MID TERM EVALUATION REPORT

(BY W.D. KEMPER, USDA CONSULTANT)

OF THE

ON FARM WATER MANAGEMENT RESEARCH PROJECT

(KALANKUTTIYA)

WHICH IS FUNDED BY

THE IRRIGATION DEPARTMENT

THE MAHAWELI DEVELOPMENT BOARD

AND

THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

SUMMARY

Status of Findings and Budget

The research farms have been terraced, leveled or graded and are being irrigated using various methods to determine the efficiencies of the leveling and irrigation systems and the degree to which they facilitate good coop production.

The general purpose of this project is to increase crop production per unit of water used. A vital specific goal is to develop an economically attractive alternative to paddy rice on Red Brown Earths, where high paddy infiltration and bund leakage rates are now allowing the major part of the irrigation and rain water to go to the drains. Results to date indicate that upland crops including chillies, cotton, groundnuts and particularly soyabeans grown on sloped furrowed terraces can provide this alternative. Soyabeans have been shown to produce good yields during both Yala and Maha seasons, being more tolerant than the other upland crops tested to high water tables that accompany Maha monsoons.

High water tables which generally reduce upland crop yields are common on Red Brown Earths, even on the research farms, generally being fed from rice paddies in adjacent portions of the hydrologic unit.

Most of the crop production-water management findings need the replication that another year will bring before they are ready for the demonstration and training phase. The primary demonstration and training efforts to date are the farm itself and a manual titled 'Leveling Small Farms in Bench Terraces.' This manual needs to be published immediately.

Of the original $ 800,000 USAID grant, $ 480,000 has been spent or committed, leaving a total of $ 320,000 to be spent. This includes $ 117,000 for Technical Assistance, $ 25,000 for Commodities, $ 88,000 for Special Studies and $ 90,000 for training. Transfers of up to 30% of the amounts designated in these categories can be made in response to needs perceived by the project director without asking for USAID amendment of the budget and Agreement.

Estimates of the extent of completion of the planned activities are given in the following table:

Activities Planned		% Completion
(1+2)	Methods of Land preparation & Land leveling	60%
(3)	Methods of Irrigation and Drainage	40%
(4)	Crop, Soil and Water Management	50%
(5)	Demonstration and Training	10%
(6)	Water Balance	0%
(7)	Structures & Water Measurement	20%

Conclusions

(1) Since about 60% of the 5-year project period has elapsed, it is apparent that substantial additional effort must be made in activity areas 5, 6 and 7, if the original objectives are to be achieved.

(2) The primary constraint on the project to date has been a deficiency in numbers of trained permanent CSL staff who are needed to take and analyze the large amount of data and make the farmer contacts essential to achievement of the project goals.

(3) Discussions with Mahaweli Irrigation Department and Agriculture Department administrators indicate that the benefits that would accompany attainments of the objectives of this project are even more apparent today, than when the project was written. Consequently, the objectives must be attained. Approaches to full achievement of the objectives would be to lengthen the time period for the project and/or to find means of using present resources to achieve the objectives more rapidly.

(4) One of the most critical needs is for researchers to take ideas, techniques and equipment which can facilitate water management to the farmers and find which of them are most helpful to the farmer and best adapted to the farmers resource positions and social patterns on the field channels. Integrating the farmers and technology and studying the reactions and benefits to identify the best combinations is a necessary part of this research. Means must be found to get more researchers into the field where they can bring about this integration.

(5) Subsurface transfer of water from adjacent areas is often a major factor affecting water table heights and crop production on the research farms and in other areas where upland crops should be grown. Hydraulic conductivities of subsurface layers are needed to predict these effects. To identify potentials for improving existing water management, and estimate the cost and benefits of attaining those potentials, more information is needed on how much of the rain and irrigation water is reaching the drains and how it gets there.

Recommendations

(1) In addition to the farm manager, two researchers on permanent appointments should be assigned to the project and stationed at Kalankuttiya. One should be given responsibilities for obtaining and analyzing data on irrigation and drainage trials, land leveling and soil preparation studies and water measurement determinations. The other should be given responsibility for crop-soil water management studies on the research farms. Departments within the PGIA with which the research assistant programs would be developed are indicated in the following table:

Note: USAID has commented that a greater commitment by the Government is required, especially in terms of permanent personnel, before additional USAID funding can be provided.

(2) The grant research funds should be used to accelerate the attainment of the project objectives on which the activities are currently behind schedule. This should be done primarily by hiring persons with the Irrigation Department or the Mahaweli Development Board. Research Assistanships from the USAID Grant and funds should be awarded to those who meet the academic requirements of the Post Graduate Institute of Agriculture for work on specific research programs designated by the Project Director which with which the research programs would be developed are indicated in the following table.

Activities Planned	Research Assistants Proposed Departments of		
	Agr Engrg.	Econ & Extension	Soils
Methods of Irrigation and Drainage			1
Demonstration and training	1	1	1
Water Balance	1	1	1
Structures and Measurement	1	1	

3) The project should be extended for an additional year (6 total) to allow attainment of objectives. Current USAID funding should be used to cover the costs of the approved items during this additional year as far as possible. If additional funds are needed, they should be requested before January 1, 1932.

4) Since the program will be expanded substantially, the Project Director will have many more contacts to make, more coordinating to do, more planning, more analysis of data and report writing. To help the project director achieve these goals it is recommended that when the former director returns the two men both work on the project. If the previous director does not return, the current director will need additional help. It is doubtful that the quality of the work can be maintained at an acceptable level without a long-term expatriate advisor unless this equivalent input is obtained from within country.

5) Short-term expatriate advisors with backgrounds in hydrology, irrigation engineering and extension should be brought in to help these programs if adequate advisors cannot be obtained from within the country.

6) To allow the project staff adequate time to obtain the best inputs (such as crop varieties, weed control chemicals, etc.) and to plant on early schedules, the planning meeting should be held at least 60 days before the anticipated first planting date.

APPENDIX TO EVALUATION AND RECOMMENDATION REPORT*

Training, Meeting Attendance and Study Tours

Additional persons with advanced training in On-Farm Water Management are needed in Sri Lanka. Consequently, it is proposed that two persons be sent overseas for training at institutions such as the Asian Institute of Technology (Bangkok), the University of Hawaii, or Colorado State University. Mr. W.J.K.U. Ranjit, should be considered as one of the two candidates, with identification of personnel and timing of training to depend on when, and how many of the needed personnel can be assigned to the project.

The most accurate and reproducible means for measuring water content of Upland Soils is the neutron probe. Three of these are available in the country, but pnly one of the three is working. A USAID-initiated training program for Dr. Osman Fadl of Sudan has been developed to help him become proficient in the calibration, operation, repair and maintenance of neutron probes. This program will involve approximately a week at the manufacturers (Trolexers) plant in North Carolina and about a month during the irrigation season (about July 1981) at the Snake River Conservation Research Center in Twin Falls, Idaho where these probes are in constant use in irrigation research studies. Water management research in Sri Lanka would benefit by having two persons join Dr. Fadl in this training. Proposed participants are W. Gunasekere and A.C. Nagel.

If the International Farm Water Management Symposium is held in Pakistan during 1981 as proposed, the Project Director should participate. It would be beneficial if Mr. Lyvers could contact Mr. M. Mohamed Ashraf in WAPDA and/or Mr. Mushtaq Gill in the Punjab On Farm Water Management Program or Mr. Kango in the National Program to determine the status of that symposium, and if it will be held, to suggest that the project director and one other person be selected to report on this project. Additional personnel (2-3 people) should also be sent for the USAID sponsored Water Management Project, primarily being implemented in Gal Oya.

Estimated Costs of these items are

Two, two-year training programs at the M.Sc. level @ $ 22,000 each	$ 44,000
Two, six-week training programs for Neutron Probe use in research	$ 11,000
Attendance of two persons at the International Symposium in Pakistan	$ 3,000

* Prepared in consultation with Project Director after the Steering Committee Review.

Advisers

It is recommended that when qualified consultants are available in country, that they be used and that rates be paid for their consultation, which are in line with those paid for consultants in the private sector.

It is anticipated that during the three remaining years (2 planned plus 1 proposed) there will be need for advisers in the subject matter areas of

Irrigation, Water Measurement & Field Structures	(6 months)
Extension and Farmer Organization	(3 months)
Effects of High Water Tables on Redox Potentials, Rhizobia and Crop Production	(2 months)
Hydrology	(3 months)
Land Levelling and Soil Preparation	(3 months)

These advisers should generally participate in the planning, initiation and training stage and then come again during the final data taking, analysis and of results stage.

EVALUATION OF THE MAHAWELI ON-FARM WATER MANAGEMENT PROJECT

(AT KALANKUTTIYA-KALAWEWA)

1. Project Participants, Inception and Funding:

This project was initiated by the Land Use Division of the Irrigation Department and Mahaweli Development Board of Sri Lanka in the last quarter of 1977. Chemonics International Consulting Division of Chemonics Industries contracted with the GSL on June 21, 1978 to provide the services of a field team consisting of long and short-term experts to provide technical assistance to the GSL, through the Mahaweli Development Board and the Department of Irrigation to assist in the planning and implementation of this project. Funding for this project included a USAID grant for $300,000. This grant pays for the expatriate advisors, vehicles, farm equipment, research equipment, books and publications, training and scientific visits, spare parts and "special studies." Funding for local personnel, buildings, equipment operations, and miscellaneous is provided by the Government of Sri Lanka through the Irrigation Department and the Mahaweli Development Board. The major input in conception of this project came from the GSL scientists, with assistance from USAID water management specialists from what is now the Development Support Bureau.

2. Problem Definition, Basic Assumption and Justification:

Analyses of the nations resources have shown that the amount of water available cannot supply the available land with irrigation at the rate at which water is supplied to existing irrigation systems. Only a small portion of the water supplied to these systems is consumptively used in evapotranspiration by the crops. The remainder passes through the system, along with runoff from rains, via surface and subsurface drainage. In many cases this drainage water is caught by tanks and other structures and used as part or all of the supply for other downstream systems. In other cases it is lost by flow to the sea.

The high proportion of the irrigation water going to the drains is a result of water flowing through bunds by leakage or deliberate spilling (surface flow) or percolating down thru the soil (subsurface flow). Both of these factors are intensified where paddy rice is grown on Red Brown Earth soils which generally occupy the upper portions of the landscape where elevation differences between fields are relatively large and which have relatively high permeabilities comparable to the Low Humic Gley soils. Use of RBE soils for paddy rice also brings the water table to the soil surface and thereby eleminates their capacity to sorb and hold monsoon rains in the soil profile. Consequently when the bunds are leaky, most of the monsoon rainfall joins most of the irrigation water in the drains.

Farmers on the Red Brown Earths are commonly at or near the heads of the irrigation field channels where they physically have first access to the water supply. These soils have the greatest potential for water loss through the bunds and through downward percolation. The farmer could reduce this loss by better bund maintenance and puddling of his soils. However, he faces the temptation of taking more than his share of the water to avoid this extra work. The fact that he commonly succumbs to this temptation is evident by the common lack of water for farmers at the tail ends of these field channels.

Strict and enforced rotation of water among field channel users could reduce the inequity of this water distribution. This enforcement would be expensive to the Government in terms of salaries for officers to police the outlets and the inevitable resentment that the farmers on the Red Brown Earths at the head of the channel would develop toward these officers and the Government which they represent. On the other hand, the existing system is also expensive in terms of conflict between farmers at the head and tail ends of the channels, lost production at the tail ends and losing a major portion of the highly valuable Mahaweli system water so that substantial portions of the planned commanded area will be chronically short of water.

An engineering solution to this problem would be to recover more of the drain water through the construction of more structures and pumping systems and provide this through pipes or other conduits to the tail end farmers. This can be done in many cases, but is not a general solution.

The basic objective of the Mahaweli project is to allow the country to become self sufficient in its food and fiber needs. In the case of rice this goal is near attainment. However, in the cases of sugar, cotton and additional protein (e.g. ground nuts and soya bean) only a small fraction of the country's needs are produced. These needs involve upland crops, suited to the Red Brown Earths. In general they have economic return potentials which exceed that of paddy rice.

The basic assumption of this project is that if the farmers can be helped to realize the high economic returns from these upland crops, the following benefits will be achieved:

1. The farmers will voluntarily change from growing paddy rice to growing these higher value crops on the Red Brown Earths.
2. Water use on the Red Brown Earth soils, will be substantially reduced.
3. Farmers at the tail ends of the field channels will receive more water and increase their crop production.
4. Incomes of all farmers will increase substantially.
5. The cost of food and fiber imports will be substantially decreased.
6. Conflicts between farmers and the between farmers and Government will be reduced.

3. Project Purpose and Expected Activities: (basically as per original and amended project descriptions)

With the substantial potential benefits described above as the objective, the project was designed to: develop water delivery systems and schedules; land layout and leveling and associated irrigation and drainage techniques: weed control and fertilization programs and identify crop species and varieties to help farmers on the Red Brown Earths to achieve those economic returns. Desires on the part of many farmers to grow their own food requires that cultural practices to achieve good yields of upland rice also be developed if paddy rice on the Red Brown Earths is to be avoided on a voluntary basis.

The results will be applicable to both new irrigation projects and rehabilitation of older ones. Specifically the project consists of an "experimental farm" of about 50 acres and adjacent "demonstration area" occupied by 2.5 acre farmers in the Kalawewa area where the following activities will first be tested and demonstrated and then carried out in Mahaweli.

1. Methods of land preparation: This will include ungraded, contour, bench and flat terraces. Various methods of construction will be tried to determine the economics and degree of precision obtainable.

2. Land leveling: Small soil scrapers and land planes (both tractor drawn and those pulled by bullocks) will be built and used to level the experimental farm and farmers' land in the demonstration unit. Techniques and procedures developed will be replicated, at least on a pilot basis, in the Mahaweli area.

3. Methods of Irrigation: Various types of furrows, basins and furrow-basin systems will be tested to determine the best type of irrigation application system to fit each type of terrace and cropping pattern.

4. Crop, Soil and Water Management: Combined with the testing of methods of Irrigation, there will be an evaluation of methods of planting, weed control and irrigation requirements for various crops, especially upland rice.

5. Demonstration and Training Activities: The better terracing, furrowing and other improved water management and irrigation techniques learned on the experimental farm will be tried on the demonstration unit with farmers and then in other areas of Mahaweli in farmers' fields.

6. Water Balance: A complete water balance study will be made of the distributary serving the test area.

7. Structures and Measurement: Locally made structures and measuring devices will be installed to evaluate their quality as water control and/or measuring devices.

8. Special Studies: Various types of special water management and irrigation related studies will be conducted by Sri Lankan institutions financed by this grant.

4. Progress Evaluation and Recommendations on Expected Activities:

A. 1. & 2. Methods of Land Preparation and Land Leveling

a. Progress

Procedures have been developed and tested for formation of level benched and graded benched terraces on the research farms and adjacent farms. A manuscript has been prepared by Dr. W.D. Joshua and G.D. Knierim titled "Leveling Small Farms in Bench Terraces." It is easily understood and could be effectively used in training MDB officers engaged in helping farmers lay out and level their lands for irrigation.

Mr. Fernando has received on-the-job-training in the construction of these terraces on the four demonstration farms completed to date from Mr. Swaggerty and has also received overseas training which have given him the ability to lay out farms and level additional terraces as needed.

Limitations of existing buffalo and farm size tractor equipment in terms of earth moving on dry soils were identified and outlined in a report by Mr. Swaggerty. Earth moving efficiencies were low and equipment damage occurred frequently on the dry soils. A list of large size tractors and equipment which could efficiently accomplish the needed earth moving was prepared and earth moving with this heavy equipment was estimated to cost about Rs.2,000 per acre.

b. Evaluation

Progress in this activity has been substantial. About half of the objectives have been achieved. The large size equipment proposed by Mr. Swaggerty should be considered by the MDB for accomplishing their implementation program. However, its cost is beyond the funds available in this research project.

c. Recommendations

(1) The manual titled "Leveling Small Farms in Bench Terraces" should be published as soon as possible. A training session should be developed at Kalankuttiya for specialists of the Agriculture Extension Department where they can participate with Mr. Fernando in the leveling of small farms as described in this manual. In the process of leveling these small farms, the relative efficiencies of dry earth moving should be measured and compared to those in moving earth in water using equipment developed by and available to the project and equipment used by farmers for this purpose. A report on these evaluations should be made available to the extension service. (2) A major program of leveling farms should not be initiated until the research on types of irrigation has reached a point where the most desirable types of terraces have been identified.

B. Methods of Irrigation and Surface Drainage

a. Progress on Irrigation and Surface Drainage Methods

It was found experimentally that when the time required to fill a basin for irrigation was equal to or less than 0.3 of the time required for the water to wet the root zone, that the uniformity of application was satisfactory. Further, assuming a water supply rate of 5 litres/second, which does not require a large ditch, and the average measured infiltration rate on these RBE soils, it was concluded that the size of the basin to be irrigated should not exceed about $85m^2$ if the area with lowest application was to be 80% or more of the highest application. Field experience corroborated that reasonably good irrigation uniformity was achieved if basins of these dimensions were watered from a small field ditch running along terraces that were graded at 0.2% slope. This furrowed basin irrigation system became a standard design for a large portion of the fields on the research farm because it was assumed that farmers who often used small basins, would easily adapt to this system. To facilitate cultivation and furrow and ridge construction, the cross bunds on the terrace which form these basins were constructed after the cultivation, furrowing and ridging were completed. The cross bunds were removed following the crop harvest. These terraces were constructed on a grade of 0.2%. If surface drainage was needed to dispose of heavy rains it was necessary to breech the bunds between the basins.

Better yields of most upland crops have been found on the graded furrowed terraces, as compared to the flat furrowed terraces in studies at this site and at Maha Illuppallama, apparently due to better surface drainage. However, if a farmer wishes to switch back to rice during the Maha season on the graded terraces in the RBEs, he must make numerous cross bunds along the terrace to hold the water in place. Perhaps this can be counted as an advantage in the interest of helping farmers opt for the upland crops.

Project personnel have noted that imperfect grading leaves more pockets of standing water after irrigation rains along the graded terraces with 0.2% slope than on those graded with more slope. Observations on the research farms and on the Irrigation Systems Trials in Block 404 of System H indicates negligible erosion by irrigation and rains on terraces with slopes up to 1%.

This indicates the possibility of achieving better surface drainage and requiring less fill and cut along terraces when slopes varying from 0.2 to 1.0% are allowed. Such terraces would not be adapted to paddies for rice but could accommodate upland crops and be irrigated by either furrow or border type irrigation. These types of irrigation have not been tested extensively in the past because they were considered to require more technical capability than the farmers could master.

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* Surface drainage is considered along with irrigation in this activity because the land preparation for irrigation affects surface drainage, which is critically important to upland crop production when heavy monsoon rains occur.

b. Evaluation of Irrigation and Surface Drainage Activities

Surface drainage and irrigation studies have identified furrowed basins as an irrigation system which is similar to the one which farmers use, which facilitates relatively uniform application of water and reasonably good surface drainage and crop production. However, this system requires intensive labor for bund construction, irrigation and drainage which can be eliminated in some of the other types of sloped systems being tested such as furrow or border irrigation in long terraces. Since it has not been proven that farmers cannot manage these longer sloped runs, it cannot be concluded that the furrowed basin irrigation system is the best one.

c. Recommendations on Irrigation and Surface Drainage Activities

In view of the potential reduction in land preparation costs,* bund making and irrigation labor when longer fields are used and better surface drainage when steeper slopes are used, the technical feasibility and farmer adaptability of steeper, longer sloped terraces should be determined. It would have been economically discriminatory to commit farmers on the Red Brown Earths to such steeply graded terraces when paddy rice was considered to provide the highest net economic returns because such steeply sloped terraces are not easily amenable to paddy cultivation. However, when the project has provided better economic alternatives (i.e. soyabeans and/or other upland crops) farmers with steeply graded terraces will be economically favored. At that time, farmers should be informed of the full range of alternative irrigation systems and relative benefits of each and encouraged to try and adopt them under the guidance of a post graduate research assistant who has evaluated them and mastered their use on the research farms. Their water use efficiencies, labor inputs and crop production should then be monitored to establish which is the best irrigation system. The irrigation evaluations and farmer adoption could be used as the basis for a thesis in the Post Graduate Institute of Agriculture.

Water table and Subsurface Drainage Observations

Water table monitoring was part of the original plan to characterize the hydrology of the research area and to help determine cause and effect relations between land preparation and leveling practices, irrigation and crop production.

Studies at this location and at Maha Illuppallama indicate that while soyabeans will provide reasonably good yields even when the water table rises occasionally to less than 2 feet from the soil surface, yields of most other upland crops are decreased by this condition. At this point

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* Preliminary observations indicate that the area cultivated per hour of tractor time could be increased 50 to 100% by increasing the lengths of fields from 30 feet to 200 feet.

it appears that drainage to keep water tables below 2 feet is desirable to give farmers flexibility in producing the range of upland crops which are most profitable to the farmer and/or the country as needs fluctuate and prices and availability of inputs change.

The demarcation line between Red Brown Earth and Low Humic Gley soils is often not apparent to the untrained person. Farmers on Red Brown Earths generally perceive so discontinuity between their soils and those of farmers immediately below them on Low Humic Gleys. This has been identified as one of the problems in convincing farmers on the RBE's to grow upland crops. A transition phase is often identified as "Imperfectly Drained Red Brown Earths," which for land use classification is often included with the LHGs for crop production capabilities. In other words, drainage is a primary factor in land use classification. These facts can be used to help farmers recognize which land use category their land is in by placing a demarcating channel near the bottom edge of the Red Brown Earths such as the interceptor channel in the Mahakandarawa study. Such a demarcation channel could be even more effective if it was deeper. (In some areas it might be used to vent artesian pressure in underlying strata) and provide a lowered water table at the bottom edge of the Red Brown Earths. The water obtained can generally be used in paddy rice fields at lower elevations.

The research farms offer at least one location where a drain could be installed to lower water tables and the costs and benefits could be evaluated under different cropping systems. The new Project Director has raised the possibility of installing such drains, which could be stopped during dry seasons to supplement water to upland crops growing on the Red Brown Earths and opened during wet seasons when the water tables need to be kept down. The new Project Director also feels a need to further characterize the hydrology of the area by measuring the hydraulic conductivity of layers down to bedrock which can then be used with piezometric head observations to estimate rates of subsurface flow between the upper and lower landscape areas, and between field channel areas, probable water table recession rates etc.

e. Recommendations Concerning Water Table Measurement & Associated Conductivity Measurements

This information is valuable to this and other projects attempting to understand the cause and effect relations between irrigation, drainage and yields of crops. The measurements should be continued at the observation stations currently established and on a new set of holes on a transect downhill across the high water table area. These measurements should be coupled with hydraulic conductivity measurements of the unconsolidated material down to bedrock, to determine whether a drain or drains in this area are needed. If they are needed, crop production before and after their installation should be determined and benefits and cost should be determined. Possibilities of using demarcation drains should be evaluated in terms of potential water removal rates, probable water table draw downs, benefits from using the water on lower paddy areas and probable overall benefits and costs. If it appears that costs could be recovered within a few years, an experimental demarcation drain should be constructed on the research farm.

C. Crop, Soil and Water Management

a. Progress

Trials have been underway during the last two years comparing effects of different methods and schedules of irrigation on yields of several upland crops and paddy rice when grown on the Red Brown Earth (RBE) and Low Humic Gley (LHG) soils which are common in this area. Various methods of planting and weed control and levels of fertilization have also been incorporated in these studies. During the first few seasons of the study, the emphasis was on getting the physical and biological systems operating and the quality and quantity of data collected was less than adequate. This was recognized by the Project Director and in a report by W.C. Higgins in 1979. The services of Ms. Joanne Hale were obtained in early 1980 thru Chemonics to help organize the data collection, develop methods of checking the data and assist in planning the studies and writing the reports.

Data obtained to date indicate that yield potential of upland rice on the RBEs is less than that of paddy rice on the LHGs due to lack of weed competition in the paddies and occasional water stress in the upland rice resulting from high permeabilities of the RBE soils. The researchers involved are confident that they can develop timing and cultural treatment and find varieties which will increase the upland rice yields. However, the possibility of obtaining yields equal to those of paddy rice appears to be small.

Reasonable to good yields have been obtained in the Yala season and the RBEs of several upland crops including tomatoes, eggplant, chillies, maize, cotton, groundnuts and soyabeans. Yields of soyabeans and groundnuts were also good during the Maha season. In general, these findings are supported by trials conducted by the Agriculture Department on research plots in Catchment C at Maha Iluppallama. Soyabeans have proven to be most capable of "tolerating wet feet" and have produced yields sufficiently high to make them an economically attractive alternative* to paddy rice in both the Yala and Maha seasons. This is an important finding which can eventually play a major role in convincing farmers to stop growing rice on the Red Brown Earths which is currently using a major portion of the Mahaweli system waters which are needed for new lands.

To enhance the attractiveness of soyabean production, the project is studying early seeding (i.e. in September for the Maha season) which allows planting of the soyabeans and initial weed control before the Maha rains begin. This has provided excellent stands and weed control, but with the short season, varieties presently used in the area will probably result in maturation in December before the rains stop. This may cause some problems, so the soyabean people at Intsoy and Maha Iluppallama have been contacted to determine the possibility of obtaining longer season varieties.

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*This economically attractive comparison is contingent on continuing support prices and buyers for the beans at those prices. Department of Agriculture personnel indicated that processing plants in place or under construction will be able to handle a steadily increasing soyabean production.

They indicate that some longer season (4 month) varieties are being used in rainfed (chena) areas and that others can be developed with yield potentials which are higher than those of the short season (3 month) varieties currently grown under irrigation. This water management in expanded soyabean production, utilizing the complete Maha rains and limited supplemental irrigation, could play a major role in leaving more water in the tanks following Maha season so there could be more adequate water for the Yala season. Substantial substitution of soyabeans for paddy rice on the FFPs during the Yala season would contribute further to the solution of this problem.

The Project Directors, concerned with the increasing costs of fuel for cultivation, have been investigating methods of chemical weed control. They recently contacted Ray Wijeywardena, Director of the International Institute of Tropical Agriculture, Sri Lanka Project. He has helped develop hand operated spray and seeding equipment which facilitate 'no till' crop culture. Trial plots using the IITA equipment have been seeded. The Maha rains had already commenced and the soil was too wet for optimal operation of the seeder. However, it appears likely that early seeding when soil water level can be controlled, can provide conditions under which this equipment and these chemicals will achieve good stands and weed control.

b. Evaluation

The Project Director and Advisor should be complimented on the extensive amount of work accomplished and improved quality of the data on Crop, Soil and Water Management during the past year. Despite the poor start in this activity area, the project now appears to be approximately on schedule. Failure to plant on the desired dates, common in past years, no longer occur. However, the rather short time between the committee meeting and planting time of some of the crops has resulted in using available varieties rather than the best varieties in several cases.

c. Recommendations

To allow the project staff more time to obtain the best possible varieties for planting and to plant on early schedule, the planning meeting should be held at least 60 days before the anticipated first planting date.

More frequent communication with the Agriculture Department Crop Specialists and Breeders (specifically in soyabeans, groundnuts, sugar cane and cotton) should be made to acquaint them with the water management data obtained on their crops and to obtain their suggestions and plant materials to facilitate the project.

Limited work on water management to optimize upland and lowland rice yield should continue, but more emphasis should be placed on upland crops including soyabeans, groundnuts, cotton and sugar cane to determine their yield potentials under optimal management of water and other conditions on farm size fields. Reasons for this emphasis are given in detail in the section on "Problem definition, basic assumption and justification."

In view of the continuing increases expected in the price of liquid hydrocarbon energy, no till crop production, utilizing chemical weed control, and developing water management practices to optimize stands and weed control should receive continuing and increased attention.

D. Demonstration and Training Activities:

a. Progress

The research farm is to some extent a demonstration activity. Four of the farms in the adjacent area where demonstrations on farmers fields were planned have been terraced according to the methods developed on the farm and outlined in the manual. Two of these are now farmed by persons other than their owners under conditions which make them less than ideal for further demonstration.

The Chairman of the MTP showed keen interest in the project and said that as soon as results were available, he would have them incorporated into the training program which MTP helps prepare for new farmers. However, suitability of many of the water management practices, such as furrow and border irrigation on long terraces, can be certified only after they have been used successfully by farmers.

b. Evaluation

Under ideal conditions the demonstration activities should have begun about a year ago, but given the constraints encountered in getting equipment to the site and appointing permanent personnel to several of the posts in the project the present status represents a reasonable level of accomplishment.

c. Recommendations

The choice of farmer is generally more important to the success of a demonstration than the choice of farm. Moreover, demonstrations generally have more effect if they are surrounded by non demonstration farms. Consequently it is recommended that the area in which demonstrations may be located be widened to include any farms within walking distance (one mile) of the research farm. Choices of the locations should be based on the farmers desire to participate and his ability to understand the principles involved and how the new practice or system should benefit him. This will require that at least one research officer spend considerable time with farmers in the areas so he can assess their capabilities as farmers and their reliability. These initial contacts could be made through a survey of the type being conducted by Mr. Karunaratne but should also involve taking measurements of aspects of the farmers water management system (e.g. flow-rates into his farm, size of his lyaddes, surface drainage from his fields, infiltration rates, water table levels, depth of fine textured soil etc.) which are pertinent to possible demonstrations and will be of general interest to the farmers. The water management information obtained can be used to evaluate the degree to which relevant conditions on that farm are characteristic of the surrounding area.

To put this off-station demonstration program into action it is recommended that two researchers be assigned full-time to this endeavour. Their initial responsibilities would include assisting with the various types of irrigation and their evalution, land lay out and leveling, water flow measurement, water table measurement etc., on the farm as assigned by the Project Director and other Advisors and coordinated by the farm manager. When they are competent in the relevant measurement techniques, the researchers should develop survey programs and longer range demonstration programs with the Director and other appropriate advisors. The long range demonstration programs will be subject to amendment as they gain understanding of farmers needs and priorities.

Since extensive economics and engineering advice would be beneficial on such a program and since the respective department chairman have indicated that such a program could serve as the research for masters degree theses in the Extension and Economics Dept. or the Agricultural Engineering Department of the Post Graduate Institute of Agriculture, it is proposed that the assigned individuals be granted research assistantships, paid for by the USAID grant research funds, with funds also being granted to the PGIA to compensate the advising professor for time which he spends on the project. This method of accomplishing this work is recommended because personnel presently on board do not have the time to do it, because post graduate students are doubly motivated, because their work time can be flexible so they can meet with farmers at times convenient to farmers such as the evening or weekends and because the funds are available. Candidates for these positions would have to have academic qualification to satisfy the PGIA, but could be drawn from the Irrigation Department, new graduates, Agriculture Department and other sources. They should be provided with motorcycle transportation. Since their training and field study period would probably extend over two years, and they would need to be at the University for at least nine months of that time, they may need field assistants from the farm to help them take needed data and maintain contact with the farmers. Interaction of the programs of the post graduate students from the two departments should be coordinated by the project director to achieve project objectives.

An additional Research Assistantship and a project to conduct studies and demonstrate improved soil and water management and/or weed control techniques should be developed with the student. The Soil Science Department should be added to this demonstration team if information from the farmers indicate priority needs in this direction.

E. Water Balance Activities:

a. Progress

Measurement of the water delivered to the distributary and from the distributary to each field channel and calculation of losses from the channel has not been done. Orifice plates of the type constructed for measuring flows on the field channels could be used for this purpose although a larger orifice would be needed to accommodate flows of the size encountered at the upper end of the distributaries.

b. Evaluation

This work has not begun

The results are still needed.

c. Recommendations

The water balance on the distributary and on several of the field channels should be done at least one time during both the Yala and Maha season in 1981 and 1982. It is recommended that these be incorporated into a broader hydrologic balance study for the following reasons:

Major programs are being considered for improving the use of Mahaweli Project water whose success will depend on hydrology of the surface and lower layers with little information being available on that hydrology. For instance the program which would pipe water and make it always available to all farmers assumes that when the water table is brought to the surface in the LHG soils, farmers will stop over-irrigating because the downward movement and transfer of water from the area will be practically negligible, even under paddy rice. Data is needed to evaluate that assumption and to provide a sound basis for evaluation of proposed systems for managing water in the distribution conduits, on the farms and in the drains.

Consequently it is recommended that the hydrologic balance of the drainage catchment (about 2 square miles) serving the research farm be studied. This would involve (1) defining the catchment area and installing a large flume and stage recorder on the drain at the lower end of this catchment; (2) installation of at least two recording rain gauges in addition to the one at the research farm weather station; (3) monitoring flows into the field channels serving the catchment area; (4) estimating seepage losses from field and distributary channels that contribute to the ground water of the area; (5) estimating consumptive use of water in the area; (6) measuring hydraulic conductivities and water table (and/or piezometric head) gradients and calculating flow rates through the consolidated materials over the bedrock; (7) identifying primary channels through which surface flow enters the drain, determining areas from which they draw water and monitoring flows of such channels; (8) measurement of water tables (and/or piezometric heads) and relating their fluctuations to irrigation practices, rain and surface drainage, depth of rooting and transpiration of crops and subsurface transfer of water; (9) salinity measurement of water at selected points to determine salinity pickup and water routing.

This would be a major undertaking which would require two researchers. One of these should be at the project site for at least half of the time for two years and could hold an M.Sc. Research Assistantship in Agriculture or Civil Engineering. The second should hold a Research Assistantship for a Ph.D. and should be committed to be on site for at least half of the time for 3 years and would take responsibility, along with the project director, for the integration of this water balance activity. In addition to these researchers, 2 reliable data collectors will be needed to monitor the variables withing the measurement network. The results of previous and on-going hydrologic measurements, such as these taken in the Kaudulla area adviced by Japanese expatriates and those at H 404 should be studied before the final plans for this hydraulic balance study are formulated. The need of considerable equipment and transport and initial and occasional advice from an expatriate advisor may cause the cost of this study to exceed the funds available in the research grant which are not committed to other projects. If so, amendment of the agreement to provide more USAID funds or reducing the scope or intensity of the hydrologic balance study should be considred as alternatives.

F. Structures and Measurement Activities:

a. Progress

Drop structures were constructed on the field channel serving the research area which are serving the purpose of lowering the water, but some erosion is occuring on the downstream end. The amount of masonry used in these structures appears to be excessive.

Short sections of plastic pipe placed through bunds leading from the supply ditches were used for two seasons for distribution and measurement structures on the farm. A staff gauge was provided in front of them and water level was maintained at a prescribed level by adjusting a wooden by-pass. Apparently free flow was assumed at the pipe outlet. Personnel who used these pipe outlets could not be contacted because they have left the project. There is question as to whether these pipes were carefully leveled when installed. Their use was discontinued on the basis that the irrigators did not have time to make the careful adjustments needed and attend to the frequent moves of water required in the small basin irrigation system which was in common use. Consequently, concrete flumes were established at the outlets from field channels into the farms which were used to determine the amount of flow into the farms. For reasons discussed in the irrigation and drainage activities section, it was decided that this flow (about 0.5 cusecs or 15 litres/sec) should be divided into three small streams, each of about 5 litres/sec. This was done by using portable wooden dividers. When these wooden structures were not warped and were carefully leveled at right angles to the stream and if given sufficient slope down-stream to avoid backwater from the outlet turnpoint causing head difference at the division point, these structures provided reasonably accurate division of the channel water.

b. Evaluation

Due to monsoon rains, actual irrigation was not observed. The position of the wooden divider boxes left in the channel from previous irrigations indicated that they had not been precisely leveled at right angles to the flow and there was not sufficient slope in the direction of the flow to avoid some back water effect on water elevations at the division point. It is probable that the accuracy of division under operating conditions is no better than $\pm$ 10% of the total flow.

This activity has begun. Much is left to do including observation of farmers practices, consultation with them concerning their needs regarding schedule and rates of water delivery and ascertaining what type of structures are needed to assist them in providing equitable distribution of water. To illustrate the last point, in one of the field channels inspected, the responsibility of distributing water from the field channel had been turned over to the farmers and they had decided to allow equal flow to all 20 users. The farmers at the head of the channel came and complained that farmers on the downstream channel had broken out a structure which made it impossible for him to get the share of water to which he was accustomed from the channel. Observation of the flow to his field indicated (to persons practiced in measuring water flows) that he was taking more than 10% of the channel flow. Inspection of a drain below his farm showed that most of his water was spilling from his paddies into that drain, from which it couldnot be recovered by downstream users of that field channel. Because of the lack of measuring device at this outlet, this farmer who was taking more than twice his share of the water, felt sincerely that he was being deprived. Simple measurement structures will not alone assure equitable distribution, but they are essential to equitable distribution and consequently this activity of the project should be accelerated.

c. Recommendations

The policy and actual practice of the MDB and farmers should be determined with regard to distribution of water from the field channels. If, as indicated in the current practice, the distribution is to be managed by the farmers, consultations with the farmers and measurements of flow into and from field channels should be initiated. Meetings with farmers served by a field channel should be organized through the appointed farm leaders. The purpose of such meetings should be for the farmers to jointly discuss the problems of distribution of water from their field channel as they perceive them, to give them information collected on actual flow rates in their system and to discuss rotational schedules, using the structures currently in place which ocild serve their needs and facilitate equitable distribution. If there are indications of needs for other types of structures (for instance to equitably partition constant flow) such structures should be constructed as demonstrations on the research farm channel. Subsequent meetings should be held to help them decide on a plan of action to solve their problems. Basic elements of such a plan should include: (1) election of assistants to the farmer leader and commitment by the farmers to support these leaders in the cleaning and maintenance of the system and in sanctions against 'free riders' and individuals who damage the system or use it improperly to obtain more than their share; (2) a commitment by the farmers to do the labor involved; (3) a commitment by the research project representative to furnish, act as an arbitrator, and if needed, to modify the existing structures to facilitate the desired distribution; (4) a schedule for the improvement activities. The research project should assist and observe the farmers in the implementation of this plan.

Records should be kept of basemark mesurements, surveys, discussions, meetings, improvement activities, costs, problems, benefits and lessons learned to document this case history of adapting the field channel delivery system and its structures to facilitate distribution of the water. Several successive case histories may be needed to refine the extension procedures for dealing with the farmers and identifying the types of structures which serve the farmers best.

Two post graduate types of researchers will be needed. One should be associated with the Economics and Extension Department at Post Graduate Institute of Agriculture and the other with the Agricultural Engineering Department.

Their studies should be closely coordinated; both attending the initial meetings with the farmers. The engineer should come to these meetings with a clear understanding of the design and planned method of operation of existing structures, obtained from the IDP engineers and a broad acquaintance with other types of structures that could be used. Types of delivery channels, structures and rotations to be considered could include:

1. The present structural system with rotations designed to provide water to the farmers at 0.5 cusecs for 12 hours per week. Variations could be: 12 hours once every 7 days.
   6 hours once every 3½ days etc.

2. Constant flow of 0.05 cusec to each farm with pipe outlets and check structures such that the flow cannot be appreciably increased. These could be supplemented by special siphons to be kept at the farmer leaders home and loaned to farmers who had permission to borrow water from neighbours who didn't need it and were willing to have their outlets blocked.

3. Constant flow of 0.17 cusec, which could be closed and could deliver to each farm in rotation for 36 hours/week, or two 18 hour periods/week. Siphons would be issued from the farm leaders home for legal borrowing of water.

4. Calibrated adjustable gates which can be closed or opened and deliver measured rates of water from 0.05 to 0.5 cusecs These could be operated in any manner agreed upon by the farmers.

5. A channel with no gates from which water would be issued to farmers at their designated locations by rotating use of large or small siphons as decided upon by the farmers, designed by the engineer, adapted to seasonal needs and coordinated by the farmer leader.

The engineer would construct and evaluate on the research farm, at least one example of each type of outlet to be considered. They should be constructed at locations where groups of interested farmers could come to see and operate any or all of them on designated days of the week. The engineer would participate with the extension-economist in taking flow measurements on inflow and outflows from the field channel.

The extension economist would take the lead in making contacts with the farmers and farm leaders. The extension economist and engineer would jointly predict benefits and cost ratios and present them to the farmers and would re-assess these after each case history was complete. The extension person would produce an efficient plan for helping farmers organize for equitable and timely distribution of their field channel water. The engineer would produce a set of specifications for and performance data on structures which farmers were able to use to distribute water to their satisfaction on field channels.

5. A. Special Studies:

a. Progress

A survey of crop production and water management practices is underway among farmers and in the vicinity of the research farms. The post graduate "surveyor" will use the information as a thesis in the Department of Economics and Extension at the PGIA.

The surveyor, Mr. Karunaratne Banda found that the water was not being delivered to farmers on the rotational schedule originally organized by the IDB. Instead, responsibility for distribution is left to the leader farmer, who normally is not able to achieve orderly or equitable distribution. A commonly occurring situation is for most farmers on the top end of the field channel to be taking a small stream that is more than their share, with farmers on the bottom and receiving smaller streams or none at all. Some of the farmers contacted reported that they like the new system better than the old one. Significantly, farms at the bottom end which have been abandoned had no spokesmen. In another area a farmer said that the farmers on his channel had not been able to arrive at a rotation schedule acceptable to all concerned. Social conflict was extreme and physical conflict occurred frequently over the water. He said they would welcome an IDB officer to help them set up a distribution schedule.

Mr. Banda's survey is producing facts about the farmers which will help define their problems. The extreme partioning of the water made its measurement with the available flumes extremely difficult. Consequently the project director and his farm manager have constructed orifice plates which can be used with a set of tables developed by Mr. V. Premakumar of USAID to determine flow rates down to 0.001 cusecs from head loss measurements across these plates.

b. Evaluation

The data from Mr. Banda's survey has not yet been evaluated. However, his enthusiasm and hard work and the positive attitude of the PGIA director and staff in this and other departments already indicate that this can be a good avenue for investing the grant research fund's to achieve project objectives.

c. Recommendations

It is recommended that additional Research Assistantships similar to the one now held by Mr. Karunaratne Banda be instituted with the PGIA in the activity areas indicated in the following table. In this same table the reviewer outlines his estimate of the degree to which originally planned activities of the project have been completed. As may be seen in the table, the recommended Research Assistantship programs are planned to supplement those areas in which progress is behind schedule.

The research recommended for these Post Graduate Research Assistants are listed in sections B, D, E and F.

Activities (Planned in Original Project)	Research Assistants Proposed in Depts. of			Estimated Present Completion of Activity
	Agr. Engrg.	Econ. & Exten.	Soils	
(1+2) Methods of Land Preparation & leveling				60%
(3) Methods of Irrigation & Drainage			1	40%
(4) Crop, Soil & Water Management				50%
(5) Demonstration & Training	1	1	1	10%
(6) Water Balance	1	1	1	0
(7) Structures & Measurement	2			20%

6. A. Contractor Performance:

a. Suitability of Personnel for Project Needs

(i) George Knierim, land leveler and applied engineer was not effective in planning data taking or writing up research results. However, he did help the CSL personnel get the project started by designing and building scrapers and putting together other equipment that could be used until the new equipment arrived. His knowledge of equipment was especially helpful in the initial stages of laying out the land and preparing it for cultivation. He planned and supervised the leveling of the majority of the farms and co-authored the bulletin on land leveling. Illness caused him to ask for termination of his contract six months early. Considering needs foreseen at the onset of the project, his suitability for those needs was good.

(ii) Joanne T. Hale was recruited in response to a need perceived by the project director and F.C. Wiggin, a short-term consultant, for help in organizing, planning, data taking and assisting in write up of the project. She is an Agronomist with considerable training and experience in crop production research and factors including water management involved therein. Since her arrival there has been some discussion concerning her lack of sufficient expertise in hydrology. However, she has done a good job of what she was brought here to do. The farm managers expressed special appreciation for her help in organizing their data collection and data checking system.

(iii) D.C. Wiggin, on a short-term assignment to help write up the reports for 1978-79 seasons analyzed the collected data and found it to be unreliable. This finding, though negative in nature helped correct the situation.

(iv) Jack Swaggerty helped train Mr. Fernando and organized the leveling of 4 of the demonstration farms. The project personnel were favorably impressed with his efforts to get these jobs done and get the related equipment into operating condition.

In general, the contractor has provided personnel who were not the most outstanding in their fields, but were competent in the areas for which assistance was requested.

b. Relations with the Government of Sri Lanka

A tide of self confidence has been rising in the engineers and Scientists of this project as well as in Sri Lanka as a whole. The developing attitude is that they have learned the necessary procedures and have a desire to be on their own with only occasional assistance from expatriate advisors in the planning and analyses of the projects. This does not appear to be a specific reaction to Chemonics performance, but involves a perception on the part of the host country scientists that the experts provided by Foreign AID programs are generally average ability researchers and engineers back in the developed country of origin. They conclude that available funding can go much further if they can use in-country advisors.

7. A. GSL Support of the Project:

Official support of the project by Administrators in the Irrigation Department and the Mahaweli Development Board is strong. In fact, when one line official was asked if he thought the project should continue, he replied "The Project will continue! Its objectives were designed by the GSL scientists to fill SL needs and the GSL will provide funds for its continuance. The decision to be made is only whether USAID is willing to help so our objectives can be reached more quickly."

The Director of Agriculture was also positive about the project. When asked whether it should be in the Agriculture Department, he replied "It will be more effective in the MDB where they do not have as much red tape.