4.3.5 Market Information Systems

(1) General

Numerous activities are performed by Market Information System such as prices, places of sale, grade requirement as well as output, enterprises involved in food processing, seller of farm implements, and array of statistical data which could be used to make informed decisions.

Two key economic factors affect the supply of agricultural market information services: the willingness of producers to pay for the services alone or in a package with other goods and services, and the likelihood that suppliers will be able to recover the costs of providing information services relative to the potential benefits.

The public sector, NGOs and farmers' associations are likely to participate in the supply of agricultural information when it is required to improve the living standard of farmers, or to increase national agricultural production.

SEA provides limited market information to farmers on an irregular basis. Usually information includes prices at the national, regional and local markets.

In the study area, there is an ongoing pilot market information system project with the Junta Agroempresarial Dominicana, Inc. (JAD) with farmers' associations in San Juan and Azua. The participating institutions are the Asociación de Productores Agrícolas de San Juan (San Juan Farmer Association) and the Federacion de Productores y Campesinos (FEPROCA). This program is still in its initial stage and needs to be strengthened.

For the study area it is proposed a Market information System which would provide farmers with timely information to make sound economic decision.

(2) Proposed Plan

The system should work in both directions. In the supply side there is the need include information on:

- Availability of land allocated to different agricultural activities (crops, forest and livestock production)
- type of soil by farmers
- access to credit facilities,
- irrigated land in the zone and by farmers
- Cost of production by commodities and by techniques
- Prices received by their commodities
- Number of producers by crops and agricultural activities (include amount of land).

In the Demand side:

- Number of associations and cooperatives
- Number and location of Non Government Organizations working the area
- Number and location of agribusiness in the area and nationally
- Number and location of wholesalers
- Storage facilities and cost of storage in the area
- Local prices for their product (currently and historically)
- Climatic information (weather, rainfall, etc.)
- Technical information on crops and livestock easily accessible to producers. (New crops, new varieties, diseases, pest, etc.)
- Feasibility studies for new and existing crops
- Information on local and international market
- Forecast on local, national and international production and conditions.
- List of Marketing organizations both local, national and international.
- On line information
- Regular reporting and projection of agricultural marketing specially price and volume.
- Development of marketing extension services for producers and marketing administration.

The project would set a market information system that would cover the four provinces of the study area with a headquarters located in Santo Domingo. Specifically the project would strengthen the system in San Juan and Azua and set up new facilities in Barahona and Neyba as shown in Figure 4.3.6.

(3) Organization and Management

Information centers would be located at farmer associations in San Juan, Barahona, Neyba and Azua. In the case of San Juan, it would be located at the Asociacion de productores de San Juan de la Maguana (San Juan Farmer Association). In the case of Azua it can work with the Federation of Farmers and Peasants (FEPROCA) or with Federacion de Campesinos Independientes Mama Tingo (FECAIMAT). In Barahona the Coffee grower's association has infrastructure to be part of the Market information systems network. In the case of Neyba, there would be the need to identify a farmer Organization that could participate in this proposed information network.

The headquarters of the Market Information System could be handled by the Dominican Agribusiness Council (JAD). JAD would provide the already existing network and know-how to process the information and feedback the market information centers in the study area.

(4) Costs

For the market information system, there would be the need for computer equipment, telephone service and technical assistance. This project component would include computers, fax-modem, and photocopy machines. A detailed list of equipment and facilities is shown in Table 4.3.11

4.4 Overall Water Management Plan in the Yaque del Sur Basin

4.4.1 Principle

(1) Basic rule of water allocation

Water resources in the San Juan river and Sabaneta dam should be primarily allocated to the area in San Juan irrigation zone. Water of the Yaque del Sur river, as a fundamental rule should be primarily utilized in the Yaque del Sur river basin and water created by Sabana Yegua dam should be fairly diverted between Yaque del Sur - Lago Enriquillo area and Azua area in proportion to the registered irrigation area. (Although the allocation rate will be changed in accordance with the irrigation water demands during the period when the river flow is abundant. Cropping area and kind of crops are not the reason to change the allocation rate during the drought time when water is insufficient against the water demands.) If the allocation is based on this consideration, about 70 percent of the Yaque del Sur river flow should be allocated to the Yaque del Sur - Lago Enriquillo area and remaining should be diverted to the Azua area. Water shortage in the Azua area, if any should be supplemented by groundwater resources, since the Azua irrigation area has a great potential of groundwater resources estimated at about 40 MCM to be utilized every year according to the report of PLANIACAS studied in year 1983. At present, most of the groundwater resources are left with little utilization.

(2) Early implementation of improvement works of Villarpando headworks

Among the headworks, the Villarpando headworks is the most important headworks, which commands the large irrigation area in the Azua and the Yaque del Sur - Lago Enriquillo areas. As described in Section 3.5, it can not fairly and accurately divert river water. The Barahona- Neyba area often suffers from the shortage of irrigation water after the river water was diverted to the Azua area through the YSURA canal. In fact, the records of discharge measurement carried out at the Villarpando in this January indicate that about two-third of total flow was diverted to the YSURA canal and remaining one-third only was flowing down to the Yaque del Sur - Lago Enriquillo area against the fact that the Yaque del Sur - Lago Enriquillo area is two times larger than the Azua, notwithstanding the rule that water allocation is kept in the diversion ratio of 2 for Yaque del Sur - Lago Enriquillo areas and 1 for Azua during the draught season. Such imbalance in the water distribution at the Villarpando is mainly caused by the defective of the Villarpando diversion works giving a disadvantage to the Yaque del Sur - Lago Enriquillo areas as described in Section 3.5, although no care in the water distribution for the sake of the Yaque del Sur downstream reaches is also one of a large element of the cause. It should accordingly be improved so as to be able to exactly divert river water as soon as possible.

(3) Conception for share of O&M works in future and Establishment of Water Management Office at Villarpando

The large-scale dams should be operated directly by INDRHI and CDE, the same as at present. Villarpando headworks, which is related to both Azua and Yaque del Sur - Lago Enriquillo irrigation areas is proposed to be managed by an organization independent from both Azua and Lago Enriquillo-Yaque del Sur Irrigation Districts. Intake facilities of the major irrigation systems diverting water from the Yaque del Sur river should be managed under the responsibility of INDRHI in collaboration with water users' organizations in the actual operation and maintenance of intake facilities. Small intake facilities and all the irrigation and drainage facilities in all the irrigation and drainage systems are proposed to be managed by water users' organizations in future.

The organization so-called the Villarpando water management office will function as a head office to manage the river water distribution to both Azua and Yaque del Sur - Lago Enriquillo areas through monitoring and regulating river discharge to meet the water demands more accurately than the present and to issue a flood warning in the lower river basin from the Sabana Yegua dam. For this purpose, a tele-metering system and communication device will be proposed to detect and monitor the river water levels and flows at key points and to direct site staffs to control discharge at key points.

4.4.2 Organization

(1) Overall Organization

Water management will be conducted and supervised conformed to proposed water management institutions which consist of three management levels as follows:

(a) Inter-basin water management (LEVEL-1)

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

The central office for the overall water management would be established for the said purpose at Villarpando headworks as "Yaque del Sur Water Management Center" which is to be operated and maintained by the national budget. The office 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), national project offices such as PRODAS, PROMASIR, etc.

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. These organizations operate not only Sabaneta and Sabana Yegua dams but also other five (5) national dams. 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. Details on the Council and the Committee are mentioned in Sub-section 4.4.3.

(b) Basin water management (LEVEL-2)

This management covers several irrigation areas in each hydrological basin, and the functions will be entrusted to the Irrigation District Offices. A field office will be established at the Sabaneta Dam to operate and maintain Sabaneta headworks, observe and send hydrological data at Sabaneta dam, José Joaquin Puello canal, San Juan river, and to coordinate water allocation for San Juan, Hato del Padre and José Joaquin Puello irrigation systems in collaboration with the existing water management committee.

In Azua basin, the Irrigation Districts Office will perform the functions of Level - 2 management. Coordination of water allocation between related irrigation areas within each zone, operation and maintenance of major structures such as Ysura Headrace Canal and Tabara headworks.

In Yaque del Sur - Lago Enriquillo basin, a field office will be established at Santana headworks. The office will consist of staff of Lago Enriquillo and Yaque del Sur Irrigation Districts. The office will monitor and send the discharge data of the Yaque del Sur River, Santana canal, operate Santana headworks by managing telemetering system. All the hydrological records will be sent directly to the Yaque del Sur Water Management Center. Coordination on water allocation will be done by the water management committee which will be organized by the proposed project.

(c) Irrigation area water management (LEVEL-3)

Irrigation area water management is a basic unit of the water management, which covers an irrigation system with one intake and its command area. The management itself will be entrusted to Water Users' Organization (WUO), including maintenance of all the irrigation facilities, collection of water charges, etc. Each Irrigation District will support the WUOs on maintenance of irrigation facilities, water management techniques, farming practices and coordination between government organizations and WUOs. Details are mentioned in the Sub-section 4.5.7 (2) "Water users' organization".

Location of the offices and related irrigation systems are illustrated in Fig. 4.4.1, and an overall administrative chart is given in Fig. 4.4.2.

(2) Yaque del Sur Water Management Center (Level-1)

Functions of the Yaque del Sur Water Management Center (herinafter referred to as "the Center") are; (i) to monitor and evaluate water budget at relevant control points, (ii) to operate and maintain facilities directly and indirectly according to the results of evaluation, (iii) to coordinate water distribution through a year, and iv) training of staff and WUOs,

The Center will consist of; (i) data processing unit, (ii) evaluation unit, (iii) operation and maintenance unit, (iv) coordination unit, (v) extension and training unit, and (vi) administration unit. The chief of the Center, who is equivalent to the section chief of the INDRHI headquarters both in terms of experience and capability, will be nominated by

INDRHI.

The Center will collect basic data on hydrology and operation of facilities from the Irrigation District in each basin, process and evaluate the data, modify and determine the operational rules of the dams and Villarpando headworks, water distributing schedules, and give instructions on operation to the Irrigation Districts, and supervise their activities. Training and guidance for the WUOs and staff of the Irrigation Districts will also be conducted by the Center (See Sub-section 4.4.7).

It is also recommended to invite experienced consultants or foreign experts on a project basis, particularly for the initial stage (1 to 5 years) using a technical cooperation program such as "project-type technical cooperation conducted by JICA.

Facilities and locations which will be operated, maintained or monitored by the Center is mentioned in the following:

(a) Sabaneta dam and proposed José Joaquin Puello reservoir

Waters from the reservoir are supposed to be used for San Juan and Las Matas areas. In this sense, the dam might be operated by the Irrigation District of San Juan. However, considering optimal use of limited water sources and technical level required for the dam operation, Sabaneta dam is proposed to be operated by the Center.

José Joaquin Puello reservoir, which is proposed along the José Joaquin Puello Canal aiming at optimizing of the available water source at the Sabaneta reservoir, will be operated by the San Juan Field Office (Level-2) under supervision of the Center in collaboration with the existing Sabaneta Dam Irrigation Committee.

(b) Sabana Alta and Sabana Yegua dam

Located at the end reach of the San Juan basin, discharges of the San Juan river at Sabana Alta will be monitored by the Center as one of "in-flows" to the Azua and Yaque del Sur - Lago Enriquillo basin.

Sabana Yegua dam is the main water source for Azua and Yaque del Sur - Lago Enriquillo basins. Taking into consideration its large capacity and water shortage in Yaque del Sur - Lago Enriquillo basin, optimization of the reservoir will give the greatest impact to the command area.

(c) Villarpando headworks and Los Guiros

Villarpando headworks are to be operated taking into account the water budget of the Azua basin. Discharge of the San Juan river at Sabana Alta and water release at Sabana Yegua dam are considered as "input" to the zone, while diversion to the Ysura Headrace Canal and the discharge of the Yaque del Sur river at Los Guiros are considered as "output". The operation of the headworks should be determined according to the water balance at these points.

(3) Irrigation District Office (Level-2)

Two field offices will be established for the Level-2 water management. Proposed functions and activities in each basin are mentioned in the following:

(a) San Juan Field Office

San Juan Field Office will be established near the Sabaneta dam. The functions of the office are; (i) monitoring and sending of hydrological data such as rainfall, discharge, water level of the reservoirs, rivers and canals, (ii) operation and maintenance of José Joaquin Puello conveyance system (including Sabaneta headworks and the proposed reservoir at Arroyo Rolo), (iii) coordination of water distribution between J.J.Puello irrigation area and other irrigation areas such as San Juan, Hato del Padre, which are located on the downstream of the Sabaneta headworks, and (iv) supporting services for WUOs in the San Juan basin.

(b) Azua Irrigation District Office

The functions of the office in the overall water management are; (i) monitoring and sending of hydrological data such as rainfall and discharge of canals, (ii) operation and maintenance of Ysura irrigation system, (iii) coordination and controlling of water extraction along Ysura Headrace Canal, (iv) monitoring of existing tubewells (number, location, groundwater table, discharge, water quality particularly on salinity, and (v) supporting services for WUOs in the Azua basin.

(c) Yaque del Sur-Lago Enriquillo Field Office

Yaque del Sur-Lago Enriquillo Field Office will be established at Santana headworks. The functions of the office are; (i) operation of Santana headworks, and (ii) hydrological data collection and forwarding to the Center. Coordination of water distribution between Barahona zone or Yaque del Sur Irrigation District and Neyba zone or Lago Enriquillo Irrigation District will be conducted by the Center. Supporting services for WUOs will be performed by each Irrigation District Office. Monitoring of existing tubewells (number, location, groundwater table, discharge, and water quality) in Neyba-Galvan area will be done by Lago Enriquillo Irrigation District Office.

4.4.3 Operation Rule of Sabaneta and Sabana Yegua Dams

(1) Organization for Operation of Dams

Operation of the dams in the Dominican Republic is being undertaken according to the agreement between INDRHI and the Dominican Electric Corporation (CDE)[1].

In the Chapter I of the agreement, it is mentioned that the INDRHI will be the institution which is responsible for the waters regulated in the existing and future dam basins, conserving a criterion of optimum operation and ensuring sufficient quality of water to cover the various uses which may satisfy the needs for purposes of irrigation, supply for domestic and industrial use, and in all cases, the maximum hydro-electric production.

For the following-up of the above concept, two administrative bodies were established. They are; i) the Council on the Control of Dam Basins, as the highest level organization to establish general policy, and ii) the Committee for the Operation of Dam Basins, as a body

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[1] : Convenio de Coordinacion Interinstitucional entre El Instituto Nacional de Recursos Hidraulicos y La Corporacion Dominicana de Electricidad.

independent of the other, for the purposes of direct execution of the policies established by the Council of Control.

The Council for the Control of Dam Basins is made up by the Executive Director of the INDRHI and the General Administrator of the CDE, as well as the highest-level executives of each institution.

The Committee for the Operation of the Dam Basins is made up by three (3) members of each one of the institutions signing the agreement, who in turn, designate an Alternative Representative, should it be necessary, who will be invested with all the prerogatives of a titular member; plus one representative of each one of the Board of Irrigators, legally constituted, as observer.

The responsibilities of the Committee for the Operation of Dam Basins are:

To receive and carry out the executive actions conceived and established by the Council on the Control of Dam Basins,

To review and to evaluate periodically the operational practices and operational procedures,

To formulate, under emergency conditions, the decisions on the operation of the dam basins, by means of agreements adopted by unanimity, taking into account emergency procedures for the dams with basins, established by the CDE,

To hold ordinary meetings, *at least once per month*, and extraordinary meetings in agreement with requests by any of its members, under previously established conditions,

To submit a copy of its Operational Agreements and its Annual Reports to the Council on the Control of Basins, and

To refer to the decision of the Council on the Control of Basins, those matters which because of disagreements, may require the interpretation of policies and criteria previously established by that organism.

Seven (7) dams are being operated under the control of the administrative bodies; they are Tavera dam, Valdesia dam, ***Sabana Yegua dam***, ***Sabaneta dam***, Hatillo dam, Rincon dam, and Jiguey dam. In 1996, an extraordinary meeting was held on the Hurricane Hortense in September, while in 1997, one extraordinary meeting was held in December for controlling water use because of low storage level of Sabana Yegua Dam.

Considering smooth implementation and management of the project, it is recommended to utilize the present organizations and systems of the dam operations. As for the operation of ***Sabana Yegua*** and ***Sabaneta*** dams, the chief of *the Yaque del Sur Water Management Center* will be a member of the Committee for the Dam Control of Basins.

(2) Ordinary Operation

Operation of dams during ordinary operation period is determined by the water demands as far as the available water volume is sufficient in the reservoirs. The water

demands for each dam are revised every year as mentioned in Sub-section 4.5.6. On the other hand, certain control in discharging of stored water is necessary during drought periods. In this case, *a standard storage curve* is required for each dam.

So far no standard storage curve has been established in the Dominican Republic. It is recommended to generate a ***standard drought storage curve***, which is to be used for maintaining required volume of storage and securing stable water supply during drought periods. In this study, drought storage curves for Sabaneta dam and Sabana Yegua dam were generated according to the results of the dam operation simulation which is mentioned in Sub-section 4.7.2.

The simulated monthly water levels of Sabaneta dam and Sabana Yegua dam for 14 years (1981-1994) are given in Table 4.4.1 and 4.4.2. These water levels are plotting of the simulation results under the proposed conditions, such as cropping patterns, irrigation efficiencies, etc. Among simulated monthly water levels of the 14 years, *the third lowest water level* for each month is taken as *"1 in 5 years" drought water level of the month*. The standard drought storage curve of the dam was generated connecting these water levels through a year. The standard drought storage curves of Sabaneta dam and Sabana Yegua dam are given in Fig. 4.4.3.

The dam operation during the ordinary period will be conducted so that the water levels of the reservoirs are maintained above the standard levels.

(a) Sabaneta dam

Discharge from Sabaneta dam is determined based on the water requirements of three irrigation systems, namely José Joaquin Puello, San Juan and Hato del Padre. Runoff from the catchment between the Sabaneta headworks and San Juan or Hato del Padre headworks (128 km^2) is to be estimated and deducted from the water duty at the dam.

According to the results of the water balance simulation, the average annual irrigation water demands and the runoff between Sabaneta dam and the San Juan or Hato del Padre headworks for 1981 to 1994 are as follows:

Demand/Runoff	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Demands												
(1)J.J.Puello (m^3/s)	7.1	4.2	1.0	0.9	2.6	5.3	4.4	3.8	2.4	1.5	1.7	4.4
(2)San Juan (m^3/s)	6.5	4.4	1.2	0.6	2.5	5.3	5.1	4.2	3.0	1.7	1.2	4.0
(3)Hato del Padre(m^3/s)	1.6	1.0	0.4	0.2	0.8	1.6	1.5	1.3	1.0	0.5	0.2	0.9
(4), (2)+(3), (m^3/s)	8.1	5.4	1.5	0.8	3.4	7.0	6.5	5.5	4.0	2.3	1.4	4.9
Runoff (estimate)												
(5)San Juan HW (m^3/s)	0.7	0.6	0.6	0.8	1.6	1.3	1.3	1.7	2.6	2.5	1.5	0.8
(5)/(4), (%)	9	12	39	99	48	18	21	30	66	111	105	17

According to the above results, it is found that 10 to 100 % of the water demands of San Juan and Hato del Padre irrigation areas can be supplied by the runoff from the residual catchment between the headworks and the dam.

It is considered reasonable to deduct from the total water demands of San Juan and Hato del Padre irrigation systems by *0.5 m^3/sec* during the first cropping season

(November – April) and *1.0 m³/sec* during the second cropping season (May – October). The proposed discharges are to *be evaluated and revised every two weeks* by the Water Management Center on the basis of the water level of the reservoir.

(b) Sabana Yegua dam

Discharges from Sabana Yegua dam are determined based on the water requirements of the irrigation systems in Azua and Yaque del Sur - Lago Enriquillo basins. On the other hand, runoff of the San Juan river at Sabana Alta accounts for a large part of waters available for those systems as shown below:

Demand/Runoff	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Demands												
(1)Villarpando (m³/s)	28.6	29.0	26.8	25.8	21.3	26.8	35.5	28.0	22.9	15.5	20.6	25.5
Runoff (estimate)												
(4)San Juan river (m³/s)	5.7	5.2	4.7	6.3	13.2	11.6	10.2	11.9	18.3	17.6	11.3	6.8
(4)/(5), (%)	20	18	18	25	62	43	29	42	80	113	55	27

Note: Demands at Villarpando consist of those of Azua and Barahona-Neyba blocks

It is found that about 20 % of the total demands of Azua and Yaque del Sur - Lago Enriquillo irrigation areas are covered by the remaining water resources from the San Juan block even during the dry periods. Since the runoff from the San Juan river accounts for a large part of the total volume of the water available for the downstream areas, continuous and real-time monitoring of the river discharge at Sabana Alta should be done to determine the discharge from the Sabana Yegua dam and to optimize the limited water resources. The proposed discharges are to *be evaluated and revised every two weeks* by the Water Management Center on the basis of the water level of the reservoir.

(3) Emergency Operation

The operation rule for the emergency period is given in "Instruction of Operation in Emergency[2]" which was prepared in 1994 for the seven (7) national-level dams, by the Emergency Dam Operation Committee[3] (COEE). The rule gives basic operations for the emergency period (high water level or quick rise of water level in the reservoir) to maintain the water level more than one (1) meter below the maximum operation level, and in case that the water level exceeds the level, it is instructed that the same amount of water as inflow should be discharged through the outlets.

In 1996, COEE made site inspection visits for each dam, and indicated the maximum operation levels through a year. The maximum operation levels of Sabaneta dam and Sabana Yegua dam are given below.

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[2]: Instructivo de OperaciÛn durante Emergencias.

[3]: ComitÈ de OperaciÛn de Embalses en Emergencia.

(a) Sabaneta Dam

January to May		643.00 above the mean sea level (amsl), constant
June to July	abasement	Linear variation from 643.00 to 636.00
August to September	critical	636.00 amsl, constant
October to November	recovering	Linear variation to 636.00 to 643.00 amsl
December		643.00 amsl, constant

(b) Sabana Yegua Dam

January to May		396.40 above the mean sea level (amsl), constant
June to July	abasement	Linear variation from 396.40 to 386.00 amsl
August to September	critical	386.00 amsl, constant
October to November	recovering	Linear variation to 386.00 to 396.40 amsl
December		396.40 amsl, constant

The design flood discharge of Sabana Yegua dam is being re-evaluated. The maximum operation level of 386.0 amsl during the Hurricane season (August and September)was determined tentatively to discharge the revised flood inflow (14,000 m^3/sec, PMF[4]). The emergency spillway of Sabaneta dam is being rehabilitated. The maximum operation levels of the two dams will be applied until the rehabilitation works of the spillways are completed. The maximum and minimum operation levels of Sabaneta dam and Sabana Yegua dam are illustrated in Fig. 4.4.4 and Fig. 4.4.5.

4.4.4 Operation Rule of Villarpando Headworks

(1) General

Villarpando headworks are the one of the most important facilities for the Project area along with Sabana Yegua dam. The main function of the headworks is the determination of water volume distributed to the Azua block and Yaque del Sur - Lago Enriquillo block.

The Yaque del Sur Water Management Center will operate these two facilities synthetically according to the water demands and the availability of waters. The basic concept of the operation of the headworks is *"even distribution of available water"* through the year, even while the total volume of available water is less than that of demands.

Being located at the downmost control point to both Barahona and Azua irrigation areas, Villarpando headworks has a decisive function in the water distribution. Even if the operation of Sabana Yegua dam is well-managed, the waters can not be distributed properly without good operations of the headworks. In this sense, the operation of Sabana Yegua dam during dry periods might be considered as a part of operations of Villarpando headworks.

(2) Basic Approach of Operation

(a) The operation of the headworks is conducted by the Yaque del Sur Water Management Center established at the Villarpando headworks.

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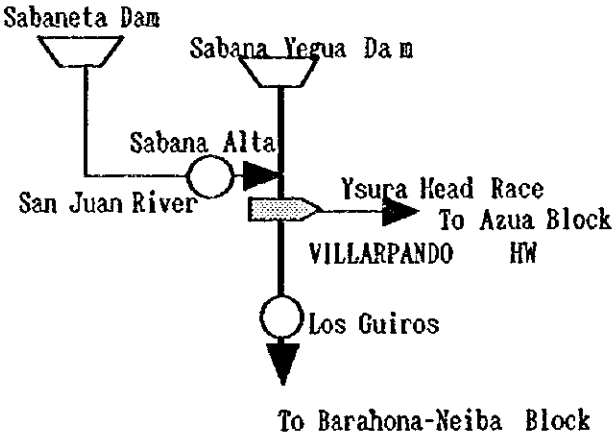
[4]: Original design flood discharge (inflow) is 7,800 m^3/sec of which return period is 1 in 1,000 years.

(b) Hydrological check points of which discharge data are used for determining of the operation are; (i) Sabana Alta on the San Juan river, and (ii) Los Guiros on the Yaque del Sur river. A conceptual diagram is given below:



(c) The Water Management Center will collect and compile the discharge records from Sabana Alta using the telemeter system, then determine or adjust the discharge from the Sabana Yegua dam.

(d) The waters at the headworks are diverted to the Ysura Head Race Canal according to the water demands of Azua and Neyba-Barahona basin. The river discharge at Los Guiros will be monitored simultaneously.

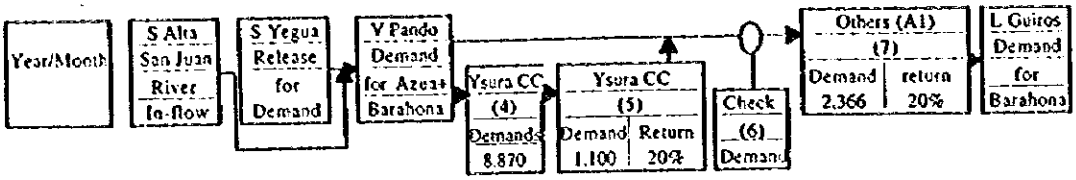
(e) If the discharge at Los Guiros is smaller than the proposed discharge for the period and the water level at Sabana Yegua dam is above that of the standard storage curve, the discharge from the dam will be increased.

(f) If the discharge at Los Guiros is smaller than the proposed discharge and the water level at Sabana Yegua dam is also lower than that of the storage curve, diversion discharge to the Ysura Headrace Canal will be reduced.

(g) If the river discharge at Villarpando does not meet the demands due to insufficient storage of Sabana Yegua dam, the available water at the headworks will be distributed in reduced volume.

(3) Distribution of Available Water at Villarpando

The results of the water balance simulation at Villarpando headworks are given below:



(unit)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)	(MCM)
1981	504.6	283.6	721.7	250.6	21.9	4.4	471.2	65.2	13.0	428.8
1982	305.3	506.5	807.7	250.6	21.9	4.4	557.1	65.2	13.0	514.1
1983	295.2	569.2	848.8	250.6	21.9	4.4	598.2	65.2	13.0	560.0
1984	303.6	552.3	853.7	250.6	21.9	4.4	603.2	65.2	13.0	563.7
1985	243.7	576.0	805.6	250.6	21.9	4.4	555.1	65.2	13.0	512.4
1986	291.1	448.4	722.6	250.6	21.9	4.4	472.0	65.2	13.0	430.1
1987	386.0	448.7	815.4	250.6	21.9	4.4	564.9	65.2	13.0	523.9
1988	331.6	479.5	793.8	250.6	21.9	4.4	543.3	65.2	13.0	504.1
1989	379.3	493.1	837.3	250.6	21.9	4.4	586.7	65.2	13.0	550.5
1990	307.2	549.0	821.1	250.6	21.9	4.4	570.6	65.2	13.0	535.0
1991	199.5	641.2	840.7	250.6	21.9	4.4	590.1	65.2	13.0	558.5
1992	388.9	480.1	835.8	250.6	21.9	4.4	585.2	65.2	13.0	548.2
1993	344.7	458.7	791.6	250.6	21.9	4.4	541.0	65.2	13.0	502.9
1994	242.3	540.3	778.0	250.6	21.9	4.4	527.5	65.2	13.0	491.1
Mean	323.1	501.9	805.3	250.6	21.9	4.4	554.7	65.2	13.0	515.9

Note: MCM Million cubic meter

The total demand for Yaque del Sur - Lago Enriquillo basin at Los Guiros, the end point of the Azua basin is 516 million cubic meters (MCM) on the average. The volume equivalent to the return flow from the small irrigation systems which take waters from the Ysura Headrace Canal and runoff from the residual catchment between Los Guiros and Villarpando headworks is deducted from the demand at Villarpando resulting in a total of 805 MCM.

Out of 805 MCM, 251 MCM or 31 % is to be diverted to Ysura Headrace Canal on the average. Monthly variation of diversion rate at Villarpando is summarized below:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Villarpando (m^3/sec)	28.6	29.0	26.8	25.8	21.3	26.8	35.5	28.0	22.9	15.5	20.6	25.5
Diversion to Ysura (m^3/sec)	10.0	10.5	8.7	9.0	7.0	9.0	10.0	7.2	4.9	3.0	6.7	9.3
(%)	35%	36%	33%	35%	33%	34%	28%	26%	21%	19%	32%	37%
Demand at Los Guiros (m^3/sec)	16.8	16.4	16.3	15.7	13.7	16.7	23.5	19.5	17.4	12.4	13.2	14.8

From the view point of irrigation water demand, it is clear that the diversion rate to the Ysura head race canal is less than 40 %. On the other hand, actual operation of the headworks in the field study period in 1998, sixty percent (60 %) of available water at the headworks was diverted to Ysura head race canal because of the following reasons:

- Crops planted in the Azua basin are sensitive to water shortage and continuous watering is required, and
- A large amount of water from the small irrigation systems along the Ysura

Headrace Canal and seepage from the Headrace return to the Yaque del Sur river.

Considering the improvement brought by the future projects, such as Ysura Area Improvement Project, Ysura Headrace Small Irrigation Project, Ysura Headrace Maintenance Project, Night Storage Pond Project, as mentioned in Sub-section 4.5.4, the above-mentioned problems will also be solved and the diversion rate should be determined in accordance with the irrigation water demands.

As mentioned in "Basic Approach of Operation", the discharge of the Yaque del Sur River at Los Guiros should also be monitored to meet the demands for Yaque del Sur - Lago Enriquillo areas at Los Guiros. In case that the discharge is less or more than the demands, the diversion rate should be maintained in total volume of waters.

Practical operation of the headwork's, whether the volume is to be controlled by the discharge or time scheduling, will be determined on the basis of the conditions of improved or newly constructed irrigation facilities of Ysura Canal Irrigation System.

4.4.5 Improvement Project of Villarpando Headworks

(1) Basic Plan of Facilities

Villarpando Headworks located at downstream of the Sabana Yegua Dam to split water into the downstream area (Neyba/Barahona) and Azua area through the Ysura Headrace and Ysura Main canal. The existing Villarpando Headworks consist of i) intake structure, ii) sand flushing sluice, iii) concrete fixed weir of spillway and iv) earth dike.

In order to execute overall water management properly, the improvement of the related structures is inevitable. At present, in addition to the malfunction of the gates, there is the structural defect on the headworks as mentioned in section 3.5.3. In this context, a discharging sluice facilities should be provided on the existing weir for the sake of releasing water to the downstream reaches steadily. In this structure, the sill of the gates should be set at the same elevation of it of the intakes so as to put the both structures under similar hydraulic conditions. And furthermore, in the point of operation and maintenance, dimension of the intake gate will be applied to the gate in the discharging sluice. On the other hand, all the existing gates in the intake and the sand flushing sluice should be replaced with new ones including motor-driven lifting devices.

Stone masonry work should be provided as protection works at the portion where erosion and scouring will be occurred (specially adjacent parts to the sand flushing sluice and discharging sluice).

(2) Project Works

- Replacement of gates and lifting devices at intake / sand flushing sluice structure;
  - i) 3 nos. of slide gates with motor-driven lifting device ; 1.9m (B) x 2.5m (H)
  - ii) 1 radial gate with motor-driven lifting device : 4m (B) x 7.2m(R)
- Rehabilitation of protection works at up/downstream portion of sand flushing sluice, discharging sluice and concrete fixed weir

- Provision of discharging sluice with 3 nos. of steel roller gates [1.9m (B) x 2.5m (H) x 3 nos.]

General features of the improvement project of Villarpando Headworks is shown in Fig. 4.4.6.

4.4.6 Hydrological Network and Telemetering System

(1) Flood Warning System

A flood warning system aims at giving a cautionary notice of likelihood of flood levels or flows exceeding specified limits, given from upstream station to points downstream, to enable timely protective measures to be taken to minimize damage to life and property.

Flood damages in the project area have largely decreased since 1979 or 1981 in which Sabaneta dam and Sabana Yegua dam were constructed. Both dams have function of flood routing in the original design concept but it has not been performed because of lack of proper spillways. The emergency spillway of Sabaneta dam is being constructed to discharge revised design flood of 5,000 m^3/sec, while the design flood of Sabana Yegua dam is being revised and the rehabilitation of the spillway is proposed. Actually, the water levels of the two reservoirs have been controlled lower than the normal operation levels expecting bigger floods than the designed one, and the emergency spillways have not been used.

However, after completion of the rehabilitation works of the spillways, certain amount of water will be discharged through the spillways, and the flood warning system is required for the dam operation.

When the release of water from the reservoir causes great changes in the river discharge on the downstream, warnings should be given properly. The warning system of Sabana Yegua dam will cover the area along the Yaque del Sur river down to the confluence of the Yaque del Sur river and the Viajama river which is located 15 km downstream of the Villarpando headworks.

The proposed warning system consists of the following facilities:

- Electric (motor) siren with remote control system
- Loudspeaker with remote control system
- Patrol car with a loudspeaker system
- Sign plates

These facilities will be located at residential areas or town/villages such as Villarpando, Magueyal and Hato Nuevo de Cortés. The warning system will be operated and maintained by the Water Management Center.

(2) Irrigation Water Distribution System

The telemeter system for the irrigation water distribution will be operated by the Yaque del Sur Water Management Center. The primary telemeter system covers data control and operations of Sabaneta dam, Sabana Yegua dam, Villarpando headworks, Sabana Alta on the San Juan river, and Los Guiros on the Yaque del Sur river. The secondary telemeter system is proposed for the operation of Tabara headworks and Santana

headworks between the Center and the headworks. The telemeter system within individual irrigation system is not proposed under present situations.

(a) Dams

The telemeter system of the dams will be established in order to realize safe and accurate operations to secure sufficient storage to meet the demand and to discharge excess water in the reservoir for safe operation of the dams. The following data control and operation will be performed automatically or manually using the system:

- Control and monitoring of outlet valves or gates
- Guidance of operation and monitoring on CRT
- Hourly, daily and monthly recording of operations
- Estimation of inflow to the reservoir
- Estimation of released volume using equations for sluice gates and/or free overflow weir
- Calculation of accumulated volume of the released water
- Recording of precipitation in the catchment

All the records and data will be collected at the dam sites and sent to the Center for further operations.

(b) Headworks

Facilities to be controlled, monitored or operated with the telemeter system of the headworks are;

- Water level on the upstream of the weir
- Degree of opening of scouring gates
- Degree of opening of intake gates
- Water level on the downstream of the weir
- Water level of the main or headrace canal

All the records and data will be collected at the sites and sent to the Center for further operations.

The intake discharge will be controlled taking into account the water levels of the rivers and demand at each diversion point. Operation of the gates of headworks will be done manually by field operators according to instructions and orders from the Center.

Information sent from the fields will be displayed in the Center. Discharges and water levels will be monitored in analog display, while conditions (on/off) and/or troubles will be notified by signal lamps.

(c) Hydrological Check Point

As mentioned above, the hydrological check points on river discharge are proposed at Sabana Alta on the San Juan river and at Los Guiros on the Yaque del Sur river. Water level of the rivers will be monitored and sent to the Center by the

telemeter system. The relations between the water level and the discharge, so called "rating curve" should be revised frequently.

(d) Storage Pond

Storage ponds which are proposed on the main or headrace canal will also be operated using the telemeter system. Facilities to be controlled, monitored or operated are;

- Water level in the pond or reservoir
- Degree of opening of intake gates
- Discharge from the outlet to the canal

The gates will be controlled manually according to the orders and instructions of the Center or Irrigation District Offices and the above data are sent to the.

(3) Data Control System

The data control system is composed of transmission system, monitoring and operation system, data processing system, and power supply system.

(a) Transmission System

The transmission system consists of (i) terminal units, (ii) input/output terminal devices, (iii) telemetering and/or tele-control devices, and (iv) transmission line.

The terminal unit gathers all the input and output signals at the Center and distributes the information to relevant devices. The terminal unit connects transmission lines or devices with telemetering circuit.

The I/O terminal converts and distributes signals to and from the filed devices and the telemetering devices such as data processing devices, graphic panel, control panel, etc.

Telemetering devices are installed at field stations to send data to the Center, while the tele-control devices are installed at the Center to control the devices at field stations. The telemetering devices are used for monitoring of operation of gates, valves, etc.

Since the public telecommunication services are not available at the proposed facilities, radio communication system is primarily adopted for the transmission of signals. However, cable communication system might be also applicable between Sabana Alta, Sabana Yegua dam and the Center.

(b) Monitoring and Operation System

The monitoring and operation system consists of (i) graphic panel, (ii) analog-type recording devices, and (iii) alarms.

The graphic panel indicates degree of opening of gates and valves, alarm on troubles, river and canal discharges, water levels of the reservoirs, etc.

Analog-type recording devices such as pen-recorders are installed as back-up of digital data recording.

Alarming system inform operators of the troubles at the field stations. The alarming methods should be different by type of the troubles, such as significance,

location, and type of devices.

(c) Data Processing System

The data processing system consists of (i) data processing devices, (ii) back-up memory devices, (iii) I/O control interface, (iv) console-type input devices, and (v) printing devices.

- Functions of the data processing devices are;
- Collection, compilation and storage of data
- Analysis of the data such as converting of water level data to discharge, storage volume, precipitation
- Storage of the results of analysis
- Output of results to printers, graphic displays, etc.
- Operational analysis for facility control such as degree of opening of gates, valves, etc.
- Warning on abnormal figures of hydrological and/or hydraulic data observed.

The data processing system consists of (i) data processing devices, (ii) back-up memory devices, (iii) I/O control interface, (iv) console-type input devices, and (v) printing devices.

The back-up devices are hard disks and/or compact disks with write-protect functions.

I/O control interface plays a role of connecting the data processing devices with other devices such as I/O terminal, telemetering or tele-controlling devices, graphic panel, etc. The I/O interface includes serial interface, analog interface, parallel interface, DI/DO interface, etc. The console-type input devices are substituted by personal computers to modify the analytical programs and make corrections on data and records.

(d) Power Supply System

Power supply systems such as generator with automatic switcher and battery back-up are necessary to avoid failures in operating of the telemeter system. Solar battery system is also applicable for back-up power supply or main energy source at remote stations.

(4) Basic Plan of Facilities

The telemetering system is proposed for Level-1 and Level-2/3 water management. The Level-1 system consists of The Yaque del Sur Water Management Center as the central station, Villarpando headworks station which is located at the Center, Sabana Yegua and Sabaneta dam stations, Sabana Alta and Los Guiros hydrological stations, and repeater stations.

The Leve-2/3 system consists of the telemetering stations of Tabara headworks, Santana headworks, and repeater stations.

(5) Project Works

The central station of the system will be established at the Yaque del Sur Water Management Center at Villarpando. The station consists of a supervisory equipment and data processing equipment, a tele-communication system, a mimic display panel, a data display panel with output devices and a power supply system with back-up battery system (UPS).

Villarpando headworks station is located in the Water Management Center consisting of terminal equipment for the data control for Villarpando headworks, sensors for water levels (pressure gauge) and gate operations, control panels, and a power supply system.

Hydrological control points, namely Los Guiros and Sabana Alta will have telemetering system for river water levels. A remote terminal equipment system with wireless transmission facilities, a pressure gauge type water level gauge, an analog-type water level gauge with a recorder, and a power supply system will be installed for each station.

Telemetering stations at Sabaneta and Sabana Yegua dams will have remote terminal equipment with radio system, sensors such as raingauge, reservoir water level gauge, monitoring devices of the valve operation, flow meter for measuring discharge from the reservoir, a control panel, and a power supply system with back-up batteries. These station will also have the control panel of flood warning systems.

A repeater station is required for relaying telemetering signals and communications between the Sabaneta dam station and the Center at Villarpando. The repeater station consists of repeater equipment with radio system, antennas, solar cells and storage batteries, power distribution board, etc. The repeater station will be located in/around San Juan.

Telemetering stations will also be proposed at Tabara headworks on the Ysura Canal system in Azua, and at Santana headworks. These stations consist of terminal equipment with radio system for the data control and telemetering, sensors for water levels (pressure gauge) and gate operations, analog-type water level gauges with pen-recorders, control panels, and power supply equipment. The repeater stations are also required for these stations.

4.4.7 Training Program

(1) Program

Training on the water management is proposed for each management level, i.e.; (i) water users' organizations (WUO), (ii) staff of the Irrigation District Offices, and (iii) staff of the Yaque del Sur Water Management Center. Intensive training course will be prepared and practiced at the initial stage of the project for the staff of the water management center, and trainers for WUOs. Periodical training will be continued by the trainers. Training programs for the staff of the Center and the Irrigation District Offices are mentioned in the following, while those for WUOs are mentioned in Sub-section 4.5.7:

(a) Irrigation District

(i) Training programs on water management or operation which are to be prepared for engineers and supporting technical staff of the office, will include; i) hydrological observation procedures (recording and processing

of data, maintenance of equipment), ii) operation of intake facilities based on the instructions from the Center, iii) field monitoring, and iv) coordination between irrigation areas or WUOs. Water management during dry periods is one of the most significant issues for the staff of the Center. Controlled but fair water distribution will be practiced and experienced through OJT at the initial stage of the project.

(ii) At the initial stage of the project, prior to the training on maintenance works, drawings of facilities, such as canal layout, longitudinal profiles and cross-sections, major structures, etc. should be reproduced. An inventory of structures and facilities will also be established. Then, a maintenance manual will be prepared by the project, with a "check list" on maintenance works which will be used for confirming if the facilities keep the designed functions. Mandatory maintenance works will be performed according to the check list. Staff training at the Center will be carried out once a year, and trainers of the center will visit the sites and instruct periodically.

(b) Water Management Center

(i) The national hydrological office of INDRHI will take responsibility on staff training for the data processing unit of the Center. Prior to the commencement of the operation of the Center, key staff of the national hydrological office and the Center should participate in intensive training course on telemetering system. Certain period of consultation by the system engineer or designer of the telemetering system will be given at the initial stage of the operation at the WM Center.

(ii) Department of Irrigation District of INDRHI will take responsibility on the training of staff of evaluation. The training program of the staff of the evaluation unit consists of methodology and practical procedures on; i) determination and modification of cropping patterns for each irrigation system, ii) estimation of irrigation water requirements, iii) modification of operation rules of Sabaneta and Sabana Yegua dams, and Villarpando headworks, iv) determination of irrigation schedule of the basin water management (Level-2).

(iii) Training for the staff of operation and maintenance unit will also be taken charge of by the Department of Irrigation District. The training program includes; (i) operation of intake facilities such as gates and pumps, (ii) operation of diversion or distributing facilities (gate control), (iii) emergency control, (iv) training procedures on the field, (v) operation and maintenance of equipment, and (vi) reporting and documentation.

(2) Equipment

(a) Water management center

Following equipment will be facilitated for the training at the WM Center:

(i)	personal computer	5 sets
(ii)	television and video	1 set
(iii)	video camera	1 set

(iv)	camera	2 sets
(v)	micro bus	1 no.
(vi)	pick-up truck	1 no.
(vii)	motor cycle	5 nos.
(viii)	handy radio transceiver	5 sets
(ix)	copy machine	2 sets
(x)	overhead projector	1 set
(xi)	office furniture and utilities	1 LS

(b) Field offices and/or Irrigation Districts

Following equipment will prepared for the field offices and or Irrigation District offices.

(i)	motor cycle	6 nos.
(ii)	pick-up track	3 nos.
(iii)	copy machine	3 nos.
(iv)	personal computer	3 nos.
(v)	camera	3 sets
(vi)	furniture and utilities	1 LS

4.4.8 Cost

Project costs for Water Management Project are summarized in the following table.

Costs for Water Management Project

	Items	Cost (x 1000 RD$)
1)	Improvement of Villarpando Headworks	35,239
2)	Yaque del Sur Water Management Center / Villarpando Headworks Operation Unit	21,980
3)	Sabaneta Dam Remote Station	6,888
4)	Sabana Yegua Dam Remote Station	6,048
5)	Sabana Alta Hydrological Remote Station	1,932
6)	Los Guiros Hydrological Station	1,932
7)	Tabara Remote Station	5,516
8)	Santana Remote Station	5,516
9)	Training Program A (for Level-2 staff. 20 courses, 25 participants each)	392
10)	Training Program B (for Level-1 staff. 10 courses, 20 participants each)	798
	Total	86,239

4.5 Irrigation and Drainage Development Plan

4.5.1 Development Concept

(1) Efficient use of Limited Water Resources by Improving Irrigation Water Management

According to the hearing to water user's organizations and farmers, water shortage was often taken up in the discussion among them and also the water balance study made in Chapter 3 indicates that water availability is tight even in the normal hydrological year under the present cropping with the intensity of only 80 % in the area benefited by the Yaque del Sur river. The most important subject is, therefore, how to effectively utilize limited water resources in the Yaque del Sur river basin to increase cropping intensity and yields through improving irrigation efficiency. In this context, there is still room for improvement in the existing irrigation facilities and water management systems and thus the irrigation development plan using surface water resources should place a first priority on the improvement of water management system and existing irrigation systems instead of the expansion of irrigation area.

In order to efficiently use water,

(a) diversion structures and intakes which are not working well and free intakes should be improved or replaced with new ones to exactly divert water to meet the scheduled amount, then

(b) a water management site office having a responsibility for and a right of overall water distribution to Azua and Lago Enriquillo-Yaque del Sur Irrigation Districts area, furnished with a reliable monitoring and direction system should be established independently from the Irrigation District offices to fairly and timely distribute water Azua and Lago Enriquillo-Yaque del Sur Irrigation Districts areas watching the river flow distribution at a real time as described in Section 4.4,

(c) water users organization enabling farmers to be more involved in the O&M of irrigation and drainage systems should be founded in each of or a group of irrigation systems and reinforced so as to manage systems by themselves, and

(d) existing irrigation and drainage systems should be rehabilitated and improved, if necessary so that the water users receive the systems in good operation condition.

(2) Setting-up and Reinforcement of Water Users Organization

Operation and maintenance system is poor at present especially in the irrigation areas where no water users' organizations exist and as a result canals and the related facilities are deteriorated and much amount of water is wasted. Without proper operation and maintenance organization, even if the facilities were rehabilitated and improved, these facilities would be deteriorated again. It is most desirable in principle that beneficiaries manage all the irrigation and drainage facilities on their own responsibility and expenses.

In the J. J. Puello area, the canal system operation and maintenance made by the Sabaneta Irrigation Committee is going well and collection rate of water charges is remarkably improved in recent years. The YSURA area of Azua zone is managed well by the water users' organization as well. According to the interview survey, most of farmers who own their farms in the place where no water users' organization exists mostly agree to the establishment of water users' organization in principle.

Accordingly, in line with the principle of the beneficiaries participatory approach, which is expected to bring the efficient use of limited water resources and prolong the life of irrigation and drainage facilities, to contribute to the increase of food production and improvement of living standards, INDRHI have put the high priority on the formulation of water user's organization for entire irrigation systems and strengthening existing organizations in order to execute O&M of irrigation and drainage systems by farmers themselves. Law No. 5852 legislated in March 29 1962, of Surface Water Control and Distribution of Public Waters is a support of the above policy. In line with this policy, irrigation development in the Yaque del Sur basin will be executed putting an emphasis on founding and reinforcing water users organization in parallel to the rehabilitation and improvement of facilities so that all the irrigation and drainage systems except large-scale facilities such as reservoir dams and Villarpando headworks are directly managed by water users' organizations.

In San Juan Irrigation zone, the existing Sabaneta Irrigation Committee will extend the management to all the irrigation systems served by the San Juan river and Sabaneta dam through the establishment of water user's organizations in the San Juan and Guanito San Juan irrigation systems. All the Azua irrigation areas served by the Yaque del Sur river and Sabana Yegua dam will be incorporated into the existing YSURA Irrigation Committee. Also, in Lago Enriquillo-Yaque del Sur Irrigation Districts area served by the Yaque del Sur farmers will be newly organized into water users' organization in each of irrigation systems and an Irrigation Committee provisionally called the Yaque del Sur Irrigation Committee, of which jurisdiction is all the areas located in the downstream of the Villarpando served by the Yaque del Sur river will be organized.

Instead of the commission of irrigation water management to water users' organizations, 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 the users' organizations in the operation and maintenance works and as a force to carry out repairing and maintenance works of major facilities.

(3) Rehabilitation and Improvement of Irrigation and Drainage Systems

San Juan irrigation zone and Azua irrigation zone have been relatively well developed since 1970s. At present in the San Juan Irrigation zone various irrigation systems are being rehabilitated and improved or have a definite rehabilitation and improvement plan under PRODAS and PROMASIR. Also, Azua area has a definite plan to improve the drainage problem caused in the south of the YSURA area. Major existing irrigation and drainage

systems left with no concrete and definite plans distribute especially in Lago Enriquillo-Yaque del Sur Irrigation Districts zone where is physically the most severe zone with dry climate and less availability of water. Many of the systems are required for rehabilitation and improvement. The Lago Enriquillo-Yaque del Sur Irrigation Districts zone must be placed as a most important zone for the rehabilitation and improvement.

The Santana irrigation system, which was built in 1916 has been mostly deteriorated and can not regulate irrigation water flow. Many pump stations located along the lower reaches of the Yaque del Sur river suffers from the irregular interference of electric supply in addition to the shortage of usable water and salt intrusion in the most downstream as explained in Section 3.5. In order to solve the problem, two alternatives are conceivable; one is a provision of a gravity irrigation system from the upstream instead of existing pumping stations, the other is to provide generators. In either case, early implementation to solve the problem is required. Rehabilitation of small irrigation systems, of which the most take water freely with no intake gates is also an urgent subject especially for efficient use of water as well as the founding of water users organization.

The privately-installed plastic pipes taking water from the YSURA head race by using siphon effect should be replaced with permanent intake structures. Prior to the construction, however, an agreement should be exchanged between INDRHI and water users to organize a water user's organization to manage a newly constructed facilities on their own responsibility and to follow the regulations agreed between INDRHI and users.

Water resources of the Yaque del Sur basin are very tight at present as explained in the water balance study. Therefore irrigation sector is strongly requested to efficiently use water delivered to the irrigation systems. All the irrigation systems in the Yaque del Sur river basin have no room to tentatively store water conveyed through the irrigation systems. Thus farmers are obliged to use water even at midnight. If they are not working in the dark, much amount of water is to be wasted. Even if the night irrigation practices are carried out, low efficiency of irrigation water application is inevitable. Moreover, the night irrigation incurs water logging due to the poor water management, which is sometimes harmful for crop growth and leads salinization. In order to realize the efficient use, in addition to the rehabilitation and improvement of existing facilities, therefore night storage ponds are proposed to be provided near or in the irrigation fields so that the irrigation water is once stored in the ponds during night time and released during the following daytime from early morning to evening when farmers are working in the fields. Thus the training and reinforcement of water users organization should be implemented. Further, a sprinkler and drip irrigation systems are recommended especially in undulating areas. These facilities, of course, request the water user's organization to carry out more punctual management.

(4) New Irrigation and Drainage Development Project

As already explained in Chapter 3, there are several new on-going irrigation development projects in the Yaque del Sur Basin such as Amiama Gomez and Biafara projects in Azua District and Aguacatico project in Lago Enriquillo Irrigation District , which are all depending the water resources on the Yaque del Sur river. As explained in the water balance study presented in this report, however, the Yaque del Sur water resources

are insufficient to cover the entire benefited area or to irrigate all the existing benefited area at present. In such a situation, it is difficult to recommend the increase of the irrigation area depending on the Yaque del Sur river more than the present, although there is a view that water should be fairly distributed to the areas as much as possible if physically possible. In principle, a new irrigation project should be developed with water resources. In this connection, the groundwater resources development in the Azua plain is a promising project. Also Galvan of Neyba plain should be a promising area.

Development of Neyba valley with water drained from the sugarcane fields should be prudently studied, because if intensive irrigation is practiced in the sugarcane fields, the flow, which is around 1.0 m3/sec on a baseflow average at present will decrease and conversely salt content, which is around 2 mmhos/cm will increase.

4.5.2 Irrigation Water Requirements

This section presents the irrigation areas and the prospective irrigation water demand balancing with the available water resources in the Yaque del Sur river. The water balance study itself is presented in Section 4.7. On-going irrigation projects such as the extension of the San Juan irrigation area, Amiama Gomez, Biafara, and Aguacatico project are taken into account in the estimate of the irrigation water requirements in addition to the existing irrigation areas. Irrigation efficiency is estimated in consideration of the improvement of irrigation facilities and water management in future.

(1) Cropping Patterns and Net Irrigation Water Requirement

Cropping patterns for estimating irrigation water requirements are based on the present patterns a little modified in crop growing period and sugarcane cropping area as follows:

- Crop growing periods of paddy and beans are set at 120 days and 90 days, respectively instead of 135 days and 105 days, which are adopted in order to estimate irrigation water requirements under the present condition, assuming that the short growing varieties are introduced. Pigeon peas are also estimated to be cultivated two times during the present cropping period of 7 months in the traditional pigeon peas.

- Planting area of sugarcane is assumed to be replaced with other valuable crops and be decreased from the present acreage of 8,800 ha to 4,560 ha as presented in Section 4.2.

Net irrigation water requirements are estimated by the same method estimating those for the present cropping pattern (refer to Section 3.5.4). The results are shown in Table 4.5.1.

(2) Irrigation Efficiency

Irrigation efficiency is generally presented by the product of conveyance efficiency, field canal efficiency, and field application efficiency. The efficiency is determined in

consideration of the future improvement of water management and irrigation facilities.

(a) Conveyance Efficiency

(i) Large irrigation system

Conveyance efficiency is assumed as follows considering that all the canals are of lining type.

J.J. Puello system : 0.85, the same as the present condition.

YSURA canal to the YSURA area : 0.85, since the conveyance efficiency is expected to be improved by replacing privately installed-pipe intakes with permanent ones with proper water management.

Other systems : 0.9, the same as the present condition.

(ii) Small irrigation system

The conveyance efficiency is assumed to be 0.9, the same as the present condition.

As for the pump irrigation system located along the lower reaches of the Yaque del Sur river, the conveyance efficiency is assumed to be 0.9 in consideration that the pump irrigation systems are unified into a large irrigation system, instead that it has been neglected in the estimate of irrigation water requirements in the present cropping patterns on the assumption that the conveyance efficiency is included in the field canal efficiency since the conveyance system is short.

(b) Field Canal Efficiency

All the major existing field canals are supposed to be of lining type furnished with a night storage pond at the head of a field canal. Irrigation water supply is limited during the daytime when farmers are working in their fields. Considering such a future situation, the field canal efficiency is supposed to be 0.8.

(c) Field Application Efficiency

Water application to fields is carried out during the daytime when farmers are working in the fields, so that the high irrigation application efficiency is expected under proper water application practices. Here the field application efficiency is estimated at 0.65 for upland crops and 0.80 for paddy. The reason why high field application efficiency is adopted in the paddy fields is that the percolation losses are already incorporated into the irrigation water requirements. Based on the above considerations, the irrigation efficiency is determined as shown below.

(d) Irrigation Efficiency

Irrigation efficiency with project condition is estimated as follows:

Irrigation systems other than J.J. Puello and YSURA areas

0.47 for upland crops
0.58 for paddy

J.J. Puello and YSURA areas

0.44 for upland crops
0.54 for paddy

(3) Leaching Requirement

(a) Necessity of Leaching

Electric conductivity (ECw) of the river water is 1.0 mmhos/cm at Santana headworks according to the measurement in January and February in 1998. Evapotranspiration (ET) in one cropping season of upland crops is estimated in the range from 500 mm to 800 mm, approximately 650 mm on an average. The design field application efficiency is set at 0.65 as previously described.

Major crops Tomato (medium tolerance)
ECe = 2.5 mmhos/cm at 100 % yield level
ECe = 3.5 mmhos/cm at 90% yield level
Corn, sugarcane (low tolerance)
ECe = 1.7 mmhos/cm at 100 % yield level
ECe = 2.5 mmhos/cm at 90% yield level

From Table 36 of crop water requirements FAO Irrigation and Drainage Paper 24

Leaching requirements are calculated by the following equation substituting the ECe of the expected yield potential of crops.

$$LR = \frac{ECw}{5(ECe) - ECw}$$

LR

Yield level	100%	90%
Tomato	0.09	0.06
Corn	0.13	0.09

Water requirements (AW) to satisfy both ET and leaching are calculated by the following equation.

$$AW = \frac{ET}{1 - LR}$$

AW

Yield level	100%	90%
Tomato	712	692
Corn	750	712

In order to properly irrigate to meet ET of 650 mm, water amount of 1000 mm is

required. As the amount estimated by the field application efficiency of 0.65 is extremely larger than AW to satisfy both ET and leaching, no additional water is required for leaching under proper irrigation practices.

(b) Leaching Requirement for Restoring the Salinized Area

The Santana sugarcane area has been partly abandoned with no cropping due to soil salinization. According to the Feasibility Study of Barahona Sugarcane Area, CEA - World Bank, 1986, the salinity level in the sugarcane fields is as follows:

Category of Salinized Area in Santana Area

Area Category	EC (mmhos/cm)	Area (ha)
1	Less than 4	9,100
2	4 to 8	1,100
3	8 to 16	2,200
Total		12,400

Requirements for leaching are estimated by the following equation.

$$\frac{Dw}{Ds} = \frac{1}{5C/Co} + 0.15 \qquad \text{(Reeve et. al.)}$$

Dw/Ds = Amount of water(Dw) to soil depth (Ds) to be leached
C/Co = Last salinity level (C) to Initial salinity level (Co)

In case that soil salinity level is lowered to 2 mmhos/cm in which almost all crops can grow with no crop yield decrease, the following amount of water is required.

Area Category	Leaching requirement (mm) in Soil Depth of 60 cm
1	no need of special leaching
2	450
3	810

Also, leaching requirements can be estimated by the following equation.

$$Y \quad n1*n2*n3*400x*100 \qquad \text{(Kovda)}$$

Y = Leaching requirement
x = average containing soluble salt
n1 = soil coefficient , sand = 0.5, loam = 1.0, clay = 2.0
n2 = coefficient of groundwater level, 3.0 for depth 1.5 - 2 m, 1.5 for depth 2 - 5 m, 1.0 for 7 - 10 m
n3 = coefficient of salt content in groundwater, 1.0 for low, 2.0 for medium, 3.0 for high.

Area Category	Leaching requirement (mm)
1	no need of special leaching
2	480
3	960

Under the condition that n1 = 1, n2 = 3.0, n3 = 1.0, x = 0.4 for area 2 and 0.8 % in area 3

From these preliminary estimations, about 800 to 1,000 mm of water is required for restoring the Salinized area of category 3 and 400 to 500 mm of water for the area of category 2.

(4) Irrigable Area and Irrigation Water Requirements

The irrigable areas balancing with the available water resources of the Yaque del Sur river in the drought year of 80 % dependability with project condition are summarized in Section 4.7.2 and in each of irrigation systems presented in Table 4.5.1 with the irrigation water requirements. The summary is shown in the following table. The requirements do not contain the leaching requirements for restoring the salinized area, because the leaching works for restoring the salinized areas can be done during the wet season when the water resources is larger than the irrigation water demands.

Summary of Irrigation Water Requirements in the Area served by the Yaque del Sul River balancing with the available river water resources with Project Condition

(Drought in 80% dependability)

Irrigation Zone & System	Nov.	Dec.	Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
San Juan Irrigation Zone													
J.J.Puello	4.4	11.9	19.0	10.2	2.8	2.4	7.1	13.8	11.7	10.2	6.2	4.1	103.7
San Juan	3.0	10.7	18.6	10.5	3.1	1.5	6.8	13.8	13.5	11.3	7.8	4.6	105.4
Hato de Padre	0.6	2.4	4.4	2.5	0.9	0.6	2.3	4.2	3.9	3.5	2.6	1.5	29.4
Guanito S. Juan	0.4	1.8	3.2	1.6	0.2	2.0	3.1	4.7	3.9	2.7	1.3	0.5	25.4
Other systems	0.7	2.8	5.2	2.9	0.9	0.6	2.7	5.2	4.9	4.4	3.1	1.8	35.3
Mijo	2.7	3.5	5.2	3.1	1.3	1.1	3.2	5.8	7.2	5.6	4.2	3.1	45.9
Vallejuelo	0.9	1.0	0.4	0.1	0.2	0.3	0.2	0.5	0.5	0.3	0.1	0.1	4.5
Total	11.8	33.0	55.5	30.8	9.3	8.3	25.1	47.6	45.2	37.7	25.1	15.5	345.0
Azua Irrigation District Zone													
YSURA H.R	1.5	2.2	2.7	2.2	1.8	1.6	1.3	1.8	2.6	1.9	1.3	0.9	21.9
A&B	2.8	3.4	3.6	3.8	4.3	3.9	3.0	3.8	5.1	3.7	2.5	1.6	41.5
YSURA area	13.0	19.4	20.4	19.3	17.3	17.8	14.5	17.7	19.3	13.5	8.8	5.6	186.7
Total	17.3	25.0	26.7	25.4	23.4	23.4	18.9	23.4	26.9	19.2	12.6	8.1	250.1
Yaque del Sur - Lago Enriquillo Zone													
Area A1 (Azua)	4.1	5.9	7.3	7.3	6.7	4.8	3.8	5.2	7.7	5.9	3.9	2.5	65.0
Area B1	5.6	6.2	7.0	7.0	8.5	7.9	6.6	7.1	9.7	7.8	6.3	5.3	85.0
Aguacatico	1.5	1.6	1.9	1.8	2.2	2.1	1.8	1.9	2.5	2.0	1.7	1.4	22.5
Area B2	23.1	26.7	28.6	22.3	20.8	20.1	20.7	25.5	35.9	31.5	29.7	22.0	306.9
Area B3	5.8	6.4	7.2	7.2	8.6	8.1	6.7	7.2	9.9	7.9	6.5	5.4	86.9
Area B4	0.7	0.8	0.9	0.9	1.1	1.0	0.9	0.9	1.3	1.0	0.8	0.7	11.3
Area B5	3.3	3.7	4.1	4.1	4.8	4.5	3.7	4.0	5.5	4.5	3.7	3.2	48.9
Area B6	5.8	6.3	7.0	6.8	8.2	7.6	6.2	6.8	9.4	7.7	6.5	5.6	83.7
Total	50.0	57.6	64.0	57.5	60.9	56.0	50.2	58.7	81.8	68.3	59.1	46.0	710.1
Grand Total	79.1	115.6	146.2	113.7	93.6	87.7	94.2	129.6	153.9	125.2	96.9	69.6	1305.2

YSURA H.R : a group of small areas directly derived water from YSURA Head Race by private pipes.
A&B : Amiama Gomez & Biafara area, newly completed project
YSURA area : including the extension area about 1,140 ha
Area A1 : irrigation area in the reaches from Villarpando to Los Guiros up (Azua Irrigation Zone)
Area B1 : irrigation area in the reaches from Los Guiros to Santana upstream
Area B2 : Santana irrigation area
Area B3 : irrigation area in the reaches from Santana downstream to Tomate-Mena upstream
Area B4 : irrigation area in the Tomate-Mena system
Area B5 : irrigation area in the reaches from Tomate-Mena downstream to Palo Alto upstream
Area B6 : irrigation area in the reaches from Palo Alto to the sea.

4.5.3 Irrigation and Drainage Development Plan in San Juan Irrigation Area

(1) Night Storage Pond Projects

The project area lies in the San Juan area, comprising i) J.J.Puello irrigation area (10,986 ha), ii) Hato del Padre irrigation (2,059 ha), San Juan irrigation area (5,526 ha) served by San Juan river and iv) Mijo irrigation area (2,390 ha) served by Mijo river. General location of the projects which planned in the study are shown in the General Map.

To allocate more amount of water to the Jose Joaquin Puello area is hardly possible from the water resources point of view as well as other systems such as the Hato de Padre and the San Juan served by Sabaneta dam. The irrigation systems from the main to tertiary canals is improved by the other projects such as PRODAS and PROMASIR with provision of concrete lining and elevated flumes and thus the conveyance system efficiency is assumed to be rather high. In order to further enhance the irrigation efficiency, it is proposed to

provide night storage ponds so that the irrigation water is once stored in the ponds during night time and released during daytime from early morning to evening when farmers are working in the fields. The night storage ponds should be located near the benefited fields so that the water users easily control the water distribution from such ponds. In the J.J.Puello, the heads and the middle reaches of laterals, where a drop structure exists or extra energy head is available will be the sites proposed for the ponds.

Typical features of a night storage pond is shown in Figure 4.5.1

(a) Basic Plan of Facilities

Night storage pond consists of following components; i) a storage pond in a rectangular shape surrounded by earth dikes, which is coated with concrete or equivalent impermeable materials at bottom and side, ii) inlet and outlet structures equipped with manual operating steel slide gates, iii) spillway for returning excess water safely to the parental canal and iv) connection canals between the parental canal and the pond. The pond can easily take an effective water depth of 1.5 m, if the pond is located by the existing drop structure, since the canal longitudinal gradient is rather steep. Only the major disadvantage of this solution is that it will be necessary in some cases to use a current agricultural area to provide the pond. The required area for provision of pond in San Juan area is, however, estimated at only 102 ha, which account for only 0.4 % of total area (20,958 ha).

The pond will be provided so as to have its commanded area in the range from 500 ha to 1,000 ha taking into consideration of delivering distance of irrigation water and its time lag (irrigation water should be conveyed from the pond to the farthest fields within two hours so as to immediately response to the field water demands). Capacity of a night storage pond is calculated based on this command area, the peak irrigation requirement of 1.1 lit./sec/ha and operation time of 12 hours.

There are two type of connection between canal and pond. One is parallel connection type and another is direct connection type. In both methods, there are advantages and disadvantages from operational, economical and engineering point of view. Thus selection of type of connection should be carefully done based on actual conditions. The conceptual sketches are shown in Fig. 4.5.1

In the water management after provision of ponds, it is important that distribution and field canals convey water with their full capacity during the day time and rotation will be made in each of distribution blocks in order to keep high irrigation efficiency. Amount of water supply is mainly adjusted by irrigation supply hour and not by discharge.

The night storage ponds will request the farmers organization to rearrange irrigation associations managing lateral blocks, which divide the existing irrigation area into some number of sub-area to meet the requirements of the water management with night storage ponds. Farmers and gate operators should be trained.

(b) Project Works

System	Area	Night Storage Ponds: Total capacity of ponds ($x10^3m^3$)	Nos. of ponds	Volume of earthwork ($x10^3m^3$)
J.J. Puello	10,986 ha	523	15	560
Hato de Padre	2,559 ha	98	3	120
San Juan	5,526 ha	263	8	300
Mijo	2,390 ha	114	5	170

(2) Guanito San Juan System Improvement Project

(a) Basic Plan of Facilities

Guanito San Juan area is located at the southern part of San Juan river and irrigated by San Juan river. The irrigated area is 1,000 ha in total.

Main purpose in this project is improvement of efficient use of the limited irrigation water resources as well as in the other irrigation systems in San Juan area. Comparing with other systems, the irrigation efficiency in Guanito San Juan system seems not to be so high, because the earth canal occupies approximately 40 % of total length in the main conveyance system.

In order to reduce seepage loss in canals, the earth canal sections should be improved with concrete lining. Also, night storage ponds mentioned in the previous section is proposed to be provided in the canal system.

(b) Project Works

- Total irrigation ; 1,000 ha
- Total storage capacity of the night storage ponds ; 48,000m^3
- 2 nos. of ponds with inlet, outlet, spillway structures and connection canals
- Total volume of earth work ; approximately 70,000m^3
- Concrete lining in the last reaches of 8 km of the main canal.

4.5.4 Irrigation and Drainage Development Plan in Azua Irrigation Area

Azua area is irrigated by the water diverted at Villarpando / Tabara Headworks and delivered through YSURA Headrace and YSURA Main canals. The irrigation area in Azua are divided roughly into the following areas; i) YSURA improvement area (7,732 ha), ii) YSURA extension area (2,275 ha), iii) YSURA headrace small irrigation area (1,100 ha), iv) Small gravity irrigation area (2,370 ha, exclude [B1] area located in Neyba/Barahona area)

Irrigation development in the Azua area should be concentrated in the reinforcement of present YSURA Irrigation Committee with the improvement of existing facilities including the extension area between the Jura river and the Via river and the improvement of drainage condition in the southern part of the Azua area where the symptom of salinity is revealed due to the poor drainage condition. The improvement of drainage systems will be implemented under PROMATRES. General location of the projects which planned in the study area shown in the General Map.

(1) YSURA Area Improvement Project

In YSURA improvement area (in total 7,732 ha), the main canal, 6 numbers of lateral canals with related structures serve water to the field. The condition of irrigation facilities are quite well in general, but some structures, specially steel slide gates in the intake structures, seem to have problems for proper daily operation as well as Tabara Headworks.

(a) Basic Plan of Facilities

(i) Repairing or replacement of damaged gates on YSURA conveyance system including Tabara Headworks.

(ii) Improvement of facilities with provision of the night storage ponds in the YSURA area

According to the interview survey to farmers in Azua plain, they execute irrigation even at night time in accordance with the irrigation schedule, but the most of the farmers do not want to work during night time. Actually night time irrigation practices are difficult in the dark and resulted in low irrigation application efficiency, and it is resulted in water logging and waste of much amount of water. These phenomena also expedite the drainage problem. Irrigation should be primarily carried out during daytime when farmers are working in the fields. It is, therefore, proposed that the night storage pond system mentioned in the section 4.5.3 should be applied in YSURA area.

(b) Project Works

- Repair and replacement of gates of turnouts, checks and other related structures on YSURA Main and lateral canals, approximately 180 structures
- Repairing damaged portion of concrete lining on YSURA Main, lateral canals and distributor system.
- Replacement of gates at Tabara Headworks;
  1) 3 nos. of slide gates with motor-driven lifting device : 1.9m (B) x 2.5m (H)
  2) 1 radial gate with motor-driven lifting device : 4m (B) x 7.2m(R),
- repairing of related structures at Tabara Headworks [i.e. protection works located at downstream portion of sand flashing gate etc.],

- Night Storage Ponds

Lateral	Area (ha)	Total capacity of ponds ($x10^3$ m^3)	Nos. of ponds earthwork	Volume of ($x10^3$ m^3)
1	2,237	107	5	149
2	1,116	54	2	66
3	184	-	-	-
4	1,104	53	2	66
5	1,408	67	2	75
6	1,683	80	3	101
Total	7,732	361	14	457

Note: Total capacity is estimated on the assumption of the peak irrigation requirement of 1.1 l/s/ha and 12 hours operation for water releasing from the pond.

(2) YSURA Extension Area Development Project

The project area is 2,275 ha in total, located at the downstream reaches of YSURA irrigation area between the Jura river and the Via river, and served by old and quite poor irrigation systems consisting of poor earth canals and deteriorated related structures. Based on results of the water balance study and the evaluation of the groundwater survey, it is recommended that both of water resources, surface water and groundwater can be utilized for improvement of irrigation system in this area.

(a) Basic Plan of Facilities

(i) Surface water irrigation system

Surface water from YSURA Main canal takes charge of half of the extension area, which is about 1,138 ha, thus the design capacity of the canal should be 1.3 m3/sec. Canal dimension is roughly calculated as follows;

height:	1.8 m
bottom width:	1.5 m
side slope :	1.5 : 1

(ii) Groundwater irrigation system

Remaining area (1,137 ha) will be irrigated by groundwater. A command area for a pump station is assumed to be from 20 to 30 ha and depth of well is approximately 100 m from the point of view of economical capacity of a pump, its water recharging rate from aquifer into a well hole and surface irrigation distance. Based on the command area, unit irrigation requirement (1.1 lit/sec/ha) and actual operation hour of pumps, a capacity of pump will be set around from 30 to 50 liter/sec. After pumping up, water will be delivered through a traditional irrigation system or a sprinkler system to the plot.

(b) Project Works

- Improvement of YSURA Main Canal with concrete lining in the downstream

extension reaches about 8 km,

- rehabilitation and improvement of existing canal system with concrete lining (lateral canal ; 10 km),
- provision of 2 nos. of night storage ponds in the extension area of about half of the extension area (1,138 ha ; capacity = 55,000m^3)
- reinforcement of water users organization, which will be incorporated into the YSURA Committee.
- provision of approximately 60 of deep wells with sprinkler irrigation system.

(3) YSURA Headrace Small Irrigation System Improvement Project

Small Irrigation System for 1,100 ha of total area is located discontinuously along south side of YSURA Headrace canal. This area is irrigated by the water from YSURA Headrace canal through the privately installed portable pipes. Because of disorder of farmers' activities for taking water from the headrace, farmers tend to take the irrigation water much more than that they need. It causes a lot of water losses and water logging problems in the downstream reaches. The project aims to improve put such a disorder by setting up and reinforcing a water users organization and installation of permanent intake structures.

(a) Basic Plan of Facilities

Newly installed intake should be permanent structure comprising a cast iron pipe (diameter: 150 to 250 mm), steel manually operated valve, concrete casing and protection works. Location of new intake should be selected so as to unify the existing private small-scale pipe intakes as much as possible. Conveyance systems between the permanent intakes and farm plots will be improved by lining concrete and establishment of related structures.

(b) Project Works

- Installation of new intakes on YSURA Headrace canal ; 75 nos.
- Improvement of conveyance system for total area of 1,100 ha.

4.5.5 Irrigation and Drainage Development Plan in Lago Enriquillo and Yaque del Sur Irrigation Area and Small Gravity Irrigation System Improvement Project

Irrigation development in the Lago Enriquillo and Yaque del Sur Irrigation area should be proceeded placing an emphasis on the rehabilitation and improvement of the existing deteriorated irrigation and drainage systems. Without rehabilitation and improvement, water users' organizations, which is proposed to be established can not properly manage the irrigation systems.

the Lago Enriquillo and Yaque del Sur Irrigation area are divided into three projects and its locations are shown in the General Map.

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

(a) Basic Plan of Facilities

Yaque del Sur Lower Reaches Irrigation and Drainage Improvement Project is located at downstream of Santana Headworks, and irrigated by the water from Santana Headworks in the whole area (19,458 ha).

The main components of the facilities proposed by this improvement project are as follows ; i) Santana Headworks, ii) Santana irrigation system (sugarcane area), iii) left bank irrigation system and iv) other irrigation systems.

The Santana irrigation system, which was built in 1916 should be completely improved in whole the area with provision of concrete lining and night storage ponds, etc..

Many small irrigation systems, of which the most are served by pumps located along the lower reaches of the Yaque del Sur river can be unified into two long main canal systems every left and right side areas of the Yaque del Sur river. The right side area will be served by the existing Santana canal system to be completely improved. The left side area will be served by a new canal. Some small pump irrigation systems excluded reluctantly from the above gravity systems due to the geographical difficulty will be improved with canal lining rehabilitation and provision of the related structures.

The Santana headworks is conceivable as an intake site for the proposed left side canal as well as the Santana main canal. In this context and as a series of the improvement of Santana system, the existing intake and sand flushing sluice will be demolished and a new intake structure will be constructed for both right bank Santana system and the left bank system. As the river water flow is biased along the right bank side, which is a concave side where the intake exists, the new intake will be constructed at the same place as the existing intake and a conduit will be provided across the river to convey water to the proposed left side canal. The fixed weir of the Santana will be improved on the surface and the downstream apron. The right and left main canals will be laid out so as to connect the main canals of the existing irrigation systems served by pumps at present. At or near every connecting points, night storage ponds will be provided.

General Layout of the irrigation system is shown in Fig. 4.5.2.

(b) Project Works

(b-1) Diversion Structures at Santana Headworks

- Demolishment of facilities;
  1) Intake structures at right side bank for Santana irrigation system (12,000 ha)
  2) Sand flushing sluice including radial gates [2.5m (B) x 2 nos.] with downstream protection works; total volume of demolished concrete = 1,000 m3 approximately.
- New facilities ;
  1) Unified intake structure for right and left bank area ;
     (i) capacity : 22.0 m3/sec in total

(ii) gate : 5 nos. of steel roller gates [dimension = 1.5m (B) x 1.5m (H)] with motor-driven lifting devices

(iii) Box culvert conduits connecting between intake and main canals

2) A siphon conduit conveying water from the intake at right side to the proposed left side canal system ; Double box culvert [rectangular 1.5m(B) x 1.5m(H)] approximately 150 m in length with steel gates at its inlets.

3) Sand flushing sluice with 2 nos. of steel roller gates [dimension; 3.0m (B) x 3.0m (H)] with motor-driven lifting devices and protection work of stone masonry.

- Rehabilitation of facilities

1) Concrete fixed weir ; :approx. 1,700m^2 for surface treatment

2) Protection work around the weir

(b-2) Conveyance system

- Rehabilitation / construction of the Santana system, left bank, and other irrigation system

Total canal length for main, lateral, distribution and field canals ; 900 km for 20,000 ha in total

- Night Storage Ponds

system	Area (ha)	Total capacity of ponds (x10^{3}m^3)	Nos. of ponds	Volume of earthwork (x10^{3}m^3)
Santana	12,000	580	17	640
Left bank	5,800	340	10	370
Other area	2,200	110	4	150
Total	20,000	1,030	31	1,160

Note: Total capacity is estimated on the assumptions of the peak irrigation requirement of 1.1 l/s/ha and the operation time of 12 hours for releasing water from a pond.

(2) Galvan Groundwater Irrigation Project

(a) Basic Plan of Facilities

A command area for a pump station is assumed to be from 20 to 30 ha and the depth of well is approximately 100 m from the points of economical capacity of a pump, its recharging rate in a well from aquifer, and surface irrigation distance. Based on the command area, unit irrigation requirement (1.1 lit/sec/ha) and actual operation hour in field, a capacity of pump will be set around from 30 to 50 lit/sec.

(b) Project Works

- Provision of approximately 20 numbers of deep wells with pumps.

- Construction of distribution and field canals.

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

This project consists of the improvement of small free intake irrigation systems along the Yaque del Sur river in the downstream reaches from the Guanito San Juan system, Villarpando headworks to Santana headworks and Vallejuelo irrigation system in San Juan.

(a) Basic Plan of Facilities

All the free intakes along the Yaque del Sur river will be improved with provision of intake structures each equipped with a steel gate and a measuring device. The gate should be a steel slide gate easily operated by manual and having an easy maintained lifting system. One of the important points is to be strongly-built standing against flood. In order to cope with flood, the inlet portion of the intake should be protected with concrete wall and head reaches of the conveyance canal where is frequently exposed to the danger of flood submergence will be strongly built or protected by concrete lining and stone masonry so as not to be washed away. A measuring device (a broad crested weir or a Parshall flume) will be furnished near the inlet so as to evaluate the amount of water diverted to the canal. Major canals will be improved with concrete lining in the reaches where seepage loss is large. Access roads with gravel pavement will be provided for the convenience of daily operation activities.

Fig. 4.5.3 shows the sample of the improvement works for an existing free intake.

(b) Project Works

- Installation of new intakes along the Yaque del Sur River ; 40 nos.
- Improvement and/or construction of the access road to each of intakes for 2 km on an average.
- Provision of concrete lining and related structures.
- Protection works against a flood ; 1km for concrete lining / stone masonry

4.5.6 Operation and Maintenance Plan

INDRHI is taking the initiative to operate and maintain the irrigation and drainage facilities through the Irrigation District Offices at present. Even in the area where the water users organizations (WUO) are existing, INDRHI staff are directly participating in the operation and maintenance (O&M) managed by the WUO or occupy key positions in the organizations. In the above aspect, the existing WUOs have not completely set themselves up in O&M management yet. Actually the O&M management is poor not only on INDRHI and WUO levels but also on farmer's level. It is causing several problems in the fields such as waste of water, water-logging, soil salinization, destruction of arable lands and water dispute between farmers.

It is essential that all the irrigation and drainage facilities should be operated and maintained by the farmers themselves. For this purpose, the farmers in every irrigation systems should organize a WUO and in line with this policy, the operation and maintenance

plan is discussed in this section.

(1) Operation

As explained in the previous Section 4.4, water stored in the reservoirs is to be released in accordance with the water demands in the downstream basin.

A cropping program and an irrigation schedule are prepared immediate before the cropping season. Water released from the dams and flowing the river is diverted from the river at the intake of each of irrigation systems and conveyed through the conveyance system up to the night storage ponds on the 24 hours basis in the case of the large irrigation systems. Then, water is once stored in the ponds during the night time and distributed from the ponds through distribution and field canals to the fields during the daytime. In the small irrigation systems, it is proposed that water is diverted from the river to the fields during the daytime by daily operation of the intake gates.

(a) Preparation of Seasonal Irrigation Schedule

It is very important to prepare the cropping plan and irrigation schedule for the proper water management, since the irrigation systems from the heads to the field level are operated basically in accordance with the irrigation schedule. It is also essential that each of farmers recognizes how many hectares can be irrigated by the available water resources in his field before the planting season in order to avoid water dispute among them. Thus the operation is started from the preparation of the irrigation schedule in consideration of seasonal cropping plan and the available water resources. The following procedure to prepare the irrigation schedule is one of the example which can be applied.

(i) Preliminary estimate of the irrigation water requirements : Each of the Irrigation District Offices provisionally estimates the irrigation water requirements based on the last year's and/or typical cropping patterns and hands over them to the proposed Yaque del Sur Water Management Center.

(ii) Preliminary estimate of the irrigable area : The Center estimates the irrigable area for the coming cropping season through the water balance study between the water demands and available amount of water estimated from actual storage in the reservoirs, rainfall and river discharge tendencies. Then, the Center informs the Irrigation District Offices the preliminary estimated irrigable areas with the estimated available amount of water.

(iii) Preparation of draft cropping program : Each of the Irrigation District Offices fairly allocates the irrigable areas to every irrigation systems and informs them to the WUOs. Based on this, the WUO assists and advises each of member farmers to make a draft crop planting plan (CPP) considering an irrigable area to be allocated to him from the view point of available water resources, because it is very important that the organization adjusts the total cropping area to be nearly equal to the estimated irrigable

area. Farmers make the draft CPP simply composed of kind of crops, planting area, and planting schedule and submit it to WUO.

Each of the WUOs compiles the draft CPPs at each of the field distribution canal level, the lateral level, and the diversion points from the river, checking the cropping areas from the view point of the balance and fairness among irrigation systems.

(iv) Estimate of the irrigation water requirements : the Irrigation District Offices estimate irrigation requirements at the diversion points from the river based on the draft CPPs.

(v) Estimate of the irrigable area : the Center estimates the irrigable areas through the balance study between the irrigation water requirements and available amount of water simulated from actual storage in the reservoirs and rainfall and river discharge tendencies and inform them to the Irrigation District Offices and WUO.

(vi) Revision of the CPPs : the Irrigation District Offices and the WUOs revise the irrigated cropping areas of the CPPs at the diversion points from the river in order to meet the allocated amount of water resources.

(vii) Authorization of irrigation area : the Center holds a meeting under the attendance of the chiefs of the Irrigation District Offices and the WUOs and person in charge of CDE in order to authorize the irrigation areas and the allocation plan of the expected available water resources at the diversion points from the river and the water-releasing plan from the dams.

(viii) Finalization of the CPPs : Immediate after the authorization, the WUO adjusts fairly among the farmers the draft CPP of the individual farmer such as the irrigated cropping areas and the planting date under the participation of the farmers so that the total cropping areas meet the total areas authorized in the step 7. Then the WUO integrates the CPPs at each of the field distribution canal level and the lateral level.

(ix) Preparation of irrigation schedule : Based on the CPPs at the head of the field distribution canal level and the lateral canal level, WUO estimates irrigation water requirements at the respective levels.

(b) Preparation of monthly or half-monthly Irrigation Schedule and water distribution schedule

Based on the irrigation schedule, a water distribution schedule, which mentions the time schedule of water delivery to every fields and discharge is prepared in each of the distribution system or in each of the small irrigation systems by the irrigation sub-committees.

During the cropping season at least once or twice, the WUO should investigate

the kind of crops and the cropping area in the field and compile them at the irrigation system head level. Based on these data, the WUO or the Irrigation District Office should estimate the irrigation water requirements and modify the seasonal irrigation schedule, if necessary and inform to the Center. When a drought is expected, the Center should instruct the Irrigation District Office and WUO to modify the irrigation schedule and water distribution schedule in consideration of the decrease of the allocated amount of water. The crop sensitivity to the water shortage is also taken into account in the modification of the irrigation schedule.

(c) Operation of large gravity irrigation system

(i) Headworks and conveyance system

Water is continuously diverted from the river and conveyed through the conveyance system to the night storage ponds. The intake gates should be operated to divert water in accordance with the irrigation schedule. When a flood comes, the intake gates should be fully closed. The check and offtakes on the conveyance system are adjusted once or twice a month in accordance with the irrigation schedule. While during the drought period when water resources are expected to be insufficient against the water demands, rotational water supply may be made among the irrigation systems, the same as at present in such that the J. J. Puello receives water for 3.5 days a week and the Hato de Padre and San Juan irrigation systems get water for the other 3.5 days and also among the lateral canals. The intake gate of the headworks will be operated by the technical staff employed by WUO under the supervision of the staff of INDRHI. The technical staff also operate all the control structures.

(ii) Night storage ponds and distribution systems

During the night time, water delivered through the conveyance system is once stored in the night storage pond. At the morning time, the outlet gate of the pond is opened and water is distributed from the pond to fields through a distribution canal system. It is important that distribution and field canals convey water with their full capacity during the day time and rotation will be made in each of Nucleus blocks in order to keep high irrigation efficiency. Amount of water supply is mainly adjusted by irrigation supply hour and not by discharge. The control gates of the night storage ponds should be operated by the technical staff employed by WUO. In the distribution system, farmers themselves distribute water in accordance with the predetermined water distribution schedule operating small offtake gates. During the irrigation application day, the farmer whose farms are to be irrigated shall always manage water in his fields. Without his presence, water should not be delivered.

(d) Small gravity irrigation system

In case of the small gravity irrigation systems, which are proposed to be improved with the provision of an intake gate, water is diverted during the daytime only in accordance with the authorized irrigation schedule. The intake

gate should be opened at the morning time and closed at the evening time. During the drought period when water resources are expected to be insufficient against the basin water demands, rotational water supply will be made between the small irrigation systems. The intake gate should be operated by the technical staff of WUO. The canal facilities should be operated by the member farmers themselves. During a storm time the intake gate should be completely closed.

(2) Maintenance

(a) Classification of maintenance works

The maintenance works are broadly classified into routine maintenance works and emergency repair works. The routine works are composed of routine inspection and maintenance works and minor repairing and rehabilitation works. The routine inspection and maintenance works are periodically carried out in accordance with the predetermined maintenance schedule. These are :

- routine inspection of irrigation and drainage facilities,
- lubrication of the spindles of all the steel gates,
- removal of floating debris from the front of the inlet of headworks and the front of inlets of culvert, checks, and siphons,
- removal of sediments from the inside of small canals,
- weeding and rooting trees up from the right of way of canals.

Of the minor repairing and rehabilitation works, portion of the facilities above the water surface should be repaired and rehabilitated throughout a year in accordance with the maintenance schedule. These works are :

- heightening depressing portions of canal embankment with earth materials,
- reshaping the outside slope of canal embankment, etc..
- repairing cracks of canal lining in small canals.

In the maintenance period, all water in the irrigation canal systems should be completely drained and dried up and damaged portions of canal inside should be repaired. Major maintenance works during the maintenance period are as follows:

- removal of deposits and weeds from canal insides.
- repairing eroded and damaged portions of canal insides.
- painting of the gates' frame and leaves

(b) Share of maintenance works

Small distribution and field canals will be maintained by farmers themselves of every Nucleuses as a communal work. Nucleus chief or representatives of member farmers will prepare a maintenance schedule for distribution canals and the correspondent drains containing an allotment of works to every farmers and the date of the works. Technical staff of WUO will advise the Nucleus to prepare it especially for

adjusting the date among the distribution systems so as not to coincide it each other. Generally, the maintenance works are carried out twice to four times a year. Every farmers should attend the maintenance works of the distribution canals and the drains with tools. If he can not attend, his proxy should attend or he will pay some amount of money to employ labors for maintenance works. All the maintenance works except the maintenance of concrete and metal works will be directly executed by farmers themselves. Concrete works and metal works will be maintained and repaired by technical staff employed by WUO. As for the field canals, which covers a few farmer's fields, farmers who own the fields covered by the field canal should maintain the field canal in cooperation with each other.

Major irrigation facilities such as headworks, main and lateral canals, the related structures, night storage ponds, and major drainage canals will be maintained by the staff employed by WUO with light equipment on WUO's responsibility. WUO will employ maintenance staff on a permanent basis and labor and routine maintenance workers on a part time basis. The technical staff will prepare the annual maintenance schedule in consultation with the Irrigation District Office containing the date, the location, the kind of works, number of staff and labors, equipment and tools to be mobilized, and the expenses. Then WUO will authorize the schedule. In accordance with this schedule, the technical staff will manage maintenance works mobilizing laborers with light equipment and tools. The representative of farmers including the farmers relating to the maintenance site will evaluate the quality of the maintenance works including performance of the maintenance workers. In case that the emergency repairing or a large-scale maintenance and repairing is required, the Irrigation District Office will assist WUO to repair the damaged portion or to carry out the large-scale maintenance works mobilizing construction equipment owned by the Irrigation District office.

(c) YSURA Headrace Maintenance Project

YSURA Headrace suffers from the surface sliding and erosion in the upstream reaches. Sand continuously falls the slope and enters into the canal. Large fallen stones are also observed. Fortunately the design canal capacity is 25 m3/sec, while water demands is 12 m3/sec and the canal still has a capacity more than 12 m3/sec. The slope consists of loose and fragile materials. To remove all the dangerous materials is very costly. To remove eroded materials constantly as a series of the maintenance works is the most realistic measures at present. By this means, a horizontal space or a berm between the canal and the lower end of the slope should be kept in order to deposit the eroded materials on the berm and to prevent from entering much amount of the eroded materials into the canal. For this purpose, a work force is proposed to be arranged under the Azua Irrigation District office. The force will work in the site throughout a year with a shovel-dozer and a few tippers.

(3) Sub-projects for data arrangement for O&M and water-saving management

(a) Data arrangement for O&M works

Both the Irrigation District Offices and the Irrigation Committees have not sufficient data of irrigation and drainage facilities such as length of canals, canal commanding areas, canal dimensions, physical conditions of canals including the related structures, cropping data such as kind of crops, planting area and date, and cadastral data of agricultural lands or even if they have the sufficient data, staff often encounters the difficulty to find them and they waste much time to arrange them as required because the data are not systematically compiled in their offices. In such a poor condition, they can not make detailed irrigation and maintenance programs. If the data are not available or insufficient, field inventory survey should be carried out in detail. If cadastral maps are not available, the cadastral survey should be carried out. Or instead of it, if appropriate aerophotographs are available, agricultural area of each of farmers may be identified and measured on them with a supplemental field survey. All the data of irrigation and drainage systems including the related structures and the cadastral maps indicating the agricultural area of every farmers and canal layout should be kept in a computer by use of an appropriate data base software. These data should be updated every year. Based on these basic statistics together with climate data, practical O&M programs can be made. Together with these data, an information system in and between the organizations should be established.

(b) Project for studying irrigation method for water-saving in paddy field

Irrigation water supply to the paddy fields is largely classified into two methods such as continuous supply and intermittent supply. From the view point of water saving in the paddy fields, the intermittent supply is recommendable. Adopting the intermittent irrigation water supply, amount of irrigation water itself can be saved and also as the opportunity the field water depth is kept shallow is much, field storage function is kept high. It has been confirmed in the paddy field composed of sandy loam that if irrigation is applied 2 to 3 days after the field water depth is zero, water use efficiency is heightened from 3.6 kg/mm to 5.7 kg/mm, which is equivalent to the increase of 40 % in the water saving ratio, in the yield decrease of 7% or less (Water and Land Management Training and Research Institute (WALAMTARI): Brief note on project development and demonstration farm Chegal. 1996)).

Considering the above fact and actual deficit of water resources in the San Juan valley where paddy fields largely extends, it is proposed that INDRHI carries out the study including field experiments to establish the water supply method to the paddy fields. If not only improvement of irrigation efficiency, but also the amount of irrigation water itself can be reduced without yield-lowering, the crucial shortage of water is drastically mitigated.

Period	: a few cropping seasons
Site	: few sites depending on the soil types and topography
Staff	: one irrigation engineer, the site-own farmers, a few site operation staffs

Investigation items : field topography and soil properties, daily water depth, daily water level, daily inflow and outflow, crop yields,
Material and Equipment : small discharge measurement devises, water level recorders, etc..

(c) Experiment for restoring salinized area by leaching and monitoring salinity level

According to the water balance study, the irrigation area can be extended at the level of a few thousand hectares in the Lago Enriquillo and Yaque del Sur Irrigation District area. The most of the areas were, however, abandoned and contains much amount of salt. As explained in Section 4.5.2, leaching of salt needs much amount of water from 400 mm to 1,000 mm in depth. Generally intermittent leaching takes longer time than the continuous leaching, but the intermittent leaching needs smaller amount of water than the continuous leaching. In order to obtain the data of the leaching effect and to establish the leaching method, field experiments are proposed to be carried out in the detailed design stage. Drainage canal depth and the interval between the drainage canals also should be studied through field tests or tests in a pilot farm.

Period : a few months
Site : few sites depending on the soil types and salinity level
Staff : one irrigation engineer, the site-own farmers, a few site operation staffs
Investigation items : field topography including canal layouts and soil properties, daily water depth to be applied, daily groundwater level, daily outflow through drainage,
Material and Equipment : small discharge measurement devises, water level recorders, soil sampler, EC meter, thermometer, etc..

4.5.7 Organization

All the irrigation and drainage facilities to be rehabilitated and newly constructed will be operated and maintained by the farmers themselves. For this purpose, the farmers have to organize WUO in every irrigation systems and following to the set-up of WUO, the O&M works are committed from the Irrigation District and Zone Offices to WUOs.

(1) Irrigation District and Zone Office

At present in the area where no WUO is founded, INDRHI is directly managing irrigation and drainage systems through Irrigation District and Zone offices. In future, as WUO is founded one by one irrigation system, some of INDRHI staff will be employed by WUO as a technical and an administration staff and INDRHI will commit WUO to carry out water management and maintenance of irrigation and drainage facilities. Under such a situation, all the Irrigation District Offices will be reduced especially in the Conservation and Improvement Unit, the Water and Soil Management Unit, and the Pump Operation and Maintenance Unit. The Conservation Unit may be unified to the Supervision and Investigation Unit. All the zone offices will be also reduced and finally abolished. Major

functions of the Irrigation District Offices after WUO functions will be to supervise and assist WUO to make the water management in the irrigation canal system and O&M of facilities including preparation of overall irrigation program, to supervise major construction works carried out on the contract basis, and to send the data of diversion discharges from the River to the proposed water management center and record them as well as to maintain and operate the water measurement equipment to be installed at major diversion points.

(2) Water User's Organization (WUO)

All of the irrigation facilities rehabilitated and newly constructed by the Project will be operated and maintained by the farmers themselves. For the operation and maintenance of the irrigation facilities, the farmers in each scheme should organize a WUO. The proposed WUO in each scheme will be basically similar to the present Sabaneta Dam Irrigation Committee as described hereinafter.

(a) Objectives of WUO

The main objective of WUO is to operate and maintain the irrigation and drainage facilities in order to effectively use the limited water resources and to increase the agricultural productivity. The members of WUO is the water users of the irrigation systems, and its membership will be given to them, irrespective of their gender.

(b) Proposed Organization

The organization of WUO is basically similar to the present organization of the Sabaneta Dam Irrigation Committee. WUO will have an organization structure of member farmers corresponding to the irrigation system level as shown below.

Nucleus	One distribution canal or a few field canals level 1 - 50 farmers, 20 ha to 60 ha
Sub-committee	One night storage pond, one pump irrigation system level, or one or a few small independent irrigation system level 50 - 500 farmers, 100 ha to 1,000 ha
Association	One large irrigation system, large lateral canal or a group of the small irrigation systems 500 - 1,000 farmers, 1000 ha to 10,000 ha
Irrigation Committee (Junta de Regantes)	One irrigation zone benefited by one river

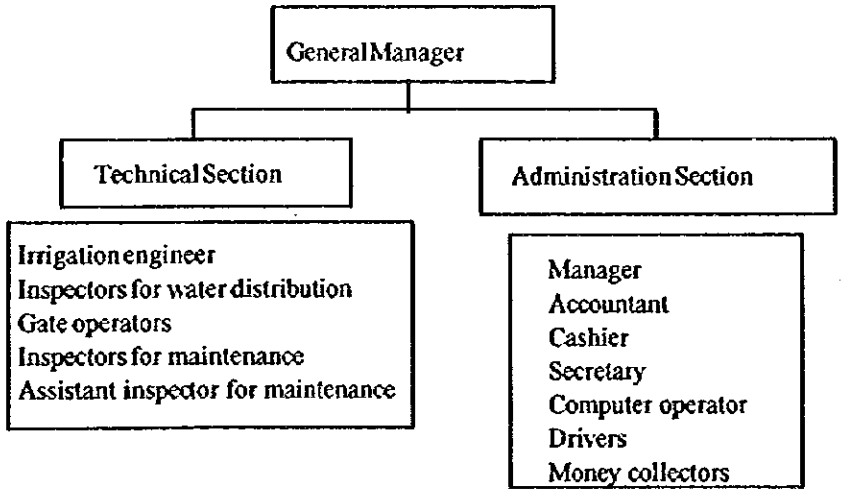
A small irrigation system, which is independent from the other systems such as Vallejuelo will be managed by a small Irrigation Committee having only a few Nucleuses. A medium-scale independent irrigation system like the Mijo irrigation system will be managed by an Irrigation Committee consisting of nucleuses and associations. In the existing Irrigation Committees, the night storage ponds will request the farmers organization to rearrange irrigation associations managing lateral blocks, which divide the existing irrigation area into some number of sub-area to meet

the requirements of the water management with night storage ponds.

The functions of WUO is almost similar to the present Sabaneta Irrigation Committee (see Section 3.5.2). WUO will employ technical and administration 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. Under the Board of Directors of an Irrigation Committee, a force of management staff will be organized under one manager.

The force is largely divided into a technical section and a management section. The technical section will be composed of an irrigation engineer, inspectors for water distribution and for maintenance, gate operators and part time labors. The irrigation engineer assists the manager in the technical management aspect and mainly does the preparation of irrigation schedules and maintenance schedules including the cost estimate for budgeting, and the supervision of water distribution and maintenance works. The inspectors for water distribution assist the irrigation engineer and do directly supervise the gate operators and instruct Nucleuses in the irrigation practices in their fields in accordance with the irrigation schedule. The gate operators operate gates in accordance with the irrigation distribution schedule and also maintain the gates with lubricant and remove floating debris in and around the gates. The inspectors for maintenance works assist the irrigation engineer in the maintenance works, prepare the detailed maintenance program and carry out the maintenance works in the fields mobilizing part-time labors. The part-time labors should be selected from petty farmers in the benefited area.

The administration section will be composed of a manager, an accountant, a cashier, a secretary, money collectors and so on.



The number of personnel required for O&M management depends on the scale of an irrigation system and frequency of routine operation and maintenance works. A

standard of the number of workers is assumed as follows:

General manager	: one person
Irrigation engineer	: one person for every 2,000 - 5,000 ha
Inspector for water management	: one person for every 1,000 - 2,000 ha
Gate operator	: one person for every 500 -1,000 ha
Inspector for maintenance	: one person for every 2,000 - 5,000 ha
Assistant for maintenance	: one person for every 1,000 - 2,000 ha
Manager	: one person for every 5,000 - 10,000 ha
Accountant	: one person for every 2,000 - 5,000 ha
Cashier	: one person for every 2,000 - 5,000 ha
Computer operator	: one person for every 2,000 - 5,000 ha
Driver	: one person for every 1,000 - 2,500 ha
Money collector	: one person for every 1,000 - 2,500 ha

(c) Jurisdiction of WUO

The San Juan irrigation area including the future extension area so-called Janova will be incorporated into the existing Sabaneta Dam Irrigation Committee (SDIC) under the guidance of PRODAS. The Mijo and Vallejuelo systems will be independently organized into one organization, respectively, since they are independent in the water resources from the other San Juan zone irrigation systems. While, in the Guanito San Juan, which is served by the San Juan river farmers will make their WUO at the association level under SDIC.

Farmers now taking irrigation water directly from YSURA head race by privately installed pipes should organize Nucleuses in one or a few irrigation systems. Then one or two Sub-committees will be formulated among them. Finally, all the farmers will be unified into one Association together with newly built Amiama Gomez and Biafara systems under the YSURA Irrigation Committee.

YSURA Irrigation Committee should extend the jurisdiction to all the area served by the YSURA canal system including an area irrigated by private pumps located hilly side along YSURA main canal and the extension area served by YSURA main canal setting up WUO in each of the two areas in addition to the area served by YSURA head race. Also, areas served by INDRHI's-managed wells located in and around the YSURA area should be gradually incorporated into the Committee, if groundwater resources are expected to be largely utilized with surface water resources in the form of conjunctive use in future.

Farmers of small irrigation systems diverting water from the Yaque del Sur should be organized in each of small irrigation systems and formulate one Association for all the systems in the reaches from Villarpando to Los Guiros, which are the Azua Irrigation District jurisdiction.

In the same manner, a Nucleus or a Sub-committee will be formulated for each of

small irrigation systems existing along the Yaque del Sur in the lower reaches from Los Guiros. Then, the organizations will be grouped into three associations; upper reaches association, and lower reaches right and left associations.

Contemplated Jurisdiction of Water User's Organizations

Irrigation System		Water Users' Organization
Jose Joaquin Puello,	existing	Sabaneta Dam Irrigation Committee
Hato de Padre,	existing	supported under PRODAS by INDRHI
San Juan, Janova		to be incorporated into Sabaneta Dam and
Guanito San Juan		Irrigation Committee
Mijo irrigation system		to be founded under PROMASIR by INDRHI
YSURA system (lat.1 to 6), existing		YSURA Irrigation Committee
Small systems served by YSURA headrace including Biafara system		proposed to form an association and join to YSURA I. Committee
The YSURA extension area		proposed to form an association and join to YSURA I. Committee
Small systems served by the Yaque del Sur in Azua Irrigation Zone		proposed to form an irrigation committee in each of the small systems and to form an association for all. Then,
Small systems served by the Yaque to Santana headworks		committee in each of the small systems and to form an association for all. Then,
Santana		proposed to form an association. Then,
Small systems served by the Yaque del Sur in the lower reaches from Santana headworks		proposed to form an irrigation committee in each of the small systems and to form an association for all.
Then,		the Irrigation Committee of Yaque del Sur River will be formed by the latter four associations.

(3) Irrigation Water Charge

In the early years from the establishment of WUO, the water charge may be controlled at a low price by subsidy from INDRHI so that farmers pay easily. Actually at present, the water charge has been set by the existing WUO based on its marginal costs or less than the costs required for the O&M. All the O&M costs, however, should be covered by the irrigation water charges collected from the farmers in principle. As the distribution and field canals are proposed to be maintained and operated by each of the farmers themselves,

the water charge should not contain the O&M costs for these canals.

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 CPPs, 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. In the amount of water consumed for a year, perennial crops and long-term growing crops such as plantain, banana, sugarcane and tree crops are almost the same as rice. Thus from the view point of water consumption, the water charge for such perennial or long-term growing crops should be the same as that for one crop season paddy, especially in the Lago Enriquillo and Yaque del Sur Irrigation District areas. In case of the ordinary upland crops such as maize, beans, and tomato, the water charge will be reasonably a half of the paddy.

The water charge will be collected before each cropping season. At the step 8 for preparation of irrigation schedule, the amount of water charge will be calculated and charged every farmers. A nucleus chief 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 who is 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.

(4) O&M Facilities and Equipment

Irrigation District Offices will be reduced in the staffing as the O&M works are committed to WUO. Only the conservation and improvement unit will be maintained in the same scale as present. The construction equipment is maintained and replaced as usual. In addition to the replacement in turn of already depreciated goods, computer sets should be introduced in every divisions in order to prepare and compile all the useful data and information and make the computer communication.

WUO needs an office space, light equipment and tools for the water management and routine operation and maintenance works. In case of a large WUO, offices will be provided at each association level as a branch office in addition to a head office.

(a) Equipment and tools for field works
- Light trucks for inspection and transportation of materials and labors,
- Motorbikes and bicycles for inspection and movement for gate operation,
- Chain saws for cutting trees,

- Cutter for cutting small trees and grasses,
- Walkie-talkies for communication in the fields especially for water management.
- Hand shovel, hand plow, etc..

(b) Equipment for office works
- Office furniture and computer sets

(5) 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 RD$ 700 / ha in total consisting of RD$ 600 / ha in the personnel expenses including part-time labors and RD$ 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 who will continuously assist and advise WUO technically and administratively on the O&M works, directly carry out maintenance works by his heavy construction equipment and maintain and operate large-scale facilities such as Sabaneta dam, Sabana Yegua dam, Villarpando headworks and the proposed Yaque del Sur Water Management Center. According to the data of the budget in recent years, the budget of the Irrigation District Office is RD$ 1,200 / ha on an average, although it largely differs among the Irrigation Districts. As WUO is set up and growing one by one irrigation system, Irrigation District Offices will reduce in their scale. If the office scale becomes a half in the activities, the required expenses are RD$ 600 / ha. If WUO shares the half, the amount paid by WUO is RD$ 300. From these estimation and assumption, WUO needs at least about RD$ 1,000 / ha.

(6) Approach to Setting Up of Water User's Organization

The existing WUOs like Sabaneta Dam and YSURA irrigation Committees take a long time to reinforce their institutions and have not completed yet. YSURA Irrigation Committee has already experienced irrigation management more than 10 years since it was founded, but INDRHI staffs are still placed at key positions in it. It probably means that INDRHI is bringing up the Committee indulgently for a long time or can not abandon his perverted Paternalism. In such a situation, the Committee can not be independent from INDRHI. In order to attain a successful transference from INDRHI to WUO as smoothly and certainly as possible, we should concentrate more supporting efforts at the initial time of the formulation process to the users so that WUO can execute proper water management technically and administratively soon probably within a few year. For this perspective, training at the initial stage is the most important.

It can be, however, said that the program for transferring the responsibility of O&M to WUO should be implemented step by step 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.

Generally the following process will be taken for newly setting up WUO.

(i) Identification of resources - farmers and leaders' capability, education level, will, organizer's ability, physical conditions, water availability, condition of irrigation and drainage facilities, etc.
(ii) Setting-up of an executing team
(iii) Preliminary orientation to farmers' leader and groups
(iv) Selection of pilot project areas.
(v) Orientation to farmers' leaders and farmers belonging to the selected areas
(vi) Formation of nucleuses and training about O&M of facilities and administration management
(vii) Formation of sub irrigation committees in a lateral level or a pump station level and support of them
(viii) Commission of irrigation water management in their irrigation systems.
(ix) Formation of the irrigation association and support to them.
(x) Commission of irrigation water management for whole a major system in their irrigation systems.

(7) Training

The training for staff of both the Irrigation District Offices and the Center is previously stated in Section 4.4.7. Here in this Section, training for WUO is mentioned.

Training aims to the attainment of sustainable water management by water users themselves through diminishing the present constraints such as the low technical and institutional capacity of irrigation water users, scarce knowledge on the concept of WUO, apathy of some farmers to participate in the irrigation water management, and much amount of water losses and damages to the environment caused by improper practices in water usage. The training program intends to assist the setting up of WUO, to fortify the organizational structures of WUO and to expedite the commission of O&M and irrigation water management from INDRHI to WUO as well as to provide the water users with the technical, managing, legal and environmental knowledge for the proper and efficient administration in the irrigation system operation and water management under their responsibility. The training measures contain lectures, educational videos, field practices, workshops, field trips, propaganda, etc..

The training is firstly adapted to leading farmers playing an important role to set up WUO and then extended to all the farmers. The training is actually adapted to persons actually engaged in agricultural activities and for such reason, they require the necessary time to maintain their activities. In this matter the training program has to be arranged flexible as much as possible so that they can participate to the program without completely separating from their main activities. Also, consultants and experts sometimes come to

their convenient point instead of them. The program will include not only engineering and agro-economy, but also general affairs, administration, account, and legal aspects concerning the irrigation water management and O&M works.

In case of the existing Irrigation Committees, prior to this Project, training have been executed and the major modification proposed by this Project is only the daytime water supply in the irrigation distribution systems with provision of night storage ponds. Thus, the training will concentrate technical and administrative matters concerning the water management in the daytime operation with night storage ponds.

The training program for WUO will be practiced as follows:

(a) Aiming at training of key personnel of WUO, a training manual will be prepared consisting of institutional development, participatory management system, water management and O&M system including practical procedures of water charge collection, supporting services for improving farming techniques, post harvest processing, marketing and financial management.

(b) In order to cover all the users, training will be provided every Irrigation Nucleuses to be set up as a basic cell of WUO. Three to five leading farmers, who will play a role of a trainer after getting trained by the project using the above mentioned training manual will be assigned for the training of Nucleuses together with INDRHI staff.

4.5.8 Costs

The costs for the irrigation and drainage development projects mentioned in section from 4.5.3 to 4.5.7 are summarized in the following table.

Project Costs

Project	Project Area [ha]	Project Cost [RD$ million]
Development Plan in San Juan Area		
(1) Night Storage Pond Projects	20,961	841.5 (419.8)
(2) Guanito San Juan System improvement Project	1,000	75.0
Development Plan in Azua Area		
(1) YSURA Area Improvement Project	7,732	459.0
(2) YSURA Extension Area Development Project	2,275	353.9
(3) YSURA Headrace Small Irrigation System Improvement Project	1,100	43.2
Development Plan in Lago Enriquillo and Yaque del Sur Areas		
(1) Yaque del Sur Lower Reaches Irrigation and Drainage Improvement Project	20,000	2426.8
(2) Yaque del Sur Small Gravity Irrigation System Improvement Project	7,500	382.1
(3) Galvan Groundwater Irrigation Project	540	65.5

4.6 Rural Infrastructure Development Plan

4.6.1 General

To support the agricultural activities as well as to improve the living environment in the rural area, development of rural infrastructure is indispensable in various components. The main constraints are observed to be the poor public services on the basic human needs, which refer to remarkable gaps between the rural areas and the urban areas. Also, social infrastructure and supporting facilities for the agricultural activities are limited, causing restriction on the agricultural development and social economy in the rural area. In addition, some institutional constraints and budgetary problems are observed, which obviously hinder the development of the rural infrastructure in the Study area.

To cope with the above constraints, higher priority is given to the provision of the basic needs which will widely contribute to the basin development. Electric power and water supply are therefore considered as one of the priority components. High priority is also given to the development which contributes to the agricultural activities and social economy in the rural area. Therefore, rural road improvement is also considered as one of the priority components.

4.6.2 Roads

(1) Rural Roads

Main national road networks are relatively well maintained, rehabilitated and extended by the SEOPC through its own program. Minor national roads are also managed and some of them are rehabilitated under the BID financial assistance at moment. Most of the rural

roads are however not sufficiently maintained reportedly due to the lack of financial resources, badly affecting the transportation of farm inputs and products especially in the rainy season. In the present study, construction of canal inspection roads are planned along the major canals which will be utilized as farm road, and hence improvement of the roads linking these inspection roads and villages are considered in this section. The standard of improvement includes shaping, grading and repairing, repairing / installation of the related structures, and the road metalling where required. Total length of the improvement is estimated based on the SEOPC inventory and topographic map with a scale of 1/50,000 as follows.

		Rehabilitation of rural road (National road)	Partially Improvement of rural road (National road)	Improvement of farm road
i)	Azua province	20 km	108 km	48 km
ii)	San Juan province	5 km	26 km	40 km
iii)	Bahoruco province	15 km	85 km	32 km
iv)	Barahona province	0 km	29 km	24 km

(2) Coffee Roads and Reforestation Road

As described in sections 4.2.4 and 4.9.1, implementation of the coffee project and the reforestation project requires improvement of the access roads for transportation of inputs and products. These roads will have the function of not only the access for the project but also for the villager's traveling and transportation in the hilly area. The standard of improvement includes shaping, grading and repairing, additional installation of the related structures especially road surface drainage facilities but excluding the road metalling. Total length of the improvement and the construction of the access roads are estimated below, of which costs are included in the total implementation cost of the respective projects.

		New construction	Improvement of existing road	Improvement of existing footpath
i)	Coffee pilot scheme	-	-	1 km
ii)	Guayabar coffee scheme	-	-	14 km
iii)	Monte Bonito coffee scheme	-	-	7 km
iv)	Peralta coffee scheme	-	7 km	9 km
v)	Los Frios coffee scheme	14 km	3 km	-
vi)	Aplonar Perdomo coffee scheme	-	4 km	8 km
vii)	Reforestation road	-	-	27 km

(3) Supply of Road Maintenance Equipment

Supply of maintenance equipment are included in the project in order to enable the local government to continuously maintain the farm road network. The responsible organization is assumed to be the public work section of the provincial office. Proposed maintenance equipment to be procured under the project are bulldozer, back hoe, grader, dump truck, water tanker, macadam roller and their garages. Required numbers are shown below.

i)	Bulldozer	8 nos.
ii)	Back hoe	8 nos.
iii)	Grader	8 nos.
iv)	Dump truck	8 nos.
v)	Water tanker	8 nos.
vi)	Macadam roller	8 nos.
vii)	Garage	8 nos.

4.6.3 Rural Water Supply

(1) Target of the Present Master Plan

Water supply facility are generally inadequate to satisfy total requirements in the rural area. The ratio of the potable water supply in the study area is about 10% lower than the national average. Especially, Bahoruco province and the hilly areas in Azua and San Juan province are worth as shown in Table 3.6.1.

INAPA has various plans and projects for the development of the rural water supply, of which location and inventory are shown in Fig. 3.6.3 and Table 3.6.2, respectively, including a large scale project of the Barahona water supply project covering entire Neyba and Barahona area with the water source from the San Rafaera spring (0.25 m^3/sec) and the Yaque del Sur river (1 m^3/sec). INAPA plan however does not envisage a long term program of works to be carried out in the study area. In the present master plan study, a target is preliminary set up to achieve that the ration of rural water supply catches up with the national average level within the period of action plan. The projection of water supply service coverage in the study area is summarized below and the details are given in Table 4.6.1 and Fig. 4.6.1.

Present water supply coverage		Projected population (2010)	Existing INAPA design and plan		Target population coverage
i)	Azua area	64 %	463,000	3	13,300
ii)	San Juan area	55 %	191,000	4	22,300
iii)	Bahoruco area	58 %	130,000	2	10,600
iv)	Barahona area	76 %	153,000	5	4,000

(2) Proposed Rural Water Supply Schemes

Based on the projection of water supply service coverage during the period of the master plan, the proposed rural water supply development plan is summarized below. It is also proposed that the stage-wise development strategy be adopted as mentioned in the action plan in section 4.11.4. Construction work includes 1) tube well ,100 m and pump, 0.5m^3/min. or intake facilities and settling basin, 2) supply pipe, 3) reservoir, 4) booster pump, 5) distribution pipe and 6) elevated tank.

	Present master plan quantity	
	Tube well	Gravity
i) Azua province	0	4
ii) San Juan province	0	2
iii) Bahoruco province	2	1
iv) Barahona province	1	0

(3) Improvement of the Existing Water Supply System and Small Scale Scheme

Rehabilitation of the existing water supply system including the water treatment plants would also be managed by INAPA as the national program. On the other hand, necessity of the small scale water supply scheme is scattered in wide range, which mainly consists of the development of shallow tube wells, dug wells or windmills. These small schemes are considered to be performed under the specific INAPA program and/or NGOs' activities.

4.6.4 Rural Electrification

(1) General

Generation of the electricity in the Study area is absolutely short, in which deficit would be covered by the development of new power stations. To cope with the rural electrification, INDRHI has a strong intention to develop some hydropower stations, both dam projects and mini-hydropower stations in the Yaque del Sur river basin. The potential projects have been identified since early 1970's, and the INDRHI made various studies and designs, most of which however have not been realized so far, due mainly to the lack of budgetary arrangement and the relevant data and information have been mostly lost.

Table 4.6.2 and Fig.4.6.2 show the inventory and location of the identified hydropower development, out of which, however, only the Los Toros project is on-going under the financial assistance of the Lome IV program. The rest requires financial source and more detailed investigations or up-dating for their early realization. Since promising dam project has not been identified based on the present water balance study, it can be said that the mini-hydropower development has some advantages considering its urgent necessity.

Electrification to the individual household are essential in the rural area. CDE's program is steadily effective covering the Study area, however, physical constraints on illegal consumption are considerably making troubles on the proper management and causes electrical accidents. Rural electrification is therefore expedited taking this issue into consideration for appropriate distribution network.

(2) Mini-Hydropower Project

Based on the INDRHI's list, 1) José Joakin Puello, 2) Santana and 3) Magueyal mini-hydropower project have been selected for the preliminary comparison, which includes estimate of potential power generation and review of the cost estimate. Their locations are shown in Fig. 4.6.2 and result of preliminary study are tabulated in Table 4.6.3.

(a) José Joakin Puello Mini-hydropower Project

José Joakin Puello project has been planned to be constructed on the existing José Joakin Puello canal taking canal water from just upstream of the existing chute for power generation utilizing it effective head of 58 m. The project has been formulated and designed by the Chinese mission in 1995 and its potential generation capacity has been identified as one of the promising project. However, the designed discharge in the José Joakin Puello canal are projected to reduce according to the present water balance study based on the improved irrigation efficiency, and the expected power generation are then decreased. Therefore, this project is not considered to be promising compared to the original design. The features of the project are summarized below.

- Location : Punta Caña, San Juan province
- Water source : José Joakin canal
- Designed discharge : 6.5 m^3/sec
- Effective head : 58 m
- Installation capacity : 3,000 kW
- Possible power generation : 21 GWh / year

(b) Santana Mini-hydropower Project

Santana project, of which feasibility study was made in 1989, was designed to be constructed on the existing Santana irrigation canal to make use of the head of 6 m at the existing drop. However, the designed discharge in the Santana canal are planned to decrease according to the overall effective water distribution plan in the present water balance study. Therefore, this project is also not considered to be feasible compared to the original design. The features of the project are summarized below.

- Location : Tamayo la Caida, Barahona province
- Water source : Santana main canal
- Designed discharge : 11 m^3/sec
- Effective head : 6 m
- Installation capacity : 574 kW
- Possible power generation : 4.1 GWh / year

(c) Magueyal Mini-hydropower Project

Magueyal project has been identified by INDRHI but the formulation of the project has not been made. For this scheme, a mini-hydropower station is planned to be constructed on the existing Ysura headrace utilizing the canal water taken at Villarpand intake for power generation. After power generation, tail water is flowing to the tributary of the Yaque del Sur river and finally returned into the Yaque del Sur river, not affecting the water distribution for the proposed irrigation projects. Though this scheme is considered to be promising in terms of power generation potential, it

requires rehabilitation of the intake at Villarpand including installation of the gates and replacement of the culvert. The result of preliminary study in the present master plan is described below.

- Location : Magueyal, Azua province
- Water source : Ysura headrace canal
- Designed discharge : 8 m^3/sec
- Effective head : 40 m
- Installation capacity : 2,600 kW
- Possible power generation : 22 GWh / year

Based on the preliminary comparison study among José Joakin Puello, Santana and Magueyal mini-hydropower potential schemes, Magueyal scheme are considered promising in terms of power generation potential. This scheme however needs more detailed investigation including topographic survey and geological study before implementation. Also, during the period of action plan, another master plan study is proposed for identification of the potential of the mini-hydropower project to be implemented in near future.

(3) Power Distribution and Installation of the Small Diesel Generator

For the improvement of transmission and distribution, the CDE's long term program is effective at moment, which covers the year of 1996 - 2015 consisting of the extension and replacing of the transmission lines and construction or rehabilitation of the transformer sub-stations (see location map on Fig. 3.6.4). Since rural electrification is expedited taking into consideration the illegal consumption, detailed investigation on the illegal connection is proposed to be done in the period of the action plan.

In the remote area, on the other hand, one solution refers the provision of small diesel engine generator which will be managed on a community basis, particularly in the hilly area with low accessibility to the high voltage transmission line along the main road network. In this issue, advantage is that operation cost are considerably lower than the construction cost on the extension of transmission line.

4.6.5 Sanitary Service and Other Social Infrastructure

Community level development programs are to include the improvement of sanitary conditions particularly on the individual lavatory and the rubbish disposal systems, on which the program are to be composed harmoniously of the improvement of the living standard, such as increase in cash income, security of domestic water supply, and improvement of the nutrition and hygiene, etc. Accordingly it is desirable to implement development programs and construction of the facilities in collaboration with the authorities concerned, international organizations and NGOs. On the other hand, malfunctioning and insufficient sewerage water treatment system causes water contamination and pollution in the river basin. Its main physical constraints are the lack of the maintenance, and hence rehabilitation of the sewerage treatment system is also proposed.

The health care service is insufficient due to inadequate facilities and manpower, as well as the education and the other public facilities in the rural area. Financial and institutional issues, are still essential for the improvement of social infrastructure, which refers to the inadequacy of funding support. Emphasis is therefore put on strengthening of the services and improvement of the facilities as an urgent issues, particularly regarding to the normal health care, hygiene and primary education, etc. This activities are also expected to be carried out in collaboration with the authorities concerned, international organizations and NGOs.

For the present study on the river basin agricultural development, construction of the community hall and water user's office are proposed in connection with the proposed agricultural development and the strengthening of water users' activities in the irrigation area. Proposed facilities to be constructed in each area areas follows.

	Community hall	Water User's Office
i) Azua	9	4
ii) San Juan	3	0
iii) Bahoruco	3	2
iv) Barahona	4	1

4.6.6 Costs

Project implementation cost for the above rural infrastructure development is summarized below.

	Direct construction cost (million RD$)
Road improvement project	
- Rural road improvement	217
- Coffee road and reforestation road	(33)
(Cost is included in the respective projects)	
- Supply of Maintenance Equipment	140
Rural water supply project	
- Water supply system by groundwater	67
- Water supply system by surface water	48
Supporting facilities	198
Mini-hydropower project	
- Magueyal mini-hydropower project	250