- PN-AAT-688 41946 -

IRRIGATION SECTOR ASSESSMENT

HAITI

USAID

WATER MANAGEMENT SYNTHESIS II PROJECT

WMS REPORT 36

IRRIGATION SECTOR ASSESSMENT

USAID/HAITI

This study is an output of
Water Management Synthesis II Project
under support of
United States Agency for International Development
Contract DAN-4127-C-00-2086-00

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Review Draft Submitted - September 1984
Mission Comments Received - April 1985
Date of Final Draft - August 1985

WMS Report 36

PREFACE

This study was conducted as part of the Water Management Synthesis II Project, a program funded and assisted by the United States Agency for International Development through the Consortium for International Development. Utah State University, Colorado State University and Cornell University serve as co-lead universities for the Project.

The key objective is to provide services in irrigated regions of the world for improving water management practices in the design and operation of existing and future irrigation projects and give guidance for USAID for selecting and implementing development options and investment strategies.

For more information about the Project and any of its services, contact the Water Management Synthesis II Project.

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ACKNOWLEDGMENTS

The WMS II Team expresses its sincere appreciation to technicians and officials of the Government of Haiti who granted many interviews in support of irrigation subsector assessment objectives. The time granted the Team by the Ministers of Plan (M. Blanchard) and Agriculture (Sandiq/Dr. F. Flambert) was especially helpful. Jean Renault Sam, Ministry of Plan, accompanied the Team to many of the study sites.

Ambassador Clayton MacManaway and other members of the U.S. Mission to Haiti gave the Team their full support. Special thanks go to Dr. J.V.D. Lewis, who structured the field research and worked with the Team during most of the study period. Dr. P. Aitken-Soux, Haiti representative for IICA, kindly arranged office facilities, research assistance and much of the necessary transportation. Humberto Pizzaro, IICA engineer, assisted the Team with local field visits and provided other valuable information.

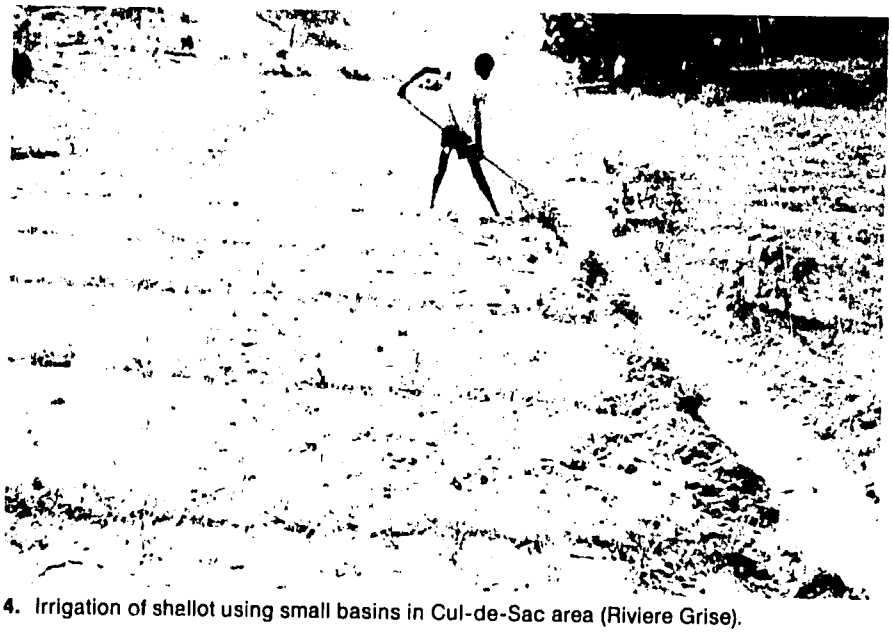
ACRONYMS

DARNDR (MARNDR)	- Departement de l'Agriculture Des Ressources Naturelles et du Developpement Rural (located at Damien)
DATPE	- Direction de l'Amenagement du Teniturire et Protection de l'Environement
GOH	- Government of Haiti
IDB	- Interamerican Development Bank
IICA	- Instituto Interamericano de Ciencias Agrícolas
ODPG	- Organisation de Developpement de la Plaine des Gonaines
ODVA	- Organisation de Developpement de la Vallee de l'Artibonite
ODN	- Organisation pour le Developpement du Nord
PDAI	- USAID/Haiti Integrated Agriculture Development Project
ROCAP	- Regional Office for Central American Programs
WMS II	- (USAID/Washington) Water Management Synthesis II Project

1. Damaged diversion structure at source Merlene M. San Raphael.

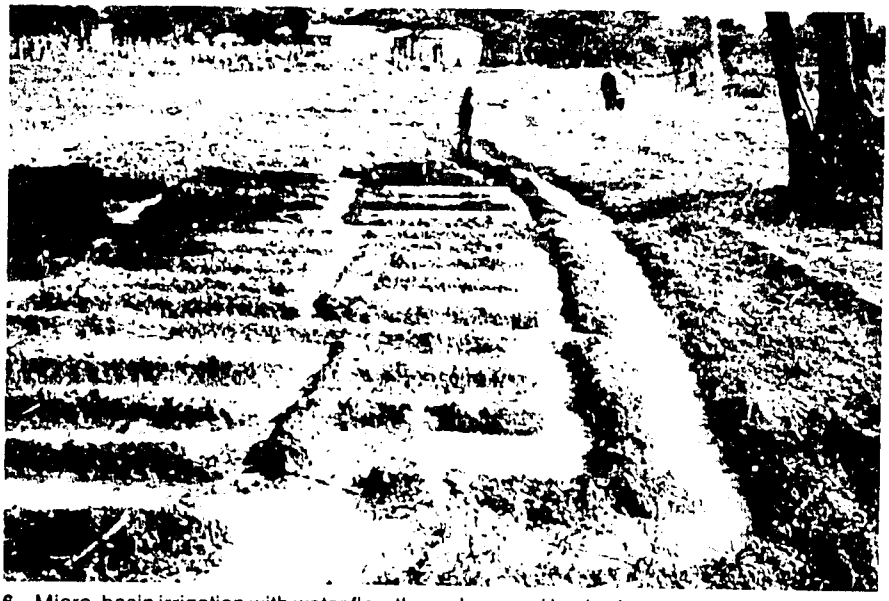
2. Gravel deposits above diversion structure on Ravine d'Sud for Avesac system, Les Caye Plain.

3. Downstream view of Riviere Blanch diversion site. Concrete diversion dam at this site (and at sister site, Riviere Grise) is completely buried by gravel.



4. Irrigation of shallot using small basins in Cul-de-Sac area (Riviere Grise).

5. Vertical standing spoil banks from recently cleaned canal of Melon System in Maniche Valley. Rocks and other debris had already been knocked back into canal from foot traffic along banks prior to re-introduction of irrigation water.



6. Micro-basin irrigation with water flow through several basins in succession, Cul-de-Sac area.

7. Water Management Synthesis II Team visiting engineer and water users at diversion structure of Abraham irrigation system, Fond des Negres.

8. Stream channel bypass of partially completed diversion structure on Torbeck River, Les Caye Plain, resulting from flood conditions and inadequate wingwalls during construction.

EXECUTIVE SUMMARY

Background and Main Conclusions

This report has been developed from an irrigation sector review made at the request of the Minister of Plan by arrangement with USAID/Haiti and the Water Management Synthesis II Project. The WMS II Team personnel were provided by Utah State University as a co-sponsor of that project. The review was conducted during the period of August 20 to September 15, 1984. What is reported has a generally technical focus which reflects the make-up of the Review Team and USAID/Haiti emphasis on visiting a broad cross-section of irrigation sites and conditions.

A considerable part of Haiti's agriculture history is conditioned by irrigation's role as a supplement to natural rainfall. Over time an extensive system of hydraulic works and water conveyance features have been put into place, used, refurbished or sometimes abandoned. Today important segments of this system are troubled to varying degrees by three interrelated negative forces: quality of upkeep, watershed conditions and supply management. Rural income and employment levels are below what they might be, and hoped-for benefits from expensive programs of renovation are problematical.

WMS II Team Approach

If we imagine water supply management to be a partial function of "institutional" arrangements and divide irrigation systems according to whether or not they are protected from degraded watershed sources, we have part of the classification necessary to dissect the Haitian irrigation scene. Other aspects are system sizes (mini, small, intermediate, large) and long- and short-run time horizons.

Generally speaking, the mini and small systems are the least impacted by failures in management institutions or lack of O&M inputs (but if there are any short-run improvements in these elements, the benefits should carry over to the long-run). Improved water supply management institutions and O&M arrangements would especially help intermediate and large systems in both the short- and long-run. These latter-sized systems will need public financing arrangements for new construction, whereas the mini and small systems might not.

Mini and small systems tend to occupy the protected locations; the intermediate and large (non-underground) systems are relatively the most environmentally threatened. In the long-run, continual watershed degradation has the potential to shut down all the systems, even those now classified as protected. The watershed issue is critical, and some ameliorating efforts are under way, but there is no way to predict the outcome. Watersheds can be rehabilitated, but the benefits to the existing irrigation works will not be measureable except in the long run.

Given this rough categorization of topical problems, the elements selected for emphasis by the WMS II Team are either related to short-run consequences or solutions, protected environments or to institutional adjustments that have lasting as well as immediate impacts.

Problem Emphasis and Solution

Certain themes dominate the mass of literature dissecting and analyzing the recent history of agriculture development in Haiti: population growth/exploitation of hillsides; growth of food output/domestic food needs; performance of existing irrigation systems/potential for increasing irrigated area; absolute amount of GOH resource commitment to agriculture sector/institutional capacity of the technocracy; and, most of all, security of land tenure/peasant initiatives (Werleigh, 1983; Stutler, 1983; USAID/Haiti, 1984; Berg Ass., 1984; Kite and Pryor, 1983; Hauge, 1984; Purcell, 1974; Bertrand, 1976; Murray, 1978 and 1982; Zuvakas, 1980; I.D.B., 1974, 1981, 1982, 1983a, 1983b). On-site visits to a large number of projects and conversations with knowledgable persons have confirmed the broad outlines of the situation and many of the specific points made in the cited sources.

The subsector picture, however, is not as negative as most of this literature suggests. Some irrigation systems work quite well. They may be found both inside and outside the Irrigation Districts, but tend to be small enough to allow user equity considerations to be resolved internally. It is unlikely that all such systems appear on the usual inventory lists.

Certain situations within irrigation districts permit Departement de l'Agriculture, des Resources Nautrelles et du Developpement Rural (DARNDR) personnel, led by the District Agronome and the engineer from the Irrigation Service, to provide good support. Some examples have been given by Hauge (1984). Cards signed by the Agronome and the Engineer have been and can be issued to each user, specifying the regular date and time period for receipt of water. Again, such examples involve situations where maintenance and repair requirements are not so demanding, and where users are willing to help get things done.

In the Les Cayes region several small systems, also inside the irrigation districts, have been rejuvenated to some degree by users which have in turn been organized and trained by local priests. Thus far the original capital has been donated, but some user groups have agreed to build up their own funds for future system upkeep.

Such small successes dramatize the failures in the larger more complex systems. The latter seem to suffer to a greater or lesser degree from the effects of lack of trained personnel, lack of maintenance, design flaws, unfair water distribution and poor on-farm management technique. As near as can be ascertained, many technical assistance

devices have been tried, usually more than once, but subsequent evaluations disclose the same pattern of weak performance. In the opinion of the WMS II Team, nothing that donors can do in terms of new subsector investment, Ministry reshuffling, more farmer level technical assistance, etc., will be cost-effective until two things happen: water users must have more say in the operation and maintenance of the systems (and shoulder far larger percentages of the fiscal burdens), and order must be imposed upon utilization of all water by unbiased application of up-to-date laws and rules.

If user fees generated a reasonable amount of revenue, a reasonable number of well-trained people could maintain the systems both to prevent and repair damage. Once security of water delivery is assured, farmers will be more prone to utilize better on-farm technologies.

Little is gained by arguing that the farmers cannot afford to pay; either it is worth repairing and replacing these extensive, complex systems or it is not. Someone should be able to pay. It is difficult to believe that net profits are not being accumulated somewhere in a situation permitting continuous cropping of products for which there are reasonable internal markets.

These comments are not meant to play down the cost side of the picture. Some of the irrigation systems in Haiti are exceptionally difficult to operate since cleaning or repair is required so often. They are constant victims of destructive natural forces. It is probable that certain systems can never pay for themselves. In such cases it may be better not to fight against nature until it is determined whether there is any way to counter or avoid the force or timing of floods that cause so much damage.

Donors who are attempting to have an impact upon rural development in Haiti should adopt a realistic view of what can be accomplished through volunteerism or cooperation as a driving force in water user groups. Such groups or amalgamations of groups cannot substitute fully for other institutional imperfections further up the line. Besides, such combinations are hard to sustain because membership naturally includes individuals or groups whose interests are best served by failure of cooperation. Farmers who have had free water do not like the thought of being forced to pay for it.

The most useful immediate extension of responsibilities for user groups is found in recent ideas being pushed by USAID/Haiti covering ease and right to form such groups and their freedom to collect and control member fees. These goals are necessary steps in the right direction (USAID/Haiti, 1984; Coffee, 1984; Delatour, 1984).

Something else is necessary, however, in order to prevent even well-meaning user groups from inadvertently hurting each other with conflicting surface diversions or underground withdrawals. Water resources have to be managed in terms of present equity and future

national need. This requires strong application of tenure and development rights according to law and scientific information about locations and amounts of the resource.

In an irrigation society, the keystones are equity and order. These cannot be induced from the bottom up except in simple, close-knit systems; the notion of beneficial use must be imposed from the top down. Few exceptions to water law may be permitted, but user rights may be readjudicated based on new, more accurate information. The law needs to be applied without fear or favor to rich and poor alike.

At the present time the following functions are not being well performed by any existing Haitian institutions: 1) how much water a group or association of groups or certain projects will be allowed to divert; 2) location and utilization of all water sources and; 3) balancing the demands of non-agriculture users. As conflict over ever-tightening water supplies mounts, these functions will be extremely important. Generally, parallel arguments also apply for information, rational utilization and law and enforcement where environmental (watershed) issues are concerned.

Findings and Recommendations

Subsector Planning

Numerous studies of agriculture (and irrigation) in Haiti are available. Some of these involve engineering feasibility of irrigation developments. The recommended locations for development have been selected generally by economic criteria and then ranked in some fashion. Other issues affecting the viability of irrigation in Haitian agriculture are land tenure patterns, community organization capabilities, differential between rainfed and irrigated cropping potentials, sedimentation hazards, and other physical, social and political factors. Thus, while much is already known about the agricultural sector there are yet some missing data elements which are important to rational analysis and planning studies. Much of this need is manifiest in a lack of hard knowledge about basic biophysical, social and economic conditions.

The global relationship of potential net benefits from irrigation network improvement relative to social costs is unknown. The reason for this is that there is no good way to calculate a ratio because all sorts of really fundamental data are lacking, such as census of population and agriculture; export market potential; crop and livestock production and consumption time series; ground and surface water availabilty and hydrology; soil and water pollution and extensive soil surveys; meteorology; land ownership and control records (surveys). As a consequence it is not possible to foresee some unintended side effects from government policies, planning and executing projects is seriously delayed and mistakes are inevitable. Some possibilities are:

1. Completed and ongoing land capability studies are important but they are only a start. Non-existent or inadequate statistical collection and reporting services are a real hindrance to rational planning and development budget programming. The Government of Haiti really cannot do without minimal information, and some substantial budgetary recognition of these continuing needs is necessary.

2. Determination of the seasonal changes in irrigated areas and estimates of adequacy of water supply are important. These would require the use of satellite or other remote sensing information. This step might be encouraged after early 1985 when Landsat 4 data are available.

3. Development of revised irrigation project evaluation and ranking criteria to include some measure of command area stability and system longevity, i.e., dependability of water source, gravel/sedimentation hazards, relative water supply for double and triple cropping, potential with rainfed only, existence of viable organization for operation and maintenance, drainage conditions, etc.

Subsector Institutions

The most fundamental aspect of persons coming together to control a water source for irrigation purposes is organization. Even the most casual observation of any group's system reveals that at least two things must be happening for the systems to work at all: 1) farmers have to know when they will get water; and 2) they all have to be getting it on some fair (acceptable) basis. In the western U.S., for example, irrigation systems may be poorly maintained and need investment to bring them up to standard, but no one thinks about the fundamentals mentioned because they are taken for granted.

The basic foundation for improving performance of the irrigation subsector in Haiti is to create an institutional climate and structure that will allow each and every system (group of users) to cross the thresholds described. Some systems are working, but in a lot of situations observed by the WMS II Team, where a viable combination of volunteerism, leadership and trust is missing, an institutional requirement is not being met, i.e., maintenance of law and order so that equity in water distribution is more or less guaranteed.

It may be possible to secure distributional equity on a system-by-system basis following the pattern in Leogane, as suggested to the Team by DARNDR Minister Flambert. That model does not provide, however, for very important, necessary additional functions involving such things as resolving conflicts over diversions from the same source, shifting supplies as new land is brought under irrigation or for a scientific way to optimize conjunctive use of ground and surface supplies where several systems may be involved. The model does not provide for tempering adjudication of conflicting water rights claims with accurate

information about the resource itself. Provision for future needs through legal interpretations may or may not be present in the model.

1. A way needs to be found to require adherence to a comprehensive system of water laws governing tenure and use rights for individuals. It is recommended that serious consideration be given to creation of a powerful governmental position that might be termed "High Commissioner for Water." A scientist having demonstrated abilities would be appointed to this position. Utilizing a small staff he would oversee the conflicts in diversions, protect tenure rights and make sure that the necessary data are collected and employed to ensure wise use of water resources for general public benefit. A Commissioner for Environmental Protection having equal scientific qualifications should also be appointed and provided with equivalent powers. The Environmental Commissioner would ensure that a data base would be created to support environmental control programs. He would monitor all experience from existing and new projects so that the best ideas are extended and improved upon. Both offices might be combined in one person. The model is that of "State Engineer" in the U.S.A.

2. A scientific, interdisciplinary approach to resolving contradictions in land and water policy would be facilitated since line ministries would be able to draw on the commissioner's office for advice in meeting national development goals.

3. A separate, autonomous authority is necessary because for the last three decades the Ministry of Agriculture has not been willing or able to make the tough decisions required to bring order into resource management in Haiti. Managers of the autonomous development zones have also fallen short in this regard. Technocrats in the Ministry of Public Works may enjoy a relatively good reputation, however, the office described is not a construction agency and could not be housed there. All water laws must be codified, revised and amended to meet modern circumstances and future needs. Land tenure laws should be updated and enforced. At present there is not enough hard infomation to design, let alone enforce, the massive environmental protection measures that are needed (see Annex D and cf. DGSNP, 1985).

Irrigation Investment

The best lands and easy-to-tap water sources have already been developed. Additional areas will become ever more expensive to bring under control. Pertinent planning data are sparse. To bring extra land under irrigation would require considerable determination.

1. The most cost-effective way to obtain benefits from irrigation investment in Haiti is to rehabilitate existing systems, giving priority to those situations where longevity seems most assured. Longevity can be influenced by system compactness or because favorable hydrologic and sedimentation factors are present or viable internal O&M capability is

present on a routine basis. Development of springs and drainage channels should be encouraged if no water quality problems are present. In all cases, an intent should be to push out the irrigated perimeters wherever water availability and/or alterations in main system management will support such action. The Abraham (Fondev) system near Petit Goave exemplifies a system that possibly could be enlarged. This is one of the best ways of doing "rehabilitation."

a. Barrages should be rebuilt and maintained by using tractors or human and animal labor wherever natural conditions are such that frequent destruction occurs because of sand and gravel deposition.

b. Canal intake structures should be designed to exclude gravel and other debris during periods of flooding. Complementary operating procedures must be set in place to assure effective, timely operation of the gates.

c. Because of worldwide trends in petroleum costs and their impact upon foreign exchange reserves, and because of lack of domestic generating facilities, any groundwater development (made at public expense) based upon pumps should have immediate prospects of high payoffs (see Annex B).

d. There are a few systems which are situated in such a manner as to lend themselves to conversion to gravity pressure sprinkler operation. Experience elsewhere has shown that obtaining the important technological and sociological advantages of sprinklers can be auto-financed. System Robert may be such a site. The Team recommends an immediate reconnaissance of such possibilities to learn if a PID is justified.

e. Drainage improvements are needed in many systems, especially "along the seaward margins of most of the coastal plains" (Hargreaves, 1955).

2. Good examples of this approach can be found in USAID/Haiti's existing activities in the subsector. The WMS II Team recommends continuation of the very small-scale "$10,000 program." This is accomplishing its goals. The program readily could be extended to some aspect of system development in the Gastone zone where private initiative is being pushed (users need loan funds). The Mission entered the Dubreuil scene aiming to finish up the secondary distribution system; so the intentions were in harmony with the approach suggested (there was even a watershed program (Reynolds, c. 1983)). There is still plenty of opportunity to build good local institutional features that will help the system to function well as it comes on line (Stutler, 1983; also, the current water user group program of the Land Tenure Center). At the present time, an opportunity to obtain high marginal return on investment exists in the Canal d'Avezac system. The WMS II Team recommends that the Mission investigate this possibility.

No doubt there are other instances where the notion of doing the easiest things first (building on what already has bee accomplished) will prove beneficial. But proposals have to be judged very carefully from a technical standpoint, i.e., from an aspect where the Mission is weak. System Torbeck is a case in point: some poor engineering thinking has recently wasted an injection of Canadian donor money on a risky dam site; a distinctly clever design is needed if this system is to be rehabilitated.

3. On a considerably higher commitment scale would be rehabilitation of such systems as Torcelle, Courjolle and Matheux. From a technical standpoint there is no doubt that they can be improved, but in contrast to Torbeck, they are working fairly well at present. Therefore, these systems present a good opportunity for the GOH to institute some reforms in terms of water rights, enforcement of laws and general operating procedures that would generally be effective inside the boundaries of any irrigation water supply system. Some improvements in output and in smoother system operation ought to be possible. The spirit and substance of the WMS II Team's national level recommendation could be invoked and tested before a lot of money is committed.

4. Investments in complex systems, particularly where high risk factors associated with large eroded watersheds and higher elevations are present, should be avoided unless viable, long-term, internal O&M capability can be demonstrated either from agriculture or from tangible multipurpose benefits (such as electricity sales).

Operation, Maintenance and Cost Recovery

Many irrigation systems are in good physical condition and should be able to perform as designed. This holds true especially where the water source is a spring or drain. Other systems require constant, expensive upkeep. If maintenance is not carried out, farmers at the far end of the systems steadily lose access to water delivery and revert to rainfed cultivation. Maintenance is not carried out due to lack of funds or inherent difficulty in organizing human resources. There is a direct correlation between the level of ablility to do an adequate job of O&M and achievement of equity in water distribution. Where there is insecurity of water delivery, the probability of farmers adopting better cultural methods is greatly reduced.

Some smaller irrigation systems are totally maintained by water users, and in some cases have been responsible for construction or reconstruction as well. This means that subsidy is reduced or absent. The Irrigation Service representatives or District Agronomes appear to impose a minimum of restrictions on such groups. For example, District supervisors have no incentive to hire and pay a Syndic when none is needed. Also, user-operated and built systems may not be subject to water tax.

1. It is probable that such user groups exist in greater numbers than commonly supposed by outside observers. To the extent this conjecture is accurate, it is somewhat illogical to continue to subsidize the lion's share of reconstruction and O&M costs in other systems more directly under public control. Subsidy from any source masks the actual comparative advantage situation in the subsector, provides insulation from competitive forces and makes speculation in land easier.

2. Only modest improvement in irrigation subsector performance can be obtained by reshuffling institutional control of public O&M responsibilities. It is also unrealistic to expect complex user organizational arrangements to carry out irrigation system O&M where system layouts and structures are complex and involve several user groups. The basic solution in either case is adequate operating budgets. The WMS II Team recommends that the Mission explore with GOH a reasonable method for water user groups to organize and tax themselves (Stutler, 1983; Coffee, et. al., 1984, Sec. 6.2.4).

3. Another administrative boon to be sought is the right and obligation of recognized user groups to help set O&M priorities and scheduling. The long-run aim should be to move to a system of user fees that will recover costs of construction as well as O&M costs. Warning: users should not be expected to pay for engineering and construction mistakes made by "experts."

Agronomy

The WMS II Team observed some on-farm water management practices that are quite good. These practices seemed to be correlated with close supervision of day laborers and tighter water supplies. In contrast some farmers probably have more water than they need (Jean-Noel, 1984).

If in the future agriculture production must make a quantum leap, consideration must be given to new technology as a means of holding unit costs of production under control while fostering larger-scale commercial operations.

1. Except for growing rice and possibly sugar cane, not very many people understand "on-farm water management." This is true in Haiti as much as anywhere else. Thus, there is little information to extend. The WMS II Team recommends that USAID/Haiti set up a technology transfer activity centered on the AID/Washington historic experience in on-farm water management contracts let during the 1970s and that USAID/Haiti determine if the International Irrigation Center's "Irrigation Program Modules" are suitable or adaptable to Haiti; the Mission should contact the Regional Office for Central American Programs (ROCAP) and Instituto Interamericano Ciencias Agricolas (IICA) in Central America (request WMS II support for part of this activity).

2. The WMS II Team recommends that the Mission establish strong ties with the on-farm water management demonstration and action program recently initiated in the Dominican Republic. For example, some Haitian agronomists and irrigation engineers could be sent to the test site in the Alta Yaque del Norte Irrigation District to participate in project activities for an extended period of time (one full cropping season at least). The program mentioned is scheduled to last for five years. This subactivity could be managed for the Mission by the local office of IICA.

3. The considerable rainfed agronomic research (especially in the Southwest zone) needs to be adapted to irrigated conditions because not all farmers in that area who have access to water will be able to grow rice. Delatour, et. al. (1984) suggest the area go to a rice economy. In this connection better availabilty of improved varieties is obviously an important initiative (Wahab, 1984).

Watershed Management

Generalized erosion is evident everywhere and there are localized situations of extreme erosion, but no one really knows the extent of soil losses. There is also a potential for on-farm erosion in the irrigated areas.

Severe natural threats to structural integrity are represented in the situations to be seen at Riviere Grise and Riviere Blanche. It is unlikely that manmade structures can long survive the extensive gravel deposits caused by extremely rapid runoff of flood waters. Hargreaves (1982) claims that river beds have widened greatly during the past 30 years (cf. MARNDR, 1985). These peaks in river runoff mean that less and less water is available for irrigation, i.e., more and more is wasting to the sea (MARNDR, 1985). An additional claim is that aquifer recharge is also adversly affected (Roi, 1984).

The ratio of flood peaks to average streamflow can only be reduced in a few ways. One is a series of upstream dams (detention basins) that are allowed to fill with debris in succession (very expensive). Massive revegetation of the entire watershed could be attempted, emphasizing grasses. These methods could be combined, but a revegetation program probably restricts use of the watersheds by farmers forever and requires tightly controlled animal use after the vegetation is well established.

There may be a third possibility if farmers are allowed to remain on the watersheds. A large system of terraces would have to be constructed to control or arrest erosion. Such terraces are widespread in those areas of the world such as Southeast Asia where rainfall patterns are more evenly distributed than is the case for Haiti. Uneven rainfall may prevent high intensity year around cultivation which otherwise provides natural incentive to build and maintain terraces. The knowledge of terrace construction is not part of rural culture.

Time and effort will be required to build up the soils on the terraces. Some terracing and revegetation efforts are under investigation, and some positive results were pointed out to the Team during its visit to the Peligre area. The actual costs of such programs, however, are unknown. All that is certain is that soil conservation generally is very expensive and involves a long-term, cause-and-effect process.

1. The approach and program of conservation projects such as that in Upper Artibonite should be encouraged. Elie and Snyder (1984) did not find the erosion problems too bad in the Peligre watershed.

2. Irrigators are not necessarily the immediate beneficiaries of adjacent hillside farming conservation, at least in the short-run, since effects of erosion on production are not observed immediately, only gradually. So the major beneficiaries are usually the hillside farmers themselves who do not necessarily own land in the downslope irrigated regions. Taxing one group to subsidize the other's conservation efforts suggests an administrative nightmare. The only way irrigators could be taxed would be if the money improved "their watershed" and nobody was exploiting it (except, possibly, for some grazing).

3. If it is socially, economically and equitably possible to prevent farmers from working land on steep slopes (as proposed to the WMS II Team by the Ministry of Plan technicians), such a program should be instituted without delay. Continuity of conservation programs must be ensured by built-in incentive programs. Every possibility for resettlement of hillside dwellers should be investigated.

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SECTION ONE

ASSESSMENT OF HAITI'S IRRIGATION SUBSECTOR

Introduction

This report is based on a rapid appraisal of the whole irrigation sector and does not include comprehensive evaluations of specific irrigation projects. See Annex A for examples of site data collected.

Data

The main focus of the WMS II Team's sector review was on performance of irrigation systems viewed from technical and farmer standpoints. A search was made for the physical and institutional situations leading to success and those leading to failure. Climatic, environmental, financial, policy and human capital factors were all taken into account. The resulting analysis suggests inferences about immediate investments in the subsector and required policy changes which will enhance sector output and reduce waste in future investment.

Part of the considerable literature devoted to Haiti's irrigable subsector was reviewed. These sources ranged from engineering assessments of various water systems to economic and social analysis of operation and maintenance of systems. Members of the WMS II Team visited over 40 systems, large and small, and observed apparent strengths and weaknesses in operational arrangements as well as technical aspects of recent or planned reconstruction. In addition, where possible, pertinent questions were asked of farmers and on-site managers of the various systems. Meetings were held with a large number of persons in policy making and executing positions in the Ministry of Plan and the Ministry of Agriculture, as well as with private individuals and representatives of major donor organizations. Members of the Team were unable to speak personally to farmers except through translators.

Method

Given the data base described and background knowledge of what contributes to success or failure of irrigation systems and rural development policies elsewhere, the Team has attempted to set out or define the framework within which solutions to the current irrigation investment/O&M production dilemmas must be found. The Team has created its own interpretation or view of the realities of the irrigation scene in Haiti. This is necessarily imperfect, but we feel it is accurate enough to deduce a set of mutually consistent conclusions and point out relevant policy options.

Haiti Irrigation Potential

Irrigation potential depends upon the average annual amount of water that might be developed from surface and underground supplies coupled with the amount of land suitable for irrigation that could be serviced at reasonable cost. As of yet these relationships are not well defined primarily because the hydrologic data have not been defined in potential irrigation terms (USAID, 1985, Table IV). It is, however, possible to obtain an impression of upper bounds upon potential from the standpoint of land area if attention is focused upon valleys and plains. It would never be cost-effective or even technologically possible to irrigate the entire area, but the total can be compared to estimates of the land areas currently under irrigation. Relevant data are shown in Table 1.

FAO experts have estimated that about five-sevenths of the valley and plains total are concentrated in the plains. According to the DATPE photo intrepretation work, 3,974 km^2 in the two zones are utilized for irrigation in some way. The zones contain about 3,054 km^2 of class 1a soils, most of which would have possibilities for irrigation since topography would not be limiting. This estimate is one-third more than the total mentioned in the recent USOM draft CEP report (USAID, 1985). Currently, 1,572 km^2 are in specialized crop production, and the DATPE study estimates about two-thirds of this to be in irrigated rice or annual crops. Some additional allowance must be made for irrigated sugarcane. (An earlier FAO estimate of 700 km^2 of irrigated land is the most commonly quoted figure in estimates of Haitian agriculture sector information.) Although there is significant variance among sources of data, in total, even the high estimates of irrigated area are well below the low estimate of 2,050 km^2 of 1a land. From the standpoint of land resources alone the CEP estimates of 1a land may be taken as a current best estimate of the maximum amount of land that could be irrigated regardless of necessary effort and cost.

A detailed inventory of existing systems in the main plains and valleys was made in 1972 by the Integrated T.A. Mission of the OAS. These areas were found to contain 106 systems, commanding about 75,000 ha. According to Walker (1983) the Irrigation Service of the Department of Agriculture controls 71 of these systems, which command 48,000 ha and serve 36,000 families. A February 1984 estimate of large and small systems reported to be controlled by le Departement de l'agriculture des Resources Naturales et des Development Rural set the number at 128 (quoted in USAID, 1985). The area irrigated in these systems was estimated at 95,880 ha serving 80,699 users.

Both the 1972 and the 1984 totals seem to fit the data from Table 1 fairly well. A current grand total of land irrigated to some degree seems to lie between 90,000 and 110,000 ha.

Table 1. DATPE and other estimates of 1978 land occupation in valleys and plains--Km^2.

Category	North	Transversale*	West	South	Haiti
Valleys and Plains Total	1087.1	2076.4	805.4	976.4	4936
(FAO est. plains only)					(3515)
Area in agriculture	918	1596	637.5	823	3974
Class Ia Lands (all)**	785.8	1046.3	588.7	633.7	3054
(CEP est. of Ia lands)					(2050)
Land Use					
Specialized crops	371	573	285	343	1572
(FAO est. irr. area)					(700)
Irrigated annuals	45.4	266.6	28.0	162.4	504
Rice	42.8	316.6	46.8	63.6	470
Irrig. sugarcane	?	?	?	?	?

* Estimates of irrigated area are evidently incorrect since the sum exceeds the total of the area of specialized crops.

**Ia = good soils with possibilities for irrigation, suitable for mechanization, high productivity, topography not limiting.

Source: USAID, 1985, draft (agriculture) for DATPE data, Tables 3 and 4; also pp. 3 and 4 for FAO and CEP estimates. Delatour cites DATPE data: 89,900 irrigated; 98,250 could be irrigated.

According to the IBD socioeconomic report of 1975 and GOH Five-Year Plan (1981-1986), the total area that can be irrigated is 125,000 ha (USAID, 1985). The 1984 IICA survey of available data plus field site visits to many systems contains an estimated potential area of over 144,000 ha within 231 identified systems, subsystems and water source locations (Pizzaro). Therefore, there may be an already identified potential for additional irrigated area of 25,000 to 45,000 ha, i.e., about 30 percent more than at present. How much of this areas enjoys constant, year around irrigation water supply is unknown, but it appears that many systems are fully or partially shut down for extended periods of time.

According to a 1979 Harza study, additional potential for underground sources is not great (USAID, 1985, Table 7). Whether additional surface supplies could be developed by creating storage is not clear. Hargreaves (1955) argues that there is considerable underground potential and states that there are storage sites. Extensive engineering studies and reconnaissance have been carried out from time to time, but proposals for major dams are notably absent. Numerous sites (37) have been identified for creating hydro power, and some of them probably could satisfy some irrigation water storage needs, but the potential is unknown to the WMS II Team (USAID, 1985, Table 6).

In summary, a combination of more intensive utilization of already existing irrigation infrastructure plus development of some additional pre-identified surface sources could increase the effective area irrigated in Haiti by a considerable margin, probably at least 50 percent. This is a very rough figure, of course, but it seems that there is ample margin to absorb all the financial and human energy for irrigation development that could reasonably be expected to become available in the near future.

Assumptions

From the standpoint of external donors, the current situation is as politically and culturally intractable as it is technologically and environmentally intolerable. Therefore, it seemed that the immediate and important question facing the WMS II Team was, "What is possible within the existing administrative, institutional and technological constraints?" Within this bounded domain some of the most important considerations for successful system development and operation, in rough order of priority are the following:

- Administrative ease (minimum pressure on the "system");
- Minimal reliance upon complex support arrangements;
- Good payoff (least risk?)/dollar spent (economic and longevity); and

- High or discernable impact upon the farmers involved (human capital development self-help situations).

The practical consequences of entertaining such considerations is to focus attention upon irrigation systems least likely to be threatened by the environmental degradation of the country--springs, drains, simple (rebuildable) diversions--and upon smaller groups of users that are already working well together for whatever reason, and towards those irrigation districts or river situations where private initiative is least mired by bureacratic quicksand.

This orientation has an inherent disadvantage: the absolute amount of any hoped-for output increases from individual projects is probably not large. Presumably if enough of them are undertaken, there will be impact upon food supplies.

In order to obtain big jumps in crop and livestock output anywhere, not just in Haiti, it is necessary to employ advanced technology in every aspect of the production process. This includes the delivery and application of irrigation water. (Normally this involves a commercial orientation not always found among small farmers whose lands are dedicated to basic grains production.) In Haiti a "high tech" approach might be implemented to some degree by the private sector on land areas that are not quite level enough for surface irrigation (assuming the requisite water source can be developed). But for the bulk of the public systems, such a step would be difficult to take because under current legal, bureaucratic, environmental and operational constraints there is no way to move to intensive planning and control of the irrigation regime that would be required.

Field Visits to Irrigation Sites in Haiti

General Characteristics

The Team visited irrigation systems in the Cul-de-Sac, Archaie, Artibonite, Central Plateau, Plaine du Nord, Gonaives, Marigot, Jacmel, Petit Goave, Les Cayes and Leogane areas. Many specific systems are identified on the accompanying map (Figure 1). Some 42 irrigation systems were directly observed during these field trips. A few systems close to Port-au-Prince were visited more than once. Discussions were held with more than 80 persons, including 40 farmers who responded to inquiries relative to agronomic and irrigation conditions. At one site alone (Maissade) more than 150 persons were present to demonstrate their interest in a possible irrigation project. At another (Melon) about 50 persons accompanied the Team 2.5 km to the diversion. Contacts were made with representatives from four private voluntary organizations (PVO) and with several engineers knowlegeable about the history of irrigation O&M in Haiti.

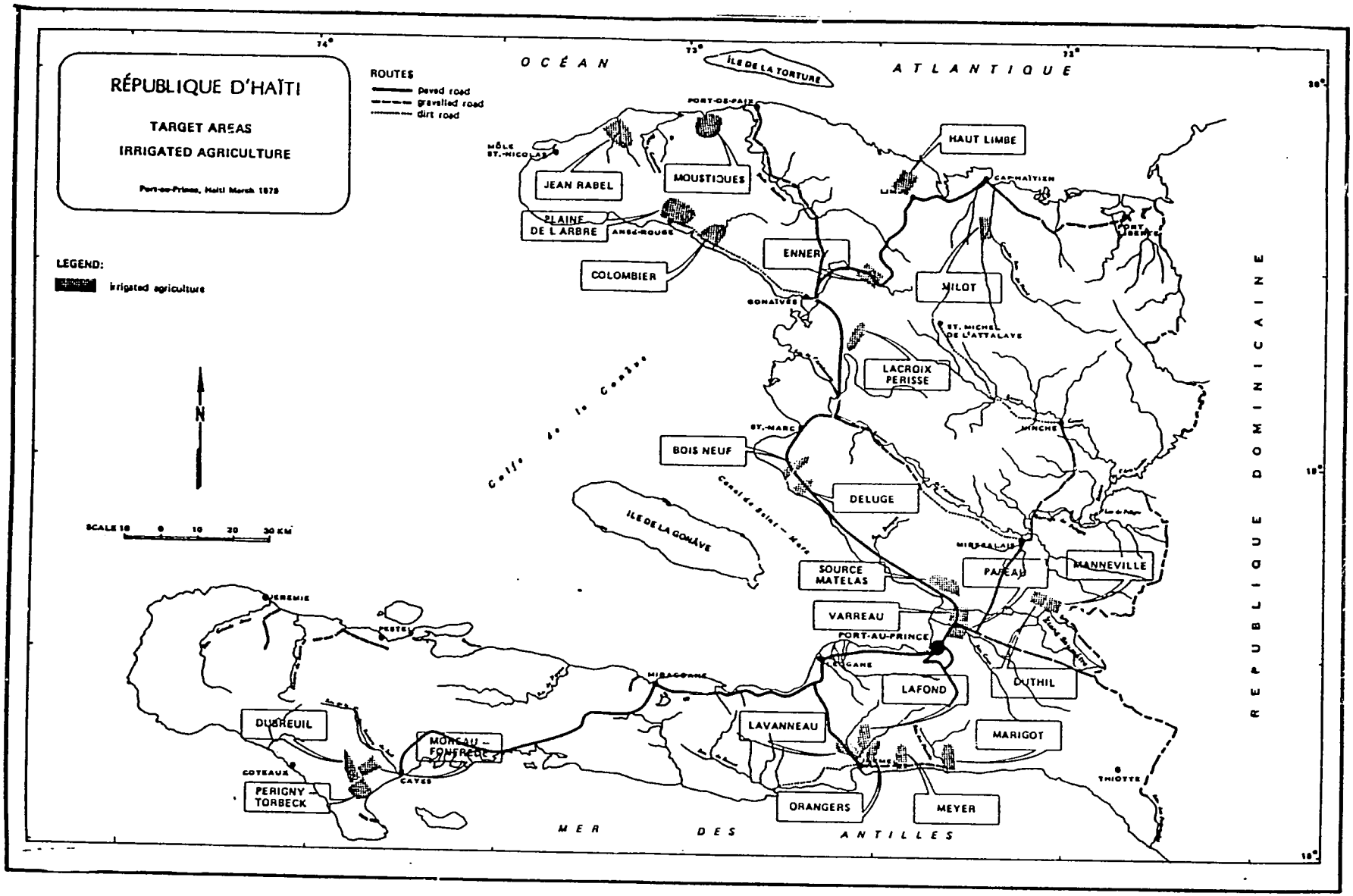

Figure 1. Map of Haiti with location of some irrigation systems. (Adapted from Harza, 1979.)

The systems varied in size from 23,000 ha (ODVA) to fewer than 20 ha (Tapion, Menoisier) of actually irrigated area. While the water sources of the majority were diversions from rivers, some were from springs, some were from drainage collection canals and a few were from pumps. Only one pump was observed in action (Manneville) and that was at the specific request of the Team. One pump in the Cul-de-Sac had been inoperative for five months while the high cost of energy or the unavailability of electricity for pumping has restriced the use of other pumps.

Diversion structures ranged from farmer-constructed rock dams (rebuilt after each rainy season) through midsize to large concrete barrages and up to one large dam at Lac Peligre. One farmer had created his own spring by breaking a 3-foot diameter buried mainline and blocking the pipe with rocks for flow control. Other farmers had constructed their own wood and earth dams and channels to divert spring water to their land.

Irrigated soils were predominately heavy with some medium and light textural areas. The heavy soils were mainly in the Artibonite, Central Plateau and Les Cayes areas, with some scattered pockets in other areas. The medium to lighter soils were observed in the Plaine du Nord, Cul-de-Sac, Archaie, Leoganes, Jacmel and Marigot regions. The Marigot soils could probably be described as gravelly (cobble size in places), sand intermingled.

Rice appeared to be almost universally grown in all areas (except Jacmel and Marigot) if the farmers have enough water and are on suitable soils. In several areas bananas were irrigated in small plots, while in other situations they occupied the border areas. Other irrigated crops included taro, corn, beans, sugarcane, shallot and other vegetables. Vegetables were more predominant near large cities such as in the Cul-de-Sac.

In the Leogane area sugarcane was irrigated on a shallow loamy sand soil underlain by fine sands.

Most of the farmers interviewed owned at least two plots and many owned three or more or were working others under some arrangement. One or two plots would be in different irrigated areas, and perhaps one would be on a hillside or other non-irrigated location. Extensive use was made of day labor for land preparation, rice transplanting, weeding and harvesting. Some sharecroppers or day laborers were interviewed. Fertilizer use seemed to be limited. Availability of credit was also problematic. Farmers seldom mentioned membership in organizations or associations. However, some groupings obviously exist (to maintain and fuel pumps, for example), and some water users are being orgainized here and there; so it is difficult to generalize.

Irrigation Infrastructure

Conveyance works dating from colonial times were observed in almost all major irrigated areas. These structures were still operational in many instances. Other significant infusions of capital in irrigation structures occurred during the 1920s when the U.S. Marines occupied Haiti, and again in the 1940s and 1950s with the U.S. Point 4 programs. Other donors such as IDB, FAO, World Bank, USAID, etc., have made significant investments in recent years. Nevertheless, many of the same structures are in need of rehabilitation to various degrees. Site conditions at the locations of many of these structures impose severe restrictions on functional longevity because of geologic and/or hydrologic factors.

Rehabilitation needs, from a strictly hydraulic or structural integrity viewpoint, were varied but generally included repair of intake gates, repair/rebuilding of sluice gates on larger barrages, clean out of any existing debris traps, restoration of measurement devices, and repair of damaged masonry canal linings and distribution structures (Photos 1 and 2). Capacity of closed or covered conduits in most instances had been severely reduced as a result of sediment deposition. Canals on some systems were never completed or were not rehabilitated along with work on intakes. Linings were never finished or were not put properly in place.

Water carrying capacity could be increased in many earth-lined canals by proper shaping of the cross-section, along with restoration of the bottom slope to original design.

Sedimentation and Its Impact

The run-of-the-river irrigation systems exhibited a significant degree of susceptability to sedimentation. Deposition of sediments ranging from silts and fine sands on up to 10 cm and larger gravel was observed in nearly all such systems. The extreme disaster systems were Riviere Griese and Riviere Blanche in the Cul-de-Sac area. Large concrete barrage structures at these sites have been completely buried by gravel (up to 10 to 20 cm size) (Photo 3). This destruction process has been repeated at least twice for each river in recent history. There is no evidence that it will not happen again. The gravel seems to be coming from previously deposited alluvial embankments which are re-eroded as a result of high peak flood flows. Currently the water is routed into the canal intakes by using a bulldozer to reconstruct a gravel dam after each major flood event.

Sedimentation occurs in most of the spring-fed systems, although not to the same degree as in run-of-the-river type. Some of these appeared to be the result of local surface runoff from storms. Aquatic weed growth also appeared to be more significant in springs, particularly those from lowland drainage collection situations.

System Operation

The various systems seemed to have similar operation practices in common regardless of size. For example, field plot water delivery was accomplished by rotation among fields along the tertiary canals, rotation among tertiaries along the secondaries and rotation among secondaries along the primaries. Generally there was continuous flow in the main or "mama" canals. This description may not fit in the small systems, where the main canal really serves as a farm distributary (tertiary). Rotation intervals varied, officially from 8 to 15 to 30 days depending on water supply. Several farmers indicated they could informally get water every five days by working it out among themelves. Some systems have ample water compared to the number of users (land area).

Rotation delivery has significant advantages where irrigation water is directed to relatively small plots. Equitable quantities of water can be provided to each farmer, proportionate to area irrigated, by reference to length of time only. This is possible if the flow rate is reasonably constant throughout the rotation area during any given cycle. Water measurement is therefore not required at the farm turnout. Equity of water distribution along the main canal could be accomplished by flow measurement at the primaries as well as at the head end. While a few measuring structures were observed in the canals, no evidence was found of any measurements currently being taken except at the overflow weir at the Despuzeau spring. There was also no evidence of any streamflow measurements being taken.

Water Management Efficiency

On-farm irrigation practice for all crops, except sugarcane, employs small (1m x 2m or 2m x 4m) basins up to paddy size areas. Sugarcane, if irrigated as in Leogane area, appeared to be furrow irrigation. Observed on-farm irrigation in small basins (Photo 4) was exceptionally manpower and water distribution efficient. Application efficiencies (uniformity) were estimated to be 65 percent for 2m x 4m basins without flowthrough. If these basins were dead level, the application efficiency could approach 90 percent.

Distribution system conveyance efficiencies did not appear to be very good, particularly in earth-lined channels. Leakage past farm turnouts and tertiary and secondary gates was universally observed. Even lined channels had cracks and holes in the bottom and sides. Apparently there have been no system evaluation measurements taken which would quantify conveyance and on-farm distribution and application efficiencies.

Irrigation scheduling based on the 8-day interval may not be appropriate for shallow rooted vegetable crops or for sugarcane on shallow sandy soils. The existing practice may result in excess water

applications at the time of irrigation with accompanying deep drainage below the root zone. The crop uses water at a potential rate for a few days until the soil water storage is reduced to low levels. The crop water use is reduced and drought stress occurs which adversely affects yield prior to the next irrigation. Thus a continuous cycle of "feast and famine" could occur within each successive irrigation rotation interval.

Drainage

It is impossible to maintain the proper salt and water balance in irrigated soils unless proper allowance is made for drainage. These engineering aspects largely seem to be overlooked in Haiti. The 30,000 ha ODVA project, the largest in the country, "is experiencing a lot of irrigation-drainage and salinity problems..." (Bishay, 1981). A need for surface and subsurface drainage also exists in areas having flat slopes and heavier soils in other portions of the lower Artibonite valley and Les Cayes Plain. Similar needs were apparent in many low lying lands of other irrigated areas such as near San Raphael and in Maissade. Spring-fed systems are not immune (Nan Pol). Waterlogging and salinity are part of the reasons why so much of the nominal irrigated area in Haiti is partially used or out of use.

Maintenance Chores and Administration

Maintenance requirements are highly correlated to sediment and debris removal which is a continuing and enormous task. It is of such magnitude in certain high risk areas and in larger systems as to exceed local community energy and organizational ability. On some of the larger systems, such as operated by ODN near San Raphael, one day per week is set aside for main system cleaning. All farmers desiring water are supposed to be represented in the work. It was not clear how stringently water cutoff was enforced for non-cooperators. On smaller systems maintenance tends to be carried out by the water users working together apparently without much, if any, government intervention. On State systems, large or small, the cleaning appears to be organized by District technicians.

Many canal systems had been cleaned during the previous few months by manual labor paid in turn through the "food for work" program. In some instances this may have been the first significant cleaning in several years (Photo 5). The role of the Syndic (ditch rider) in canal maintenance was not always clear. In a few instances the Syndic had apparently helped organize the canal cleaning activities, while in other situations he may have also been responsible for routine daily canal inspection and removal of obvious obstructions. A universal complaint, other than within ODVA and perhaps within Leogane, was that the so-called irrigation tax was not returned to the districts to support maintenance activities. A very great number of farmers expect the

government to "provide the water." In all cases the assessed tax was a fraction of what would actually be required to maintain main and primary canals. The farmers do not pay the tax if they have not been getting water or can get the water anyway. The 50 percent compliance rate may be indicative of the degree of inequity of water delivery in government-controlled systems.

No generalization should be made about the actual ability or willingness of government or private entities to operate and maintain all the irrigation systems in Haiti. Many small systems work very well under the circumstances; some of them have considerable Ministry of Agriculture support or input. Water users on such systems may or may not pay nominal water fees--it appears to depend mostly on whether or not they built the systems themselves. Permission for private groups to reconstruct or start up a small system can be obtained from the local irrigation district representatives. A Syndic will not be appointed if the users get on well together and no water use conflicts develop.

Where "public" systems are failing because they have broken down or have reduced capacity for any reason, the deeper problems emerge which have drawn so much comment. Farmers short of water will naturally try to get the Syndic to favor them with special treatment. Powerful owners will get their way, etc. The basic order required for an irrigation system to function will be replaced by chaos and distrust. If the systems were maintained to a standard which permitted them to function, many of these complaints and disagreements would disappear.

A point which may be reemphasized in discussion of user apathy and maintenance shortcomings in Haiti's irrigation works is that the location and layout of some systems involves incredible amounts of cleanout and repair. The costs in time and effort may be very high in relation to the expected increment in production over and above the rainfed alternative (this is a conjecture that might be investigated). In such situations (given a strong farmer belief that the government should do the cleaning if it collects water taxes, plus any weakness in local leadership, Syndic authority, or other unharmonious elements enumerated above) inertia simply takes over.

Water Charges and Use Efficiency

One implication of this argument is that the O&M situation in some irrigation systems is so bad that it is unlikely that the local users could ever meet the costs of upgrading. However, as a general rule based on experience, income from irrigated production can usually bear O&M expenses (this contention must be tempered by and be related to the reality of plot sizes and minimum subsistence requirements of the farm familes involved). This applies to Haiti as well. For instance, Hauge (1984) reports irrigators on pump systems in the Cul-de-Sac paying $200+/ha/yr for irrigation water.

These paragraphs concerning O&M have emphasized only "cost recovery;" some ill-informed persons believe that irrigation water charges can also be a vehicle for improving on-farm water application efficiencies. An example from the Dubreuil system illustrates an important shortcoming of this belief. The WMS II Team interviewed a woman producing corn and beans upon 5 carreaux of rented land. She relied upon machine land preparation, hired 4 to 5 laborers on a daily basis to accomplish specific tasks, applied fertilizers and pesticides and gave every indication of expecting good returns from these practices. Her method was to ask for irrigation water when and if she needed it by giving advance notification to the syndic. She paid for only the deliveries received.

Her rented parcel was served directly by a main channel which seemed always to contain water. She was able to treat her irrigation supply as a demand system--she could turn it on and off at will as though it were a tap which could be left open for varying lengths of time. Since each draught is charged for separately, changing the price she pays conceivably could have some impact upon the amount of water she would be willing to apply to her crops from time to time. RULE: Altering water prices in order to induce greater on-farm water application efficiencies requires that the farmers be serviced by a "metered" demand system.

Demand systems are few and far between and are not easy or cheap to create. To begin with, they usually require storage features--from the standpoint of the woman farmer in Dubreuil, access to a constant flow amounts to the same thing. The Dubreuil system is still being developed, and quite a bit of water is available to the land blocks thus far opened to irrigation. A more common situation is that systems are designed or develop in such a manner that available water supplies must be "stretched" to cover the land irrigated. Whenever water is generally in short supply or is short during dry portions of a crop season, farmers automatically handle what is available as efficiently as they know how; charging for water to achieve exactly the same result would be superfluous.

It is true that if farmers do have adequate water and a fee is imposed, and if they respond by taking less, then the "excess" not diverted onto their lands might be used by someone else downstream. However, even if currently "too much" water is diverted, the plants can only transpire at a natural rate; any "excess" water will usually pass back into the watercourse by underground or overland flow and may still be available somewhere else. This means that "efficiency" must be looked at in a global sense in order to form sound judgements about system operation (Keller, 1984). (There are cases where farmers with ample supply plus adjacent unirrigated land will try to change to sprinklers and irrigate an additional increment.)

Choice of Irrigation Water Management Technology

An irrigation system is much more than a hydraulic system. Sound operation requires the application of basic principles of agronomy, soil science, water requirements of crops and other disciplines which must be combined with engineering hydraulics to form the rather complex art of irrigation. The aim is management of the soil moisture environment for enhancing agricultural production. It is axiomatic that the benefits of irrigation are realized only when the water reaches the cropped land. To obtain the full benefits requires that enough water be available to satisfy crop water requirements (Bishop, 1974).

Water management activities pertaining to irrigation involve four levels, classified by function:

- Source (watershed, surface or underground);
- Distribution (conveyance and control structures);
- Application (on-farm water management); and
- Drainage (removal of excess surface and subsurface water).

Characteristics of Water Sources. The source of water for agricultural crop growth is ultimately found somewhere in the hydrologic cycle. In rainfed agriculture, the water for crop growth is obtained directly from rainfall stored as soil moisture. Irrigated agriculture additionally depends on arrangements for water collection, storage and conveyance from a watershed. Any of these elements may be modified by the actions of man. If there are no significant surface reservoirs upstream from an irrigation diversion, it is known as a "run-of-the-river" system. The great majority of irrigation systems in Haiti are of this type. Exceptions to this are the Artibonite, which is supplied through the Lac Peligre Reservoir, and the systems supplied by springs or wells in areas such as Gonaives, Cul-de-Sac and Les Cayes.

Water is supplied for irrigation directly from the available stream slow in a run-of-the-river irrigation system. Since there is no reservoir to store the water for future use, flows must be used as they exist or not be used at all. Depending upon watershed conditions, irrigation water will be available only during or immediately following the rainy reason. The ideal watershed conditions would be such that all of the rainwater would infiltrate the soil and any excess, not transpired, would percolate into the groundwater aquifers for later discharge in streams and rivers. This would lengthen the recession portion of the streamflow hydrograph and greatly extend the possible irrigation season. It would also cause a run-of-the-river system to look like a spring-fed water source. The available water is diverted by means of a diversion dam from the stream into the main canal, to the laterals, to the sublaterals and the farm ditches before reaching the

point of use. Well-planned farming activities within the service area of the system are essential in order to realize all of the potential benefits. The cropping plan must allow for the expected hydrograph of the streamflow as a function of season.

The watershed conditions in Haiti are such that a significant portion of rainfall very rapidly runs off as flood flows. This reduces the baseflow portion of the supply hydrograph for run-of-the-river diversions. The attendant increased volume of sediment transport ranging in size from silt to gravel, creates additional difficulties in canal maintenance if flood flows are also diverted.

Main system management in a run-of-the-river design normally reduces to diverting all the water possible (within limits of main canal capacity). This leads to continuous, fluctuating flows, 24 hours per day, in order not to "lose water to the sea." Irrigation authority technocrats view their public responsibility as a "calling" to push all the water possible through the structures which they manage. The most they can do for farmers is to deliver every drop. What the farmers do with the fluctuating supply is something else.

Those water sources which incorporate a reservoir confer additional flexibility in that excess water during flood periods can be stored for subsequent use to augment flows in dry seasons. The possible irrigated area that can be served is determined by the reservoir storage capacity, rainfall during the irrigation season, crop water requirements, conveyance and application efficiencies and the magnitude of other required releases (i.e., for hydro-electric power) which cannot be used for irrigation. A potential for conflict between irrigation and hydropower exists for water stored in Lac Peligre. This will intensify as demand for electric power increases in urban areas of Haiti. Further reservoir development is limited by availability of suitable dam sites, political and economic considerations and lack of hydrologic and watershed factors favoring reduced sedimentation rates and maximum stored water yields. Relatively high costs are associated with construction of the dam and attendant facilities; however, distribution system maintenance costs may be reduced as a result of flow stabilization and lower sediment transport rates.

Water supplied by a groundwater reservoir has two main advantages over surface water storage in Haiti: a minimal sediment transport problem and essentially no evaporation losses. These advantages are fully realized in spring-fed systems. The same advantages can be obtained from wells. However, additional costs are associated with development of wells for pumped irrigation supplies. In Haiti, availability of fuel and maintenance may be a severe constraint on dependability of pumped water supplies. The diffuse nature of a pumping scheme in which each unit may supply water for 100 to 200 hectares could present a possible cost advantage over a large-scale reservoir or even run-of-the-river systems. This is possible because large canals capable of supplying hundreds or thousands of hectares in the command area are not needed. The scale of such a pumping scheme may approach the

extended family size operation for an individual pump. Something similar seems seems to operate fairly well without official intervention in small Haitian run-of-the-river systems.

The estimated potential for groundwater development was presented in a 1979 Harza report. This estimate ranged from 1,444 to 2,374 liters per second for 12 out of 29 aquifers (Table 7, ESCOP). If flows are comparable in the other 17 aquifers, a maximum of 5,100 to 5,700 lps may be available for development. It was not clear if already-developed springs and wells were included in these estimates. Assuming a crop water use of 5 mm/day (Hargreaves, 1982), and irrigation efficiency of 50 percent for typical Haitian conditions, 1.16 lps/ha is the required design flow rate. It is possible that such irrigation requirements may be satisfied only 5 to 6 months out of the year, depending upon locality and seasonal rainfall patterns. In any case, the area which could be fully irrigated by these potential groundwater sources may not exceed 4,400 to 4,900 hectares, which is approximately five percent of the estimated total land area now irrigated.

Massive watershed rehabilitation work will be required to obtain any increase in availability of groundwater supplied spring or pumped irrigation systems in Haiti. Greater water retention on the watershed must be promoted to maximize ground water recharge potentials. Since the base flow of most run-of-the-river systems is also from springs, all irrigation water supply conditions will be improved by better watershed management.

Water Distribution Methods. Distribution of irrigation water requires conveyance and control facilities for moving water from the point of diversion at the source to the delivery point at the farm. The necessary facilities become increasingly more extensive as the service area per diversion point increases. Distribution methods can be continous flow, rotation, demand or some combination according to the temporal availability of water at the delivery point.

Continuous flow distribution systems supply water continually at the point of use. This tends to minimize system capacity requirements and may match the legal definition of a water right as a specified flow rate per unit area (e.g., 0.6 lps/ha). However, these systems may impose inefficient application techniques if surface irrigated plots are small. It is also difficult to make the most of natural precipitation and requires 24 hour per day irrigation by users. Sprinkle and trickle irrigation applications are most suited to continuous flow delivery.

Rotation delivery schemes were an outgrowth of the inability to obtain adequate water heads simultaneously to many small plots under continuous flow arrangements. Direct water flow rate measurement at the farm level is not required because the water turn is on a time basis (e.g., all of the stream for each three hours turn per ha) up and down the lateral. There is usually continuous flow in the main and submain canals with rotation within blocks served by laterals, depending on project size.

Complete flexibility in water supply to the user is implied in a demand system. In a practical sense this means complete control of timing, duration and amount of water delivery within system limits as designed and/or operated and maintained. This imposes extra requirements for water storage, additional measurement and regulatory structures, greater system design capacity, increased operation staff and more record keeping (in a typical large gravity system). A pumped groundwater irrigation system serving a small area may operate in a demand mode. As a general rule, demand system conditions will be achieved whenever any water use quantity is a relatively small portion of the water available at the source. Typically, "head end" irrigators in surface systems manage to operate on a demand basis.

The water distribution methods observed in Haiti were predominately rotation along the farm ditch and laterals. Continuous flow was generally maintained in the main canals. There was evidence that head end users could operate with water on demand while some "tailenders" obviously were chronically short of water. In the latter cases, rotation intervals were sometimes extended to 30 days or more between irrigations.

Irrigation Application Methods. Four water application techniques are used on farms: surface, sprinkle, trickle and subsurface. These are listed (roughly) in order of increasing application efficiency and cost, except for subsurface. No sprinkle or trickle systems were observed during the Team's field visits, although apparently a local agriculture consulting firm is considering their use in sugarcane on lighter soils.

Subsurface irrigation may take the form of underground trickle using buried pipes with holes at intervals, or may be some form of water table management. The buried pipe approach has many practical difficulties such a breaks, plugging, root clogging of outlets, which may be difficult to detect. Thus, this form is not used in practical situations. Water table management, either deliberate or inadvertent, is used in many irrigated areas.

Conditions favoring such "subirrigation" are light to intermediate soils underlain by an impermeable layer at a shallow depth (2 to 4 meters) with good lateral drainage rates. This situation facilitates ready control by supplying water in surface ditches to raise the water table. Stopping the supply allows the lateral drainage to take place and lower the water table for field work. The water supply and drainage situation must be such that removal of excess salts from the root zone is readily accomplished. There is considerable evidence of inadvertent subirrigation in Haiti as a result of excess irrigation water in flatter areas which raise the water table downstream such as in the Artibonite and Les Caye Plains.

Surface irrigation with small basins, 1 x 5 meters up to 5 x 8 meters, are used throughout Haiti for almost all irrigated crops. Furrow irrigation of sugarcane was observed in the Leogane Plain.

Irrigation efficiencies in small basins could approach 85 to 90 percent where water is supplied to each basin individually in turn at relatively high flow rates. However, when the water is channeled through the basins in succession, the opportunity for excess infiltration is increased and efficiencies may drop to 40 to 50 percent (Photo 6). Both types of basin utilization were observed during the field visits.

Land grading and good surface irrigation practice go together to make the higher efficiencies possible. There were indications of a need for leveling in the small basins in the Cul-de-Sac area and in some of the rice paddyies in ODN near San Rafael. Another important aspect of efficient surface irrigation is to match practices to soils. The Team observed rice paddies on sandy to gravelly loam soils in the Artibonite Valley above the ODVA project. While the farmers' desire to grow rice is understandable, the excessive loss of water to percolation under these conditions may not be desirable or beneficial.

Drainage Requirements. The foundation of any long-lived irrigation project is good arrangement for drainage. Drainage, whether it be natural or artificial, is required to remove excess precipitation and irrigation water, along with the salts, from irrigated soils.

All irrigation waters contain salts which remain in the root zone following evapotranspiration of water by the plants. These salts must be periodically removed by leaching and drainage to allow continuous crop production. This is why irrigation can never be 100 percent efficient, unless pure water is used, because in time, the soil salinity increase would not allow plant growth.

Presence of a high water table can cause salts to move upwards into the root zone by capillary action. An excess water situation is called "waterlogging" and leads to plant growth difficulties due to reduced soil aeration. With the exception of a few crops (especially paddy rice or taro), viable production is possible only with properly aerated soils.

Drainage is needed also for removal of exceess surface water due to high rainfall or excess irrigation water which may pond and kill crops if not removed within two to four days.

In Haiti, flatter areas of irrigated valleys and anywhere heavier soils predominate, are candidates for drainage. At present there is little or no evidence of any kind of drainage investigations to develop necessary criteria such as depth and spacing of field drains, i.e., hydrological soil characteristics and drainage criteria: minimum permissible depth of groundwater and projected discharge; and optimum groundwater regime for production of various crops.

Economy of Choice. If irrigation benefits are thought of in terms of what happens at the farm level, four factors are most important:

quantity and stability of the supply, energy the farmer is willing or able to commit, and cost. Other things equal, it makes no difference to individual farmers whether the water source is on the surface or underground or whether it is delivered from a big or small system. Farmers allow for degree of control they have over their total resource base, their family needs and potential markets, and adjust their cropping patterns (and possibly) their production practices accordingly. In Haiti, for example, a secure, "ample" water supply induces farmers to grow rice.

In other words, an "irrigated" crop budget takes for granted an adequate supply of water and assumes the same returns per hectare regardless of system characteristics (excluding any necessary investment recovery fees). System scale or type would not be a factor in establishing net benefits per ha.

Therefore, the most basic economic parameter of interest to farmers or to society as a whole is the overall cost of the water development in relation to the land area to be served--the per hectare cost. Other than the possibility that altering the size or type of project (say, including storage) might affect on-farm per ha development costs, there is no necessary link between project scale and on-farm technique. On a per hectare basis some small projects are expensive, some large ones are cheap and some underground ones can develop the same amount of water at less cost than an alternative surface plan.

Usually the local natural resource endowment determines the engineering solution to be applied. If there are no surface sources, pumping may be the only option; if all of a river basin's supplies have been developed, transmountain diversions may be the only technological option to obtain more water. It is not unusual to have only one reasonable technological choice available at one time; it is probably less usual to have two (although this is a common situation in Haiti, as alluded to above).

Nothing can be much cheaper from the standpoint of Haiti's public treasury than some of the small, private systems. This is not because size itself is the important factor, but rather that if they are more or less built and maintained by hand, they are simple; otherwise, they could not have been financed by available private resources. Most important of all, if they fail there is little or no sense of draining the national exchequer.

Anything the public must pay for in the way of irrigation development can be measured in the first instance on the basis of relative cost per ha, allowing for initial investment plus subsequent public O&M burdens. The most direct economic tie to cost per hectare is degree of complexity. Each additonal feature adds cost; diversions may be ambitious, dams are expensive and interbasin transfers are the most expensive of all. Expected O&M burdens also are influenced by the degree of complexity--checking and measuring deliveries, adjusting turnouts, etc.

Experience has shown that investments of $2,000 to $2,500 per hectare (excluding O&M) are at the upper range of affordability, regardless of international location, if fairly common crops are to be grown. There is a trade-off between quality of initial construction and subsequent O&M requirements. Long-lived distribution systems can "bear" more investment burden than can short-lived dams.

Suppose a new $4,000,000 barrage is placed on Riviere Grise and that 9,000 ha actually will be irrigated versus the 5,000 ha at present. The effective per ha cost will be about $1,000 ($4M/$4,000). At first glance this is not too bad. But O&M financing will have to be expanded to the whole system (an adequate rate would probably be $40 to $50/yr.), and the barrage may have a short life--20 years would not be out of reason. Still, the cost per hectare would not appear unreasonable if the assumption about the effective net increase in land area is correct. It may not be. The question that needs answering is, "How much more water will the barrage actually be able to capture?" A new barrage will not change the river flow patterns, runoff intensities, or peaks, from what they are now. The annual cost/additional ha for 20 years would be about ($101.78 + 50.00) = $150/yr. A bulldozer barrage (BB) might accomplish the same purpose for $75/yr. (incl. O&M) and, if no new land is brought in, a BB would cost about $13/yr/ha for the existing 5,000 hectares.

Development of potential groundwater sources may add some 4,900 hectares of cropped land, as suggested earlier, under full irrigation. If the average pumping lift were 20 m, irrigation efficiency 50 percent, pump efficiency 75 percent, and if a 50 hp diesel engine were used for power, then 118 hectares of land could be fully irrigated, with each pump set supplying 143 lps (see Annex F for supporting calculations). The estimated annual cost (capital recovery plus O&M) of operating such a plant 3,000 hours each year, under western U.S. conditions would be $107/ha. A conservative escalation for Haitian conditions may be three times that amount, or $321/ha.

The potential area of 4,900 hectares would thus cost $1,572,900 each year to operate, maintain and recover the capital investent in wells and pumping plants alone, assuming no inflation in annual O&M costs. The initial capital investment is approximately $400/ha for these assumed conditions.

Note that the pumping figures do not allow for any conveyance system O&M, but the annual amount per hectare may be assumed to equal the requirements for other systems (if they are maintained). Thus, on balance, the 4,000 marginal hectare inside the commmand area of the Riviere Grise might be brought into use for annual outlays below what pumping would require--if the run-of-the-river supply is really available today. (The WMS II Team was unable to review the TAHAL estimates on this point.)

Calculations of this sort illustrate how difficult investment choices can be. The amount of land in either case is about the same.

The barrge, not unexpectedly, represents a heavy per hectare initial investment relative to wells; annual O&M on the pump sets is a big offsetting factor. Under U.S. conditions and price relationships, the money costs would not be significantly different: $150/yr. for the barrage versus $107 + $50 (conveyance O&M) for the wells. Given the Haiti situation, a big factor would have to be added to the cost of wells and the barrage turns out to be a waste if more land actually cannot be brought under full irrigation. There is no clear-cut answer because the data sources and information base are not clear-cut.

Factors other than simple cost comparisons which should be considered when dealing with wells include availability and source of capital and maintenance funds; (outside donor or domestic); and fuel availability and availibility of spare parts and trained mechanics at reasonable prices. The potential yield of aquifers, which must be adequate to supply demands of pumped wells, is unknown at present in most of Haiti. There seem to be some indications of trouble for pumped groundwater in Haiti in the area of energy availability for electric motors as well as diesel. Urban consumers seem to demand as much electric power as is produced. This explains why the above comparisons referred to diesel only.

Thus, while relative investment cost per hectare is the simple economic criterion for ranking projects (if expected cropping patterns are about the same), other pertinent questions must be addressed in individual cases. In the ODVA zone, to mention an example, O&M costs are $95/ha/yr, exclusive of any investment recovery.

Working or Workable Institutional Arrangements

Apparently, a simple juxtaposition of land, labor and capital is not enough to make irrigated agriculture successful because of many of these factors having been brought together around the world with mixed results. It is now clear to everyone that institutional arrangements play a major role in irrigation project performance. Experience has also shown that only certain arrangements work. Examples of working arrangements exist in Haiti, and a brief description of specific situations will show what we mean.

High Degree of Cooperation. 1) Abraham system in Fond des Negres area has a drainage water collection source. Consequently siltation and structural failure is minimized. Cleaning is not a burden. A lot of rice can be raised. Some recent maintenance had been carried out. Probably the arrangements had been made by the irrigation district officials who get along well with users. Discussions with users revealed that there was ample water for all (Photo 7). RULE: "Excess water takes the tension out of user interactions." This is one of several reasons why project evaluators do not like to see water streached too thin.

2) Barettes system in Petite Goave is a run-of-the-river system. The main structure is in fairly good repair. Two years ago the present engineer (assigned by the Irrigation Service) arrived. He required every user to declare the amount of area to be irrigated, adjusted planned deliveries where necessary, and set up a schedule of water turns wherein each plot received water on the same day of the week at the same hour. Signed "turn cards" were issued for every plot. The engineer stated that some "stronger" owners struggled against the new system but were brought into line. The users were cleaning the system at the time of the Team's visit. Apparently no difficulty had been encountered in organizing the effort. Some food for work had been distributed (rice), but district officials stated that everyone understood that the distribution was a one-time thing. The engineer was clever. He gave slightly longer water turns at head end of ditches as an inducement to those plot owners to share in cleaning that cannot benefit themselves. RULE: Make an equitable distribution of available water resources and make a commensurate requirement for the labor or cash burden of obtaining the supply.

High Degree of Control. At Leogane the local sugar mill management (parastatal) desired a firm supply of cane for processing. Energy and resources, therefore, had been invested in the local irrigation system. Whether the capital for new headgates and some other reconstruction were supplied by the firm or through the Water District was unclear. The canals had been cleaned and water was distributed to laterals on a strict rotation system. Several Syndics were directed by a "controller." The ditches were patrolled every day. Water allocations were being enforced by means of heavy pressure on Syndics by the firm's management and by a full-time "extension advisor" stationed in the system by Damien. All of these Ministry people were getting salary supplements (from the firm?). Violations in water use had occurred, and the offenders were immediately taken to court and fined.

At present, when the canals needed cleaning, the controller told the extension supervisor who verified the facts and demanded money from MARNDR. When it arrived, the controller recruited a work crew and payed according to contract. The firm was supporting efforts of "Action Communitaire" organizers who had divided the users into groups who eventually served as the contractors (apparently for less money) on the primaries and secondaries.

This system would work because everyone knew his place and human and financial resources were available on demand.

According to Mr. Flambert, the new Minister of Agriculture at the time of the Team's visit, all irrigation systems could have their operation straightened out by following the same pattern. Once any of them are running in an orderly way, only a few technical people (i.e., powerful) are necessary to maintain control. It is unclear how MARNDAR will find the O&M funds necessary to replicate the model. RULE: Naked power can also be used to enforce equity in water distribution--the

outcome depends on the rules made and their logic and constistency in application.

Given these two polar examples, readers may infer a kind of institutional continum along which various tradeoffs can be made, hoping to end up weighted toward a high level of cooperation. But such a continum is not a very realistic mental image because as a little reflection will show, most semi-functioning irrigation systems are somewhere on just such a continuum--and indeed, either polar extreme is probably better than anywhere in the middle.

There is, however, a third institutional arrangement, a third pole, that may be of service in the Haitian situation. (The arrangement to be described is not unknown, but it is not a part of the literature on irrigation development and appears in this report and this context for the first time so far as is known by the WMS II Team.)

Order Through Law. Utilizing funds supplied through the German Council of Bishops, DCCH (Misereal), a local organization in Les Cayes has undertaken renovation of the Canal Avezac irrigation system. The potential command area at this stage is about 1,800 hectares. Over 20 habitations were affected. Until recently, two expatriates, an agronomist and engineer, were supervising technical details. The agronomist, with the help of Haitian district engineers is trying to wrap-up the the organizational details, provide some consultation and put the system into full operation.

Considerable effort has gone into calculating the amount of water that will be delivered to each hectare per water rotation (.08 lps) and turnouts have been sized accordingly. Meetings have been held with various user groups to explain the new regime. For example, the DCCH has prepared a model set of bylaws for users and groups which it hopes to have approved by Damien. Users have been told they will have to abide by the new rules, part of which involve paying $20+/ha/yr. for water received. The aim is to make the entire system self-sustaining.

A zone containing seven habitations has been chosen for pilot operation of the measured distribution/user fee scheme. At least two of the seven habitations have been getting water, essentially for nothing, all along. The others are eager to get on with the program and want to pay the proposed fees. Until now the "upstream" groups have said nothing, apparently going along with the outlet sizing, the idea of formal membership bylaws, payment for O&M, etc. However, once it became apparent that the sponsors were serious and that things were going to happen, they balked.

These "head enders" have been enjoying such ample, free water that they are raising rice on lighter textured soils while other habitations get nothing. They are now faced with having to give up rice production, to have their water "metered," and pay for what was formerly free. They not only refuse payment, but they also might be able to get more water

than the pilot plan calls for if they use force to obtain it. If they are successful in thwarting the pilot trial, there is a real possibility that much of the effort for the entire scheme plus $1 million or more of donated money will go the way of past investments, since future O&M will not be carried out.[1]

The sponsor group made a fundamental error in not foreseeing that this outcome was inevitable. They missed their chance to apply government threats (in advance) and put pressure on those who would be bound to lose some benefits in order to do what is necessary for the greater number. (A sponsor group from the western U.S., where the "sociology" of irrigation is well understood, would have known what to expect and would have not spent any money without having some official guarantee that all users would be held in line and that early agreements would not be breached.) See Annex C.

The WMS II Team could not have asked for a better demonstration of an important thesis than provided by this example. RULE: Orderly operations of large or complex systems require users to adjust individual actions to the dictates of a collective; planners ignore the "sociology of irrigation" at their own risk. But this example has other, even more important, lessons.

Substantive aspects of "law" were ready to be put into place; users had agreed to bylaws of operation which implied water allocation rights for each plot; (the entire group--due to existence of the canal--already held traditional rights to river flows); government authorities had been asked to "ratify" the bylaws (such concurrence would have created an additional line of argument concerning claims on water service as well as a new precident in establishing a mechanism for enforcing equity within the system laterals). All of these factors form the foundation of an institutional model that needs only elements of land and water rights registration and national or regional enforcement mechanisims to be complete. This model for obtaining national social benefits from water "duty," while maintaning harmony and equity within irrigation systems, operates everywhere in the western U.S.

Summary. As we have seen, individual actions inside an irrigation "collective" can be regulated by volunteerism or by force. They can also be controlled by law if clearer notions about rights and responsibilities are spelled out for administrators and technicians as well as farmers. This is the third way.

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[1]At the time of the Team's visit, the sponsors appealed to the new Minister of Agriculture to step in and control the situation so that the program would not be disrupted. After this was written, the WMS II Team learned that no official action was taken. The sponsors were "left out on a limb."

Consideration of Arguments Concerning What Can Be Accomplished Through Irrigation Development

The brief observations which follow are reactions to certain arguments noted as part of the WMS Team's document review. They are intended merely to suggest questions or clarifications of certain points in order to illustrate the Team's frame of reference.[2]

Strong Water User Organizations Can Reduce or Eliminate the Need for Public Subsidy of Recurring Costs (USAID 1984)

In the case of irrigation works, which always need constant attention in greater or lesser degree, GOH has provided some technical staff in the Irrigation Service and the Irrigation Districts, and varying levels of day-to-day operating budget. The need for major injections of new capital to prop up the system have been handled by appeal to donor support--in a situation where lots of other recurring costs must be covered if the assistance is to have long-run impact. Since the GOH has shown no willingness to foot the bill from the general exchequer or via user charges (cf. Hauge, 1984), the natural inclination is to ask whether there might not be some other way to induce users to take over significant maintenance chores (which can be labor intensive) on a group (voluntary) basis and possibly pay other operating costs as well.

Where there is a strong need for food security that is highly dependent on the availability of irrigation water and where the systems are relatively simple (a diversion and a ditch), such groups form themselves naturally and assume the necessary responsibilities (LeBaron, 1984). This holds true in many Haitian situations, as described by Hauge (1984) and observed by the WMS II Team. But when systems are more complex, i.e., too many villages, or when the varying moisture demands of a wide range of crops need to be met, or food security is not critical (good rainfed agriculture in American Midwest), cooperation becomes difficult and the requirements of users to abide by the rules of a collective organization are achieved only by respect for law or through brute force.

Complexity works against inter-habitation (inter-group) cooperation within Haiti's larger public systems and autonomous agencies because there is two-way lack of respect for law and persons. (This has been verified through discussions with individuals knowledgeable about the Haitian irrigation scene and is amply documented by Hauge (1984; TAMU, 1983; Hargreaves, 1982; Stutler, et. al., 1983).)

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[2]See Annex E for discussion of other selected aspects of GOH and donor policy in the agriculture sector.

Presumably, legal demands upon users to participate in cleaning activities could be enforced through the political system extending to each Section Rurales, or, the Leogane model described above could be invoked if government authorities so choose.

However, there remains the question of why need for food security would not itself provide sufficient stimulus to call forth a lot more group motivated ditch and canal maintenance effort? No doubt several factors explain why this does not happen, but the root causes seem fairly clear: (a) a great deal can be accomplished on a rainfed basis if the ditch runs dry; (b) basic subsistence is supported by many alternative food sources; (c) individuals and groups cannot really capture the benefits of their maintenance efforts; and (d) some farmers on the head-end of the systems get water in any case.

The general solution where the interlocking groups cannot assume responsibility for maintenance is a system of differential assessments correlated with water received. Unfortunately, this might be an expensive and difficult administrative hassle until a way can be found to put the chief collection burden onto villages or groups and until there is high level political determination to earmark funds and require commensurate shifts in bureaucratic mentalities.

The WMS II Team heard comment to the effect that the autonomous development agencies are "working," especially in connection with ODVA. Presumably this refers to the fact that the physical acts of maintenance are more or less being carried out. Hauge has shown and the BID and FAO representatives in Haiti have confirmed that although the charges collected are better controlled, and rates are set at much higher levels than the national average, and amounts collected are roughly 50 percent of what has been assessed. Moreover, even if 100 percent collection success were achieved, the total would be one-sixth or one-eighth of what is actually being spent for O&M alone. How much more would be required in addition to amortize capital costs (even at concessionary loan rates) is open to conjecture.

Bottlenecks in the Existing Irrigation System

- Inadequate maintenance;
- Irregularity of supply;
- Inequities in allocation; and
- Low quality of on-farm water management (Hauge, 1984).

All of the elements identified by Hauge are playing some negative role in the irrigation subsector. However, in some situations the first

three do not seem too important.[3] These are the cases where irrigation structures are okay and supply irregularities are due solely to seasonal river flows, not human cussedness. In situations where maintenance, irregularity and equity are important, the surest way to permanent progress would be to obtain the distrust and lack of tenure security out of the rural social structure.

The quality of on-farm water management is very important--yields can easily be doubled with the right tillage, soil conservation and water application practices. However, skills vary from place to place. There is little or no hard data in any of the documents studied by the WMS II Team. Some farmers are using techniques which, in association with some leveling, would run their on-farm application efficiencies towards 90 percent.

As mentioned earlier, once enough trust is put back into the sociology of the irrigation network by even-handed application of law and administrative procedures, the systems must be productive enough to stand water user fee collections to keep them up to standard. This should be possible, since vegetables and other valuable crops can be grown, or good yields on staple crops can be obtained. As hinted above, this process should lead to some price benefits for consumers. (Hauge was quoted earlier that members of co-ops depending on pumps are paying as much as $200 plus per season to obtain a bean crop--apparently this is per hectare; as much as $20/carreaux for a single irrigation is passed among individuals in the Les Cayes area when water is short.)

More Irrigation Infrastructure Will Increase Output

It is necessary to make clear on what is meant by new infrastructure. The WMS II Team visited systems where expensive new construction was proposed, i.e., new intakes. Replacement may not affect crop output to a significant degree. Other projects proposed involve rehabilitations of another sort; they might make more water available and therefore enhance output. Some crude estimates of what might be expected from canal lining, for example, are included in the next section. New water and land combinations utilizing new technology have potential if the arrangements are economic. In any case, some additional output should be attainable.

In the event more land can be irrigated, the discussion of domestic market absorptive capacity applies. Other output growth conceivable could be absorbed in the form of exports. But with sugarcane in the

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[3]Nader claims that many laws are ignored by the "controllers" (ditch riders), especially in the systems where "large and small farmers must co-exist" (1984).

doldrums and no banana trade, exactly what besides coffee is exportable must be considered. Some current and potential export crops are not irrigated given present state-of-the-art. Some are highly destructive of the hillsides.

Markets (Domestic) Can Absorb A Large Increase in New Output

The draft Title III Project Paper argues that "There is much room and great need for increases in the local food supply" (USAID, 1984). Part of this contention is based on estimates of nutritional shortfalls and part is based on estimates about food demand growth (Kite and Pryor, 1984).

Shortfalls in nutrition, even if correctly documented and expanded to encompass the total population, do not necessarily translate into taste and preferences and effective demand in the marketplace. It is doubtful that the real nutrition situation in Haiti is known; cross-checks from consumption patterns are not available (Berg, 1984; Kite and Pryor, 1983) and crop and livestock production figures are unreliable as well (USAID, 1984).

As an example, we would expect lots of undocumented sugar to be entering rural diets. This might be picked up in a nutrition sample, but would not show up in other data sources.

It is natural to expect the nutrition of consumers in general to improve if food prices are lowered, due to some subsitution and income effects (an increase in quantity demand). But since the food policies recommended to USAID/Haiti involve greater cereals imports, not less, there may be little or no demand "gap" for farmers to fill. Actual domestic markets may not be able to absorb too large a jump in domestic cereal production after all. Is expanded irrigation production to be concentrated in "high valued" crops?

From the standpoint of raising farmer incomes the conservative position is to exploit growth in the domestic market at a rate which barely keeps pace with demand growth and holds imports out. This might be 2 to 3 percent per year for basic staples and 4 percent for products linked to future higher consumer income elasticities. The potential impacts of many small farmers adopting new technology must be carefully evaluated in relation to the size of their usual markets. Export markets will grow at their own pace (Keller and LeBaron, 1983).

A related point is that not all farmers in a small country can get rich at the same time unless a majority share and specialize in well-developed foreign markets for primary or agro-industrial products. To the degree that some get rich, others will be driven from the land. This is why the notion of self-sustaining subsistence agriculture for large numbers of small families (say, through colonization) is not an

option to be brushed aside. For example, many South American nations have virgin territory available or estates that might be opened up to the landless. Haiti does not really have such an option. Off-farm employment opportunities and rapid non-rural jobs expansion are badly needed.

Barriers to Agriculture in General

- Sparsity of new technology; and
- Lack of O&M in existing irrigation systems (Berg, 1984).

Usually firm markets are all that are required to induce adoption of new technology. This applies to rainfed as well as irrigated situations (Keller, 1984). How well this applies in Haiti is difficult to infer from the available data (USAID, 1984; Werleigh, 1983). Prices appear to be pretty good. Security of land tenure may be imagined to weight a large number of holder farming small decisions regardless of prices. Even if appropriate technology were available, only the elements that could be gotten in and out of production fast might have any management appeal.

The irrigation O&M and policy barriers have already been reviewed, but it cannot be stressed too much that the long-run viability of Haitian basic grains production depends upon bringing real resource costs of production into reasonable balance with international prices. A country as dependent as Haiti upon its agriculture sector must recognize that an enormous jump in efficiency is required, not so much to run yields up, although that would be good, but to simply cut unit costs of production as well as to make better use of the resources already committed and to gain elbow room to break out into new and better exports. The overriding requirement for turning Haiti's agriculture sector around is dedicated, powerful and correct leadership.

SECTION TWO

IMPLICATIONS FOR SUBSECTOR PLANNING AND DEVELOPMENT

Data Base For Subsector Planning

One of the major prerequisites for rational planning in the agriculture sector is the exstence of an adequate data base, in a retrievable form. This should include biophysical and socioeconomic information. Desired data include the following:

Meteorologic

Daily maximum and minimum temperatures and rainfall are a minimum which should be obtained in all significant irrigated areas. Solar radiation, humidity and wind run would be adequate if obtained on a daily basis at Les Cayes, Port-au-Prince and Cap-Haitien.

Hydrologic

Daily average streamflow and flood peaks of major rivers in each region of Haiti. Monthly or quarterly spot measurements of smaller rivers and springs supplying irrigated areas in excess of 25 hectares or so. La Peligre inflow, outflow and storage levels.

Soils

Reconnaissance survey of arable and potentially irrigable land is required where texture, depth, structure, bulk density, soil moisture properties, soil fertility and salinity parameters, erodibility and some dynamic properties are determined for purposes of feasible agronomic practices, and watershed management. Eventually a detailed comprehensive soil survey is needed for the country in order to be able to recommend proper land use plans.

Land Use

There appears to be no known determination of actual irrigated area in Haiti. The Team observed that actual area in some systems was 1/10 to 1/20 of what was shown in Ministry of Plan official tables. The first estimate of irrigated area could come from infrared photos taken in February, 1978: (refer to the discussion of "Haiti Irrigation Potential" above). Field checks could come from local Syndics.

Non-irrigated upland area should also be estimated and assessments made for proper land use.

Socioeconomic

The data base for agriculture sector planning or strategic forcasting is very weak in Haiti. Various statistics are collected by different GOH agencies, but for agricultural sector planning purposes, import/export figures and product selling prices in certain markets appear to be the only ones available on a regular and accurate basis.

National crop and livestock production and hectarage data are inaccurate so total availabilities and apparent consumption are guesses. Nothing in the literature reviewed contained references to animal feed consumption.

Rural and household consumption data are not available as cross-checks; demand/supply forecasts are very difficult to make; elasticity values are crude or wrong. Agricultural census data is out of date and inaccurate (Zuvakas, 1980).

It is unlikely that value added estimates for the agriculture sector are accurate; a macro view of the whole sector is difficult to formulate. Population statistics are estimated but not everyone agrees with the results.

Apparent Conservation Opportunities in Irrigated Farming

Much attention has been given by government, private and international agencies on improving the irrigation structures and on repairing old non-functional systems. Yet no remarkable success has been achieved so far in many places either in rebuilding or to prevent subsequent damage by proper watershed management. On the other hand, in places where structures are functioning, although with inadequate maintenance, it is believed that limited parallel efforts are being made to improve the agronomic practices in the systems served. If improved techniques are combined with water availability in the right proportions, large yield increases are possible. Infrastructure and other services complete the picture and ensure success of the irrigation program. The following suggested conservation opportunities are based on interviews and from review of available documents.

Soil and Crop Management Practices

Land preparation could be better improved to fit region, crop and soil factors. Plowing parallel to the contour for field crops will still pay in most areas (during the rainy season) because it optimizes water storage from rainfall. Land leveling in rice fields helps to minimize erosion and cut down on fertilizer losses as well as ensure higher water application efficiency in the plot. Also important is leveling in sandy soils where field crops are planted to reduce erosion. Productivity of very gravelly soils should be evaluated to determine

whether it is feasible to irrigate those lands, especially for rice. Burning of plants on hills and irrigated fields should be avoided because of its detrimental effects on perennial crops.

Fertilizer and Chemicals

Fertilizer and chemical pesticide application should be encouraged where production benefits may be realized and methods are controlled. More attention could be given to the forms of fertilizers used and on the rates applied after considering soil properties, climate and crop. Amounts of supplementary irrigation should be considered very carefully because of their effects on fertilizer efficiency. Farmers seem to be aware of the importance of fertilizers and other chemicals but cannot apply them because of lack of credit.

Improved Varieties

Alternative crop varieties and types could be considered. Productivity was boosted significantly (CIMMYT) by introducing new varieties. It is understandable that farmers often prefer local varieties for taste and market purposes; however, this can be compensated for in breeding programs. Emphasis could be put on testing seeding rates and dates of planting for different crops in different regions considering climate, soils, and market so as to optimize production. It is desirable to utilize what has been learned in the Texas A&M, CIMMYT, Damien and other crop research programs. The 1983 report evaluating the Research and Extension component of PDAI (Martin, et al., 1983) emphasises the need to increase the amount of new seed available. At the time of the WMS II Teams's visit, USAID/Haiti was beginning the implementation of such a program (Wahab, 1983).

Apparent Irrigation Resource Opportunities

Field observations and discussions with various groups suggested that there are possibilities for improving the utility of existing irrigation resources. Those opportunities which were noticed by the WMS II Team are presented, in no particular priority.

Structure Siting

A few structural failures apparently have occurred because of unstable foundations or highly erodible embankments. The rehabilitation of existing or design of new structures at such sites should be reviewed by a competent geologic/soils engineer. Particular attention should be given to appropriate wing walls and cutoff curtains to minimize damage potential from overtopping or piping (Photo 8).

Diversion Structures

The irrigators along the Ennery and Jacmel rivers, as well as at other places, have been using an effective alternative to concrete diversion dams. They use a disposable, easily rebuilt rock barrage which they construct at the beginning of the dry season, or when necessary following floods. These rock dams are capable of intercepting all the river flow, or at least what the farmers need. In other locations (Riv. Grise, Riv. Blanche, Leoganes) bulldozers such as a D6 caterpillar have been used to rebuild gravel barrages after each flood. The WMS II Team recommends the "bulldozer barrage" (BB) concept as an economically viable alternative to continuing reconstruction of massive concrete structures such as have been repeatedly inundated by gravel at Riviers Blanche and Grise. A recent engineering study contemplates a $4 million concrete structure at the latter site. Past experience at that site with hurricane and other flood damage suggests that the expected structure life may be five to fifteen years.

With an assumed 10-year life and an interest rate of 10 percent (capital recovery factor is 0.16275), the annual capital repayment is $651,000 on the $4 million dam. A 200 hp bulldozer (D7 caterpillar) currently costs $180,000 at PAP; assuming a 10-year life and 10 percent interest the annual payment is $29,300. Local DARNDR technicians estimate that the rock dam may need to be rebuilt up to 30 times each year, which may amount to 200 operating hours for the bulldozer. A generous estimate of fuel, operator, transport, storage, maintenance and spare parts would be about $15,000 per year. The total cost of the BB at Riv. Grise would thus be $44,000 per year, or about 1/15 of the concrete dam capital cost alone. The work might be subcontracted locally for similar costs. It is probable that the benefits, i.e., same amount of water diverted, will be identical for both alternatives. The potential cost savings multiplied throughout Haiti should be obvious.

Sediment Exclusion Devices

All large, and many of the smaller concrete barrages, were built with sluiceway channel and gates. These were designed to be opened during flood flows (canal inlet gates closed) to bypass bedload gravel. More attention should be given to correct operating procedures, including employing trained gate keepers at the sites, in order to realize the desired reduction in canal maintenance. In some cases extensive repair is required on the radial sluiceway gates to reduce leakage when closed.

Closed conduits and siphons should be avoided in situations where entrance of sand and gravel is likely. It is impossible to clean pipelines of any length over 10 feet by locally available technology.

Conveyance Channels and Distribution Structures

Canals on most of the larger systems are masonry-lined down through the end of the primaries. The smaller systems and secondaries and tertiaries on the large systems tend to be earth channels, but with masonry control structures in some places. Some new earth-lined canal construction was observed in sandy and gravelly soils in Les Cayes and Leogane areas. To the extent that downstream recapture and reuse of seepage losses may be possible and adequate water is available, masonry lining may not be beneficial. However, in situations where distribution equity can be improved through the use of masonry control structures on secondaries and tertiaries, the incremental benefit may justify the cost.

Operation and Maintenance Procedures

The concept of preventative maintenance appears to be unknown in Haitian irrigation systems. The only possible exception may be in ODVA, where the main canals are reportedly cleaned twice a year. A significant improvement could probably be realized if the DARNDR budget for O&M staff and equipment were significantly increased. Training programs should be instituted to upgrade the abilities of Agronomes and engineers to develop O&M programs. Some improvement could be realized by modifying the Syndic's job responsibilities to include more routine patrol and maintenance and less tax verification or, better yet, increase the number of Syndics.

The use of manual labor to clean canals and ditches at low flow periods is recommended in most situations. However, on the large canals at ODVA, which are cleaned while full, machinery is required. A narrow bucket backhoe was observed cleaning one of the ODVA canals. There are more effective ways. One such improvement would be the use of a 1-1/2 to 2 m-wide blade bucket mounted on telescoping boom machine such as a gradall.

Placement of debris removed during cleaning operations should be such that it is not likely to get pushed back into the channel by local foot traffic. While some aquatic weeds were observed, no significant problems were evident.

Measurement of Irrigation Water

The measurement of water in an irrigation conveyance network is imperative for equity reasons as well as for resource accounting. Daily measurements of water inflow should be made at the inlet of all irrigation systems larger than 50 hectares supplied as run-of-the-river. Measurements within any systems should be taken to the level of unit command area (UCA) where 50 to 100 ha are served by one or more primary

canals. Measurements on springs where daily variation is reduced may be performed on a weekly or biweekly basis. Reports should be compiled and forwarded to regional authorities at monthly intervals.

Recent improvements in broadcrested weirs for irrigation canals (Bos, et. al., 1984) are cost effective, locally buildable and accurate devices suitable for Haitian conditions. In many instances, if existing weir pools were cleaned out, accurate measurement could be made immediately using textbook formulas.

On-Farm Application Efficiencies

Observed application distribution efficiency in small basins (1/2 x 1m up to 2 x 4m) was estimated to be 50 to 60 percent. This is as good as many U.S. sprinkler systems achieve. Improvements could be realized by eliminating water flow through the basins and by dead leveling within the basin. Also, the basin size should be matched to available inflow stream such that the water advances across the basin in one-fifth or less of the total irrigation time. With these changes uniformity efficiencies in the 90 to 95 percent range could be readily achieved by the farmers.

Furrow irrigation is not generally recommended to these small plots because it is hard to manage by hand. The correct match among stream size, slope and soil intake must be realized by the irrigator for effective management. Thus, it may not be feasible for small farmers to irrigate with furrows.

Irrigation Scheduling

A significant factor in the effective use of irrigation is the degree to which the irrigation water gets used by the crop. Irrigation scheduling includes both the correct timing and the right amount of water stored in the root zone. This requires proper integration of soil water holding capacity, rooting depths and crop water use rates to determine farmers' irrigation practices. There is some evidence that excess water is being applied with too long an interval on medium to light soils with shallow root zones. Crop yields could likely be increased in such situations by readjustment of rotation schedules to better fit the soil-water-plant interactions. However, labor requirements would likely be increased.

Appropriate/High Technology Potential

An appropriate new technology may be the introduction of small canvas dams similar to those used in the western U.S. These could aid water distribution to farm turnouts on smaller canals (secondary and tertiary sites) where masonry structures are not in place.

The Team noticed several places in the Central Plateau, Cul-de-Sac and north of the lower Artibonite Valley (for example) where center pivots would likely work well if clean water is available. Such high technology is better left to the private sector to develop. There is some potential to develop gravity pressurized systems.

Farmer Involvement

There are strong indications that where the farmers are involved in the construction of irrigation infrastructure, they tend to be involved in maintenance. They understand how to make the system work. This may be one reason why the small systems seem to be kept up by users.

Some Subsector Impacts of GOH and Donor Policy

Government of Haiti (GOH) budget resources at present will not cover the recurring costs of development projects as they increase in size and number (IDB, 1982). Suggestions which involve donor financing of such costs have been made. The fact that revenue increasing measures such as water user fees or effective methods of income tax collection have not already been put into place by GOH is further evidence of institutional incapacity to absorb the development assistance being offered (IDB, 1981, 1982, 1983). Indeed, since much of the assistance takes the form of grants as opposed to loans, the apparent lack of success in maximizing the flow of project benefits must discourage and dampen donor interest.

Inadequate Recurring Cost Budgets

As noted earlier, complexity of certain irrigation systems requires that maintenance be organized for water users by third parties, and that funds must be available for this task. Technicians of the Irrigation Districts and the Irrigation Service are not responsible for finding funds.

Moreover, the failure to maintain infrastructure that is govenment responsibility is not new. A number of project shortfalls due to lack of ongoing financial or human support, dating back 20 or more years, were recalled for the WMS II Team by knowledgeable individuals. Examples are centralization and standardization of marketing information gathered by disparate agencies (1970s); donated health station materials that are not matched by GOH, so they can go into operation (current); what happened after SCIPA left the country (Werleigh, 1983). During field trips farmers told the WMS II Team of canal cleaning and fertilizer purchase programs that ceased as soon as international subsidy was withdrawn.

Subsidy (See Annex E)

Objectionable aspects of some donor policy go beyond the distorted cost signals continued subsidy introduces into the annual cropping system. There is a wider impact on incentives for productive use of irrigable land. In any situation where sharecropping and renting are common, refurbishing relatively expensive infrastructure at no cost to owners simply makes it easier to hold onto land and wait for values to rise. If an owner wants to do more with his land he always can but at worst he knows that if he waits long enough some international organization is going to come along, fix everything up again and raise land values another increment at no cost to himself. This is happening for thousands and thousands of Haitians, rich and poor alike. The remedy is enough taxation or a set of fees to move land into best use or force its sale.

To outside observers it would appear that the most steady, consistent support for farmers is provided by efforts of private volunter organizations. Of course a lot of subsidy is involved here too, but it does have the virtue of being injected right at the poorest of the poor level. Spokesmen for two PVO orgainzations stated that they look for projects that increase "labor productivity." This seems to imply something about not impacting wealth positions in real property, since both groups were interested in farm animals and make a particular point to stay away from irrigation schemes.

Quality of Analysis

One positive note in the policy arena is a general absence of attempts to hold urban consumer prices down at the expense of the agriculture sector; however, certain proposals may alter this situation (USAID, 1984). Basic grains prices are reported to be good. Whether the prices have called forth a commensurate increase in production apparently is open to question because the claim is also made that food deficits exist and are worsening (USAID, 1984). If farmers are not pumping out food grains in response to good prices it would be preferable to discover the cause before becoming totally committed to a new approach. The Title III food policy proposed will have disastrous effects upon rural sector income without any guarantee that offsetting increases in non-grain agricultural production will appear.

Shifting Recurrent Costs to User Organizations

One expressed aim of the USAID Mission's Title III proposals is to find a way to cut GOH budgeting pressures represented by long-run recurrent costs. In the case of irrigation investment programming, this takes the form of a hope to shift maintenance and operating costs onto the actual water users to the extent possible. The vehicle most discussed in Mission documents is the formation of viable, cooperative user groups that are willing to undertake the necessary responsibilities.

Demarcating Responsibility

Certain attempts along this line are under way (in Dubreuil) involving "three tiered" organizations that are a direct result of AID initiative. (According to statements by members of a team representing the Land Tenure Center, it is too early to judge success.) The WMS II Team would not expect any hiarchical model to be too successful due to the complexity of the interlocking group interests that are found within the perimeters of all but the smallest irrigation systems.[1] However, this does not mean that the attempt to work with user groups should not be made. According to Nader (1984) some attempts at user organization have worsened the situation. Persons responsible for these programs ought to press for the general right of such groups to organize and to be legally entitled to collect fees and utilize them as the groups see fit (Cheaney and Taylor, 1983; Stutler, 1983). But even if these rights are not granted there is no guarantee that individuals, their representatives and super committees will always be motivated by a strong spirit of cooperation; it normally takes a long period of time for an irrigation system such as Dubreuil "to settle down," eight to 12 years is not uncommon.

The maintenance shortcomings in the (generally) larger, more complex public systems or those especially difficult to maintain are probably not so much due to institutional incapacity as to lack of means to do the job. It is true that there might be some improvement if the present Irrigation Service were switched to Ministry of Public Works or if technicians were paid better wages, but no amount of institutional modification is going to turn up a corrective as long as more resources are not made available to those responsible for the work. One source of funds that comes to mind is irrigation water user fees.

Water Tariffs

Haiti has a long history of charging farmers something for water supplied under state systems, although the amounts have been small. Table 2 contains data from 50 years ago that show collections averaging well under 1 percent of the under of production. The compliance rate, however, was quite high in these examples except from the users of the Canal d'Avezac and possibly the Riviere Bois supply (for which data are not given). Collections as a share of O&M expenditures were about 17 to 20 percent.

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[1]The idea of solving mintenance problems by promoting hierarchies of user groups can be pushed only so far. Farmers who are getting water have no reason to worry about those who are not (due to theft, clogging or other failure in upkeep). Therefore, in the absence of "rights" mentioned in the text, O&M must to arranged and coordinated at a higher level; that is to say, by Irrigation District staff. The staff, of course have minimal budget.

Table 2. Water tariff collections plus O&M expenditures as a share of production values on State systems--1935-36 example (Gourdes).

System	Locality	Area Commanded ha	Value of Crop Production	Tariff: Amount Set	Tariff: Collections: Amount	Tariff: Collections: As Share of Production	O&M Expenses: Admin.	O&M Expenses: Repairs	O&M Expenses: Total	O&M Expenses: As Share of Production	Tariff Collection as a Share of Expense
Riviere Grise	Cul-de-Sac	9,900	1,860,035	6,850	6,089	0.33%					
Riviere Blanche	Cul-de-Sac	5,000	973,612	1,975	2,214	0.25%					
Depuzeau et Palmiste	Cul-de-Sac	3,450	918,157	2,286	1,855	0.20%	-> 37,189	2,131	39,320	1.05%	26.00%
Riv. Tomance et Verguier	Leogane Pl.	4,200	2,262,553	2,457	1,789	0.08%	9,459	4,051	13,510	0.60%	13.00%
Riv. Matheaux	Arcahaie Pl.	2,200	362,846	1,061	954	0.26%	2,919	-	2,219	1.56%	33.00%
Canal Avezac	Cayes Plain	5,000	545,724	2,768	399	0.07%	4,064	1,611	5,675	1.04%	7.00%
Riviere Bois	Artibonite	3,000	-	-	-	-	18,317	-	18,317	-	-
TOTALS		32,750					71,949	7,973	79,742	6.00%*	17.00%*
(Additional area administ.		32,750)									

* This value shown in source document.

Source: DGTH, c. 1937, p. 41.

It is interesting to note that a half century later both of these ratios are in the range of similar calculations recently made in the Dominican Republic. In 1981, for example, FAO experts reported that the collection of water fees as a share of O&M expenditures was about 6 percent. Ratios of the collections as a share of value of production of selected crops in the same year ranged from 0.03 to 0.10 percent (FAO, 1984). In reference to O&M, the collection ratios are a function of the particular budget level that national leaders choose to set, and therefore there is a risk that such comparisons are not very meaningful. However, in this instance it may be assumed that both nations budgeted very little to O&M then or now.

Currently in Haiti the water fees collected per hectare have reached the equivalent of $11 to $12 in the ODVA zone and are $2 or $4 elsewhere (if collected). In the Dominican Republic, by comparison, although fees have been raised greatly starting with the 1984-85 crop year, the ultimate level to be reached by 1990 is about $8 for non-rice crops and $16 for rice. On balance, therefore, Haiti's efforts at levying and collecting water fees appear to be advanced relative to the experience of the Dominican Republic.

Levels and Collections

This argument cannot prove very much by itself, but a relative comparison with Haiti's neighbor can be useful in additional ways. The Dominican Republic policy aim is to have the water users cover O&M in their local districts and sectors to the degree possible. Annual rates may vary according to next year's O&M budget, as planned with the help of the users. Rice growers have to pay twice as much per hectare as on all other crops because they demand so much water. Collections, even at the proposed higher levels, will be enforced because each District must find its own money for the necessary O&M. Obviously, this is an interesting model that might have application in Haiti if it proves impossible to move very far in the direction of a system of individual and group water user "rights" (as recommended by the WMS II Team). For example, if the local District technicians have to announce each year's fee level in advance and have to carry out the scheduled maintenance as budgeted, they will have a strong incentive to make the collections.

How high can the annual fees be? There is no exact answer to this question. Some recent research into international experience has led to the speculation that 5 percent of production value might be the magic number. This does not sound like much, but whether it looks big or small to an individual farmer depends upon how many hectares he operates. In Haiti 5 percent generally would amount to $10-20/ha and, coupled with a high compliance rate, would generate a tremendous increment in O&M resources relative to what is available today. In Les Cayes the WMS II Team heard of offers of $20 to obtain one "irrigation" by rent or trade at critical growing season times. Therefore, water can become very valuable.

The important issue is not particularly the level at which fees are set, but who collects them, keeps them and spends them. If the collections from a District are not earmarked or matched by more or less equivalent offsetting expenditures, no charging system will work.

Required Modifications in Water Institutions

In those parts of the world where water must be conveyed from a source to a place of utilization, a high degree of management and social control are necessary. Haiti's original irrigation network was managed and controlled by force. Water flowed in canals, and fields were irrigated according to plan. Since that early time force has been less of a factor except for some strong organizational interludes involving plantation or pseudo-plantation operations on a large-scale. Nader (1984) states that the farmers "did not take up irrigation until the mills shut down." The results have been enumerated by many observers who have studied Haiti's agriculture sector. The modern need is to settle upon an arrangement that will impose orderly operation upon the entire irrigation subsector.

Conflicting Demands

When we look to the future, what do we see? There will be steady pressure on land and water resources. What can be irrigated should be irrigated if the cost structure is acceptable. Demands will be made for more land to be brought under irrigation. Some existing water supplies may have to be shifted to new irrigated lands, and existing users will be unhappy. As depletions are increased, streamflows will be altered in unexpected ways. More and more water will be needed for industrial and municipal purposes. Making electricity may upset settled irrigation routines. As time goes on, balancing of critical needs will demand attention (DGSNDP, 1985; CONADEPA, 1985). Expert information and knowledge will become more important. As the pressures mount, the general public will become more and more suspicious of the usual political wheeling and dealing (although urban users are usually confident they will be accommodated).

Haiti needs to export more agriculture products if the agriculture sector is capable of responding. More domestic food will be needed. More commercial agriculture may be required in order to achieve such goals. This implies a different type of private sector farmer to manage such enterprises.

The way Haiti's irrigation network operates at present will be totally out of phase with such demands. There is a lack of order in many systems, laws are not respected, regulations are not enforced, etc. Volunteerism and cooperative effort goes some way to prevent chaos, but that spirit has inherent limitations. If brute force is ruled out, the only solution is law and order--and it must be imposed from the top down.

Enforcing Laws and Rights

Water laws and tenure rights need to be codified and enforced (somewhat opposite position taken by Hauge, 1984). Individuals must know their rights and not live in fear that they will be abridged. A way needs to be found to organize land tenure and related records according to actual ownership and location. All the past lack of accurate record keeping is coming home to haunt the Government of Haiti.

At present there is no institutional structure that can resolve impending water conflicts on a scientific basis. Haitian water law seems to be a mix of riparian aand appropriation doctrine. If this is true, there will be a lot of potential for conflicts and overlaps that should be checked and rectified in order that a recognized, recorded system of water tenure rights can be evolved and judgments about new water developments or requests for water can be handled according to accurate resource availability information and law. At present, there is totally inadequate data to guide conservation and water policy in Haiti.

What is required is an independent office equivalent to what in the arid parts of the U.S.A would be called the "state engineer." This person has the power to adjust water allocations to some degree, within the law, and is responsible to foster equity as well as efficient use of the scarce resource. He must balance equity against efficiency by resorting to the concept of "beneficial use." Customary rights to water greater than what can be put to beneficial use may be adjusted downward. Groundwater and surface water may be utilized in a conjunctive way to increase efficiency. Water cannot be diverted or shifted from customary use without obtaining permission of this office. Exploitation of certain resources can be protected for future generations.

The functions described must be met in some reasonable way or the water management situation in Haiti will get worse, not better, as new demands are put upon a vital public resource. Parallel arguments apply in the case of watershed protection, although it is not so easy to spell out duties of such a powerful office.

Benefits of Irrigation Investment

Haiti has had considerable recent success in utilization of labor intensive methods for road building. At first glance there seem to be obvious parallels as a mechanism for injecting investment in the irrigation subsector. And, in fact, any public investment in irrigation would mirror the road works experience as long as the funds are available to pay maintenance crews in the same way laborers will have to be paid for continuous maintenance of roads. In reality, this is unlikely to happen for two reasons, as set forth below.

Source of Finance

In the first place, roadways, especially those that are well traveled, occupy a grey area between investments such as for defense and education or certain types of environmental protection which have to be subsidized by the general public, who receive the overall benefits in return, and investments that benefit a particular group. Therefore, it is not unusual for roadways to be financed from general budget resources. This is why roads and electricity grids are popular and beneficial tools of development. Even so, it is not uncommon to levy motor fuel and licensing fees upon those who get the most direct production and consumption benefits from road use. (It is simple to measure and sell electricity by the unit.) In contrast, it is less easy to collect fees on a metered water use basis from irrigators. This is the second reason.

But irrigation works do not occupy a similar grey area because a clear set of direct beneficiaries can always be identified. If irrigators are really entitled to general public subsidy, rainfed farmers could make the same claim. This is why correct social accounting is necessary when primary benefits are captured by a particular group (not taxed; see Annex C). In the absence of a showing of clearcut overall social gains, why would urban Haiti want to bear the subsidy burden?: (1) hold rural people in place?; (2) develop new regions?; or (3) urbanites really want more food? If (3) applies, urbanites can be expected to prefer lowest cost options, which may eliminate expensive recurring irrigation investment.

Limitations on Benefits

Although at least one study claims the benefits of upgrading a moderate sized system(s) are acceptable (Tahal, 1981), not much data actually exist upon which to draw some wider, more general conclusions for the whole network. Some small systems seem to require simple, cheap upkeep that should be amply rewarded in productivity gains but others look expensive, and the benefits may not be as great as expected.

Some irrigation systems are not fully functional because they need to be cleaned or require some structural repair. They might be returned to productive service at low immediate costs plus tolerable expectations about future O&M requirements. But it should not be forgotten that most systems in Haiti already deliver some amount of water to some amount of land. Investment in reconstruction, refurbishing and in future upkeep will call forth only that increment of production obtainable from lands now inadequately watered. This increment will be more or less what can be obtained over and above the rainfed alternative, less any increment the current level of irrigation is supporting. Sometimes the increment will be substantial but other times not. This raises the possibility that the marginal benefits might not cover even the improvement and upkeep costs mentioned.

Irrigation in Haiti supplements natural rainfall and in some wet years is not much relied on, especially in the southern sections of the country. Levels of expenditures should be tailored to this situation, yet still achieve the goal of pulling yields up.

Admittedly, assured water supplies make the application of additional inputs look more attractive. Still, the conservative approach is not to value this possibility too highly in the short run. Lots of areas which have adequate water at present continue to be farmed with fairly simple technique. The truth is that a lot of agricultural value is coming off rainfed lands.

As noted elsewhere, there are some extreme but important situations in which big investments in structures will have very little impact upon output and and incomes. Rivieres Grise and Blanche are cases in point. At present whatever water is in the rivers is being diverted to the canals. Building new barrages will not increase the water into the canals by very much. These systems can probably be made more productive by reducing transmission losses and by altering field application methods where either or both practices are cost-effective and by reliable and equitable delivery to as many users as possible.

Probably there is some scope in Haiti for private irrigation investment geared totally to crop and livestock production on a commercial basis. This thought is mentioned elsewhere in this report in the context of future competitive demands for water and appropriate technology.

USAID/Haiti Commitments in the Irrigation Subsector

The WMS II Team recognizes that USAID/Haiti has ongoing commitments for supporting irrigation improvement projects in the Southwest with the Les Anglais, Dubreuil, Torbeck and Avezac Systems. In addition, the GOH proposes to rehabilitate the systems Riviere Grise, Torcelle, Courjolle and Matheux and seeks USAID assistance in the task. How do findings from the field visits and document review impinge upon these broader interests?

In this section three elements are covered: (1) the RDO's "$10,000 grants" projects; (2) the irrigation component in and around the PDAI area in the West; and (3) GOH support requests.

Mini- and Small-Scale Projects

The WMS II Team recommends major concentration upon small projects, where design is not complicated, and where beneficiaries form coherent, easy-to-define homogenous user groups, where there is good order, and which need minimal support from established irrigation district staff, and:

- Will tend to augment and/or stablilize supplies and/or distribute them better;

- Might emphasize sources such as springs and drains which are somewhat protected from erosion hazards;

- There is stable group organization and desire for the project; and

- It is possible to work to some extent with PVOs in order to obtain leadership and direction in harmony with the assumptions listed on page 3 of this report.

The Mission has successfully completed several projects that to a considerable degree satisfy these criteria. The procedures are all worked out. Skills of local engineers and contractors are being built and utilized. The beneficiaries see that something is happening--a minimum amount of time elapses between initiation and execution. A continuation of this program will be worthwhile even if the national level recommendations on water rights or other recommendations of the WMS II Team are not implemented.

A simple evaluation of the before and after effects of these small project investments might be very useful. This could be accomplished by setting up a work plan and an operating budget for a university student in the Faculty of Veterinary Medicine and Agricultural Science at DARNDR.

USAID/Haiti Medium Size Project Agenda

Mission involvement in the southwest part of the country obviously must continue. Quite a bit of infrastructure, financing and cadre of Haitian engineers and extension agents already are in place.[2] The Acul and Revine d'Sud diversions do not seem so prone to damage from annual flooding as is the case in some other systems. Coffee (1984) forecasts mounting problems.

Parts of the Dubreuil system are coming into full operation at the present time. User groups are being organized. Their objectives should be to have impact on management of their whole systems or at least upon what happens whenever a supply lateral or canal has water turned into it. Users should be given cards showing times and lengths of water

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[2]At least two assessments have been made of the general and specific thrust of the USAID PDAI program, so these findings need not be reviewed here (Hargreaves, 1982; Stutler, et. al., 1983). Also, see the caveats in Delatour (1984). A well-documented report of the agriculture situation in the Cayes area is contained in Coffee (1984), esp. Sec. 6.2.4.

turns, as is being done at Petite Goave. Agreements on operational bylaws and user responsibilties should be copied from the plan at d'Avezac. All changes in procedures involving user control of collections, etc., should be ratified by DARNDR (Cheaney, et. al., 1983).

If there are gaps in current delivery arrangements or failure of institutions to guarantee equity in water distribution and to hold waste to a minimum, or if the probable operational impacts of Dubreuil main system management upon users have not been thought out, now is the time to get organized. Probably an operational study is needed in this system, or the contractor should be asked to state how the system is expected to run.

Note that a key element in these arrangements should be a pre-set, agreed method of "shorting" all users when water supplies are lowest, during the dryest part of the year. Another key element is to plan something workable for night irrigation.[3] Where possible, stop collecting water use fees from individuals--levy on groups instead.

Creating the conditions for reliable irrigation supply involves more that just construction and refurbrishing of conveyance and delivery works. Farmers or farmer groups should be able to reach up the system, if necessary, by constructing and maintaining their own tertiary channels, and the reliable supply should have enough value in use that they will pay for the resource costs of obtaining it. This is one way to gain some benefit from private initiative.

Dubreuil. Determine if individual farmers are going to be able to count upon a reliable water supply and whether deliveries will be equitable and not wasteful. Continue to help user group formation. Probably new types of legal arrangements or institutions, such as to collect some water use fees, will be necessary if the system is to run in an orderly way. It is unlikely that user groups alone are up to the task. In this connection, some or all elements of the Canal d'Avezac model might be transferred.

Recommendations the Mission has already received in connection with finalizing the construction stages should be implemented. There is danger that the attitudes and working methods that have developed among project personnel during a protracted construction period, will carry over into the operating phase of the project's life, to the detriment of all concerned.

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[3]In the Alta Yaque del Norte irrigation system in the Dominican Republic, rice growers must take water at night. Other crops are watered alternately during the daylight hours on weekdays. All of the main canal water is delivered to the bottom of the system throughout the weekends.

Some conservation and irrigation resource opportunities are:

- Improved soil, fertility, and crop management practices;
- On-farm water management training (plus irrigation scheduling);
- Land smoothing and leveling; and
- Secondary canals and farm turnout structure construction and maintanence.

Canal d'Avezac. The Mission might be able to help get some "legal heavyweight" into the picture in order to control rowdy farmers for the benefit of the majority of water users. After this has been done, and the pilot test results are in, evaluate the German and other volunteer group experience, make adjustments in the system bylaws, auto financing and in operating procedures. Then inject the resources necessary to get the whole project running as quickly as possible. The program needed involves setting up a system of operational requirements that must be followed by any supervisory personnel assigned by DARNDR.

In the case of d'Avezac these include the following:

1. Measurement of water deliveries; estimates of consumptive use and administrative criteria of what constitutes "beneficial use;" resizing outlets where not already done; fine tuning deliveries to laterals and secondaries; how to allocate short water supplies.

2. Enforcement of water quotas by means of constant supervision of the activities of the Syndics and insistence upon good water delivery records; Syndics should not handle money at the present time; every instance of water waste and theft should be dealt with by a User Committee by means of fines or other punishment; update bylaws as conditions change.

USAID/Haiti should provide a simple, reliable financing source (by grant, if necessary) if some further construction is required. Canal d'Avezac is a very visable, important place to inject and test a facsimile of the WMS II Team national level suggestions, and either it or Dubreuil are likely candidates for on-farm water management demonstrations involving the best information available from the Texas A&M and other research that has been done in the area. The Mission should be able to get more benefits per dollar spent in Canal d'Avezac than it will obtain at Dubreuil.

3. Output enhancing recommendations as made for Dubreuil.

Charlette (Torbeck Plain). The lower Charlette area is of some interest to the WMS II Team because extending this system appears to represent an opportunity to impact upon quite a few farmers at low cost.

The users in the area are being brought under the guidance of local church leaders. (This is widespread activity on the Cayes and Torbeck Plains.) Immediate organizational, operational, legal and system management problems may be simplified or held under control. The idea of auto financing is spreading; the Church Fathers are trying to arrange loans, and all this seems to be accepted by the users. Mission support mechanism for loans should be arranged by some sort of link to a (very simple, low cost) private sector intermediary person or institution. The concept of auto financing should have great appeal to the Mission because the results will be a test of what can or cannot be accomplished without subsidy.

The next or simultaneous step is for USAID/Haiti to invest directly in some useful aspect of the system rehabilitation and expansion by means of a grant. This action is justified since the overall rehabilitation of this system might be thought of mainly as an extension of the current "$10,000" small projects program the Mission has had experience with.

One idea that could be financed is investigation of moving to higher technology such as dead level basins, improved irrigation scheduling and improved farm turnout structures; there is a quite a lot of land that could be irrigated if the water could be stretched (Coffee, 1984).

Torbeck. Torbeck system commands a significant amount of land (2,000 ha). The photograph of the situation at the barrage site is worth 1,000 words (Photo 9). The barrage could not even be gotten into place; the sheet metal piling design used for temporary coffer dams was not up to the requirements of flood peak control during construction. The high flows simply cut a channal around one end (visible in the picture) and the donor financing was wasted. Quality engineering is necessary here.

Government of Haiti Rehabilitation Requests

USAID/Haiti hs been asked to help rehabilitate the systems Riviere Grise, Torcelle, Courjolle and Matheaux. The Israeli firm of TAHAL Engineering Consultants, Ltd. has made feasibility studies of the rehabilitions mentioned. The reports made availble to the WMS II Team call attention to the fact that the TAHAL engineers had inadequate hydrologic and other data important for thorough design work, and little basic data (engineering and basis for costs) appear in these volumes. Thus, it is not possible to evaluate the reports on the grounds of technical accuracy.

What these studies show is the general layout of the existing irrigated area perimeters, the service canals, laterals, land area commanded and some information about estimated water supplies. The contents of Volume IV of the TAHAL report is a program of development for Torcell,

Matheaux and Courjolle systems. Stage I, lasting three years, is aimed at getting farmers to better utilize what already exists, plus some upgrading of the present distribution system. Stage II (or III) involves a plan for storage reservoirs, although the discussion is not clear about which opitions seem the best, i.e., either inside the canyons or in some kind of depressions outside on the plains. From a financial standpoint practically the whole scheme turns upon expanded production of bananas, for which the TAHAL experts believe there will be a strong domestic market.

Three years are alloted to Stage I, with heavy emphasis upon the Israel training and visitation extension system (scheduled meetings with lead farmers). An important share of the overall benefits are expected to come from this stage. The T&V system requires a substantial cadre of dedicated extension agents in order to be successful.

Phase II provides the increased water supply for year around production and impacts overall sales income from the project areas. This phase takes five years.

Phase I is dspecially critical because the basic program during the period implicitly takes for granted that the water distribution problems current in the systems are all solved (apparently as part of the T&V activity). But the TAHAL engineers say nothing about how T&V will be organized to get at equity, distribution and system management problems. In contrast, the intent of the WMS II Team's national level recommendation perfectly fits the situation in Torcell, Courjolle and Matheaux: get order and equity into the operation of those systems before anything else is tried.

WMS II Team Response. In keeping with the general rule to improve what already exists before starting new construction (this is also the TAHAL goal), the following may be suggested:

- Get ditch cleanout and regular maintenance organized.
- Get order into the three systems. Solve head end/tail end problems if they exist:
  - i. Give tail end farmers suggestions about cropping patterns and farm management relative to the greater water availability they can expect.
  - ii. Adjust main system management (lateral and turnout sizing and scheduling) in order to streach the water and raise the on-farm application efficiency of some wasteful users.
- Look for worst cases of conveyance loss and repair the weakest segments of the canal systems. Loop back through (i) and (ii).

- Determine if the results of the above actions support higher technology at the farm level; decide what will work best; strive for private inititive.

- Last, decide whether development of expensive additional water supplies will fall within direct beneficiaries' ability to pay. This might mean, for example, to find out if bananas can be raised, and marketed in the quantities, and at the prices assumed in the TAHAL study. (The I.R.R. values included in Table 3 below are impressive.)

Suggested USAID Response. No rehabilitation efforts will be supported until the GOH can demonstrate conclusively that:

- Distribution of existing water in the three systems is under the control of a tested adminstrative system that ensures equity among users (and that any wasteful use has been wrung out);

- Users have a clear role in scheduling O&M;

- User charges have been increased and that collections thereof are fully accounted for and remain in the systems to offset a significant part of budgeted O&M;

- O&M is being carried out on schedule and is up to standard; and

- A production response has taken place as measured in value and volume terms.

These requirements may be met by imposing the Leogane model (full managerial control) or by a tightened-up, operational Canal d'Avezac model (written obligations and written, guaranteed supply rights, plus the water charge control rights sought in the Dubreuil system and general user input into operation of the systems).

If these "conditions precedent" are met, USAID should offer to set up by grant, a 30- or 40-year life revolving fund to finance these and subsequent qualifiying projects, (water fees will be raised another increment to recover O&M plus investment costs plus interest). The fund will not be disbursed until USAID is satisfied about farmers' ability to pay and that the farmers' organizations and GOH have created a legal method for the user groups' own funds to be received and disbursed in a manner satisfactory to the grantor. For example, the interior of project perimeters could be turned into a special improvement taxing district if the Leogane model is not utlilized. If the latter is used, it is simply up to the parastatal managers to earn enough money to meet their annual repayment obligations to the loan fund.

Riviere Grise. The neagtive aspects of rehabilitating this project have been covered in some detail already; a man-made structure probably cannot survive; flood flow peaking is intensifying; the river bed is

Table 3. Comparison of Haiti Irrigation Project Feasibility Analyses.*

	Rev./ha		Est. # ha Affected		Est. Cost		Annual Inc. in Revenue		I.R.R.	O&M/Yr.
	Current	Future	Total	New	Total ($M)	Per New ha	Per ha	Per $1000 Invest.	(%)	($)
Marigot/large			785	400	2.20	2,800				
" " /small			250	150	0.55	3,700				
Dubreuil I & II			925	625	2.20	3,520	973	280	19	59
Jean Robel			350	275	0.88	3,900	1,500	320		
Thomazeau				126	0.53	3,500	1,500	420		
Les Anglais	750	2,550	550	150	1.27	2,140	1,398	653	55	20
" "			990	?		3,157				
Torcelle	2,073	3,346	545	155	?	?				
Stage I			686		0.48	700			50	7
Stages II & III					4.50	7,250			50	90
Full			1,370	700	4.98	3,600			66	99
Courjolle	2,073	3,346	720	80	0.69	767				
Stage I			997		1.51	1,515			50	8
Stages II & III			1,700		4.125	5,900			50	101
Full					5.68	3,350			27	109
Matheaux	2,073	3,346	841	160	?	?				
Stage I			900	260	0.69	767			50	7
Stages II & III			900	1,000	6.75	7,500			50	135
Full			1,985		7.74	3,900			42	142

*Allows for double cropping where shown in documents. Sources: Stutler, 1983; TAHAL, 1981, Vol. IV.

Note: There is a subtle but important difference in the way results are presented or arrived at by TAHAL on one hand and the PDAI evaluation on the other. It will be recalled that Phase I of the TAHAL projects is basically the T&V stage. An internal rate of return calculation for Phase I is, in effect, a calculation of the benefits of technical assistance alone. The TAHAL calculations of I.R.R. for all phases include capital and other hardware items as well as T.A. In the PDAI analysis, overall I.R.R. includes the same items. But the sub-calculation in this case is for investment costs alone, T.A. is left out. Therefore, the only way to compare the two analyses is at the total or full investment level of expenditures. These are the I.R.R. values shown in the Table.

widening at an appreciable rate; and it is possible that all the water that can realistically be diverted into the system is already being diverted (by means of a rebuildable rock barrage). All of these factors are tied to a degraded watershed, canyon topography and weather patterns in the catchment area. The only immediate offsetting benefit would be an argument that more water can be diverted and that more of the original 9,000 hectares can be irrigated than at present. Presumably, the answer can be found somewhere in the engineering studies that have been made to support the idea of rehabilitation. As a practical matter, regardless of what such studies may reveal on this point, rehabilitation of the watershed and its subsequent management appears to be the critical issue.

USAID/Haiti might want to confine any participation in a rehabilitation program to some aspects of the system that have potential for a longer life or a less threatened life than a new barrage. Generally, this response could take virtually the same form as in the case of the projects just discussed; refurbishing the distribution system might be the main physical focus. GOH could be asked to establish a significant watershed program for this and its sister system, Riviere Blanche. Meanwhile, the USAID Mission could offer to set up and totally support a bulldozer barrage for an indeterminant, number of years.

Economic Comparisons

Table 3 summarizes a range of cost and benefit measures as reported in various engineering studies made available to the WMS II Team. In a few of the examples internal rates of return are available; this is an important planning statistic. However, its magnitude is pretty much a function of what is assumed for benefits when the economic analysis is made. For example, although the I.R.R. is the most generalized, "dimensionless" parameter by which to compare or rank projects, the moment different crop mixes are assumed on the benefit side, I.R.R. comparisons start to get a little tricky. At the same time, if the cropping patterns are assumed to be the same, everything is pretty well determined by costs. These are some of the reasons why the Team has put emphasis upon construction costs per hectare elsewhere in this report. (Note that the per hectare costs and the I.R.R are not well correlated.)

In practice, where rough and ready data are all that are available, the best assumption is that I.R.R. is inversely related to proposed per hectare costs. Two other simple measures, sometimes useful for planning decisions, are calculations of expected employment benefits (see the TAHAL studies) or revenues per dollar invested. The latter is shown in Table 3 for some of the examples.

All things considered, the Mission should put its money where the payoffs to the marginal dollar are likely to be highest. By this rule it is easy to imagine that those activities where the investments have already been made, where the costs have already been sunk, should be

looked at rather closely to see if they might not be topped off in some way. Often the marginal costs of completing a job may be quite low and the benefits high. This may involve some sort of separate reevaluations of the investment options. It is necessary to do more than simply unravel any "technical" reasons for why "ranking" coefficients may differ, as implied in earlier discussion of Table 3. What is necessary is to weigh a lot of non-economic elements that may influence how a project will actually function. (Note that this does not refer to such things as "social soundness" even though such criteria may also be important.) For example, the 1983 PDAI review (Stutler, et. al., 1983) contains an argument about abandoning Phase II at Dubreuil if certain performance factors do not improve.

One outline of revised irrigation project evaluation and ranking criteria might include some measure of command area stability and system longevity, i.e., dependability of water source, gravel/sedimentation hazards, relative water supply for double and triple cropping, potential with rainfed only, existence of viable organization for operation and maintenance, drainage conditions, etc. The utility of such a ranking/evaluation scheme could be demonstrated by applying part or all of the methodology to the projects contained in the various and numerous feasibility studies, such as those of Harza, J.G. White, TAHAL, and DARNDR.

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ANNEX A

OBSERVATIONS BASED ON FIELD VISITS TO IRRIGATION SITES IN HAITI

OBSERVATIONS BASED ON FIELD VISITS TO IRRIGATION SITES IN HAITI

Specific Characteristics by Systems

The information presented herein was obtained during the site visit from individuals familiar in varying degrees with each system. Independent verification of data accuracy was not attempted. The field notes included in this Annex are meant to illustrate a range of conditions encountered. Only limited data were available on many of the sites.

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SITE VISITS USAID / HAITI WMS II

SITE Riv. Grise, Riv. Blanche DATE VISITED 22, 25 Aug & 3 Sep 84

LOCATION Cul de Sac

AREA IRRIGATED : ACTUAL Grise 8200 Blanch ha; POTENTIAL Grise 9000 Blanche 5000 ha

SOILS : Medium

WATER SOURCE : Riv. Grise, Riv. Blanche

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION Colonial, 1920's, 1950's (Concrete)

EXISTING Diversion dams inundated by Gravel canals silted up (sand & Gravel also)

DESIRED New diversion dams (recommend bulldozer barrage)

MAINTENANCE CONDITIONS: Long intervals between cleaning of canals (Food for Work program being used now for cleaning)

EQUITY AND RELIABILITY : Problems in tail end areas, low flow season - distinct problem.

DRAINAGE NEEDS : None apparent in higher areas

AGRONOMIC PRACTICES :

CROPS some rice, shallot, some trees, corn, other veg.

SOIL MANAGEMENT moderate leveling done, need for more

IRRIGATION APPLICATION small basins, could be improved with leveling

EROSION POTENTIAL : moderate to high on greater slopes

POSSIBLE TA/INFRASTRUCTURE NEEDS : upstream watershed improvement improvement of farm ditches

OTHER : Pump irrigating 60 ha north of highway in lower end had been in-operative for 5 months due to lack of repair parts.

Irrigation intervals become excessive (up to 30 days) during low flow periods. Irrigation tax apparently does not return to help project maintenance

Flood flow peaks extremely debri laden

SITE VISITS USAID / HAITI WMS II

SITE Torcelle, Matheux, Courjolles DATE VISITED 24 Aug 84

LOCATION Archaie, (Duvalierville)

AREA IRRIGATED : ACTUAL ? ha; POTENTIAL 1300, 1800, 2200 ha ?

SOILS : Medium

WATER SOURCE : Riv. Torcelle, Riv. Matheux, Riv. Courjolles

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION 1922 - 1926 Concrete Diversions

EXISTING above - somewhat battered (Des Matheux) by tropical storm floods

DESIRED

MAINTENANCE CONDITIONS: Needs debri clean out of diversions channel work

EQUITY AND RELIABILITY : ?

DRAINAGE NEEDS : ?

AGRONOMIC PRACTICES :

CROPS Bananas (Sugar Cane)

SOIL MANAGEMENT

IRRIGATION APPLICATION small basin

EROSION POTENTIAL :

POSSIBLE TA/INFRASTRUCTURE NEEDS : some structure rehabilitation

OTHER : structures have been functioning for some years without destruction - not near the evidence of gravel deposits as seen at Riv. Grise + Riv. Blanche
Parshall flume at left branch of Torcelle diversion

SITE VISITS USAID / HAITI WMS II

SITE ODVA DATE VISITED 30 Aug 84

LOCATION Artibonite Valley (lower)

AREA IRRIGATED : ACTUAL 23,000 + ha; POTENTIAL 33,000 (?) ha

SOILS : Medium to Heavy, predominately Heavy

WATER SOURCE : Artibonite River (Lac Pelegre Dam

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION 1950's (?)

EXISTING Concrete lined and earth lined canals

DESIRED still extending system with new concrete lined canals (Canal Sud)

MAINTENANCE CONDITIONS: Fair

EQUITY AND RELIABILITY : Tail end problems, particularly in dry season

DRAINAGE NEEDS: surface and subsurface needed, especially in low areas

AGRONOMIC PRACTICES :

CROPS Mainly Rice, some vegetables, bananas, beans

SOIL MANAGEMENT paddy, some need for leveling

IRRIGATION APPLICATION small basins (paddy rice) 8 day rotation (except in dry season)

EROSION POTENTIAL : low on flat slopes

POSSIBLE TA/INFRASTRUCTURE NEEDS : water measurement ? on farm water management

OTHER : Lot of dryland corn adjacent to project area
Some concern about illegal "tapping" into water from outside lands.
Provides training for farmers through COOP
ODVA collects and keeps tax money

SITE VISITS USAID / HAITI WMS II

SITE Maissade DATE VISITED 31 Aug 84

LOCATION Near Town of Maissade

AREA IRRIGATED : ACTUAL — ha; POTENTIAL 500 ha

SOILS : medium to heavy

WATER SOURCE : Rio Frio (estimate 2 m^3/sec at visit)

INFRASTRUCTURE : (Not now functioning)

ORIGINAL CONSTRUCTION DARNDR (?)

EXISTING concrete/masonry part way, in disrepair

DESIRED extend canal, construct diversion

MAINTENANCE CONDITIONS: poor at present

EQUITY AND RELIABILITY : NOT KNOWN

DRAINAGE NEEDS May be some after irrigation starts

AGRONOMIC PRACTICES :

CROPS Future would likely be rice, present corn, coffee, sugar cane, etc.

SOIL MANAGEMENT ?

IRRIGATION APPLICATION Surface, basin or paddy

EROSION POTENTIAL : in some areas

POSSIBLE TA/INFRASTRUCTURE NEEDS : Rock dam (bulldozer barrage)
Repair and reconstruct existing masonry

OTHER : Extend main canal, construct laterals

Farmers very enthusiastic to get water in canal

SITE VISITS USAID / HAITI WMS II

SITE ODN DATE VISITED 1 Sep 1984

LOCATION San Raphael

AREA IRRIGATED : ACTUAL 800 ? ha; POTENTIAL 2000 ? ha

SOILS : heavy (black hydromorphic)

WATER SOURCE : River Bouyaha

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION 1950's, Concrete Diversion

EXISTING Earth Lined canal, Diversion still operable
No check structures at head end.

DESIRED extend canal further, control structures on secondaries & tertiaries

MAINTENANCE CONDITIONS: Some gravel deposit at diversion
evidence of cleaning by ODN & Farmers

EQUITY AND RELIABILITY : ?, possible tail end shortages and unreliability

DRAINAGE NEEDS Some evidence of need

AGRONOMIC PRACTICES :

CROPS Rice where water supply is assured, some bananas
Trees interspersed throughout

SOIL MANAGEMENT Not known (handlabor plowing) Leveling needs

IRRIGATION APPLICATION Surface paddy

EROSION POTENTIAL : slight

POSSIBLE TA/INFRASTRUCTURE NEEDS : Land leveling

OTHER : No water delivery to farmers who don't help in cleaning
May be some grass weed problems.

SITE VISITS USAID / HAITI WMS II

SITE St. Michel de l'Attalaye DATE VISITED 2 Sep 84

LOCATION St. Michel de L Attalaye, Upper Artibonite (Savannah)

AREA IRRIGATED : ACTUAL 400 ha; POTENTIAL 4000 ha

SOILS : Sandy to medium

WATER SOURCE : Riv. Canot

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION ?

EXISTING

DESIRED Dam to divert water to Savannah area plus some storage

MAINTENANCE CONDITIONS:

EQUITY AND RELIABILITY :

DRAINAGE NEEDS

AGRONOMIC PRACTICES :

CROPS

SOIL MANAGEMENT

IRRIGATION APPLICATION

EROSION POTENTIAL : could be high if any slopes irrigated

POSSIBLE TA/INFRASTRUCTURE NEEDS :

OTHER : potential dam site not good geologically for storage - possible diversion structure could be maintained with careful design & construction

SITE VISITS USAID / HAITI WMS II

SITE Non Pol DATE VISITED 2 Sep 84

LOCATION Quartier Mamon

AREA IRRIGATED : ACTUAL _____ ha; POTENTIAL 2500 ? ha

SOILS : heavy

WATER SOURCE : 3 large springs, 10 small ones

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION Farmer ?

EXISTING earth dams and earth lined ditches

DESIRED ? improved diversions

MAINTENANCE CONDITIONS: could be better

EQUITY AND RELIABILITY : some problems

DRAINAGE NEEDS : Evident in low areas

AGRONOMIC PRACTICES :

CROPS paddy rice, corn in higher areas,

SOIL MANAGEMENT

IRRIGATION APPLICATION paddy, small basins

EROSION POTENTIAL : some

POSSIBLE TA/INFRASTRUCTURE NEEDS : on farm water management
crop diversification

OTHER : Apparently land is held by very few people
not clear who has some ownership rights

SITE VISITS USAID / HAITI WMS II

SITE Rodailles, Belle Roche, Pavé DATE VISITED 5 Sep 84

LOCATION Marigot

AREA IRRIGATED : ACTUAL 50, 60, 15 (125) ha; POTENTIAL 600 ha

SOILS : Alluvial sandy loams, loamy sands, gravelly,

WATER SOURCE : Riv. des Plantils (Rodailles), Riv. Belle Roche

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION 1940's J.G. white

EXISTING structures in disrepair, destroyed by hurricane

DESIRED improve structures, replace, maintain

MAINTENANCE CONDITIONS: poor if closed conduit (Rodailles) pipe was 1/2 to 2/3 full of sediment - no way to clean out

EQUITY AND RELIABILITY : tail end problems

DRAINAGE NEEDS : ?

AGRONOMIC PRACTICES :

CROPS Bananas

SOIL MANAGEMENT

IRRIGATION APPLICATION small basins

EROSION POTENTIAL : unknown

POSSIBLE TA/INFRASTRUCTURE NEEDS : on farm water management diversion and conveyance structures

OTHER : Farmer on Rodailles system had created his own "spring" by breaking pipe with rocks where pressure existed.
Invert of structure at Bell Roche diversion was about 1 meter above present water surface in river

SITE VISITS USAID / HAITI WMS II

SITE Lafond, Orangers, Menosiel DATE VISITED 5 Sep 84

LOCATION Jacmel

AREA IRRIGATED : ACTUAL 30, 30, 13 ha; POTENTIAL 150, 70, ? ha (167)

SOILS : medium to light, some loam

WATER SOURCE : La Gossaline (Lafond), Orangiers, Gr. Riv. de Jacmel

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION J.G. white, farmer

EXISTING concrete diversions, gravel diversions

DESIRED ?

MAINTENANCE CONDITIONS: poor to fair. current clean out of sand at Lafond system inlet channel

EQUITY AND RELIABILITY : ?

DRAINAGE NEEDS : ?

AGRONOMIC PRACTICES :

CROPS Bananas, vegetables (some)

SOIL MANAGEMENT

IRRIGATION APPLICATION

EROSION POTENTIAL :

POSSIBLE TA/INFRASTRUCTURE NEEDS : land leveling in small basins use of canvas dams (plastic dams) for diversion onto fields.

OTHER : Several small systems (10 or 11) off of Gr. Riv. de Jacmel, similar to Menosiel. Gravel + brush diversions, farmer constructed, etc.

SITE VISITS USAID / HAITI WMS II

SITE Petit Goâves (Baret) DATE VISITED 6 Sep 84

LOCATION Petit Goâves

AREA IRRIGATED : ACTUAL 300 ha; POTENTIAL _____ ha

SOILS : light to medium with gravel

WATER SOURCE : Riv. Baret

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION 1979 J.G. white original concrete diversion structure

EXISTING concrete lined canals

DESIRED

MAINTENANCE CONDITIONS: moderate

EQUITY AND RELIABILITY. : Seems to be very good

DRAINAGE NEEDS : ?

AGRONOMIC PRACTICES :

CROPS

SOIL MANAGEMENT

IRRIGATION APPLICATION Small basins

EROSION POTENTIAL : moderate to high on slopes

POSSIBLE TA/INFRASTRUCTURE NEEDS :

OTHER : Farmers are given tickets stating when and How much water they get on Their turne. They need reciept showing payment of contribution before they will be included in the irrigation schedule

An Engineer is still on site for system management (Remnant of DRIPP System design & Construction ?)

SITE VISITS USAID / HAITI WMS II

SITE Abraham (Fondeu) DATE VISITED 6 Sep 84

LOCATION Fond des Negres

AREA IRRIGATED : ACTUAL 400 ha; POTENTIAL 800-(1200?) ha

SOILS : Heavy

WATER SOURCE : Drainage

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION 1950's

EXISTING Rehabilitated 1981 - 1982

DESIRED Planned structure would allow 400 (800?) ha of land to be irrigated in addition to present

MAINTENANCE CONDITIONS: moderate to Good

EQUITY AND RELIABILITY : Lots of water, farmers appear to be happy

DRAINAGE NEEDS : May be some in lower lands

AGRONOMIC PRACTICES :

CROPS Rice, other - ?

SOIL MANAGEMENT

IRRIGATION APPLICATION Small basis

EROSION POTENTIAL : ~

POSSIBLE TA/INFRASTRUCTURE NEEDS : Check for salinity problems in water

OTHER :

SITE VISITS USAID / HAITI WMS II

SITE Riv. Torbeck DATE VISITED 7 Sep 84

LOCATION Les Cayes

AREA IRRIGATED : ACTUAL — ha; POTENTIAL 2000 ha

SOILS : Medium to heavy

WATER SOURCE : Riv. Torbeck

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION

EXISTING Partially constructed diversion, sheet piling in place some concrete poured, washed out around

DESIRED Construct appropriate diversion + channels for site conditions

MAINTENANCE CONDITIONS: —

EQUITY AND RELIABILITY : —

DRAINAGE NEEDS : —

AGRONOMIC PRACTICES : —

CROPS Sugar cane ?

SOIL MANAGEMENT

IRRIGATION APPLICATION

EROSION POTENTIAL : —

POSSIBLE TA/INFRASTRUCTURE NEEDS : CORRECT ENGINEERING SOIL MECHANICS + Geological design to fit site

OTHER :

Quebec project met disaster from flood waters at abandoned partially built site - serious site/foundation/embankment problems.

Local private engineer considering rebuilding project

SITE VISITS USAID / HAITI WMS II

SITE AVEZAC DATE VISITED 7Sep 84

LOCATION Les Cayes (DCCH)

AREA IRRIGATED : ACTUAL 1800 ha; POTENTIAL 3000 ha

SOILS : (Medium to heavy), Some mostly lighter soils (gravelly sand)

WATER SOURCE : Grande Ravine du Sud

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION 1769 Large concrete barrage diversion

EXISTING Rehab in 1945 on diversion and canals

DESIRED Present rehab of existing channels and new construction of turnouts, etc. by PVO since 1979

MAINTENANCE CONDITIONS: Good on main canal (and primaries)

EQUITY AND RELIABILITY : Will be excellent if DCCH is able to effect organization bylaws, etc.

DRAINAGE NEEDS: ?

AGRONOMIC PRACTICES :

CROPS

SOIL MANAGEMENT

IRRIGATION APPLICATION 7 day rotation to secondaries

EROSION POTENTIAL :

POSSIBLE TA/INFRASTRUCTURE NEEDS : Some help in water measurement more rehab on diversion structure

OTHER : Could have serious problems with upstream users as full system goes into operation

User's Groups setup on Secondary canals, farmers construct secondary & tertiary - DCCH constructs primary canals.

SITE VISITS USAID / HAITI WMS II

SITE Melon DATE VISITED 7 Sep 84

LOCATION Maniche Valley

AREA IRRIGATED : ACTUAL 50-80? ha; POTENTIAL 120 ? ha

SOILS : light to medium, some heavy soils

WATER SOURCE : Riv. Cavaillon

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION JG White 1950

EXISTING Some, some covered ditch in cuts
High spoil banks on sides of canal

DESIRED IMPROVE diversion structure

MAINTENANCE CONDITIONS: supply ditch cleaned within 6 months prior to visit (still being cleaned)

EQUITY AND RELIABILITY : ?

DRAINAGE NEEDS : ?

AGRONOMIC PRACTICES :

CROPS

SOIL MANAGEMENT

IRRIGATION APPLICATION

EROSION POTENTIAL :

POSSIBLE TA/INFRASTRUCTURE NEEDS : shape spoil banks to flatter slope away from canal edges, Diversion structure work

OTHER : The cleaning was reportedly the first in 34 years. The spoil bank problems, covered sections and below grade canal design - illustrates nature of problems with maintence under these conditions

SITE VISITS USAID / HAITI WMS II

SITE Leogane DATE VISITED 11 Sep 84

LOCATION Leogane Plain (Several systems and diversions)

AREA IRRIGATED : ACTUAL 3500 ha; POTENTIAL _____ ha

SOILS : Sandy loam, loamy sand, sand

WATER SOURCE : Momance (main source)

INFRASTRUCTURE :

ORIGINAL CONSTRUCTION 1954

EXISTING

DESIRED Perhaps some headworks construction on laterals

MAINTENANCE CONDITIONS: No measurement structures usable
Distribution basins seemed to be working,

EQUITY AND RELIABILITY : Seems to be fair

DRAINAGE NEEDS : ?

AGRONOMIC PRACTICES :

CROPS Sugar cane, some vegetables, bananas

SOIL MANAGEMENT

IRRIGATION APPLICATION Furrows, 8 day rotation interval

EROSION POTENTIAL : High due to sandy soils

POSSIBLE TA/INFRASTRUCTURE NEEDS : Some surface drainage needs, channeling
On farm water management training, irrigation scheduling

OTHER : The 8 day rotation interval on lighter soils may be too long for best production

ANNEX B

COMPARISON OF ELECTRIC VERSUS DIESEL POWERED PUMPS

COMPARISON OF ELECTRIC VERSUS DIESEL POWERED PUMPS

The following comparison is based on western U.S. conditions for ease of data collection. The same calculation procedure would apply to Haiti if comparable cost figures are available. Assume 1,500 hours of operation per season, 50 hp. unit, electric power available at the site, and money is available at an interest rate of 10 percent for the recovery period. Thus, using current (1985) western U.S. costs and excluding fuel costs, the various economic comparison components are:

Power Unit	Installed Cost	Recovery Period (Years)	Capital Recovery Factor	Annual Capital Cost	Annual O&M	Total Annual Cost
Electric	$5,400	25	0.1102	$ 595	$ 60	$ 755
Diesel	$9,000	14	0.1357	$1,221	$916	$2,137

(The O&M cost per 1,000 hrs is $611 for diesel and $40 for electric.)

The average cost of power line extension is currently $20,000 per mile in the Utah Power and Light Company service area, including transformers, etc. If the electric line is not at the site, then an annual cost increment of $2,204 ($20,000 x 0.1102 = $2,204) per mile of extension should be added to the electric power costs. The validity of the capital and O&M cost comparison is based on the equal and reasonable availability of service, technology and repair parts for both diesel and electric.

The cost and uncertainty of fuel availability should also be considered. Table 1 shows the amount of pump work done per unit of fuel, current cost of each fuel, and a comparison of fuels in amount of the most work done per dollar of fuel. Note that natural gas produces the most work per dollar, followed by electricity (depending on the costs) and then by diesel. In each of these, it is assumed that the appropriate motor, tanks, or service lines are in place and only the cost of the power or fuel is included.

For the 50 hp. unit, as before, with 1,500 hours of operation per season, and assuming a pumping efficiency of 75 percent, giving 56,250 whp-hrs/season (56,250 = 0.75 x 50 x 1,500), the seasonal energy cost for various fuels is:

Diesel	Gasoline	Propane	N. Gas	Electric (¢/kwh)	
$4,401	$6,541	$5,841	$3,008	$3,409(.05)	$4,091(.06)
				$4,775(.07)	5,456(.08)
				$6,134(.09)	6,818(.10)

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Thus, electric energy at 6 1/2¢ per kwh is equivalent to diesel considering only the cost of energy.

The estimated total annual cost for diesel, including capital, O&M and energy, is $6,538 (6,538= 2,137 + 4,401). If the average cost per kwh were less than 8 1/2¢, then the combined capital, O&M and energy cost for electric would be less than diesel.

Table 1. Performance standards for pumping, cost of various fuels and comparative pump energy output per dollar of fuel, western U.S. 1985.

Fuel	Brake-Hp-Hours Per Unit of Fuel (Bhp - Hrs)	Cost Per Unit of Fuel	Bhp-Hrs Per Dollar	Whp-Hrs Per Dollar
	(a)	(b)	(c)	(d)
Diesel	15.0/gallon	$0.88	17.05	12.78
Gasoline	11.7/gallon	1.02	11.47	8.60
Propane	9.5/gallon	0.74	12.84	9.63
Natural Gas	8.5/100 cu. ft.	0.341	24.93	18.70
Electric	1.10/kwh	.05	22.00	16.50
		.06	18.33	13.75
		.07	15.71	11.78
		.08	13.75	10.31
		.09	12.22	9.17
		.10	11.00	8.25

(a) Adapted from ASAE yearbook of Standards 1983, (Nebraska Tractor Tests) and from Ames Irrigation Handbook Table XII-8, (Lockwood-Ames, Gering, Nebraska) for properly designed and operated installations.

(b) Based on survey of Utah dealers, March 1, 1985, courtesy of J.C. Andersen, Utah State University Ag. Economist. Electricity costs depend on size of unit and amount of use per billing period. Natural gas costs are for an installation needing about 50 hp. Costs may be slightly higher for a smaller unit, slightly lower for a larger unit.

(c) Values in Column (c) equal those in Column (a) divided by those in Column (b).

(d) Assuming a pumping efficiency of 75 percent, water-horsepower-hours per dollar equal Bhp - hrs/$ multiplied by 0.75. This represents the actual work accomplished by the total system (pump and engine) per dollar spent on energy.

An area of 231 hectares could possibly be irrigated by the 50 hp pumping unit under in these comparisons. This was estimated by assuming a pumping lift of 10 meters, pump efficiency of 75 percent, irrigation conveyance and application efficiency of 50 percent, and cropwater use averaging 0.6 liters per second per hectare. The available flow rate is 285 lps (285 = 75 x 50/10) which would supply 237 hectares (237 = 5.5 x 285/.6). The annual capital and O&M costs for a diesel powered irrigation pumping unit would be equivalent to $28 per hectare $28 = [2137 + 4401]/237), exclusive of well drilling, and conveyance system capital and maintenance costs. A reasonable estimate of the well drilling cost is $300 per meter depth for a .3 m diameter well. This would add $407 (407 = 300 x 10 x .1357) to annual cost of the pumping plant. The resultant total cost would be $29/ha. [29 = (2137 + 407 + 4401)/237].

A well 20 meters deep would serve only half the land area if a 50 hp pump engine were used, thereby increasing the cost to more than double including extra drilling. If the seasonal operating hours were also to be doubled to 3,000, which is about 8 hours/day over a year, then the total annual cost of a diesel pumping set could be:

$$TAC = 1,221 + 3 \times 611 + 2 \times 407 + 2 \times 4,401 = \$12,670$$

Since the area served is only 118 ha (118 = 237/2), the annual cost becomes $107/ha (107 = 12,670/118).

Thus, depending on the pumping lift and seasonal operating hours, the annual cost, could range from $29 to $107/ha, under western U.S. conditions. It may not be unreasonable to assume a multiplication of three times for costs in Haiti with a corresponding annual cost range of operation of $87 to $321/ha.

Factors other than simple cost comparisons which should be considered include availability and source of capital and maintenance funds; (outside donor or in-country); fuel availability and availibility of spare parts and trained mechanics at reasonable prices. The potential yield of aquifers which must be adequate to supply demands of pumped wells is unknown at present in most of Haiti. There seems to be some indication of trouble for pumped groundwater in Haiti in the area of fuel availability for both diesel and electric. Urban consumers seem to demand as much electric power as is produced which tends to deprive the pumped irrigators.

ANNEX C

NOTES ON SOCIOECONOMIC CONSIDERATIONS IN IRRIGATION DEVELOPMENT

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NOTES ON SOCIOECONOMIC CONSIDERATIONS IN IRRIGATION DEVELOPMENT[1]

Sociology of Irrigation

The essential point in Wittfogel's description of the roots of the power structure in "hydraulic societies" is that groups who turn to irrigation are faced with a political choice: in order to have water, members must give up some freedom of action.[2]

In the 1970s John W. Powell had noted the organizational features of many Mormon and ex-mining communities in the desert areas of the American West and concluded that the development plan needed was directed settlement in organized river basin units. Although Powell's vision was never implemented as public policy, he had realized something the pioneer settlers of the arid zone had always known: in order to corral and control water supplies, everyone had to accept a role as member of a collective and had to put group interests ahead of individual desires. This is what is meant by the phrase, "life under the ditch."

Given this requirement, how can society obtain the benefits that private initiative confers in development, yet temper individuals' self-interest inside a collective? Unfettered individualism must be given up, yet initiative retained. This amalgam has never been achieved beyond the level of "mutual irrigation companies" except on a foundation of public subsidy.

In other cultures it may be natural for farmers to understand and work within a framework of local collective interests, but the larger society will not be able to obtain dynamic economic impacts of individual innovation and enterprise. An example of this might be found in the strong group traditions of an indigenous society such as exists among the Indians in the Andean Highlands. There, even an overlay of compensating (ameliorating) subsidy may not tap initiative unless the group has dynamic, innovative leaders.

Water Source Tenure and Development

One way or another, those who develop water source/conveyance structures have to be guaranteed user rights. If these rights are

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[1]Adapted from LeBaron, 1984.

[2]K.A. Wittfogel, Oriental Despotism, Chapter 1, Pt. D. New Haven: Yale University Press, 1957.

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retained by the State, the possible implication is that only the State is in a position to guide and manage what is created. On the other hand, if individuals or groups have some form of recognized tenure rights to water sources, automatic development will tend to occur. If the State owns all the water, then as ancient history has shown, the population will be subject to many controls of centralized power. However, if the State does not choose to direct all things in a despotic way, the farmers may not do all things with the created system that are technically feasible. That is, if the State retains management control and still expects voluntary response, it may be disappointed at the reaction from farmers. This suggests a possible rule of development: The State should only develop and control a source down to a level where it can create the counterpart of a "spring" for potential users lying below. The users might be expected to "reach up" the system as far as possible to find their "spring" and be responsible to develop and manage all the area commanded by this subsource.

In modern times State-mandated development of public works has been rationalized on various grounds. One of the most commonly cited is the inability of a diverse group of water users to obtain large amounts of investment capital. Obviously, once built such works are not likely to be any more profitable for the State than they would be for private enterprise, especially since all easily developed areas have already been exploited. In addition, earlier irrigation works may have been situated to command the best lands. Of course, the State may be able to improve existing simple systems by introducing storage of late season water by irrigating additional land on the boundaries of what already exists, or it may be able to direct some water away from current users to be employed elsewhere.

As projects become more complex, legal considerations proliferate. Tenure rights and their enforcement exact more and more attention and resources. Additional legal and legislative adjustments are needed to resolve questions of project financing. If water beneficiaries are required to bear some financial burdens, additional restrictions are placed upon individuals because the money must be collected. An engineering and administrative technostructure emerges and eventually gathers to itself the trappings of power and control that financial ability to move and shift vital resources confers. Tenure rights and water law are required as a countervailing offset.

Measuring Social Benefits of Irrigation Development

One reason the concept of the "spring" is important is that no one expects even a voluntary, non-profit collective to expend effort or resources in development unless potential payoffs are likely to cover the costs. Assuming the collective evaluates its alternatives carefully and that markets for the necessary labor, capital and other inputs are relatively free, any decision to go forward is a rough indication that society as a whole will benefit to a greater degree than if an alternate

use of the resources had been chosen. In other words, a "correct" evaluation of society's opportunity costs is made somewhat automatically by numerous market forces playing themselves out in the private arena.

The same opportunity cost principle may be invoked when evaluating economic choices made by the State. Indeed, such application is important because large projects tend to be expensive and often return less than the value of their construction and support resources, as measured by their value in alternative uses. Nevertheless, sometimes this subsidy is deliberately made. The reason consideration should be given to charging farmers "full cost" for water supplies is that if they are not, it is possible for them to perform at a level which they measure as profitable, but which in fact is not equal to full social cost.

But even if no subsidy is intended, it should not be imagined that society actually will be reimbursed for the resources it devotes to irrigation works whether successful or failed. Such a felicific arrangement would exist only if the direct beneficiaries were charged the full costs of the water conveyance features constructed by the State. In practice, such levies are not made, although the farming population obtains most, though not all, of the direct benefits. Thus, whether or not society gains on economic balance from committing resources to irrigation works depends upon whether the net value of increased farmer production is great enough to raise GNP by an amount commensurate with the annualized costs of the project. The increase in GNP must be as great or greater than the increase in the net value of production as compared to the "without project" status.

Markets and Finances

Although instances of financial success are reported in World Bank or other evaluations, it is difficult to imagine any more than a narrow spectrum of situations where irrigation plays a natural, successful economic role. The key variable is markets. Only if they are able to absorb the jumps in irrigated productivity is there any hope for farmers to cover production as well as construction costs. Markets for expanded agricultural output may be opened up due to import substitution or via foreign sales. These are the main short-run possibilities. Longer-run domestic markets expand due to higher on-farm consumption, more raw material requirements to process intermediate food products, some upgrading of tastes for higher value crops and greater meat consumption, but mostly there is normal demand growth due to incrases in population. All told, domestic long-run markets may expand at about 4 to 5 percent per year. In a small nation, such percentages might not represent an absorbtive capacity greater than what could be satisfied from a small project or from technically achievable advances in yields within the structure of the existing agricultural system.

More and more international donors are insisting upon financially sound projects. This requirement stiffens up the repayment burden by shifting the load from the general exchequer onto the backs of direct beneficiaries. Tightening up performance requirements is one explanation of donor interest in repayment ability of farmers and upon schemes to charge for water. Donors realize that all subsidy has to be covered, and if the projects cannot stand on their own feet financially, then the subsidy repayment must come from other sectors in society. And most nations in need of increased production and economic development, as well as social programs, are not the kinds of societies that have a lot of surplus paying power in non-agriculture sectors.

ANNEX D

NOTES ON THE GENERAL EROSION PROBLEMS IN HAITI

NOTES ON THE GENERAL EROSION PROBLEMS IN HAITI

The problem of soil erosion in Haiti has been approached by many agencies and scientists during recent years. The people in charge are very much aware of the seriousness of the situation, but they are either helpless or careless in facing their responsibilities. Too many reports have been written, and too much work has been done, but most of it has concentrated on the constraints to soil conservation and watershed management in Haiti rather than on finding solutions. Yet many of these reports were never based on real data, since it doesn't exist or is obsolete as processes are changing dramatically fast and no real attempts seem to have been taken to collect enough urgently needed data in exact studies and problem analysis.

It is fair to mention that some of the reports available are based on actual encounters and are worth considerations (Murray, 1979; Hauge, 1984).

The major biophysical constraints for soil conservation in Haiti encountered in our visits and adduced through interviews with officials from government and international and private groups or individuals and from available reports can be summarized as follows:

1. Vegetation. In areas where man interferred with nature by cutting trees (Cayes, Cap-Haitian), burning plants (Jacmel, Marigot, North Plains), cultivation, etc., (Riviere Grise, Central Plateau, Quartier Morin, La Beaulieu, Grison Garde, Limbe, St. Michel, Belle Roche, Jacmel, Des Mornes) because of food needs and low productivity of originally cultivated low land, and failure of irrigation structures due to poor maintenance, erosion is extremely severe. In contrast, areas where vegetation still exists (Courjolle, Matieux, Torcelle) and where man has not much influence a certain natural balance still holds, and erosion is not as significant. This can be detected by the relatively cleaner water and less debris deposited downstream. Man's interference due to overpopulation and food needs is neither controlled nor productive. Laws are not updated or enforced. Farming operations are not technologically sound, either due to lack of institutional interference or to poor quality technicians or lack of capital to provide services, infrastructure incentives, lack of research to decide on proper cropping patterns and varieties, lack soil surveys, data collection, etc.

2. Climate. Rainfall intensities, distribution and amounts are variable. Some regions receive precipitation all year around. Some locations get hurricanes of 500 mm per day, such as what happened in Jacmel in 1944, or due to Cyclone Hazel (1954) in Cayes. Some places get an average of 200 to 350 mm/month (Kenscoff, Jacmel, Ridoree, Cap-Haitian, Hinche), which might come in few rainfalls and cause erosion. Temperature data is missing through most of the country.

Climate is a factor that we cannot control, but with proper watershed management and improved cultural practices, we can control its effects.

3. Topography. Sixty-three percent of Haiti has slopes 20 percent or higher (sometimes up to 120 percent) and only 29 percent of the land has slopes less than 10 percent.

4. Land Resources. No detailed comprehensive soil survey has been done for the country except for L'Acul Basin. The land capability studies show about 233,000 ha of Class II land; 305,000 ha of Class III land; and 255,000 of Class IV land. The remaining area is of Classes V-VIII. The areas of Classes III-VIII need some sort of conservation practices, i.e., on about 92 percent of the total area of Haiti (2,769,000 ha). Out of the 233,000 ha of Class II, it is estimated that 90,000 ha are under irrigation, and one can safely assume that man is cultivating the remaining area of Class II under rainfed conditions. Therefore, these lands require more attention in terms of management and studies to ensure erosion control and optimize production. Especially needed are the fertility status of the soils in different regions since farmers have been depleting the soil nutrient capability and do not apply fertilizers.

5. Water Resources. Water is abundant in Haiti, but not really studied with respect to streamflow, quantities, use, and with respect to soil moisture storage and depletion, crop water requirements, groundwater fluctuations and capacities, evaporation, etc. The reports available mostly show estimates or use empirical approaches. No continuous monitoring of watershed systems, or rainfall amounts, or groundwater fluctuations could be found except for very few places. Such data is of utmost necessity for proper watershed management, for engineering design purposes, and for irrigation scheduling and conservation practices, as well as for cropping selection and cropping pattern adoption in different areas so as to maximize production by optimizing cropping management techniques.

The major socioeconomic and institutional constraints to soil conservation in the uplands are well known so only a few statements are necessary:

1. Off-Farm Employment. Any time spent in conservation practices must be balanced against wage work or sharecropping. Any efforts to increase yields must be balanced the same way.

2. Food Security. It is not clear how much pressure for family food can be relied upon to induce some effort at soil conservation. The relationship between operating tree plantations and obtaining food security is unknown. Most tree planting thus far has not been on the hillsides, except in the lac Peligre watershed program.

3. Communication and Coordination. There is lack of communication between farmers and technicians from the GOH agencies and between

farmers and technicians from the GOH agencies and between farmers and specialized agencies and among agencies. Local engineers, agronomists and localized agencies work alone, without benefit of new programs or technology that might have succeeded elsewhere.

4. Discontinuity and Motivation. Except for the Peligre area, follow-on activities cease once the terraces are built. Poor management of projects is due to poor technician motivation, their need to hold more than one job, etc.

5. Law and Enforcement. A part of any soil conservation solution is to utilize legal sanctions as far as they will work, even if that is not much. Any laws that exist appear to be ignored; new ideas for regulation are not implemented with dispatch.

6. Household Fuel Alternative. At present the only charcoal policy seems to be to replace cut trees at least as fast as they are being taken out (this does not mean that the policy is successful). There is little or no evidence that GOH has an effective program to stop indiscriminate cutting of existing trees. Is a viable charcoal substitute in urban areas impossible to find?

7. Lack of Commitment to Solutions. Very few projects of soil conservation were observed, given the need. This is certainly due to lack of budget. Most projects require some government planning or help. More awareness of the dangers of the present situation should be taught to every child who attends school. The support of urban residents for watershed protection is needed. Their own water supplies are threatened. Pipes being replaced in PAP at the present time are full of silt. No doubt GOH needs assistance of the international community to battle the nations's serious erosion problems, but is it doing all that it can on its own?

Perhaps a National Soil Conservation Authority could be established which would be strongly backed by the government. All disciplines involved should be represented with the objectives of planning, designing, executing, maintaining and financing conservation projects.

A review of laws of soil conservation and land fragmentation could be conducted. It is important that these laws are respected and enforced. In the U.S. there are laws that govern the control of soil erosion from a certain uphill parcel to another downslope. Farmers can be sued by their neighbors if they leave their land uncontrolled with respect to erosion and sedimentation. In Haiti we understand that similar laws dealing with farming on slopes exist, but evidently those laws are not enforced.

The environmentally damaging cultivation of hillsides and mountains is being carried out by two very general farmer classifications. The first is made up of those who can find little or no food security in any other way. The second is composed of farmers who have some food

security base in the plains. Additional subcategories could be defined, but the essential point is that it might be easier, politically speaking, to invoke sanctions against the latter category.

Population density is high, food reserves are low and it is questionable whether any conventional soil conservation programs are applicable. A detailed feasibility study for the different watersheds may reveal that to achieve a successful program it might be more feasible to organize a large rehabilitation program by which people are moved to new areas where viable mobilization alternative (urbanization) might prove more useful and economical.

In summary, GOH is the major entity that can perform the job (with the help of international agencies). Consideration of the local needs and traditions must be balanced against the country's ecological and agricultural needs, which together with successful law enforcement and continuity in management and control, could create a feasible soil and watershed management program. GOH might have to invest in these programs much more than what it could ever hope to get from taxing the irrigators.

ANNEX E

NOTES ON AGRICULTURE SECTOR POLICY PROPOSALS

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Wheat Substitution Policy and Export Tax Reduction

> "...stimulate further substitution of wheat for home produced food grains, thereby lowering prices in general and reducing the pressure to produce food crops on at risk lands" (Kite and Pryor, 1983).

Prices will have to fall an awfully long way before farmers in Haiti are going to leave land idle. Cash receipts may be reduced and some farmers may shift to tree crops, but the desire for food security will keep most hillsides in production more or less as at present.

> Food grain policy to force corn and sorghum prices downward and export tax reduction to encourage coffee production (USAID, 1984; Berg, 1984; Kite and Pryor, 1983.)

The idea is that farmers who are confronted with lower corn and sorghum prices will find the increased profitability in coffee (due to export tax reduction) great enough to induce planting of this tree crop in the hills. Ignoring the lead time to get trees into production, especially on 100 percent slopes, it is obvious that not all hill land will support coffee trees. Will farmers move smoothly into a cash crop/food purchase (imported staples) way of living, or will there be a lot of pain and misery?

The reasons advanced for a different foodgrains policy have some logic, but it is difficult to have faith that all interlocked benefits identified by the authors will materialize. The big negative impact will be on rainfed farmers to the extent they now have cash sales of maize and sorghum. We also doubt that rice growers will be exempt from downward price pressures despite arguments to the contrary (Kite and Pryor, 1984). The only ones who will shift to coffee are those who know something about the crop. The brunt of the adjustment will be taken in the rural areas. Urban consumers will benefit through a major shift in domestic agriculture sector terms of trade.

The argument that lower food grain prices will enable presently undernourished persons to increase their food intake may apply to urban poor, but it seems to overlook the fact that agriculture sector income will fall in general and the rural hungry will still not have the money to buy even at lower prices.

An associated argument is that current high domestic grain prices "impose a terrible resource burden on the nation" (USAID, 1984). No

evidence of magnitude is presented. In fact, the actual burden may not be too bad compared to the immediate and long range negative rural income consequences of what is proposed in the 'food for development program.'

A different policy would tighten the tax screws on urban consumers to finance dissemination of cost cutting technology to farmers for crops that have genuine potential for absolute advantage (export) in production or towards parity at world prices (costs of basic staples). (The trend in world grain prices is down, and parity gets harder and harder for any country to achieve.) Consumer prices for basic grains can be left a little high to benefit rural sector income. Many fancy imports should be choked off, strict foreign exchange controls should be applied, and in general, selected protectionist policies should be the rule, at least for the short run.

More food may well be needed in Haiti, but an attempted solution should not involve destruction of the primary sector and exacerbation of already extreme class and power differentials.

Subsidy of the Agriculture Sector Is Justified At Least in the Short Run

Paternalism Versus "Productivism"

One of the most striking elements of current GOH agriculture sector management is the reliance for development upon a structure of donor grants from private sources as well as international agencies. The associated policy issue is the degree to which government ministries are willing to erect a foundation for long-term sustainable agriculture on the basis of external subsidy.

The Minister of Plan told the WMS II Team that the GOH wished to move away from paternalism and wanted a self-sustaining agriculture sector. The former Minister of Agriculture stated that there were other important rural objectives besides mere "productivism." His position appeared to be that small farmers could carry the food burden if only they were given enough transitional support at public expense.

Probably there is a connection between depth of poverty and higher justification for subsidy. Nevertheless, what any subsidy is meant to accomplish should be thought out. A sharp distinction might be drawn between production and welfare activities. The latter are usually but not always subsidized. If the international community chooses to bear a subsidy burden for productive investment, it is their choice. As far as a country in Haiti's position is concerned, the best rule of development planning is that every State-initiated productive effort should be able to stand on its own feet in the long-term. The only nations that can afford perpetual internal subsidy are the rich ones. The GOH should be cautious about utilizing its own development budget on any productive

activity which will need subsidy; it has enough problems financing health, sanitation, education and other welfare (consumption).

Constant subsidy injections mask real costs in Haiti's agriculture sector and may not even be generating hoped-for "transition" and greater private initiative since a majority of funds are filtered through inefficient GOH structures that may or may not be supportive of articulated aims and goals. Subsidies slow or prevent the required shifts in the direction of long-run productive viability (sustainability). From a strategic forecasting perspective, the important question to ask is, Where would Haiti's agriculture sector be if most subsidy were squeezed out? What would be the impacts on the poor? On the rich? Apparently, international donors feel the cure would be worse than the disease.

In sum, subsidy arguments can be twisted every which way, but they always come back to the starting point: somebody pays, somewhere, sometime.

Global Rural Development Policy

Haiti is possibly the world's premier example of Malthusian prophecy come true--population size and a degraded resource base are totally out of balance. The present issue is, Can such a balance be reestablished? And what form would the result take?

Some unknown but large percentage of people farming and exploiting any of the critical watersheds, slopes, or topographically sensitive sites have got to be moved to the lowlands. Extensive rehabilitation must then be undertaken.

The next point to be recognized is that there is no likelihood that the farming systems of the lowlands can be arranged so as to absorb the displaced "hill people." By-and-large, these displaced persons must become urbanites.

All of the ideas and proposed actions that aim to reestablish a balance via comprehensive rural development efforts can probably be written off. This does not mean that there should not be efforts at reforestation, or that a fuel and energy policy will not be needed or that particular segments of the rural scene such as irrigation should not be made more productive, etc. (Delatour, 1984).

However, it is selected urban zones that must be changed and developed to provide the jobs and livelihood for the relatively large population of Haiti. These actions and programs will have to be subsidized from the "outside" for some indefinite length of time by worldwide institutional and international donors. (Americans will have to buy from Japanese plants located in Haiti.) This line of reasoning may appear radical and seem to move too far too fast, but such a program is at least technically feasible, whereas attempts to somehow turn rural Haiti into the nation's leading sector never will work.

ANNEX F

CHRONOLOGICAL LIST OF ACTIVITIES

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Annex F

CHRONOLOGICAL LIST OF ACTIVITIES

USAID/Haiti - WMS II Irrigation Sector Review
August 20 - September 15, 1984

Team: Dr. Allen D. LeBaron, Resource Economist, Team Leader
Dr. Robert W. Hill, Irrigation Engineer and Hydrologist
Dr. Anwar M. Battikhi, Soils and Irrigation Scientist

In-Country Coordination Provided by Dr. John V.D. Lewis, USAID
Assisted by Humberto Pizarro, Irrigation Engineer, IICA

Monday August 20	R.W. Hill arrived Port-au-Prince (PAP). (IICA assigned H. Pizarro and provided local transportation for PAP and vicinity.)
Tuesday August 21	R.W. Hill met with IICA staff, H. Pizarro and Ariel Azael. Discussed rainfall adequacy and irrigation systems inventory studies (also some related discussion with Dr. Downard, USDA veterinarian and Dr. Amelingmeier, IICA veterinarian, about their programs and Haitian situations). Discussions with Dr. Percy Aitken-Soux (IICA) and J.V.D. Lewis (USAID). Meeting at USAID with J.V.D. Lewis, Gustave Menager (Agronomist, USAID), and Mohammed Rahman (Sheladia Assoc.). Reviewed generalities of irrigation and soil conservation in Haiti. Further discussion with Richard Byess and J.V.D. Lewis.
Wednesday August 22	Traveled to Irrigation District headquarters at Croix des Bouquets in company of Luis Oberti (IDB), H. Pizarro and M. Rahman. Meet with Director Fritz Boutin and Eng. Guy Bernadotte. Discussed Riviere Blanche and Riviere Grise projects as well as overview of general operation and maintenance activities. Visited Riviere Grise diversion site. Further discussion with Mr. Andre Cham, water controller, relative to irrigation tax procedures and rotation schedules. A.D. LeBaron arrived; further discussion with P. Aitken-Soux.

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Thursday August 23	Met at IICA with P. Aitken-Soux and Ariel Azael. Background information, typical projects, some institutional aspects of Ministry of Agriculture (MARNDR), and regional development organizations. Political control at village level. At AID discussed proposed travel itinerary with J.V.D. Lewis and Gus Menager. Visited Ministry of Economics and Department of Commerce, looked for import/export data. Mr. Dumont of Ministry of Finance Customs Department agreed to summarize data. Looked at deforestation, estimating work of Warren Cohen, an AID forester. Further discussion with J.V.D. Lewis relative to purpose of Team study of irrigation sector. Obtained information on food for work soil conservation programs from Peter Graeff of Church World Service.
Friday August 24	Hill and LeBaron traveled with J.V.D. Lewis, Jim Talbot and H. Pizzaro to Croix des Bouquets; joined by F. Boutin and G. Bernadotte. Continued on to Duvalierville and visited diversion works of Torcelle, Courjolles and Des Matheux systems. Observed AID-financed small projects flume construction on right hand Torcelle canal. Attended debriefing of Land Tenure Center rural sociologists, Suzy Mathieu and Gina Gerdes, relative to Dubreuil system.
Saturday August 25	A.D. LeBaron, R.W. Hill, J.V.D. Lewis, H. Pizarro and Mohammed Rahman (of Sheladia), joined by F. Boutin at Croix des Bouquets, traveled to the east. Talked with farmer irrigating shallots with small basins. Visited colonial irrigation development at Despiuzeau springs and on up to Riviere Blanche diversion. Returned along left side canal to co-op pump station by highway. Traveled to Thomazeau, joined by Marcel Duret, then continued to Manneville and Duthil springs. Inspected pumping systems. Returned to Croix des Bouquets and up to Riviere Grise diversion. Talked to farmers irrigating shallot and other vegetables.
Sunday August 26	Strategy and study plan discussions (A.D. LeBaron and R.W. Hill).

Monday August 27	Reviewed documents at IICA. Met with Abdul H. Wahab and J.V.D. Lewis at AID, discussed rural sociological and agronomic studies. Met with Vince Cusumano and J.V.D. Lewis, discuss study Team constraints and desired production. With Richard Byess, AID economist, reviewed available economic information. Acting AID director, Phyllis Dichter, instructed Team as to main objectives of study. A.M. Battikhi arrived. Further strategy discussions. AID interventions decided.
Tuesday August 28	U.S. Ambassador, Clayuton McManaway, received Team August along with P. Dichter, V. Cusumano, J.V.D. Lewis and Ken Lauren, Peace Corp Director. Discussion of USAID expectations and probable Team results. A.M. Battikhi and R.W. Hill met with soils scientist, Agr. LaFortune and meterologist, Agr. Dorvillier (R.W. Hill) of the University faculty. Determined what studies have been and are being conducted and what data may be available. Minister of Plan, Mr. Blanchard, and selected staff meet with Team and J.V.D. Lewis and H. Pizarro. Discussion of their programs related to agriculture and irrigation. Desire for money made clear. Minister of Agriculture, Mr. Saint Dic, and selected staff met with Team and J.V.D. Lewis, H. Pizarro and J-R. Sam (Director Agricultural Division Ministry of Plan). Presentation of MARDNR program emphasis, goals and policies. Against "productivism"--need lots of "transition" money and peasants will will work their way off subsidy.
Wednesday August 29	At IICA continued document review. A.M. Battikhi to MARNDR met with Agr. R. Cassagnol, Head Div. of Natural Resources Eng. J. Roy, Irrigation Service and Agr. F. Hyppolite, Programming. Visited with Danielle of IICA about rural rural social conditions. Team and J.V.D. Lewis, H. Pizarro and J-R. Sam visited Mr. Guy Chapond of FAO. He reviewed various programs and areas of emphasis, particularly in ODVA and ODN localities. Group continued on to IDB where Dr. Luis Oberti reviewed history of ODVA and IDB involvement. Failure to cover O&M costs.

August 30 thru Sept. 2	Field trip Team composed of J.V.D. Lewis, G. Menager, H. Pizarro, A.M. Battikhi and R.W. Hill traveled toward Cap-Haitien via St. Marc, Lac Peligre, Hinche and returned via Limbe, St. Michel de l'Attalaye, Gonaives and St. Marc to PAP. A.C. LeBaron remained in Port-au-Prince.
Thursday August 30	L. Oberti and J-R. Sam accompanied field trip Team (FTT) to ODVA. Along the way identify many small irrigation systems that are apparently community maintained and operated, i.e., Montrouis, Lenzac, Pierre Payen, Bois Neuf, Camarie, several on Canot riv. etc. Met with ODVA Director General, Jean Andre Victor and Eng. Grand Pierre. Mr. Victor discussed major constraints ODVA is faced with. He indicated that there were six small nearby systems, of which ODVA (and FAO) may help two or three for rehabilitation. Eng. Grand Pierre then gave a guided tour of ODVA areas on up to the diversion works. The Team talked to three farmers on ODVA and two farmers on Riv. Bois system. All grew rice. Traveled up the Artibonite Valley past Boucan LaFete and Zeppelin and other small systems, past LaChapelle dam site on to Mirebalais; then to Peligre guest house. Agr. Henri Louis-Jeune described Electricite d'Haiti soil erosion/conservation program on Lac Peligre watershed.
Friday August 31	Henri Louis-Jeune described transversal region of Haiti, ODBFA and CORCO Plan. Traveled to Thomonde, Hinche and Maissade. Visited old diversion structure near Maissade (via horseback). The potential irrigated area appears to be productive as is. About 150 to 200 persons of the local population came to express interest. Returned to Hinche, visit reforestation nursery.
Saturday Sept. 1	Traveled from Hinche north to San Raphael. Looked at ODN project, talked to President of Farmers Association, learned about operation and maintenance procedures. Observed diversion structure on the Bouyaha River; it is still in relatively good condition. Visited source Merlene with farmer and volunteer syndic, southwest of San Raphael.

Traveled north through Pignon, stopped at the barrage for the La Tannerie system. Continued through the Plaine du Nord, looked for various small irrigation systems (La Beaulieu, Grisongarde), arrived at Cap-Haitien.

Sunday Sept. 2

Traveled from Cap-Haitian southerly through Limbe area, observed FAO soil erosion control project conditions. Traveled along the Ennery River, observed small (10-11 ha.) irrigation systems with farmer constructed rock barrages.

Looked at proposed dam site on the upper Canot River at the confluence of two tributaries.

Picked up Pastor Lubin at Saint Michel de l'Attalaye, traveled on to Nan Paul and then to Quartier Mamon. Observed irrigated rice land with local chief. Apparently irrigated by farmer constructed ditches and dams built of local available materials. Water source was a spring. Reportedly there were two other larger springs downstream.

Returned to Saint Michel de l'Attalaye and then traveled to ODPG area. Looked at diversion and pump at La Quinte.

Traveled to Gonaives and on south into the lower Artibonite valley. Passed through lands which would be suitable for center pivot irrigation schemes.

Visited the Tapion irrigation system, where a unique elevated precast concrete flume had been constructed in the 1970s. Returned to Port-au-Prince.

August 30 thru Sept. 2

A.D. LeBaron remained in Port-au-Prince. Document review, writing and meetings with G. Werleigh regarding market statistics and old IICA project, Agr. Duplan marketing. Vice Dean J.E. Alexis did not keep appointment. Also, interviewed J-R. Sam. Customs and equipment cost data obtained.

Monday Sept. 3

Document review. Some discussions with Jack D. Hancox, Ken Heneise and R. Amelingmeier about PVO activities and displacement of irrigators on State projects.

A.D. LeBaron, R.W. Hill and H. Pizarro visited Riviere Blanche and talked with pump co-operative member and another farmer. Took a series of flow estimates along canal Ti Marche.

Tuesday Sept.4	A.M. Battikhi visited Riviere Courjolles and Riviere Grise head water areas with Esteban Hernandez of IICA. A.D. LeBaron met with Eugene Roy to discuss historical maintenance and reduction of effective river flows. A.D. LeBaron, R.W. Hill, J.V.D. Lewis and J-R. Sam visited DATPE Director, Pierre Saint Albin. Discussed Ministry of Plan role in regional planning and environmental protection. Obtained some summary information on actual and potential irrigated area. Research assistant to get contractors' costs for concrete placement.
Wednesday Sept. 5	A.M. Battikhi, R.W. Hill, H. Pizarro and J-R. Sam travel to Jacmel, met with Director of District, Agronome Noel and Eng. E. Faucaud. Discussed the general activities of the district. Eng. Foucauld accompanied the group in the field to visit Marigot area and Belle Roche (on Riviere des Plantils) and Pave irrigation systems (which were apparently J.G. White construction in the 1950s). Talked with farmers at Rodaille who had created own spring from hole in buried concrete pipe main. Returned to Jacmel; visited rock dam diversion site of LaFond System on LesGosselines River and small concrete barrage on Riv. Orangiers. Looked at the 13 ha Menoisiel system, one of ten or so farmer constructed and maintained systems on the Grande Riviere de Jacmel. Returned to Port-au-Prince. A.D. LeBaron remained in Port-au-Prince, continued writing and document review, met with R. Byess, Jane Westcoff and G. Caprio discuss Title III assumptions.
Thursday Sept. 6	(AM) Document review and writing at IICA. Submitted proposed outlines of report and memorandums to Dr. Cusumano. (PM) A.D. LeBaron, J.V.D. Lewis, H. Pizarro, A.M. Battikhi, R.W. Hill accompanied by J-R. Sam and Judy Ingalls departed Port-au-Prince for field trip to Les Cayes area. Met Eng. Charles Montes at Petit Goave. Looked at System Barrettes barrage and other structures. Discussed farmer water turn cards, etc. This system was a J.G. White original and R and B in 1979. Visited Fond des Negres (Abraham) system which is a drainage collection canal. Continued to Les Cayes, pass by the St. Louis du Sud irrigation system. Arrived at Les Cayes. Met with Michael Yeates, anthropologist working with a CYMMIT field trial program for corn on non-irrigated areas.

Friday Sept. 7

The Team was joined by Amal Chatterjee, agronomist for farming systems projects (U. of Arkansas) and Eng. Eric Armand, local private consultant, who had worked with some of AID's 10 K programs. Visited systems irrigated by drainage canals in Torbeck area; Syst. Bourry d'Agrodrip (Riv. Guilleme), Syst. Desrochers (Riv. Ti Simon Deronceray). Talked to presidents of community groups and farmers. Visited DaParafres du Canot (Quebec project) barrage disaster. Observed culvert and channel bank problems limiting canal capacity at system Chalette on Riviere La Battre.

Visited the DCCH headquarters of the Avezac irrigation project. Agr. Felix Lorenstein presented an overview of the canal system design and layout along with organizational strategies. Design capacity is 0.9 lps per hectare of continuous flow at the end of the primary canal. Visited the main system and diversion works with Felix. Discussed water measuring structures, suggested possible use of broad crested weirs. The barrage was first built in 1769 and rehabilitated in 1945, and still functions with some repair needed on radial gate.

Traveled to Maniche Valley north of Les Cayes. Agr. Gardy Fleurantin took Team to Melon irrigation system, which has been cleaned over the past six months. Also visited Syst. Robert from Source Tet. Both systems are J.G. White vintage and difficult to maintain.

Saturday Sept. 8

Team was joined by M. Rahman (Sheladia), Eng. Lucien Badeau, Eng. Mesidor of PDAI and Eng. Myrville, District Engineer. Traveled into the Dubreuil project area, followed main canal (J.G. White construction) up to diversion barrage. Observed masonary construction practices on the laterals (secondaries) and tertiary turnouts. Talked to farmers. Observed 200 lps spring that joins main canal. Riv. Acul is the water supply at the barrage.

Visited colonial aqueduct still standing almost entirely across Ravine Seche.

Traveled to Chantal system which is on right bank of Acul opposite the Dubreuil system but obtains water from a spring. Continued around to Riv. Des Mornes, looked at potential dam site. Continued to Syst. de Minere (Riv. Muscadin) north drainage source with Eric designed distribution basin.

Met with Pere La Coste who had helped with organization and funding of Gaston, Chalette and other systems. Discussed his approach and experiences.

Visited Riv. l'Islet (AID 10 K) barrage. Well done structure, canal excavation is under way; funded from another source.

Returned to Port-au-Prince.

Sunday Sept. 9	Report writing, some document review.
Monday Sept. 10	V. Cusumano, J.V.D. Lewis, P. Aitken and the Team met with new Minister of Agriculture, Mr. Flambert, at Damien. Discussed topics of interest to the Minister as well as brief presentation of findings by the Team. Visited the Irrigation Service offices and talked with several staff members. Further discussion with Director, Julio Roy. A.M. Battikhi and R.W. Hill met with AID engineers Ed Oriol and F.M. Temmel. Visited Service Geodesie et Cartographic with J. Talbot and J. Ingalls. Looked at Feb. 1978 infrared photo set of Haiti (1:40,000). Discussed possibility of using Landsat 4 data. A.D. LeBaron visited R. Byess, reviewed Haitian version of policy GOH wants from Title III. Team, along with V. Cusumano, J. Lewis and J. Ingalls, met with U.S. Ambassador for debriefing of findings and conclusions to date.
Tuesday Sept. 11	(AM) Report writing. (PM) Traveled to Leogane irrigated area with J. Lewis and J. Ingalls. Met with extension director Josue Bartholome. Looked at features of irrigation system, discussed their programs and situation.
Wednesday Sept. 12	Report writing.
Thursday Sept. 13	Report writing.
Friday Sept. 14	At IICA sorted through documents. Took material to AID. Team, with J. Lewis, met at Ministry of Plan with Dir. Gen. Yuon Buirand, P. Saint Albin, P. Mathurin and J-R. Sam. Debriefed on principal findings and recommendations of Team.

Finished up last details at AID.

Met with Ann Hauge of Agri-Supply Co., Brunet George and Marcel Duret of AgricCorp. Went with Ann Hauge to meet with retired engineer Tabon.

Saturday Sept. 15 — Team departed Haiti.

Note on Terms of Reference

Five objectives stressed by the Acting Mission Director may be mentioned as follows:

1. Suggestions about a categorized way for donor agencies to look at potential projects in the subsector, including methods of approach, contracting facilities and sharing co-sponsorship;

2. Suggest ways to interface soil conservation measures with irrigation system O&M;

3. Suggest institutional rearrangements that alleviate some of the rehabilitation and maintenance problems now plaguing the network;

4. Specific review and comment upon particular systems in which the USAID Mission seeks investment counseling; and

5. Make specific recommendations for USAID interventions in soil conservation and irrigation.

Due to the amount of time the Team could devote to this assignement and the possibilities for obtaining relevant site specific data, Topics (1) and (2) were given minimum attention. The main focus of this report is upon the many aspects of irrigation system operation and maintenance that impinge upon Topics (3), (4) and (5). Topics (4) and (5) are given additional coverage by separate memoranda to USAID/Haiti.

WATER MANAGEMENT SYNTHESIS PROJECT REPORTS

WMS 1 Irrigation Projects Document Review

Executive Summary
Appendix A: The Indian Subcontinent
Appendix B: East Asia
Appendix C: Near East and Africa
Appendix D: Central and South America

WMS 2 Nepal/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 3 Bangladesh/USAID Irrigation Development Options and Investment Strategies for the 1980's

WMS 4 Pakistan/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 5 Thailand/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 6 India/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 7 General Asian Overview

WMS 8 Command Area Development Authorities for Improved Water Management

WMS 9 Senegal/USAID: Project Review for Bakel Small Irrigated Perimeters Project No. 685-0208

WMS 10 Sri Lanka/USAID Evaluation Review of the Water Management Project No. 383-0057

WMS 11 Sri Lanka/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 12 Ecuador/USAID: Irrigation Sector Review

WMS 13 Maintenance Plan for the Lam Nam Oon Irrigation System in Northeast Thailand

WMS 14 Peru/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 15 Diagnostic Analysis of Five Deep Tubewell Irrigation Systems in Joydebpur, Bangladesh

WMS 16 System H of the Mahaweli Development Project, Sri Lanka: 1980 Diagnostic Analysis

WMS 17 Diagnostic Analysis of Farm Irrigation Sysems on the Gambhiri Irrigation Project, Rajasthan, India: Volumes I-V

WMS 18 Diagnostic Analysis of Farm Irrigation in the Mahi-Kadana Irrigation Project, Gujarat, India

WMS 19 The Rajangana Irrigation Scheme, Sri Lanka: 1982 Diagnostic Analysis

WMS 20 System H of the Mahaweli Development Project, Sri Lanka: 1983 Diagnostic Analysis

WMS 21 Haiti/USAID: Evaluation of the Irrigation Component of the Integrated Agricultural Development Project No. 521-0078

WMS 22 Synthesis of Lessons Learned for Rapid Appraisal of Irrigation Strategies

WMS 23 Tanzania/USAID: Rapid Mini Appraisal of Irrigation Development Options and Investment Strategies

WMS 24 Tanzania/USAID: Assessment of Rift Valley Pilot Rice Project and Recommendations for Follow-On Activities

WMS 25 Interdisciplinary Diagnostic Analysis of a Work Plan for the Dahod Tank Irrigation Project, Madhya Pradesh, India

WMS 26 Prospects for Small-Scale Irrigation Development in the Sahel

WMS 27 Improving Policies and Programs for the Development of Small-Scale Irrigation Systems

WMS 28 Selected Alternatives for Irrigated Agricultural Development in Azua Valley, Dominican Republic

WMS 29 Evaluation of Project No. 519-0184 USAID/El Salvador, Office of Small-Scale Irrigation - Small Farm Irrigation Systems Project

WMS 30 Review of Irrigation Facilities, Operation and Maintenance for Jordan Valley Authority

WMS 31 Training Consultancy Report: Irrigation Management and Training Program

WMS 32 Small-Scale Development: Indonesia/USAID

WMS 33 Irrigation Systems Management Project Design Report: Sri Lanka

WMS 34 Community Participation and Local Organization for Small-Scale Irrigation

WMS 35 Irrigation Sector Strategy Review: USAID/India; with Appendices, Volumes I and II (3 volumes)

WMS 36 Irrigation Sector Assessment: USAID/Haiti

WMS 37 African Irrigation: An Overview; with An Annotated Bibliography (2 volumes)