. The problems relating to water, both for drinking and irrigation, were mainly pointed out.

Table Environmental Problems for Local People in the Project area

Problems	No. of case
Bad drinking water quality	28
Shortage of irrigated water	22
Shortage of drinking water	20
Bad housing condition	20
Shortage of electric supply	10
Others	31 (noise, deforestation, garbage, etc.)

Source: Interview survey done by the study team, 53 samples taken in the Project area

3.9 Consideration on Hurricane Georges

3.9.1 General

The 1998 season was an active one in terms of hurricanes, though not as active as the recent 1995 and 1996 hurricane seasons. Ranking seasons by the measure of Net Tropical Cyclone, which represents frequency of hurricanes, were 168 against the normal of 100 (average of 1950 – 1998). Only the hurricane seasons of 1950, 1955, 1961, 1995 and 1996 were more active than 1998. This high level of activity occurred despite the hurricane suppressing influence of an easterly Quasi-Biennial Oscillation, dry conditions in western Africa before August 1, and lagging El Niño conditions in the eastern equatorial Pacific.

In Dominican Republic, Georges brought the most serious damage in recent 20 years, while David (1979) and Gordon (1994) are fresh in the people's memory as other major hurricanes.

Georges was identified as a tropical depression[1] on September 15 at 9°00' N and 25°54' W and proceeded westerly toward the Island of Hispaniola. The hurricane landed at the Dominican Republic on the morning (around 9 o'clock) of September 22 as a "Category 2" hurricane in Saffir-Simpson Scale[2]. The hurricane passed through the country late 22 nd (about 11 o'clock at night). The course, status, and time of the hurricane are shown in Figure 3.9.1.

3.9.2 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 as shown below.

Station		Daily Rainfall (mm)			Total for 3 days (mm)
		22	23	24	
4605	Azua				205.2
4903	San Juan	270.5	120.0	0.0	390.5
4905	Cabral*				226.4
4907	La Florida	198.5	51.9	0.0	250.4
4913	Villarpando	8.0	83.0	1.8	92.8
4915	Vallejuelo	140.5	90.6	0.0	231.1
4916	Padre las Casas	310.0	11.0	0.0	321.0
5001	Barahona				62.0
5103	Polo*				479.0
	Santana**	161.5	10.9	9.9	182.3
	Cruce del Quince, Azua**	227.9	35.0	41.6	304.5
	Sabaneta**	47.8	246.9	3.4	298.1
	Villa Nizao**	389.8	144.3	39.8	573.9

Source: INDRHI, *; ONAMET, **; AQUATER (PLANIACAS-II)

In the upper basin of the Yaque del Sur River including the San Juan River received intensive rainfall during the passage of the hurricane, which brought rapid increase of water levels at Sabaneta and Sabana Yegua dams.

According to results of interview survey on inundation in the lower reach from Santana headworks down to Habanero, there seemed to exist certain difference in magnitude of rainfall during the hurricane. The duration of the rainfall replied by the residents varied from one day to one week by location. In the location, which received less rainfall, they felt that the floods or inundation in the area were caused by the operation of the dams on the upstream.

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1 Classified by the maximum wind speed. Tropical Depression (20 to 34 knots or 10.2 to 17.5 m/sec); Tropical Storm (35 to 64 knots or 17.6 to 32.9 m/sec); Hurricane (over 65 knots or 33 m/sec).

2 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

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 Georges 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 for the hurricane period, and it caused floods or inundation on the lower reach.

3.9.3 Flood Discharge

Hydrographs at Sabaneta and Sabana Yegua dams during the hurricane period are shown in Figure 3.9.2 and Figure 3.9.3. 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 were 2,254 m^3/sec (5:00 AM on September 23), and 7,987 m^3/sec (0:00 AM on September 23), respectively. Specific discharges for the peaks are 4.8 $m^3/sec/km^2$ for the both dams.

The study team estimated the return periods of the inflows to the dams. Since long-term hourly inflow records are not available, mean daily inflow discharges, which were derived from the daily water level records of the dams, were used. The mean daily inflow discharges for Georges were 642 m^3/sec for Sabaneta and 2,171 m^3/sec for Sabana Yegua. According to frequency analysis, the both discharges are estimated to be less than 1 in 200 years' flood inflows as shown below:

Return Period	Sabaneta (m^3/sec)		Sabana Yegua (m^3/sec)	
	Log Pearson-III	Gumbel-I	Log Pearson-III	Gumbel-I
2	36.4	62.8	143.9	262.4
5	77.9	211.0	374.6	867.0
10	137.3	308.6	702.1	1,264.6
50	507.3	525.6	2,653.5	1,650.2
100	888.1	617.4	4,558.0	2,149.3
200	1,553.7	707.8	7,741.6	2,523.6

Note: Numbers of data are 18 for Sabaneta and 20 for Sabana Yegua.

The peak inflow discharge to Sabana Yegua dam during David was reported at 7,800 m^3/sec, while the daily mean inflow was 2,735 m^3/sec which is more than 1 in 200 years recurrence level. The peak inflow discharge by Georges was almost same as that of David, but the total volume was less due to rapid decrease of the inflow.

On the other hand, the flood discharges on the lower reaches seemed to be more than those by David or to be the maximum during a few decades. The maximum flood discharge during Georges is estimated at more than 10,000 m^3/sec at Santana headworks on the basis of peak flood water level[3]. Specific discharge for the flood is 2.2 m^3/sec. Judging from these, the flood at the lower reach is estimated to have longer return periods (bigger), which will be evaluated in further analysis.

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[3] Santana headworks was submerged at the peak flood period. The water depth, width of the flood flow and mean current speed are estimated at 5 m, 1,000 m and 2 m/sec, respectively. Thus the peak flood is estimated at 10,000 m^3/sec.

3.9.4 Casualties

It is reported that a number of residents were flushed away to death at Mesopotamia in San Juan city. The area is located in the lower river course and subject to inundation by floods, and densely populated. Announcements or orders for evacuation were issued in advance of Georges' approaching 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.

In other locations, few casualties are reported. In Tabara Abajo, Azua, four people were flushed away to die in a similar situation to San Juan. In Tamayo, which is also densely populated and was inundated during the hurricane, few casualties were reported. The inundation was serious there but the current was slower in wider and flatter topography compared with upper reaches such as San Juan.

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

3.9.5 Flood Prone Area

According to the field survey, several locations were identified as "flood prone" or "high flood risk" area. 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)

These flood prone or high-risk areas below Santana headworks are shown in Figure 3.9.4.

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. It is considered because of overflowing of the flood waters on the upstream at Canoa, Jaquimeyes, or Rincon Lagoon.

3.9.6 Effects of Dams

Some people conjectured that the flood damages were caused partly because of operation of Sabaneta and Sabana Yegua dams, but it is not appropriate to connect the damages with the dam operations hastily taking activities of related officials and residents into consideration. As mentioned before, the related officials such as Emergency Dam Operation Committee (COEE) and the emergency and rescue committees issued orders of evacuation to the residents at Mesopotamia in San Juan in advance. However, some of the residents remained there being anxious about burglary during absence for the

evacuation. The committee members visited each house and tried to evacuate them, but some people locked the door inside and did not follow the orders.

Sabaneta Dam met Georges 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.

One month before Georges came, the reservoir water level was 638 m, while that of one week before was 643 m, maximum operation level. On September 23, the water level instantaneously exceeds 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 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 1 st of 1979, soon after 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 improvement of the dam.

The peak inflow discharge by Georges was similar to that of David, but the total volume was less than that of David. 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 of September 22 to five (5) o'clock of 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. The discharge from the service spillway during this period was 630 m^3/sec, same as the capacity.

Judging from the above-mentioned situation, it is probable that the flood water should overflow the emergency spillway. It can be said that Sabana Yegua dam was well operated during the hurricane period demonstrating its flood control effect fully. If the dams did not exist, uncontrolled flood discharge on the downstream might be a few times larger. However, even with the dams, it should be also noted that there was certain possibility to cause serious flood damages by using the emergency spillway.

Operation of eleven large dams in the country is determined and supervised by the Committee for the Operation of Dam Basins and the Emergency Dam Operation Committee in Santo Domingo. Staffs at the dam sites get instruction from Santo Domingo and operate gates and valves, and report records on the operation, water level, etc. to Santo Domingo periodically by written formats or verbal communication such as

radio or telephone system. The existing centralized system without telemetering facilities is not considered fully efficient particularly during the emergency period, in which some unexpected accidents might occur, and complicated communication and prompt judgement are required.

3.9.7 Activities of Institutions against Georges

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

(1) General

In the Dominican Republic, a permanent committee for reservoir operation is organized by technical staff of INDRHI, Dominican Electric Corporation (CDE), Institute of Potable Water and Sewerage (INAPA), Santo Domingo Water Supply and Sewerage Corporation (CAASD) and Santiago Water Supply and Sewerage Corporation (CORAASAN). In emergency situations such as the hurricane, Army and Civil Defense also associate with the committee.

This committee is responsible for the operation of the reservoirs such as maintenance of certain water levels and determination of the discharge through the spillway so that safety of the dam should be guaranteed, and damages by the discharge should be minimized on the downstream during the emergency period as Hurricane Georges.

The official organization, which issues bulletins on approach of the hurricanes, is the National Office of Meteorology (ONAMET). ONAMET receives bulletins on weather forecast from the Miami Hurricane Center in the USA, which plays a part of roles of the World Meteorological Organization (WMO) for four (4) regions, i.e., North America, Central America, Caribbean Sea, Venezuela and Columbia.

The announcement issued by ONAMET has three categories. They are; Alert Warning and Notice, which are determined, conformed to the distance between the cyclones and the territory by time. The institution responsible for security and protection of the people is the Civil Defense.

(2) Preventive Measures

(a) Emergency Reservoir Operation Committee (COEE)

Operations and actions that 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, in which Hurricane Georges passed Puerto Rico and enter 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, which were prepared after Hurricane David and Tropical Storm Federico in 1979. The Committee decided to operate the two dams in the following way from the day until 21 nd (24 hours before):

(i) Sabaneta Dam (Free overflow spillway without control gates)

From 18 th to 20 th of September, the hydroelectric station was operated for 24 hours using the full capacity of 11 m^3/sec conformed to the operation rule for September based on the water level of the reservoir, which was accumulated by precipitations in prior months.

Although the hurricane was approaching, the operation was continued at the full capacity discharging 11m^3/sec. A spillway tunnel started its operation at 12:00 (noon) discharging 14.5 m^3/sec, while at 16:00, the other spillway tunnel started discharging 14.5 m^3/sec. The discharge up to this time totaled approximately to 40 m^3/sec (through the turbine and the spillway tunnels); however, the water level continued to rise this day.

On September 22 nd, as it rained intensively in the basin, the water level in the reservoir had also increased continuously and not only the service spillway but also the emergency spillway started operation to a maximum discharge of 1,500 m^3/sec, which accounted for 66.5 % of inflow of 2,254 m^3/sec.

(ii) Sabana Yegua Dam

From 18 th to 20 th of September, the hydropower station was operated to generate 10 MW during the peak consumption hours, and a discharge of 2 m^3/sec was maintained through the by-pass valve for the remaining hours.

On September 21 st, the hydroelectric station was continuously operated at a full capacity. The water level reached the maximum operation level of 386 m AMSL, and the gates of the spillway tunnels were opened to maintain the water level.

September 22 nd ;
At 8:00am they operated the gates to discharge 50 m^3/sec through the spillway tunnel, then gradually increased the opening until it reached the maximum of 600 m^3/sec at 12:00 (noon), while the water level continuously increased. The peak flood received by the reservoir was 7,456m^3/sec, while the total discharge was 630 m^3/sec accounting for 8.45% of the inflow.

(b) INDRHI

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

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

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

To lift the flushing gates of headworks and regulation gates of canals, to control the discharge of the canal at a minimum of 20 % of the operation discharge to avoid destruction due to negative pressure by the flushing waters.

To remove debris at the ends of the drains and rivers for smoothing flow of drained waters and for impeding the rise of groundwater level.

To close the diversion gates (at laterals) for the canals without branches so that drained waters to the canals should not overflow.

To close intake gates of the main canal that has laterals without diversion gates (free inflow), in order to let the flood waters discharged through the canals without regulation.

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.

(c) ONAMET

The National Office of Meteorology usually issues daily bulletins with the information of the time. In presence of an atmospheric phenomenon of high intensity such as Hurricane Georges, bulletins are issued every three (3) hours.

On Saturday 19 of September, there was certain discrepancy between the interpretation of the reports received from the Miami Hurricane Center and the possible affected areas in the Dominican Republic, as Hurricane Georges approached. This caused delay of implementation of some preventive measures.

On Monday 21 st, 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.

The bulletin #18, issued at 10:00 p.m. on Monday 21 st, September, kept announcing "Notice" on the hurricane to the coastal and populated areas of the whole country that the hurricane was located and approaching at the latitude of 18.2 North, longitude of 66.5 West, about 200 km to the southeast from the territory, at about 22 km/hr toward the northwest or west direction, accompanied with strong winds, expected rains of 300 to 400 mm in total. and high waves of 4 to 7 feet.

(d) Civil Defense

On Monday, September 21 st, 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 river banks, river beds, downstream of the dams. However, in many cases, they met opposition by the people that were afraid of assault.

Evacuation at the initial stage and the following process were delayed in some areas on the lower Yaque del Sur River basin, such as Vicente Noble, Jaquimeyes, Palo Alto, and El Jobo.

3.10 Public Consultation Meeting

3.10.1 First Public Consultation Meeting

The JICA Study Team and Dominican Counterpart Team held a public consultation meeting for the Integrated Rural Development Project of the Yaque del Sur river basin on December 16 at Vicente Noble. Participants to be invited to this meeting area from i) INDRHI (Yaque del Sur Irrigation District and PROMASIR), ii) SEA regional office, iii) IAD regional office, iv) Farmers Organizations, v) Women Associations and Non Government Organizations. Participants are listed in Table 3.10.1.

The JICA Study Team and Dominican Counterpart Team explained the following matters to the participants:

- The background of the Integrated Rural Development Project in the Yaque del Sur river basin
- Aims of the Project
- Content of the development plans in the Master Plan
- Methodology for selection of the high priority Project among the above development plans
- Content of the high priority Project ('the Yaque del Sur Low Reaches Irrigation and Drainage Project including Villarpando Rehabilitation Project and overall water management
- Plan of operation of the Feasibility Study of the priority Project

After an explanation of the above, the discussion about the above matters was made between participants and Study Team. Main tops of the discussion were countermeasures against floods and rehabilitation of the damaged facilities affected by hurricane George matters.

Main comments, opinions, suggestions and desires from the participants were shown below:

- It is necessary to ensure the continuous water supply from Yaque del Sur river to Rincon Lagoon
- Improvement of Cano Trujillo canal is requested in order to facilitate the water supply to Rincon Lagoon.
- It is suggested to construct an inspection dike along the edge of Rincon Lagoon and to control land use around the Lagoon
- It is common to see water spill from the existing canals. It is necessary to construct irrigation canals with adequate capacity to convey water in order to avoid water loss and damages to the farm road caused by water spill from inadequate existing canals.
- The flood caused by Hurricane George deposited large quantity of sediments that make the farm lands higher than before, therefore it is necessary to find alternative solutions in order to adequate the irrigation system to this new condition.
- It is recommended that a flood diversion canal passing by the two bridges near Canoa should be constructed to protect Jaquimeyes town.
- During the frequent drought periods that affect the agriculture of the area, in Azua district and the sugar cane area of CEA there is much wasting of water that worsen the effect of drought. INDRHI must find a way to ensure the adequate and efficient distribution and use of water.
- INDRHI should develop serious training program for training both, INDRHI 's personnel and water users in order to achieve a more efficient use of water
- It is necessary to do river training in the lower part of Yaque del Sur river, because the river cross section is not enough to discharge large floods.
- The construction of a flood diversion canal near Canoa would benefit the town of Jaquimeyes only. The improvement of Cano Trujillo to divert the flood water into Rincon Lagoon is more effective and protect an would reduce flood damage for a larger area
- It is suggested that this kind of event (Public Consultation Meetings) in all the communities related to the Project area should be continued in order to get the support of local people for smooth Project implementation.
- It is requested that the construction of "Monte Grande" dam, including the construction of a flood diversion canal from Monte Grande dam to the sea should be done.
- Reforestation program is badly needed in the Yaque del Sur river basin.

- It is necessary that construction of a dike should be performed to Tamayo town from floods taking into consideration negative influence to Vicente Noble town.

3.10.2 Second Public Consultation Meeting

Second public consultation meeting was held on January 23 1999 at Barahona town. The JICA Study Team and Dominican Counterpart Team explained the results for the Progress report –2 and preliminary formulation of development plans to participants who come from local government offices, representative farmer's organizations, representative water user's associations, NGOs, Women's associations, and so forth.

After an explanation of the above, the discussion about the above matters was made between participants and Study Team. Main comments, opinions, suggestions and desires from the participants were shown below:

(1) Mr. Daniel Guerrero, Livestock producer Association of Barahona

First, agree with the words of INDRHI's director that the "lack of leadership is one of the main cause high incidence of poverty in the region. Second, the people leaving down stream of Tamayo were preoccupied by the proposed plan to construct a dike to protect Tamayo town. The explanation made by Mrs. Mayra Sanchez clarified that the construction of such a dike will not worsened the impact of floods in down stream towns because other measures will be included in the plan, such as the improvement of Caño Trujillo and the construction of a spillway and diversion channel near Canoa, etc.

(2) Mr. Guerrero presented a list of "Suggestions that could be taken into consideration for the Integrated Rural Development Project of Yaque del Sur river Basin".

Construction of a second reservoir somewhere down stream of Sabana Yegua dam, in order to keep the water that under present conditions is being loss to the sea; this water would be used during the dry seasons.

Construction of two (2) canals along both margins of Yaque del Sur river, in order to distribute water by gravity and eliminate pumping systems. The intake of these two canals should be located in a site that covers as much beneficiaries as possible.

Construction of a canal near Canoa for discharging flooding water directly to the sea in the point named Port Alejandro.

Enlargement of cross section of Yaque del Sur river, which was significantly reduce by the flood of hurricane George.

River training of lowers part of Yaque del Sur river.

To keep the Caño Trujillo in good condition for efficient diversion of excess water to Rincon lagoon during flooding time. Also, to define the area that should be kept for the lagoon. To improve the canals that discharge water from Rincon lagoon to Enriquillo lake in order to avoid overflooding of the lagoon into nearby towns such as Peñon, Mena, Cabral, La Lista, Cristobal, etc.

To re-construct the "Caño Cabral" which diverts water from Rincon lagoon back to Yaque del Sur river.

Rehabilitation of Santana dike in order to achieve a better diversion and distribution of water.

To construct the necessary drainage system to facilitate discharge of excess water to Rincon lagoon.

(3) Mrs. Lupe (lady on Christian mission from Spain): The people from Jaquimeyes town have bee struggling for twenty-five (25) years in order to have install an aqueduct and water supply system. They hope that this Project can help to solve their long waiting.

(4) Mr. Morgan Batista, Farmer: Request the construction of Monte Grande dam and a spillway and canal that discharges flood water from the dam directly to the sea.

(5) Mrs. Noris Meran, woman farmer: What is the INDRHI's plan to improve the maintenance of pumping systems. Also, Is the Project considering the installation of demonstration plots in order to introduce adequate on-farm water application. Recommends that each farmer should give some small percentage of their profit to create a fund to support cooperative activities.

(6) Mr. Dominishi, farmer: The Project should give priority to the community participation in Project implementation. Alternative crops should be studied.

(7) Mr. Daniel Mancebo, Saving and Credit Cooperative of Neyba: The Project do not proposes solutions for the irrigation of Neyba valley.

(8) Mrs. Milagros Volquez, Vicente Noble's development committee: I do not agree with the opinion said here by others related to the lack of leadership in this region. The Project do not have specific component for women participation. Does the Project contemplate the Aguacatico canal systems?.

(9) Mr. Mato Feliz, Ministry of Agriculture: This is a very good Project which is looking to solve the irrigation problems of this zone.

The flood mitigation component should be studied separately.

The reforestation of Yaque del Sur river basin should be included.

(10) Mr. Raúl Peña, farmer from Mena Abajo village: In the community there is lack of schools, in Mena Abajo village children receive classes under the trees. Without adequate education it is not possible to achieve development.

In Mena Abajo people are badly suffering the lack of water supply, both, drinking water and irrigation water. The crops are dying because of lack of irrigation water.

(11) Mr. Blass De Leon, farmer from Canoa: The increase of land use intensity and agriculture production with Project condition may increase the use of pesticides. Organic farming should be introduced. It is necessary to introduce control in the use of pesticides that could reach the water bodies.

(12) Mr. Garivaldi Floriano, Association of Engineers (CODIA), Barahona: The Project presented here is very complete, comprehensive. It is necessary to define the

institutional arrangement for Project implementation, as it is an integrated development Project.

Recommend the installation of research and demonstration farms in the research area that belong to the Ministry of Agriculture, located in Palo Alto. Recommend that farmers have participation in the development of demonstration plots.

(13) Mr. Salvador Medina, Water User Organization from Peñon: The Project presented here is ver nice, but unfortunately it do not include Peñon as beneficiary area for gravity irrigation. Request that pumping system be rehabilitated and small gates should be installed in the canals.

(14) Mr. Tomas Gonzalez, Plantain and Tomato producer association of Vicente Noble: The town of Vicente Noble still do not have drinking water supply in some sectors of the town. The land leveling problem is seriously affecting the replanting of plantain in the area.

(15) Mr. Domingo Peña, farmer from Mena Abajo: Due to the lack of irrigation water, the production of plantain is very low. The rehabilitation of pumping station is urgently needed.

Women should be taken in consideration in Project implementation.

They are ready to do any thing that they can in order to make possible the implementation of this Project.

(16) Mr. Mario Montero, Regional director of Agrarian Reform (IAD): Proposed to have a discussion of the Project component and implementation with the participation of representatives from Azua and San Juan provinces.

Almost all the agrarian reform settlements within the Project area depend on pumping system for irrigation water supply; therefore, it is necessary to establish a good coordination between INDRHI and IAD

4. THE PROJECT

4.1 Basic Development Concept

4.1.1 Development Constraints

As explained in Chapter 6, the high priority area is the most little 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 situation, agriculture in the Project area can not be performed without irrigation water.

Main constraints on agricultural development in the Project area are: i) Because the existing irrigation facilities are deteriorated and their operation/maintenance is not properly functioned, an overall irrigation efficiency in the Project area is very low, which brings about great loss of irrigation water within limited water sources. ii) Because Villarpando intake weir ,which delivers Yaque del sur river water into 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 do not properly allocate to the Project area especially in dry season. iii) Improved irrigation farming can not 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 received loans from the agricultural bank. v) Agricultural research and extension services are poor. vi) Farmgate price is lower as it is 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% in spite 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, has 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 subsistence 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.

4.1.2 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 of the farmers and iii) creation of job opportunity for local people and improvement social welfare. The basic development concept of the agricultural development in the Project area is:

(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 are made by improvement of the existing irrigation systems, setting up and strengthening water user's organization create, 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 in 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 of the target yield.

It is planned that an annual cropping intensity is targeted at 113% with Project condition from 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 tier 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), Villarpando 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, is made.

In order to reinforce agricultural services for agricultural development in the Project area, the following matters will be made: i) With respect to research services, a research program of adaptive and applied on-farm research for plantain will be carried out on sub-let basis of private sectors. ii) Extension service in the Project will be given not to an individual farmer but to nucleus of water users. In order to strengthen extension services, training programs are carried out to extension workers along with leaders of nucleus of water users to develop their capacity. iii) A most serious constraints of access to credit services in the Project area are 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 registered will be made for provision of a base to farmers to get loans. iv) It is considered necessary as the first step that agricultural cooperative, which are able to provide services to farmers, should be strengthened as a model agricultural cooperative. A market information system, which will provide timely information to farmers to make sound economic decision, is 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 be not dealt with in the Project. As a result, rural water supply systems and multipurpose community centers will be provided to improve quality of life of farmers.

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

4.2 Agricultural Farming Improvement Plan

4.2.1 Land Use Plan

The future land use With Project condition will be same as present condition. Agricultural land use in the Project area is possible only under irrigation condition; the monthly potential evapo-transpiration is more than twice the monthly rainfall during ten (10) months of the year. The net irrigable Project area is 5,885 ha; the present land use intensity is estimated at only about 75 %. With Project condition, the entire net irrigable land area of 5,885 ha will be used for irrigated agriculture with higher land use intensity.

4.2.2 Proposed Cropping Pattern

(1) Crop Selection

The selection of proposed crops is made considering i) Farmers experience in crop management; ii) Present performance of crops; iii) Farmers preferences; iv) Profitability and marketability of crops; v) Present condition of research and extension services; and vi) Soil conditions. The main crops to be planted With Project condition are plantain, banana, cassava, pepper, tomato, melon, papaya, sweet potato, eggplant, pigeon pea, corn, bean, and rice.

(2) Cropping Pattern

Formulation of the proposed cropping pattern in made considering the following points: i) The planting period of industrial tomato is fixed, by regulation of SEA, during the cool season (October to March) in order to minimize damages caused by insects and diseases; also, tomato can not be planted consecutively for more than one harvest in a cropping season; ii) Planting period for other crops such as melon, pepper, eggplant, and red bean is fixed, by regulation of SEA, during the cool season (October to March) in order to minimize damages caused by insects and diseases; iii) Pigeon pea variety of 80 days growing period will be introduced in substitution of varieties of 270 days growing period, in order to minimize irrigation water requirement; iv) Replanting of plantain and banana after 5 year of continuos harvesting will be introduced; v) Inter-cropping of annual crops in areas of newly replanted plantain, banana and papaya will be pursued.

(3) Planting Area by Crop

The area distribution of each crop under With Project condition is estimated taking in consideration: i) availability of irrigation water; ii) present proportional distribution of area planted by crop; iii) government policy and regulations for crop production in the region of the Project area; iv) crop preference expressed by farmers during household survey; v) profitability of crop.

The government policy for the region of the Project area is not to increase the area planted to rice crop. According to estimates made by the Ministry of Agriculture, the area planted to banana at present in the entire country is larger than the area required to ensure food security up to the year 2005, therefore the area planted to banana in the Project area will not be increased. Farmer interviewed during the household survey expressed their crop preferences in the following order: i) plantain, ii) tomato, iii) melon, iv) papaya, and v) pepper. Some farmers in the Project area plant annual crops inter-cropping within the newly replanted plantain fields; the Project will promote inter-cropping of annual crops at the time of replanting plantain and banana crops every 5 years, and papaya every 2 years.

After evaluation of all items indicated above, the areas proposed to be planted by crop with Project condition is indicated below and the proposed cropping pattern is shown in Figure 4.2.1.

Proposed planting area by crop

	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

The crops and their respective annual areas proposed for inter-cropping after replanting plantain and banana every 5 years and papaya every two years are estimated as follows:

	Crop	Proposed Area (ha)	Proportion of Cropping Intensity (%)
1	Tomato	640	10.9
2	Melon 1	105	1.8
	Melon 2	105	1.8
3	Pepper	125	2.1
4	Sweet potato	100	1.7
5	Eggplant	90	1.5
	Total	1,165	19.8

The estimated target maximum cropping intensity to be achieved in the Project area, at full Project development stage, is 113 % in normal planting areas (5885 ha) and it could be increased up to about 133 % by introducing inter-cropping of annual crops immediately after replanting plantain, banana and papaya crops.

4.2.3 Proposed Farming Practices

To attain the crop yield targeted by the Project, it is necessary to improve the present level of farming practices for proposed crops. Large increase in crops yield could be attain in the Project area after ensuring a stable irrigation water supply and introducing appropriate farming practices. The proposed farming practices will be introduced gradually as accepted by farmers (Ref. Table 4.2.1).

(1) Use of Good Quality Seedlings and Seeds

To reduce crop damages caused by insects and nematodes, extensive use of plantain and banana seedling produced by tissue culture method will be introduced in the Project area. Seedlings produced by tissue culture are available at commercial level in several places of Dominican Republic. Farmers as organized group will acquire the tissue cultured seedlings of plantain and banana from the existing providers. Seed of "Indian" variety of pigeon pea will be produced mainly by CIAZA. The tomato paste processing companies will provide seeds of recommended tomato varieties, as at the present.

(2) Adequate On-farm Water Management

The availability of irrigation water is the main factor taken in consideration for estimating the proposed cropping areas With Project condition. In addition to ensuring the supply of irrigation water at the canal level, it necessary to improve the knowledge of extension workers and farmers in adequate on-farm water management. The purpose of on-farm water management practice is to demonstrate to farmers when they should irrigate and how much water they should apply at each irrigation. Demonstration plots on appropriate on-farm water management for main crops will be installed for each irrigation committee; one demonstration plot of about 0.2 ha will be install for selected crop for two years. The Project will provide small equipment for water measuring and written technical guidelines about on-farm water management.

(3) Recommended Fertilization Practice

Fertilization practices are generally poorly done by majority of farmers in the Project area. Approximately 29 per cent of farmers in the Project area do not apply fertilizers to their crop; and majority of those that apply fertilizer do not apply right amounts. Also, farmers in the Project area do not know the best timing and form of placing the fertilizers.

The amounts of plant nutrients recommended With Project condition are significantly higher than the quantities applied under present conditions as shows the table below.

Unit: kg/ha

	With Project			Present		
	N	P	K	N	P	K
Plantain	160	110	200	80	50	40
Tomato	200	150	150	150	75	75
Sweet potato	75	75	75	36	36	36
Melon	210	180	210	180	150	180
Pepper	125	90	90	90	60	60
Papaya	150	90	90	103	55	55
Cassava	90	60	60	38	38	38
Banana	300	150	150	90	50	50
Pigeon pea	45	45	30	15	15	15
Corn	90	60	60	30	15	15
Bean	75	95	40	40	40	30
Eggplant	150	120	120	105	75	75
Rice	200	115	90	110	75	60

Demonstration plots will be installed to show farmers the benefit of proper fertilization, including quantity of fertilizer applied, timing of application and recommended form of placing the fertilizers. Fertilization demonstration plots of about 0.2 ha will be developed for each water user irrigation committee for selected major crop. The extension worker will work together with the water user nucleus and irrigation committees for choosing the farm for installing demonstration plots and designing activities. The costs of fertilizers to be used in the demonstration plots will be born by the Project. The fertilization demonstration plot for annual crops will be done for two years.

(4) Control of Insects and Nematodes

The introduction and extensive use of Integrated Pest Management (IPM) practices will be a main farming improvement activity of the Project aiming the control of insects and nematodes that affect proposed crops, and at the same time reduce dependence on the use of chemical pesticides. Some advanced plantain farmers in the Project area said that they have obtained higher yield with the introduction of IPM in their fields. The components of the IPM include: i) use of seedlings not contaminated with nematode; ii) keeping healthy crops by adequate fertilization and irrigation; iii) timely control of weeds; iv) planting of annual crops according to regulation of SEA; v) use of most pest resistant varieties; vi) installation of tramps for manually trapping adults of Comopolites sordidus, main insect problem for plantain and banana; vii) proper disposal of stems of plantain; and viii) production and liberalization of fungus, protozoa, and nematode that are recognized as useful for biological control of most important insects and nematodes that affect plantain and banana crops.

As part of the proposed research program, the Project will implement works for identification, reproduction, and liberalization of species of fungus and nematodes that function as biological control of other species of insects and nematodes that affect plantain and banana crops. This type of biological pest control is not being implemented extensively in the country yet, but the Crop Protection Division of the Ministry of Agriculture expressed that they have high interest in introducing these activities for biological control of pest that affect plantain and banana.

The research program for biological control of insect Cosmopolites sordidus and several species of nematodes such as Helicotylenchus, Rotylenchulus, Pratylenchus, and

Meloidogyne that affect plantain in the Project area will consist in: i) Identification in sites and/or introduction, multiplication in laboratory, and testing in the field the fungus species Beauveria bassiana and the species of nematode Steinernema carpocapsae for biological control of the insect Cosmopolites sordidus; ii) Identification in sites and/or introduction and multiplication of the protozoa Pasteurina penetrants for control of nematodes that affect plantain and banana crops in the Project area.

The research program for biological control of insects and nematodes will be implemented during a period of two (2) years; after the research phase, will continue the multiplication and liberalization of fungus, protozoa, and nematodes identified as effective for biological control of the insects and nematodes that affect plantain and banana. The costs for biological control research program is estimated at about 5.64 million Dominican pesos divided in two years.

(5) Replanting Plantain and Banana, Adoption of Optimum Planting Densities, and Inter-cropping of Annual Crops with Plantain, banana, and papaya

Under present condition majority of farmers in the Project area do not replant their plantain and banana farms for periods as long as 30 years. It is known that the yield of plantain decreases after the 5th year of continuos harvesting. The Project will promote the extensive renewing of plantain and banana after the 5th year of continuos harvesting. The inter-cropping of annual crops such as tomato, melon, pepper, eggplant, and sweet potato will be extensively pursued in the newly replanted area of plantain, banana and papaya, aiming at making the most intensive use of the land.

The present planting density used by majority of farmers in the Project area is not optimum for obtaining maximum yield with adequate water supply. The planting density of plantain and banana will be increased from present 1,300 plants/ha up to 2,000 plants/ha. For papaya the planting density will be increased from present 1,200 plants/ha up to 1,600 plants/ha. A large increase in planting density of pigeon pea will be introduced with the change of present tall varieties by dwarf variety of shorter growing period. Also, for annual crops such as tomato, melon and pepper higher planting density will be pursued.

4.2.4 Anticipated Yields and Crops Production

The target yield of crops under With Project condition is set considering maximum 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

4.2.5 Requirement of Farm Inputs

The recommended farm inputs per hectare necessary for attaining the target yields With Project conditions were estimated following recommendation from Ministry of Agriculture and the Dominican Foundation for Agriculture Development (FDA). The estimate of total input requirement in the Project area is shown in Table 4.2.2.

The second main factor that limits the achievement of higher land use intensity in the Project area is the shortage of agricultural machinery for timely land preparation. The Ministry of Agriculture (SEA) has some 13 tractors (80 HP) in the three agricultural sub-zones of Vicente Noble, Tamayo, and Fundación that cover the Project area. These 13 tractors provide land preparation services to an estimated area of about 9,400 ha, including the 5,885 ha of the Project area. About 44 % of farmers interviewed during the household survey indicated that they confront problems in attaining tractors when they need it for land preparation. The demand for land preparation will increase with proposed cropping pattern With Project condition.

The Ministry of Agriculture (SEA) through its Center for Agricultural Machinery Services (CESMA) is the institution providing land preparation service in the Project area. With Project condition, the land preparation services in the Project area will be provided following the same system as in present condition. To achieve a higher land use intensity it is necessary to ensure timely land preparation service by strengthening the CESMA. In addition to the 13 tractors that CESMA has in the three sub-zones that cover the Project area, it is necessary to acquire 10 new tractors of about 80 HP; this considering only the unsatisfied demand of tractors within the Project area (Ref. Table 4.2.3). The market cost of one 80 HP tractor, including attachments for land preparation, is about DR $ 550,000.

4.2.6 Labor Requirement

Under present condition in the Project area, all farming activities, except land preparation, are done manually by family and hired labor; With Project condition farming activities will be done similarly. The labor requirement under With Project condition will be significantly higher than labor requirement under present condition because: i) higher cropping intensity; ii) more frequent irrigation intervals; iii) introduction of farming practices such as replanting of plantain every 5 years, introduction of inter-cropping in

newly replanted plantain and banana fields, and Integrated Pest Management; and iv) expected high crop yield, and therefore more time needed for harvesting. The only crop that will require less labor with Project condition than without Project is pigeon pea, because the recommended variety of significantly shorter growing period.

The estimated average available family labor is 50 man-day/month; this quantity of available labor is sufficient to cover requirement of up to 3 ha of plantain. Family labor is also sufficient to cover requirement for average farm size of 1.3 ha cultivated of crops such as melon, eggplant, sweet potato, cassava, pigeon pea, etc; family labor is not sufficient to cover labor requirement for average farm size of 1.3 ha cultivated of crops such as tomato and pepper. In the cases that there is deficit of family labor for a household to manage their agricultural production, it can be easily satisfied by the large quantity of labor available for hire within the Project area and its surrounding communities. The estimated labor requirement and family labor balance is shown in Table 4.2.4.

4.2.7 Crop Budget

Crop budget for each crop under Present/Without Project condition was prepared based on the analysis of farm survey to 59 farmers made by JICA study team in the Project area and comparing to the crop budget prepared by the Agricultural Bank. The crop budget With Project condition was estimated taking the recommended quantities of farm inputs and the local market prices of inputs in the Project area. The results of crop budget are presented in Table 4.2.5.

4.3 Plan for Strengthening Agricultural Support Services

Low productivity of crops in the Study area can be traced to weak research an extension services; low cropping intensity; inefficient management of farms; high cost of inputs; and land tenure and the related limited access to formal credit. To assure the success of the irrigation and agricultural activities of the Project it would be necessary an adequate provision of the basic agricultural support services. The objectivetree for agriculture support services is shown in Figure 4.3.1.

The agricultural support services (adaptive research, extension services, institutional building and market related services) would be strengthened and delivered by the appropriate government agencies and/or the private sector using the Water User Organization structure instead of the individual farmer approach. The Project would not include a credit component but it would include a program to work with water user associations and farmers to ease access to credit for farmer groups.

4.3.1 Extension and Research Services

(1) Research

The profitability of small farmers in the Study area depends on the development and adoption of agricultural techniques that increase yield, and make better use of the natural resource base. To strengthen agricultural research the Project would launch an Adaptive

Research Program to develop and deliver methods and agricultural techniques aimed at improving the agricultural production systems in the Project area, which would bring about increases in agricultural production and improvement in water use efficiency, as stated in the in the Project goal. The topics to be emphasized would be:

(a) Integrated Pest Management;

(b) On-farm water management issues

(c) Feasibility of New Crops in the Study area

The integrated pest management component would focus on finding answers to the problem of the main pest and diseases identified in the Project area. Specifically, adaptive research would focus on ; i) identification of insects, nematodes and fungi which are the main carriers of plantain and banana pest and diseases of economic importance in the Project area, ii) identification of insects, nematodes and fungi which are natural enemies of the main pests and diseases carriers identified in i) ; iii) multiplication of the natural pest and diseases' enemies in a controlled environment (laboratory) and, iv) field dissemination of natural enemies in the Project area.

On-farm water management research activities would be conducted through validation and experimental plots to evaluate three main issues; i) advantages of basin irrigation methods against furrow irrigation; ii) effect of irrigation intervals on crop yield, and iii) effect of irrigation water layer application in each irrigation turn.

The third line of adaptive research would focus on the identification and trial of potentially profitable new crops for the Project area. Special attention would be given to the introduction and acclimatization of crops such as onion, wheat, and fruit trees (grapes and citrus). Test would be performed on: i) variety adaptability, ii) Fertilization level, iii) problem with insects, diseases and nematodes, and iv) water requirement.

Research activities would be carried out for a period of 2 years starting from the 3rd year of the Project. Research activities would be contracted out by the Project among the national private institutions engaged in agricultural research such as the Instituto Superior de Agricultura (Superior Institute for Agriculture, ISA), Politécnico Loyola, Universidad Autónoma de Santo Domingo (UASD) and Universidad Pedro Henríquez Ureña (UNPHU). The selection of the research institution(s) would be done based on the soundness of the research proposals presented.

The selected institution(s) would use the Palo Alto Experimental Station to carry out the required research activities. The experimental station is facing some problems with irrigation water availability. So the Project would provide water pump for irrigation and improvement of field conditions including drainage, ditches and land leveling.

To assure an effective adoption of research findings, a series of workshops would be delivered to extension workers who provide technical assistance to the water user associations. Additionally, the design and location of the demonstration plots would the responsibility of research workers in coordination with extension workers. Extension

workers would be responsible for the operation of those demonstration plots.

(2) Extension Services and Training Programs

(a) Extension Services

In this Project component, it is suggested a program to provide extension services to water user associations. In order to reach most of the farmers of the Study area, the water user association would be used as the organizational structure, instead of using the current approach of working with individual farmers. Extension services would be provided using the nucleus of water users as a unit. An extension worker would assist farmers from the same nucleus.

It has been estimated that 200 nucleus of water users would be established in the Study area. Each nucleus would consist of 15-25 farmers who would be served by the same water intake. In addition, there would be 10 water user committees composed of 20 nucleus in average (one committee in each night storage pond). Furthermore, 4 water User Organizations would be established comprised of representatives of the 10 irrigation committees. The presiding organizational mechanism would the Water User Board.

For the provision of extension services, an extension worker would cover 10 nucleus of water users. Therefore, the Project area would demand 20 extension workers. These extension workers would be selected from the SEA extension workers who actually provide extension services in the Project area. SEA extension workers would be coordinated under the Project and they would receive additional job incentives. Figure 4.3.2 depicts the diagram for the extension services delivery system in the Project area.

Extension services would be provided on scheduling of land preparation, management and supply of farm inputs, monitoring of cultivated area, technical guidance on farm practices and management. In addition, extension workers would set up demonstration plots on selected farms in the Study area, to encourage the adoption of the suggested farming techniques. Extension services would be provided for four years starting from the second year of the Project.

The extension services component program would coordinate activities with the adaptive research program as well as with the program for institutional building capacity of the plantain grower cooperative.

(b) Training Program

There would be a training program for the 20 extension workers who provide extension services to the irrigation nucleus in the Project area. Extension workers would be trained on four aspects: i) technical issues (crop production, soil conservation and management, water management, integrated pest management and sustainable farming practices); ii) methodological aspects (use of audiovisual aids such as the use of computers,

how to prepare a presentation with local inputs, overhead projectors, etc.); iii) Managerial aspects (loan request preparation, bookkeeping for farmers and farm planning) and, iv) Organizational aspects (institutional strengthening for agricultural associations and marketing skills and community development).

Similarly, training would be provided to the farmers emphasizing on leaders of the nucleus of WOAs. Farmer would be trained on managerial skills, leadership and institutional aspects. The Project would train at least 200 leaders from the nucleus of irrigation water users.

This training would be carried out during the 3rd and 4th years of the Project and would include short courses, workshops, seminar conference and field trips.

Specialists on different subjects would offer training to the extension workers and farmer leaders. 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. Similarly, the extension Department could make collaborative arrangements with other agencies engaged in extension training such as the Inter American Institute for Agricultural Cooperation (IICA) and private companies.

The SEA training center in Barahona would be used for the training activities. Although the centers have the physical infrastructure, some remodeling is needed. It would also ask for equipment and furniture. This center consists of two classrooms with capacity for 44 people each as well as dormitories to accommodate 45 people. In addition the center has a kitchen/cafeteria with a capacity for 50 people.

(c) Demonstration Plots

Demonstration plots would be set up at farmer sites, to help on the transfer of technology by the extension workers. 10 Demonstration plots would be set up covering the main crops in the Project area (plantain, banana, sweet potato, tomato, pepper, papaya and cassava). Those demonstration units would be used to show the suggested technological practices mostly developed by the adaptive research program implemented as another component of the Project. Demonstration plots would be carried out during the 3rd and 4th years of the Project.

4.3.2 Credit Services

One of the main constraints found in the Project area is the inability to access formal credit. This in is turn prevent farmers from introducing modern techniques and increase production and income. Among the factors preventing farmers access to credit in the Project area, the lack of definite title and the small size of the farm are considered the most pressing constraints.

In order to ease the accessibility to credit, there would be the need to reduce the constraint of lack of land title in the Project area. The Project would include a component

to implement a cadastral survey that would help in the clarification and provision of definite title to most of the farmers in the Project area. To carry out the cadastral survey a private firm would be hired. The cadastral survey would be completed in full in 5 years for the whole Project area (around 6,000 ha.). This cadastral survey would include cadastral map at a scale 1/1,000 for all farms included in the Project area (about 4,500 farms).

Alongside, the Project would set up a cadastral unit. This unit would be responsible for i) monitoring the activities of the cadastral survey which would be carry out by the private firm, and ii) help farmers obtain definite land titles from the national cadastral office. This unit would need high-quality professional assistance both in cadastral and legal issues.

To reduce the credit constraint brought about by the small size of the farmer plot, and the high transaction cost associated with it, the Project would pursue the establishment of group loans among the nucleus of water users. Emphasis would be put on helping the nucleus of water users (composed of 15-25 farmers each) to prepare credit requests and managing group loans. The Project would work closely with irrigation nucleus to make them aware of the need and benefits of group loans, as well as the shared responsibility associated with it.

Starting the first year, the Project would work with those farmers who already hold definitive land titles and would incorporate more farmers as the cadastral survey develops and farmers get their corresponding land titles. The extension worker responsible for the provision of extension services, would also work with the nucleus on the estimation of credit demand, in the preparation of group loan requests and on the submission of credit request to the financial institution. It would be expected that all farmers in the Project area would have definitive land titles by the end of the 5th year of the Project.

4.3.3 Agricultural Cooperatives and Marketing Information System

(1) Marketing Support

In the Project area operates a significant number of small farmer associations but farmers' participation is very limited. They do not have infrastructure to handle production nor they offer any marketing services to their members such as storage, transportation, processing and buying of their member agricultural production.

Due to the weak institutional capacity of farmer organizations and their inability to provide market services to the farmers in the Project area, the Project would set up a pilot Project with the plantain grower association of Vicente Noble. This association has been operating in the area and it has the potential to capture a sizable number of plantain growers in the Project area. Activities would include: i) increase cooperative members, ii) improve the capacity of the member of the cooperative board, iii) improvement of development and iv) strengthening of procurement power of farm inputs.

The Project would provide outside support to institutionally strengthen the plantain

grower association and help it on the development of markets for the production of plantain. A market specialist would be provided for the first year of the Project to work on a daily basis with the plantain growers association's board members. The market specialist would work closely with the board members to sharpen their marketing and managerial skills, and join them on the design and implementation of a strategy to increase the number of members of the association and identification and development of new market outlets. It would be expected that plantain growers affiliation to the Vicente Noble association would increase up to at least 100 members.

In order to strengthen the association's procurement power, the Project would provide a means of transportation (truck) and scales (3) as well as office facilities. Additionally, the Project would help with the establishment of a storage house for the main agricultural inputs demanded by the plantain growers in the Project area. Start up funding for operation during the first year would be necessary.

Activities from this component would be carried out during the 4th year of the Project. The Project could establish collaborative arrangements with the Dominican Agribusiness Council (JAD) to provide market assistance to the Vicente Noble plantain grower association. The plantain growers cooperative would make use of the Market Information System to be established in the Project area to make decisions on when and to whom the production will be sold.

(2) Marketing Information Systems

For the Project area it is proposed a Market information System which would provide farmers with timely information to make sound economic decisions. The Project would set a market information system that would cover the Project area with headquarters located in Santo Domingo and setting up new facilities in Barahona and Neiba.

In terms of market information, it would provide weekly information on local prices for agricultural products at the different level (farmgate, wholesale and retail); information on input prices (fertilizer, chemical inputs, machinery service, interest rate); information on potential buyers of their product as well as their credit history. Another type of market related services to be provided by this program should be feasibility studies for alternative crops and technical information on Integrated Pest Management, animal feed, crop budgets and animal health.

Similarly, it would be necessary to include: number of associations and cooperatives; number and location of NGOs working the area; storage facilities and cost of storage in the area; on line information; and regular reporting and projection of agricultural marketing specially price and volume. These activities would start right from the beginning of the Project.

The information centers would be located at the farmer associations in Vicente Noble and Tamayo. The headquarters of the Market Information System could be handled by the Dominican Agribusiness Council (JAD). There is an ongoing pilot market

information system Project with the Junta Agroempresarial Dominicana, Inc. JAD with farmers' associations in San Juan and Azua which has been working properly. JAD would provide the already existing network and know-how regarding data processing, information dissemination and it would feedback the market information centers in the Project area.

4.4 Overall Water Management Plan

As a result of the Master Plan Study, the Yaque del Sur Lower Reach Irrigation and Drainage Project was selected for the feasibility study. The proposed Project area is located on the lowest reach of the Yaque del Sur River basin. The area has long been suffering from water shortage due to the disadvantage on the location. A common situation for all the irrigation schemes is "more water use by upstream users". It will be significant to control the water use for the whole river stretch to distribute the waters properly.

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:

4.4.1 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 Yaque del Sur river has a catchment area of 4,600 km^2 at the confluence, and the telemetering system is prerequisite for the overall water management, of which benefits on the irrigation sector were discussed in the Master Plan Study (Phase-1).

Taking into account serious flood damages brought by Hurricane Georges and significant effects of the dam operation, flood or discharge warning system, which is mentioned in the above sub-section, is considered as a part of the telemetering system.

The overall water management system that is proposed in the Master Plan is given in Fig. 4.4.1. 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 station,
- Los Guiros hydrometric station,
- Santana headworks control station, and
- Rincon Lagoon hydrometric and water quality monitoring 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. The system will consist of ;

- 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,
- Telemetering facilities and radio communication equipment in each station, and
- A repeater station at San Juan (common use with flood/discharge warning system)

(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. The system will consist of ;

- 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[4],
- 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

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. The system will include;

- 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
- water level gauge and a raingauge (telemetering) at Palo Alto

Location of the stations are shown in Fig. 4.4.2.

4.4.2 Water Management Organizations

Water management will be conducted and supervised conformed to propose water management institutions, which is proposed in the Master Plan. The management level is divided into three, 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 that 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 Yaque del Sur Water Management Center. The Center would be independent not only from Irrigation Districts of INDRHI but also from local administrations. 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).

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4 Yaque del Sur Lower Reach Irrigation and Drainage Project

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 Fig. 4.4.3.

4.4.3 Yaque del Sur Water Management Center

The Yaque del Sur Water Management 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. The available area is estimated at about 2,400 m^2 (30 m by 80 m) without any residents. There existed an observatory deck at the time of inauguration of the Villarpando headworks in the proposed location.

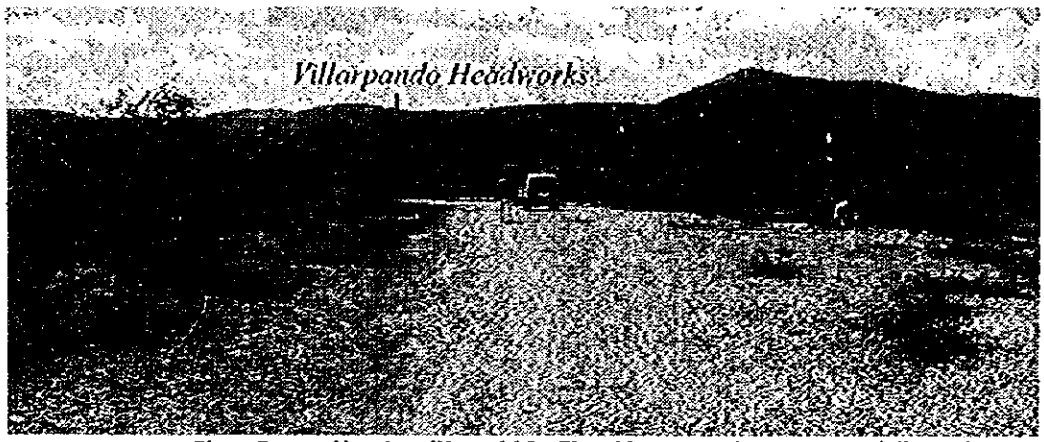

Photo: Proposed location of Yaque del Sur Water Management Center at Canoa, Villarpando

The proposed building of the Center will have two floors consisting of a oreration 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 Fig. 4.4.4.

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 for ordinary working hours and emergency periods. At least one engineer will stay at the Center all the time.

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

4.4.4 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, etc.

4.4.5 Possibility of Utilization of Rincon Lagoon for Irrigation

The floods and rainfall by Hurricane Georges filled up Rincon Lagoon, and the waters overflowed across the national road between Cabral and El Peñon to the Yaque del Sur River. According to a storage volume curve (Fig. 4.4.5) given by "Proyecto Yaque Sur – Valle Neiba, Riego del Valle de Neiba" (1974), the total volume of Rincon Lagoon is about 220 MCM at 7.6 m AMSL which is approximately the level of the national road.

The study team conducted water sampling and measurement of depth of the Lagoon druing this study period. The results are shown in Fig. 4.4.6 and Table 4.4.1. It should be noted that the depth at point #6 was about 3.0 m, but the point was almost at the edge of water surface on January 8 th, 1998. Provided that the water level has risen by three meters, the volume is equivalent to 150 MCM.

As for water quality, which is the most significant limiting factor for utilization of the water of Rincon Lagoon, the study team investigated pH and EC value. Since it was suspected that high-salinity water stagnates on the lower layer, water samples were taken by depth and checked. The results show that the electric conductivity (EC) values are similar for each depth at about 0.8 mS/cm, which is about one-tenth of the previous ones. Judging from this, it is considered that most of the water in Rincon lagoon was flushed away or replaced with the inflow by the hurricane.

The water is classified into C3 on salinity in USDA classification as shown below, while the river waters of the Yaque del Sur in the Project area during this (Phase-2) study period are classified into C2.

	Salinity class description	EC(mS/cm)
C1	Low salinity water can be used for irrigation with most crops on most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices, except in soils of extremely low permeability.	<0.25
C2	Medium salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control..	0.25 - 0.75
C3	High salinity water cannot be used on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.	0.75 - 2.25
C4	Very high salinity water is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.	>2.25

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

C3 is not considered highly suitable for the irrigation purpose, but the value of 0.8 mS/cm is less than those of waters taken in the lower Yaque del Sur River during the previous study period[5].

According to the water balance simulation made in the Master Plan, 270 MCM/year is discharged to the sea on the average. It is possible to extract excess waters to Rincon Lagoon during the wet season, in order to maintain both the quantity and quality of the water.

On the other hand, several uncertain factors remain for concluding the possibility of usage of Rincon Lagoon for irrigation. The following investigations are strongly recommended for further steps:

- Bathometric survey to know the present capacity,
- Water quality monitoring to know the relationship between water volume and water quality,
- Environmental evaluation in relation with water volume of the Lagoon, and
- Demarcation of proposed irrigation area.

A telemetric station with a raingauge, a water level gauge and water quality sensors (pH and EC) is proposed as a part of the Yaque del Sur Water Management Center Project for an integrated purpose of irrigation, flood mitigation and environmental management on Rincon Lagoon.

4.5 Irrigation Development Plan

4.5.1 Basic Development Concept

Irrigation development Project is the most important as one of the sectors of the Project to aim to alleviate the poverty or directly to income increase of farmers, because irrigation is indispensable to sustain the agriculture in the severe dry climate of the Project area. As indicated in our Master Plan Report, however, water resources of the Yaque del Sur river are limited and water users are asked to efficiently use the limited water resources as much as possible in recent years. While, INDRHI suffers the shortage of funds in operation and maintenance of the existing facilities. In line with the principle of the

5 Refer to Table 3.2.12 of the Interim Report, page T-20.

beneficiaries participatory approach, INDRHI have put the high priority on the formulation of water user's organization for entire irrigation systems in the nation and strengthening existing organizations in order to execute O&M of irrigation and drainage systems by farmers themselves. Under such circumstances, water users themselves have to 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. Water users are also requested to have consciousness for innovation of their fundamental attitude to positive approach to the Project.

4.5.2 Objective Analysis and Irrigation Development Approach

Based on the problem analysis, objective analysis was made. A direct objective in the irrigation sector is efficient use of water and mitigation in water shortage in the dry season. The objective trees are shown in Figure 4.5.1 (1/3 to 3/3). In this figure, several approaches related to the irrigation development are conceivable. Those are:

A. Irrigation water management improvement approach,
B. Irrigation facilities improvement approach,
C. Villarpando headworks improvement approach,
D. River water management improvement approach for irrigation.

Approach A and B should be inseparably executed, because as the irrigation facilities are not functioning well in the areas, proper water management can not be realized without their rehabilitation and improvement. Approach C should be executed before the Approach D or at least at the same time, because even if the water management office is established with a modern communication systems, water can not be diverted properly to meet the demands downstream with no improvement of Villarpando. Thus, an approach combined A + B or combined C + D is conceivable.

E = A + B. so-called Integrated irrigation improvement approach

F = C + D. so-called Integrated river water management approach

Further, an approach in which all the approaches are comprehensively executed is conceivable.

G = E + F. so-called Comprehensive irrigation development approach

These approaches are preliminary evaluated in the view points of investment amount, required technology level, social influence, and possibility of attainment on the efficient use of water as shown in Table 4.5.1. As it is clearly understood, the simultaneous implementation is the most desirable to bring most effective results. In this feasibility study stage, the comprehensive irrigation development approach is taken as the one component of the Project.

Major activities are:

(1) Approach A : Irrigation Water Management Improvement Approach

- To carry out the activities for farmers to understand the Project and their duty and right in the Project.
- To prepare Bylaw, water rules & distribution manual.
- To organize farmers and establish water users organization.
- To prepare training programs and provide training.
- To purchase vehicles for operation activities.
- To check and instruct farmers and technical staffs to keep rules in their field activities.

(2) Approach B : Irrigation Facilities Improvement

- To improve irrigation facilities.
- To provide regulation ponds.
- To purchase maintenance equipment.
- To prepare operation and maintenance manuals and provide training in accordance with the O&M manuals.

(3) Approach C : Villarpando Headworks Improvement Approach

- To provide sluice gates to supply water to the Yaque del Sur downstream.
- To replace intake and sand flush gates with new gates.
- To train operation and maintenance staff.

(4) Approach D : River Water Management Reinforcement Approach

- To establish a new water management office.
- To purchase office instrument and vehicles.
- To introduce a telemetering system.
- To make a training program and train staffs for river water management.
- To establish demand-oriented river water management.

Table 4.5.2 shows the Project design matrix of the comprehensive irrigation development Project.

Of the activities mentioned above, approach A, B, and C except the training of the O&M staff of Villarpando headworks are explained in this Section. Others on the above are dealt in Section 4.4.

4.5.3 Alternative Study of Irrigation System

As explained in section 3.5.1, several free intakes including the Vicente Noble intake existing in Tamayo and Vicente Noble areas along the Yaque del Sur river are suffering from taking water from the Yaque del Sur river especially in the dry season when the river water level is low, since they can not raise the water level with no weir. Two types of weir are conceivable: fixed overflow weir type and gated weir type. The gated type weir is expensive and difficult in operation and maintenance. Considering that farmers themselves in future operate the irrigation facilities, the weir should be a simple fixed

overflow type. These sites of the intakes are not structurally strong against flood and topographically fixed type of weir is not suitable, because the fixed type of weir reduces the cross sectional area of the river flow. Instead of the improvement of these free intakes, it is conceivable that water is diverted at the Santana headworks and distributes from the Santana to the existing canals through a new main canal. The Santana is standing more than 70 years stably keeping the river watercourse along the right side. Thus the site is suitable for diversion of water and the existing fixed overflow weir can be utilized with a little rehabilitation.

As for the pumping irrigation systems, the interruption of electric supply is beyond the control of INDRHI. Three alternatives are conceivable to solve the disturbance by the interruption of electric supply; i) replacement of pumping station with gravity system, ii) provision of a diesel generator and iii) provision of a regulation pond. Considering the present condition of the pumps, of which some are out of order and waiting for repair for a long time, gravity irrigation system is the best solution. From this point, it is an alternative that the proposed main canal conveying water from the Santana headworks to the existing gravity irrigation system in Tamayo and Vicente Noble areas is extended to the downstream along the left side of the Yaque del Sur river. By this extension of the proposed main canal, the most of the irrigation areas located in the left side bank of the Yaque del Sur river can be served by the main canal. About the right side bank, however, the downstream area of about 1,280 ha is not geographically covered by the gravity irrigation system, because an alternative that a canal is provided from the Santana to the downstream is not economical solution, since a very long canal is required for small commanding area and also sites suitable for the diversion headworks can not be found along the Yaque del Sur river in the downstream of the Santana headworks. Accordingly, second or third alternative is recommended. The second alternative, which is provision of diesel generator, if farmers maintain it in future, is not recommended, because it is difficult for farmers to maintain it. In the third alternative, a regulation pond, which is used to supply water when pumps can not supply water due to the interruption of electricity supply or out of order will be provided near the pumping station. Its maintenance is easy the same as gravity irrigation system. It is, therefore, proposed that a pond be provided in each of pump stations.

In accordance with the above consideration, 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	5,885 ha
Irrigation area served by the proposed main canal	5,532 ha

The Project area	4,292 ha
Sugarcane area of CEA	1,241 ha

The proposed irrigation system and irrigation diagram are shown in Figure 4.5.2 and Drawing 4.5.12.

It is proposed from the view of water management that night storage ponds are provided along the main canal to have a regulation capacity of water in the irrigation system for the purpose of efficient utilization of water. The location is selected at 10 points along the main canal in consideration of the existing irrigation systems, the topographic condition, and the distance from the faraway fields.

4.5.4 Irrigation Water Requirement and Water Balance

(1) Irrigation Water Requirement

The irrigation water requirements with Project condition was estimated in accordance with the proposed cropping pattern by the same method adopted in the Master Plan study.

In the estimate, the irrigation water efficiency is taken as follows:

Upland crops	: 0.47
Paddy	: 0.58

The results of the calculation are shown in Table 4.5.3 and summarized below.

Irrigation Water Requirements

(MCM)

	Nov.	Dec.	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Diversion Requirement in total*1	14.6	16.3	18.3	17.7	20.4	18.8	15.3	16.9	23.7	19.5	15.9	13.4
in the Project area (MCM)	11.4	13.1	14.9	14.6	16.8	15.6	12.7	13.9	19.5	15.7	12.4	10.2
in sugarcane area*2	3.2	3.2	3.4	3.1	3.6	3.2	2.6	2.9	4.2	3.8	3.5	3.2
at Santana weir	12.1	13.5	15.0	14.6	16.7	15.5	12.5	13.8	19.5	16.1	13.2	11.2
to Main canal	11.5	12.8	14.2	13.8	15.8	14.6	11.8	13.1	18.5	15.2	12.6	10.7
to Santana canal	0.6	0.7	0.8	0.8	0.9	0.8	0.7	0.7	1.0	0.8	0.7	0.5
in the downstream pump area	2.5	2.8	3.2	3.2	3.6	3.4	2.8	3.0	4.2	3.4	2.7	2.2

Note: *1 : including sugarcane area of CEA to be served by the proposed main canal.
*2 : private area only served by the existing Santana canal system.

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 in July, which is a 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, are considered for determining the irrigable area and evaluating the Project.

The water balance simulation is conducted in the following manner:

(a) The water balance model of with-Project condition for the Mater Plan is applied.

(b) The irrigation efficiencies under present condition are used for the systems in San Juan Block, Azua Block, B1 (Los Gurios to Santana headworks), B2 (Sugarcane area covered by the Santana Canal System) in Barahona Block.

(c) B3, B4 and B5 in Barahona Block are reorganized into; i) gravity irrigation area covered by the proposed irrigation system from the Santana headworks (B7) and ii) pump irrigation systems (B8) as shown in Fig. 4.5.3. The irrigation efficiencies for new irrigation systems such as Biafara, Amiama Goméz (Azua) and Aguacatico (Barahona) are for those of proposed conditions.

(d) The total water volume diverted at Villarpando headworks[6] is maintained to be same as that under the present conditions. Having new irrigation areas of Amiama Gomez and Biafara, the irrigable area for the other areas, namely, Ysura canal command area, will be reduced under the present conditions.

(e) The irrigable areas along the Yaque del Sur River in the Azua and Barahona/Neiba block (A1, B1, B2) are maintained to be same as those under the present conditions.

(f) The water balance is examined on a demand basis from the downstream to the upstream. The irrigation area is adjusted so that Sabana Yegua Dam would accommodate the area with 80 % dependability[7].

The simulation results show that the available volume of the water for the Project area (B7 and B8) under the above-mentioned assumptions would decrease by eight (8) per cent mainly due to large losses in the sugarcane area of CEA (B2, 12,000 ha). 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 until the completion of the improvement for the other systems.

The irrigable areas covered by Villarpando headworks (Azua and Barahona/Neiba block) are summarized below:

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[6] Average annual diversion volume (1981'1998) in the water balance simulation.

[7] The irrigation area can be irrigated through the growing period for four out of five seasons.

Code	Name of Area	Irrigable Area (ha)					
		Present 1)		Fully Developed 2)		Partly Developed 3)	
		1st*	2nd*	1st	2nd	1st	2nd
	Ysura Canal + half of extension area	8,289	4,464	9,662	5,153	6,823	3,675
	Amiama Gomez + Biafara	-	-	1,515	1,768	1,515	1,768
A_{off}	Ysura Head Race Canal	682	614	1,012	949	600	781
	YSURA TOTAL	8,971	5,078	12,189	7,870	8,938	6,224
A1	Villarpando ~ Los Guiros	1,112	1,001	2,004	1,800	1,112	1,001
B1	Los Guiros ~ Santana	1,915	1,956	2,726	2,785	1,915	1,956
	Aguacatico	-	-	740	792	740	792
B2	Sugarcane (CEA)	5,982	6,062	9,685	12,681	5,982	6,062
B3	Vicente Noble/Tamayo-El Jobo	1,885	1,918	2,798	2,846	-	-
B4	Trujillo Canal ~ Los Tomate Drain	261	267	360	369	-	-
B5	Trujillo Canal ~ Palo Alto	867	872	1,557	1,562	-	-
B6	Palo Alto ~	1,712	1,741	2,620	2,664	-	-
B7	Feasibility Study (Santana HW)	(4,124)	(4,181)	(7,609)	(7,727)	6,171	6,268
B8	Feasibility Study (puming system)						
	BELOW VILLARPANDO TOTAL	13,734	13,817	22,490	25,499	15,920	16,079

Remarks; *; 1st= first cropping season, 2nd=second cropping season

Note: 1) Irrigable area under the present conditions (low irrigation efficiency)
2) Irrigable area in the Master Plan Study (all the irrigation efficiencies are under proposed conditions)
3) Irrigable area for the Feasibility Study (proposed irrigation efficiencies for B7, B8, and new systems, and present efficiencies for the others)

The irrigable for B7/B8 areas under present condition (4,124 ha, 4,181 ha) are estimated by using the present irrigation efficiencies[8] for the same volume of available waters (188.0 MCM) under the Feasibility Study conditions (partly developed). The irrigable areas under full development condition (7,609 ha, 7,727 ha) are estimated by using the proposed irrigation efficiencies for the total available volume of waters for B3, B4, B5 and B6 (230.7 MCM) estimated in the water balance study in the Master Plan Study.

The irrigable areas under present condition, full-developed condition and partly developed condition are compared by crop in Table 4.5.4.

4.5.5 Basic Plan of Irrigation Facilities

Major Project facilities to be improved are:

- Villarpando headworks — Replacement of intake gates and Construction of gated sluice to supply water to Yaque del Sur downstream
- Santana headworks — Reconstruction of intake and sand flushing sluice
- Main canal — 21 km long
- Regulation pond along main canal — 10 numbers, regulation capacity
- Laterals — 45 km long
- Inspection road — 35 km
- Regulation pond for existing pump stations — 10 numbers

[8] : Irrigation efficiency for upland crop = 0.32, for paddy = 0.44

(1) Improvement of Villarpando Headworks

As explained in the Annex I report, 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 than that to the Yaque del Sur - Lago Enriquillo area. Also very lengthy crest of the overflow weir with shallow overflow depth brings about difficulty of the flow measurement.

In order to divert water between the Azua area and the Yaque del Sur- Lago Enriquillo area precisely, a structure, which is the same type as the existing intake to the YSURA is proposed to discharge water to the Yaque del Sur downstream. The required diversion discharge is 30 m^3/sec at a peak period. The structure will be provided across the earthfill dike between the sand flushing sluice and the overflow type weir. It will be equipped with three sluice gates. The span is set at 1.83 m in net the same as that of the existing YSURA intake gates. The sill of the sluice gates is also set at the same elevation as that of the intake gates aiming to reveal the similar hydraulic conditions to the existing YSURA intake gates. The detail feature and dimensions are shown in Drawing 4.5.15 - 4.5.16.

Besides the existing intake gates and the sand flushing gate will be replaced with new gates so as to be operated by both electric motor and manual.

(2) Improvement of Santana Headworks

The Santana headworks will be used as a headworks for the proposed main canal as well as the existing Santana canal. The existing intake structure has to be totally replaced with new one for the proposed main canal system and also the sand-flushing sluice is to be totally replaced, since the radial gates and piers of the structure are seriously damaged. The overflow section will be remained as it is without rehabilitation.

The diversion discharge is 25 m^3/sec consisting of 7.2 m^3/sec for the Project area and 18 m^3/sec for the Santana canal. The proposed intake structure will be furnished with nine sluice gates. Three gates are equipped for the proposed main canal system and six gates are for the Santana canal system. The scale of the gate is determined at 1.75 m in net width and 1.75 m in height so that the approaching flow velocity is nearly 1 m/sec. The sill of the intake gates is set at one-meter higher position from the bed of the sand-flushing sluice. The sand flushing structure will be almost similar to the existing one in the scale. Instead of the radial gate, sluice gates are provided. The details are shown in Drawing 4.5.13 and 4.5.14.

(3) Main Canal and flood protection dike

The route of the proposed main canal is shown in Figure 4.5.2. The proposed main canal will run along the right bank of the Yaque del Sur river in the first reaches of about

1.2 km from the Santana headworks to the Vicente Noble-Tamayo road. Then, crossing the road it will turn to the left and run in parallel to the road across the Yaque del Sur river, where a siphon (hereinafter called as Siphon No.1) will be provided. Then it will meet the existing main canal of the Vicente Noble irrigation area and run along the existing main canal up to Canoa where the distance from the Santana intake is about 8.5 km. At Canoa, the main canal will cross the Azua-Barahona highway and just after turn to the right and then cross a depression which is a natural flood way of the Yaque del Sur river by provision of a siphon (hereinafter called as Siphon No.2). Then the main canal will be laid along the Azua-Barahona highway till Palo Alto where the distance from the Santana intake is 14.5 km. Then apart from the highway at Palo Alto, the main canal will run in parallel to the Yaque del Sur river. The total length is about 21 km.

The area of the first reaches from the Santana to the siphon No.1 is composed of riverine coarse materials, which are expected to have high permeability. Also the area is one of those exposed to the danger of the flood of the Yaque del Sur river. Considering these two elements, reinforced concrete flume type is adopted in these reaches and a flood protection dike is proposed in parallel to the canal from the Santana headworks to the Vicente Noble-Tamayo road, which is also functioning as a flood protection dike against flood except a large one. The flood protection dike will have a length of about 1,300-m and a crest width of 4 m. The crest elevation is around 36.5 m at just downstream of the Santana headworks or around 34.6 m at the meeting point with the road. The height of the dike is around 3 m on an average. The riverside slope of the dike will be protected by gabion. The main canal, in the other than the first reaches, will be of concrete-lining canal having a trapezoidal cross section. The primary features are shown in the following table, and the detail layout of Canals and typical cross section are shown in Drawing 4.5.1 - 4.5.4, and 4.5.21.

Primary Features of the Main Canal

CHAINAGE		Discharge	Gradient	Velocity	Water depth	BottomWidth	Inside slope	Canal Height
		(m^3/sec)	(1 : I)	V (m/s)	h (m)	B (m)	(1: x)	(m)
+57	1+202	7.200	4,700	0.95	1.69	4.50	0	2.00
1+202	1+353	6.380	3,000	1.45	2.49	2.50	0	2.85
2+003	2+095	6.380	2,300	1.43	1.50	1.50	1.5	1.80
2+095	4+018	5.660	1,100	1.43	1.22	1.50	1.5	1.55
4+018	4+925	4.990	1,000	1.38	1.13	1.50	1.5	1.45
4+925	6+000	4.570	1,400	1.22	1.15	1.50	1.5	1.45
6+000	8+827	4.570	5,800	0.76	1.56	1.50	1.5	1.85
8+827	11+620	4.570	4,700	0.82	1.49	1.50	1.5	1.80
11+620	14+293	2.840	8,400	0.59	1.36	1.50	1.5	1.60
14+293	15+570	2.840	6,400	0.65	1.28	1.50	1.5	1.55
15+570	18+699	1.260	6,300	0.53	0.96	1.00	1.5	1.20
18+699	19+647	0.810	4,800	0.53	0.73	1.00	1.5	0.95
19+647	20+812	0.470	1,500	0.68	0.49	0.70	1.5	0.70

(4) Major structures of the main canal – Siphon

As explained in (3), two siphons the siphon No.1 and No.2 are to be provided on the main canal. The cross-sectional flow area is determined so that the flow velocity is 1.3 times that of the upstream reaches of the siphons or more.

The barrel of 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 inlets of the siphon are furnished with trashracks and slide gates. The trashracks prevent obstacles to enter the barrels. The gates will be closed during the extraordinary flood in order to prevent from flooding debris entering into the barrel. Just upstream of the inlet structure, a sand trap will be provided. It is a structure only that the bottom of the flume is lowered by 1 m so as to trap the coarse sand and gravel coming from the upstream. A slide gate is installed in the sidewall of the flume to flush out sand and gravel deposited in the sand trap.

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. In the inlet, a sand trap, a trashrack, and a gate will be provided for the same purpose as the siphon No.1.

The details are shown in Drawing 4.5.17 and 4.5.18.

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

The night storage ponds will have 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 and a drop, an outlet and a spillway. The check is a gate structure combined with overflow weir. A drop will follow it. The inlet should be an overflow type. The inflow is measured by the conversion of flow depth at the overflow weir and regulated by the check gate. The outlet is equipped with a sluice gate and an automatic gate to keep outflow regularly. The spillway will be of overflow type provided to drain excess water to the main canal or to the lateral. A drop provided just after the check keeps the main canal water level lower so that excess water coming from the spillway is safely drained into the main canal. The details of the Ponds and the related structures are shown in Drawing 4.5.19, 4.5.20 and 4.5.22 - 4.5.24.

Primary features of the Night Storage Pond

No. of Pond	Irrigation Area	Design Inflow (m^3/sec)	EffectiveStorage Capa. (m^3)	Length of long side (m)	Length of short side (m)	Effective water depth (m)	Design Outflow (m^3/sec)
1	Tamayo	0.83	34,400	185	125	1.5	1.5
2	Vicente Noble	0.75	30,400	175	115	1.5	1.19
3	Vicente Noble	0.75	28,500	170	115	1.5	1.24
4	Vicente Noble	0.45	17,800	140	90	1.5	0.78
5	Canoa	0.59	22,900	150	100	1.5	0.62
6	Jaquimeyes- Palo Alto	0.52	20,600	145	95	1.5	0.61
7	Fundacion-Pescaderia	0.67	27,100	165	110	1.5	0.88
8	Hundacion south	0.45	18,900	140	95	1.5	0.55
9	Hundacion south	0.37	14,400	125	85	1.5	0.56
10	Hundacion south	0.52	20,100	145	95	1.5	0.66

(6) Pump systems

Eleven pump stations, of which all are located along the right side of the Yaque del Sur river in the downstream are remained without unification by the main irrigation canal system. For each of these pump irrigation systems, a regulation pond will be provided

near the pump station. The interruption of electricity is mostly less than eight hours according to the farmers in the Project area. The river water continuously flows for 24hours a day, while the 11 pump stations will take water on the rotational basis allocating the 24 hours so as to meet the river discharge. Some of the pump stations are allocated midnight for pumping water. Considering the rotational operation of pumps and frequent interruption of electricity, the storage capacity of the ponds is decided at the rate of water stored for 12 hours per day.

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	7,500
2	Guaba de Mena	82	4,300
3	Palo de Leche	162	8,500
4	Penon I	117	6,100
5	Penon II	108	5,700
6	La Guinea	61	3,200
7	Paso de Elena	24	1,300
8	Cabellero	77	4,000
9	LaHoya	104	5,400
10	Habanero	175	9,200
11	Dumit	33	1,800

Note: Irrigation areas are subject to be investigated in detail.

The regulation ponds will be almost similar to the night storage ponds to be provided in the gravity irrigation system. The ponds will consist of an inlet, which is directly connected with the outlet pipe of the pumps, an outlet, and a spillway. The outlet is equipped with a sluice gate and an automatic gate to keep outflow regularly. The spillway will be of overflow type provided to drain excess water to the river or the canal.

(7) Improvement of existing irrigation systems

In the proposed gravity irrigation system unifying the existing gravity and pump irrigation systems, the existing main canals and laterals become lateral and sub-laterals, respectively. A night storage pond will be provided between the proposed main canal and the laterals. The discharge in the lateral will be twice the present discharge, since water supply from the night storage pond is limited in daytime or the time when farmers are working in the fields aiming at efficient use of water. Thus the laterals and sub-laterals have to be improved so as to have larger capacity than the present one. The most of the laterals and sub-laterals are earth canal at present. These canals will be improved with provision of concrete lining or wet stone masonry for mainly increasing the canal capacity. Also the deteriorated turnout and check gates will be replaced with new ones.

In the Vicente Noble area, existing main canals, which are excessive deep and wide will be used as laterals by heightening both the canal beds and side banks so as to easily divert water to the fields. Existing laterals will be abandoned in the most of the reaches and instead laterals will be newly constructed, because the existing laterals are excessive deep earth canals and severely damaged by flood of Hurricane George.

As for the field canals, it is recommended that farmers should carry out the improvement works as a communal work.

(8) Inspection road

Main canals and laterals needs inspection roads in the reaches where an existing road is not available. In case of the main canal, an inspection road will be provided except the sections in which the main canal runs along the Tamayo-Vicente Noble road, the Azua-Barahona highway, and the Palo Alto --Fundacion road. The inspection road will be 6 m in total width and 5 m in effective width, which is paved with gravel metaling. Inspection roads provided along the laterals will be 5 m wide.

(9) Drainage canals

There are some depressed areas surrounded by the riverine terrace in the most downstream area located along the Yaque del Sur river. These depressed areas are expected to suffer from the mal-drainage condition, when irrigation is commenced. Thus an open drainage canals are planed in these areas to drain excess water and to keep the ground water level lower. The target area is estimated at 310 ha. The drainage canal is only simply earth-excavated open canal of which depth is around 2m.

(10) Work Quantity

Work quantity of irrigation and drainage Project is shown in Chapter 6.2.

4.5.6 Plan of Setting up and Strengthening Water Users' Organization

(1) Objective of WUO

The main objective of WUO is to operate and maintain the irrigation facilities. In addition, WUO will play a role as a communication channel for farming management especially for mobilization of tractors and distribution of farm inputs like fertilizer and pesticide, since the farming schedule closely relates to the irrigation schedule and tractors mobilization schedule has to meet the irrigation schedule.

(2) Share of O&M works

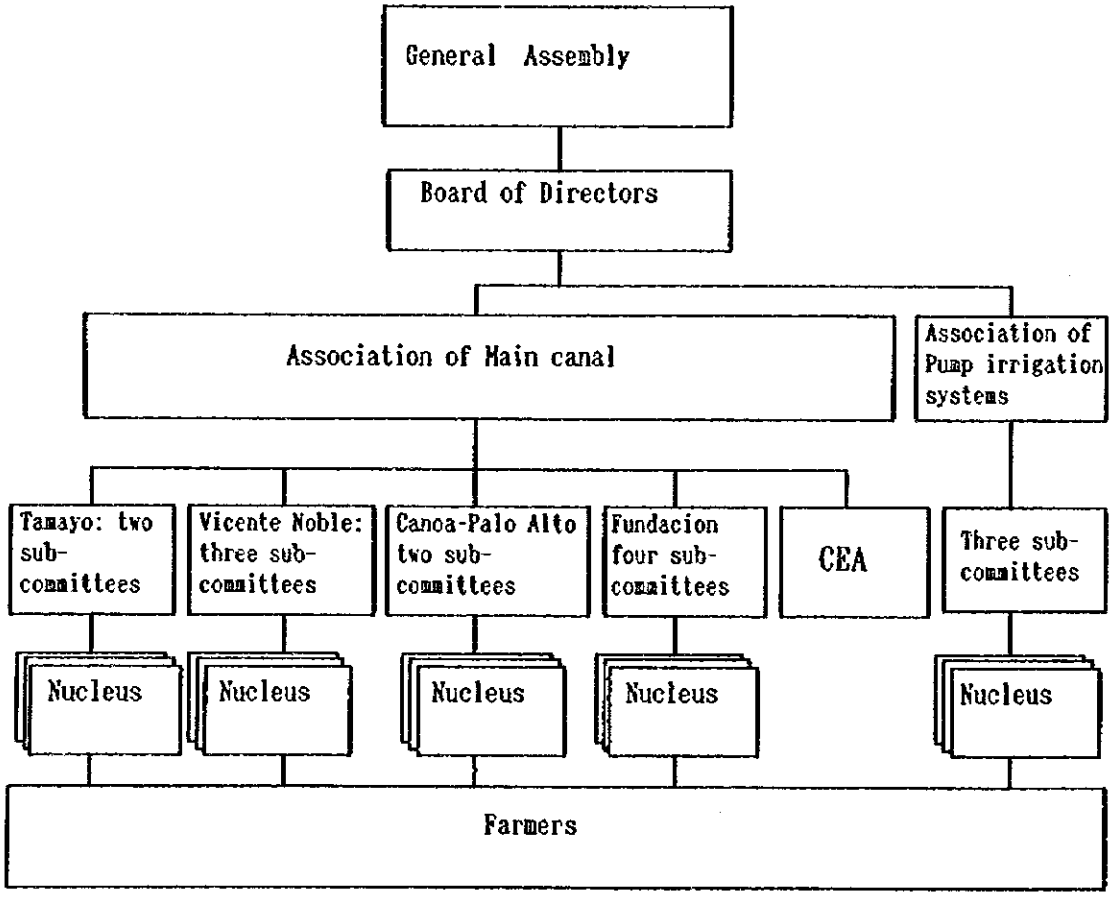
It is recommended that INDRHI should take charge of the operation and maintenance of the Santana headworks, since it is related to both CEA and the Project. WUO will share a responsibility for operation and maintenance for all the irrigation and drainage facilities except the Santana headworks. The most 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 farmers communal work system under the responsibility of each of nucleuses, which are the smallest unit 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. The structure of proposed WUO is shown in the following Figure.

Organization of Yaque del Sur Lower Reaches Irrigation Committee

All the farmers in the Project area should be the members of the WUO. A nucleus, which is the smallest unit of WUO will be formed in one tertiary block, a few distribution canals or one small pump irrigation system. The jurisdiction area and the members will be in the range from 15 ha to 60 ha depending on the canal layout and land holding size, and from 15 persons to 30 persons, respectively. A general chief, a treasurer, a water distributor and a maintenance chief will be elected among the nucleus members.



Then it is proposed to formulate a sub-committee in each of the night storage pond level or a group of pump irrigation systems. This Project probably needs 14 sub-committees. Ten (10) sub-committees will be formed every night storage pond level to be located along the proposed main canal. One sub-committee will be formed in the area served by the Santana canal and remaining three sub-committees will be formed in the irrigation area served by the pump stations, which are divided into the upstream, the middle,

and the downstream area. In addition, as the main canal will supply water to the sugarcane fields located in the left side of the Yaque del Sur river, which is managed by CEA irrigated by pumps at present, CEA will also become a member of WUO at the sub-committee level. Except the CEA, the sub-committee will be composed of the chiefs of nucleuses and the representative of the sub-committee will be elected among the chiefs of nucleuses. Then an association is formed above such sub-committees. The pump irrigation systems depends on water of the Yaque del Sur river and in the dry season, the rotation among the pump stations has to be carried out, since the river flow is smaller than the pump capacity. It is, therefore, proposed to formulate an association in order to carry out smoothly the water management among the pump stations. Also one association will be formulated for the proposed main canal system. The association will be composed of the representatives of the sub-committees. One representative will be selected among them.

The General Assembly, as a maximum authority will be held twice (2) a year and at a necessary time. Attendance of the General Assembly will be the nucleus chiefs of which number is estimated about 200 in the Project area.

The General Assembly will be responsible for

- Approval or reform of by-laws,
- Election of the board directors,
- Reward for the board directors,
- Approval of the water charge, actual expense and budget of the Irrigation Committee every year,
- Approval of the irrigation plan for each agricultural cycle, and

The Board of Directors is responsible for the management and administration of the Irrigation Committee and employing technical and administration staff that are the actual work force for operation and maintenance of irrigation and drainage facilities. The Board of Directors is made up of one president, one vice president, a treasurer, two secretaries (one for documentation and the other for organization) and other few members. They are chosen by the General Assembly from the representatives of sub-committees and will remain for two years in their position. The association representatives will automatically become the board directors. The directors will get some reward of which amount shall be approved by the General Assembly.

The main duties of the Board are:

- To carry out and help to carry out all agreements made by the General Assembly,
- To select technical and administrative staff and approve the remuneration of the staff,
- To be responsible to the Irrigation Committee for managing budget and water charge approved by the General Assembly.

- To prepare the annual report that must be given to the Ordinary General Assembly by the president,
- To supervise the work forces composed of technical and administrative staff in the operation and maintenance of the irrigation systems and office management,

Each of the associations will be composed of the representatives of the sub-committees. The main duties are:

- To transfer all the information from the Board of Directors to the sub-committees executives,
- To supervise the work force composed of technical and administrative staff in the operation and maintenance of the major irrigation facilities,

In addition, the main duties of the association of the pump irrigation systems are:

- To assist the work force to make the irrigation rotation schedule of pump operation among the irrigation sub-committee level and to inform it to the sub-committees and
- To watch the river water flowing downstream at the Santana headworks.

The main duties of the association of the main canal system are:

- To inform the irrigation schedule to the irrigation sub-committees in collaboration with the work force, and
- To watch and evaluate the performance of the work force employed by WUO in the operation and maintenance of the main canal and the related structures.

The main duties of the irrigation sub-committee are:

- To transfer all the information from the association to the nucleus,
- To watch the performance of work force employed by WUO for the operation and maintenance of the night storage ponds and the lateral canal systems, and
- To assist money collectors to collect money from nucleus.

The main duties of the nucleus are:

- To make cropping plan and to submit the sub-committee,
- To make irrigation rotation schedule among fields,
- To operate and maintain field canal systems, and
- To pay water charge.

(4) Work forces

The Irrigation Committee will employ technical and management staff who actually assist WUO to prepare 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 charge as explained in Master Plan Study.

The number and duties of major personnel required for O&M management of the irrigation facilities are assumed as follows:

(a) Technical Section

General manager	: one person in charge of all the operation and maintenance works to WUO.
Irrigation engineer	: one person for making irrigation schedule and overall maintenance program and assist and advise WUO in the irrigation water distribution at the nucleus level.
Inspector	: six persons in total, one person for Santana headworks, who will come from INDRHI, one person for pump irrigation systems and four persons for the main canal system. The inspector who is in charge of pump irrigation systems will make pump operation schedule of all the eleven pump stations and supervise the pump operator in the pump operation. The inspectors of the main irrigation system will supervise the water distribution operators and monitor the canal discharge.
Water distribution operator	: 14 persons in total, one person for each of sub-committee level.
	The water distribution operators will directly operate the check gates and turnout gates on the proposed main canal and outlet gates of the night storage ponds and direct assistant operators in lateral system.
Assistant operator	: 14 persons in total, one or two persons for each of irrigation sub-committee.
	Assistant operator will do water distribution from laterals to field canals.
Pump operator	: 11 persons, one person for each of pump stations.
Pump assistant operator	: 11 persons, one person for each of pump stations.

Maintenance staff : 16 persons in total, one person each for the Santana headworks and the main canal and one person for each of sub-committee level.

He will directly make the light maintenance works like greasing the gate, and mobilize labors and supervise the maintenance works by part time labors.

(b) Administration Section

Administration manager	: one person in charge of all the administration matters.
Accountant	: one person
Cashier cum money collector	: 4 persons
Procurement officer	: one person
Procurement assistant	: one person

(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 in their office scale and staffing. They will function as a superintendent who 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 needs an 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 working for WUO, but also play 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 trucks : 5 for inspection and transportation of materials and labors,
- Motorbikes : 9 for inspection and movement for gate operation,
- Bicycles : 74 for inspection and movement
- Chain saws for cutting trees : a few sets
- Cutters for cutting small trees and grasses,
- Walkie-talkies : about 10 sets for communication in the fields

especially for water management.

- Hand shovel, hand plow, etc.

(b) Equipment for office works

- Office furniture
- Personal desk and chair : about 18 sets,
- Meeting desk : 4 sets
- Locker and bookshelf : 20 sets, etc
- Telephone set : 5 handsets
- Copy machine : 3 sets
- Personal computer sets : 5 sets

Besides, Irrigation District Office will 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 generally consist of personnel expenses for the staff and part-time labors, material cost such as fuel, lubricants, and construction materials, machinery and equipment costs including the cost of depreciation, and office maintenance and stationary costs. These costs are approximately estimated at DR$ 1,100 / ha in total consisting of DR$ 1000 / ha in the personnel expenses including part-time labors and DR$ 100 / ha in the other costs, in which cost of heavy construction equipment is not included. In addition to these costs, WUO will pay a certain amount of O&M costs to INDRHI. Because INDRHI will continuously assist and advise WUO technically and administratively on the O&M works and will directly carry out maintenance works by his heavy construction equipment. Also INDRHI is maintaining and operating large-scale facilities such as Sabaneta dam, Sabana Yegua dam, Villarpando headworks and the proposed Yaque del Sur Water Management Center.

(8) Irrigation Water Charge

A per-capita water charge will be simply determined in each of two crop seasons a year in proportion to the individual scheduled irrigation areas based on the finalized crop planting plan, divided into upland crop fields and paddy fields, or more simply determined in proportion to the area of the agricultural land owned by each of farmers. 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 this system, the water charge will be collected once a year.

All the O&M costs of irrigation and drainage facilities except for the operation and maintenance of the field canals, which are made by farmers themselves should be covered by the irrigation water charges collected from the farmers in principle. The unit rate of the required O&M costs including O&M overall water management is approximately estimated

at DR$ 1,100 /ha/year. Farmers will have a sufficient capacity to pay it from the view of the farmer's economy. It is, therefore, expected that all the farmers accept the principle of the O&M cost burden and cooperate to determine the unit rate of water charge around DR$ 1,100 /ha/year.

The amount of water charge will be calculated and charged every farmer. A nucleus chief and a treasurer will collect the water charges from the member farmers and pay 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 should instruct them to pay the charge.

To achieve a good progress on collecting water charge, it is recommended to include some punishment and incentive in by-laws, for example,

(a) To a farmer or a nucleus not able to pay on time, WUO fines him some percentage of total water charge per month during the non-payment period.

(b) When a farmer or a nucleus pay full amount on time, some percentage of its full amount is reimbursed to him as an incentive.

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

The program for transferring the responsibility of O&M to WUO will be implemented step by step as the improvement works of the Project facilities are implemented so that the water users acquire the capability to undertake such responsibilities for O&M. The continuous training and evaluation of their capability should be the basis for deciding a further step in the process of transferring responsibility of O&M.

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

(a) Formation of nucleus

(i) Demarcation of tertiary blocks and identification of resources - farmers and leaders' capability, education level, physical conditions,

(ii) Setting-up of a working team consisting of principally one organizer and one assistant with some leading farmers assisted by various kinds of experts belonging to the Institutional Building Division of the proposed executing body (refer to Chap.5).

(iii) Preliminary orientation to farmers' leaders in each tertiary block,

(iv) Preliminary orientation to farmers by farmers leaders,

(v) Preparation of lists of farmers and farmers' irrigation area,

(vi) Formation of nucleuses and election of nucleus chief and other directors such as a treasurer, a water distributor and a maintenance chief,

(vii) Prepration of sketch maps indicating field canal system and location of irrigation area of every farmers, which is used for making irrigation rotation schedule,

(viii) Training nucleus chief and other directors about O&M of field canals and administration management,

(ix) Execution of rehabilitation and improvement works of field canals by the nucleus farmers themselves assisted by the Project,

(x) Commission of O&M of field canals in the tertiary block to the nucleus,

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

(xi) Upon the completion of the formation of the nucleuses at all the areas commanded by one night storage pond or served by pump stations, formation of a sub irrigation committee at the pond level or a group of pump stations'. The president and other directors will be elected among the nucleus chiefs.

(xii) Training the president and other directors for management of the sub-committee,

(xiii) Selection and training technical and administration staff organizing a work force under the sub-committee,

(xiv) Commission of O&M of lateral irrigation facilities to the sub-committee,

(xv) Upon the completion of the formation of sub-committees in all the main canal area or the pump irrigation area, an association will be formulated and the president and other directors will be elected. Also the Irrigation Committee will be formulated. The president and the directors will be elected by the General assembly.

(xvi) Training the president and directors to manage the association and the Irrigation Committee.

(xvii) Unification of all the work forces of sub-committees to the Irrigation Committee under the Board of Directors by reinforcing the staffing.

(xviii) Commition of all the Project facilities except Santana and Villarpando headworks to 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 and the assistants, operation and maintenance experts of irrigation facilities, local government staff, a financial assistant, and leading farmers. In addition, it is proposed to assign consultant experts such as an institutional expert and an O&M expert and specialists, if necessary.

One organizer and one assistant will form a team and will work at the front line to organize the farmers. The assistants will be selected from the leading farmers in the target area, since they know the farmer's capability, physical conditions, and problems etc.. Manpower required for the field activities is estimated at five (5) organizers and five (5) assistants on the assumption that number of the nucleus is around 200 in the Project area and that one team consisting of one organizer and one assistant will set up 10 nucleuses a year. Five motorbikes, which is one motorbike for one team are required for them.

4.6 Rural Infrastructure Plan

4.6.1 Basic Concept

Rural infrastructure improvement is on-going by the concerned organizations with their own middle / short term program, which satisfies the minimum required provision level in the most part of the Project area. Rural infrastructure improvement is discussed and formulated based on the following basic concept.

(1) Improvement target is set up to catch up with the national averaged level

(2) Gaps among the villages in the Project area is to be minimized

(3) The improvement of rural infrastructure should be integrated with the irrigation development within this Project

It is however noted that rehabilitation for the existing systems and present development program under the respective organizations would be excluded from this present study. Electrification with CDE system, water supply system with existing INAPA aqueduct, education and health care services are thus excluded in this Project. Farm road improvement is necessary in the Project area and to be included in this study. The farm road rehabilitation, extension and construction are however discussed in the development plan of irrigation because the canal inspection roads are attached to the proposed canals, and linking these road in-between and among the villages are thus included in this road network. The present study therefore includes;

(1) Construction of rural water supply facilities in the area not covered by the existing INAPA system, and

(2) Construction of community centers linked with the proposed strengthening plan of the water users' organization.

4.6.2 Rural Water Supply Plan

(1) General

Rural water supply has been developed by INAPA and its systems have been established in almost villages in the Project area, though the systems have various constraints due to the deterioration, population pressure and damages to their facilities by the hurricane in 1998. INAPA systems are however under the rehabilitation or extension

in accordance with the INAPA own plan and program, therefore their improvement are to be excluded from this study. As mentioned in previous section 3.6, some villages are not covered yet by the existing INAPA water supply system at present, and though INAPA's long term plan shows development plan including wide water supply Project of which source will the Yaque del Sur river and extension of the existing systems, they are not realistic yet. Water supply plan is therefore formulated in three villages namely i) Bombita, ii) Los Robres, and iii) Altagracia which are located out of the existing INAPA system and hence facing the serious shortage of drinking water supply. These villages are mostly of the settlement of sugarcane labors and there are remarkable gap compared to the villages of irrigated farmers. Their location is shown on Drawing 4.6.1.

(2) Design Conditions

Bombita and Altagracia villages are located along the proposed main canal, therefore economical water supply systems can be designed with its available water source, while Los Robres system will depend its water source on the Yaque del Sur river. Target year of the proposed systems is set at 2018 (20 years) following the INAPA standard and designed to serve drinking water to each house. Proposed rural water supply systems for these villages are summarized as follows.

Village	Bombita	Los Robres	Altagracia
Estimated Population(1998)	1,100	350	850
Growing Ratio	3.0%	1.3%	3.0%
Designed Beneficiary(2018)	2,000	500	1,600
Water Source	Proposed Main Canal	Proposed Main Canal	Yaque del Sur river

Each proposed water supply system consists of i) pump, ii) settling pond and filtration gallery, iii) chlorinating, iv) elevated water tank, and v) gravity distribution system with PVC pipe line. For the Bombita system and the Altagracia system, water will be pumped up at intake facilities on the night storage ponds which are designed between proposed main canal and lateral canals, and through settling pond, filtration gallery, and chlorination plant, it will be discharged into the elevated water tank in order to distribute to each house. For the Los Robres system, water will be pumped up from the Yaque del Sur river and be distributed through same way as the other systems.

(3) Hydraulic design

The following Hazen-Williams formula was used for the hydraulic design of the pipeline system.

$$h = 10.666 \times L \times C^{-1.85} \times D^{-4.87} \times Q^{1.85}$$

where,

h = Head loss (m)
L = Pipe length (m)
C = Coefficient (110)
D = Diameter (m)
Q = Discharge (m^3/sec)

Other design assumption applied is as follows.

- Pressure rating of pipes : Max. =15m, Min. = 3.5m
- Velocity limits in pipes : Max. 3.0m, Min.=0.3m
- Head loss in fitting and other miscellaneous : 30% of pipe head loss

(4) Proposed Water Supply Project

Proposed water supply Project is shown in Table 4.6.1, Drawing 4.6.1 and 4.6.2 summarized below.

Village	Bombita	Los Robres	Altagracia
Designed beneficiary	2,000	500	1,600
Beneficiaries per faucet	4.3	4.3	4.3
Averaged daily water requirement	125 *lit*/day	125 *lit*/day	125 *lit*/day
Max. daily water requirement	380 m^3/day	95 m^3/day	304 m^3/day
Intake pump, design discharge	260 *lit*/min	66 *lit*/min	210 *lit*/min
Head	2.4 m	7.4 m	6.1 m
Discharge pump, design discharge	260 *lit*/min	66 *lit*/min	210 *lit*/min
Head	14.1 m	19.4 m	13.1 m
Elevated water tank, capacity	200 m^3	48 m^3	150 m^3
Distribution pipe	ϕ 4", ϕ 2"	ϕ 2"	ϕ 4", ϕ 2"

4.6.3 Community Center Plan

Community center is designed as a multipurpose hall with two functions of 1) office of the water users' organization (WUO), and 2) village level communication center. These also aim to sustain training activities for both Project management/operation staff and farmers. Locations of these centers are allocated based on the development plan for the proposed WUOs as described in section 4.5. Since main office of WUO will be established in Vicente Noble, office of the association of main canal in Fundación, and office of pump system in El Peñon, these three villages are selected for the construction of the community centers. Proposed communication center consists of i) office(s) for board members and stationed staff, ii) meeting room(s), iii) main hall, and vi) other rooms. The floor area will be 540 m^2 for type-A (Vicente Noble) and 420 m^2 for type-B (Fundación and El Peñon).

Proposed communication center is summarized below and their floor plans are shown on Drawing 4.6.3.

Name of Center	Function of Water User's Organization (Ref. Section 4.5.5)		Type (Building Space)
	Association	Sub-committee	
Vicente Noble Center	- General Assembly & Board of Directors, and		Type A (540 m^2)
	- Association of Main Canal	Tamayo sub-committees (2) Vicente Noble sub-committees (3)	
Fundación Center	- Association of Main Canal	Canoa-Palo Alto sub-committees (2) Fundación sub-committees (4)	Type B (420 m^2)
El Peñon Center	- Association of Pump Irrigation System	Pump Sub- committees (3)	Type B (420 m^2)